Fiscal Policy, Asset Pricing and Economic Activity in a Savers-Spenders Economy*

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Abstract

We study the quantitative implications of fiscal policy decisions in a heterogeneous agent model with incomplete markets where equity and government debt are not perfect substitutes. The model closely fits the main macroeconomic and asset pricing moments, and generates substantial wealth and consumption heterogeneity. Consistent with stylized facts, a large fraction of households ("spenders") save very little and wealth is concentrated among the remaining households ("savers").

The distinction between government bonds and equity leads to a connection between fiscal variables, asset prices and capital accumulation through households’ portfolio re-allocation decisions. As a result, we find that even lump sum taxation will have substantial macroeconomic and asset pricing effects. More precisely, lump-sum taxation implies 75% of the crowding-out effect obtained with distortionary taxes. Overall, higher government debt decreases the equity premium, increases the riskless rate, and can crowd out capital substantially. Paying for higher government debt with higher (distortionary) capital income taxes makes the quantitative results even stronger. On the other hand, the crowding-out effect of taxes through the tightening of liquidity constraints is negligible since the households potentially affected by these constraints own a very small fraction of the capital stock.

JEL Classification: E21, G11.

Key Words: Fiscal Policy, Household Heterogeneity, Incomplete Risk Sharing, Life-Cycle Models, Limited Stock Market Participation.
1 Introduction

What are the effects of permanent and temporary changes in taxation and government debt on asset prices and aggregate economic activity? Despite the central importance of this question for fiscal policy analysis, there is no widespread agreement on a specific model that can be used to quantitatively examine this issue. In particular, there is a notable absence of theoretical models at the nexus of macroeconomics and finance which would allow for the quantitative evaluation of fiscal policy effects on the rate of return of risky assets, and on the equity premium. We think this arises for two reasons. First, due to a common simplifying assumption in these models, that government debt and productive capital are perfect substitutes in household portfolios, therefore earning the same rate of return. Second, due to the strength of the equity premium puzzle that limits the range of plausible models which can be used to examine this question. In this paper we attempt to address both of these concerns and build a model which can shed light on the quantitative asset pricing implications of fiscal policy decisions.

We consider a general equilibrium overlapping generations model with heterogeneous agents which combines several relevant extensions of the neoclassical production economy paradigm. First, we have two different securities: one-period government bonds, and equity. Government bonds are riskless while equity is a claim on the capital stock and thus earns a risky return. Second, we explicitly consider the role of taxes and government debt. Third, we carefully model wealth heterogeneity. Recent empirical evidence shows that, for a large group of households, consumption tends to track income over substantial parts of the life cycle, and responds to transitory and/or expected changes in income. Relatedly, a large number of households never accumulate a substantial amount of assets and are unable to smooth consumption. We model this behavior by introducing idiosyncratic labor

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1 See, for instance, Carroll (1997), Attanasio, Banks, Meghir and Weber (1999) and Gourinchas and Parker (2002).
3 Data from the U.S. Survey of Consumer Finances (SCF) routinely show significant wealth concentration with approximately 82% of total wealth being held in the top quintile of the wealth distribution (Budría...
income shocks and liquidity constraints in the household problem, following the buffer-stock literature (e.g. Deaton (1991), Carroll (1992, 1997)). Finally, a significant fraction of households do not participate in the stock market, either directly or through pension funds and the non-participation is much more pervasive among poor households.\textsuperscript{4} We therefore separate stock market participants and non-participants in the model, while carefully replicating the observed significant wealth heterogeneity between these two groups.\textsuperscript{5} In our model, the differences in wealth accumulation arise from differences in elasticities of intertemporal substitution and discount factors.

Our model economy endogenously generates the structure familiar from a savers-spenders model. In the latter model, by assumption, two groups of agents have different savings behavior. The savers are life cycle rational optimizers who behave according to the Permanent Income Hypothesis, while the spenders are exogenously assumed to consume current income (or pension) every period. The microeconomic evidence mentioned above accords well with this type of heterogeneity. This has motivated applications of the model in several recent studies of social security reform, for example, Abel (2001) and Diamond and Geanakoplos (2003). The model has also been shown by Campbell and Mankiw (1989) to approximate well the dynamics of aggregate consumption.\textsuperscript{6} Our model therefore is useful for addressing issues where the savers-spenders dichotomy is likely to be important and it has an advantage because it allows for endogenous reaction of households to policy changes.

We calibrate the model to replicate several key macroeconomic and asset pricing moments. In particular, it delivers a low mean and standard deviation of the return on short-term government bonds (around 2% and 3%, respectively) and a sizeable equity premium.

\textsuperscript{4}For example, in the 2001 SCF the overall participation rate is 45% and it is 88.84% among households with wealth above the median, and only 15.21% for those with wealth below the median.

\textsuperscript{5}The limited participation is imposed exogenously, as in Guvenen (2003) and Basak and Cuoco (1998), but given the significant endogenous heterogeneity in wealth accumulation, we implicitly assume that a small fixed cost prevents poor agents from holding equity (as in Gomes and Michaelides (2005)).

\textsuperscript{6}Mankiw (2000) and Gali et. al (2004) also emphasize that the available evidence requires a savers-spender model, the former study focuses on fiscal policy and the latter one focuses on the evaluation of monetary policy based on such a model.
(around 4%) with a higher volatility of equity returns (14.3%).\textsuperscript{7} With respect to aggregate macroeconomic variables, the model closely matches the ratios of consumption, government expenditures, investment and government bonds to output. In addition, aggregate consumption growth is smoother than aggregate output growth, and the consumption of stockholders is more volatile than the consumption of non-stockholders, in line with recent empirical evidence (e.g. Malloy, Moskowitz and Jørgensen (2006)).

Given the reasonable empirical predictions of the model, we investigate its fiscal policy implications for asset prices and aggregate variables in the stochastic steady state. We consider three different fiscal policy decision variables: lump-sum taxes, distortionary taxes (on capital income), and public debt.\textsuperscript{8} Since we don’t have perfect substitutability between government bonds and claims to the capital stock, fiscal policy changes will have quantitatively important implications for the equity premium, through its crowding out effect on the capital stock. More precisely, any policy decision that leads to an increase in the ratio of aggregate capital stock to government debt implies (on average) a shift in household portfolios towards risky capital, which in equilibrium leads to a higher equity premium.

Interestingly, we find significant crowding out effects from lump-sum taxes, coming from the effect of non-distortionary income taxes on household portfolio rebalancing. Lump-sum taxes correspond to negative riskless bond holdings, with the tax payments behaving like fixed coupon payments. In a model where bonds and equity are not perfect substitutes, households must compensate for this by decreasing equity holdings. In equilibrium this results in a lower level of the capital stock. We show that this effect is quantitatively very large. An 10% increase in the ratio of government debt to GDP decreases the capital to GDP ratio by 2% if interest payments are financed by higher lump-sum taxes. To put this number in perspective, the crowding-out effect would be 2.7% if we considered distortionary capital income taxes instead. Thus, lump-sum taxation implies 75% of the crowding-out effect obtained with distortionary taxes. This channel of crowding out, through household

\textsuperscript{7}The mean and the variance of the equity return are still lower than their historical average counterparts.

\textsuperscript{8}We refer to lump-sum taxes are taxes on labor income interchangeably since in the model, for tractability reasons, we do not include a household labor supply decision and, consistent with the data, household-level labor income is uncorrelated with stock returns (Heaton and Lucas (1997)).
portfolio re-allocations, illustrates the importance of considering models where bonds and stocks are not perfect substitutes in the portfolio, when investigating the implications of exogenous policy changes.\textsuperscript{9}

Overall, we find substantial quantitative effects of government debt on key aggregate variables. An increase in the government debt relative to GDP by 10 percentage points causes a permanent reduction of the average output (GDP) ranging from 1% to 1.5%, depending on how the new debt is financed.\textsuperscript{10} In the same experiment, the mean return on government debt rises by 60 to 80 basis points (from 1.9\% to 2.5\%-2.7\%) inducing households to hold the extra government debt. This elasticity is consistent with the empirical results in Engen and Hubbard (2004) where it is found that an increase in the government debt to GDP ratio by one percentage point raises the return on government debt by 3 basis points.\textsuperscript{11} Given the crowding out of the capital stock, the mean return on equity rises, but to induce the portfolio reallocation towards more debt, it increases less than the riskless rate. As a result, the equity premium falls by 33 to 42 basis points (from 3.87\% to 3.54\%-3.45\%) across several experiments.

