Tax Uncertainty, Leverage and Asset Prices*

M. M. Croce, H. Kung and L. Schmid†

PRELIMINARY AND INCOMPLETE
DO NOT CIRCULATE

Abstract

In post-war US data, the market price-dividend ratio has risen up until the end of 2008, while corporate tax rates have slowly fallen. We replicate this negative link in a general equilibrium production-based asset pricing model with financial frictions where persistent stochastic changes in the corporate tax rate affect long-term productivity. By calibrating a corporate tax process to US data, we find that: 1) firms optimal response to tax shocks induces persistent swings in macroeconomic variables; 2) with recursive preferences these fluctuations strongly affect asset valuations; 3) endogenous leverage and financial frictions amplify the relevance of tax uncertainty.

Keywords: Tax Uncertainty Risk, Financial Leverage, Asset Pricing.
First Draft: February 11, 2010. *This Draft:* February 15, 2010

---

*We thank Ravi Bansal, Michael Brandt, and the participants to the Financial Econometrics Lunch Group at Duke Universitiy.

†Mariano Massimiliano Croce is affiliated to the Kenan-Flagler Business School, UNC at Chapel Hill; Howard Kung and Lukas Schmid are at the Fuqua School of Business at Duke University.

1 Introduction

Stock market valuations have displayed distinct long-term movements over the postwar period. For example, price-dividend ratios have slowly, but steadily risen until the end of 2008. While a long literature has studied the short-term volatility of stock markets, the determinants of long-term volatility have been less explored. In this paper, we pursue a productivity-based explanation of long-term volatility.

The starting point of our analysis is the observation that while price-dividend ratios have slowly risen, corporate taxes rates have slowly, but steadily fallen. In fact, the corporate tax rate series and the negative log price-dividend series track each other remarkably closely, as documented in figure 1. The annual correlation between the two series is about 0.6. Furthermore, the figure demonstrates that the corporate tax rate process is fairly persistent and volatile. In particular, casual inspection suggests that both corporate tax rates and price-dividend ratios exhibit long swings that appear to arise at lower than business cycle frequency. This observation suggests that long-term movements in asset valuations are intimately connected with changes in corporate taxation. In this paper, we develop a production-based general equilibrium model with financing frictions in order to quantitatively examine the link between tax uncertainty and asset prices. Asset valuations are determined through firms' optimal investment and financing policies in the presence of tax uncertainty in general equilibrium. In our model, stochastic changes in taxation affect long-term productivity.

In the model the link between asset valuations and tax uncertainty arises through two channels, both of which will be shown to be quantitatively significant in our calibrations. First, tax uncertainty impacts on the economy's long-term growth prospects through firms' investment policies. Second, given that firms can use debt financing to shield profits from taxes in accordance with the US tax code, tax uncertainty affects asset valuation through its effect on firms' capital structures. Concerning the first channel, changes in corporate tax rates affect long-term growth rate dynamics through their effects on productivity. More specifically, consistent with the empirical evidence, an increase in the corporate tax rate leads to a small, but persistent decline in productivity. In our production-based setting, firms optimally adjust their investment plans in response to changes in productivity. This mechanism induces long and persistent swings in investment, output and consumption. Similarly, firms optimally adjust their capital structures in response to a change in tax rate, as the net benefits of debt financing are altered. These capital structure adjustments lead to slow movements in leverage, which in turn induce a small persistent component in dividends. Taken together, firms' optimal responses to tax shocks therefore induce persistent fluctuations in key macroeconomic variables through both an investment and a financing channel.

These dynamics of macroeconomic variables affect asset valuations given our preference specification. 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 calibrated versions of our model, we show that these effects are quantitatively significant. Using aggregate post-war data, we construct a series of corporate tax rates for the US and calibrate a stochastic process to it. Our baseline calibration generates a sizeable equity premium and a low and smooth risk free rate.Our model is broadly consistent with both macro data and the dynamic behavior of firms' capital structure. Tax uncertainty affects asset valuations through two distinct channels that are both quantitatively important: the investment channel through long-term growth accounts for roughly two thirds of the equity premium, while the financing channel through capital structures accounts for the remaining one third. Importantly, leverage and financial frictions amplify the relevance of tax uncertainty in a quantitatively significant way.

The model also generates co-movement between corporate tax rates and financial market data in line with the empirical evidence. In particular, a sudden decrease in corporate tax rates generates a long and persistent increase in equity values, consistent with the evidence documented in figure 1. Since a fall in the corporate tax rate induces a small but persistent increase in after-tax productivity, the economy's long-term growth prospects improve significantly. Accordingly, expected dividend growth increases, and so do equity values. This channel suggests that corporate tax uncertainty is an important determinant of long-term stock market dynamics. Quantitatively, this effect is amplified through the presence of capital adjustment costs, which lead to considerable time variation of the price of capital. When we further allow for a negative long-run relationship between productivity growth and tax rates, the implied risk premium more than doubles.

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 a collateral constraint, 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. Hence our model gives rise to financial accelerator effects.

Our paper is related to several strands of recent literature. A number of papers 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 is also the mechanism 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.

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 corporate tax shocks as an important macroeconomic source of long-run risk. 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 the detail the link between corporate taxation and productivity. In section 3 we outline our calibration strategy. Quantitative model results are presented and discussed in section 4 and 5. Section 6 concludes. Details concerning data construction are collected in Appendix A.

