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THREE ESSAYS IN MACROECONOMICS

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THREE ESSAYS IN MACROECONOMICS

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THREE ESSAYS IN MACROECONOMICS

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Chapters one and two of the dissertation investigate the effects of political disagreement on macroeconomic outcomes. I introduce a model of governments with heterogeneous preferences over the composition of consumption between private and public goods alternating in power. Unable to commit to future policies, the party in power has incentive not only to shape consumption according to their preferences but also to manipulate the future state faced by successive governments to influence the decisions of future policy makers. Alternating governments give rise to political business cycles; fluctuations in economy-wide variables due to the political system. Political business cycles help explain the divergence in outcomes of economic variables across countries with different levels of political disagreement and political stability.

The first chapter adapts a real business cycle model to include political shocks in addition to the productivity shocks. This is motivated by a key puzzle in the business cycle literature: for emerging economies the volatility

of consumption is higher than the volatility of output, a feature of the data that is not explained by standard theory. The goal of this chapter is not only to replicate the data but to understand how consumption responds to political shocks differently than shocks to productivity. This model is also able to recreate endogenously the high level of volatility in government expenditure observed in the data. The model can explain up to 29% of the variation in the relative volatility of consumption across countries.

Chapter two focuses on a similar model in the presence of debt instead of capital to develop a positive theory for fiscal policy (debt, expenditure, and deficits) over the business cycle to compare to historical observation. I find that political shocks are important to understand observed U.S. data moments.

Chapter three investigates the welfare effects of tax-deferred retirement accounts (similar to Traditional IRAs in the US). I find that such accounts increase aggregate welfare as well as increasing economy-wide inequality. I find from an aggregate welfare perspective the optimal contribution limit for IRAs is to not have a contribution limit.

Table of Contents

List of Tables

List of Figures

Chapter 1

Partisan cycles in the macroeconomy

1.1 Introduction

Standard real business cycle theory predicts that consumption should be smoother than output. Agents focus on permanent rather than temporary income when making decisions, so they react to an increase in income by saving part of it for future consumption. This prediction holds for developed countries, where the volatility of consumption is in general smaller than the volatility of output. In emerging economies however consumption is more volatile than income (23% at annual frequencies and 40% at quarterly frequencies), a phenomenon known as the Consumption Volatility Puzzle. In this chapter I explore whether the introduction of political frictions into a standard real business cycle model can qualitatively and quantitatively explain this puzzle.

I am motivated by three observations drawn from analyzing stylized facts in emerging versus developed economies. First that there is a positive correlation between the variability of private and public consumption. Second

[*] This chapter based on "Why is consumption more volatile than income in emerging economies?", a paper co-authored with Marina Azzimonti, University of Texas-Austin. A largely collaborative effort, my main solo contribution here is the numerical implementation.

that the relative volatility of consumption is positively correlated with the degree of political polarization (the dispersion in political preferences among the population). Finally, emerging economies tend to be more polarized. Figure 1.1 illustrates the last two points.

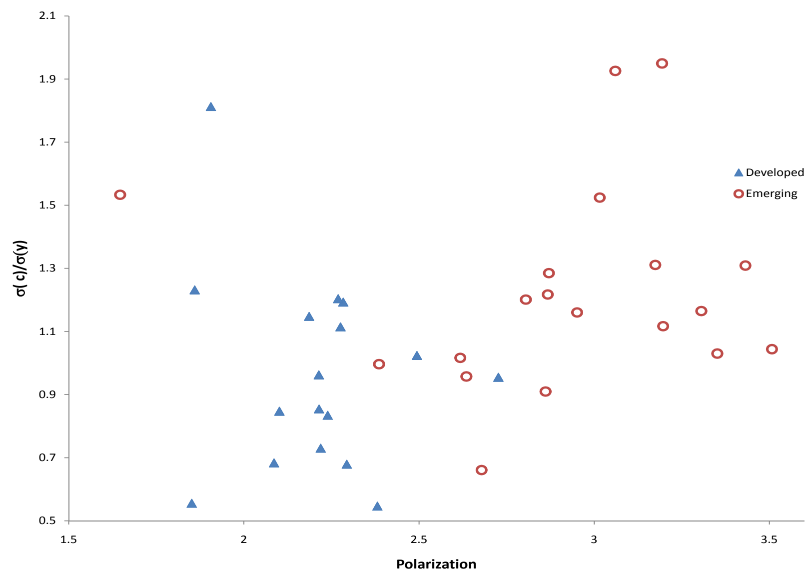

Figure 1.1: Relative volatility of consumption and polarization.

My main hypothesis is that fluctuations in economic variables are not only caused by innovations to productivity but also by shifts in ideology regarding the size of government. Countries that are more polarized exhibit larger swings in the level of spending. Because consumption responds more than output to the resulting changes in taxation these countries will tend to have a larger relative volatility of consumption. I elaborate this argument in a dynamic political economy model and provide intuition by looking at an example economy for which analytical solutions can be computed. I then calibrate the more general environment to a set of emerging and developed economies in order to quantify how much of the variability in relative consumption volatility can be explained by the model by varying their degree of political polarization.

The setup embeds Persson and Svensson's (1989) political economy model of public-goods provision in a neoclassical growth framework. Political parties that disagree on the size of the government alternate in power. Left-wing parties place more weight on public spending than right-wing parties and hence tax income at a higher rate in order to finance a larger level of expenditures. This introduces an additional source of volatility for economic variables triggered by changes in government policy which can be interpreted as *political shocks*. In contrast to TFP shocks, a political shock affects consumption immediately through changes in agents' disposable income, while the response of output (caused by changes in investment) is delayed and muted. As a result, consumption volatility can be larger than output volatility in the presence of political shocks. The mechanism is related to the earlier work of Dotsey (1990) and Baxter and King (1993) who study the effects of exogenous government expenditure shocks on macroeconomic activity. A main departure is that public policy is endogenous in this model. I am able to generate the stylized fact that government spending is more volatile in emerging economies than in developed ones (the average volatility is three times as large, as shown in Table 3.3) and to provide a reasonable channel by which this happens[1].

I endogenize public spending by building on a growing literature on political macroeconomics. There are two important frictions borrowed form this literature—in addition to political disagreement—relative to a standard neoclassical economy that are key for the results. The first is that the policymaker lacks commitment. Inefficiencies are introduced because neither party can credibly commit to follow a particular sequence of taxes and spending. This relates to the theories of political failure presented by Persson and Svensson (1989) and Besley and Coate (1998) in two-period models. I focus instead on an infinite horizon economy and characterize time-consistent outcomes as Markov-perfect equilibria following Klein, Krusell and Rios-Rull (2008).

The second friction results from the outcome of future elections being uncertain at the time policy choices are taken, together with market incompleteness, since there does not exist a set of contingent claims that allow the current policymaker to insure against shocks. This generates additional inefficiencies because the incumbent party is more short-sighted than its constituency when subject to political uncertainty. This was first pointed to by Alesina and Tabellini (1990) and more recently studied in fully dynamic models by Aguiar and Amador (2010) and Azzimonti (2010)[2]. While their

[1] Woo (2005) also relies on political shocks of the sort studied here to generate large levels of public consumption volatility, but by assuming that policymakers only care about public goods.

[2] Similar effects have been studied in environments with debt instead of capital by Amador (2008), Caballero and Yared (2008), Devereux and Wen (1998), and Iltzezki (2010).

environment is completely symmetric, the ideology of the policymaker may change over time here so I analyze equilibria where policy functions are asymmetric. Persson and Svensson (1989) and Cuikerman, Edwards and Tabellini (1992) study asymmetric equilibria, but in two-period deterministic models where the emphasis is on manipulation of government policy. In this environment the incumbent party also has incentives to use policy strategically because changes in the tax level, by affecting individual savings, modify the tax base inherited by their successor. The interaction of these two frictions gives rise to politically driven business cycles. This is related to an earlier literature on partisan cycles by Alesina (1987). While he focuses on disagreement over inflation and unemployment the focus here is on the effect of public spending and taxation on real macroeconomic variables[3]. In addition to the endogenous partisan business cycle driven by asymmetric policy I introduce aggregate shocks to productivity in the tradition of the macroeconomics literature which is absent in most of the political economy work. An exception is Barseghyan, Battaglini and Coate (2010), who study fiscal policy over the business cycle in a non-standard neoclassical environment. Because they abstract from capital and agents are risk neutral, their model is silent on the effects of these policies on consumption volatility. An important methodological contribution of this work is thus the implementation of global numerical methods to compute stochastic politico-economic equilibria in a neoclassical

[3]Milesi-Ferreti and Spolaore (1994) and more recently Song (2009) study the effect of strategic manipulation on partisan cycles. See Drazen (2000) for a comprehensive review of the data and theory.

environment. To the best of my knowledge this has not been done in the past.

This chapter also complements two strands of literature that have tried to account for the consumption volatility puzzle. The first one focuses on stochastic productivity trends and is based on the permanent income hypothesis. The idea is that the volatility of permanent income dominates the volatility of transitory shocks to income in emerging economies, as postulated by Aguiar and Gopinath (2007) and studied by Schmitt-Grohe and Uribe (2011). A second explanation relies on the existence of financial frictions and is based on the financing of firm's working capital. For example, in Neumeyer and Perri (2005) current interest rate shocks affect labor (and hence output) with a lag, while private savings (and hence consumption) adjust immediately. This creates a larger overall response of consumption to shocks (see also Fernandez-Villaverde et al [2009] for more recent work). The emphasis in these models is on real shocks to the economy, either through TFP (transitory vs. permanent) or interest rates. In this chapter I propose a novel explanation for the puzzle based on ideological swings of policymakers, which can be interpreted as political shocks.

The chapter is organized as follows. Section 1.2 describes a set of stylized facts that characterize the business cycle properties of emerging and developed economies for a panel of countries. The main assumptions of the model are summarized in Section 1.3, where the stochastic politico-economic equilibrium is defined. Intuition on how this model helps explain the puzzle is provided in Section 1.4, where I find tractable analytical expressions and decompose the volatility of consumption between TFP and political shocks. I calibrate the model to the US economy in Section 1.5 and perform the main experiment by varying the degree of political polarization across countries in Section 1.5.2. The main business cycle moments for the artificial economy are computed and contrasted with the ones analyzed in Section 1.2. Conclusions and extensions are contained in Section 1.6. All proofs are relegated to the Appendix.

1.2 Stylized facts

In this section I present business cycle properties of a broad set of countries and point to some key differences between emerging and developed economies. The countries under study are summarized in Table A.1, Appendix A. Following Aguiar and Gopinath (2007), I use the S&P classification for Developed Markets for the developed economies and classify all other countries as emerging[4].

The data is obtained from Kaminsky, Reinhart, and Végh (2004) who compile a comprehensive cross-country panel for the main variables of interest from the IMF World Economic Outlook (WEO) and IMF Government Financial Statistics (GFS) datasets. I compute business cycle moments (volatilities, autocorrelations and correlations) on Hodrick-Prescott filtered (with smooth-

[4] Two primary criteria used in defining a country as a Developed Market are (i) it is located in a high income country as defined by the World Bank and (ii) its capital markets are highly developed and transparent with large market capitalization

ing parameter 100) natural logs of each (GDP deflated) variable on the available time series for each country. Since data availability is not consistent across the four variables for individual countries, the period studied in each case reflects the longest time span for which I have complete data for that country. Sample lengths for each country are reported in Table A.1, Appendix A.

Table 1.1: Business cycle moments (averages)

Moment	Developed Economies	Emerging Economies
$\sigma(y)$	2.37e-2	4.28e-2
$\sigma(c)/\sigma(y)$	0.96	1.23
$\sigma(I)/\sigma(y)$	3.79	3.85
$\sigma(g_c)/\sigma(y)$	1.41	3.03
$\rho(y)$	0.61	0.56
$\rho(g_c)$	0.60	0.38
$\rho(y, c)$	0.80	0.71
$\rho(y, I)$	0.85	0.62
$\rho(y, g_c)$	0.24	0.22

Note: This table contains the average value of moments computed for a set of emerging and developed economies. Relative volatility measures for each country can be found in Table A.2 in Appendix A. Data is obtained from Kaminsky, Reinhart and Vegh (2004).

Output in emerging economies is about twice as volatile as output in developed economies with roughly the same autocorrelation. This has previously been documented by Aguiar and Gopinath (2007) for quarterly data in a smaller sample of countries. They also pointed to the striking difference in the volatility of consumption relative to output between the two groups. Consumption is less volatile than output for developed economies but 23% more volatile than income in my sample for emerging economies. There are some exceptions, as can be seen in the first column of Table A.2 in Appendix A, which reports the individual values for each country. Much of the focus on cross country differences in the business cycle properties of government expenditure has centered on the difference in the volatility of government consumption in developed versus emerging economies (see Bachman and Bai [2010] for an analysis of the US economy or Lane [2003] for a comparison across OECD countries). Consistent with this literature, I find that public consumption is much more volatile both absolutely and relative to output volatility in emerging economies. I find that at business cycle frequencies it is more volatile than output by a factor of three, more than double that for developed economies. I also find support for the pro-cyclicality of public spending both in developed and emerging economies[5].

Part of the motivation for this analysis comes from the correlation of government expenditure volatility to consumption volatility. Figure 1.2 shows that countries with large observed relative volatility of private consumption also tend to have more volatile public expenditure. The correlation of these variables is 0.24. This relationship is important as increases in polarization in the model affect the degree of volatility for both, a channel explored further in

[5]Ilzetzki [2010] and Ilzetzki and Végh (2008) document that government expenditure is pro-cyclical in emerging economies and weakly counter-cyclical in developed economies. The cyclicality of government expenditure depends largely on transfers, which I do not directly model, so I focus on the series of *public consumption* rather than on total public expenditures. Ideally, I would want to present business cycle moments of government expenditures net of transfers, but unfortunately data on transfers is not available for most emerging economies. I do have data for the US and Mexico, which will be used in the model's calibration.

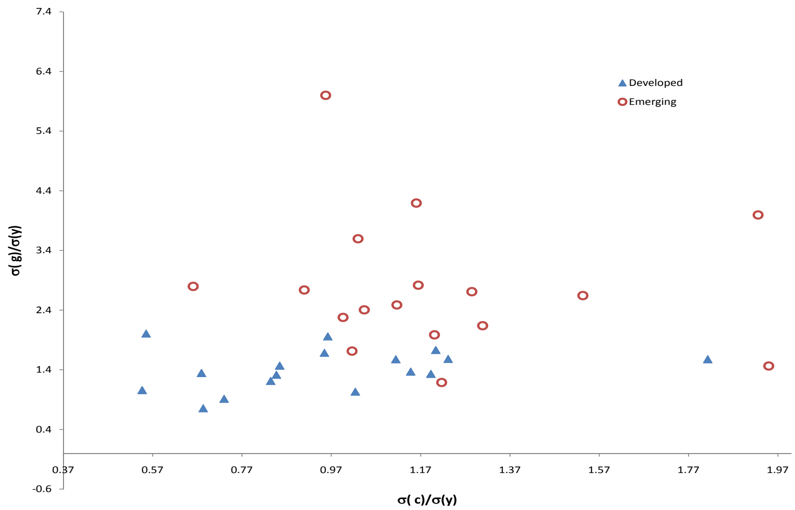

Figure 1.2: Relative volatility of public and private consumption.

succeeding sections. A line of empirical research has studied the effects of the variability of shocks to governments expenditure on macroeconomic outcomes. Fátas and Mihov (2003) estimate that for every percent increase in volatility of output driven by volatility of fiscal policy reduces growth by 0.75 percentage points.

The observation that the relative volatility of investment is roughly the same for developed and emerging economies is consistent with findings in the literature. Given the wide differences in consumption and public spending volatilities, this suggests the presence of adjustment costs to investment.

Empirical studies using polarization offer reassuring but ultimately unsatisfying support for the hypothesis that polarization matters for economic stability. Starting with Easterly and Levine (1997) a large literature has developed attributing economic outcomes to ideological differences in the population. However most of these papers use non-partisan heterogeneity in the population; for example employing ethnic, religious, and linguistic divisions as their polarization measures delivering negative outcomes[6]. Closer to my partisan model Alt and Dreyer Lassen (2000) and Lindqvist and Östling (2007) empirically link political polarization to economic performance using different and more relevant measures of partisan disagreement over the size of government. I adopt the measure from Lindqvist and Östling directly. They use self-reported political preferences from the 1999-2002 World Values Survey (a description of their method can be found in Appendix A). Importantly they find that political polarization is not endogenous to economic performance, in line with the assumption of the model presented here. Using this measure I find the motivating stylized facts mentioned in the introduction, that the relative volatility of both government expenditure and consumption are positively related to polarization and emerging economies display higher levels of polarization, as shown above in Figure 1.1.

1.3 Environment

The setup embeds Persson and Svensson's (1989) political economy model of public-goods provision in a neoclassical growth framework.

[6]Alesina and Zhuravskaya (2008) provide a recent novel measure of population heterogeneity and its effect on the quality of government.

1.3.1 Economic environment

Technology is characterized by a Cobb-Douglas production function that utilizes capital k and labor l to produce a single consumption good

$$F(z, k, l) = e^z k^\alpha l^{1-\alpha}.$$

The variable z represents an aggregate productivity shock that follows an AR(1) process

$$z' = \rho z + \epsilon'$$

where ϵ is a draw from an iid normal distribution and $|\rho| < 1$. Capital depreciates at rate δ and investment is subject to capital adjustment costs $\Phi(k, k')$

$$\Phi(k, k') = \phi \left(\frac{k'}{k} - 1 \right)^2 k$$

as modeled by Greenwood, Hercowitz and Krusell (2000).

There is also a public good, denoted by g, that can be produced from the consumption good according to a linear technology. I normalize the time endowment in the economy to 1. Thus, the aggregate resource constraint reads

$$c + g + k' = F(z, k, 1) + (1 - \delta)k - \Phi(k, k').$$

There are competitive labor and capital markets and competitive production of the public good. The relative price of private and public goods is one in equilibrium. The wage rate is denoted by w and the rental rate of capital by r. Firms hire labor and capital in order to maximize profits after observing their productivity shock. Their decision problem is static and deterministic, implying

$$w = F_l(z, k, l) \text{ and } r = F_k(z, k, l). \tag{1.1}$$

Citizens live forever and discount the future at rate $\beta < 1$. They derive utility from the consumption of private and public goods. Political disagreement arises from heterogeneity in agents' preferences regarding the overall size of the government. I assume that there are two types indexed by i, with $i \in \{L, R\}$.

The instantaneous utility of a type i agent is separable in private and public consumption

$$(1 - \lambda_i)u(c) + \lambda_i v(g)$$

where u and v are increasing and concave, and the weights on public consumption satisfy $\lambda_L = \bar{\lambda} + \xi$ and $\lambda_R = \bar{\lambda} - \xi$. Since $\lambda^R < \lambda^L$, one can think of R as right-wing (small government) and L as left-wing (large government) individuals. The variance of λ_i is determined by ξ, which can be interpreted as a measure of the degree of political polarization in society. If ξ was equal to zero, agents would be completely homogeneous. As ξ increases, views regarding the provision of g become more conflicting. This parameter will be the key variable governing the volatility of government distortions in cross country comparisons. Complementarity between private and public consumption would induce a direct co-movement between the two goods and additional volatility in consumption. By assuming separability I am reducing this degree of freedom.

Citizens finance private consumption and investment with capital and labor income, which are taxed at the proportional rate τ

$$c_i = (1-\tau)[wl_i + rk_i + (1-\delta)k] - k_i' - \Phi(k, k').$$

Since leisure is not valued, the supply of labor is inelastic. The choice of investment k_i' is inter-temporal and depends on government policy. While the current level of taxes τ is known at the time of making decisions, citizens need to form expectations about future policy τ'. I postpone a description about how these expectations are formed until the next section. Note that because all agents face the same policy and preferences are additively separable, investment decisions are independent of type. As a result I can focus the analysis on a representative agent that accumulates capital according to a standard Euler equation with adjustment costs

$$u_c(c)(1 + \Phi_{k'}(k, k')) = \beta \mathbb{E}\left[[(1-\tau')(r' + 1 - \delta) - \Phi_k(k', k'')]u_c(c')\right].$$

The government is subject to a period-by-period balanced budget constraint

$$\tau f(z, k) = g,$$

where I simplify notation by defining $f(z, k) \equiv F(z, k, 1)$.

