Long-Run Fiscal Uncertainty, Growth and Asset Prices*

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UNDER REVISION, COMMENTS WELCOME

Abstract

Following massive government interventions during the great recession of 2007-2009, governments' indebtedness has skyrocketed around the globe. These dramatic financing needs raise uncertainty about the future stance of fiscal policies and their effects on the growth prospects of the economy. In this paper, we reconsider the link between short-run stabilization and uncertainty about long-term fiscal policies from an asset pricing perspective. Asset prices contain important information about both short-run fluctuations and long-term growth prospects. We analyze this information in a general equilibrium model with real and financial frictions that is consistent with both quantities and prices. Focusing on debt and persistent stochastic corporate tax rates as fiscal policy instruments, we first show that firms optimal response to tax shocks induces persistent swings in macroeconomic variables, which coupled with recursive preferences command high risk premia in asset markets. We then evaluate the welfare implications of simple fiscal policy rules linking government's debt and corporate tax policies to the state of the economy. In models calibrated to match asset price data, we show that the welfare costs of countercyclical fiscal policies are positive and can be substantial.

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1 Introduction

After the onset of the financial crisis in fall 2008, the world has witnessed government interventions on an unprecedented scale. All over the globe, governments massively increased spending in an attempt to prevent the world economy from slipping into a major global depression. While the recent return of the world economy to positive growth appears to indicate that governments' efforts at short-run stabilization were successful, questions about the long-term effects of these policies arise naturally. Together with such fiscal stimulus packages come sharp increases in projected government debt. In the United States, the congressional budget office estimates government debt to reach the level of GDP by 2011, and to be around 277% of GDP by 2040. While these projections are conditional on current tax regimes, it is clear that such massive bursts in government expenditures need to be financed, either by increases in government debt, increases in taxes, or both. This raises considerable uncertainty about the future stance of fiscal policy. Given the distortionary nature of active fiscal policy instruments, the effects of fiscal policy uncertainty on the long-term growth prospects of the economy may be substantial. In particular, short-run stabilization of the economy may come at the cost of dimmer long-term prospects.

Of course, in the end, the evaluation of the trade-off between short-run stabilization and long-term growth prospects is a quantitative question. In this paper, we revisit this link from an asset pricing perspective. Clearly, prices of risky assets contain important information both about short-run fluctuations and an economy's uncertain long-term growth prospects. Disentangling the sensitivity of asset prices to such short-run versus long-run risks therefore allows to gauge the relative costs of exposure to them. We interpret and quantify this information by means of a general equilibrium asset pricing model with real and financial frictions which is quantitatively consistent with both the dynamics of macroeconomic quantities as well as asset prices. As a novel feature in the asset pricing literature, we explicitly model a government which can finance a given expenditure stream using a combination of debt and distortionary corporate taxation.

In a calibrated version of our model, we first show that uncertainty about the future stance of fiscal policy has significant effects on asset prices. To that end, we start by quantifying fiscal policy uncertainty by means of a stochastic process calibrated to historical US corporate tax rate series. Historically, US corporate tax rates have undergone changes mainly because of variations in the statutory corporate tax rates, corporate tax base, and investment tax credits. These types of changes occur on a fairly frequent basis, rendering the time series for both effective marginal and average tax rates both volatile and persistent. We show that in our model firms' optimal responses to persistent tax uncertainty induces long and persistent swings in the growth rates of key macroeconomic variables, or, in order words, they lead to substantial uncertainty about the long-term growth prospects of the economy. In particular, increases in marginal tax rates lead to significantly negative effects on economic growth (Lee and Gordon (2005), Djankov, Ganser, McLiesh, Ramalho, and Shleifer (2010)). Hence uncertainty about corporate taxation raises uncertainty about future growth rates. In the presence of financial frictions, this effect is amplified by the US tax code, which encourages leverage because of the tax deductibility of interest payments.

Given our preference specification, these dynamics of macroeconomic variables affect asset valuations. We assume that households have recursive Epstein and Zin (1989) preferences with a preference for early resolution of uncertainty. Under this assumption, households are strongly averse to long-run uncertainty in macroeconomic quantities. In particular, the persistence of consumption and dividend growth implied by firms' optimal policies render equity claims very risky in equilibrium. In our benchmark calibration, we show that these effects are quantitatively significant. In particular, exposure to persistent fiscal uncertainty generates a realistically sizeable equity premium and a low and smooth risk free rate, while being consistent with the dynamics of key macroeconomic quantities.

In this environment with realistic asset pricing implications, we next link corporate taxation explicitly to the government's debt policy by means of simple fiscal policy rules. Such fiscal policy rules determine how aggressively the government seeks to stabilize short-run fluctuations by means of debt financed spending. Tax rates will then adjust to satisfy the government's budget constraint. Such fiscal policy rules are a convenient way to capture the notion of countercyclical or procyclical fiscal policies, which allows us to evaluate the welfare implications of these. Importantly, we show that in our setting with both realistic asset price and quantity implications, the welfare costs of countercyclical fiscal policies are positive, and can be quantitatively substantial. Our estimates indicate that they can reach up to 5% of life-time consumption. Intuitively, while debt financed government spending helps stabilize short-run fluctuations and hence reduces exposure to such short-run risks, the associated future financing needs bring about uncertainty about future distortionary taxation thereby leading to uncertainty about long-term growth prospects. Hence, in asset pricing language, reducing the exposure to short-run risks comes at the cost of increased exposure to long-run risks. In a setting with recursive utility with a preference for early resolution of uncertainty, such long-run risks command high risk premia. This aversion towards uncertainty about long-run growth prospects reflected in risk premia is naturally associated with high welfare costs. Quantitatively, in our model, the welfare costs associated with uncertainty about long-term growth prospects annihilate the benefits of short-run stabilization. Since our estimates of welfare costs of countercyclical fiscal policy rules are most readily thought of as lower bounds implied by asset market data, at the least this suggests caution towards excessive fiscal stimulus packages.

An independent contribution of this paper is to explicitly model and examine the role of leverage and capital structure in the determination of stock market values. Most of the asset pricing literature models environments in which the Modigliani-Miller theorem applies, and firms' capital structures are indeterminate and have no impact on quantities. Our setup with taxes, instead, gives an explicit role for capital structure. Consistent with the US tax code, in our economy firms can deduce interest payments on debt from their taxable income, therefore they have an incentive for debt over equity financing. On the other hand, we assume that debt financing is limited by financial distress costs that are increasing in leverage, which gives rise to an optimal capital structure. Therefore the Modigliani-Miller theorem does not apply in our setting, and firms' financing policies have a impact on their investment policies, as they have to be jointly determined. Our results suggest that the interplay between firms' financing and investment policies have a significant effect on both the dynamics of macroeconomic variables and stock prices. In particular, our setup with real and financial frictions allows us to generate realistic equity premia and investment volatility with a low and smooth risk-free rate and high stock return volatility, which typically present challenges for production-based asset pricing models.

Our paper is related to several strands of recent literature. First of all, it is related to a small number of very recent papers that address the link between government policies and asset prices. Pastor and Veronesi (2010) analyze announcement effects in stock prices after policy changes.

Gomes, Michaelides, and Polkovnichenko (2010) calculate the distortionary costs of the government interventions of 2008 and 2009 in a model which is also consistent with basic asset market data. Neither of these papers address risk premia driven by fiscal policy uncertainty in an economy where tax rate fluctuations induce variations in growth prospects and capital structure. Moreover, we propose a novel welfare analysis.

Broadly, our paper is related to a long list of papers in macro and growth that examine the effects of fiscal policy on the macroeconomy. The impact of fiscal policy on growth that our model exhibits is consistent with the implications of policy on growth developed in the endogenous growth literature (King and Rebelo (1990), Rebelo (1991)). Our specifications of fiscal policy rules are similar to Schmitt-Grohe and Uribe (2005) and Schmitt-Grohe and Uribe (2007), who show that such rules approximate the optimal Ramsey policies fairly well in the context of medium-scale macro models with nominal rigidities. A number of authors have examined the macroeconomic implications of stochastic fiscal policies in real business cycle models (Dotsey (1990), Ludvigson (1996)). More recently, David, Leeper, and Walker (2009), Li and Leeper (2010), Leeper, Plante, and Traum (2009), explicitly examine the implications of uncertainty about future fiscal policies for the macroeconomy in stochastic growth models. Our paper differs from these contributions by linking policy to asset market data, and by emphasizing the information content of asset prices for policy-making.

Linking welfare costs of fluctuations to risk premia in asset markets is in the spirit of Tallarini (2000), and Alvarez and Jermann (2004). By means of calibration Tallarini shows that in settings with recursive preferences calibrated to match asset market data and hence high risk aversion, the welfare costs of fluctuations can be substantial. On the other hand, Alvarez and Jermann estimate the marginal costs of fluctuations directly from asset prices, without relying on a parametric model. They find that, confirming Lucas' (1987) seminal calculations, the costs of fluctuations at business cycle frequency are negligible, while the welfare gains of eliminating all consumption uncertainty, and hence of lower frequency movements in consumption, are substantial. In contrast to these papers, our work explicitly considers government policies and links their implications for uncertainty at various frequencies to asset market data.

Similarly, the paper is also related to the literature examining how long persistent fluctuations in macroeconomic variables can arise endogenously in production economies with recursive preferences (Croce (2008), Lochstoer and Kaltenbrunner (2008), Campanale, Castro, and Clementi (2008), Ai (2009), Ai, Croce, and Li (2010), Kuehn (2008)). In contrast to these papers, we identify fiscal policy and especially corporate tax shocks as an important macroeconomic source of such low-frequency movements. From an asset pricing perspective this relates the paper to the original contribution by Bansal and Yaron (2004), who under the label of long-run risks were the first to examine the asset pricing implications of low-frequency movements in quantities coupled with recursive preferences in endowment economies. From a more macroeconomic perspective, fiscal policy and tax shocks are akin to news shocks in the sense of Jaimovich and Rebelo (2009).