2 Model

This section presents the general equilibrium model used to explore the relationship between tax shocks, leverage, macroeconomic aggregates, and asset prices. We begin by outlining the economic environment of the representative firm, including a rich description of its financial structure. We then specify the dynamics of the corporate income tax rate and productivity, and present the saving problem of the representative household.

2.1 Representative Firm

The representative firm has access to constant returns to scale production technology:

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

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. The capital stock evolves as in Jermann (1998):

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

We introduce corporate income taxes and allow interest payments to be tax deductible, so that there is an explicit role for financial leverage. The firm can issue one-period bonds sold at par with face value B_t and interest rate $r_{b,t}$. Let us define operating profits, Π_t,as follows:

$$\Pi_t \equiv Y_t - W_t H_t.$$

Formally, the firm faces the corporate income tax rate τ_t on operating profits net of interest payout. Since interest payments are tax-deductible, debt-financing is preferred over equity-financing. The firm, however, has the option to default. We assume that the value of collateral is worth ηK_{t+1}, where we impose $\eta < (1-\delta)$ to capture the notion that distressed capital is sold at a discount. In the debt contract, the lender requires the following collateral constraint to be satisfied:

$$B_{t+1} \leq \eta K_{t+1}.$$

This ensures that the loan is repaid in all contingencies and places an endogenous upper bound on the debt capacity of the firm. To capture capital structure rigidities or the inability of firms to substitute between debt and equity rapidly, we introduce quadratic debt adjustment costs with intensity ν:

$$\nu \cdot (B_{t+1} - B_t)^2.$$

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:

$$\begin{aligned}
\max_{\{D_t, I_t, H_t, K_{t+1}, B_{t+1}^s\}_{t=j}^{\infty}} V_{d,j} &= E_j \left[\sum_{t=j}^{\infty} M_t D_t \right] \quad (1) \\
& s.t. \\
I_t &= (1-\tau_t)\Pi_t - D_t + B_{t+1}^s - (1 + r_{b,t})B_t^s + \tau_t r_{b,t} B_t^s - \nu \cdot (B_{t+1}^s - B_t^s)^2, \\
K_{t+1} &= (1-\delta)K_t + \phi(\frac{I_t}{K_t})K_t, \\
B_{t+1}^s &\leq \eta K_{t+1}.
\end{aligned}$$

Note that M_t is the stochastic discount factor. If $D_t < 0$, then the firm is a net issuer.

2.2 Taxes and Productivity Dynamics

Tax and productivity growth rate are exogenously specified stochastic processes. A key feature of the specification is that we explicitly model the effect of the level of taxes on productivity growth. Assume that the tax process τ_t follows an AR(1) in logs:

$$\begin{aligned}
\tau_t &\equiv e^{\omega_t}, \quad (2) \\
\omega_t &= (1-\rho)\mu_\tau + \rho\omega_{t-1} + \zeta_t, \\
\zeta_t &\sim N(0, \sigma_\zeta).
\end{aligned}$$

Define $\Delta z_t \equiv ln(Z_t) - ln(Z_{t-1})$. Then, assume

$$\begin{aligned} \Delta z_t &= \mu + \phi_\tau \cdot (\omega_{t-1} - \mu_\tau) + \epsilon_t, \qquad (3) \\ \epsilon_t &\sim N(0, \sigma_\epsilon). \end{aligned}$$

For parsimony, we assume $corr(\zeta_t, \epsilon_t) = 0$. Note that the term $\phi_\tau \cdot (\omega_{t-1} - \mu_\tau)$ captures the effect of corporate income taxes on economic growth. Work in growth economics (for example Lee and Gordon (2005)) suggest 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.

2.3 Household

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

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

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 the long-run risk literature, the parametrization $\psi > \frac{1}{\gamma}$ is assumed, 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.

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:

$$\max_{\{C_t, H_t, S_{t+1}, B_{t+1}^d\}_{t=j}^{\infty}} U_j = \left\{ (1-\beta) C_j^{\frac{1-\gamma}{\theta}} + \beta (E_j [U_{j+1}^{1-\gamma}])^{\frac{1}{\theta}} \right\}^{\frac{\theta}{1-\gamma}} \tag{4}$$

$$s.t.$$

$$\begin{aligned} C_t + S_{t+1} P_t + B_{t+1}^d &\leq (1 + r_{b,t}) B_t^d + S_t (D_t + P_t) + W_t H_t + T_t \\ H_t &\leq 1 \\ S_{t+1} &\leq 1, \end{aligned}$$

where S_t is number of equity shares, P_t is the price per share, W_t is the wage rate, and T_t is a lump-sum transfer equal to the net corporate taxes. The household consumes and invests out of total wealth, which consists of financial wealth, labor income, and a lump-sum tax transfer. The financial portfolio of the household consists of debt and equity securities issued by the firm.