1.3.2 Political environment

There are two political parties L and R representing each group in the population. The incumbent party is chosen at the beginning of a period and sets policy in order to maximize the utility of its constituency. Agents and firms then choose allocations taking as given current policy and expectations of future policy. Parties alternate in power following an exogenous Markov process, where p denotes the type-independent probability of retaining office in the next period. Despite the fact that there are two symmetric parties the re-election probability may be larger than 0.5 due to incumbency advantage effects. The micro-foundations of this specification come from a probabilistic voting model as shown in Azzimonti (2010).

A key feature of the environment is the government's lack of commitment; tax and spending policy promises are not credible unless they are ex-post efficient. The party in power plays a game against the opposition taking their policy as given. Alternate realizations of history (defined by the sequence of policies and realizations of productivity shocks up to time t) may result in different current policies. In principle, this dynamic game allows for multiple subgame perfect equilibria that can be constructed using reputation mechanisms. I will rule out such mechanisms and focus instead on Markov perfect equilibria (MPE), defined as a set of strategies that depend only on the current payoff-relevant states of the economy: k and z. Because parties have different objectives their policy choices differ in equilibrium, so strategies are functions of their type.

The two key equilibrium objects are the spending rule of incumbent i, $\mathcal{G}_i(z,k)$ and the investment decision of the representative citizen $\mathcal{H}_i(z,k)$. Note that the latter is a function of the identity of the party in power due to the effect of tax policies on savings behavior. The tax rule $\mathcal{T}_i(z,k)$ is trivially determined from the government's budget constraint. The value function of a citizen type i when his group is in power will be denoted by $V_i(z,k)$ and when his group is out of power by $W_i(z,k)$.

1.3.3 Political equilibrium

An incumbent party chooses the provision of public good g knowing that it might be replaced by a different policymaker with probability p. Suppose that a left-wing government L is elected. Given the stock of public capital k and the current realization of the shock z, the incumbent's objective function today is given by

$$\max_{g}\ (1-\lambda_L)u(c)+\lambda_L v(g)+\beta\mathbb{E}_z[pV_L(z',k')+(1-p)W_L(z',k')]$$

where the consumption of its constituency satisfies

$$c=f(z,k)+(1-\delta)k-g-k'-\Phi(k,k')\equiv\mathcal{C}(z,k,k',g).$$

Private savings k' given current spending g satisfies the Euler equation

$$u_c(c)(1+\Phi_{k'}(k,k'))=\beta\mathbb{E}_{zL}\left[\left(\left(1-\tau_j'\right)\left[F_k(z',k')+1-\delta\right]-\Phi_k(k',k'')\right)u_c(c')\right] \tag{1.2}$$

where $c' = \mathcal{C}(z', k', \mathcal{H}_j(z', k'), \mathcal{G}_j(z', k'))$ and future taxes satisfy the government budget constraint $\tau_j' = \frac{\mathcal{G}_j(z',k')}{F(z',k')}$. Expectations $\mathbb{E}_{zL}$ are taken with respect to productivity z' and political shocks j (i.e. the identity of tomorrow's incumbent), given that L is currently in power and the current realization of TFP is z.

The functional equation (1.2) determines future capital as a function of current capital, productivity, and public spending, $k' = H_L(z, k, g)$. It summarizes an agent's optimal reaction to a one-period deviation of g from the equilibrium rule that an incumbent would follow in the Markov-perfect equilibrium, $\mathcal{G}_L(z, k)$. Agents expect tomorrow's incumbent of type j to follow the equilibrium strategy $g_j' = \mathcal{G}_j(z', k')$, and capital to satisfy $k'' = \mathcal{H}_j(z', k')$ under such policy. Consistency requires that $\mathcal{H}_i(z, k) = H_i(z, k, \mathcal{G}_i(z, k))$ for all i.

The description of the problem is completed by defining the functions $V_L(z, k)$ and $W_L(z, k)$:

$$V_L(z,k) = (1-\lambda_L)u\left(\mathcal{C}_L(z,k)\right)+\lambda_L v\left(\mathcal{G}_L(z,k)\right)+\beta\mathbb{E}_z[pV_L(z',k')+(1-p)W_L(z',k')] \tag{1.3}$$

and

$$W_L(z,k) = (1-\lambda_L)u\left(\mathcal{C}_R(z,k)\right)+\lambda_L v\left(\mathcal{G}_R(z,k)\right)+\beta\mathbb{E}_z[(1-p)V_L(z',k')+pW_L(z',k')] \tag{1.4}$$

where $\mathcal{C}_i(z, k) = \mathcal{C}(z, k, \mathcal{H}_i(z, k), \mathcal{G}_i(z, k))$. The main difference between equations (1.3) and (1.4) is that spending levels in the second equation are chosen by a right-wing party, and hence do not maximize the objective of incumbent L. A second difference comes from the expectation over political shocks since p denotes the probability of retaining power for a given incumbent.

The political uncertainty, combined with the conflict over the provision of public goods, creates incentives to act strategically. This becomes clear when analyzing incumbent L's first order condition,

$$(1-\lambda_L)u_c(-1-H_g(1+\Phi_{k'}))+\lambda_L v_g+\beta\mathbb{E}_z[pV'_{k,L}+(1-p)W'_{k,L}]H_g=0.$$

When choosing g, the decision maker trades-off the current benefit of larger government expenditures given by the increase in $v(g)$ to the current cost of financing this increase via taxes, which lowers today's consumption c. In addition, it takes into account the dynamic effects of this policy change, since larger taxes reduce current savings by H_g. This affects continuation utilities V and W directly by reducing future income and indirectly by lowering future spending of incumbent j. By controlling the level of investment—via changes in the tax system—an incumbent party can affect the spending level of future policymakers through changes of tomorrow's tax base. This form of manipulation has been extensively studied in the political economy literature in the context of optimal debt management pioneered by Persson and Svensson (1989), but received less attention in economies where private rather than public savings are affected.

Definition 1.3.1 (MPE)**.** *A Markov-perfect equilibrium satisfies* *i. Given current policy and expectations on future policy, agent's and firm's decisions are a competitive equilibrium.*

ii. Given equilibrium allocations and expectations on future policy, current policy solves incumbent i's problem.

iii. The incumbent party's choices are consistent with private expectations,

$$g = \mathcal{G}_i(z, k).$$

This definition imposes consistency between citizens' and government's decisions. Additionally it implies that private expectations are correct and no incumbent has incentive to deviate from the MPE. A theoretical characterization of the MPE is non-trivial in general, but under some restrictive assumptions on the primitives of the economy it is possible to find an analytical characterization. This will allow us to shed some light on how the main mechanism driving the volatility of output, consumption and expenditures operates in this environment.

1.4 Example Economy

Political shocks affect economic variables differently than standard innovations to productivity. In particular, consumption reacts instantaneously to a political shock while output changes with a one-period lag. Keeping TFP constant, this results in consumption volatility being larger than output volatility. To illustrate this further it is useful to analyze an example economy.

Assumption 1.4.1. *Suppose that (i) preferences over private and public consumption, u and v, are logarithmic, (ii) productivity innovations follow a 2-state Markov process: z_s with $s \in \{H, L\}$, (iii) there is full depreciation $\delta = 1$ and (iv) there are no adjustment costs $\phi = 0$.*

Under these assumptions I can show that private investment is proportional to output $y_z = e^z k^\alpha$ and decreasing in public spending, $H(z, k, g) = \alpha\beta y_z - g$. Because private consumption is also linear in output, I guess that government spending follows a linear and type-dependent rule. This guess is verified in the following proposition.

Proposition 1.4.1. *Under Assumption 1, the MPE satisfies*

$$\mathcal{G}_i(z,k) = \lambda_i \eta e^z k^\alpha, \quad \mathcal{H}_i(z,k) = \alpha\beta(1-\lambda_i\eta)e^z k^\alpha, \quad \textit{and}$$

$$\mathcal{C}_i(z,k) = (1-\alpha\beta)(1-\lambda_i\eta)e^z k^\alpha \quad \textit{where} \quad \eta = \frac{1-2\alpha\beta p - \alpha^2\beta^2(1-2p)}{1+\alpha\beta(1-2p)}.$$

Proof 1.4.1. *See Appendix B.1*

The marginal propensity to spend on public goods of right-wing governments $\lambda_R\eta$ is smaller than that of left-wing incumbents. The model thus predicts a smaller size of the government under an R incumbent party and a lower tax burden on the private sector. Since disposable income is larger, individuals choose higher consumption and investment than when a left-wing party is in power. This has interesting implications regarding the underlying dynamics of the model.

1.4.1 Long-run dynamics

To make the exposition simpler ignore TFP shocks for the moment; focusing only on the political dimension. Figure 1.3 depicts private investment as a function of the current stock of capital. Keeping $z = z_H$, the line $\mathcal{H}_L(z_H, k)$ represents tomorrow's value of capital assuming that L is currently in power. If there was no political turnover (that is, L was in power forever) capital would eventually converge to k^*_{LH}. If instead a right-wing party was in power forever steady state capital, k^*_{RH}, would be larger. Moreover the speed of convergence for a given value of z, defined as

$$\gamma_{iz} = \alpha\beta(1 - \lambda_i\eta)e^z k^{\alpha-1},$$

is higher under $i = R$. That is, growth is faster and the economy converges to a larger steady state level of capital under governments that have a smaller weight on public consumption. The intuition lies on the fact that a left-wing party prefers a larger share of output to be devoted to public goods provision. Because financing this good is costly under proportional taxation, inefficiencies are more pronounced than under an R-type government and have long-term distortionary consequences in the economy.

1.4.2 Short-run dynamics

Now consider the response of the economy to a political shock, starting from the steady state attained under a left-wing government. Suppose that party R gains power for only one period and L regains control of the government forever after. The impulse-response function of consumption and output

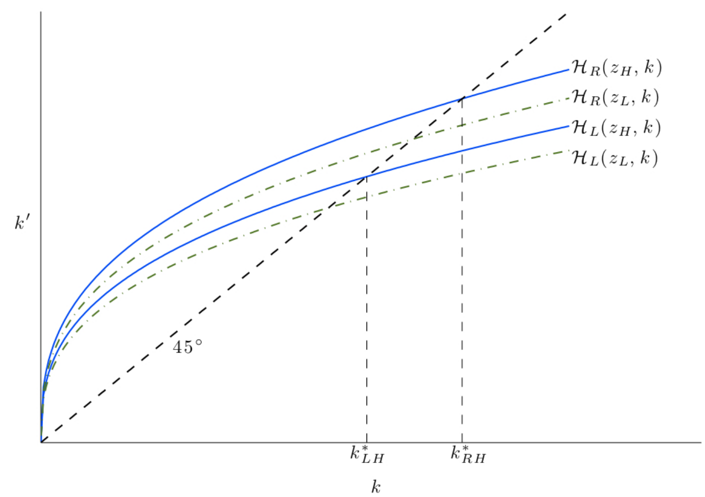

Figure 1.3: Evolution of capital

is depicted in Panel A of Figure 1.4. The main difference in both variables lies in the timing of responses: consumption reacts immediately while output only jumps upwards with a one period lag. The reason is the following: the switch in political ideology generates a reduction on public spending and taxes, which triggers an increase in current consumption. Output remains unchanged due to the fact that capital is given and labor is inelastic. Individuals also increase investment in response to the change in regime, since lower taxes behave similarly to a positive income shock. The larger stock of capital in the second period increases production at that point. As time goes by the effects of the shock dissipate slowly until the economy converges to the original steady state.

A positive TFP shock has the same effects on economic variables as those found in a standard RBC model. In particular, current output increases

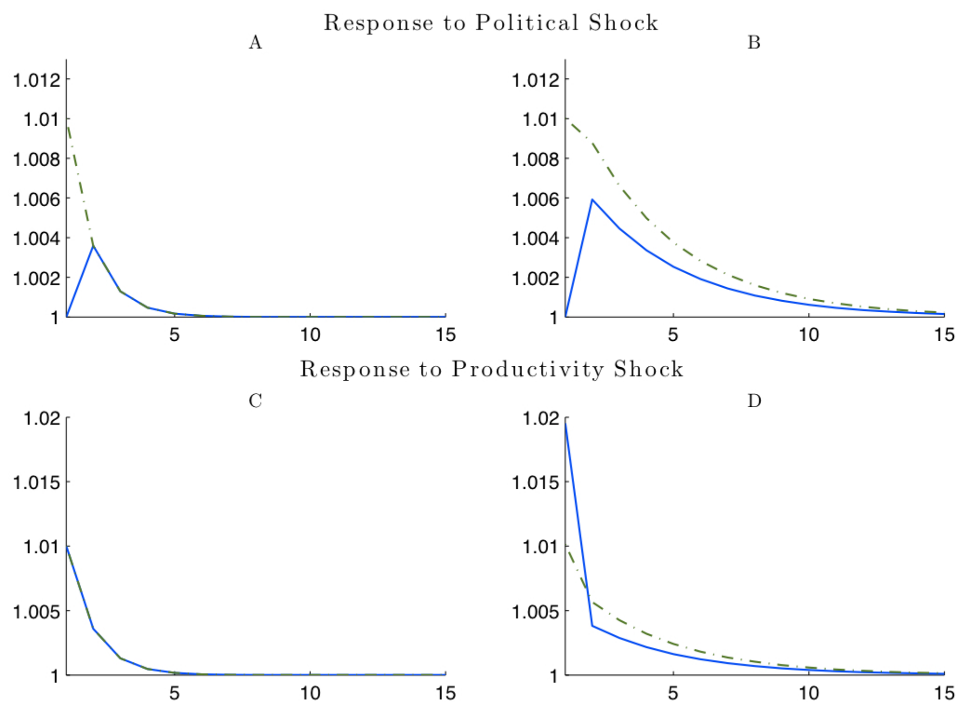

Figure 1.4: Impulse response to productivity and political shocks (– consumption and – output)

immediately as the economy becomes more productive. The positive income effect induces a concurrent increase in consumption, which individuals smooth out over time by also raising investment. Under logarithmic utility it turns out that a one percent increase in output results in exactly one percent rise in consumption. This can be seen clearly in Panel C of Figure 1.4 where the size of the response to the shock coincides for both variables.

The previous discussion makes it clear that while both positive TFP shocks (increases in z) and political shocks (power switches from L to R) increase agents' disposable income, they have very different implications for output dynamics. An immediate testable implication of the model is that consumption boosts that are observed leading GDP booms are associated to changes in ideological views of the government (i.e. on government spending), rather than innovations in productivity. Traditional TFP shocks result in coincidental movements in private consumption instead.

Proposition 1.4.2 presents a decomposition of the volatility of consumption due to each type of shock.

Proposition 1.4.2. *Suppose that* $p > 0.5$. *Let* $\hat{c}_t = \ln c_t$, $\hat{y}_t = \ln y_t$, *and* $\hat{x}_t = \ln(1 - \lambda_i \eta)$, *then the variance of (log) consumption satisfies*

$$Var(\hat{c}_t) = Var(\hat{y}_t) + Var(\hat{x}_t) + 2Cov(\hat{y}_t, \hat{x}_t) \tag{1.5}$$

where $Cov(\hat{y}_t, \hat{x}_t) = \sum_{k=1}^{t} \alpha^k 0.5^2 (2p-1)^k (\hat{x}_L - \hat{x}_R)^2$.

Proof 1.4.2. *See Appendix B.2*

This proposition illustrates the consumption volatility puzzle that arises under the lens of a traditional neoclassical framework. Because political shocks are abstracted from, $Var(\hat{x}_t) = Cov(\hat{y}_t, \hat{x}_t) = 0$, so consumption is predicted to be as volatile as output. When the model is augmented to include volatility in political ideology then $Var(\hat{c}_t) > Var(\hat{y}_t)$ as the covariance between political and economic shocks is positive (as long as $p > 0.5$, which is the empirically relevant domain for the probability of re-election). Also the larger the degree of polarization the bigger the second and third terms in equation (1.5).

An obvious question is whether the model can generate $Var(\hat{c}_t) < Var(\hat{y}_t)$ under some specification. A partial answer can be found in panels B and D of Figure 1.4, where I depict the impulse responses of the model under less than full depreciation, setting $\delta = 0.1$. While consumption still increases more than output when there is a switch from L to R, its response to TFP shocks is much smaller; a one percent change in output results in less than a one percent increase in consumption. It is then reasonable to expect that depending on the relative strength of these two shocks, I could observe economies where $Var(\hat{c}_t) \lesseqgtr Var(\hat{y}_t)$. Whether the predictions of the model are consistent with the stylized facts observed in the data is then a quantitative question. I address this by analyzing a more general environment where some of the restrictive assumptions of this section are relaxed.

Notice also from Figure 1.4 that the relative volatility of consumption will be decreasing as aggregate volatility due to the TFP process increases. If emerging economies simply had more volatile TFP processes while holding the political process constant; the effects of Panel D would dominate the effects of Panel B, leading to *less* volatile consumption relative to income. It is not enough in a standard RBC model to simply alter the productivity process, more volatility due to politics is required to generate higher $\sigma(c)/\sigma(y)$.

1.5 Quantitative Analysis

In this section I calibrate the benchmark model and test whether its quantitative implications are in line with stylized facts from the US economy. I then analyze how some key moments change as I modify the degree of political polarization using the empirical measure of this variable. In particular, my aim is to quantify how much of the difference in the relative volatility of consumption to output can be explained by the mechanisms outlined in previous sections. The numerical procedure used to solve the model involves finding a fixed point in equilibrium policy rules. Details of this approach are described Appendix C. Computation is non-trivial because it is necessary to guess four functions: the savings rules for individuals under a left and right government $\mathcal{H}_L(z,k)$ and $\mathcal{H}_R(z,k)$, and the spending rules of each party $\mathcal{G}_L(z,k)$ and $\mathcal{G}_R(z,k)$. In addition, I need to solve for the savings function under a one period deviation $H(z,k,g)$.

1.5.1 Calibration

Because I am building on the neoclassical framework many of the parameters are standard. A time period represents a year, so the discount factor is $\beta = 0.95$. The share of capital α is set to 0.36 and depreciation rate δ is 0.1. Preferences are logarithmic.

There are 6 parameters that still need to be determined. One of them sets adjustment costs, ϕ. Two of them, ρ and vol(ϵ), govern the behavior of TFP shocks. The remaining three, p, ξ, and $\bar{\lambda}$, set the behavior of political shocks. They are selected in order to match 6 empirical moments, which are computed using data for the US over the sample period 1960-2003. The model implied moments are obtained by simulating the political equilibrium for 11000 periods where the first 1000 are discarded to eliminate the effects of initial conditions. Table 1.2 summarizes the values of the parameters obtained from the calibration along with the target moments.

Table 1.2: Calibrated parameters

U.S.		
parameter	parameter value	target
ρ	0.92	corr(y_t, y_{t-1})= 0.53
vol(ϵ)	1.86e-2	vol(y)=1.98e-2
ϕ	0.57	vol(I)=6.65e-2
p	0.9	ave. pol. tenure =10 yrs.
ξ	1.38e-2	vol(g)= 2.47e-2
$\bar{\lambda}$	0.37	mean(g/y)=0.24

Note: Cyclical moments computed by HP-filtering ($w = 100$) the natural logs variables over the sample 1960-2003. I and y are obtained Kaminsky, Reinhart and Vegh (2004), g is consolidated government expenditures net of transfers, from NIPA Table 3.1 Government Current Receipts and Expenditures.