Our paper is also related to a number of papers that have recently studied the determinants of the long-term movements in stock market values. They mostly relate long swings in stock market valuations to slow diffusions of new technologies (Comin, Gertler, and Santacreu (2009), Garleanu, Panageas, and Yu (2009), Iraola and Santos (2009)). We pursue an alternative and likely complementary explanation, namely corporate tax uncertainty. Changes in the tax system are also considered by McGrattan and Prescott (2005). However, they focus on dividend taxation rather than corporate taxation, and abstract from the link between taxation and productivity, which is at the center of our paper. Kung and Schmid (2010) pursue a complementary explanation in an endogenous growth model, where long-run risks arise through the optimal growth process.

Given our explicit modeling of capital structure, the paper is also related to the long literature on the effect of financial frictions on the macroeconomy. A partial list of influential contributions here includes Bernanke, Gertler and Gilchrist (1998), Kiyotaki and Moore (1998), Cooley, Marimon, Quadrini (2004). Our model of firms' financial structure is closely related to the specification in Jermann and Quadrini (2009). In contrast to this paper, we examine the impact of financing frictions on asset prices in a model with significant risk premia. In this sense, the paper is also related to Gomes and Schmid (2009), who focus on the pricing of corporate bonds in a general equilibrium model with default.

More broadly, the paper is related to the growing literature on asset pricing in production economies in general equilibrium. A partial list addressing the aggregate equity premium includes Jermann (1998) and Boldrin, Christiano, and Fisher (2001), who use habit preferences and Gourio

(2009) who introduces rare disasters in an otherwise standard real business cycle model with recursive preferences. On the other hand, a partial list of recent papers addressing the cross-section of returns in general equilibrium models with production includes Gomes, Kogan, and Zhang (2003), Gala (2005), Gourio (2006), and Papanikolaou (2008).

The paper is organized as follows. We present the model in section 2, where we also detail the link between corporate taxation and productivity. Quantitative model results are presented and discussed in section 3.2 and **??**. Section 5 concludes. Details concerning data construction are collected in Appendix A.

2 Model

This section presents the general equilibrium model used to quantitatively examine the link between fiscal shocks, leverage, macroeconomic aggregates and asset prices. There is a representative firm, a representative household and a government, which sets fiscal policy. We begin by outlining the economic environment of the representative firm, including a rich description of its financial structure, and the household's problem, taking government policies as given. We then provide a description of the government's fiscal policy instruments and policies, which we assume come in the form of simple policy rules, similar to those considered in Schmitt-Grohe and Uribe (2005) and Schmitt-Grohe and Uribe (2007).

Representative Firm and Technology. The representative firm has access to constant returns to scale production technology:

$$Y_t = (Z_t H_t)^{1-\alpha} K_{t-1}^{\alpha},$$

where Y_t is output, Z_t is the level aggregate technology, H_t is hours of labor input, and K_t is the capital input. A critical ingredient of our setup is the specification of the evolution of aggregate technology. Specifically, we assume that the log growth rate of productivity, $\Delta z_t \equiv \log(Z_t) -$

$\log(Z_{t-1})$, evolves as follows:

$$\begin{aligned} \Delta z_t &= \mu + \phi_\tau \cdot (\tau_{t-1} - E[\tau_t]) + \epsilon_t, \\ \epsilon_t &\sim N(0, \sigma_\epsilon), \end{aligned}$$

where τ_t is the corporate marginal tax rate at time t, and where ϕ_τ explicitly captures the effect that corporate taxation can have on long-run productivity growth. In general, τ_t will be time-varying, and we discuss its determination below, in conjunction with the government's fiscal policy options.

Empirical work in growth economics (for example Lee and Gordon (2005), Djankov, Ganser, McLiesh, Ramalho, and Shleifer (2010)) suggests that $\phi_\tau < 0$, so that an increase in τ_t reduces productivity growth. The economic intuition is that increasing taxes inhibits entrepreneurial activity and risk-taking, which are the drivers of productivity growth. This is also consistent with the implications of endogenous growth theory on the effects of taxation on growth (King and Rebelo (1990), Rebelo (1991), or in an asset pricing context Kung and Schmid (2010)).

The capital stock evolves as in Jermann (1998):

$$\begin{aligned} K_t &= (1-\delta)K_{t-1} + \phi\left(\frac{I_t}{K_{t-1}}\right)K_{t-1} \\ \phi\left(\frac{I_t}{K_{t-1}}\right) &:= \left[\frac{\alpha_1}{1-1/\xi}\left(\frac{I_t}{K_{t-1}}\right)^{1-1/\xi} + \alpha_2\right]. \end{aligned}$$

The current US tax code allows interest payments on corporate debt to be tax deductible, so that debt-financing is preferred over equity-financing, that is, there is an explicit role for financial leverage. Consistent with this, we explicitly model corporate financial structure. We assume that the firm can issue one-period bonds (sold at par with face value B_t and interest rate $r_{b,t}$) and is exposed to financial distress costs, C_t^E:

$$C_t^E = \phi_0 e^{-\phi_1 \cdot \left(\frac{\eta K_t}{B_t} - 1\right)},$$

where ϕ_0, ϕ_1 and η are positive constants. The parameter η captures the liquidation value of the collateral K and is set so that $\eta < (1-\delta)$, implying that distressed capital is sold at a discount. The parameter ϕ_1 is set to a high number to discourage the firm from borrowing more than the collateral value. The parameter ϕ_0 is set to a small number to make the firm willing to choose $B = \eta K$ at the steady state. This cost formulation can also be seen as a continuous and differentiable function approximating the following collateral constraint: $B_t \leq \eta K_t$. This implies that in equilibrium, the loan is repaid in all contingencies and r_b equals the risk-free rate. The introduction of distress costs will partly offset the firm's strong incentives to issue debt given its preferential tax treatment.

In order to generate realistically persistent dynamics for leverage (Leary and Roberts (2005), Mike Lemmon and Zender (2008)) we introduce capital structure rigidities. We model capital structure rigidities through the following quadratic debt adjustment costs function:

$$C_t^B = C^B(B_t) \equiv \nu \cdot \left(\frac{B_t}{Y_t} - \frac{\overline{B}}{Y}\right)^2 \cdot Z_{t-1}.$$

This formulation captures that issuing new debt is more costly in downturns, when output is low, and cheaper in good times.

The objective of the firm is to maximize equity-holder's wealth, by optimally choosing physical investment, I_t, hours worked, H_t, and supply of corporate debt, B_t^s, in each period:

$$\begin{aligned} V_{d,t} &= \max_{\{D_j, I_j, H_j, K_j, B_j^s\}_{j=t}^{\infty}} E_t\left[\sum_{j=t}^{\infty} M_j D_j\right] \qquad (1) \\ & s.t. \\ D_t &\leq Y_t - W_t H_t - T_t - I_t + B_t - (1 + r_{b,t-1})B_{t-1} - C_t^B - C_t^E, \\ K_t &\leq (1-\delta)K_{t-1} + \phi\left(\frac{I_t}{K_{t-1}}\right) K_{t-1}, \\ \Delta z_t &= \mu + \phi_\tau \cdot (\tau_{t-1} - E[\tau_t]) + \epsilon_t, \\ \epsilon_t &\sim N(0, \sigma_\epsilon). \end{aligned}$$

D_t are dividends or net payout, M_t is the stochastic discount factor and it is taken as given by the firm. Total corporate taxes are denoted by T_t, which, as described below, include taxes on profits and tax savings on corporate interest rate payments. We assume that the firm takes into account all tax margins implied by the tax code and knows the stochastic evolution of τ_t determined by the fiscal policy that we will define when describing the government. If $D_t < 0$, then the firm is a net issuer.

Optimal Investment and Financing Decisions. The optimal investment policy has to satisfy the following Euler equation:

$$q_t = E_t \left[M_{t+1} \left\{ (1-\tau_{t+1}) \frac{\partial Y_{t+1}}{\partial K_t} - \frac{\partial C^B_{t+1}}{\partial K_t} + q_{t+1} \left(1 - \delta - \frac{\phi'_{t+1} I_{t+1}}{K_t} + \phi_{t+1} \right) \right\} \right] - \frac{\partial C^E_t}{\partial K_t} \quad (2)$$

where $q_t \equiv \frac{1}{\phi'_t}$ and ϕ' denotes the first derivative of the function ϕ. This equation differs from Jermann (1998)'s one in three respects. First, the firm cares about after-tax marginal product of capital and is exposed to tax rate uncertainty. Second, the term $-\frac{\partial C^E_t}{\partial K_t}$ reflects the reduction in the distress costs generated through additional capital. Third, the term $-\frac{\partial C^B_{t+1}}{\partial K_t}$ reflects the fact that an additional unit of capital also affects future borrowing by increasing output.

At the optimum, marginal benefit and marginal cost of debt need to be equal:

$$1 - \frac{\partial C^B_t}{\partial B_t} - \frac{\partial C^E_t}{\partial B_t} = E_t \left[M_{t+1} (1 + (1-\tau_{t+1}) r_{b,t}) \right]. \quad (3)$$

The marginal benefit is equal to one extra unit of consumption net of distress and debt adjustment costs. The marginal cost of debt is equal to the expected present value of the future repayment adjusted by the tax shield. Since at the equilibrium the corporate bond yield is equal to the risk-free rate, r_f, by no arbitrage we can also write:

$$\frac{\partial C^B_t}{\partial B_t} + \frac{\partial C^E_t}{\partial B_t} = E_t \left[M_{t+1} \tau_{t+1} \right] r_{f,t},$$

where the right hand side is the marginal value of the debt tax advantage. Further details of the firm's optimization are reported in Appendix B.