2.4 Market clearing

Given our assumptions, the goods, labor and financial markets need to clear as follows:

$$\begin{aligned} Y_t &= C_t + I_t, \quad H_t = 1 \\ S_t &= 1, \qquad B_t^d = B_t^s. \end{aligned} \tag{5}$$

3 Calibration

We focus on four 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 leverage level, η, is consistent with US data, while the intensity of the debt adjustment costs, ν, is set as in Jermann and Quadrini (2009). The capital adjustment costs elasticity, ξ, is set to a mild level to keep investment volatile enough (see Jermann (1998)). All the parameters for both productivity growth and tax rate 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 three elements: *1)* financial leverage, *2)* tax rate uncertainty, and *3)* long-run productivity risk. Since we are interested in disentangling the role of these three elements, we analyze other three models as well. 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 only for one reason: it features financial leverage, but it has no tax rate uncertainty ($\sigma_\zeta = 0$). Finally, Model 4 differs from Model 3 as we further assume that the firm cannot issue debt ($\eta = 0$). Model 4, hence, features no leverage and can be thought as a simple real business cycle model with capital adjustment costs and recursive preferences. Finally, we reduce a bit the volatility of the short-run productivity shock, σ_ϵ, in order to keep the volatility of consumption consistent with the data. We summarize

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

the key features of our four models in the following table.

	Model 1	Model 2	Model 3	Model 4
Leverage	Yes ($\eta > 0$)	Yes ($\eta > 0$)	Yes ($\eta > 0$)	No ($\eta = 0$)
Tax Uncertainty	Yes ($\sigma_\zeta > 0$)	Yes ($\sigma_\zeta > 0$)	No ($\sigma_\zeta = 0$)	No ($\sigma_\zeta = 0$)
Long-run Productvity Risk	Yes ($\phi_\tau \neq 0$)	No ($\phi_\tau = 0$)	No ($\phi_\tau = 0$)	No ($\phi_\tau = 0$)

4 Results

We find it convenient to start our analysis by comparing Model 3 and 4. We report the moments generated by these models in the last two columns of table 2; in figure 2 we plot their impulse response functions with respect to a one-standard deviation productivity shock. The model with financial leverage produces more volatile excess returns and stochastic discount factor, hence, higher risk-premia. The fifth panel of figure 2 shows that leverage helps us to obtain a stronger positive response in the value of equity, while the bottom panel shows that the leverage ratio is counter-cyclical as in the data (i.e. the value of debt adjusts less than the value of equity).

Thanks to financial leverage, the response of investment to the exogenous productivity shocks is much more intense than in a basic real business cycle model. While in Model 4 the volatility of investment is just 2.5 times greater than that of consumption, in Model 3 this volatility ratio is much closer to what we see in the data. Financial leverage alone, hence, allows us to get both higher returns and volatile investment, an improvement with respect to Campanale, Castro, and Clementi (2008), Croce (2008), and Lochstoer and Kaltenbrunner (2008). Furthermore, financial leverage does not significantly alter the time-series properties of consumption growth.

In figure 3, 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 on the left column refer to short-run productivity shocks, as in figure 2. 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 can strongly affect 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 3 (right column), small negative tax shocks produce substantial positive adjustments in price of capital, excess returns, and capital structure.

Second, turning our attention to table 2, we can see that Model 2 better reproduces the moderate correlation between consumption and investment growth, and market excess returns. The average equity premium, however, is equal to that obtained in Model 3. As shown in the fourth panel of figure 3 (right column, dashed line), this is due to the fact that tax shocks do not alter the intertemporal distribution of consumption growth and so do not generate significant adjustments in the stochastic discount factor. Thanks to both capital and debt adjustment costs, Model 2 features relevant long-run fluctuations in dividend growth (reflected in the persistent dynamics of the value of capital, q), but no long-run uncertainty in consumption. At the equilibrium, therefore, financial frictions produce significant long-run dividends uncertainty carrying zero risk-premium.

Third, when tax shocks have a negative impact on long-run productivity growth rates, they introduce strong long-run consumption risk. 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 much higher equity premium (Figure 3, 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 ($\phi_\tau \sigma_\zeta \approx 2.2\% \sigma_\epsilon$), hence our results are not driven by implausibly high long-run risk. This allows us to keep the autocorrelation of consumption growth consistent with the data.

As shown in table 3, the equity premium is now more than doubled with respect to that obtained in Model 2. This is one of the most important results of our analysis as it shows that tax uncertainty can substantially increase risk-premia and reduce overall welfare.

5 Financial Accelerator

Figure and Figure show normalized debt and equity value in Model 1 and 2, respectively.

Since debt is proportional to physical capital, in both figures the solid line shows also the log-deviation from steady state of normalized capital. The dashed lines, instead, show log-deviations of cum-dividend value of equity. The vertical difference in the dashed and solid line, therefore, is related to fluctuations in the average value of equity. These two figures show that in both models, the average value of capital is subject to relevant fluctuations. This suggests that a model where debt is related to the market value of the assets, instead of the book value, should produce even stronger and richer dynamics for leverage and asset prices. In this section we study the behavior of our model, once the borrowing constraint is modified as in Jermann and Quadrini (2009).

[TO BE COMPLETED.]

6 Conclusion

In US postwar data stock market valuations exhibit long and persistent movements. For example, price-dividend ratios have slowly, but steadily risen until the end of 2008. We develop a productivity-based explanation for such movements in a general equilibrium model with production and financing frictions. While most of the current literature relates long-term stock market movements to the arrival and diffusion of new technologies, we pursue a complementary explanation, namely corporate tax uncertainty. Just as stock market valuations, corporate tax rates in the US exhibit slow and persistent movements. Remarkably, corporate tax rates and log dividend-price ratios track each other quite closely. We replicate this link in a model where changes in corporate tax rates affect the long-term growth prospects of the economy. In particular, in our model, consistent with the empirical evidence, an increase in corporate tax rates leads to a small, but persistent decline in productivity.