Productivity, specified as $z' = \rho z + \epsilon'$, is discretized using a two-state

Markov process with values chosen such that ρ delivers an output autocorrelation of 0.53 and the volatility of ϵ implies an output volatility of 1.98%. Adjustment costs ϕ are chosen so that model generated investment volatility is equal to the value observed in the US of 6.67%. The probability of re-election p generates an average tenure in power of 10 years, in line with political turnover in the US. The mean value of λ_i is chosen to match the average ratio of public spending to output, while ξ is set so that the volatility of g obtained from the model is equal to the one observed in the US for the same time period, 2.47%.

Table 1.3 reports the fit of the model for a broader set of business cycle moments (those marked with asterisks are matched as part of the calibration strategy). The first thing to note is that the introduction of political frictions to an otherwise standard neoclassical framework does not undermine the fit of the model to primary economic variables. For example, the cyclical behavior of consumption and investment is remarkably close to its empirical counterpart, as seen by comparing the predicted measures of $\rho(y, c)$ and $\rho(y, I)$ to the US values. Moreover, the correlation between private consumption and investment is also close to the data. Even though it was not a target of the calibration the relative volatility of consumption to output $\sigma(c)/\sigma(y)$, the main variable of interest, is in line with the observed value for the US over the sample. The model under-predicts the level of persistence in government expenditures, as well as its cyclicality. This is due to the fact that public spending is more responsive to political swings than to TFP shocks in the model.

Given the success of the model in matching business cycle moments

Table 1.3: U.S. Data and model fit

Moment	Data	Model
$\sigma(y)$	1.98e-2	1.98e-2*
$\sigma(c)/\sigma(y)$	0.83	0.96
$\sigma(I)/\sigma(y)$	3.35	3.35*
$\sigma(g)/\sigma(y)$	1.25	1.25*
$\rho(y)$	0.53	0.53*
$\rho(g)$	0.65	0.48
$\rho(y,c)$	0.92	0.98
$\rho(y,I)$	0.88	0.85
$\rho(y,g)$	0.31	0.06
$\rho(c,I)$	0.71	0.88

* calibrated moments.

for key economic as well as and political variables, I can now move towards computing the relative volatility of consumption and public spending for the cross-section of countries in the sample.

1.5.2 Political business cycles

In this section I analyze the effects of political polarization on the cyclical components of consumption c, investment I, output y, and public spending g. In the first exercise I abstract from other forms of heterogeneity across countries. I then allow different income processes for emerging and developed countries. Finally I allow stability p to vary across countries, calibrating it to a political stability dataset.

1.5.2.1 Heterogeneity in polarization

In order to isolate political factors from productivity differences across countries, which have been studied at length in previous literature, I fix all parameters to the calibrated levels of the benchmark economy except for one: polarization. Therefore the main experiment consists of allowing ξ_j to vary across countries. Recall that a type R agent living in country j has preferences that satisfy

$$(1-\lambda_{Rj})u(c)+\lambda_{Rj}v(g), \text{ with } \lambda_{Rj}=\bar{\lambda}-\xi_j.$$

Changes in ξ_j across countries imply differences in their degree of polarization. The mapping between the empirical measure of polarization and ξ_j is inferred from two points: ξ_{US} and ξ_{Mex}, each chosen to match the implied relative volatility of public spending $\sigma(g)/\sigma(y)$ with its data counterpart for the US and Mexico[7].

These two countries were chosen as representative for developed and emerging economies. I then impute ξ_j from the following linear relationship

$$\xi_j=\xi_{US}+\frac{P_j-P_{US}}{P_{Mex}-P_{US}}(\xi_{Mex}-\xi_{US}),$$

where P_j denotes country j's value of polarization from the Lindqvist and Östling (2007) dataset. After inferring ξ_j, I re-compute and simulate the

[7]Data on g for Mexico is obtained from the Mexican Central Bank, Table 'Gastos Presupuestales del Sector Publico'. I construct g to be consistent with the US measure by subtracting Transfers from Total Expenditures for the consolidated government. The sample period is also 1960-2003. To compute the volatility I take the logarithm of g and HP filter it with $w=100$.

political equilibrium for each country in the sample (see Table A.1 in Appendix A for a list of countries included). The relative volatility of consumption to output for different polarization values implied by the model can be contrasted to the actual data in Figure 1.5.

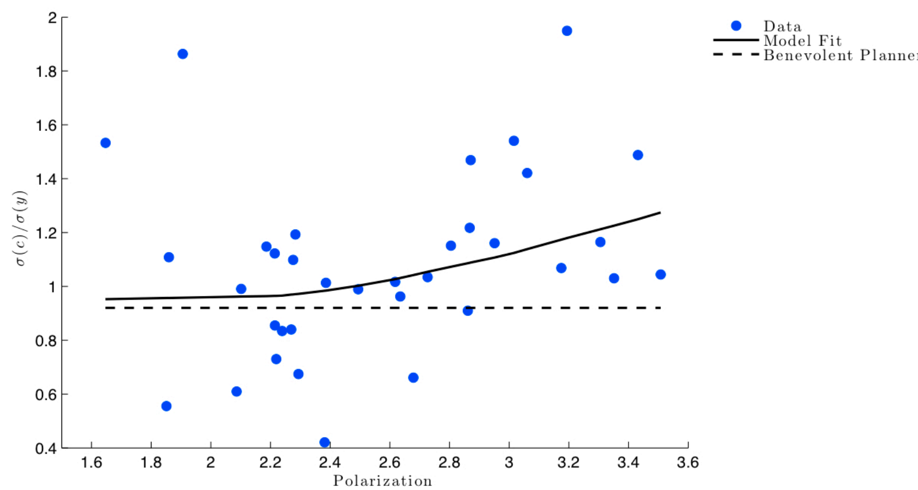

Figure 1.5: Relative volatility of consumption and polarization.

Other than for Norway and Pakistan, the model resembles the bulk of the observations. I can quantify the fit as follows

$$F = 1 - \sum_{j=1}^{35} \frac{\left[\sigma(c_j)/\sigma(y_j) - \hat{\sigma}(c_j)/\hat{\sigma}(y_j)\right]^2}{\left[\sigma(c_j)/\sigma(y_j) - \overline{\sigma(c)/\sigma(y)}\right]^2}$$

where $\hat{\sigma}$ denotes volatility predicted by the model and j the country observation. When all the countries in the sample are included, $F = 0.13$. If the two outliers (Norway and Pakistan) are excluded, F increases to 0.25. I take this as evidence that this theory complements existing ones in the literature, since the model is able to explain up to 25% of the variability in relative consumption volatilities across countries.

The dotted line in Figure 1.5 is the value of the relative volatility of consumption that would be obtained in an environment that abstracts from political shocks. Because I am assuming all parameters but ξ_j to be identical, the line is flat. Moreover, $\sigma(c)/\sigma(y)$ is smaller than one, as observed in developed economies but at odds with emerging economies' values. The intuition—closely linked to the one developed in Section 1.4.2—can be understood by comparing the responses of consumption and output to political versus TFP shocks, depicted in Figure 1.6. In both cases the shocks last for 10 periods, the average tenure in power of a political party. Consumption responds slightly less than output to a TFP shock, as shown in the right panel. The volatilities for y and c are thus almost identical in the simulated model.

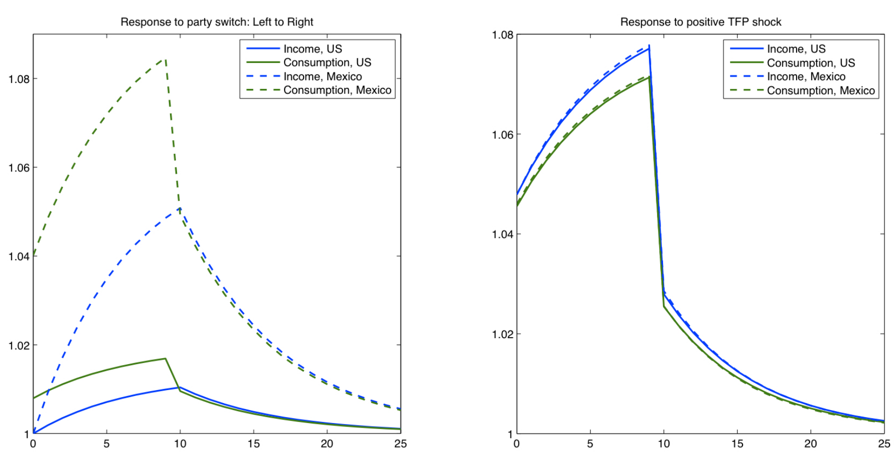

Figure 1.6: Response to a 10-period political and TFP shocks.

The left panel of of Figure 1.6 also makes clear why $\sigma(c)/\sigma(y)$ is bigger in emerging economies. The response of consumption is not only larger than that of output when there is a switch in political ideology, but the difference between them is wider in countries with bigger ξ_j. Because the degree of polarization is larger in emerging economies, policy swings resulting from changes in government type are more pronounced. This creates higher relative consumption volatility than the one observed in less polarized societies.

A summary of the average value of business cycle moments for developed and for emerging economies is contained in Table 1.4. The model does a good job predicting the average moments in developed countries. The average relative volatility of consumption for these economies predicted by this model ($\sigma(c)/\sigma(y) = 0.97$) is even closer to the empirical measure than the one reported in Table 1.3. Recall that I calibrated the model to the US economy and only varied polarization across countries.

Consistent with the data, the model predicts a significantly larger value for $\sigma(c)/\sigma(y)$ in emerging economies (1.11 versus 0.97 in developed ones). This excess volatility is consistent with the optimal behavior of consumers that react to government policy. In contrast to previous work, I do not need to make additional assumptions regarding differences in the nature of the underlying income process to generate this fact.

Table 1.4: Business cycle models: data and model fit

	Developed Economies		*Emerging Economies*	
Moment	Data	Model	Data	Model
$\sigma(y)$	2.37e-2	2.00e-2	4.28e-2	2.08e-2
$\sigma(c)/\sigma(y)$	0.96	0.97	1.23	1.11
$\sigma(I)/\sigma(y)$	3.79	3.56	3.85	4.87
$\sigma(g_c)/\sigma(y)$	1.41	1.53	3.03	2.74
$\rho(y)$	0.61	0.54	0.56	0.56
$\rho(g_c)$	0.60	0.44	0.38	0.41
$\rho(y, c)$	0.80	0.97	0.71	0.86
$\rho(y, I)$	0.85	0.82	0.62	0.49
$\rho(y, g_c)$	0.24	0.06	0.22	0.07

1.5.2.2 Heterogeneity in the TFP process

Table 1.4 reveals that the model under-predicts the volatility of output for emerging economies and over-predicts their variability of investment. The reason is that the volatility of output is twice the value in developed countries and the process is less persistent. Here I re-calibrate the income process for Mexico, which I take as a representative emerging economy, and then re-compute moments for all other countries by only changing their degree of polarization. The fit for the Mexican economy can be found in the second column of Table 1.5, while the resulting average business cycle moments moments for emerging countries is shown in the last column.

Re-calibrating the TFP shocks and persistence to match Mexico's income process improves the fit of the model regarding the volatility of output (see second column of Table 1.5) but hardly changes investment volatility (which is probably more related to adjustment costs being different in emerging versus developed economies).

Table 1.5: Re-calibrating the TFP process

	Mexico		Emerging Economies	
Moment	Data	Model2	Data	Model2
$\sigma(y)$	3.57e-2*	3.57e-2*	4.28e-2	3.52e-2
$\sigma(c)/\sigma(y)$	1.16	1.12	1.23	1.08
$\sigma(I)/\sigma(y)$	2.80	5.49	3.85	4.56
$\sigma(g_c)/\sigma(y)$	2.82		3.03	2.97
$\sigma(g)/\sigma(y)$	3.35*	3.35*		
$\rho(y)$	0.62*	0.55*	0.56	0.55
$\rho(g_c)$	0.40		0.38	0.40
$\rho(g)$	0.71	0.26		
$\rho(y,c)$	0.81	0.81	0.71	0.83
$\rho(y,I)$	0.76	0.49	0.62	0.48
$\rho(y,g_c)$	0.27	0.09	0.22	0.09

* calibrated moments.

The average relative volatility of consumption for emerging economies is 1.08, slightly lower to the value 1.11 obtained in the benchmark model, while the other moments remain basically unchanged.

1.5.2.3 Heterogeneity in political turnover

In this section I use data on government stability to construct a series of the probability of re-election for each country p_j, allowing for heterogeneity in political turnover in addition to polarization and productivity differences. The data for political stability comes from values assigned by the Political Risk Services Group's (PRS) International Country Risk Guide. The dataset is described in Appendix A, while the values for government stability are reported in the last column of Table A.2 in the Appendix. The re-election probability p_j is constructed by fixing the U.S. probability at $p_{US} = 0.9$ and adjusting the value for each country based on its stability relative to the U.S.,

$$p_j = \frac{\text{Stability}_j}{\text{Stability}_{US}} p_{US}.$$

In this model emerging countries are assumed to have a TFP process and polarization calibrated in the same manner as Model 2 with the addition of a different benchmark re-election probability. Developed countries have the TFP and polarization values of Model 1.

The results are summarized in Table 1.6, where Model 3 refers to the averages of values predicted by the model. In general the fit improves for most of the business cycle moments, in particular the cyclicality of public spending is much closer to the data for both emerging and developed economies. This results from lower re-election probabilities: while developed countries tend to have more stable governments ($\text{mean}(p_{Developed}) = 0.85$ and $\text{mean}(p_{Emerging}) = 0.75$), both are less stable than the U.S. benchmark.

More frequent turnover increases the importance of political shocks in determining aggregate volatility, which in turn increases both the relative volatility of consumption and government expenditure. Countries with lower stability should exhibit higher relative consumption volatility. This effect is tempered however for emerging economies by the calibration strategy: calibrating to a lower p increases the volatility of public expenditure so Model 3

Table 1.6: Re-calibrating the political turnover

	Developed Economies		*Emerging Economies*	
Moment	Data	Model3	Data	Model3
$\sigma(y)$	2.37e-2	2.00e-2	4.28e-2	3.55e-2
$\sigma(c)/\sigma(y)$	0.96	0.97	1.23	1.06
$\sigma(I)/\sigma(y)$	3.79	3.71	3.85	4.66
$\sigma(g_c)/\sigma(y)$	1.41	1.67	3.03	2.48
$\rho(y)$	0.61	0.51	0.56	0.49
$\rho(g_c)$	0.60	0.36	0.38	0.22
$\rho(y,c)$	0.80	0.91	0.71	0.87
$\rho(y,I)$	0.85	0.78	0.62	0.62
$\rho(y,g_c)$	0.24	0.12	0.22	0.24

has lower levels of ξ for emerging economies. The cyclicality of public spending increases to levels more in line with data observation in Model 3, however this is due largely to the filtering methodology. As p decreases the effects of political shocks come closer to standard annual business-cycle frequencies isolated by the filter.

Quantitatively the effect of including stability in the analysis is small. Graphically, this can be seen in Figure 1.7. Developed countries do not exhibit high enough levels of heterogeneity in government stability to make much of a difference. For emerging economies however there is a positive correlation between government stability and observed relative consumption volatility, which is also suggested by the model. This offers only a small improvement in fit however. The values for model fit remain essentially unchanged at $F = 0.14$ for all countries and $F = 0.27$ when removing the two outliers.

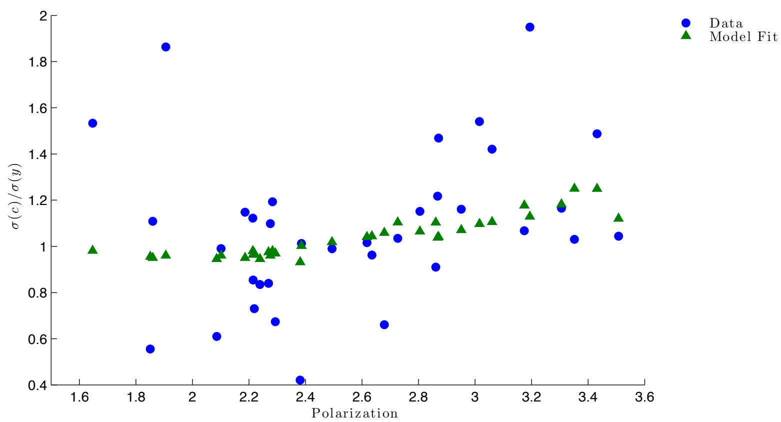

Figure 1.7: Relative volatility of consumption, polarization, and political turnover.

1.5.3 Inefficiencies

In this section, I analyze the welfare costs associated with the political process. To do this, I compute the fraction of private consumption agents would collectively forego to replace the political system with a benevolent planner who puts equal weight on each type. Its objective is given by

$$0.5[(1-\lambda_L)u(c)+\lambda_L v(g)]+0.5[(1-\lambda_R)u(c)+\lambda_R v(g)] \equiv (1-\bar{\lambda})u(c)+\bar{\lambda}v(g).$$

I assume that the planner is subject to the same frictions as any incumbent party: (i) lack of commitment, (ii) distortionary taxation, and (iii) incomplete markets to face productivity shocks. The main difference is that the planner does not suffer from political instability. The objective is thus to isolate the effects of political shocks on welfare from those implied by the other three frictions.

Define the functions $\mathcal{C}^{\text{Pol}}$, $\mathcal{G}^{\text{Pol}}$ as equilibrium consumption and government expenditure with politics for a fixed level of polarization and $\mathcal{C}^{\text{BP}}$, $\mathcal{G}^{\text{BP}}$ as the equilibrium policies for a benevolent planner. The cost η is implicitly defined by

$$\mathbb{E}_{s_t} \sum_{t=0}^{\infty} \beta^t [(1-\bar{\lambda}) u((1+\eta)\mathcal{C}(s_t)^{\text{Pol}}) + \bar{\lambda} v(\mathcal{G}(s_t)^{\text{Pol}})] =$$
$$\mathbb{E}_{s_t} \sum_{t=0}^{\infty} \beta^t [(1-\bar{\lambda}) u(\mathcal{C}(s_t)^{\text{BP}}) + \bar{\lambda} v(\mathcal{G}(s_t)^{\text{BP}})].$$

where s_t is the state triplet (i, z, k) that evolves according to equilibrium policy $\mathcal{H}$ and the transition processes for parties and productivity. The distribution of s_0 is the invariant distribution of capital, party in power and productivity given equilibrium policy[8].

The first line in Figure 1.8 represents the baseline scenario of fixing all parameters to the U.S. benchmark and adjusting polarization. Welfare costs are increasing in polarization because consumption volatility induced by political turnover is larger as polarization rises. For the second line the model is calibrated to the emerging economies income and political process, which has more volatile productivity and a lower re-election probability. Costs are lower as reducing polarization has less of an effect in reducing consumption

[8] I run 1000 simulations of the political equilibrium for 6000 periods each. Then, I compute discounted utility of each agent after dropping the first 5000 periods in order to eliminate the effect of initial conditions. This approximates the expected value function of agent type i in country j. I then add the expected values for L and R in order to obtain aggregate welfare in the political equilibrium. I perform the same exercise assuming that policy is determined by a benevolent planner then add an increasing fraction of private consumption to the model with politics until the agent is indifferent between the two. The figure shows the welfare cost in consumption for different values of polarization.