Representative Household. The representative household has Epstein and Zin (1989) preferences defined over consumption goods, C_t:

$$U_t = \left\{ (1-\beta) C_t^{1-\frac{1}{\psi}} + \beta \left(E_t [U_{t+1}^{1-\gamma}] \right)^{\frac{1-\frac{1}{\psi}}{1-\gamma}} \right\}^{\frac{1}{1-\frac{1}{\psi}}},$$

where γ is the coefficient of relative risk aversion, and ψ is the elasticity of intertemporal substitution. When $\psi \neq \frac{1}{\gamma}$, the agent cares about news regarding long-run growth prospects. In line with the literature on long-run risks in asset prices, we assume the parametrization $\psi > \frac{1}{\gamma}$, so that the agent dislikes shocks to long-run expected growth rates. We assume that the agent has no dis-utility from working, so that the supply of hours worked is fixed, and normalized to 1 for simplicity.

As shown in Epstein and Zin (1989), the stochastic discount factor in this setting is

$$M_{t+1} = \delta \left(\frac{C_{t+1}}{C_t}\right)^{-\frac{1}{\Psi}} \left(\frac{U_{t+1}}{E_t\left[U_{t+1}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}}\right)^{\frac{1}{\Psi}-\gamma}.$$

The objective of the household is to maximize lifetime utility, subject to a standard budget constraint:

$$\begin{aligned} U_t &= \max_{\{C_j, H_j, S_j, B_j^d\}_{j=t}^{\infty}} \left\{(1-\beta)C_t^{1-1/\psi} + \beta E_t[U_{t+1}^{1-\gamma}]^{\frac{1-1/\psi}{1-\gamma}}\right\}^{\frac{1}{1-\frac{1}{\psi}}} \quad (4) \\ & s.t. \\ C_t + S_t P_t + B_t^{tot} &\leq (1+r_{f,t-1})B_{t-1}^{tot} + S_{t-1}(D_t + P_t) + W_t H_t + TR_t + C_t^B + C_t^E, \\ H_t &\leq 1, \qquad S_t \leq 1, \\ B_t^{tot} &= B_t + B_t^G. \end{aligned}$$

where S_t is number of equity shares, P_t is the ex-dividend price per share ($P_t = V_t - D_t$), W_t is the wage rate, and TR_t is a lump-sum transfer from the government. The household consumes and invests out of total wealth, which consists of financial wealth, labor income, a lump-sum tax transfer, and the financial costs C^E and C^B payed by the firm. The financial portfolio of the household consists of corporate debt, B^d, public debt, B^G, and equity, $S \cdot P$. The optimal investment policy implies the following no-arbitrage equations:

$$\begin{aligned} 1 &= E_t\left[M_{t+1}\frac{V_{t+1}}{V_t - D_t}\right], \quad (5) \\ r_{f,t} &= r_{b,t} = \frac{1}{E_t[M_{t+1}]} - 1. \end{aligned}$$

The Government. The transfer TR paid by the government to the household is determined as follows:

$$
\begin{aligned}
TR_t &= \tau_t^* \left(Y_t - r_{b,t-1} B_{t-1}\right), \qquad (6)\\
\log(\tau_t^*) &= (1-\rho)\log(\mu_\tau) + \rho \log(\tau_{t-1}^*) + \epsilon_{\tau,t},\\
\epsilon_{\tau,t} &\sim N(0, \sigma_\tau), \qquad corr(\epsilon_{\tau,t}, \epsilon_t) = 0.
\end{aligned}
$$

This formulation guarantees that the rate τ_t^* and the transfer are always positive. We impose $corr(\epsilon_{\tau,t}, \epsilon_t) = 0$ in order to study fiscal policy shocks purely unrelated to the productivity dynamics. The government finances this transfer through a mix of corporate taxes, T_t, and public debt, B^G:

$$
\begin{aligned}
T_t &= \tau_t (Y_t - r_{b,t-1} B_{t-1}), \qquad (7)\\
B_t^G &= (1 + r_{f,t-1}) B_{t-1}^G + TR_t - T_t.
\end{aligned}
$$

We assume that the government's debt policy comes in the form of simple fiscal rules. These rules capture the fiscal stance in response to output fluctuations. More specifically, we assume that the government implements debt policies of the following form:

$$
\frac{B_t^G}{Z_{t-1}} = \phi_1^G \cdot (\mu - E_t[\Delta Y_{t+1}]) \cdot \left(0.5 + \frac{1}{1 + e^{-\phi_2^G (\mu - E_t[\Delta Y_{t+1}])}}\right), \qquad (8)
$$

where ϕ_1^G and ϕ_2^G are non negative constants. We analyze three cases. First, when $\phi_1^G = 0$ no public debt is allowed. In this case, $TR_t = T_t$ and $\tau_t = \tau_t^* \quad \forall t$, implying that the corporate tax rate is purely exogenous and orthogonal to productivity. We will refer to this case as a zero-deficit policy.

Second, when $\phi_1^G > 0$ and $\phi_2^G = 0$, the debt policy becomes:

$$
\frac{B_t^G}{Z_{t-1}} = \phi_1^G \cdot (\mu - E_t[\Delta Y_{t+1}]).
$$

The government issues more debt and reduces the corporate rate when future growth is expected to be below average. The opposite is true when good times are expected. We refer to this as a symmetric counter cyclical fiscal policy.

Third, when both ϕ_1^G and ϕ_2^G are positive, the public debt policy is asymmetric. In bad times, the government tends to issue more debt to significantly cut corporate taxes and help future growth. In good times, on the contrary, the government is less aggressive in adjusting its debt to avoid a sharp increase in the corporate tax rate.

Market clearing. Given our assumptions, goods, labor and equity markets need to clear as follows:

$$Y_t \quad = \quad C_t + I_t, \quad H_t = 1, \quad S_t = 1. \tag{9}$$

3 Zero Deficit Policy

We begin the quantitative analysis of our model in this section by focussing on the special case in which the government does not issue any debt. Therefore, in this section, we treat corporate tax rates as a purely exogenous stochastic process. We find this case to be interesting as it allows us to capture the basic features of our model. In the next section we will introduce more realistic scenarios involving public debt in the economy and compare two different budget policies.

3.1 Calibration

In order to disentangle the different mechanisms at work in more detail, we report results on different model specifications. We focus on five models and report their calibrations in table 1. Model 1 is our benchmark. It features both short- and long-run productivity risk through the tax channel, and it also allows for endogenous financial leverage. The preference and technology parameters are chosen in the spirit of the long-run risk and the real business cycle literature, respectively (see for example Bansal and Yaron (2004) and Kydland and Prescott (1982)). The capital adjustment costs elasticity, ξ, is set to a mild level to avoid implausibly high adjustment costs. The leverage level, η, is consistent with US data, while the intensity of the debt adjustment costs, ν, is set to match the volatility of investment. All the parameters for both productivity growth and tax rate

Table 1: Calibrated Parameter Values

MODEL:		1	2	3	4	5
Preference Parameters						
Discount Factor	β^4	0.983	0.983	0.983	0.983	0.983
Risk Aversion	γ	10	10	10	10	10
Intertemporal Elasticity of Substitution	ψ	2.0	2.0	2.0	2.0	2.0
Technology Parameters						
Capital Share	α	0.33	0.33	0.33	0.33	0.33
Depreciation Rate	δ	0.021	0.021	0.021	0.021	0.021
Elasticity of Investment Adj. Costs	ξ	2	2	2	2	2
Intensity of Debt Adj. Costs	ν	.4	.4	.4	0	0
Debt-Book Ratio	η	33%	33%	33%	33%	0
Intensity of Distress Costs	ϕ_1	1000	1000	1000	1000	0
Productivity and Tax Rate						
Average Productivity Growth	μ	.006	.006	.006	.006	.006
Short-run Productivity Volatility	σ_ϵ	2.64%	2.64%	2.64%	2.23%	2.23%
Long-run Risk Exposure	ϕ_τ	-.05	0	0	0	0
Tax Rate Constant	e^{μ_τ}	36.5%	36.5%	36.5%	36.5%	36.5%
Log Tax Rate Volatility	σ_τ	1.19%	1.19%	0	0	0
Autocorrelation of Tax Rate	ρ^4	0.980	0.980	–	–	–

Notes - This table reports the parameter values used for our quarterly calibrations. The parameters in the bottom panel refer to corporate tax rate and labor-specific productivity. The government follows a zero-debt policy, ie, $\phi_1^G = 0$.

are chosen to reproduce their average level, persistence and volatility in US data.[1] In Model 1, the exposure of productivity to long-run tax rate uncertainty is consistent to the estimates in Lee and Gordon (2005).

In our benchmark model, we use four elements: (1) financial leverage, (2) counter cyclical debt adjustment costs, (3) tax rate uncertainty, and (4) long-run productivity risk. Since we are interested in disentangling the role of these four elements, we analyze other four models as well. As reported in table 2, in Model 2 we shut down long-run productivity risk generated by tax uncertainty (ϕ_τ=0). We keep active, instead, both the financial leverage and tax rate uncertainty channel. Model 3 differs from Model 2 because it features no tax rate uncertainty ($\sigma_\tau = 0$). In Model 4 the firm can issue debt without any debt adjustment cost ($\nu = 0$). Finally, Model 5 differs from Model 4 as we further assume that the firm cannot issue debt ($\eta = 0$). Model 5, therefore, is a simple real business cycle model with capital adjustment costs and recursive preferences.