We extend a standard stochastic growth model to be able to account for these patters. First, we calibrate a stochastic process to fit US post-war corporate tax rates. Second, given a tax benefit to debt consistent with the US tax code, we explicitly model financial leverage and firms' capital structures. Third, we assume that firms face capital adjustments costs. And finally, we assume that the representative household has recursive Epstein-Zin utility with a preference for early resolution of uncertainty. Our calibrated results suggest that all these elements are significant determinants of long-term stock market movements.

Given the persistent effects of taxation on long-term growth prospects, firms optimally adjust their investments plans after a tax change. These adjustments lead to long and persistent swings in the dynamics of macroeconomic variables. Similarly, after a tax change, the net benefits of debt are altered, and hence firms adjust their financial structures thus amplifying these dynamics. Given recursive preferences, these movements in quantities strongly affect asset prices, as households are averse to persistent uncertainty in consumption and dividends.

Quantitatively, the model generates a sizeable equity premium and realistic dynamics for the risk-free rate. At the same time, it is consistent with key macroeconomic dynamics and evidence on firms' financing decisions. This suggests that tax uncertainty is an important determinant of asset prices and their long-term movements. Similarly, this indicates that movements in corporate tax rates are a significant macroeconomic source of long-run risks in asset markets.

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, $\mathtt{mvequity}_{i,t} \equiv \mathtt{PRC}_{i,t} \cdot \mathtt{SHROUT}_{i,t}$. 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, $\mathtt{totdebt}_{i,t} \equiv \mathtt{DLC}_{i,t} + \mathtt{DLTT}_{i,t}$. Then, for a given year t, aggregate over all firms to obtain aggregate values, $\mathtt{totdebt}_t = \sum_i \mathtt{totdebt}_{i,t}$ and $\mathtt{mvequity}_t = \sum_i \mathtt{mvequity}_{i,t}$. Finally, the aggregate leverage ratio is then computed as the ratio of the value of debt to the total value of the firm, $\mathtt{lev}_t \equiv \frac{\mathtt{totdebt}_t}{\mathtt{totdebt}_t + \mathtt{mvequity}_t}$. 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.

References

Ai, H. (2009). Information quality and long-run risk: Asset pricing implications. *Journal of Finance (forthcoming).*

Ai, H., M. M. Croce, and K. Li (2010). Toward a quantitative general equilibrium asset pricing model with intangible capital. Duke and UNC at Chapel Hill University Working Paper.

Bansal, R. and A. Yaron (2004, August). Risk for the long run: A potential resolution of asset pricing puzzles. *The Journal of Finance 59*(4), 1481–1509.

Boldrin, M., L. Christiano, and J. Fisher (2001, March). Habit persistence, asset returns, and the business cycle. *American Economic Review 91*(1), 149–166.

Campanale, C., R. Castro, and G. Clementi (2008). Asset pricing in a production economy with chew-dekel preferences. *Forthcoming on the Review of Economic Dynamics*.

Comin, D., M. Gertler, and A. M. Santacreu (2009). Technology innovation and diffusion as sources of output and asset price fluctuations. NYU Working Paper.

Croce, M. M. (2008). Long-run productivity risk: A new hope for production-based asset pricing.

Epstein, L. and S. E. Zin (1989, July). Substitution, risk aversion, and the temporal behavior of consumption and asset returns: A theoretical framework. *Econometrica 57*(4), 937–969.

Gala, V. (2005). Investment and returns.

Garleanu, N., S. Panageas, and J. Yu (2009). Technology growth and asset pricing. Working Paper.

Gomes, J., L. Kogan, and L. Zhang (2003, August). Euqilibrium cross section of returns. *Journal of Political Economy 111*(4).

Gomes, J. F. and L. Schmid (2009). Equilibrium credit spreads and the macroeconomy. Duke and Wharton University Working Paper.

Gourio, F. (2006). Firms.heterogeneous sensitivities to the business cycle, and the cross-section of expected returns.

Gourio, F. (2009, September). Disaster risk and business cycles.

Iraola, M. and M. Santos (2009). Long-term asset price volatility and macroeconomic fluctuations. Working Paper.

Jermann, U. and V. Quadrini (2009). Macroeconomic effects of financial shocks.

Jermann, U. J. (1998, April). Asset pricing in production economies. *Journal of Monetary Economics 41*(2), 257–275.

Kuehn, L. A. (2008). Asset pricing with real investment commitment. Working Paper.

Kung, H. and L. Schmid (2010). Optimal long run risk. Duke University Working Paper.

Kydland, F. and E. Prescott (1982, November). Time to build and aggregtae fluctuations. *50*(6), 1345–1370.

Lee, Y. and R. H. Gordon (2005, June). Tax structure and economic growth. *Journal of Public Economics 89*, 1027–1043.

Lochstoer, L. and G. Kaltenbrunner (2008, July). Long-run risk through consumption smoothing.