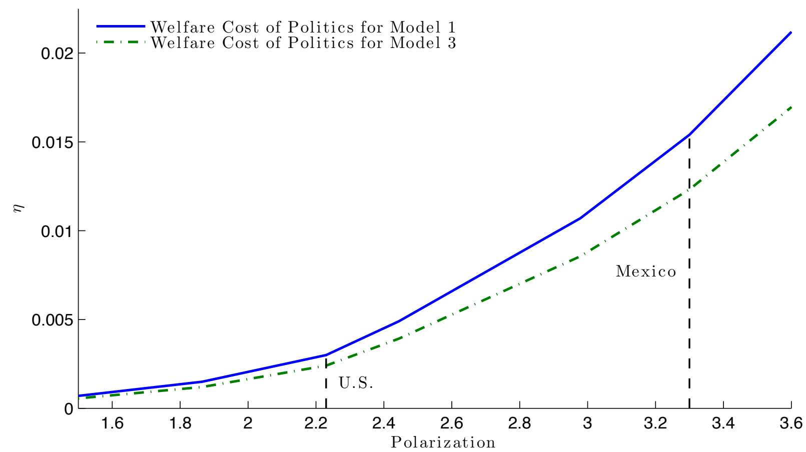

Figure 1.8: Welfare gains as a function of polarization.

volatility. For the U.S. case the representative individual would be willing to sacrifice no more than 0.3% of their consumption to remove politics, while for Mexico the fraction is much higher at 1.23% at the emerging economy benchmark.

1.6 Conclusion and extensions

I presented a model where political parties that disagree on the size of the government alternate in power. This introduces an additional source of volatility for economic variables, triggered by changes in government policy which can be interpreted as political shocks. I showed that a standard RBC model where only transitory productivity shocks are present cannot explain the consumption volatility puzzle. However, when political shocks in the form of ideological switches are incorporated (in addition to TFP shocks) the relative volatility of consumption gets closer to what is observed in the data. I simulated the model and found that political polarization explains up to 27% of the variation in the relative volatility of consumption across countries. This theory thus complements existing explanations for the puzzle found in the literature.

There are three interesting extensions to the model that are beyond the scope of this chapter, but will complement the analysis. The first one is introducing a distinction between different types of public expenditures. By adding transfers in addition to government consumption it would be possible to generate the mild counter-cyclicality of expenditures observed in many developed countries. The second extension would consider the effect of political shocks in small open economies. On the one hand, the access to international capital markets may dampen the effects of political shocks. On the other hand however this could result in government policy that responds even more to ideology switches. The final effect on the relative volatility of consumption is thus unclear. The final extension would analyze the political equilibrium where the government is not subject to a balanced budget. This would allow parties to smooth productivity shocks, which could reduce swings in taxes relative to the benchmark model. But it would also introduce a new channel for manipulation which can affect the cyclicality of deficits in non-trivial ways.

Chapter 2

Optimal tax smoothing over the business cycle

2.1 Introduction

Of fundamental importance to the macroeconomic literature over the past several decades is analyzing how individual agents and whole economies respond to business cycles. Real business cycle theory has developed focusing on cyclical innovations to productivity and individual and aggregate responses to the variations in output that occur as a result of these innovations. A natural extension of this line of research on business cycles is to analyze how fiscal policy-makers react to these real shocks to productivity. Another suggestion for the source of fluctuations in economic variables comes from partisan business cycle theory (due originally to Hibbs 1977, 1986). It posits the changing identity of the policy-maker as a possible source of these fluctuations. This chapter combines these two theories of the source of business cycles in a quantitative analysis to develop predictions for the behavior of fiscal variables to compare to historical experience in the U.S. I answer two primary questions: (1) What is optimal fiscal policy over the business cycle? (2) How do these predictions compare to the data?

This is accomplished by extending the standard literature on tax smoothing. Starting with framework of Lucas and Stokey (1983) I add business cycles and remove the complete markets and commitment assumptions. I also add valued government expenditure to endogenize fiscal policy. The predictions of my model for real shocks are somewhat surprising at first pass. In contrast to historical observation for developed countries I find that real shocks to productivity in a standard model generate a fiscal policy that is pro-cyclical. The logic however follows exactly from the tax smoothing literature with a slight twist. As consumption and government expenditure are both normal goods an increase in income incentivizes the policy-maker to increase both. An increase in expenditure must be financed with either taxes or debt. To reduce the deadweight loss associated with taxation he uses both. The reverse holds for a decrease in income. Thus debt, taxes and government expenditure are positively correlated with output. They key difference between this prediction and the existing literature on fiscal policy response to real shocks is that the economy is closed: government debt represents agent assets; a reduction in debt represents an increase in resources available to the agent.

Recent positive theories of fiscal policy responses to real business cycles suggest an opposite result closer to data findings. Two examples illustrate the primary incentives at work in this literature. Barseghyan, Battaglini and Coate (2010) introduce real business cycles to the political model of Battaglini and Coate (2008). In their model utility is linear, so agents could completely smooth consumption. Without a period by period asset market clearing condition (an open economy) they are able to. The job of the government then is to smooth taxes subject to an increase in debt decreasing future government resources. Similarly Ilzetzki (2010) has governments but not agents able to access international financial markets. Since public and private consumption are substitutes the government responds to a negative shock to consumption by borrowing to finance extra public consumption, again without the cost of reducing agent resources. In both of these models government debt acts as insurance against negative outcomes; borrowing reduces taxes without reducing private consumption. This is not possible a closed economy. Agents in these models cannot respond to changes in debt: their decisions are by design strictly static labor supply responses to tax rates. I introduce a closed economy with agents whose labor supply and consumption choices react to both taxes and debt policy. This moves closer to the optimal tax smoothing literature by assuming all debt is internal, there is no borrowing from abroad.

The model reacts similarly to changes in government expenditure. These are modeled not as exogenous expenditure shocks but as endogenous outcomes of a political process of two parties with different preferences over government expenditure alternating in power. A policy maker with a higher preference for expenditure will finance a higher provision with both an increase in taxes and debt. These higher taxes are not associated with ex ante shocks to income. Taxes, debt, and expenditure can be counter-cyclical as with endogenous labor output can go down as a result of increased taxes.

These results contribute to the literature on tax smoothing by adding business cycle uncertainty. This literature begins with Barro (1979), who suggests that debt should be used to smooth deadweight losses due to distortionary taxation over time: taxes should be smother than expenditures. Lucas and Stokey (1983) provide micro-foundations for this suggestion in a complete markets framework with commitment. Aiyagari et al (2002) extend this result to incomplete markets. They generate reasonable dynamics with exogenous bounds on debt. The need for tax smoothing in these models however comes from exogenous shocks to government expenditure and not business cycles. For much of historical (pre-1970s) record debt was increased only in times of war and decreased thereafter, making exogenous expenditure shocks (war and peace) a reasonable assumption to generate observed debt dynamics[1].

Business cycle uncertainty is adopted from the standard real business cycle literature as well as an existing literature on political frictions. Starting with Battaglini and Coate (2008) this literature examines the effect of political uncertainty, however without real shocks[2]. Partisan business cycles are analyzed by Alesina and Roubini (1997), who provide a review of the theory and evidence on how alternation in power of parties with heterogeneous preferences can cause cycles in economic (particularly fiscal policy) outcomes. For the behavior of fiscal variables they promote and test a theory that left-wing governments prefer taxation while right-wing governments prefer deficit

[1] Chari, Christiano and Kehoe (1994) extend Lucas and Stokey (1983) to include capital and business cycles, however government expenditure still has exogenous innovations and markets are complete; it is not clear how to interpret the cyclicality of debt in their model.

[2] This includes work in a similar strain by Acemoglu, Golosov and Tsyvinski (2008), Azzimonti (2010), Hassler et al (2003), Hassler at al (2005), Krusell and Rios-Rull (1999), Song, Zilliboti and Storeletten (2010), Yared (2010), and Debortoli and Nunes (2010).

spending. They find weak support for this in postwar U.S. data.

This chapter synthesizes tax smoothing, real shocks and political shocks by building on the literature of time-consistent planners setting optimal policy in a Markov-perfect equilibrium. The current planner has an incentive to manipulate the interest rate to increase the price at which bonds are sold. Unable to commit to future consumption, the planner can only manipulate future state-dependent equilibrium policy by altering the state. In a deterministic setting Krusell, Martin and Rios-Rull (2006) attempt to solve a time consistent version of Lucas and Stokey (1983) with limited success, finding a multiplicity of discontinuous steady states. Debortoli and Nunes (2010) find a continuous solution for the time consistent planner in the same environment by adding endogenous government expenditure. Martin (2006) and Diaz-Gimenez et al. (2006) examine time-consistent monetary economies with discretion where the cash-in-advance constraint is key to determine the level of debt. They find that the steady-state level of debt can be positive, negative or zero depending on the parametrization of the utility function. As with their findings the model here is somewhat sensitive to the specification of utility. Klein, Krusell and Rios-Rull (2008) and Azzimonti (2010) have a time-consistent planner endogenously choosing expenditure in deterministic models with capital. I extend this literature by introducing business cycle fluctuations. This is also done in Azzimonti and Talbert (2011), although in a model with capital instead of debt.

Due to fluctuations in the state I require global solutions for the equilibrium policy rules. This methodological contribution is adapted from recent developments by Azzimonti and Talbert (2011), who classify global solutions to stochastic Markov-perfect equilibria. I apply their equilibrium concept and extend the tools they develop to the Lucas and Stokey (1983) framework.

The empirical findings on the business cycle properties of fiscal policy offer some support for both pro- and counter-cyclicality. Gavin and Perotti (1997) and Kaminsky, Reinhart and Végh (2004) find that for emerging markets fiscal policy is almost universally pro-cyclical; governments spend, borrow, and tax more during good times. Observations from developed (primarily OECD) economies present the opposite, with counter-cyclical policies. Based on these conflicting findings an extensive literature attempts to reconcile the difference using financial and political frictions[3]. While this chapter presents a model consistent with both predictions for my purposes I do not address the issue of cross country variation in cyclicality[4].

The chapter proceeds as follows. A description of the model and equilibrium concept is followed by an illustration of the basic incentives in a two-period economy. The incentives present in the fully dynamic model are discussed before proceeding to the quantitative analysis. The quantitative anal-

[3]For recent literature on financial frictions see for example Alesina, Campante and Tabellini (2008) and Cuadra, Sanchez and Sapriza (2009); for political frictions see Talvi and Végh (2005) and Ilzetzki (2010).

[4]The literature using political frictions associates a higher degree of political inefficiency with more pro-cyclical policies. The model presented here actually generates the opposite, with a higher degree of political disagreement leading to policies which are more counter-cyclical for reasons discussed below.

ysis consists of a horse-race between three specifications of the general model: only real shocks, only political shocks, and a combination of the two. I find that the model with a combination of the two types of shocks comes closest to matching observed moments of U.S. data.

2.2 The model

In this section I propose the simplest possible model that includes all of the necessary frictions: distortionary taxation and stochastic productivity with incomplete markets. I then add the additional friction of governments with heterogeneous preferences alternating in power. To do this I build from the model of Lucas and Stokey (1983), embedding real shocks to output and Persson and Svensson's (1989) political economy model of public-goods provision into this fully dynamic framework.

2.2.1 Economic environment

Labor (l) is the only factor of production and technology is linear. The aggregate resource constraint is then

$$c + g = y, \quad y = zl.$$

In this closed economy output is split between private consumption (c) and government expenditure (g). The good is non-storable. The variable z represents time varying labor productivity that evolves stochastically according to the AR(1) process[5]

$$z' = \mu + \rho z + \epsilon,$$

where ϵ is i.i.d. normal and $|\rho| < 1$. To develop intuition from here I discretize the evolution of z into a two state Markov process with a symmetric transition matrix,

$$z \in \{z_H, z_L\}, \quad \text{Prob}(z' = z_H | z = z_H) = \text{Prob}(z' = z_L | z = z_L) = \pi.$$

2.2.2 Agents

As in Persson and Svensson (1989) agents belong to types j differentiated by their preference for public versus private consumption λ_j. Political disagreement comes from the differences in agents' preferences. They maximize utility over private consumption, labor supply, and private bond holdings (b^A) with instantaneous utility

$$(1 - \lambda_j)u(c, 1 - l) + \lambda_j v(g)$$

subject to a budget constraint each period of

$$c + qb^A = (1 - \tau)zl + b^A_{-1}$$

where q is the one period discounted cost of risk free claims to next period's consumption, the only financial asset, and b^A_{-1} is the agent's asset holdings at the beginning of the period. As in Persson and Svensson (1989) I assume

[5]Importantly I do not restrict mean(z)= 1. This will be exploited in the calibration section as the mean debt level turns out to rely heavily on average productivity.

there are two types, $i \in \{L, R\}$ with $\lambda_L > \lambda_R$. Agents of the left-wing type (L) have a higher preference for public expenditure than right-wing agents (R). Agents live forever and discount future utility at rate $\beta < 1$. The optimality conditions of an agent of type j are

$$(1-\tau)zu_c(c_j, 1-l_j) = u_l(c_j, 1-l_j), \tag{2.1}$$

$$q = \frac{\beta \mathbb{E}[u_c(c_j', 1-l_j')]}{u_c(c_j, 1-l_j)}. \tag{2.2}$$

These are the competitive equilibrium conditions for the labor and asset markets respectively. Note that because agents cannot control public expenditure their decisions do not depend on type; all agents consume, work, and save identically. The two types behave as one representative agent. From here I drop the type subscripts from the competitive equilibrium/agent optimality conditions.

2.2.3 Political parties

Political parties represent agents of each type. A government consists of a single political party in power for one period that makes all policy decisions based on its own preferences and equilibrium continuation values and policy functions. The current government cannot make credible commitments about future policy, they can only effect the equilibrium policy in future periods through manipulation of the state (in this case inherited debt of the future government b). While they cannot commit to future policies I assume they are unable to default on current debt obligations.

Political parties alternate in power according to an electoral process, with symmetric re-election probability p. A re-election probability p greater than 0.5 implies an incumbency advantage.

The government uses the tools at its disposal (taxes, debt, and expenditure) to maximize welfare given the equilibrium conditions for agents, the current realization of productivity, and inherited debt obligations b^G_{-1}. The government's budget constraint is

$$g + b^G_{-1} = \tau z l + q b^G.$$

As the financial markets are also closed to trade agent assets must equal government liabilities. The asset market clearing condition is

$$b^A = b^G.$$

In each period the government pays off debt, sets and collects taxes, sets public expenditure and issues new debt at price q. Following Aiyagari et al (2002) I combine equilibrium labor and asset market conditions with the government budget constraint to eliminate the price of debt and taxes and give a single constraint for the current period for the government's problem:

$$g + b_{-1} = \frac{z u_c - u_l}{u_c} l + \frac{\beta \mathbb{E}_{z',i'}[u'_c]}{u_c} b. \tag{2.3}$$

Similarly goods market clearing allows the elimination of l from the government's problem

$$c + g = zl \;\Rightarrow\; l = z^{-1}(c+g).$$

I do not allow reputational mechanisms, instead focusing on Markov-perfect equilibria of the type discussed in Klein, Krusell and Rios-Rull (2008). "Markov-perfect" in this setting implies that decisions depend only on current state variables. This affords the convenience of not requiring time subscripts as the problem can be expressed as a stationary function of the equilibrium conditions. Equilibria cannot be history dependent except through the current realization of the state variables. As in Klein, Krusell and Rios-Rull (2008) the equilibrium can be thought of (and is numerically confirmed) as the limit of finite horizon equilibria. The equilibrium policy functions are assumed to be continuous and differentiable. In this case current government debt obligations b_{-1}, current productivity z, and party in power $i \in [\mathrm{L}, \mathrm{R}]$ are the payoff relevant state variables for the current period. To express the government's problem I first assume equilibrium policy functions

$$
\begin{aligned}
c &= \mathcal{C}(b_{-1}, z, i), \\
g &= \mathcal{G}(b_{-1}, z, i).
\end{aligned}
$$

These are the only two equilibrium objects, as demonstrated below.

For convenience I use these equations and goods market clearing to label

$$l = \mathcal{L}(b_{-1}, z, i) = z^{-1}(\mathcal{C}(b_{-1}, z, i) + \mathcal{G}(b_{-1}, z, i)).$$

Given the equilibrium policy functions the current government's implementability constraint, equation (2.3), can be expressed as a function of the equilibrium conditions, state, and choice variables

$$g + b_{-1} = \frac{z u_c(c, 1-l) - u_l(c, 1-l)}{u_c(c, 1-l)} l + \frac{\beta \mathbb{E}_{z',i'}[u_c(\mathcal{C}(b, z', i'), 1 - \mathcal{L}(b, z', i'))]}{u_c(c, 1-l)} b. \tag{2.4}$$

Here the expectation is taken over both the realization of z' and the successor's party i'. At an interior solution this equation solves for b given the state and equilibrium policy functions. Label

$$b = \mathcal{B}(b_{-1}, z, i)$$

the value of b that solves equation (2.4) in equilibrium. The final element is to define the equilibrium continuation values.

Given the equilibrium policy functions ($\mathcal{G}$, $\mathcal{C}$) and the ancillary policy functions they define ($\mathcal{L}$, $\mathcal{B}$) the continuation values are

$$\begin{aligned} V_i(b_{-1}, z) = (1-\lambda_i) u(\mathcal{C}(b_{-1}, z, i), 1 - \mathcal{L}(b_{-1}, z, i)) + \lambda_i v(\mathcal{G}(b_{-1}, z, i)) + \\ \mathbb{E}_{z'}[p V_i(\mathcal{B}(b_{-1}, z, i), z') + (1-p) W_i(\mathcal{B}(b_{-1}, z, i), z')], \end{aligned}$$

and

$$\begin{aligned} W_i(b_{-1}, z) = (1-\lambda_i) u(\mathcal{C}(b_{-1}, z, -i), 1 - \mathcal{L}(b_{-1}, z, -i)) + \lambda_i v(\mathcal{G}(b_{-1}, z, -i)) + \\ \mathbb{E}_{z'}[(1-p) V_i(\mathcal{B}(b_{-1}, z, -i), z') + p W_i(\mathcal{B}(b_{-1}, z, -i), z')]. \end{aligned}$$

These require some explanation. V_i is the value to party i of a government of party i enacting equilibrium policy. Similarly W_i is the value to party i of a government of party $-i$ (the opposing party) enacting its equilibrium policy. The expectation in these equations is strictly over the realization of the productivity shock; the expectation over party in power is removed here using the probability of the same party remaining in power next period p.

Using the equilibrium conditions the government's problem and single constraint can be stated as a function of $\mathcal{C}$, V_i, and W_i. A government in power of party i facing productivity z and current debt obligations b_{-1} solves the problem

$$\max_{c,g,b} \; (1-\lambda_i)[u(c, 1 - z^{-1}(c+g))] + \lambda_i v(g) + \beta \mathbb{E}_{z'|z}[pV_i(b, z') + (1-p)W_i(b, z')] \tag{2.5}$$

subject to equation (2.4), the single constraint for the current period.

As discussed above, equation (2.4) can be used to solve for b given the current state, the equilibrium policy $\mathcal{C}$, and the choice of c and g. This reduces the choice variables to c and g. The recursive problem of a government of party i facing productivity shock z is then to maximize (2.5) over the choice of c and g. Solving this problem for all realizations of the state implies off-equilibrium policy functions for c and g

$$c = \tilde{\mathcal{C}}(b_{-1}, z, i)$$
$$g = \tilde{\mathcal{G}}(b_{-1}, z, i).$$

A time-consistent equilibrium is a fixed point solution to the above system. This involves finding $\mathcal{C}$ and $\mathcal{G}$ such that

$$\begin{aligned}
\tilde{\mathcal{C}}(b_{-1}, z, i) &= \mathcal{C}(b_{-1}, z, i) \\
\tilde{\mathcal{G}}(b_{-1}, z, i) &= \mathcal{G}(b_{-1}, z, i) \quad \forall \; b_{-1}, z, i.
\end{aligned}$$

Definition 1. *A Markov-perfect equilibrium with stochastic productivity and political uncertainty is a set of policy functions* $\mathcal{C}$ *and* $\mathcal{G}$ *such that*

1. *Given government policy agents maximize utility.* $\mathcal{C}$, $l = z^{-1}(\mathcal{C} + \mathcal{G})$ *satisfy agent optimality conditions* (2.1) *and* (2.2)

2. *Given agent optimality the functions* $\mathcal{C}$ *and* $\mathcal{G}$ *solve the optimization problem of the government* (2.5).