[1] We describe our data in detail in Appendix A.

Table 2: Key Elements of our Economy

	Model 1	Model 2	Model 3	Model 4	Model 5
Leverage	Yes	Yes	Yes	Yes	No
Debt Adj. Cost	Yes	Yes	Yes	No	No
Tax Uncertainty	Yes	Yes	No	No	No
Long-run Productivity Risk	Yes	No	No	No	No

Notes - This table reports the key components of our economy active in each one of our five calibrations.

3.2 Results

We start our analysis by comparing Model 3, 4 and 5. We report the moments generated by these models in the last three columns of table 3; in figure 1 we plot their impulse response functions with respect to one positive standard deviation productivity shock. Model 5 is a RBC model with recursive preferences presenting all major problems already documented in the literature, namely, low risk-premium, smooth investment, volatile consumption. By comparing Model 4 and 5, it is possible to see that financial leverage alone produces slightly more volatile excess returns, but it does not significantly alter the quantity dynamics. This result is due to the ability of the firm to costlessly substitute debt and equity. Essentially, in this specification, the preferential tax treatment of debt acts as a pure subsidy to debt holders.

The results change significantly when we introduce counter-cyclical debt adjustment costs in Model 3. These costs break the costless substitution between debt and let financing have real effects. In good times issuing more debt is cheaper, hence, attractive. All resources collected through the additional debt are used to increase investment and, hence, the collateral stock K to avoid additional distress costs. It is well known that when the IES is high enough, even small capital adjustment costs are enough to discourage investment volatility. For the same reason, in our economy even a moderate amount of counter-cyclical debt adjustment costs is sufficient to generate an incentive to significantly adjust investment. Thanks to both distress and debt adjustment costs, the response of investment to the exogenous productivity shocks is much more intense than in Model 5. While in Model 5 the volatility of investment is just 1.6 times greater than that of consumption, in Model 3 this volatility ratio is much closer to what we see in the data. The higher volatility of investment produces more volatile price of capital, and pushes the annualized volatility

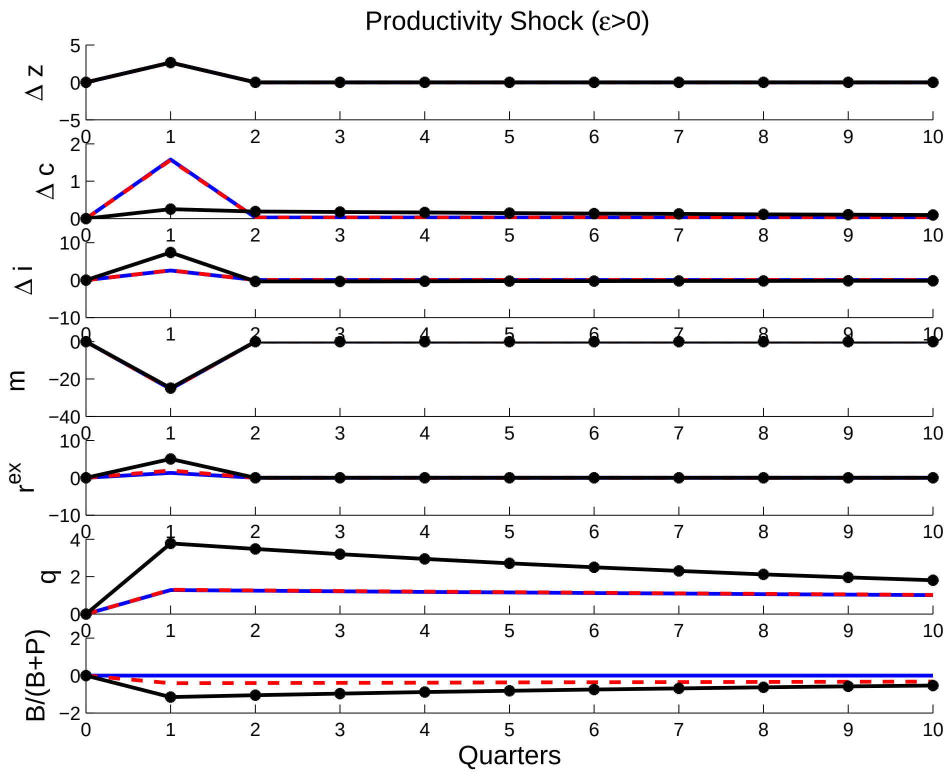

Fig. 1: Prices and Quantities in Model 3, 4 and 5.

Notes - This figure shows quarterly log-deviations from the steady state multiplied by 100. In each panel, the solid line refers to Model 5, while the dashed line refers to Model 4. The line marked with circles refers to Model 3. All the parameters are calibrated to the values reported in Table 1. We denote the value of debt and equity as B and P, respectively. We use q for the marginal value of capital, r^{ex} for the equity excess returns, m for the pricing kernel, Δi, Δc and Δz for the growth rate of investment, consumption and productivity, respectively.

of equity returns to 9.5%, the volatility of leverage to 2.5% and the equity premium to 4.85%. This also yields Sharpe ratios which are reasonably close to their empirical counterparts. This is an improvement with respect to Campanale, Castro, and Clementi (2008), Croce (2008), and Lochstoer and Kaltenbrunner (2008). Furthermore, our debt adjustment costs function makes the time-series properties of consumption growth closer to those observed in the data. The volatility of consumption drops from 3.1% to 2%, in turn reducing precautionary saving motives and pushing the risk-free rate to about 2.1%.

In figure 2, we plot impulse response functions for both Model 1 (solid lines) and 2 (dashed lines). Notice that in these models the corporate tax rate is stochastic, therefore we have two shocks and two columns of plots. The plots on the right column focus on tax shocks, while those

Table 3: Summary Statistics

	Data	Model 1	Model 2	Model 3	Model 4	Model 5
First Moments						
$E[I/Y]$	0.23	0.21	0.21	0.20	0.21	0.20
$E[r_f]$ (%)	0.96	1.08	2.08	2.07	1.50	1.49
$E[r_d - r_f]$ (%)	4.50	5.70	4.88	4.84	1.89	1.30
Second Moments						
$\sigma_{\Delta c}$ (%)	2.31	2.16	2.10	2.05	3.12	3.15
$\sigma_{\Delta i}/\sigma_{\Delta c}$	6.95	6.40	6.63	6.75	1.65	1.62
$\rho_{\Delta c,\Delta i}$	0.44	0.19	0.18	0.21	1.00	1.00
σ_{Lev} (%)	8.65	2.59	2.55	2.49	1.54	0.00
σ_{r_f} (%)	1.35	0.45	0.45	0.44	0.10	0.10
$\sigma_{r_d - r_f}$ (%)	20.14	9.47	9.48	9.43	3.89	2.65
$\rho_{\Delta c, r_d - r_f}$	0.22	0.30	0.29	0.32	1.00	1.00
$\rho_{\Delta i,\tau}$	-0.09	-0.09	-0.03	–	–	–
$ACF_1(\Delta c)$	0.44	0.16	0.17	0.17	0.02	0.02

Notes - All entries for the models are obtained from 1000 repetitions of short-sample simulations (320 periods). All figures are annualized. All models are calibrated as in table 1. Our sample ranges from 1930 to 2008. Details about our data can be found in Appendix A.

on the left column refer to short-run productivity shocks, as in figure 1. Both in Model 1 and 2 the response to short-run productivity shocks is similar to what seen in Model 3. The response to tax shocks deserves, instead, special attention as there are several things that need to be pointed out.

First, although small, tax shocks are very persistent and for this reason they have significant effects on both quantities and prices. On the one hand, a negative shock produces an incentive to invest more (substitution effect) as the post-tax marginal product of capital increases almost permanently. On the other hand, a fall in the tax rate let the agent feel richer and generates an incentive to increase consumption (income effect). As in Croce (2008), by calibrating the intertemporal elasticity of substitution above one, the substitution effect dominates. This implies that the representative investor finds it convenient to invest more when the corporate tax rate declines. The demand of capital increases, producing a strong pressure on the price of capital. As shown in the bottom three panels of figure 2 (right column), small negative tax shocks produce significative positive adjustments in price of capital, excess returns, and capital structure.

Second, turning our attention to table 3, we can see that Model 2 and 3 generate very similar average equity premium. As shown in the fourth panel of figure 2, right column (dashed line),

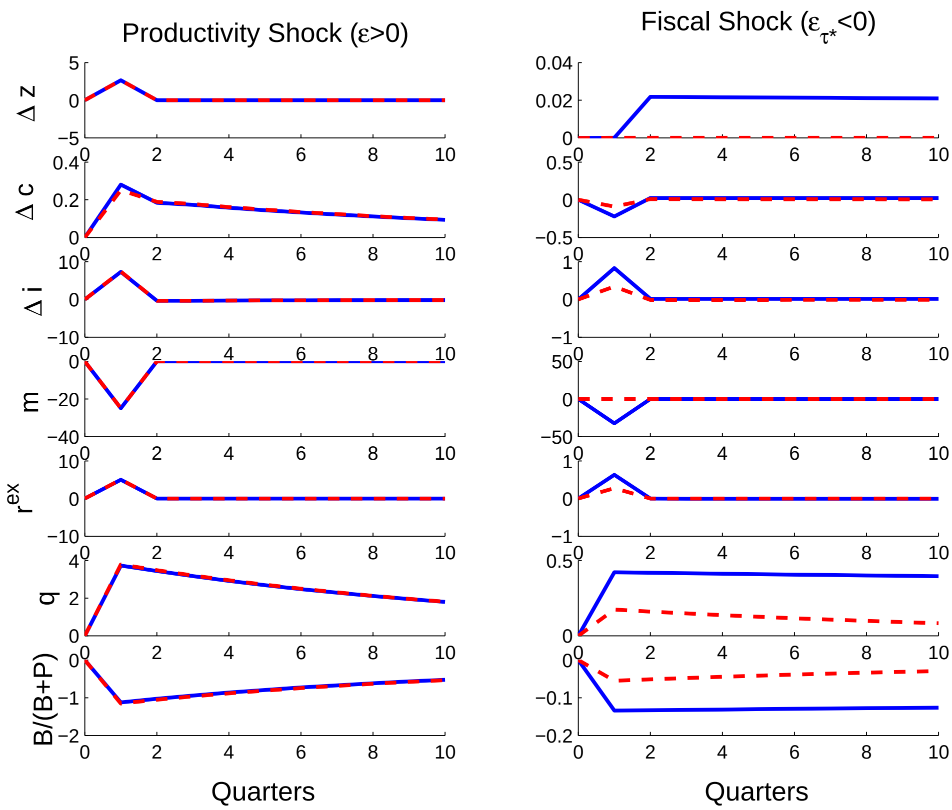

Fig. 2: Prices and Quantities in Model 1 and 2.