McGrattan, E. R. and E. C. Prescott (2005, July). Taxes, regulations, and the value of u.s. and u.k. corporations. *Review of Economic Studies 72*(3), 767–796.

Papanikolaou, D. (2008). Investment-specific shocks and asset prices.

Table 1

Calibrated Parameter Values

MODEL:		1	2	3	4
Preference Parameters					
Discount Factor	β	0.99	0.99	0.99	0.99
Risk Aversion	γ	15	15	15	15
Intertemporal Elasticity of Substitution	ψ	2.0	2.0	2.0	2.0
Technology Parameters					
Capital Share	α	0.33	0.33	0.33	0.33
Depreciation Rate	δ	0.021	0.021	0.021	0.021
Elasticity of Investment Adj. Costs	ξ	4	4	4	4
Intensity of Debt Adj. Costs	ν	.118	.118	.118	–
Debt-Book Ratio	η	30%	30%	30%	–
Productivity and Tax Rate					
Average Productivity Growth	μ	.006	.006	.006	.006
Short-run Productivity Volatility	σ_ϵ	2.64%	2.64%	2.64%	2.23%
Long-run Risk Exposure	ϕ_τ	-.05	0	0	0
Tax Rate Constant	e^{μ_τ}	36.5%	36.5%	36.5%	36.5%
Tax Rate Volatility	σ_ζ	1.19%	1.19%	0	0
Autocorrelation of Tax Rate	ρ	0.995	0.995	–	–

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.

Table 2

Summary Statistics

	Data	Model 1	Model 2	Model 3	Model 4
First Moments					
$E[I/Y]$	0.23	0.19	0.18	0.18	0.17
$E[\tau]$ (%)	36.55	36.35	35.87	35.62	36.29
$E[Lev]$	0.30	0.30	0.30	0.30	0.00
$E[r_f]$ (%)	0.96	0.97	3.71	3.71	3.87
$E[r_d - r_f]$ (%)	4.50	3.50	1.36	1.36	0.95
Second Moments					
$\sigma_{\Delta i}/\sigma_{\Delta c}$	6.95	6.47	5.86	5.97	2.42
$\sigma_{\Delta c}$ (%)	2.31	2.35	2.24	2.19	2.43
$\rho_{\Delta c,\Delta i}$	0.44	0.39	0.49	0.54	0.99
σ_τ (%)	7.4	7.38	7.38	0.00	0.00
σ_{Lev} (%)	8.65	1.31	0.91	0.88	0.00
σ_{r_f} (%)	1.35	0.73	0.61	0.62	0.12
$\sigma_{r_d - r_f}$ (%)	20.14	2.23	2.11	1.91	1.56
$\rho_{\Delta c, r_d - r_f}$	0.22	0.51	0.65	0.83	0.99
$\rho_{\Delta i,\tau}$	-0.09	-0.09	-0.03	–	–
$ACF_1(\Delta c)$	0.44	0.49	0.44	0.47	0.03

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. Returns are in log units.

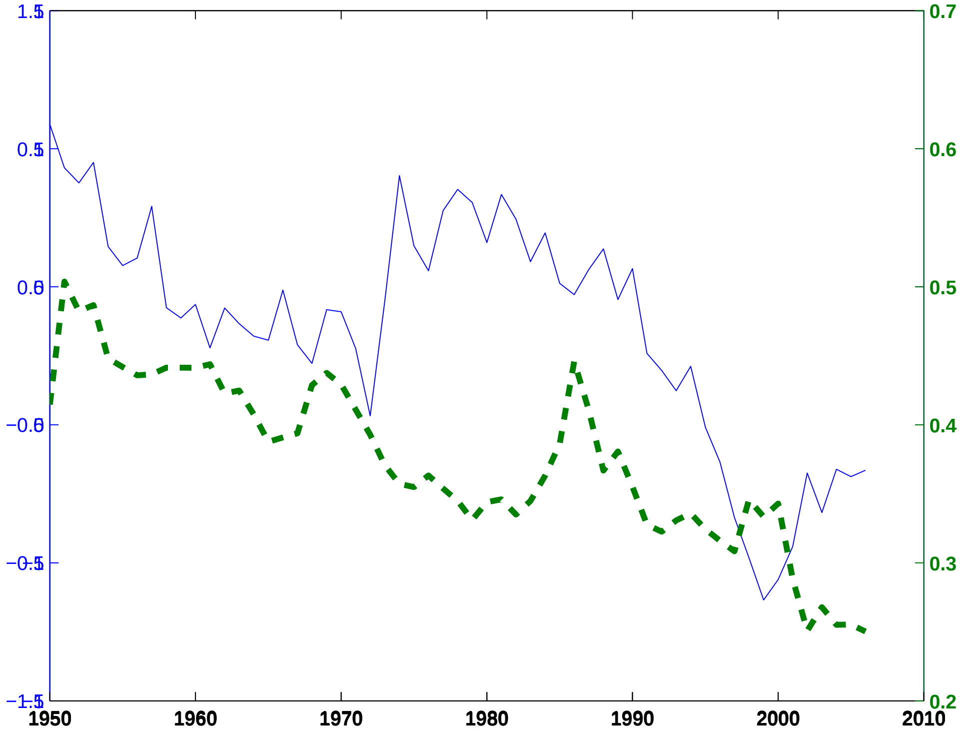

Fig. 1 – Corporate Tax Rate and Market D/P.