The crowding-out effect of taxes through their impact on the tightening of households’ liquidity constraints is negligible. The investors for which these constraints are potentially binding are those that either do not invest in equities (spenders) or have very little wealth (young savers) and thus their decisions have a small impact on the aggregate capital stock. The shareholders who own the large majority of the economy’s equity have significant accumulated wealth, and therefore are not affected by the presence of liquidity constraints.

\textsuperscript{9}Elmendorf and Kimball (2003) analyze (in a two period, partial equilibrium model) a different effect from redistributing labor income taxes across time, namely that under certain conditions revenue-neutral deferral of taxes and higher taxation reduce labor income risk and lead to higher investment in the risky asset. Our finding is different in that taxation in our case is reducing the present value of the implicit bond in the form of labor income and that leads to a reduction in equity holdings by households.

\textsuperscript{10}In our model, payments on higher debt can be financed by the reduction of government expenditures, higher lump-sum (labor income) tax, or higher capital income tax.

\textsuperscript{11}Additionally, Laubach (2005) finds somewhat larger impact of 5 to 6 basis points for 1 percent increase in debt to GDP ratio. However, the effect of government debt on interest rates remains ambiguous empirically, as Engen and Hubbard (2004) note in their review of this (large) empirical literature. Nevertheless, these recent empirical results favor an interpretation that is consistent with the magnitudes generated in our baseline economy.
On the other hand, because of the wealth heterogeneity in the model, liquidity constraints are key in generating an aggregate consumption response to transitory tax shocks. Labor income (lump-sum) transitory tax shocks have an effect on aggregate consumption because they affect spenders’ consumption via liquidity constraints. This result is consistent with the recent empirical results in Johnson et. al. (2006) and the theoretical results in Heathcote (2005) who also finds that consumption of liquidity constrained households is affected by temporary tax changes. In addition, we find that capital income tax shocks do not have any significant effect on consumption because they matter primarily for savers who have sufficient assets to insure consumption from tax uncertainty. Thus, the consumption of richer savers is not affected by transitory changes in lump-sum taxes or in proportional capital income taxes.

The paper is structured as follows. Section 2 outlines the model and the calibration while Section 3 discusses the baseline results. Section 4 discusses several comparative statics in the stochastic steady state, while Section 5 investigates the responses of different variables to transitory tax shocks in the short run. Section 6 concludes. Technical details of the computational procedure are provided in the appendix.

2 The Model

2.1 Outline

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 that is financed by taxes on current workers’ wages. Households can invest in two alternative assets: a claim to the risky capital stock (equity) and a riskless (for one period) government bond. 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 income and bequests to finance government expenditures and the interest payments on public debt. In addition, there is a social security
contribution taken out of wages to finance the social security scheme (pension income).

2.2 Production technology

2.2.1 Production function

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

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

where $K$ is the total capital stock in the economy, $L$ is the total labor supply and $Z$ is a stochastic productivity shock 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 $U_t$ follow a two-state Markov chain capturing the average business cycle duration.

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, $R^K_t$) are given by the firm’s first-order conditions

$$W_t = (1 - \alpha)Z_t(K_t/L_t)\alpha$$

and

$$R^K_t = \alpha Z_t(L_t/K_t)^{1-\alpha} - \delta_t$$

where $\delta_t$ is the depreciation rate.

2.2.2 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 (see also Cochrane (1991)).

Since we have incomplete markets, different stockholders have different stochastic discount factors. 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 captured the adjustment cost effect by assuming a stochastic depreciation rate for capital (Storesletten et al. (2001), Krueger and Kubler (2006), and Gottardi and Kubler (2004)). We follow the same route and assume that the depreciation rate is given by

\[ \delta_t = \delta + s \times \eta_t \]

where \( \eta_t \) is an i.i.d. standard normal and \( s \) is a scalar. Therefore, \( \delta_t \) is a general measure of economic depreciation, combining physical depreciation, adjustment costs, capital utilization and investment-specific productivity shocks. In the baseline case we assume that \( \eta_t \) is uncorrelated with the productivity shock \( U_t \).

### 2.3 Government debt and social security

A social security system is important to provide the model with a realistic labor income process. If we were to ignore social security transfers we would significantly increase households’ income risk and wealth accumulation. The government sector is crucial to model government bonds in positive supply, so as to match the average portfolio allocations in the data.

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12 Adjustment costs are also very important for a realistic characterization of aggregate investment flows. See, for example, Abel and Eberly (1994) or Eberly (1997).

13 Guvenen (2005) introduces adjustment costs in a model with restricted stock market participation, but in his model there is perfect risk sharing among stockholders. Therefore, there is a unique stochastic discount factor for pricing capital.

14 Hercowitz (1986) and Greenwood, Hercowitz and Huffman (1988) use the same approach to model fluctuations in capital utilization, while Greenwood, Hercowitz and Krusell (1997) use it to model investment-specific technological shocks as a reduced form for vintage capital models.
2.3.1 The social security system

The social security budget is balanced in all periods so we can discuss it separately. Given a value for the replacement ratio of working life earnings (denoted by $\lambda$), a proportional social security tax rate on labor income (denoted by $\tau_s$) is determined endogenously. This tax rate ensures that the social security taxes are equal to total retirement benefits, taking into account the demographic weights and survival probabilities.

2.3.2 The government debt

The government’s budget constraint (excluding social security) is

$$B_{t+1} = (1 + R_t^B)B_t + G_c^e - T_t$$  (3)

where $G_c^e$ is government consumption, $B$ is public debt, $R_t^B$ is the interest rate on government bonds, and $T$ denotes the tax revenues. Tax proceeds arise from proportional taxation on capital (tax rate $\tau_K$), proportional taxation on labor (tax rate $\tau_L$) and a 100% tax rate on bequests ($E$). In these models there is the potential for government debt to become non-stationary. The main problem lies with the simple observation that the evolution of $B_{t+1}$ depends on $B_t$ but through a multiplication by a time-varying coefficient that is greater than one because the riskless rate has a positive mean. As a result, if taxes and government consumption are stationary, then government debt becomes non-stationary which makes market clearing period by period impossible. Moreover, it is not obvious what normalization may be used to make $B_t$ stationary. One solution is offered by Heathcote (2005) who makes taxes (and household decisions) depend on government debt: high government debt relative to its long run average implies higher taxation. This requires the addition of one extra state variable in the model, however, making it quite difficult to solve as subsequent sections will illustrate. We therefore abstract from these complications and assume instead that the government debt is constant over time with government consumption adjusting endogenously to satisfy (3) period-by-period.

As will become clear later on, labor taxes are non-distortionary in our model because there is no household-level labor-leisure decision. As a result we will preferentially refer to
them as lump-sum taxes, which is what they effectively are. Our main comparison in this paper is therefore between the effects of lump-sum taxation and the effects of distortionary (capital income) taxation. Naturally, it would also be interesting to include distortionary labor income taxes in the model, however this would require the inclusion of a labor supply decision and/or an endogenous retirement decision, which would make the model untractable (especially in the presence of aggregate uncertainty). Given the empirical evidence that the labor supply elasticity of prime-age males is very low, this is a useful benchmark for more complicated future models that might include those endogenous decisions.

2.4 Households and financial markets

2.4.1 Preferences

Time is discrete. We follow the convention in life-cycle models and let adult age \((a)\) correspond to effective age minus 19. Each period corresponds to one year and agents live for a maximum of 81 \((A)\) periods (age 100). The probability that a consumer is alive at age \((a + 1)\), conditional on being alive at age \(a\), is denoted by \(p_a\) \((p_0 = 1)\). Households have Epstein-Zin preferences \((Epstein and Zin (1989))\) defined over a single non-durable consumption good. Let \(C_a\) and \(X_a\) denote consumption and wealth (cash-on-hand) at age \(a\), respectively. Household preferences are defined by

\[
V_a = \left\{ (1 - \beta)C_a^{1-1/\psi} + \beta \left( E_a(p_aV_{a+1}^{1-\rho}) \right)^{1-1/\psi} \right\}^{1/1-\psi}
\]

where \(\rho\) is the coefficient of relative risk aversion, \(\psi\) is the elasticity of intertemporal substitution and \(\beta\) is the discount factor.

2.4.2 Labor endowment

Before retirement all households supply labor inelastically.\(^{15}\) Let \(i\) index the households. The stochastic process for individual labor income \((H^{i}_{at})\) is given by

\[
H^{i}_{at} = W_tL^{i}_{a}
\]

\(^{15}\)Lettau (2003) shows that allowing for a labor leisure choice does not meaningfully affect the asset pricing implications of production based models.
where $L_i^a$ is the household’s labor endowment (labor supply scaled by productivity) and $W_t$ is the aggregate wage per unit of productivity. The household’s labor endowment is specified to match the standard stochastic earnings profile in life-cycle models of savings and portfolio choice. More precisely, labor income productivity combines both permanent ($P_i^a$) and transitory ($\varepsilon^i$) shocks with a deterministic age-specific profile:

$$L_i^a = P_i^a \varepsilon^i$$
$$P_i^a = \exp(f(a)) P_{a-1}^i \xi^i$$

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 $\{-.5 \cdot \sigma^2_\varepsilon, -.5 \cdot \sigma^2_\xi\}$, and variances $\sigma^2_\varepsilon$ and $\sigma^2_\xi$, respectively.