Notes - This figure shows quarterly log-deviations from the steady state multiplied by 100. In each panel, the solid (dashed) line refers to Model 1 (Model 2). The panels in the left column show responses to short-run productivity shocks. The plots to the right refer to a negative tax shock. The parameters value are reported in Table 1. We focus on the same variables described in Fig. 1.

this is due to the fact that tax shocks do not generate significant adjustments in the stochastic discount factor. On the one hand, in fact, a persistent decline in the tax rate produces good news for long-run consumption, hence, a fall in marginal utility. On the other hand, however, by substitution effect short-run consumption falls and the marginal utility tends to increase. At the equilibrium, the final adjustment of the pricing kernel is negligible. Model 2, therefore, produces relevant endogenous long-run fluctuations in dividend growth—reflected in the persistent dynamics of the value of capital, q—carrying zero risk-premium.

Third, when positive tax shocks have a negative impact on long-run productivity growth rates, they introduce a significative and persistent decline in expected consumption growth. With Epstein and Zin (1989) utility the household is very averse to such expected consumption growth slumps, as reflected by the stochastic discount factor fall. This explains why in Model 1 a negative long-run shock (good news for long-run productivity) produces such a strong decline in the marginal utility of the representative investors, and a higher equity premium (Figure 2, fourth and fifth panel, right column, solid line). It is important to notice that under our benchmark calibration the impact of tax shocks on the productivity growth rate is quite small ($\phi_\tau \sigma_\tau \approx 2.2\% \sigma_\epsilon$), hence our results are not driven by implausibly high long-run risk. This allows us to keep the autocorrelation of consumption growth at a moderate level.

As shown in table 2, under our benchmark calibration the equity premium is 5.7%, about 1% higher than in Model 2. The risk-free rate, instead, is about 1% smaller because of the additional precautionary saving motives generated by tax uncertainty. This variation in the composition of the equity returns is one of the most important results of our analysis as it shows that tax uncertainty can substantially increase risk-premia and alter capital accumulation decisions. Summarizing, with recursive preferences even small tax shocks, or small news in the sense of Jaimovich and Rebelo (2009), can have large and persistent effects on quantities and prices.

4 Public debt and cyclical tax policies

In this section we consider more realistic scenarios by allowing the government to adjust its debt to fluctuations in output. We capture the government's response to output fluctuations by allowing for $\phi_1^G \neq 0$ in the fiscal policy rules discussed earlier. We focus our attention to the case $\phi_1^G > 0$ in order to study the role of counter-cyclical public debt policies (debt increases in downturns). Clearly, in order to satisfy the government budget constraint, the corporate tax rate simultaneously adjusts with public debt.

We begin by considering a scenario with a symmetric debt policy defined by setting $\phi_2^G = 0$. In this scenario, we choose ϕ_1^G to generate an endogenous increase in the debt-output ratio of about 16% in three years along a "rare history" where the economy experiences a one-standard deviation negative productivity shock for six consecutive quarters. These dynamics are selected to broadly resemble those expected for the US economy after the 2007-08 crises. According to this calibration strategy, we fix $\phi_1^G = 250$, a value that produces overall a moderate standard deviation of the debt-output ratio.

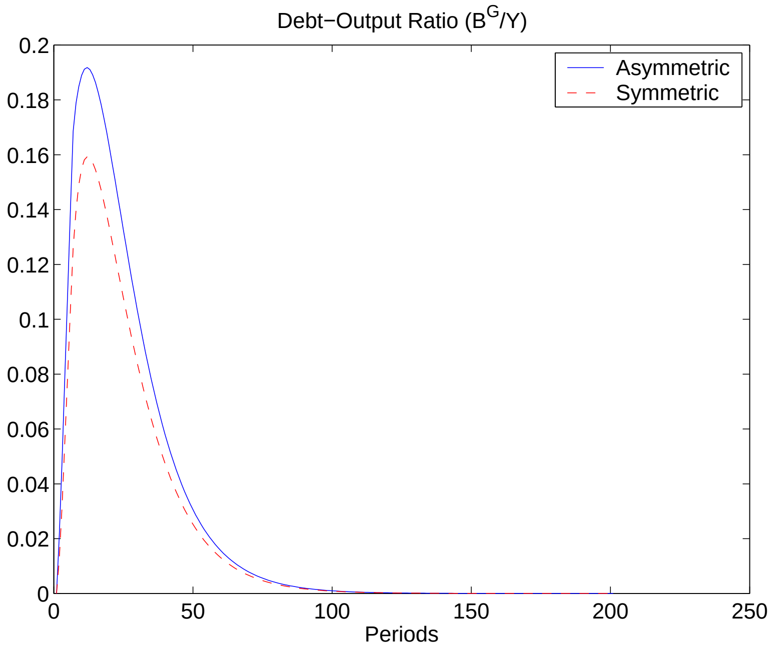

Fig. 3: Productivity and Public debt.

Notes - This figure shows quarterly deviations from the steady state for public debt divided by aggregate output. These dynamics are generated by assuming the realization of a negative one-standard deviation shock to productivity for six consecutive quarters. The calibration for the public debt policy is detailed in Table 4.

In a second scenario, we retain $\phi_1^G = 250$, but set $\phi_2^G = 110$ in order to capture the behavior of a government which is willing to aggressively issue debt and cut taxes in bad times, but is reluctant to do the opposite in good times. As shown in figure 3, under our calibrated asymmetric policy the debt-output ratio goes up by almost 20% along the same rare history considered before, a number empirically plausible.

In the next subsections we study the effects of these two policies with and without exogenous fiscal shocks to address the following question: what are the long-term effects of short-run stabilization policies?

4.1 Productivity shocks only

In this section, we shut down the exogenous fiscal shocks and use Model 3 as benchmark. The tax rate, however, is not constant, but rather it endogenously adjust to satisfy the government budget constraint and the fiscal policy rule. In figure 4 we plot the implied corporate tax rate time-series

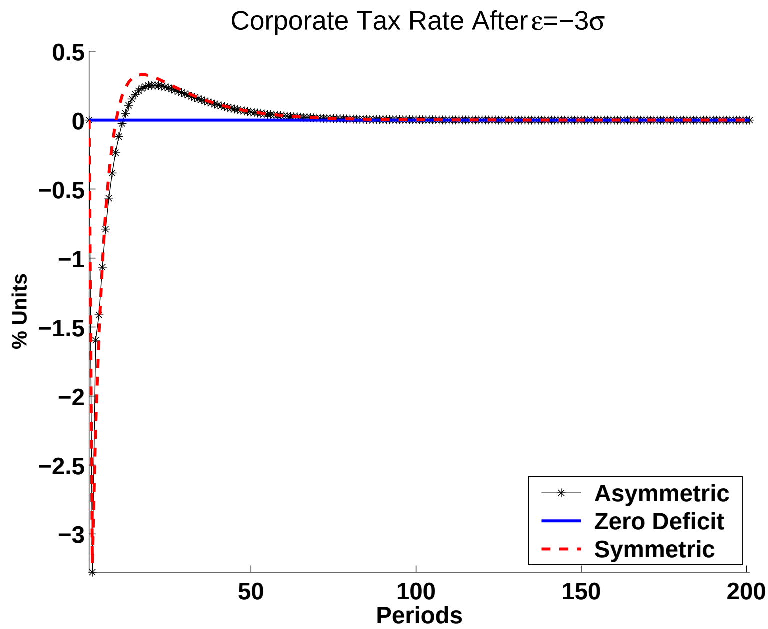

Fig. 4: Productivity and Corporate Tax Rate Policy.

Notes - This figure shows quarterly deviations from the steady state multiplied by 100 for the corporate tax rate. We focus on the case of a three-standard deviation negative shock to productivity growth. We use Model 3 as benchmark. The calibration for the public debt policy is detailed in Table 4.

generated by one single negative shock to productivity. In order to magnify the scale of the response of the tax rate we consider a shock with a magnitude equivalent to 3 standard deviations. After such a negative shock, the government stimulates the economy by reducing the corporate tax rate by 320 basis points. Fiscal sustainability, however, requires the corporate tax rate to rise at some point in order to bring down the budget deficit. Under our calibration, the tax rate remains below its unconditional mean for 5 years and then exceeds its long-run average in order to satisfy the public budget constraint. As expected, the tax cut is more pronounced under the asymmetric debt policy. Furthermore, under the symmetric policy the tax cuts are not only less pronounced, but also faster in mean-reverting, since the the government increases taxes more aggressively over time to quickly restore budget balance.