This figure shows annual corporate taxes divided by corporate profits in the US (dashed line, right scale), and log dividend-price ratio (solid line, left scale). Data sources described in Appendix A.

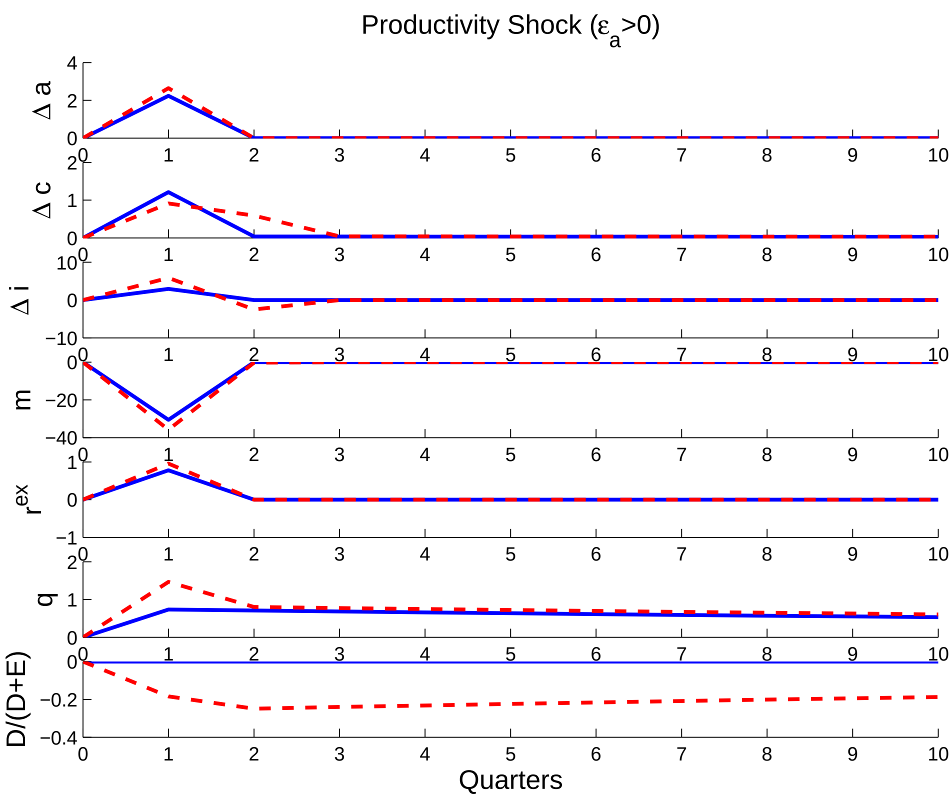

FIG. 2 – PRICES AND QUANTITIES IN MODEL 3 AND 4.

This figure shows quarterly log-deviations from the steady state. The solid lines refer to Model 4, while the dashed lines refer to Model 3. All the parameters are calibrated to the values reported in Table 1. All deviations are multiplied by 100. We denote the value of debt and equity as D and E, respectively. We use q for the measured Tobin's q, and r^{ex} for the equity excess returns.