Retirement is exogenous and deterministic. All households retire at age 65 ($a^R = 46$) and retirement earnings are given by a constant replacement ratio ($\lambda$) of their pre-retirement income, more precisely $\lambda P_{a^R}^i W_t$.

### 2.4.3 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 $R_t^B = \frac{1}{P_t^B} - 1$, where $P_t^B$ denotes the government bond price. The return on the risky asset is denoted by $R_t^K$. Total liquid wealth (cash-on-hand) can be consumed or invested in the two assets. At each age ($a$), agents enter the period with wealth invested in the bond market, $B_i^a$, and (potentially) in stocks, $S_i^a$, and receive $L_i^a W_t$ as labor income. Cash-on-hand at time $t$ is given by

$$X_t^a = K_a^i(1 + (1 - \tau_K)R_t^K) + B_a^i(1 + (1 - \tau_K)R_t^B) + L_a^i(1 - \tau_s)(1 - \tau_L)W_t$$

before retirement ($a < a^R$), and by

$$X_t^a = K_a^i(1 + (1 - \tau_K)R_t^K) + B_a^i(1 + (1 - \tau_K)R_t^B) + \lambda P_{a^R}^i W_t$$

during retirement ($a \geq a^R$).
Households cannot borrow against their future labor income, and cannot short any asset. More precisely,

\[ B_t^i \geq 0 \]
\[ K_t^i \geq 0 \]

2.4.4 Preference heterogeneity and limited participation

We consider two groups of households in the model: stock market participants and another group which invests only in bonds. In the recent data, the two groups are almost identical in size (55% and 45% respectively, using the data from the 2001 SCF).\(^{16}\) 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 take limited participation as exogenous for tractability reasons (as in Basak and Cuoco (1998) and Guvenen (2005)), but make sure that the wealth accumulation differences are consistent with the data.\(^{17}\)

We want the model to generate endogenously a savers-spenders dichotomy: some households are more likely to accumulate wealth (and therefore participate in the stock market) while others consume most of their current incomes. We obtain this by assuming ex-ante heterogeneity in the discount factor and the elasticity of intertemporal substitution. There is strong evidence for EIS heterogeneity between stockholders and non-stockholders, with the latter estimated to have a lower EIS than the former (see, for example, Vissing-Jorgensen (2002)). We therefore assume that the less wealthy non-stockholders are more impatient and have lower EIS than stockholders.

\(^{16}\)These numbers take into account households that participate in the stock market indirectly through pension funds.

\(^{17}\)Given the low wealth accumulation of non-stockholders, a small one-time entry cost would suffice to endogenize 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 (2006) show that a one-time cost of 5% of average annual income or lower would deter participation for the poorer households without affecting the macroeconomic and asset pricing implications of the model. We leave such an entry cost out of the model to reduce the computational burden.
We emphasize that the quantitative results are almost identical regardless of the method we use to generate “poor” non-stockholders, what is important is that we replicate this group within the model. The same quantitative results would be obtained under alternative specifications (for example Gomes and Michaelides (2005) consider heterogeneity in risk aversion), as long as these are calibrated to match the same heterogeneity in wealth accumulation.

2.5 The individual optimization problem

2.5.1 Household expectations

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 (1) and (2): future 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 capital stock.

Capital accumulation is determined by the cross-sectional asset wealth distribution. We would therefore need to include this as a state-variable in the household’s optimization problem. Krusell and Smith (1998) and den Haan (1997) suggest that, for this class of incomplete-markets economies, it is possible to approximate this infinite-dimensional state variable with a small set of moments. As discussed in the appendix, our model can accurately approximate the information contained in this distribution using its lagged mean (last-period’s aggregate capital stock, $K_{t-1}$) and the state-contingent realizations of the two aggregate shocks (productivity shock, $U_t$, and stochastic depreciation, $\eta_t$):

$$ K_t = \Gamma_K(K_{t-1}, U_t, \eta_t) $$

(4)

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

$$ P_t^B = \Gamma_P(P_{t-1}^B, K_{t-1}, U_t, \eta_t) $$

(5)
This introduces four additional state variables in the individual’s maximization problem \((P_{t-1}^B, K_{t-1}, U_t, \text{and} \, \eta_t)\).

2.5.2 The dynamic programming problem

We can now write the individual’s recursive optimization problem. We normalize all individual variables by the household’s permanent income \((P_i^a G_t^{1-\alpha})\) and all aggregate variables (wage and capital) by aggregate permanent income \((G_t^{1-\alpha})\). This induces stationarity in the model and reduces the dimensionality of the state vector by one variable. Normalized variables are denoted by lower case letters\(^{18}\). The value function is denoted by \(V_a(x^i_{at}; k_t, U_t, \eta_t, P_t^B)\), where \(a\) is age, \(x^i_{at}\) is individual normalized cash on hand, and the other four inputs are the aggregate variables from the forecasting equations ((4) and (5)).

The individual optimization problem now becomes:

\[
V_a(x^i_{at}; k_t, U_t, \eta_t, P_t^B) = \max_{\{k^i_{a+1,t+1}, b^i_{a+1,t+1}\}} \left\{ (1 - \beta)(c^i_{at})^{1-1/\psi} + \beta \left( E_t \left[ \left( \frac{P^i_{a+1}}{P^i_{a}} (1 + g)^{1-\alpha} \right)^{1-\rho} p_a V_{a+1}^{1-\rho}(x^i_{a+1,t+1}; k_{t+1}, U_{t+1}, \eta_{t+1}, P_{t+1}^B) \right] \right)^{1-1/\psi} \right\}^{1-1/\psi}
\]

subject to the constraints,

\[
\begin{align*}
  k^i_{a+1,t+1} & \geq 0 \\
  b^i_{a+1,t+1} & \geq 0 \\
  c^i_{at} + b^i_{a+1,t+1} + k^i_{a+1,t+1} & = x^i_{at}
\end{align*}
\]

\(^{18}\)Specifically, household-specific variables are normalized as \(x^i_{at} \equiv \frac{X^i_{at}}{P^i_{a} G_t^{1-\alpha}}, \, c^i_{at} \equiv \frac{C^i_{at}}{P^i_{a} G_t^{1-\alpha}}, \, b^i_{a+1,t+1} \equiv \frac{B^i_{a+1,t+1}}{P^i_{a} G_t^{1-\alpha}}, \, k^i_{a+1,t+1} \equiv \frac{K^i_{a+1,t+1}}{P^i_{a} G_t^{1-\alpha}}\) while aggregate variables are normalized as \(k_t \equiv \frac{K_t}{G_t^{1-\alpha}}, \, \text{and} \, w_t \equiv \frac{W_t}{G_t^{1-\alpha}}.\)
and with the laws of motion,

\[ x_{a+1,t+1}^i = \frac{[k_{a+1,t+1}^i(1 + (1 - \tau_K)R_{t+1}^K) + b_{a+1,t+1}^i(1 + (1 - \tau_B)R_{t+1}^B)]}{[(P_{a+1}^i/P_a^i)(1 + g)^{1-\alpha}]}
+ \varepsilon^i(1 - \tau_s)(1 - \tau_L)w_{t+1} \]

\[ R_{t+1}^K = R(k_{t+1}, U_{t+1}) \]

\[ w_{t+1} = W(k_{t+1}, U_{t+1}) \]

\[ k_{t+1} = \Gamma_K(k_t, U_{t+1}, \eta_{t+1}) \]

\[ P_{t+1}^B = \Gamma_P(k_t, U_{t+1}, \eta_{t+1}, P_{t+1}^B) \]

### 2.6 Equilibrium

The equilibrium consists of endogenously determined prices (bond prices, wages, and equity returns), a set of cohort specific value functions, and policy functions, \( \{V_a, b_a, k_a\}_{a=1}^A \), 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 (1) and (2).