In order to assess the long-term effects on the economy, in table 4 we compare the statistics generated by these different debt policies in table. Several implications are noteworthy.

First, the symmetric counter cyclical debt policy is able to improve welfare, although just by the tiny amount of .07% of life-time consumption. From Table 4 we can see that this policy keeps the average public debt to zero and is able to reduce the volatility of both consumption and asset prices. Overall, this policy reduces the cost of equity and stimulates capital accumulation. Importantly, by quickly restoring budget balance the government can minimize long-run distortions. Consequently, when the government can commit to raise taxes aggressively in good times, countercyclical fiscal rules can be welfare enhancing, even if only slightly so.

Second, when the government is prone to strongly increase public debt in bad times, but is reluctant to reduce it in good times by raising taxes, the economy ends up with an average debt-output ratio of 90% and more pronounced long-run distortions. At the same time, through these distortions, the equity premium increases substantially and, consequently, capital accumulation slows down. This, in turn, is reflected in significant welfare losses of 4.5% of lifetime consumption.

In order to better understand the nature of long-run distortions, in figure 5, we compare the long-run mean reversion of consumption growth under a zero-deficit, a symmetric and an asymmetric debt policy. The plot shows that the symmetric debt policy is able to reduce endogenous long-run consumption risk at every horizon relative to the zero-deficit benchmark. When implementing the asymmetric debt policy, the government is able to reduce the long-run consumption volatility only for about ten quarters after the realization of the shock (solid vs dotted line). On the one hand, the government is able to reduce the fall of consumption in bad times without slowing down too much consumption growth in good times. On the other hand, however, this short-run asymmetric stabilization comes at the cost of having more persistent and volatile endogenous long-run consumption risk at all future horizons. When the household with recursive utility has a preference for early resolution of uncertainty, even a small amount of additional long-run volatility can be very costly. This channel explains why the asymmetric policy results in significant welfare losses worth 4.5% of lifetime consumption, and increases the cost of equity by about 70%, in turn discouraging capital accumulation.

Summarizing, in the case of a government that is reluctant to aggressively restore budget balance, the welfare costs of sustained long-run tax distortions are substantial.

Table 4: **The Role of Public Debt**

	Data	Model 3	Symmetric	Asymmetric
Welfare and Public Debt				
E[log U/C] (%)	–	5.07	5.14	0.54
Welfare costs (%)	–	–	-0.07	4.53
E[B^G/Y] (%)		0.00	0.00	91.90
First Moments				
$E[I/Y]$	0.23	0.20	0.20	0.20
$E[r_f]$ (%)	0.96	2.07	2.03	2.10
$E[r_d - r_f]$ (%)	4.50	4.84	4.56	5.24
Second Moments				
$\sigma_{\Delta c}$ (%)	2.31	2.05	1.92	1.99
$\sigma_{\Delta i}/\sigma_{\Delta c}$	6.95	6.41	6.29	6.52
$\rho_{\Delta c,\Delta i}$	0.44	0.21	0.35	0.38
σ_{Lev} (%)	8.65	2.49	2.37	2.53
σ_{r_f} (%)	1.35	0.44	0.37	0.39
$\sigma_{r_d-r_f}$ (%)	20.14	9.43	8.87	9.07
$\rho_{\Delta c,r_d-r_f}$	0.22	0.32	0.46	0.49
$ACF_1(\Delta c)$	0.44	0.17	0.14	0.13

Notes - All entries for the models are obtained from 1000 repetitions of short-sample simulations (320 periods). All figures are annualized. In this table we use the calibration for Model 3 as benchmark (see table 1). The column "Symmetric" shows statistics obtained by introducing a symmetric counter-cyclical debt policy in Model 1 ($\phi_1^G = 250$, $\phi_2^G = 0$). The column "Asymmetric" refers to the case of an asymmetric counter-cyclical debt policy ($\phi_1^G = 250$, $\phi_2^G = 110$). Our sample ranges from 1930 to 2008. Details about our data can be found in Appendix A.

4.2 Debt Policy and Fiscal shocks

We now consider an economy in which, additionally, the subsidy rate τ^* is subject to exogenous shocks. We think of these shocks as fiscal policy shocks that alter the relative size of the transfer that the government gives to the representative consumer. Alternatively, one can think of these transfer shocks as an additional policy instrument at the government's discretion, namely spending shocks. Under a zero-debt policy, a fiscal shock maps one-to-one into a shock to the corporate tax rate. Under a counter-cyclical debt policy, however, this is no longer the case. In other words, the government can use its debt policy to absorb fiscal shocks rather than financing them entirely through taxation. To better understand this difference, in figure 6 we show the tax rate dynamics after a positive fiscal shock under both the zero-debt policy and the active debt policies considered so far.

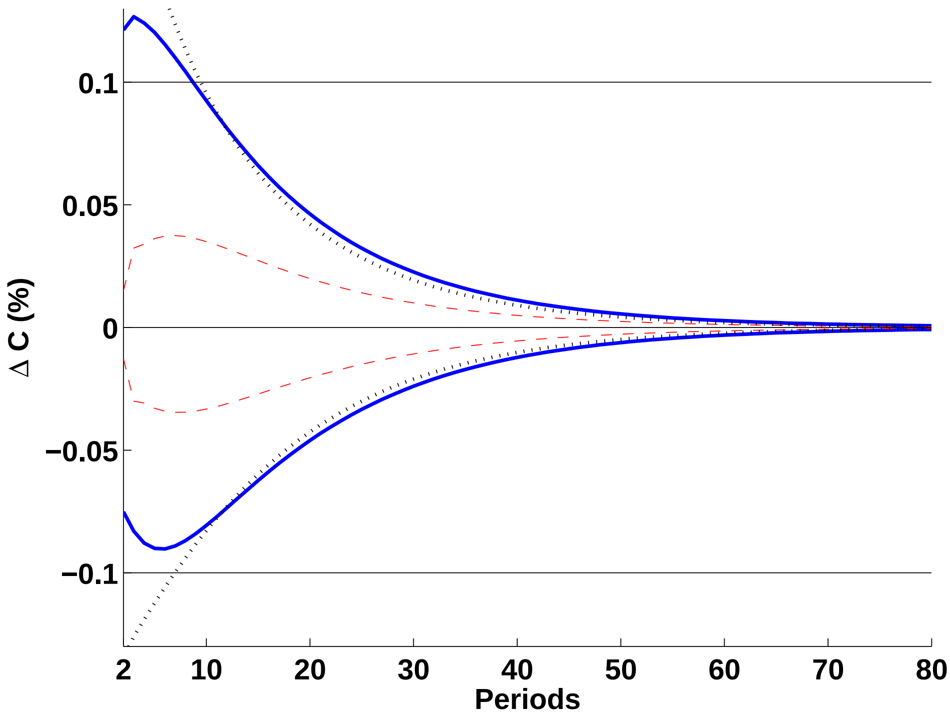

Fig. 5: Long-Run Consumption Growth.

Notes - This figure shows quarterly deviations from the steady state multiplied by 100 for consumption growth. The shock realizes at time 1, the impulse responses are plotted starting from period 2. All curves above the zero-line refer to a three-standard deviation positive productivity shock. All curves below the zero line refer to a negative productivity shock of the same magnitude. The dotted lines refers to Model 3; the dashed line is obtained by introducing a symmetric counter-cyclical debt policy in Model 3; the solid line refers to the case of an asymmetric debt policy. The calibration used in this figure is detailed in table 4.

We can see that under our fiscal policy rules the government smooths the tax rate in response to a spending shock accumulating debt in the background. If the transfer rate increases, the government anticipates that future financing needs require additional tax income going forward and that the economy will slow down because of the contraction in investment and capital accumulation. In order to counterbalance this effect, the government can in part finance this transfer issuing more debt to smoothly increase taxation over time. While this policy mitigates corporate taxation pressure in the short-run, it introduces more distortions in the long-run. As we can see from figure 6, the implied tax rate remains persistently above the subsidy rate in the long-run due to the higher service of public debt.

In table 5 we report the main statistics generated by the model under both our symmetric and

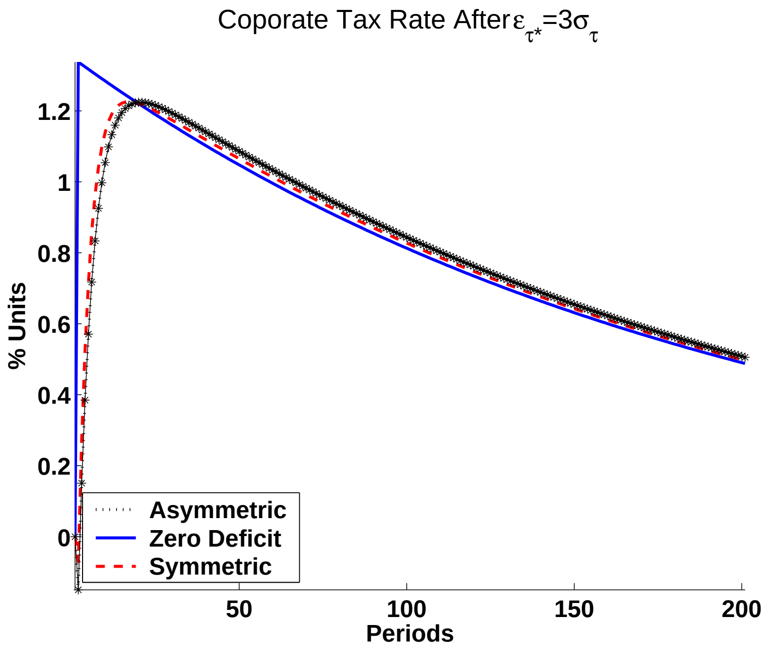

Fig. 6: Fiscal Shock and Tax Rate Policy.