Condition (1) is satisfied by the implementability constraint; condition (2) is satisfied by the fixed point in equilibrium functions. The numerical implementation consists of finding these fixed points.

2.2.4 Strategic manipulation

The current government's problem results in three first order conditions; with respect to c, g, and b. For convenience assume separability in the utility function for c and l, that is

$$u_{cl} = u_{lc} = 0.$$

The first two FOCs are strictly static. Let γ be the value of the Lagrange multiplier on the current government's implementability constraint. Then

$$\begin{aligned}(1-\lambda_i)(u_c - z^{-1}u_l) &= \gamma[u_c + u_{cc}(c - b_{-1}) + (c+g)u_{ll} - z^{-1}u_l], \quad (2.6)\\ \lambda_i v_g - (1-\lambda_i)z^{-1}u_l &= \gamma[(c+g)u_{ll} - z^{-1}u_l]. \quad (2.7)\end{aligned}$$

Provision of the public good distorts the consumption-labor and government expenditure-labor margins according to the value of the multiplier. I define these static distortions as wedges in equilibrium; for consumption, Δ_c, and government expenditure, Δ_g. They are then functions of the state

$$\begin{aligned}\Delta_c(b_{-1}, z, i) &= (1-\lambda_i)(u_c(\mathcal{C}) - z^{-1}u_l(1 - z^{-1}(\mathcal{C} + \mathcal{G})),\\ \Delta_g(b_{-1}, z, i) &= \lambda_i v_g(\mathcal{G}) - (1-\lambda_i)z^{-1}u_l(1 - z^{-1}(\mathcal{C} + \mathcal{G})).\end{aligned}$$

As long as taxes are positive there is some distortion ($\gamma \neq 0$). Government policy is aimed at reducing these (party dependent) wedges through the instruments at its disposal.

In contrast to the static optimality conditions for consumption and government expenditure the future level of debt b appears only in the implementability constraint in the current period. Recall there is no storage or trade for the good, debt is purely paper manipulation. The first order condition for b is

$$\gamma \mathbb{E}_{z',i'}[u_c(\mathcal{C}(b, z', i')) + u_{cc}(\mathcal{C}(b, z', i'))\mathcal{C}_b(b, z', i')b] = \mathbb{E}_{z'}[pV_{b,i} + (1-p)W_{b,i}]. \tag{2.8}$$

Define the left hand side of this first order condition as the intertemporal wedge Δ_b in equilibrium. It expresses the benefit of selling debt in that it increases resources available to the government (the u_c term) and the distortion due to the motivation to manipulate future consumption through debt policy (the term with u_{cc}). Combined these are the marginal benefit of selling debt. The current government wants to lower taxes by both selling debt and selling it at a more convenient price. The price manipulation is accomplished by using debt to lower future consumption through the equilibrium policy function.

The generalized Euler equation (GEE) can be expressed as a sum of the wedges. First notice that an envelope condition conveniently eliminates the unknown derivative V_b^i. If the party in power today is the party in power tomorrow, they share the same first order conditions, setting taxes and manipulating successive governments in the same way, and thus have the same wedges.

$$
\begin{aligned}
V_b^i(b_{-1}, z) &= \mathcal{C}_b(b_{-1}, z, i')[\Delta_c(b_{-1}, z, i) - \Delta_c(b_{-1}, z, i')] \\
&\quad + \mathcal{G}_b(b_{-1}, z, i')[\Delta_g(b_{-1}, z, i) - \Delta_g(b_{-1}, z, i')] \\
&\quad + \mathcal{B}_b(b_{-1}, z, i')[\Delta_b(b_{-1}, z, i) - \Delta_b(b_{-1}, z, i')]\beta \\
&\quad + \gamma u_c, \\
V_b^i(b_{-1}, z) &= \gamma u_c
\end{aligned}
$$

Variable i denotes the type of the government taking the derivative and i' is the type of the government making decisions. They are the same in the case of V_b^i. The derivative then simplifies to how inherited debt appears in the implementability constraint. The *future* cost of increasing debt when the party retains power is simply that it reduces the resources of the future government. There is still manipulation, but the government internalizes it as a *current* cost. The manipulation of future consumption only appears in the expression for the price of debt, behind the current multiplier γ. This result will be explored further in the section on the dynamics of the model.

When the opposing party controls government (as is the case for W^i) $i' = -i$; the government taking the derivative has different preferences and thus different optimality conditions and wedges than the government in power; there is no envelope condition.

$$
\begin{aligned}
W_b^i(b_{-1}, z) = \ & \mathcal{C}_b(b_{-1}, z, -i)[\Delta_c(b_{-1}, z, i) - \Delta_c(b_{-1}, z, -i)] \\
& + \mathcal{G}_b(b_{-1}, z, -i)[\Delta_g(b_{-1}, z, i) - \Delta_g(b_{-1}, z, -i)] \\
& + \mathcal{B}_b(b_{-1}, z, -i)[\Delta_b(b_{-1}, z, i) - \Delta_b(b_{-1}, z, -i)]\beta \\
& + \gamma u_c.
\end{aligned}
$$

Updating these derivatives and re-arranging terms, the GEE with political disagreement can be expressed as

$$
\begin{aligned}
& \Delta_b(b_{-1}, z, i) - \mathbb{E}_{z',i'}[\gamma' u_c'] = \\
& (1-p)\mathbb{E}_{z'}\{\mathcal{C}_b(b, z', -i)[\Delta_c(b, z', i) - \Delta_c(b, z', -i)] \\
& + \mathcal{G}_b(b, z', -i)[\Delta_g(b, z', i) - \Delta_g(b, z', -i)] \\
& + \mathcal{B}_b(b, z', -i)\beta[\Delta_b(b, z', i) - \Delta_b(b, z', -i)]\}.
\end{aligned} \tag{2.9}
$$

The interpretation of the GEE is as follows. The left hand side is simply the effect of debt policy on the budget constraint in a competitive equilibrium today and tomorrow. Notice in the current constraint bonds both reduce the tax burden and effect the price at which they are sold (the current effect of manipulation, this will be explored in the section on deterministic dynamics). This is the benefit of selling bonds, the intertemporal wedge Δ_b. It is balanced by the second term on the left hand side, the cost of increasing the debt obligations of tomorrow's government, who either must increase taxes or debt to finance the extra inherited debt. With no political disagreement (either $p = 1$ or preferences are identical) the entire right hand side disappears due to the envelope theorem. In the more interesting case of political disagreement the current government wants to manipulate all three of the choice variables of the future government if it is of the opposing party. Debt is set according to it's effect on each of the choice variables and the degree to which the optimality conditions differ between the current and opposing parties. The effect of manipulation on the dynamics of the model increases with the degree of heterogeneity in preferences.

2.3 A two-period economy

Before proceeding to the numerical analysis of the full blown model it is instructive to analyze the primary incentives driving the behavior of fiscal variables in a simple two-period economy. I show that debt is increasing in both z and λ due to changes in the cost and benefit of issuing debt resulting from a variation in these variables. I then consider the reaction of income to changes in z and λ to demonstrate the source of the positive correlation between debt and income for changes in z and the negative correlation for changes in λ that are present in the full model.

In this simple economy agents (and thus governments) are born with a preference for public consumption λ and a productivity value z, while in the second period preferences and productivity are fixed at λ' and z'. Mimicking the fully dynamic analysis I assume $\lambda' = \lambda$, the preferences of individuals and parties are the same over time. I additionally assume that productivity is perfectly persistent, that is $\text{Prob}(z' = z) = 1$. The agent optimizes over labor, leisure, and savings given productivity and preferences while the government optimizes over expenditure, taxes and debt subject to agent optimality.

The government only operates in the first period. In the second period it can only pay off inherited debt with taxes, there is no expenditure. This assumption eliminates political uncertainty, leaving a completely deterministic model.

The preferences of the agent over consumption and labor in the current and future periods and government expenditure in the current period are

$$(1 - \lambda)(c - 0.5l^2) + \lambda(g) + \beta[(1 - \lambda')(c' - 0.5l'^2)],$$

where primes denote second period variables. The agent works and is taxed in both periods and can save using the risk free bond b. Technology is the same as the full model. The agent's budget constraints are

$$\begin{aligned} c' =& (1 - \tau')z'l' + b, \\ c =& (1 - \tau)zl - qb. \end{aligned}$$

It follows easily from agent optimization that labor supply in both periods is simply a linear function of the tax rate and productivity,

$$l' = (1 - \tau')z', \quad l = (1 - \tau)z.$$

The asset market equilibrium condition with linear utility in consumption is simply

$$q = \beta.$$

This condition combined with asset market clearing implies that as long as the price of future consumption is set at the discount rate the agent will buy (sell) as much debt as the government sells (buys).

The government pays off debt in the second period while in the first period it sets expenditure and finances it with debt and taxes. The government budget constraints are

$$\tau' z' l' = b,$$

$$\tau z l + q b = g.$$

Starting in the last period, with no expenditure the tax rate is trivially solved by inserting agent optimization into the government's budget constraint and solving for τ' as a function of inherited debt and second period productivity[6],

$$\tau' = \frac{z'^2 - \sqrt{z'^2 - 4b}}{2z'^2}.$$

Define the continuation value of the second period as $V(b) = (1 - \lambda')(c' - 0.5 l'^2)$. Using the closed form expressions for labor supply and the tax rate the continuation value and its derivative V_b can be stated as a function of

[6] The second solution to the quadratic equation defining τ' is abstracted from as it is above the top of the Laffer curve, which occurs at $\tau = 1/2$ in this setting. If there is a solution (b is less than maximum revenue $\Rightarrow z'^2 - 4b > 0$) it is assumed to be at the lower tax rate.

productivity and inherited debt,

$$V(b) = (1-\lambda')\left(\left(\frac{z'^2+\sqrt{z'^2-4b}}{z'}\right)^2+b\right), \tag{2.10}$$

$$V_b(b) = -4(1-\lambda')\left(\frac{z'^2+\sqrt{z'^2-4b}}{z'^2\sqrt{z'^2-4b}}-\frac{1}{4}\right). \tag{2.11}$$

Moving to the first period I combine the two competitive equilibrium conditions (labor and asset) with preferences and the newly defined continuation value. This allows the government's problem to be stated as[7]

$$\max_{b,\tau}\ (1-\lambda)[0.5(1-\tau)^2z^2-\beta b]+\lambda[\tau(1-\tau)z^2+\beta b]+\beta V(b). \tag{2.12}$$

Lemma 2.3.1. *For the two period economy described above*

$$\frac{\delta b}{\delta \lambda} > 0, \quad \frac{\delta b}{\delta z} > 0.$$

Proof relegated to Appendix.

Lemma 1 states that as either productivity or preference for government expenditure go up the quantity of debt issued also increases. This can be easily seen in the optimality condition for the government with respect to debt issued, where the primes have been removed from to reflect the perfect persistence in λ and z,

$$-(1-\lambda)+\lambda-4(1-\lambda)\left(\frac{z^2+\sqrt{z^2-4b}}{z^2\sqrt{z^2-4b}}-\frac{1}{4}\right)=0.$$

[7] In contrast to the full model the government here is choosing the tax rate instead of consumption or expenditure. This is done for convenience without loss of generality.

In this simple economy with linear utility debt shifts resources directly from private consumption to government expenditure: the cost of a unit of debt in the current period is only that is reduces consumption by the equivalent amount to the increase in government expenditure, with marginal cost $-(1-\lambda)$ for consumption and marginal benefit (λ) for expenditure. The total current benefit of debt then is $(2\lambda-1)$. This is balanced by the fact that debt must be repaid using distortionary taxation, the V_b term, which from (2.11) is negative.

From (2.10) and (2.11) both the value and also cost of increasing debt is decreasing in λ. With increasing λ the marginal benefit of future consumption is decreased. The cost of leaving more debt to be paid off in the future is decreased as it is cheaper in utility terms to pay it back. The benefit from debt, $(2\lambda-1)$ is increasing in λ. Thus debt will increase in response to the change in incentives brought on by increasing λ (cost is reduced, benefit is increased).

The value for z however does not appear in the current benefit of debt. Without curvature in the utility of consumption there is no incentive to adjust consumption to manipulate the interest rate. The addition of no curvature in the utility of government expenditure removes current z from the debt decision entirely: a change in z does not change the marginal utility of either c or g (the price of adjusting debt), it only effects the labor supply decision. Productivity only effects the debt choice with linear utility through its persistence. An increase in z increases z', which in turn effects the cost of repaying debt. It turns out in this model the cost of repaying debt, V_b, is decreasing in z. As z

increases it becomes less costly to raise funds as the increase causes agents to work more. As they work more the tax rate required to finance a fixed level of repayment goes down. If for a given level of debt the utility cost of financing it goes down, debt will increase. This essential logic holds in the fully dynamic model with curvature.

This is tax smoothing only in that the burden of distortionary taxation appears to be shifted between periods. This is not tax smoothing as traditionally thought of, as tax and debt do not effect the cost of debt and taxes respectively. This economy abstracts from the interaction between debt and the current tax rate. The lack of curvature in utility implies b and τ do not interact but rather change c and g with independent incentives. A secular change in b does not effect the current tax rate decision and vice versa (this can be seen in the government optimality conditions in the Appendix). A traditional tax smoothing argument would be that the cost of altering the tax rate is decreasing in b: it is cheaper (in utility) to lower taxes as debt increases. The current cost of changing both debt and taxes here are constant due to linear utility. The argument being made is instead about the intertemporal incentives with regard to debt: the future repayment cost of raising debt today is decreasing in both z and λ, so debt is increasing in those two variables.

The final step in demonstrating how debt reacts to changes in income is to show the effect changes in z and λ have on income. Figure 2.1 shows the link. The top two panels show how debt responds to changes in z and λ, a visual representation of Lemma 1. The bottom two panels show how output

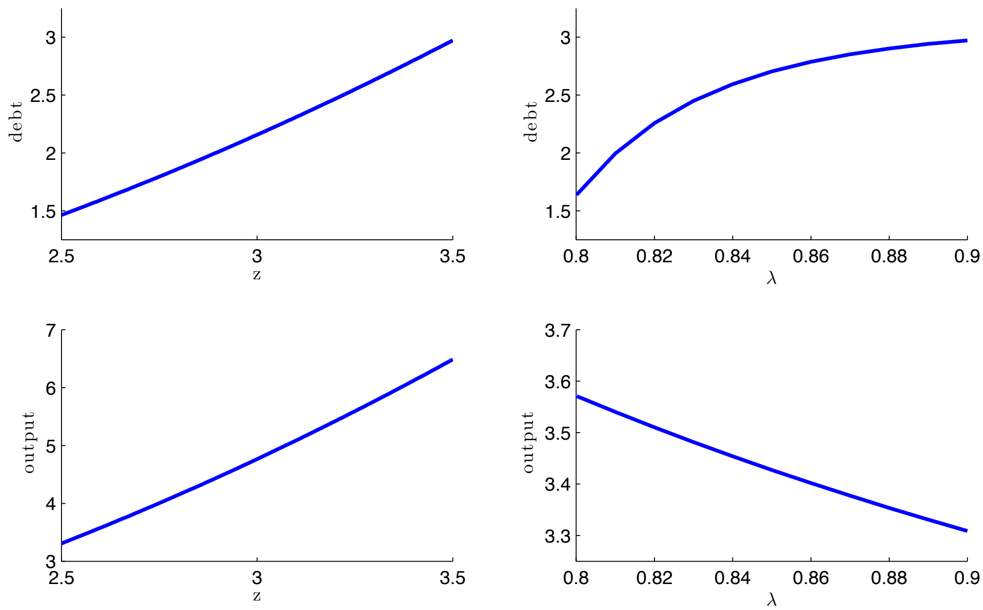

Figure 2.1: Debt and output in two-period economy

responds to the same changes, leading to Lemma 2.

Lemma 2.3.2. *For the two period economy described above, if $l > 0$ (output is positive) then*

$$\frac{\delta y}{\delta \lambda} < 0, \quad \frac{\delta y}{\delta z} > 0$$

where $y = c + g$. Proof relegated to Appendix.

Total output ($y = c + g = zl = z^2(1 - \tau)$) is decreasing in λ because the tax rate is increasing in λ. Again taxes and debt act on independent incentives (no interaction) so a higher preference for public expenditure leads to higher levels of both. Agents respond to a higher tax rate by decreasing labor supply, which reduces output.

The response of output to a change in productivity is trivially positive from the labor supply function and the fact that the tax rate is not changing in z. The tax rate does not respond to changes in z as it effects the marginal utility of consumption, labor, and government expenditure identically (it appears in all as z^2 and is thus cancelled out, this can be seen in equation (2.12)). With constant τ agents respond to an increase in z by increasing labor supply, thus increasing output.

Combining Lemmas (1) and (2) we have that

1. Income and debt will move together if the innovation to income is caused by a change in productivity.

2. Income and debt will move in opposite directions if the innovation to income is caused by a shift in preferences (political shock)[8].

These co-movements are the source of the cyclicality in the fully dynamic model. In the full model $\text{corr}(b, y) > 0$ for productivity shocks and $\text{corr}(b, y) < 0$ for political shocks.

To summarize an increase in z reduces the price of repaying debt while increasing the return on labor supplied, leading to an increase in debt and output. An increase in λ increases the current benefit of debt in addition to reducing the price of repaying it, increasing debt, however it also leads to an

[8]The same result holds for an exogenous shock to the provision of government expenditure, such as a war. In this way the model mirrors the result of Lucas and Stokey (1983)

increase in the tax rate to pay for the increased provision of public expenditure, leading to decreased output.

This simple model is highly stylized as it is difficult to find closed form solutions at any greater level of generality with agents and governments interacting. A number of incentives change as the model is expanded to be fully dynamic and is allowed more curvature in the specification for utility. First interest rate manipulation incentivizes the government to adjust debt to reduce consumption in the next period and thus reduce the price at which debt is sold. Second tax rates and debt do not interact here. With some curvature in the utility for consumption or government expenditure the amount of debt could appear in the current cost and benefit of adjusting the financing of government expenditure, which is constant with respect to debt in this setting. Debt may reduce the cost taxes, leading to a higher level of debt. The cost of adjusting taxes responds to the current state, so it is unclear in equilibrium how debt and taxes interact to increase government expenditure when there is either a positive productivity shock or a shift to a party that favors more expenditure and also how labor supply reacts to changes in debt and taxes. It turns out in all of my simulations that debt increases as expenditure increases and that output increases with productivity and decreases with shifts to the party with higher preference for expenditure.

These effects must be determined in equilibrium. They are discussed briefly in the following section on the dynamics of the full model.

2.4 Dynamics

As a novel contribution to the literature on optimal fiscal policy it is important to better understand the dynamics of the full model before moving to the quantitative analysis. This model is different in important ways from the seminal fully dynamic general equilibrium work on debt and deficits of Lucas and Stokey (1983) and Aiyagari et al (2002). In addition to dropping the assumption of commitment, uncertainty is included in a completely different manner. Instead of "war" and "peace" I have the "booms" and "recessions" of business cycles. In this model the entirety of government expenditure is endogenous; there is no war that requires mandatory excess expenditure. This amounts to a fundamental difference in what constitutes "good" and "bad" times. In Aiyagari et al (2002) "bad" times occur when government expenditure is high. In this model the opposite is true. When productivity is high ("good" periods) the government wants to increase both consumption and expenditure. Higher government expenditure is thus a sign of either a "good" time or a transition to a government with a higher preference for public consumption. This leads to a different interpretation of the results but maintains the tax-smoothing logic of Aiyagari et al (2002) and Lucas and Stokey (1983). The tax smoothing logic is simply that an increase in g is financed by both an increase in taxes and an increase in debt: debt reduces the deadweight losses due to distortionary taxation.