2. Individuals choose their optimal consumption and asset allocation by solving (6).

3. Markets clear and aggregate quantities result from individual decisions. Specifically,

\[ k_t = \int_i \int_a P_{a-1}^i k_{a,t} d\alpha d\delta \]

\[ b_t = \int_i \int_a P_{a-1}^i b_{a,t} d\alpha d\delta \]

The aggregation equation for labor supply is redundant since there is no labor-leisure choice. Once these two equations are satisfied, Walras’ law implies that total expenditure (government consumption, investment and household consumption) must equal total output:

\[ \frac{G_t^c}{G_t^r} + \int_i \int_a P_{a}^i c_{a,t} d\alpha d\delta = U_t k_t^\alpha L_t^{1-\alpha} \]
4. Accidental bequests \((E)\) are taxed at a 100\% rate, and are given by:

\[
E_t = G_t \frac{1}{\alpha} \int_i \int_a (1 - p_a) P_{a\tau} \alpha t d\alpha i
\]

5. The social security system is balanced at all times,

\[
\int_i \int_{a \in I_W} \tau_s L_a w_t d\alpha i \int_i \int_{a \in I_R} [\lambda \exp(f(aR)) w_t P_{a\tau}] d\alpha i
\]

where the left hand side is integrated over all workers \((a \in I_W)\), while the right hand side over retirees \((a \in I_R)\). We choose \(\lambda\) exogenously, thereby endogenously determining the value of \(\tau_s\) that keeps the social security system balanced in each period.

6. The government budget (equation (3)) holds every period.

7. Expectations about the future evolution of market prices (which depend on the wealth distribution) are verified in equilibrium.

Analytical solutions to this problem do not exist and we therefore use a numerical solution method (details are given in the appendix).

### 2.7 Calibration

#### 2.7.1 Aggregate variables

Decisions are made at an annual frequency. Capital’s share of output \((\alpha)\) is set to 36\%, and the average annual depreciation rate \((\delta)\) is 10\%. The parameter \(s\) (the stochastic depreciation volatility) determines the return of equity volatility and is set at 14\%. The aggregate productivity shock follows a two-state Markov Chain with a transition probability of 0.4. In the baseline case we assume that the mean capital tax rate is 15\% and the mean labor income tax rate is 20\%, while bequests are taxed at 100\%. The aggregate supply of bonds is approximately 31\% of GDP. Our calibration is based on the average value of U.S. Treasury securities held by the U.S. public which is 35\% of GDP, according to numbers from the Congressional Budget Office (from 1962 to 2003), but a significant fraction is held by foreign institutions (or foreign governments).
2.7.2 Household variables

Agents begin working life at age 20, retire at age 65, and can live up to 100 years. We use the mortality tables of the National Center for Health Statistics to parameterize the conditional survival probabilities. The idiosyncratic shocks' variances are taken from Carroll (1992): 10 percent per year for $\sigma_\xi$ and 8 percent per year for $\sigma_\epsilon$. The deterministic labor income profile reflects the hump shape of earnings over the life-cycle. The corresponding parameter values, just like the retirement transfers ($\lambda = (1 - \tau_s)0.68$), are taken from Cocco, Gomes and Maenhout (2005). From equation (5) this generates an endogenous social security tax ($\tau_s$) of approximately 9.5%.

As previously discussed we assume ex-ante preference heterogeneity between stockholders and non-stockholders. In particular, we assume that the less wealthy non-stockholders are more impatient and have lower EIS. More precisely, in the baseline version of the model, both types have the same risk aversion coefficient ($\rho = 8$), but type-A (non-stockholders) have a very low discount factor ($\beta = 0.75$) and a low elasticity of intertemporal substitution ($\psi^A = 0.3$), while type-B (stockholders) have a higher discount factor ($\beta = 0.99$) and slightly higher elasticity of intertemporal substitution ($\psi^B = 0.4$). The lower elasticity assumed for the non-stockholders is consistent with recent empirical estimates, while the low discount factor is needed because the risk aversion coefficient is the same across the two groups. Given the high level of uncertainty and liquidity constraints in the model, there exists a strong precautionary saving motive that will induce households to save substantially. We reduce saving using a low discount factor for one group and think of this group as the “spenders” in the economy. We assume that spenders do not participate in the stock market because they never accumulate a sufficient amount of assets to make stock investments worthwhile (in the presence of some costs in stock investing). Consistent with recent data from the SCF, we assume that each group makes up 50% of the population in the economy.
3 Baseline results

3.1 Aggregate wealth inequality

Table 1 reports the shares of wealth held by different percentiles of the wealth distribution in the model and in the 2001 SCF data.\textsuperscript{19} Since spenders in the model do not own capital stock we also report wealth distributions conditional on stockholding status. Stockholders are defined as households who own stocks directly or through mutual funds either in taxable accounts or in pension plans.

Comparing non-stockholders with spenders we find that the model fits these wealth distributions well. With the exception of the share of wealth in the top 1%, the model comes very close to the data. For stockholders the wealth distribution is not as skewed as in the data, there is considerably more wealth held by savers in the model below the 50th and 80th percentiles compared to the data. At the same time there is not enough wealth in the top 5% of the distribution. This is not surprising because our model does not incorporate several features that have been recently suggested as relevant in capturing the observed wealth concentration at the very top end of the distribution.\textsuperscript{20}

The last two columns of table 1 compare unconditional wealth distribution in the model and in the data. The model captures well the fact that wealth below median is negligible. Furthermore households in the top quintile by wealth hold 67% of total assets in the model. This is short of 82% for the same statistic in the data but it shows considerable concentration of assets in the simulated distribution. As with stockholders’ wealth distribution, the main differences from the data are due to insufficient concentration in the higher percentiles.

In summary, the model generates considerable wealth inequality which mimics the savers-

\textsuperscript{19}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.

\textsuperscript{20}In particular, we abstract from the effect of entrepreneurial savings (Quadrini (2000), Cagetti and De Nardi (2006)), bequest motives (Castañeda et al. (2003) and De Nardi (2004)) or skewed idiosyncratic draws (Castañeda et al. (2003)).
spenders dichotomy observed in the data with the bulk of wealth concentrated above the median, but it misses the significant concentration of wealth at the very top.

3.2 Macroeconomic variables and asset prices

Table 2 reports the statistics for macroeconomic quantities as shares of output and the volatility of different sectors in the economy. The shares of consumption, investment and government expenditures and debt relative to GDP approximately match their empirical counterparts (panel A). Panel B illustrates that consumption growth is smoother than GDP growth and the orders of magnitude match well with the long run data from Campbell (1999). Panel B also illustrates that consumption growth of stockholders is more volatile than the consumption growth of non-stockholders, consistent with the empirical evidence in Vissing-Jorgensen (2002) and Malloy, Moskowitz and Vissing-Jorgensen (2005).

Table 3 reports the main asset pricing moments implied by the model, along with their empirical U.S. counterparts again taken from Campbell (1999). The model generates a sizable equity premium, of around 4%, while simultaneously generating a low risk free rate of around 2%, with standard deviations similar to those observed in the data.\(^{21}\)

Finally, the model also has reasonable predictions with regards to the wealth to income ratios for different percentiles of the total wealth distribution. Table 4, Panel A, compares this ratio from the model to the SCF 2001 counterparts and the results are very close for the 25th, 50th and 75th percentiles. The model’s predictions can also be recast in terms of aggregate gini coefficients (table 4, Panel B). The aggregate wealth inequality in the data is 0.8, while consumption is much more evenly spread with a gini coefficient of 0.25. These compare, respectively, with values of 0.69 and 0.22 in the model. Overall, we conclude that the model does reasonably well in terms of matching the wealth and consumption distributions, even though the parameters have not been chosen to maximize its performance along these dimensions.

\(^{21}\)Gomes and Michaelides (2006) present comparative statics with regards to the determinants of asset prices in a similar asset pricing model.
3.3 Life cycle profiles

Table 5 shows the averages of wealth-income ratio over the lifecycle for stock market participants and non-participants. Non-participants behave like the infinite horizon households modeled by Deaton (1991) and Carroll (1997) and retire with a very low net worth, relying on their pension for consumption purposes during retirement. The combination of preference parameters that generates this behavior is strong impatience and a low elasticity of intertemporal substitution. Stock market participants, on the other hand, save a higher amount from the early part of their life cycle, accumulating from early on a small buffer-stock of wealth to smooth unforeseen contingencies. They also start saving for retirement at some point in the life cycle due to both higher EIS and lower discount factor. The last column in table 5 shows average lifecycle portfolio allocations for stock market participants and illustrates that households hold on average diversified portfolios, that are, nevertheless heavily skewed towards the stock market, especially amongst younger households.