Notes - This figure shows quarterly deviations from the steady state multiplied by 100 for the corporate tax rate. We focus on the case of a three-standard deviation shock to the subsidy rate. We use Model 1 as benchmark. The calibration for the public debt policy is detailed in Table 5.

asymmetric debt policy. We now choose Model 1 as comparing benchmark since it embodies both productivity and fiscal policy shocks.

As before, the symmetric counter cyclical debt policy is able to reduce consumption short-run volatility and the cost of equity. This time, however, this symmetric policy produces welfare *losses* of about 0.50% of lifetime consumption. The reason being that the long-run distortions introduced after the fiscal shocks are substantial and long lasting. Contrary to before, in the presence of persistent fiscal shocks, the government cannot quickly restore budget balance to minimize long-run distortions after an attempt to stabilize output in the short-run by issuing debt.

In light of our previous results, it is natural that these distortions are even more pronounced under the asymmetric debt policy and generate welfare losses even higher than before, of about 4.70%.

These results confirm that fiscal policy uncertainty is an important determinant of the dynamics of both quantities and asset prices and it can substantially affect welfare. In the likely case of a government that is reluctant to aggressively try to restore budget balance after stabilizing short-run

Table 5: **The Role of Public Debt (II)**

	Data	Model 1	Symmetric	Asymmetric
Welfare and Public Debt				
E[log U/C] (%)		-404.32	-404.85	-409.04
Welfare costs (%)		–	0.52	4.71
E[B^G/Y] (%)		0.00	0.00	92.00
First Moments				
$E[I/Y]$	0.23	0.21	0.21	0.21
$E[r_f]$ (%)	0.96	1.08	1.01	1.13
$E[r_d - r_f]$ (%)	4.50	5.70	5.17	5.78
Second Moments				
$\sigma_{\Delta c}$ (%)	2.31	2.16	2.05	2.09
$\sigma_{\Delta i}/\sigma_{\Delta c}$	6.95	6.40	6.22	6.49
$\rho_{\Delta c,\Delta i}$	0.44	0.19	0.35	0.37
σ_{Lev} (%)	8.65	2.59	2.47	2.64
σ_{r_f} (%)	1.35	0.45	0.39	0.40
$\sigma_{r_d - r_f}$ (%)	20.14	9.47	8.83	9.08
$\rho_{\Delta c, r_d - r_f}$	0.22	0.30	0.44	0.47
$ACF_1(\Delta c)$	0.44	0.16	0.14	0.13

Notes - All entries for the models are obtained from 1000 repetitions of short-sample simulations (320 periods). All figures are annualized. In this table we use the calibration for Model 1 as benchmark (see table 1). The column "Symmetric" shows statistics obtained by introducing a symmetric counter-cyclical debt policy in Model 1 ($\phi_1^G = 250$, $\phi_2^G = 0$). The column "Asymmetric" refers to the case of an asymmetric counter-cyclical debt policy ($\phi_1^G = 250$, $\phi_2^G = 110$). Our sample ranges from 1930 to 2008. Details about our data can be found in Appendix A.

shock fluctuations, such active policies entail substantial long-term distortions. Given that these distortions lead to significant welfare losses relative to the benchmark of a passive zero-deficit policy, this suggests that a passive fiscal policy is welfare improving in the long run. While countercyclical fiscal policies may generate some welfare gains under the condition that the government can commit to minimize long-run distortions aggressively by taking unpopular measures as sharp tax increases, these gains are likely to be small relative to the dangers of long-term distortions.

5 Conclusion

During the great recession of 2007-2009 the world economy has witnessed government interventions on an unprecedented scale. In an attempt to prevent the world economy from slipping into a major depression, governments all around the globe introduced massive fiscal stimulus packages along with unconventional monetary policy measures. While these combined measures seem to have been successful at short-run stabilization as indicated by the return to positive growth, its long-term effects are unclear at best. There is widespread concern about the sustainability of the current stance of fiscal policy and its effects on long-term growth prospects. The objective of this paper is to shed some light on the potential trade-off between short-run stabilization and long-term growth prospects from an asset pricing perspective. Due to their forward-looking nature and risk sensitivity, asset prices contain important information about short-run fluctuations (short-run risk) and long-term growth prospects (long-run risks). We analyze this information using a general equilibrium asset pricing model with an explicit role for government policy.

Our results suggest that active fiscal policy can produce at most minor welfare improvements. Furthermore, when the government is not inclined to reduce its debt after the end of a crisis, the economy is exposed to long lasting distortions extremely costly with recursive preferences. Given a calibration consistent with both quantities and prices, the welfare costs of such dim long-term distortions outweigh the benefits of short-run stabilization by a wide margin. Asset market data, therefore, suggest that unless the government can commit to aggressively restore budget balance following active countercyclical stabilization, a passive policy without long-term distortions may be optimal.

While we take a step towards linking the long-term effects of policies to asset market data, our analysis rests on a host of simplifying assumptions, many of which would be interesting to relax. First, while we have focused on the effects of fiscal policy in isolation, the recent experience has witnessed the combined efforts of fiscal and monetary policies. An analysis of the effects of coordinated fiscal and monetary interventions would therefore be fruitful, especially given the current debate on high inflation risk. Second, we implement government's fiscal policies by means of simple fiscal rules. While this allows us to easily capture the notion of countercyclical policies and these policies reasonably resemble their real world counterparts, it would be useful to compare them to the *optimal* fiscal policies.

Appendix A. Data.

Data for real annual consumption, investment, corporate profits, and corporate taxes are from the Bureau of Economic Analysis (BEA). Output is computed as the sum of consumption and investment. Government expenditures and net exports are excluded. Following McGrattan and Prescott (2005), the aggregate corporate tax rate is computed as the ratio of `taxes on corporate profits` to `corporate profits before taxes`. The sample period is from 1929 to 2008.

Monthly returns, dividends, and equity values are from CRSP and debt values are obtained from COMPUSTAT. The risk-free rate is measured by the 3-month t-bill return. Annual dividends and returns are obtained by time-aggregating the monthly ones. In order to compute the leverage ratio, we first compute, at the firm-level, equity and debt values. Specifically, for firm i, define the market value of equity as the product of the number of shares outstanding and the price per share, $\texttt{mvequity}_{i,t} \equiv \texttt{PRC}_{i,t} \cdot \texttt{SHROUT}_{i,t}$. As standard in the corporate finance literature, the book value of debt is used to proxy for the market of debt, since the market value of debt is unavailable at the firm-level. Thus, define the value of debt as the sum of the short-term and long-term debt, $\texttt{totdebt}_{i,t} \equiv \texttt{DLC}_{i,t} + \texttt{DLTT}_{i,t}$. Then, for a given year t, aggregate over all firms to obtain aggregate values, $\texttt{totdebt}_t = \sum_i \texttt{totdebt}_{i,t}$ and $\texttt{mvequity}_t = \sum_i \texttt{mvequity}_{i,t}$. Finally, the aggregate leverage ratio is then computed as the ratio of the value of debt to the total value of the firm, $\texttt{lev}_t \equiv \frac{\texttt{totdebt}_t}{\texttt{totdebt}_t + \texttt{mvequity}_t}$. All nominal variables are converted to real using the CPI index. The sample period is for the financial variables are from 1929-2008, except for the leverage ratio, which is only available for the sample period 1950-2008.

Appendix B. Model solution

Definitions. We start by listing key components of the technology in our economy.

$$
\begin{aligned}
Y_t &= (Z_t H_t)^{1-\alpha} K_{t-1}^{\alpha} \\
C_t^B &= \nu Z_{t-1} \left(\frac{B_t}{Y_t} - \frac{\widehat{B}_{ss}}{\widehat{Y}_{ss}} \right)^2 \\
C_t^E &= \phi_0 Z_{t-1} e^{-\phi_1 \left(\frac{\eta K_t}{B_t} - 1 \right)}.
\end{aligned}
$$

We can compute the following derivatives:

$$
\begin{aligned}
\frac{\partial Y_t}{\partial K_{t-1}} &= \alpha (Z_t H_t)^{1-\alpha} K_{t-1}^{\alpha-1} \\
\frac{\partial C_t^B}{\partial K_{t-1}} &= 2\nu Z_{t-1} \left(\frac{B_t}{Y_t} - \frac{\widehat{B}_{ss}}{\widehat{Y}_{ss}} \right) \left(\frac{-\alpha B_t}{Y_t} \right) \frac{1}{K_{t-1}} \\
\frac{\partial C_t^E}{\partial K_t} &= C_t^E \frac{-\phi_1 \eta}{B_t}
\end{aligned}
$$

$$
\begin{aligned}
\frac{\partial C_t^B}{\partial B_t} &= 2\nu Z_{t-1}\left(\frac{B_t}{Y_t}-\frac{\widehat{B}_{ss}}{\widehat{Y}_{ss}}\right)\frac{1}{Y_t} \\
\frac{\partial C_t^E}{\partial B_t} &= C_t^E\frac{\phi_1\eta K_t}{B_t^2} \\
\frac{\partial Y_t}{\partial H_t} &= (1-\alpha)Z_t^{1-\alpha}H_t^{-\alpha}K_{t-1}^{\alpha} \\
\frac{\partial C_t^B}{\partial H_t} &= 2\nu Z_{t-1}\left(\frac{B_t}{Y_t}-\frac{\widehat{B}_{ss}}{\widehat{Y}_{ss}}\right)\frac{(\alpha-1)B_t}{Y_tH_t}.
\end{aligned}
$$