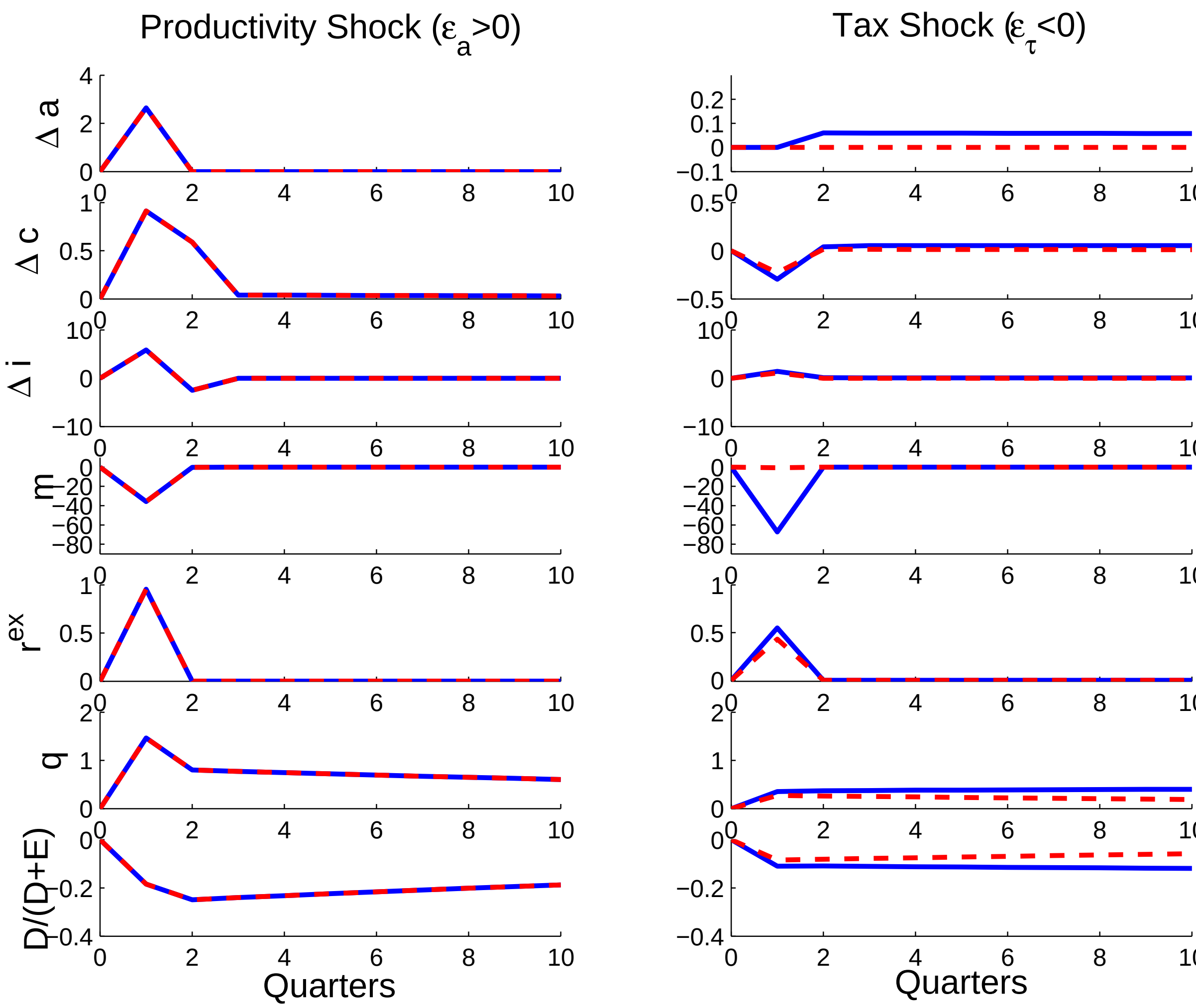

Fig. 3 – Prices and Quantities in Model 1 and 2.

This figure shows quarterly log-deviations from the steady state. The solid lines refer to Model 1, while the dashed lines refer to Model 2. All the parameters are calibrated to the values reported in Table 1; all deviations are multiplied by 100. We denote the value of debt and equity as D and E, respectively. We use q for the measured Tobin's q, and r^{ex} for the equity excess returns. The panels in the left column show responses to short-run productivity shocks, while the plots to the right refer to a negative tax shock. Starting from the second row, left and right panels have the same scale.