The combination of idiosyncratic shocks, preference heterogeneity and differences in stock market participation status induces significant cross-sectional heterogeneity in wealth accumulation and consumption. Figure 1 (left panel) plots the simulated life cycle gini coefficient for consumption. Consistent with the empirical evidence in Deaton and Paxson (1994) and more recently in Krueger and Perri (2006), consumption inequality tends to increase with age, particularly after age 40 when the savers begin accumulating a substantial amount of assets. The increase in consumption inequality is non-monotonic over the life-cycle because the inequality among spenders (not shown) is reduced in the early part of the life-cycle because they do accumulate some small precautionary balances. Even though these are small savings, particularly relative to the wealth accumulated by stock market participants, they are sufficient to actually decrease consumption inequality among spenders early on. The combined consumption inequality matches reasonably well the total inequality graphs in Krueger and Perri (2006).

\[22\text{This is similar to Attanasio et. al. (1999) and Gourinchas and Parker (2002) and more recent work on life-cycle portfolio allocation models.}\]
Figure 1 (right panel) plots the same graph for wealth inequality over the life cycle. Overall, there is substantial wealth inequality in the economy reflecting the differential savings behavior across the two different groups. Wealth inequality rises slightly from early in life (age 25 on) as the savers accumulate substantial amounts of wealth. Wealth inequality is reduced towards the end of the life cycle as stockholders run down their assets, to finance retirement consumption. Overall, total wealth inequality has a hump shape over the life cycle but does not change substantially during working life.

4 Steady state responses to fiscal policy

4.1 Changes in government debt

We first consider the impact of government debt in crowding out capital in the model economy. We permanently increase government debt and, in this section, assume that taxes do not change so that the government “pays” for servicing higher debt by reducing its expenditures. Mankiw (2000) argues that higher debt does not crowd out capital in the long run in a savers-spenders model because the long run level of capital is tied to the (constant) discount rate of savers. There are several reasons why this mechanism is not expected to work in our model. First, lack of consumption insurance disentangles the marginal product of capital from the marginal discount rate of stockholders. Second, interest rates on debt and capital are not the same in our model and stockholders may adjust their portfolios in response to either changes in the interest rate and/or the risk premium.

Table 6 shows the results from increasing debt from 31% to 41% of GDP. We find that higher debt does indeed crowd out capital in our economy: the capital-to-GDP and investment-to-GDP ratios both fall by 1.8%. In the new steady-state, the capital stock falls by 2.8% and output decreases by 1%. Higher debt also has effects on the mean interest rate, the risk premium and consumption volatility. The mean interest rate rises by 0.6% to induce households to hold the additional debt in their portfolios. Since debt is less risky than the stock market, and households use assets to insure consumption, the volatility of aggregate consumption declines. This results is particularly visible for stockholders’ consumption since
they absorb most of the new debt (non-stockholders save very little). A smoother consumption lowers the equity premium by 0.33%, which in turn also tilts the optimal portfolios towards bonds.

The crowding out effects we observe in Table 6 are already substantial, but they actually underestimate the potential full impact of higher debt in the economy. In this experiment households are partially relieved from the burden of servicing higher debt because government expenditures are reduced to maintain long-run budget stability. More precisely, the government cuts its expenditures by approximately 1.4% to compensate for the increased interest expense on its debt. Later on we will consider the impact of higher public debt when households, rather than the government, pay for servicing the increased debt through higher taxation.  

4.2 Changes in capital income taxation

Before considering the joint impact of changes in tax rates and government debt, we will study the impact of the former in isolation. In this section we start by analyzing the case of changes in the capital income tax rate. Table 7 reports the results from increasing (decreasing) the mean capital income tax rate from its baseline value of 15% to 20% and 25% (10% and 5%). As expected, a higher tax rate crowds out the capital stock and therefore consumption. Both output and investment fall, while the ratios of consumption and investment to output also decrease. On the other hand, government expenditures rise because of the higher tax rate and thus the government consumption to output ratio also rises.

The lower capital stock leads to a higher mean return in stocks, and consequently an increase in the risk free rate to persuade investors to hold the same level of government debt. Since the ratio of government debt to the capital stock has increased, household portfolios have lower equity shares, and therefore the equilibrium equity premium and consumption volatilities are all reduced.

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23In our set-up government expenditures are a deadweight-loss and therefore decreasing them to finance the increased interest expense is beneficial for the economy. However, if we consider that at least part of the government expenditures occur in a productive public sector, then the crowding-out effects in the previous analysis may affect this public sector and exacerbate the overall impact of higher debt.
Our results are informative on the debate about the distortionary impact of capital income tax. A 10% increase in the capital income tax rate leads to a 4% reduction in the economy’s average aggregate capital stock, a 2% reduction in average aggregate consumption, a 4% reduction in investment and a 1.2% reduction in output. We think that further research with this type of models can provide more insight about the quantitative implications of tax reform.

4.3 Changes in lump-sum taxation

Table 8 reports the results from increasing (decreasing) the labor income tax rate from its baseline value of 20% to 25% and 30% (15% and 10%). It is important to remember that labor income taxes are lump-sum taxes in our set-up as labor supply is exogenous. Therefore, these results should be interpreted as responses to changes in lump-sum taxation.

The crowding out effects that we observe are substantial even though the labor income tax is non-distortionary in our model. Lump sum taxes should not affect capital accumulation according to textbook models, because they do not affect decisions at the margin. Why is it then that an increase in lump sum taxation generates crowding out in the model? One possibility is that these taxes operate through making a liquidity constraint more severe. However, this is unlikely to be the case in our economy. The liquidity constraints are mostly binding for the non-stockholders and young stockholders who still have little wealth. The vast majority of the capital stock is being held by stockholders who have already accumulated a substantial amount of wealth and are therefore unlikely to be influenced by the presence of a liquidity constraint.

The crowding out, instead, comes from a change in the asset allocation behavior of stockholders. Lump-sum taxes are essentially negative riskless bond holdings, since the tax payments behaving like fixed coupon payments. In a model where bonds and equity are not perfect substitutes, households must compensate for this by decreasing equity holdings. This implies a lower level of the capital stock in equilibrium.\textsuperscript{24} This channel of crowding out

\textsuperscript{24}Higher labor income taxes imply that households are less wealthy in terms of the present discounted value of their human capital. Given that individual labor income is uncorrelated with stocks, it acts as an
(through household portfolio re-allocations) illustrates the importance of analyzing models where bonds and stocks are not perfect substitutes when investigating the impact of exogenous policy changes.

Comparing the results in tables 7 and 8 we find that, for a given constant level of government debt, an increase in lump-sum taxes finances a higher level of equilibrium government expenditure than an increase in the capital income tax rate and has thus has a higher crowding-out effect on the capital stock. This is due to the larger tax base of labor income taxes: wages have a 64% share of output while the capital’s share is only 36%. Therefore the same increase in tax rates leads to a much higher increase in tax revenues in the case of labor income taxes. As a direct result of this, both the mean risk free and risky rates rise more than their counterparts in the capital income tax experiments. However, the equity premium does not change by as much since there is no direct distortionary impact. Nevertheless it still falls, and the mechanism is the same one as for the crowding out effect: the share of risky to riskless assets in the economy is lower.

### 4.4 Simultaneous changes in government debt and taxes

In the previous sections either public debt or tax rates changed in isolation, with the corresponding budget deficit/surplus being offset by an adjustment in government expenditures. Now we will instead consider simultaneous offsetting changes in government debt and taxation, such that government expenditures remain unchanged.

We take as benchmark the results in table 6 where we increase the steady-state level of government debt from 31% (baseline case) to 41%. However, in table 9, we now study the impact of financing this change with either higher lump-sum taxes (columns 2 and 3) or higher capital income taxes (columns 4 and 5), instead of with lower government expenditures.

As previously mentioned, even lump-sum taxes have a crowding-out effect in an economy implicit financial bond. (see, for example, Heaton and Lucas (1997)).

As shown below, for the same volume of tax revenue being raised, lump-sum taxes naturally crowd-out capital less than distortionary taxes.
where the capital stock and government debt are not perfect substitutes. As we see in columns 2 and 3, the capital stock and investment fall 3.2% relative to the benchmark, which is an additional 0.4% relative to the experiment with constant tax rates (Table 6). Output declines by 1.2% while the capital-to-GDP and investment-to-GDP ratios each fall by about 2.1%.

When considering the case in which the additional debt is financed by capital income taxes the crowding out effects are naturally larger. The capital stock and investment fall by 4.2% and 4.3%, respectively, and output is 1.5% lower. The corresponding ratios of capital and investment to GDP fall by 2.7% and 2.9%, respectively. These declines in investment, capital and output are accompanied by a substantial increase in the interest rate (0.82%).

The explanation for the larger impact of capital income taxes on aggregate variables lies in the fact that capital income taxes have a smaller tax base as the share of profits in GDP is 36% while the share of wages is 64%. Moreover, since capital taxes are distortionary, they also erode the tax base. As a result, they must increase by more to be able finance the same amount of government debt.