I discuss three limited versions of the model to analyze the incentives and dynamics of each layer. The deterministic version examines the issue of time-consistency in the incentive of today's government to manipulate the interest rate. Productivity shocks introduce the concept of optimal tax and expenditure responses over the real business cycle with incomplete markets. Finally political disagreement introduces extra volatility in expenditure and thus taxes and deficits due to alternating preferences in a partisan business cycle.

2.4.1 Deterministic

With no shocks the model reduces to exactly the baseline model of Debortoli and Nunes (2010). They discuss the dynamics and incentives of this case in depth. A portion of the interpretation is given here as the dynamics of the model with uncertainty closely follow the deterministic case.

The deterministic GEE becomes

$$\Delta_b - \gamma' u_c' = 0.$$

In the deterministic steady state I confirm the result that

$$\gamma b u_{cc} \mathcal{C}_b = 0. \tag{2.13}$$

As with their model there are three steady states. $\gamma = 0$, the first best, implies the government has enough assets to cover the first best amount of endogenous expenditure through interest payments from agents. The constraint (2.4) is not binding as taxes are zero, all of the wedges are eliminated as they depended on the distortions of taxes and interest rate manipulation.

The other two steady states occur where the government has no incentive to manipulate the interest rate, $b = 0$ and $\mathcal{C}_b = 0$. Notice the amount of funds the government is able to raise by selling debt is

$$b\frac{u_c(\mathcal{C}(b))}{u_c}.$$

With no debt it is apparent there is no reason to manipulate future governments as no debt is raised. At $\mathcal{C}_b = 0$ a change in debt does not effect private consumption, and thus does not effect the interest rate. This can only occur because of endogenous government expenditure.

As debt goes up there are two effects: the government must raise taxes to pay for the debt and there is a wealth effect as debt represents agent asset holdings. Both of these effects reduce labor supply. In a model with exogenous expenditure, the aggregate resource constraint implies that the change in consumption has to equal the change in labor. This would imply $\mathcal{C}_b < 0$. However, with endogenous g the government can reduce g in response to a change in debt. This allows $\mathcal{C}_b$ to be positive or zero, in which case the effect of a change in debt on labor exactly equals the effect on government expenditure.

In fact it is precisely where $\mathcal{C}_b$ is positive that governments choose to reduce debt. Higher levels of inherited debt cause a higher motivation to raise consumption today and lower it tomorrow; thus selling debt at a more convenient price. The more debt a government has, the more desperate he is to lower interest payments by raising his current consumption. To reduce the incentive of tomorrow's government to increase their current (today's future)

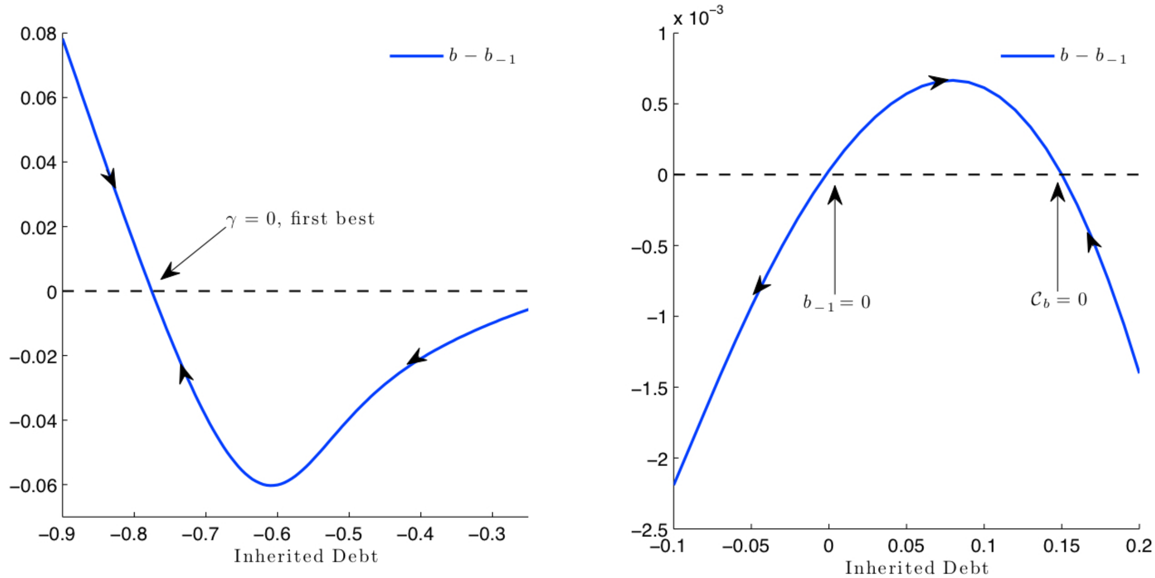

Figure 2.2: Dynamics of deterministic case

consumption, the current government leaves them with a lower level of debt. Consumption can thus be increasing in the level of debt, something that could not happen with exogenous g. However it is also the case that as debt is lowered, the tax rate can be lowered, increasing private consumption. These effects exactly cancel out at $\mathcal{C}_b = 0$.

Debortoli and Nunes (2010) focus on the dynamics given a particular level of initial debt. They find that for a reasonable calibration the $b = 0$ steady state is stable while $\mathcal{C}_b = 0$ occurs when the government holds assets and is unstable. Thus starting from any initial debt level above where $\mathcal{C}_b = 0$ debt converges to $b = 0$, while initial debt less than that point results in convergence to the first best. For my baseline calibration the dynamics are somewhat different (details of my specification and calibration in ensuing section). I find that $\mathcal{C}_b = 0$ occurs at a positive level of debt and is the stable while $b = 0$ is not. Figure 2.2 illustrates these three steady states and the dynamics of the deterministic case. The divergence in results comes from an alternate calibration for labor elasticity. With their less elastic specification for labor the cost of raising taxes is lower and raising debt is more expensive.

2.4.2 Fiscal policy over the Real Business Cycle

How should fiscal policy react to real shocks to output in a standard model? As mentioned above I find expenditure, tax rates, and debt will be procyclical. There are three effects at play here: the changing price of repaying debt (the dominant effect discussed in the two-period economy, debt is less expensive to repay tomorrow if the shock is high today), the changing price of taxes (tax smoothing), and interest rate manipulation.

The GEE for the model with productivity shocks is key to understanding the evolution of debt. It can be written

$$\gamma \mathbb{E}_{z'}[u_c' + u_{cc}' \mathcal{C}_b(b, z')b] - \mathbb{E}_{z'}[\gamma' u_c'] = 0. \tag{2.14}$$

It turns out that similar to the two-period model γ' is decreasing in productivity, or equivalently it is cheaper to raise funds when productivity is high. Agents are more willing to work as the return on working goes up, making taxes relatively less distortionary. Agents are also more willing to save when they have temporarily high income, reducing the distortion of debt. This results in the same incentive as the two-period model: $\mathbb{E}_{z'}[\gamma' u_c']$, the cost of repaying debt, is decreasing in z' and thus z due to persistence. A higher z' results in both higher consumption, lowering u_c', and a lower γ'. Just as in the two-period model a decrease in the cost of repaying debt leads to an increase in debt issued.

The two new effects in the full model are tax smoothing and interest rate manipulation. The tax smoothing motivation is simply that it is less costly to finance extra expenditure by using a combination of debt and taxes. Debt reduces the need to raise current taxes not only because it is simply a transfer of resources from consumption to expenditure but also because it changes the cost of adjusting taxes, which depends on the curvature of utility for consumption and expenditure (recall there was no curvature in two-period economy). In this model an increase in z increases the efficiency of production. This reduces the incentive to use taxation as it creates a larger disincentive to work, a greater labor distortion. Thus most of the increase in expenditure is financed through an increase in debt.

Now with interest rate manipulation observe again that the amount of funds raised by selling debt is dependent on consumption next period. All of the elements inside the current multiplier are functions of future policy $\mathcal{C}(b, z')$: debt changes the amount of funds debt can raise. A positive shock increases consumption in the current period but also increases expected future consumption due to persistence in z. Returning to equation (2.14) a decrease in u_c' increases the incentive to manipulate the price of debt. As discussed for the deterministic case the effect of debt on future policy ($\mathcal{C}_b$) and thus the price of debt is difficult to generalize. The effect of interest rate manipulation on the cyclicality of debt can only be determined in equilibrium.

The cyclicality of taxes is also difficult to classify. In the two period model the tax rate did not respond to change in productivity because productivity did not appear in the utility cost of taxation. For several simulations because debt financing becomes so much cheaper it dominates and even reduces the tax rate when there is a positive shock and expenditure increases. Tax movement can only be classified it in equilibrium, where it turns out for the my calibrations to be pro-cyclical. Pro-cyclicality in tax rates for real shocks is *not* as general a result as pro-cyclicality in government expenditure and debt.

Again the key difference between this model and the business cycle fiscal policy models of Ilzetzki (2010) and Barseghyan, Battaglini and Coate (2010) is the closed economy. The government cannot smooth over bad shocks using international capital markets. This appears most notably in the agent budget constraint

$$c + qb = (1 - \tau)zl + b_{-1}.$$

Not only can the government manipulate consumption using the tax rate, but also by setting the exact amount of debt the agent purchases. Responding to a bad shock by reducing debt *increases* consumption by reducing savings. This is the source of the opposition in findings between this chapter and the others.

Looking at impulse responses emphasizes how pro-cyclical debt facilitates tax smoothing. The top two panels of figure 2.3 show the tax rate

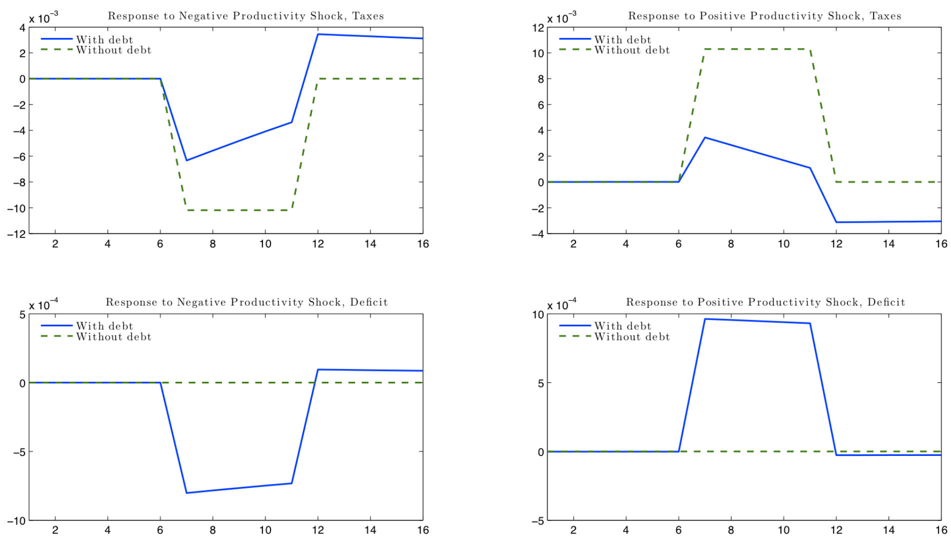

Figure 2.3: Response of taxes and deficits to five period productivity innovation

response to a five period innovation in productivity, both high and low. A model restricting debt to zero displays much higher volatility in tax rates as they are the only instrument with which to finance public consumption. The bottom two panels show the deficit reaction to the same five period innovation. For high shocks the government runs a deficit, while for low shocks a surplus reduces tax volatility.

Figure 2.4 shows the full debt policy function given inherited debt and realization of productivity. Notice how the dynamics of the deterministic case still holds; uncertainty only shifts the relationship; the endogenous bound on debt still holds. Notice also however that too much volatility could give rise to a policy for the low shock that would converge towards the first best.

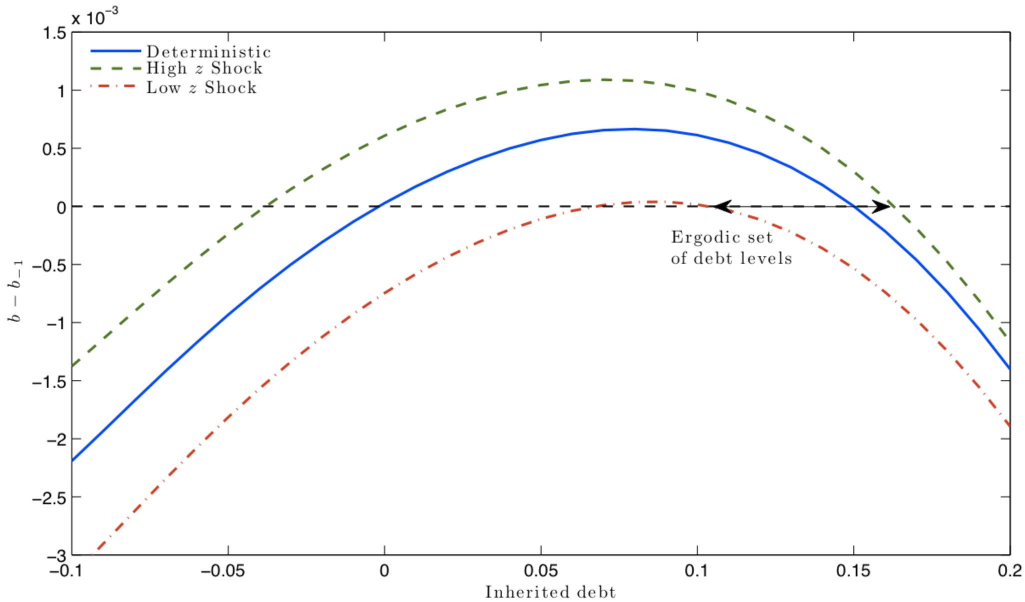

Figure 2.4: Debt policy with stochastic productivity

2.4.3 Fiscal policy over the Partisan Business Cycle

How should fiscal policy react to political shocks? The economics in this case move closer to the optimal fiscal policy literature with expenditure shocks. Instead of making these shocks exogenous however they are endogenously chosen as the result of alternating preferences interpreted as a political process. Alternating preferences add significant complication to the expression of the GEE,

$$\begin{aligned}
&\Delta_b(b_{-1}, z, i) - \mathbb{E}_{z',i'}[\gamma' u_c'] = \\
&(1-p)\mathbb{E}_{z'}\{\mathcal{C}_b(b, z', -i)[\Delta_c(b, z', i) - \Delta_c(b, z', -i)] \\
&+ \mathcal{G}_b(b, z', -i)[\Delta_g(b, z', i) - \Delta_g(b, z', -i)] \\
&+ \mathcal{B}_b(b, z', -i)\beta[\Delta_b(b, z', i) - \Delta_b(b, z', -i)]\} \qquad .
\end{aligned}$$

However this only slightly shifts the incentives from the politically deterministic ("benevolent planner") GEE where the marginal cost of public funds does not include future manipulation. Recall the only manipulation in the political agreement case is over the interest rate, while here the possibility of the opposing party taking control of government gives an incentive to alter the state to achieve an outcome closer to own-party equilibrium distortions. It is difficult to analytically characterize the manipulation; as demonstrated in the deterministic case the derivatives of the equilibrium policy functions can switch signs. In my simulations the future manipulation effects have various directions but in general are very small for two reasons. First the incumbency advantage is large in my calibrations ($0.8 < p < 0.9$). Second the wedges are similar as policy exhibits very little variation across parties. Generating the volatility of government expenditure found in the data does not require a high degree of disagreement. The result of these two effects is that the effect of the right hand side of the equation is quite small.

Similar to the discussion on real business cycles there are several incentives at play here. The main incentive is one from the two-period model, that the benefit of debt as a transfer device between consumption and expenditure is increasing in λ. The reduction in cost of paying debt back however does not generalize. In the two-period model debt was cheaper to pay back with higher λ as there was no endogenous government expenditure in the second period: debt could only reduce consumption, and consumption was less valuable with higher λ. Here the cost of repayment can go up. With a persistent political process a government with a high preference for expenditure is likely to be followed by a government of the same type. Both γ and $\mathbb{E}\gamma'$ are increasing in λ, as both need to finance more government expenditure, putting more strain on the government's budget constraint.

The primary motivation to increase debt when for a higher λ is tax smoothing. The increase in expenditure caused by an increase in λ is financed by both increased debt and taxes. The difference from the real shocks case is the change in λ does not directly influence the efficiency of labor, so the trade-off is not as sharp. Again it is not clear how the preference parameter effects the relative cost of raising taxes versus debt, however in practice the increase in expenditure is funded by a combination of debt and taxes instead of debt dominating as it does with productivity shocks.

The effect of rising λ on the interest rate manipulation motivation is again unclear. It turns out that consumption is decreasing in λ as the increase in taxes and debt are not balanced by an increase in labor efficiency. Agents want to lend less, increasing the cost of manipulating the interest rate and decreasing the amount of funds that issuing debt raises (q goes down). How this changes the incentive to manipulate future consumption again depends on the effect of debt on policy ($\mathcal{C}_b$), which is difficult to classify.

Even the response of output to a change in λ turns out to not be obvious. Because interest rates are increasing in λ agents may work more as labor responds not only to the price of labor but also to the price of saving. The decrease in labor supply due to the increase in taxes is at least partially offset by the increase in labor supply due to borrowing costs being higher.

Similar to Azzimonti and Talbert (2011) the political friction adds tax volatility compared to the equilibrium with a benevolent planner setting policy, reducing welfare. Although not explored here an interesting extension would be to analyze the welfare effects of fiscal rules limiting debt and deficits in this environment.

2.5 Quantitative analysis

The experiment is to run a horse race between three models: stochastic productivity, political disagreement, and a combination of the two. I calibrate the parameters of the models to mainly non-fiscal moments and see how well each of the models matches fiscal policy moments of U.S. postwar data. The data is for the U.S. from 1979-2010. The start date is chosen to match Barsghyan, Battaglini and Coate (2010). They start in 1979 partially to avoid the effects of WWII and the Korean war, which had significant non-business cycle impacts on fiscal variables. As discussed above this is not a model of war. They also choose a later start date to abstract from the impact of high inflationary periods in the 1970s, which had a strong impact on largely nominal government debt. The data is simply linearly detrended[9].

For the general model utility is specified as

$$u(c, 1-l) = (1-\eta_c)\frac{c^{1-\sigma_c}}{1-\sigma_c} + \eta_c \frac{(1-l)^{1-\sigma_l}}{1-\sigma_l},$$
$$v(g) = \frac{g^{1-\sigma_g}}{1-\sigma_g}.$$

The two values for political preference, λ_R and λ_L are defined by

$$\lambda_R = \bar{\lambda} - \xi,$$
$$\lambda_L = \bar{\lambda} + \xi.$$

The standard parameters are selected with two goals in mind: staying within the bounds of parameters used in the business cycle literature while also ensuring the model retains the endogenous bound on debt due to time-consistency. Particularly this requires a combination of low elasticity of substitution for private consumption and a low discount factor. The parameters σ_c, σ_g, and β are taken from Klein, Krussell and Rios-Rull (2008), who solve a similar time consistent problem of endogenous government expenditure. σ_l comes from Aiyagari et al (2002) and is the same value employed by Barseghyan, Battaglini and Coate (2010). Table 2.1 lists these standard parameters of the model.

This leaves 5 parameters to calibrate to U.S. data moments. Table 2.2 lists the calibrated parameters and their target moments. Table 2.3 gives the

[9]Data source described Appendix A

Table 2.1: Standard parameters

Parameter	σ_c	σ_l	σ_g	β
value	2	2	1 (log)	0.95

fit of each model using these moments. Model 1 has only stochastic productivity, Model 2 only political disagreement, and Model 3 includes both types of uncertainty[10]. Second moments of output (volatility, auto-correlation) are difficult in general to match simultaneously in models with endogenous labor as the sole factor of production.

The strategy for calibrating ξ is notably different from Azzimonti and Talbert (2011), who in a model with similarly specified preferences match it to the volatility of government expenditure. Here the volatility of g is naturally high due to it's elasticity being higher than consumption. This implies government expenditure ends up absorbing much of the shock to output, thus the higher volatility. The partisan effects here are instead matched to the volatility of the debt/GDP ratio. A better experiment would be not to calibrate ξ to the second moment of a fiscal variable, as those are the moments under investigation, however which alternative moment has yet to be determined.