Recursive formulation of the firm's problem. Define the vector $\mathbf{A}_t \equiv (Z_{t-1}, Z_t, \tau_t, K_{t-1}, B_{t-1})$ as the aggregate state at time t. Pricing kernel, wages and corporate interest rate are redefined as follows: $M_t \equiv M(\mathbf{A}_t|\mathbf{A}_{t-1})$, $W_t \equiv W(\mathbf{A}_t)$, and $r_{b,t-1} \equiv r_b(\mathbf{A}_{t-1})$. The firm behaves competitively and solves the following recursive problem:

$$
\begin{aligned}
V_d(K,B,\mathbf{A}) &= \max_{I,K',B',H}(1-\tau)Y - WH - I + B' - (1+(1-\tau)r_b)B - C^B - C^E \\
&+ \quad E\left[M'V_d(K',B',\mathbf{A}')\right] \\
&s.t. \\
K' &\leq (1-\delta)K + \phi\left(\frac{I}{K}\right)K.
\end{aligned}
$$

The Lagrangian associated to this problem, written with time subscripts for clarity, can be stated as

$$
\begin{aligned}
V_d(K_{t-1},B_{t-1},\mathbf{A}_t) &= \max_{I_t,K_t,B_t,H_t}(1-\tau_t)Y_t - W_tH_t - I_t + B_t - (1+(1-\tau_t)r_{b,t-1})B_{t-1} - C_t^B - C_t^E \\
&+ \quad E_t\left[M_{t+1}V_d(K_t,B_t,\mathbf{A}_{t+1})\right] \\
&+ \quad q_t\left((1-\delta)K_{t-1} + \phi\left(\frac{I_t}{K_{t-1}}\right)K_{t-1} - K_t\right)
\end{aligned}
$$

Optimality with respect to debt. The first order condition with respect to corporate debt and the Envelope theorem jointly imply:

$$
\begin{aligned}
1 &= \frac{\partial C_t^B}{\partial B_t} + \frac{\partial C_t^E}{\partial B_t} - E_t\left[M_{t+1}\frac{\partial V_{d,t+1}}{\partial B_t}\right] \\
\frac{\partial V_{d,t}}{\partial B_{t-1}} &= -(1+(1-\tau_t)r_{b,t-1}).
\end{aligned}
$$

Taking into account the fact that at the equilibrium r_b is equal to the risk-free rate:

$$
\frac{\partial C_t^B}{\partial B_t} + \frac{\partial C_t^E}{\partial B_t} = E_t\left[M_{t+1}\tau_{t+1}\right] r_{f,t}.
$$

The left-hand side refers to the total marginal cost of issuing an extra unit of debt. The right-hand side measures the value of the corporate interest tax advantage.

Optimality with respect to capital. Envelope and first order conditions with respect to investment and capital imply the following:

$$\begin{aligned}
q_t &= \frac{1}{\phi_t'} = E_t\left[M_{t+1}\frac{\partial V_{d,t+1}}{\partial K_t}\right] - \frac{\partial C_t^E}{\partial K_t} \\
\frac{\partial V_{d,t}}{\partial K_{t-1}} &= (1-\tau_t)\frac{\partial Y_t}{\partial K_{t-1}} - \frac{\partial C_t^B}{\partial K_{t-1}} + q_t\left(1-\delta-\frac{\phi_t' I_t}{K_{t-1}}+\phi_t\right).
\end{aligned}$$

A stationary system of first order stochastic difference equations. Given a stochastic process X_t, we define its normalized counterpart, $\widehat{X}_t$, as follows:

$$\widehat{X}_t \equiv \frac{X_t}{Z_{t-1}}.$$

Using this convention, we write the following set of first order stochastic difference equations.

Production side:

$$\begin{aligned}
\widehat{Y}_t &= \Delta z_t^{1-\alpha}\widehat{K}_{t-1}^{\alpha}\Delta z_{t-1}^{-\alpha}, \\
\widehat{C}_t^B &= \nu\left(\frac{\widehat{B}_t}{\widehat{Y}_t}-\frac{\widehat{B}_{ss}}{\widehat{Y}_{ss}}\right)^2, \qquad \widehat{C}_t^E = \phi_0 e^{-\phi_1\left(\frac{\eta\widehat{K}_t}{\widehat{B}_t}-1\right)}, \\
\widehat{K}_t &= (1-\delta-\phi_t)\widehat{K}_{t-1}e^{-\Delta z_{t-1}}, \quad q_t = \frac{1}{\phi_t'}, \\
1 &= E_t[M_{t+1}R_{I,t+1}], \\
R_{I,t} &\equiv \frac{1}{q_{t-1}}\left((1-\tau_t)\frac{\alpha\widehat{Y}_t\Delta z_{t-1}}{\widehat{K}_{t-1}} + 2\nu\left(\frac{\widehat{B}_t}{\widehat{Y}_t}-\frac{\widehat{B}_{ss}}{\widehat{Y}_{ss}}\right)\left(\frac{\alpha\widehat{B}_t}{\widehat{Y}_t}\right)\frac{\Delta z_{t-1}}{\widehat{K}_{t-1}} + q_t\left(1-\delta-\frac{\phi_t'\widehat{I}_t\Delta z_{t-1}}{\widehat{K}_{t-1}}+\phi_t\right)\right) \\
&+ \frac{\phi_1\eta\widehat{C}_t^E}{\widehat{B}_t}, \\
1 &= 2\nu\left(\frac{\widehat{B}_t}{\widehat{Y}_t}-\frac{\widehat{B}_{ss}}{\widehat{Y}_{ss}}\right)\frac{1}{\widehat{Y}_t} + \frac{\phi_1\eta\widehat{K}_t\widehat{C}_t^E}{\widehat{B}_t^2} + E_t\left[M_{t+1}(1+(1-\tau_{t+1})r_{b,t})\right], \\
\widehat{W}_t &= (1-\tau_t)(1-\alpha)\widehat{Y}_t - 2\nu\left(\frac{\widehat{B}_t}{\widehat{Y}_t}-\frac{\widehat{B}_{ss}}{\widehat{Y}_{ss}}\right)\frac{(\alpha-1)\widehat{B}_t}{\widehat{Y}_t}.
\end{aligned}$$

Consumption side:

$$\begin{aligned}
\widehat{C}_t &= \widehat{Y}_t - \widehat{I}_t, \\
\widehat{U}_t &= \left\{(1-\beta)\widehat{C}_t^{1-1/\psi} + \beta e^{\Delta z_t}E_t[\widehat{U}_{t+1}^{1-\gamma}]^{\frac{1-1/\psi}{1-\gamma}}\right\}^{\frac{1}{1-\frac{1}{\psi}}}, \\
M_{t+1} &= \delta\left(\frac{\widehat{C}_{t+1}e^{\Delta z_t}}{\widehat{C}_t}\right)^{-\frac{1}{\Psi}}\left(\frac{\widehat{U}_{t+1}}{E_t\left[\widehat{U}_{t+1}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}}\right)^{\frac{1}{\Psi}-\gamma}.
\end{aligned}$$

Cost of equity and cost of debt:

$$\begin{aligned}
\widehat{D}_t &= (1-\tau_t)\widehat{Y}_t - \widehat{W}_t - \widehat{I}_t + \widehat{B}_t - (1+(1-\tau_t)r_{b,t-1})\widehat{B}_{t-1}e^{-\Delta z_{t-1}} - \widehat{C}_t^B - \widehat{C}_t^E \\
\widehat{V}_{d,t} &= \widehat{D}_t + e^{\Delta z_t}E_t\left[M_{t+1}\widehat{V}_{d,t+1}\right] \\
r_{d,t} &= \frac{\widehat{V}_{d,t}}{\widehat{V}_{d,t-1}-\widehat{D}_{t-1}}\cdot e^{\Delta z_{t-1}} \\
r_{b,t} &= r_{f,t} = \frac{1}{E_t\left[M_{t+1}\right]}.
\end{aligned}$$

Deterministic Steady-State. At the deterministic steady state, we assume that the firm pays zero financial distress costs. This is equivalent to impose: $\widehat{B}_{ss} = \eta\widehat{K}_{ss}$. For given ϕ_1, we use the following two Euler equations to solve for ϕ_0 and $\widehat{K}_{ss}$:

$$\begin{aligned}
1 &= M_{ss}\left\{(1-\tau_{ss})\alpha\Delta Z_{ss}^{2-2\alpha}\widehat{K}_{ss}^{\alpha-1}+1-\delta\right\} + \frac{\phi_1\eta}{\widehat{B}_{ss}}\phi_0 e^{-\phi_1\left(\frac{\eta\widehat{K}_{ss}}{\widehat{B}_{ss}}-1\right)} \\
1 &= \frac{\phi_1\eta\widehat{K}_{ss}}{\widehat{B}_{ss}^2}\phi_0 e^{-\phi_1\left(\frac{\eta\widehat{K}_{ss}}{\widehat{B}_{ss}}-1\right)} + M_{ss}\left(1+(1-\tau_{ss})\left(\frac{1}{M_{ss}}-1\right)\right).
\end{aligned}$$

At the steady state, the following holds:

$$\begin{aligned}
\widehat{K}_{ss} &= \left\{\left(\frac{1-\eta\tau_{ss}(1-M_{ss})}{M_{ss}}-1+\delta\right)\frac{1}{(1-\tau_{ss})\alpha\Delta Z_{ss}^{2-2\alpha}}\right\}^{\frac{1}{\alpha-1}} \\
\phi_0 &= \frac{\eta\widehat{K}_{ss}\tau_{ss}(1-M_{ss})}{\phi_1}.
\end{aligned}$$

Given $\widehat{K}_{ss}$, it is possible to compute the steady state value of all other variables.

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