To summarize, our results show significant asset pricing and macroeconomic effects from changing government debt. For a 10 percentage point increase of the debt-to-GDP ratio, we obtain a 1.2% to 1.5% reduction in output depending on the method used to finance the higher debt. The risk free interest rate rises by 65 to 82 basis points while the equity premium falls by 0.34% to 0.42%. The effects of crowding out are larger if capital income taxes are used to pay for the higher debt, since its lower tax base implies the need for a much larger increase in tax rates. These results also show that the effects of changes in tax rates discussed in the previous section (see tables 7 and 8), are robust to whether the changes in tax revenues are being absorbed by government expenditures or public debt. In fact, they even become quantitatively more important when debt is adjusted due to the effect of debt on asset prices.
5 Short run implications of the model

The model has interesting implications vis-a-vis the response of consumption to fiscal policy shocks in the short-run and over the business cycle. Recent empirical evidence (Parker (1999), Souleles (1999), Johnson et. al. (2006)) indicates that consumption reacts positively to positive labor income shocks that might be coming from expected or transitory tax changes. An interesting question for our setup is whether temporary tax shocks in this model can replicate these empirical findings.

5.1 Model set-up

To investigate these responses we use a VAR analysis, we “switch off” the aggregate productivity shock and “switch on” (one at a time) a capital income or a labor income tax shock around the mean values investigated in the baseline model above. More precisely, we now assume that tax rates follow a Markov process with two values, \( \{\tau^b, \tau^g\} \), where \( \tau^g > \tau^b \). The probability of remaining in the current state (\( \pi \)) is \( 1/2 \), yielding an average tax cycle duration of four years. The standard deviation of the capital income tax shock (\( \sigma_{\tau} \)) is set to 1.5% and the mean capital tax rate is 15%, while the mean labor income tax rate is set at 20%, and the standard deviation of this tax shock is equal to 2%. Therefore both shocks have a standard deviation of approximately one tenth of their respective means.

We solve the model under this new set-up, and use simulated aggregate data to construct impulse responses from the VARs. We use a Choleski-ordering decomposition that utilizes the fact that the depreciation and tax shocks move first within the period in the model. Specifically, we estimate a simple VAR with the variables ordered as

\[
\tau, \delta_t, C_t^G, K_t, R_t, R^f_t, C_{jt}
\]

where, depending on the specific case we are considering, \( C_{jt} \) denote either aggregate consumption (\( C_t \)) or the consumption of non-stockholders (\( C_{NS} \)) or the consumption of stockholders (\( C_{St} \)). The results we report are extremely robust to the ordering of the variables,

\( ^{26} \)The quantitative predictions of the model remain essentially unchanged because the most important aggregate shock is the stochastic depreciation shock, which remains the dominant one in all cases.
their timing or the particular variables we choose to include in the VARs. Given that these simulations are also based on a theoretical model with 5000 simulated observations, there is strong statistical significance when the model predicts a particular relationship.

5.2 Changes in tax rates

Figure 2 presents the typical response of the 3 different consumption groups to changes in the labor tax rate. The effect on aggregate consumption is significant and comes from the response of non-participants, as stockholders’ consumption is barely affected. Shareholders have a substantial amount of wealth with which they can easily smooth transitory labor income tax shocks, while the households near their liquidity constraint respond negatively to a transitory increase in taxation. These results are anticipated by Mankiw (2000), and consistent with the empirical evidence of Parker (1999) and Souleles (1999). More recently, Heathcote (2005) also shows that transitory income tax changes affect liquidity constrained households’ consumption in an incomplete markets model. We also find that asset prices (the risk free rate, the equity return and the equity premium) are not statistically affected by the lump sum shocks and these results are omitted for brevity.

We also repeat the previous experiment but with shocks to the capital income tax rate. We do not find any statistically significant effects of capital income shocks on either aggregate consumption or the consumptions of the two population groups. For non-stockholders, (small) changes in the capital income tax rate are not very important because they save small amounts in the government debt market and the risk free rate is very smooth. Therefore adding some very moderate uncertainty around this return does not substantially change their ability to smooth consumption over time. For stockholders capital income tax shocks could have been more important, except that these households are richer and therefore can rely quite well on their accumulated wealth to smooth the additional uncertainty. As before, asset prices are not significantly affected, implying that only permanent shocks to the taxation system are important.
6 Conclusion

We analyze the implications of fiscal policy changes in a heterogeneous agent model with incomplete markets, and where the stock market and government debt are not perfect substitutes. The model fits the main macroeconomic and asset pricing moments, and generates substantial wealth and consumption heterogeneity, consistent with the data. We find that non-distortionary income taxation can affect both asset prices and aggregate outcomes through its impact on household asset allocation decisions. On the other hand, the presence of a substantial number of households affected by liquidity constraints does not have a quantitatively meaningful impact on asset prices. This is because those households own a very small fraction of the aggregate capital stock. The presence of liquidity constraints is more important, instead, in affecting aggregate short-run consumption fluctuations in response to transitory tax changes. Furthermore, a higher government debt generates higher equity premia and mean rates of return on government debt and can crowd out capital substantially. Paying for higher government debt with higher capital income taxes further crowds out capital and further reduces the equity premium. We view this model as a useful platform for the analysis of fiscal policy shocks on the macroeconomy and asset prices both over a long run and at shorter run horizons.

Appendix A Solving the model

A.1 Solution method outline

The solution method builds on den Haan (1994, 1997), Krusell and Smith (1997, 1998) and Storesletten et al. (2001). We start by presenting the outer loop of the code and discuss the details afterwards.

The numerical sequence works as follows:

i. Specify a set of forecasting equations ($\Gamma_K$ and $\Gamma_P$).

ii. Solve the household’s decision problem, taking prices as given, and using the forecasting equations to form expectations (details in A.2).
iii. Given the policy functions, simulate the model (5500 periods) while computing the market clearing variables at each period (details in A.3).

iv. Use the simulated time-series to update the forecasting equations (details in A.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%.

A.2 Solving the household’s decision problem

A.2.1 Normalization

We first simplify the solution by exploiting the scale-independence of the maximization problem and rewriting all individual variables as ratios to the permanent component of labor income ($P_{ia}^t$) and of the deterministic growth ($G_1^{1-\alpha}$). Likewise all aggregate variables (the wage and capital) are normalized by $G_1^{1-\alpha}$ thus inducing stationarity in the model. Using lower case letters to denote the normalized variables we have, for instance

\[
x^i_{at} = \frac{X^i_a}{P_{ia}^t G_1^{1-\alpha}}
\]

\[
k_t = \frac{K_t}{G_1^{1-\alpha}}
\]

\[
w_t = \frac{W_t}{G_1^{1-\alpha}}
\]

The equations of motion and the value function can then be rewritten as normalized variables, allowing us to reduce the number of state variables. The normalized individual cash on hand state variable follows

\[
x^i_{a+1,t+1} = \left[\frac{k^i_{a+1} (1 + (1 - \tau_K) R^K_{t+1}) + b^i_{a+1} (1 + (1 - \tau_K) R^B_{t+1})}{GR}\right] + c^i (1 - \tau_s) w_{t+1}
\]

where $GR = \frac{P_{a+1,t}^i}{P_{a,t}^i} (1 + g)^{1-\alpha}$, and the value function becomes $V_a(x^i_{at}, k_t, U_t, \eta_t, P^B_t)$. 

i. The rates of return on the factors of production can be written as

\[ R^K_t = \alpha Z_t \left( \frac{K_t}{L_t} \right)^{\alpha - 1} - \delta_t = \alpha U_t \left( \frac{k_t}{L_t} \right)^{\alpha - 1} - \delta_t \]

and

\[ W_t = (1 - \alpha) Z_t \left( \frac{k_t G_t^{1 - \alpha}}{L_t} \right)^{\alpha} = (1 - \alpha) U_t \left( \frac{k_t}{L_t} \right)^{\alpha} \]

so that \( w_t = (1 - \alpha) U_t \left( \frac{k_t}{L_t} \right)^{\alpha} \).

### A.2.2 Discretization of the state space

Age \( (a) \) is a discrete state variable taking 81 possible values. We discretize the cash-on-hand dimension \( (x_i^t) \) 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 \( (\eta_t) \) 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 high or low capital in the economy and allows higher accuracy with a fewer number of grid points. The grid is based on the idea that the expected conditional equity premium has to be positive and therefore the price of the bond is an increasing function of the available capital stock. This adaptive grid (as opposed to a fixed, rectangular grid) allows greater accuracy since it neglects points in the state space that, according to the economics of the problem, will never be visited conditional on being at a particular level of a capital stock at a given point in time. This is a guess and verify method and the simulated bond prices are confirmed ex post (after convergence) to lie within the specified range. Typically, the R-squared statistic from the bond regression is below 99.9\% when the price of the bond hits the edges of this grid during the simulation. 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 $P^B_t$ 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.