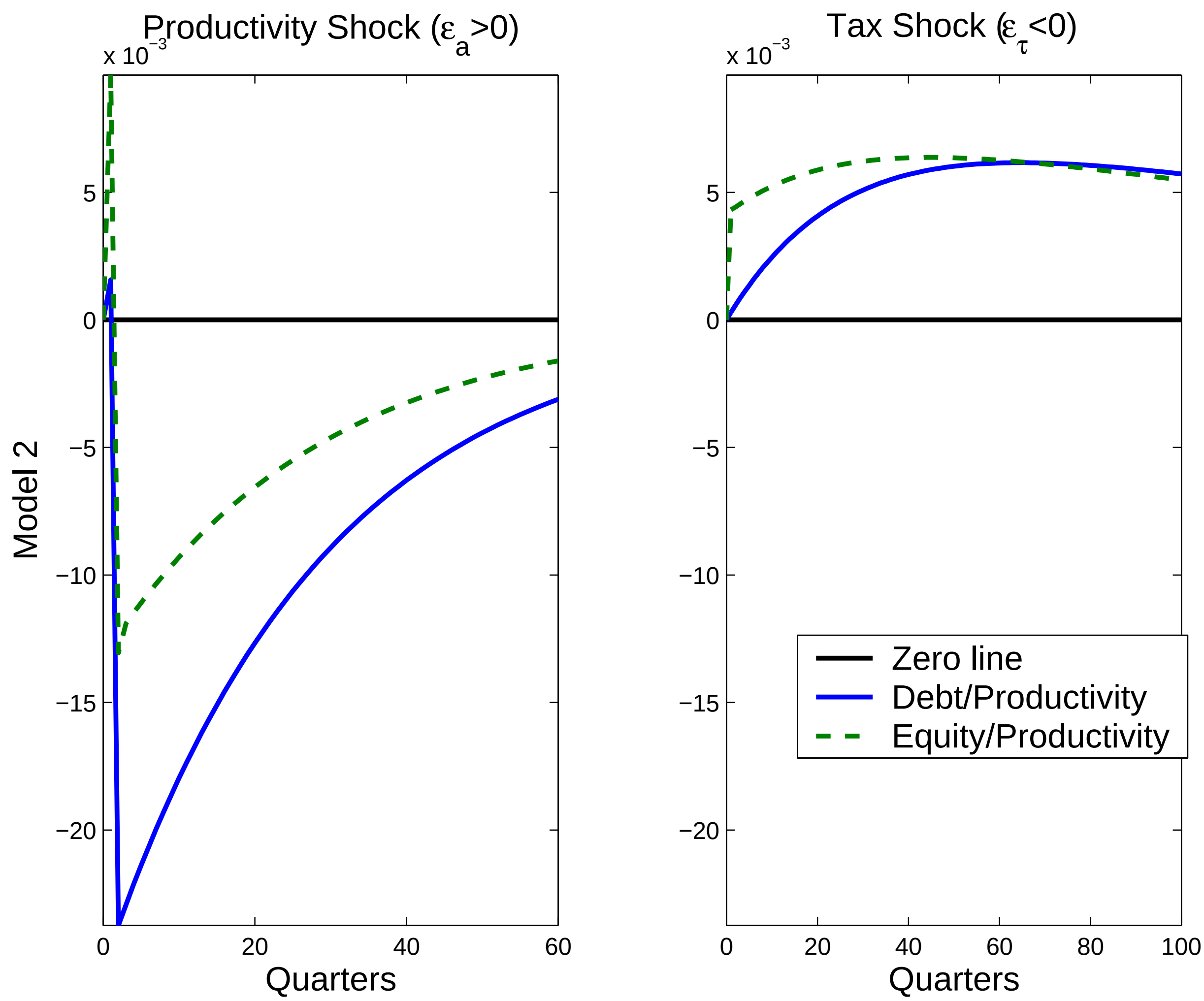

Fig. 4 – Equity- and Debt-Productivity Ratio in Model 2

This figure shows quarterly log-deviations from the steady state. The solid lines shows debt normalized by productivity, while the dashed lines show normalized equity. All the parameters are calibrated to the values reported in Table 1.

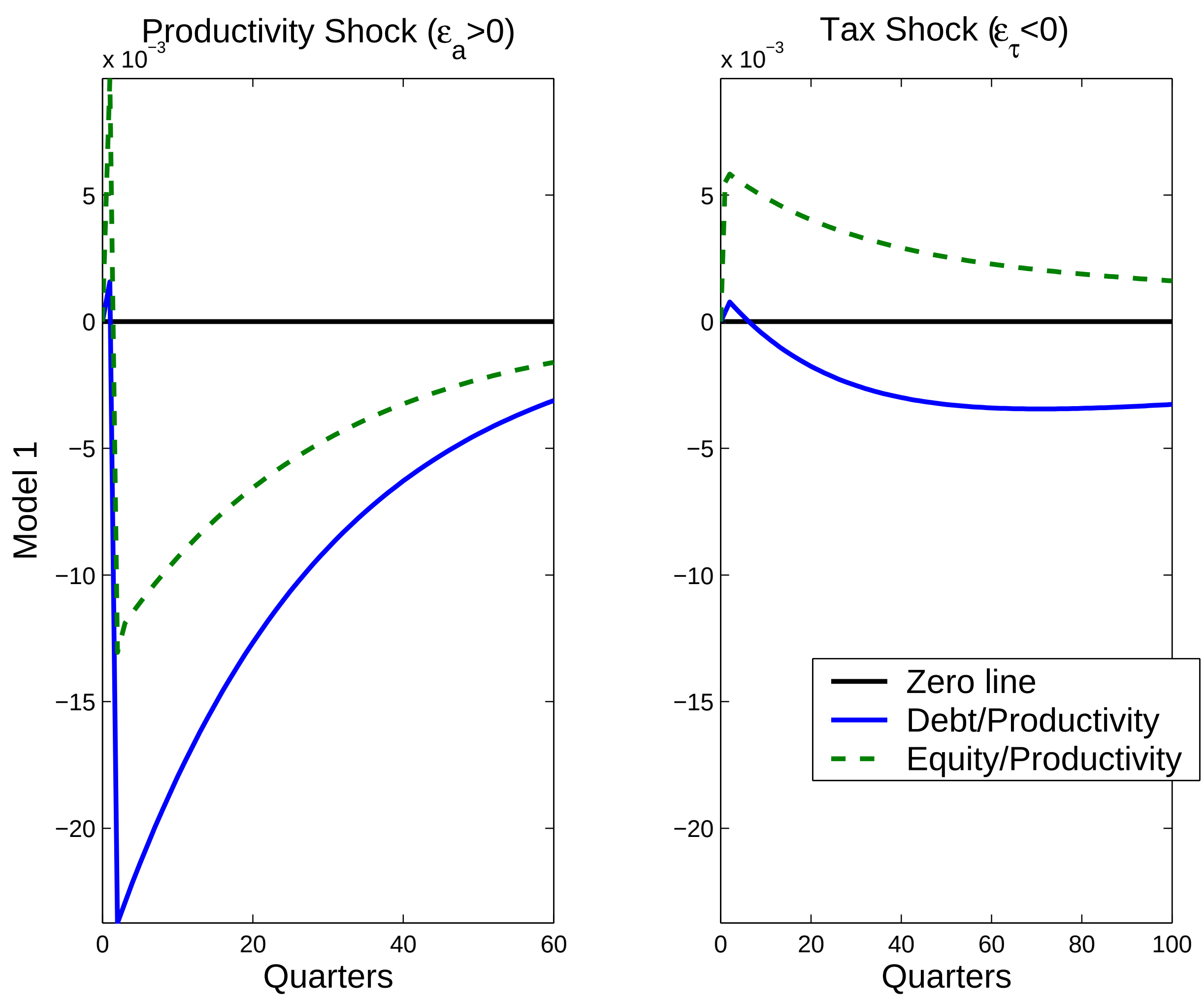

Fig. 5 – Equity- and Debt-Productivity Ratio in Model 1

This figure shows quarterly log-deviations from the steady state. The solid lines shows debt normalized by productivity, while the dashed lines show normalized equity. All the parameters are calibrated to the values reported in Table 1.