[10]The value mean(z) governs average productivity; which in turn effects the derivative $\mathcal{C}_b$, the key element in determining mean debt as seen from the deterministic model.

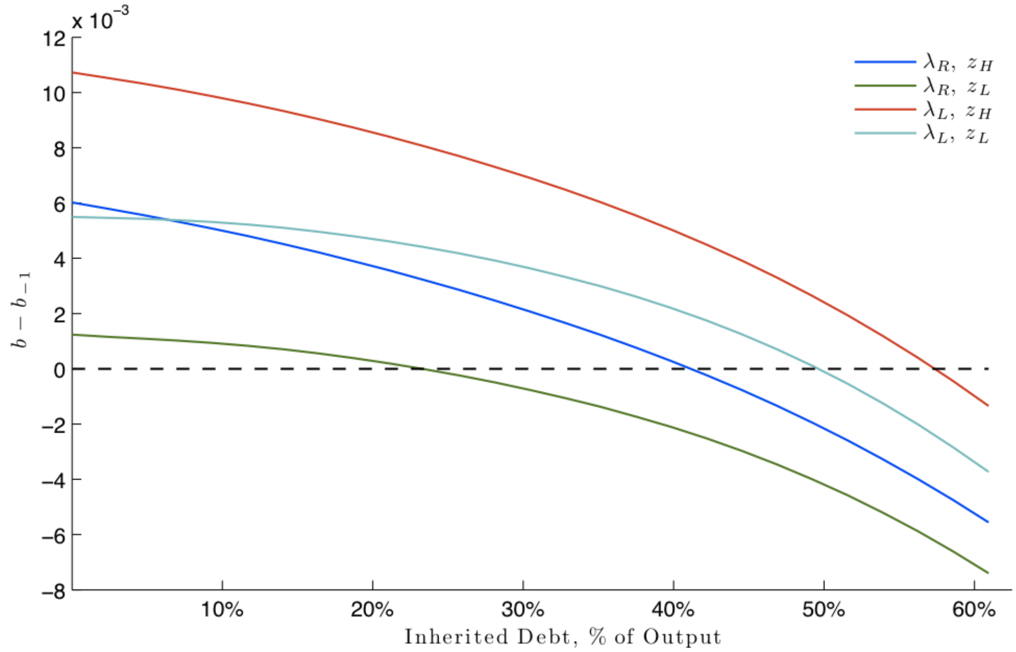

Figure 2.5: Debt policy of calibrated model 3

Table 2.2: Calibrated parameters

Parameter	Model 1	Model 2	Model 3	target
prob$(z' = z)$	0.8		0.8	corr(y, y_{-1})= 0.78
vol(z)	4.95		3.26	vol(y)=3.13
mean(z)-1	7.5e-3	4e-3	1.01	mean(b/y)=0.38
p		0.9	0.9	ave. pol. tenure =10 yrs.
ξ		9.6e-3	4.6e-3	vol(b/y)=12.93
$\bar{\lambda}$	0.17	0.17	0.17	mean(g/y)=0.21
η_c	0.16	0.16	0.16	mean(l/y)=0.33

Table 2.3: Model fit to calibrated moments

Moment	Model 1	Model 2	Model 3	Data
vol(y)	3.04	0.79*	3.21	3.13
corr(y, y_{-1})	0.64	0.76*	0.61	0.78
mean(g/y)	0.22	0.22	0.22	0.21
vol(b/y)	7.75*	13.07	13.20	12.93
mean(b/y)	0.40	0.39	0.40	0.39
mean(l/y)	0.33	0.33	0.33	0.33

* indicates moment is not calibrated to.

2.6 Results

The debt policy of the full calibrated model are demonstrated in Figure 2.5. Notice the model is easily able to retain the endogenous bounds on debt introduced by time consistency. This is in large part due to increasing mean productivity, which has the effect of shifting the policy lines of Figure 5 up. Higher productivity makes taxes more distortionary, lowering the cost of debt financing.

The simulated second moments of the fiscal policy variables for the three models are presented in Table 2.4 along with their data counterparts. Starting with the volatilities notice all models overstate the volatility of government expenditure. This again as stated above is due to the elasticity of g being much high than the elasticity of consumption or labor: government expenditure bears the brunt of the shocks to the economy as it is relatively the cheapest valued object to adjust (compared to labor or consumption). This extra volatility in g also implies an unreasonably high volatility in the tax rate τ, however tax smoothing holds as the tax rate is less volatile than expenditure[11].

Decreasing the elasticity of expenditure (raising σ_g) would seem to go a long way towards solving this issue. Additionally the elasticity of government expenditure is not well established in the literature, leaving little argument against adjusting it. This introduces problems however in matching the distribution of debt. The adjustment in σ_g required to reduce the volatility of government expenditure to levels observed in the data would imply a large accumulation of assets by the government unless exogenous bounds on debt were introduced. The inability of the model to match the volatility of expenditure is then a fundamental weakness of the model that would require a further friction to account for.

Alternately the distribution of debt is set by design, although given the low volatility implied by model 1 matching the distribution of debt justifies

[11] The data equivalent of τ is $\frac{Revenue}{GDP}$

the addition of the political process. Combining the two types of uncertainty gives a much wider range of realizations for debt, as demonstrated by Figure 5. Debt in this model ranges from 24-59% of GDP, almost double the range of model 1. The data on the range of debt between 1979-2010 ranges from a low of 25.6% to a high of 62.2% in 2010 (this only includes government debt held by the public). More frequent aggregate switches (the result of two types of independent shocks) leads to more jumps in debt as regimes switch.

Table 2.4: Model fit to fiscal policy 2nd moments

Moment	Model 1	Model 2	Model 3	Data
vol(b/y)	7.75	13.07*	13.20*	12.93
vol(g)	5.33	8.55	5.87	1.74
vol(τ)	3.18	0.84	2.57	1.15
corr(b, y)	0.99	-0.93	-0.37	-0.81
corr(g, y)	0.99	-0.86	0.34	0.10
corr(τ, y)	1.00	-0.62	0.22	0.26
corr(b, b_{-1})	0.84	0.95	0.76	0.92
corr(g, g_{-1})	0.63	0.60	0.64	0.92
corr(τ, τ_{-1})	0.61	0.65	0.59	0.73

* indicates calibrated moment.

Auto-correlations of fiscal variables for all three specifications are in line with data observation in sign, although not in magnitude. Without costs to adjusting variables they tend to exhibit sudden shocks as the aggregate state changes. Again the higher volatility of government expenditures partially causes these problems. Contemporaneous correlations with output are the main story of this chapter however.

Neither type of shock individually is able to explain the counter-cyclicality of debt and the pro-cyclicality of taxes and expenditure[12]. Real shocks are the standard assumption of the source of aggregate fluctuations in the economy yet do a terrible job of explaining fiscal co-movements with output. For debt, taxes, and expenditure a standard model predicts almost perfect positive correlation with output, a result very far removed from data observation. This is the source of the motivation to include an alternate shock process; the understood and assumed source of economic volatility not only cannot account for observation but does so in a spectacular fashion.

Including extra volatility in the expenditure through a political process brings a more realistic description of debt behavior, however it does not do well in explaining the other fiscal moments and cannot generate a large enough volatility in output. The two types of shocks independently suggest extreme responses of fiscal variables not found in the data.

A combination of the two types of shocks reduces these extreme responses to give a much more reasonable accounting of the cyclicality of fiscal variables. Model 3, including both productivity and political shocks, gives accurate signs for the correlations and also comes closer to the correct values for both expenditure and the tax rate. While the fit is improved it is not perfect, as the predicted correlation of debt with output is less than half of data observation.

[12]The filtering method is important in determining the sign of the cyclicality of observed government expenditure. For an HP-filter instead of linear de-trending this correlation is negative, although removing transfers from the larger measure of consolidated government expenditure pro-cyclicality is restored. In either case the value of the cyclicality is low

2.7 Conclusion

I presented a model of fiscal policy reacting to two types of business cycle uncertainty: real and partisan. Both of these effects cause volatility in fiscal variables, however their implications for the cyclicalities of these variables are very different. Due to a closed economy fiscal policy (including debt) is positively correlated with fluctuations in income due to productivity innovations and counter-cyclical to fluctuations in income due to political shocks. These effects do not depend on time-consistency, rather they come directly from tax smoothing. A calibrated model with both types of business cycles accounts for observed second moments of fiscal variables better than either of the types of uncertainty individually.

An interesting extension would be to use this model to analyze welfare improving fiscal rules. In particular the founding document of the European Union, the Maastricht Treaty, has provisions for fiscal rules that were adopted as the Stability and Growth Pact, limiting fiscal deficits to 3% of GDP per year and total debt to 60% of GDP. The optimality of these limits or even there existence versus requiring a balanced budget or no rules has not been analyzed in a fully dynamic neoclassical environment. This model would be particularly well suited for such an analysis as debt has both welfare improving (for stochastic productivity) and reducing (for political disagreement) properties.

Chapter 3

Tax-deferred accounts: who benefits?

3.1 Introduction

Tax benefits for retirement savings have existed since the Revenue Act of 1913, which was passed immediately following the passage of the 16th amendment permitting income taxes. The act recognized and enshrined the tax exempt nature of pension trusts. This was followed in 1962 and 1974 by the creation of Keogh plans and Individual Retirement Accounts respectively that were created specifically to extend the tax benefits of retirement savings to employees not covered by defined benefit pension plans. The final extension occurred in 1981, covering all employees. These systems along with defined contribution plans have expanded to a point where McCourt (2008) reports that there is a total of \$10 trillion in US personal wealth currently sheltered from taxation through retirement plans (compare to \$15 trillion total market capitalization of U.S. stocks). IRA and Keogh plans alone account for 32% of US personal savings[1].

The reasons behind the creation and expansion of the system of tax-favored retirement savings is not immediately clear. Much of the literature

[1]SOURCE: Federal Reserve Board of Governors, 2004 Survey of Consumer Finances

on tax-favored savings focuses on the encouragement of retirement savings as the catalyst for reforms to the system and set to measure the success of the system in achieving that aim. This chapter instead examines the welfare effects of encouraging retirement savings to ask whether tax-favored accounts are welfare improving. Abstracting from all but an asset structurally similar to the U.S. traditional IRA I construct a simple model of agents who earn, save in both tax-deferred and conventional accounts, retire and die. Traditional IRAs are chosen as the saving instrument as they have institutional features that can be manipulated to examine welfare effects such as contribution limits and early withdrawal penalties. I am also able to examine possible reforms to the system including minimum contributions and mandatory contributions. Other tax-favored plans such as the Keogh and Roth IRA differ somewhat from the standard IRA however they are much closer to IRAs than conventional savings. Defined benefit plans differ substantially from IRAs in incentives and the decision making however they result similarly in a large fraction of household wealth being tax-deferred and have been decreasing in both size and importance over the past several decades[2].

While the upside of implementing such policies is readily apparent (lower tax burden increases lifetime income) the drawbacks come from second

[2]The number of private plans has dropped from over 100,000 in 1975 to fewer than 50,000 in 1999, McCourt (2008). Recent drastic changes in private pension accounting standards (FAS 157, 2006) and suggested changes in public accounting standards have accelerated this trend. Poterba and Wise (2001) also document the transition from forced retirement savings through defined benefit plans to defined contribution plans that more closely fit the model over the past several decades.

order effects. I require policy changes to be revenue neutral; with a reduced tax base the government must increase taxes to balance its budget. Changes in the capital stock lead to changes in factor prices, which have an ambiguous effect given income inequality. Sufficient heterogeneity in earnings is important to include for welfare analysis to answer the primary question: who benefits? Any policy reform suggestion must address who the winners and losers are as well as their mass in the population.

The second order effects require general equilibrium analysis. I adapt the life-cycle model of Huggett (1996) to include retirement accounts. Labor and retirement age decisions are set exogenously to provide more clarity in modeling the consumption-savings trade-off. Unlike the optimal social security literature it is not immediately apparent that labor distortions are important since tax increases are a second order affect. Pang (2006) models the retirement decision in an environment with tax-deferred savings and finds a slight reduction in average retirement age.

The debate about the effectiveness of tax incentives in spurring new savings has been an active area of research. On the empirical side Venti and Wise (1986, 1987, 1990, 1995) and Poterba et al. (1994, 1995, 1996) find that a large part of tax-deferred account contributions are new savings while Engen and Gale (1993) and Engen et al. (1994, 1996) disagree. More recently Benjamin (2003) estimates one-half of 401(k) contributions are new savings. In a general equilibrium model similar to the one presented here Imrohoroglu et al. (1998) find that only 9% of contributions to tax-deferred accounts represent new savings. They suggest structural adjustments to increase this number. The existing literature on tax-favored accounts is limited almost exclusively to questions of whether or not they increase retirement savings.

A peculiarity that escapes the aforementioned analyses is the contribution limit. Venti and Wise (1990) and Engen, Gale and Scholz (1994) suggest that it be lifted. For agents already saving above the maximum, retirement accounts do not affect the rate of return of incremental saving. This reduces potential aggregate benefit from extra saving from individuals with already high saving, who may save less due to an income effect on the increased earnings from retirement assets. However beyond their marginal effect on agent's savings little attention is paid to the contribution limit.

Much of the previous literature on tax-deferred accounts is predicated on the belief that Americans do not save enough for retirement. Bernheim and Scholz (1992) in particular find that most Americans save too little, suggesting instead of encouraging savings through tax benefits that private pensions (mandatory retirement savings) be encouraged. As a consequence of this belief any policy that increases private savings, either for retirement or fluctuations in income, is desirable. Here I take an opposing approach by assuming agent's behave rationally and justify the existence of tax favored savings by examining the optimality of observed policy.

The model presented here is more closely related to the literature on the optimal arrangement of social security. Huggett and Ventura (1999) pose a similar question as here using a similar model to study welfare effects of social security reform. This literature however focuses on the role of such policies in providing social insurance[3]. Here the focus instead is on the government faciliatating individual agent consumption smoothing.

The main results are that tax-deferred accounts improve aggregate welfare for all specifications of contribution limit. I measure aggregate welfare as the sum over the lifetime utility of agents newly entering the workforce along with their relative mass. Adopting a persistent productivity process for agents I find that the majority of the benefit goes to agents with initially and by persistence subsequently low realizations of productivity. Higher initial productivity workers do not receive the same benefit; for several specifications of the contribution limit they are net losers as they rely more heavily on interest earnings, which are substantially reduced. The overall welfare effects are discussed in the results section.

I also find that the existence of such account greatly increases inequality, particularly among retirees. the Gini coefficient rises from 0.33 to 0.42 while the volatility of consumption across agents is increased by 11.75%.

3.2 Model economy

The following describes the overlapping generations environment used for this analysis. The variations in model economies comes from the different specifications of rules governing contributions to tax-deferred retirement

[3]Lindbeck and Persson (2003) review the literature on the efficiency gains of social security reform

accounts.

3.2.1 Environment

The economy is populated by a continuum of overlapping generations agents who live for T periods. Agents face mortality risk each period, with a probability η_t of surviving through age t given survival through age $t-1$. Population grows at rate ϕ so that agents of age t make up a constant fraction of the population μ_t defined by

$$\mu_{t+1} = \frac{\eta_{t+1}\mu_t}{1+\phi} \text{ and } \sum_{t=1}^{T} \mu_t = 1.$$

Agents have identical preferences over consumption

$$E_0 \left[\sum_{t=1}^{T} \left(\prod_{i=1}^{t} \eta_i \right) \beta^t \frac{c_t^{1-\sigma}}{1-\sigma} \right].$$

An agent's labor endowment depends on age (t) and an efficiency shock (z) following closely the method employed by Huggett (1996). This is the only source of agent heterogeneity. The value of this endowment is set by the function $e(t,z)$. The shocks follow a Markov process and are independent across individual agents, they consist of the 18 shocks and transition probabilities used in Huggett (1996). This exogenous shock process results in labor endowment that is stochastic to the agent but deterministic in the aggregate economy.

The aggregate production technology converts the total labor endowment and capital stock into constant returns to scale output

$$Y = AK^{\alpha}L^{1-\alpha}.$$

Capital is defined as the sum of regular and tax-deferred assets across agents. It depreciates at rate δ. Labor and asset markets are competitive, giving factor prices

$$r = \alpha A K^{\alpha-1} L^{\alpha} - \delta, \tag{3.1}$$

$$w = \alpha A K^{\alpha} L^{1-\alpha}. \tag{3.2}$$

3.2.2 Retirement accounts

In addition to age and idiosyncratic shock the agent's state also includes the balances of the two types of assets, conventional (a) and retirement (s). The agent's per period budget constraint reflects the rules governing contributions to the retirement account,

$$c+a' = (1+r(1-\tau))a+(1-\theta-\tau)e(z,t)lw+T+b+(1-\tau)((1+r)s-s'). \tag{3.3}$$

This requires some explanation. Pre-tax the agent earns the wage rate (w) times their age and shock dependent individual labor endowment $e(z,t)$ and labor supplied l. Here labor supply is set exogenously to 1. They pay two types of proportional taxes on labor income: income tax (τ) and social security tax (θ). Taxes are flat in this setting to retain as parsimonious a structure as possible. A progressive tax structure would provide the extra benefit of smoothing the rate of taxes on savings in addition to simply allowing them to accumulate tax free, however this incentive is abstracted from. Agents also pay income tax on the earnings from their conventional savings accounts. With mortality risk some agents die with positive asset; T is the lump sum transfer of these assets to all agents. Social security transfers b are collected after the retirement age (R). In this model there is a non-negativity constraint on both and retirement and conventional assets (agents are liquidity constrained), $a \geq 0$, $s \geq 0$.

The final element of the budget constraint is the contribution to the retirement account. A contribution would be $s' > (1+r)s$. The marginal cost in consumption of a contribution to this account is only $(1-\tau)$. Each unit of contribution reduces the equivalent amount of income subject to tax. Also note that this implies a withdrawal from the retirement account, $s' < (1+r)s$, is taxed as normal income. The rules governing the evolution of s are as follows:

$$
\begin{aligned}
s' - (1+r)s &\leq 0 \;\text{ for } t \geq R. && (3.4)\\
0 \leq & s' - (1+r)s \leq \bar{s} \;\text{ for } t < R, && (3.5)\\
\text{else if } & s' - (1+r)s < 0 && (3.6)\\
\text{then } & c = \ldots - B
\end{aligned}
$$

Equation (3.4) implies when an agent is greater than retirement age R, he is allowed to withdraw as much as he desires from his retirement account but that the balance tomorrow must be less than or equal to the balance today: he can no longer contribute to his retirement account[4]. Equation (3.5) says an agent may contribute but not withdraw from his retirement account. The

[4]While this does not quite reflect actual policy the assumption turns out to be fairly innocuous in welfare simulations

contribution limit $\bar{s}$ is the same for all agents across all states. Equation (3.6) states that if an agent withdraws from the account before retirement they pay a lump sum tax of B[5]. These features match the main institutional features of US standard IRAs.

Pay-as-you-go social security is important in this set-up as it reduces the retirement savings motivation of low income earners, who smooth consumption through this social insurance. These low earners do not benefit as much from the first order effects of retirement accounts as they utilize savings less for retirement and more to smooth consumption over income realizations.