A.2.3 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, decision to pay the fixed cost, and share of wealth invested in stocks). From the Bellman equation,

$$V_a(x^i_{at}, k_t, U_t, \eta_t, P^B_t) = \max_{\{k_{a+1,t+1}, P^B_{a+1,t+1}\}} \left\{ (1 - \beta)(c^i_{at})^{1-1/\psi} + \beta \left( E_t \left[ \left( \frac{P^i_{a+1}}{P^i_a} (1 + g) \right)^{1-\rho} p_a V_{a+1}^{1-\rho} (x^{i}_{a+1,t+1}, k_{t+1}, U_{t+1}, \eta_{t+1}, P^B_{t+1}) \right] \right)^{1-1/\psi} \right\}^{1-1/\psi}$$

these values are given as a weighted sum of current utility $((c^i_{at})^{1-1/\psi})$ and the expected continuation value $(E_t V_{a+1}(\cdot))$, which we can compute once we have obtained $V_{a+1}$. In the last period the policy functions are trivial and the value function corresponds to the indirect utility function. This gives us the terminal condition for our backward induction procedure. Once we have computed the value of all the alternatives we pick the maximum, thus obtaining the policy rules for the current period. Substituting these decision rules in the Bellman equation we obtain this period’s value function $(V_a(\cdot))$, which is then used to solve the previous period’s maximization problem. This process is iterated until $a = 1$.

We use the forecasting equations ($\Gamma_K$ and $\Gamma_P$) 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 ($\varepsilon^i$ and $\xi^i$) and the aggregate shocks ($\eta_t$ 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.

A.3 Simulating the model and clearing markets

A.3.1 Simulation

We use the policy functions for the two agent types (A and B) to simulate the behavior of 2000 agents of each type in each of the 81 cohorts (total of 324,000 households) over 5500 periods. The realizations of the aggregate random variables (stochastic depreciation $\eta_t$ and aggregate productivity $U_t$) are drawn from their original two-point distributions, while the idiosyncratic productivity shocks ($\varepsilon^i$ and $\xi^i$) 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.

A.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 $P_t^B$). 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.

A.4 Updating the forecasting equations

Using the simulated time-series (after discarding the first 500 observations) we estimate the following OLS regressions, for every pair of productivity shock ($U_{t+1}$) and depreciation shock ($\eta_{t+1}$) realizations,

$$\ln(k_{t+1}) = q_{10} + q_{11} \ln(k_t)$$  \hspace{1cm} (A.2)
and

$$\ln(P_{t+1}^B) = q_{20} + q_{21} \ln(k_t) + q_{22} \ln(P_t^B)$$

(A.3)

This gives us 8 equations and 8 sets of coefficients that forecast state-contingent capital ($k_{t+1}$) and bond prices ($P_{t+1}^B$). 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 (A.2) we obtain R-squared values around 99.99%. For the second set of equations (A.3), the R-squared values are in the 90% - 95% range when we only use $\ln(k_t)$ as a regressor, increase to about 99.9% when we add $\ln(P_t^B)$.

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Figure 1: Consumption and wealth inequality over the life-cycle. The figure shows the cross-sectional gini coefficients for consumption (left panel) and wealth (right panel) from the baseline model.
Figure 2: Consumption response to transitory income tax changes. Figures show impulse responses of aggregate (C), stockholders (B) and non-stockholders (A) consumption to transitory shocks of labor income tax rate.
Table 1: 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. Model results are reported for the baseline parameters where type-A agents (spenders) have a discount factor equal to 0.75, and elasticity of intertemporal substitution equal to 0.3, and type-B agents (savers) have a discount factor equal to 0.99 and elasticity of intertemporal substitution equal to 0.4.

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Spenders/Non-stockholders</th>
<th>Savers/Stockholders</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model</td>
<td>Data</td>
<td>Model</td>
</tr>
<tr>
<td>10th</td>
<td>0.010</td>
<td>0.009</td>
<td>0.690</td>
</tr>
<tr>
<td>20th</td>
<td>0.159</td>
<td>0.009</td>
<td>3.08</td>
</tr>
<tr>
<td>50th</td>
<td>1.25</td>
<td>2.42</td>
<td>22.03</td>
</tr>
<tr>
<td>50th-80th</td>
<td>18.17</td>
<td>18.03</td>
<td>38.18</td>
</tr>
<tr>
<td>80th-100th</td>
<td>81.08</td>
<td>79.55</td>
<td>40.29</td>
</tr>
<tr>
<td>90th-95th</td>
<td>18.76</td>
<td>14.56</td>
<td>10.24</td>
</tr>
<tr>
<td>95th-99th</td>
<td>25.09</td>
<td>22.26</td>
<td>9.55</td>
</tr>
<tr>
<td>99th-100th</td>
<td>13.25</td>
<td>26.42</td>
<td>2.93</td>
</tr>
</tbody>
</table>
Table 2: 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).

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel A: Share of Output (percent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>55</td>
<td>60</td>
</tr>
<tr>
<td>Investment</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>Government</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>Government Debt</td>
<td>31</td>
<td>35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel B: Standard deviation of growth rates (percent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Output</td>
<td>4.1</td>
<td>4.3</td>
</tr>
<tr>
<td>Aggregate Consumption</td>
<td>3.6</td>
<td>3.2</td>
</tr>
<tr>
<td>Stockholders Consumption</td>
<td>5.6</td>
<td>4.2</td>
</tr>
<tr>
<td>Non-Stockholders Consumption</td>
<td>2.4</td>
<td>3.1</td>
</tr>
</tbody>
</table>
Table 3: Unconditional asset pricing moments from the data (Campbell (1999)) and baseline model.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Moment</th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>1.9</td>
<td>1.6</td>
</tr>
<tr>
<td>$r_f$</td>
<td>Std. Dev.</td>
<td>3.0</td>
<td>5.33</td>
</tr>
<tr>
<td></td>
<td>AR(1)</td>
<td>0.86</td>
<td>0.52</td>
</tr>
<tr>
<td>$r_m$</td>
<td>Mean</td>
<td>5.8</td>
<td>8.31</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>14.3</td>
<td>19.81</td>
</tr>
<tr>
<td></td>
<td>AR(1)</td>
<td>-0.07</td>
<td>-0.06</td>
</tr>
<tr>
<td>$r_m - r_f$</td>
<td>Mean</td>
<td>3.9</td>
<td>6.74</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>15.3</td>
<td>19.0</td>
</tr>
</tbody>
</table>

Table 4: Wealth Accumulation and Inequality Statistics. The table reports values from the baseline model and the data (2001 Survey of Consumer Finances). The gini coefficient for consumption is taken from Krueger and Perri (2006).

Panel A: Wealth to Income Ratios

<table>
<thead>
<tr>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>25th percentile</td>
<td>0.6</td>
</tr>
<tr>
<td>Median</td>
<td>2.8</td>
</tr>
<tr>
<td>75th percentile</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Panel B: Inequality for Consumption and Wealth

<table>
<thead>
<tr>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gini for consumption</td>
<td>0.21</td>
</tr>
<tr>
<td>Gini for wealth</td>
<td>0.69</td>
</tr>
</tbody>
</table>
Table 5: Life cycle profiles of median wealth-to-income ratios and average portfolio allocation to stocks in the baseline model.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Wealth-Income ratio</th>
<th>Portfolio share in stock (stkhdrlrs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-Stockholders</td>
<td>Stockholders</td>
</tr>
<tr>
<td>&lt; 36</td>
<td>0.000</td>
<td>1.40</td>
</tr>
<tr>
<td>36 – 50</td>
<td>0.041</td>
<td>5.15</td>
</tr>
<tr>
<td>51 – 65</td>
<td>0.058</td>
<td>11.23</td>
</tr>
<tr>
<td>&gt; 65</td>
<td>0.012</td>
<td>12.09</td>
</tr>
</tbody>
</table>

Table 6: Changes in government debt. The table shows long-run averages of the variables in the baseline model and in the model with permanently higher government debt. Changes are reported in percentage points relative to the baseline case.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>Higher debt</th>
<th>Change (% of baseline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B/Y$</td>
<td>0.31</td>
<td>0.41</td>
<td>32.1</td>
</tr>
<tr>
<td>Agg. Cons. Vol. (%)</td>
<td>3.6</td>
<td>3.5</td>
<td>-3.3</td>
</tr>
<tr>
<td>Non-Stk. Cons. Vol. (%)</td>
<td>2.4</td>
<td>2.3</td>
<td>-0.8</td>
</tr>
<tr>
<td>Stk. Cons. Vol. (%)</td>
<td>5.6</td>
<td>5.3</td>
<td>-5.0</td>
</tr>
<tr>
<td>$K$</td>
<td>5.14</td>
<td>4.99</td>
<td>-2.8</td>
</tr>
<tr>
<td>$Y$</td>
<td>2.11</td>
<td>2.09</td>
<td>-1.0</td>
</tr>
<tr>
<td>$I$</td>
<td>0.50</td>
<td>0.49</td>
<td>-2.8</td>
</tr>
<tr>
<td>$G$</td>
<td>0.458</td>
<td>0.451</td>
<td>-1.4</td>
</tr>
<tr>
<td>$K/Y$</td>
<td>2.397</td>
<td>2.355</td>
<td>-1.8</td>
</tr>
<tr>
<td>$I/Y$</td>
<td>0.237</td>
<td>0.233</td>
<td>-1.8</td>
</tr>
<tr>
<td>$G/Y$</td>
<td>0.215</td>
<td>0.214</td>
<td>-0.5</td>
</tr>
<tr>
<td>$r_f$ (%)</td>
<td>1.88</td>
<td>2.48</td>
<td>31.9</td>
</tr>
<tr>
<td>$r_m$ (%)</td>
<td>5.75</td>
<td>6.02</td>
<td>4.7</td>
</tr>
<tr>
<td>$r_m - r_f$ (%)</td>
<td>3.87</td>
<td>3.54</td>
<td>-8.5</td>
</tr>
</tbody>
</table>
Table 7: Capital income tax comparative statics. The table shows long-run averages of the variables in the baseline model and in the model with changed capital income tax. Changes are reported in percentage points relative to the baseline case. \( \sigma(\Delta \log C^A) \), \( \sigma(\Delta \log C^{NS}) \), \( \sigma(\Delta \log C^S) \) and \( \sigma(\Delta \log Y) \) denote, respectively, the volatilities of log growth for aggregate, non-stockholders and stockholders consumption and aggregate output \( Y \).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Tax rates ( \tau_c ) and Changes (as % of baseline)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>( \sigma(\Delta \log C^A) )  (%)</td>
<td>4.1</td>
</tr>
<tr>
<td>( \sigma(\Delta \log C^{NS}) ) (%)</td>
<td>2.7</td>
</tr>
<tr>
<td>( \sigma(\Delta \log C^S) )  (%)</td>
<td>6.2</td>
</tr>
<tr>
<td>( \sigma(\Delta \log Y) )   (%)</td>
<td>4.6</td>
</tr>
<tr>
<td>( K )</td>
<td>5.29</td>
</tr>
<tr>
<td>( C )</td>
<td>1.19</td>
</tr>
<tr>
<td>( Y )</td>
<td>2.14</td>
</tr>
<tr>
<td>( I )</td>
<td>0.52</td>
</tr>
<tr>
<td>( K/Y )</td>
<td>2.44</td>
</tr>
<tr>
<td>( C/Y )</td>
<td>0.55</td>
</tr>
<tr>
<td>( I/Y )</td>
<td>0.24</td>
</tr>
<tr>
<td>( G/Y )</td>
<td>0.21</td>
</tr>
<tr>
<td>( r_m ) (% )</td>
<td>5.54</td>
</tr>
<tr>
<td>( r_f ) (% )</td>
<td>1.45</td>
</tr>
<tr>
<td>( r_m - r_f ) (% )</td>
<td>4.09</td>
</tr>
</tbody>
</table>
Table 8: Labor income tax comparative statics. The table shows long-run averages of the variables in the baseline model and in the model with permanently changed labor income tax. Changes are reported in percentage points relative to the baseline case. $\sigma(\Delta \log C^A)$, $\sigma(\Delta \log C^{NS})$, $\sigma(\Delta \log C^S)$ and $\sigma(\Delta \log Y)$ denote, respectively, the volatilities of log growth for aggregate, non-stockholders and stockholders consumption and aggregate output $Y$.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Tax rates $\tau_l$ and Changes (as % of baseline)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>$\sigma(\Delta \log C^A)$ (%)</td>
<td>3.61</td>
</tr>
<tr>
<td>$\sigma(\Delta \log C^{NS})$ (%)</td>
<td>2.44</td>
</tr>
<tr>
<td>$\sigma(\Delta \log C^S)$ (%)</td>
<td>5.58</td>
</tr>
<tr>
<td>$\sigma(\Delta \log Y)$ (%)</td>
<td>4.12</td>
</tr>
<tr>
<td>$K$</td>
<td>5.47</td>
</tr>
<tr>
<td>$C$</td>
<td>1.31</td>
</tr>
<tr>
<td>$Y$</td>
<td>2.16</td>
</tr>
<tr>
<td>$I$</td>
<td>0.53</td>
</tr>
<tr>
<td>$K/Y$</td>
<td>2.49</td>
</tr>
<tr>
<td>$C/Y$</td>
<td>0.60</td>
</tr>
<tr>
<td>$I/Y$</td>
<td>0.25</td>
</tr>
<tr>
<td>$G/Y$</td>
<td>0.15</td>
</tr>
<tr>
<td>$r_m$ (%)</td>
<td>5.15</td>
</tr>
<tr>
<td>$r_f$ (%)</td>
<td>1.18</td>
</tr>
<tr>
<td>$r_m - r_f$ (%)</td>
<td>3.98</td>
</tr>
</tbody>
</table>
Table 9: Tax-financed debt increase. The table shows long-run averages of the variables in the baseline model and in the model with permanently higher government debt. Changes are reported in percentage points relative to the baseline case. $\sigma(\Delta \log C^A)$, $\sigma(\Delta \log C^{NS})$, $\sigma(\Delta \log C^S)$ denote, respectively, the volatilities of log growth for aggregate, non-stockholders and stockholders consumption.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>Debt financed by lump-sum tax</th>
<th>Change (% baseline)</th>
<th>Debt financed by capital tax</th>
<th>Change (% baseline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B/Y$</td>
<td>0.31</td>
<td>0.41</td>
<td>32.3</td>
<td>0.41</td>
<td>32.7</td>
</tr>
<tr>
<td>$\sigma(\Delta \log C^A)$ (%)</td>
<td>3.6</td>
<td>3.5</td>
<td>-3.3</td>
<td>3.4</td>
<td>-7.7</td>
</tr>
<tr>
<td>$\sigma(\Delta \log C^{NS})$ (%)</td>
<td>2.4</td>
<td>2.4</td>
<td>-0.8</td>
<td>2.3</td>
<td>-4.6</td>
</tr>
<tr>
<td>$\sigma(\Delta \log C^S)$ (%)</td>
<td>5.6</td>
<td>5.3</td>
<td>-5.0</td>
<td>5.1</td>
<td>-9.2</td>
</tr>
<tr>
<td>$K$</td>
<td>5.14</td>
<td>4.97</td>
<td>-3.2</td>
<td>4.92</td>
<td>-4.2</td>
</tr>
<tr>
<td>$Y$</td>
<td>2.11</td>
<td>2.09</td>
<td>-1.5</td>
<td>2.09</td>
<td>-1.5</td>
</tr>
<tr>
<td>$I$</td>
<td>0.50</td>
<td>0.48</td>
<td>-3.2</td>
<td>0.48</td>
<td>-4.3</td>
</tr>
<tr>
<td>$G$</td>
<td>0.458</td>
<td>0.458</td>
<td>0.0</td>
<td>0.458</td>
<td>0.0</td>
</tr>
<tr>
<td>$K/Y$</td>
<td>2.397</td>
<td>2.35</td>
<td>-2.7</td>
<td>2.33</td>
<td>-2.7</td>
</tr>
<tr>
<td>$I/Y$</td>
<td>0.237</td>
<td>0.23</td>
<td>-2.9</td>
<td>0.23</td>
<td>-2.9</td>
</tr>
<tr>
<td>$G/Y$</td>
<td>0.215</td>
<td>0.218</td>
<td>1.1</td>
<td>0.219</td>
<td>1.5</td>
</tr>
<tr>
<td>$r_f$ (%)</td>
<td>1.88</td>
<td>2.53</td>
<td>34.6</td>
<td>2.7</td>
<td>43.6</td>
</tr>
<tr>
<td>$r_m$ (%)</td>
<td>5.75</td>
<td>6.07</td>
<td>5.6</td>
<td>6.15</td>
<td>7.0</td>
</tr>
<tr>
<td>$r_m - r_f$ (%)</td>
<td>3.87</td>
<td>3.53</td>
<td>-8.8</td>
<td>3.45</td>
<td>-10.9</td>
</tr>
</tbody>
</table>