3.2.3 Government

The government in this model performs two trivial functions, balancing it's two budgets each period. It uses income taxes to finance an exogenous level of expenditure which is assumed to be a fixed fraction of output. The budget is given by

$$G = \tau \sum_t \mu_t \int_x wle(z,t) + ra(x,t) + (1+r)s - s(x,t) d\psi_t. \qquad (3.7)$$

The tax rate is adjusted so that this equation always holds. The government also insures the social security budget is balanced, setting social security tax θ to pay for a fixed level of post retirement social security benefit

$$b = \theta \frac{wL}{\sum_{t=R}^{N} \mu_t} \text{ if } t \geq R, \quad 0 \text{ else.} \qquad (3.8)$$

[5] B is set high enough that no agent ever chooses to withdraw

3.2.4 Stationary equilibrium

For an individual agent optimal decision rules are indexed by the agent's state $x = (z, a, s)$ and age, where in addition to age and idiosyncratic shock each agent has holdings of two types of assets, conventional (a) and retirement (s). The agent's recursive problem is

$$V_t(x) = \max_{c,a',s'} u(c) + \beta\eta_{t+1}\mathbb{E}_{z'}V_{t+1}(x') \tag{3.9}$$

The equilibrium concept is adapted from Huggett (1996) and İmrohoroğlu, İmrohoroğlu & Joines (1998). For this economy a stationary equilibrium is a set of $\{\ r,\ w,\ a(x,t),\ c(x,t),\ s(x,t),\ \tau,\ \theta,\ \bar{s},\ \bar{y},\ b,\ Y,\ G,\ L,\ \psi_{t=1,\ldots,T}\ \}$ and aggregate state variable K such that the following hold:

1. Given prices and parameters, policy functions $c(x,t), a(x,t), s(x,t)$ solve agent optimality eq. (3.9) for all states and ages given constraints (3)-(6) and non-negativity in c, a, and s.

2. Firms set prices r and w competitively given K and L, eq. (3.1).

3. Markets clear

   (a) Resource: $\sum_t \mu_t \int_x (a(x,t)+c(x,t)+s(x,t))d\psi_t + G = Y + (1-\delta)K$

   (b) Assets: $\sum_t \mu_t \int_x (a(x,t)+s(x,t))d\psi_t = (1+\phi)K$

   (c) Labor: $\sum_t \mu_t \int_x le(z,t)d\psi_t = L$

4. Government sets τ such that the budget constraint (3.7) is balanced.

5. θ balances the Social Security budget (3.8).

6. Law of motion for stationary distributions of agents over states is set by policy functions.

$$\psi_{t+1}(x') = \int_x \iota(x) d\psi_t \quad \forall\ x, \quad t = 1, \ldots, T-1$$

7. Transfers equal accidental bequests

$$\left[\sum_t (1-\eta_{t+1})\mu_t \int_x (a(x,t) + s(x,t)(1+r(1-\tau)d\psi_t\right] / (1-\phi) = T$$

where the function $\iota(x)$ is an indicator for the decision rule moving the agent from x to x'. ψ_1 is exogenously given, borrowed from Huggett (1996). Agents of age 1 are assumed to be born with no assets.

3.2.5 Welfare

In order to compare the welfare of alternate policy arrangements it is necessary to adopt measures of welfare. The primary measure will be aggregate welfare of agents entering the workforce who adopt the optimal consumption and savings plans through their life-cycles. This is a non-trivial assumption, as it abstracts from both the effects of policy on current workers as well as the costs of transitions to alternate policy, which may present significant frictions to achieving the optimal arrangement. The measure of welfare for an agent i born with initial productivity z_1^i following the optimal consumption path given contribution limit $\bar{s}$, $c_t(a,s,z,\bar{s})$, is

$$U_i(z_1^i, \bar{s}) = E_0\left[\sum_{t=1}^{T}\left(\prod_{i=1}^{t}\eta_i\right)\beta^t \frac{c_t(a,s,z,\bar{s})^{1-\sigma}}{1-\sigma}\right].$$

where the expectation is integrated over all possible paths with the discrete likelihood of taking each path given initial condition z_1^i. Aggregate welfare is then this measure integrated over the initial distribution of agents

$$W(\bar{s}) = \int_z U(z, \bar{s})\psi_1.$$

3.3 Calibration

The period length is taken to be one year. Individuals are "born" at an age of 20, retire after age 65, and die with certainty at age 99. The earnings process $e(z,t)$ and associated first-order Markov process are taken from Huggett (1996), where it is drawn from U.S. income data. Discount parameter β is set to the value for life-cycle economies found by Hurd (1989). Elasticity σ is drawn from the standard macro literature. Technology parameters A, α, and depreciation δ are also drawn from the standard literature with the exception of A, which is set to normalize the capital output ratio to 3 given aggregate labor supply and the equilibrium capital level.

Table 3.1: Model parameters

Parameter	σ	β	δ	α	N	R	ϕ	θ	G/Y
value	2.0	1.011	0.06	0.36	80	45	0.012	0.1	0.195

Demographic parameters N and R are adopted from Huggett and Ventura (1999) as well as population growth ϕ, which comes from US growth rate from 1959-1994. Survival probabilities come from the Social Security Administration Survival Tables (2006).

Fiscal parameters are also set in accordance with the relevant life-cycle literature. Huggett (1996), Huggett and Ventura (1999) and İmrohoroğlu, İmrohoroğlu & Joines (1998) all use $G/Y = 0.195$ in accordance with average government consumption from 1959-1990s. The social security contribution θ comes from Huggett (1996), who sets it to match average contribution to social programs.

3.4 Results

The main results are presented in Table 3.2. Close to U.S. data number of 32% I find that for the current contribution limit 41% of total agent asset holdings are in retirement accounts. With no contribution limit this number jumps to 86%. These numbers make clear that agents, when given the opportunity, overwhelmingly save for retirement instead of transitory fluctuations in income. This extra savings helps agents smooth income. In addition the increase capital stock results in much higher production and aggregate consumption. This however comes a the cost of a much lower interest rate and higher taxes. For the volatility of lifetime consumption is greatly reduced. The value $\mathrm{vol}(c_t^i)$ represents to lifetime volatility of the consumption of an individual agent. This is done simulating 10,000 different agent life-cycles. These effects combine for the result that tax-deferred savings accounts greatly increase welfare.

Figure 3.1 demonstrates the increase in welfare is almost universal. Only for the much higher initial productivity workers are IRAs welfare reduc-

Table 3.2: Steady state equilibria

	$\bar{s} = 0$	$\bar{s} = US$	$\bar{s} = \infty$
L	0.53	0.53	0.53
K	2.86	3.24	5.12
S	0.00	1.32	4.39
τ	0.14	0.17	0.25
r	0.03	0.01	0.0
w	0.67	0.76	0.86
$W(\bar{s})$	-254.82	-253.34	-247.12
Gini	0.33	0.36	0.42
vol(c_t^i)	103%	94%	79%

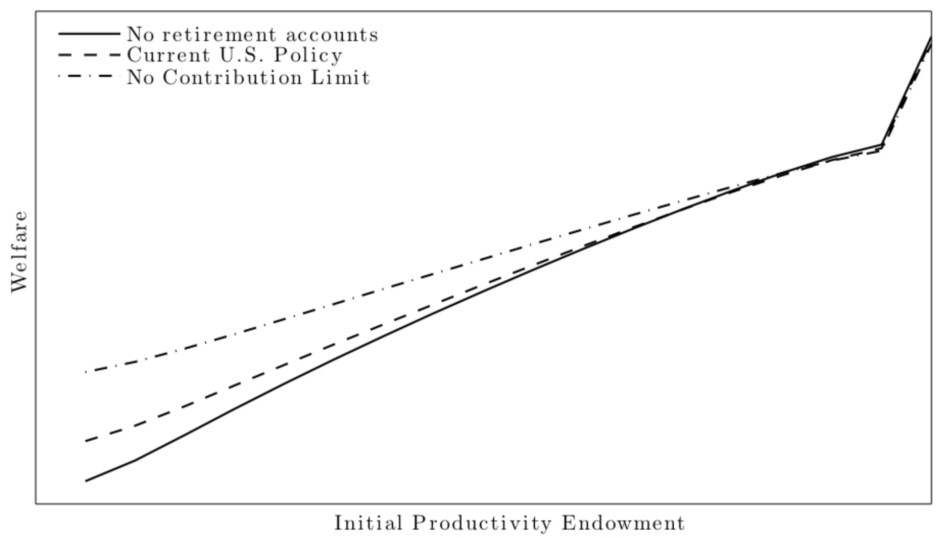

Figure 3.1: Increase in individual welfare

ing. The distribution of welfare gains is that they primarily assist the lower earners. This however is likely primarily due to the increase in wage rate as the ability to grow income tax free. In fact for no contribution limit the interest rate is zero; both types of assets are not taxed as there is no growth on them to tax.

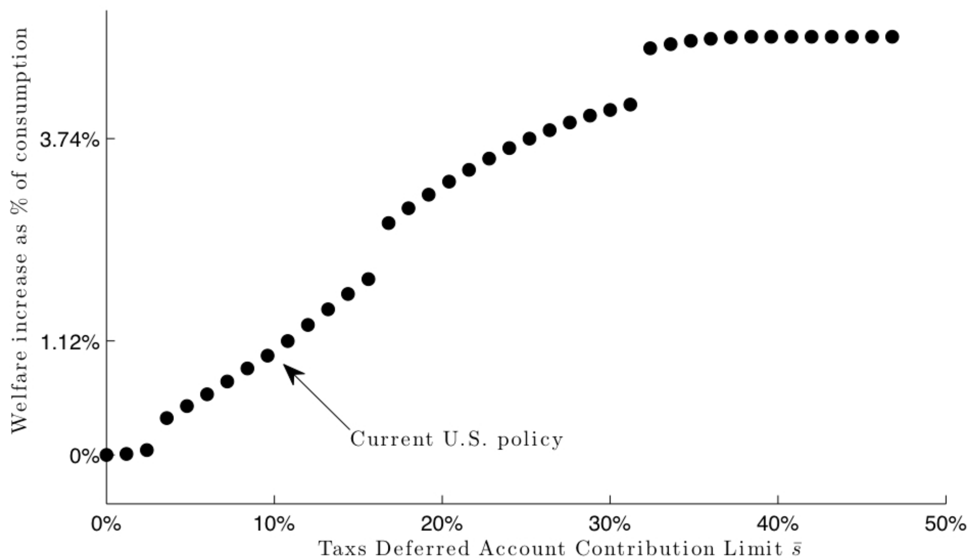

Figure 3.2: Increase in aggregate welfare

Figure 3.2 demonstrates the increase in welfare for all contribution limits. Current US policy in equivalent to a 1.12% increase in consumption in all periods for all agents. Removing the contribution limit gives an even more drastic increase of 3.74% of consumption.

The distribution of gains is important feature in analyzing the the policy is determining its effect on inequality. While low income workers are the primary beneficiaries of tax-deferred accounts the existence of the accounts increases wealth and consumption inequality. Notice from table 1 that the Gini coefficient is increasing in contribution limit. Figure 3.3 shows the Lorenz curves for each of the three specifications.

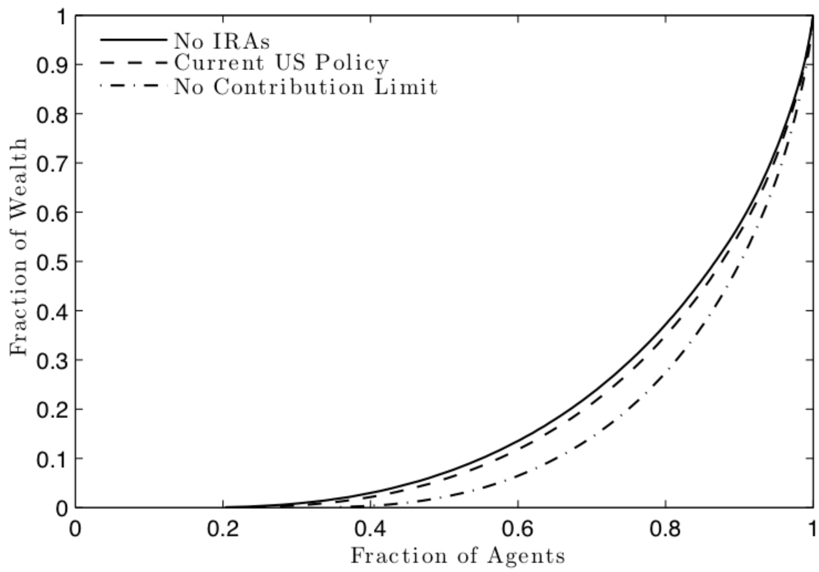

Figure 3.3: Lorenz curves

In addition to wealth inequality consumption inequality also increases. While for the individual volatility goes down, increasing welfare, for the economy the volatility of consumption is increasing. Figure 3.4 shows the volatility in consumption across age brackets. While Table 2.1 states the consumption volatility of individual agents goes down, economy-wide consumption volatility increases. This is due almost entirely to an increase in consumption volatility in retirement. tax-deferred retirement account policy thus result in a society of more unequal retirees.

Figure 3.4: Consumption volatility across agents

3.5 Extension: endogenous labor

Several issues remain given the above analysis. The gains are substantial: it would be difficult to justify current U.S. policy towards tax-deferred accounts using this general equilibrium analysis, as there are almost no losers even in transition. These substantial gains come even as the tax rate increases dramatically from 14% to 25% (the after-tax wage rate however does increase, from 0.58 to 0.65). Part of this is likely due to exogenously supplied labor. The tax is increasingly on this completely inelastic margin, becoming less distortionary. In a brief extension I allow individual labor supply to respond to changes in the tax and wage rates.

To do this I assume household preferences follow the functional form proposed by Greenwood, Hercowitz, and Huffman (1998). Agent utility becomes

$$E_0 \left[\sum_{t=1}^{T} \left(\prod_{i=1}^{t} \eta_i \right) \beta^t \frac{\left[c_t - \frac{l_t^{1+1/\epsilon}}{1+1/\epsilon} \right]^{1-\sigma}}{1-\sigma} \right].$$

All other elements remain the same except for an added labor supply function in the definition of equilibrium, $l(x,t)$. The labor market clearing condition becomes:

$$\sum_t \mu_t \int_x l(x,t) e(z,t) d\psi_t = L.$$

The particular functional form is adopted to simplify the quantitative analysis. Agents are already optimizing over the choice of two assets, so utility is specified to give a closed form solution for labor supply

$$l(x,t) = [(1-\tau)e(z,t)w]^{\epsilon},$$

where labor supply is independent of asset holdings and decision. Agents labor supply decisions respond to changes in the tax and wage rates according to the elasticity parameter ϵ.

I choose three values for ϵ to test the robustness of the exogenous labor supply results. Greenwood, Hercowitz, and Huffman (1998) suggest a value of 1.7, which I use as the baseline. The values 0.5 and 3.0 are also considered. These are within the bounds stated in Greenwood, Hercowitz, and Huffman (1998) for reasonable values. Mirroring the analysis of Figure 3.2, Figure 3.5

shows aggregate welfare change for a variety of contribution limits for each of the three values for ϵ.

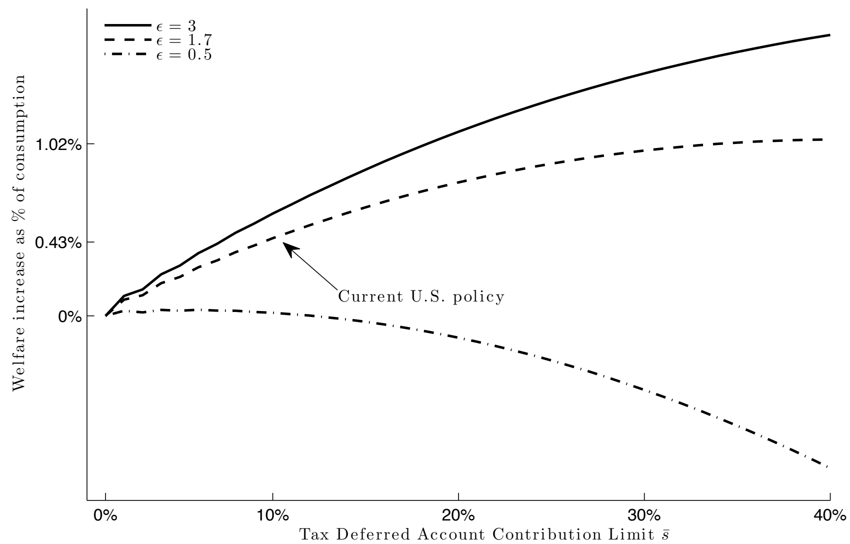

Figure 3.5: Increase in welfare, endogenous labor

Higher ϵ implies labor responds less to changes in tax rates (labor supply is less elastic to changes in taxes/wages). For the two specifications with lower elasticity the effect of tax-deferred accounts on welfare is the same as with inelastic labor: welfare is monotonically increasing in the contribution limit $\bar{s}$. However notice from Figure 3.5 also that the welfare improvement is decreasing in ϵ. For the most elastic specification tax-deferred accounts are unambiguously welfare decreasing.

Given these results it is not difficult to think that a more general specification of labor supply that allowed labor to react to wealth could generate an optimal positive contribution limit. Here labor supply does not depend on asset holdings, however individual asset holdings are substantially increasing as tax-deferred accounts are introduced. Adding the distortion to labor of increased asset accumulation would decrease again the welfare of such accounts. It is not difficult to think a specification for labor could be found that perfectly justifies this inclusion of limits.

Notice comparing Figure 3.2 and Figure 3.5 the level of welfare change is much more modest with endogenous labor. Instead of a 1.12% increase in lifetime consumption for all agents current U.S. policy only implies a 0.43% increase for the benchmark endogenous labor case, more than halving the benefit. For the optimal policy of no contribution limit the benefit almost quarters from 3.74% to 1.03%. Distortions to labor supply due to tax and wage rate changes absorb most of the benefit of IRAs, however these benefits still remain depending on the specification of utility with respect to labor.

Table 2.3 gives the results for the benchmark endogenous labor specification of $\epsilon = 1.7$. The results of the exogenous labor model still hold although with reduced magnitude. tax-deferred accounts improve welfare while increasing inequality, although to a lesser extent than before.

3.6 Conclusion

I presented a general equilibrium model of agents who save to insure agents fluctuations in income and for retirement who are able to save either on conventional account of tax-deferred accounts. I find that the introduction

Table 3.3: Steady state equilibria, endogenous labor

	$\bar{s} = 0$	$\bar{s} = US$	$\bar{s} = \infty$
L	1.26	1.21	1.12
K	5.23	6.53	9.72
S	0.00	1.32	4.39
τ	0.16	0.20	0.32
r	0.05	0.04	0.01
w	1.03	1.26	1.43
$W(\bar{s})$	-243.77	-241.53	-239.59
Gini	0.37	0.42	0.50
vol(c_t^i)	95%	86%	77%

of such accounts has effects on both welfare and inequality.

Purely from a welfare viewpoint tax-deferred accounts are desirable policy. They increase welfare for almost all agents by a substantial degree. Not only this but the majority of the benefit of these accounts goes to agents with lower productivity. I find that the optimal policy would be to remove the contribution limit on retirement accounts entirely. These account however do increase inequality, both in wealth and consumption. This is shown through an increased Gini coefficient and an increase in the volatility of consumption across agents.

These results are robust to a simple specification for valued leisure that generates endogenous labor responding to changes in wage and tax rates. While endogenous labor reduces the effect of such accounts on both welfare and inequality for the benchmark calibration IRAs are still welfare improving, with no optimal contribution limit.

Appendices

Appendix A

Data Appendix

The data for chapter 1 is obtained from Kaminsky, Reinhart, and Végh (2004), who compiled a comprehensive cross-country panel for the main variables of interest from the IMF World Economic outlook (WEO) and IMF Government Financial Statistics (GFS) datasets. Output y is 'gross domestic product'. Consumption c is 'private consumption', which combines household consumption and non-profit institutions. Investment I is 'national gross fixed capital formation'. Public consumption g_c is 'consolidated general government consumption'. The series are deflated using the GDP deflator. I compute business cycle moments (volatilities, autocorrelations and correlations) on HP filtered (with parameter 100) natural logs of each GDP deflated variable, on the available time series for each country.

Political Polarization is based on interviews with respondents in 81 countries, compiled at the World Values Survey (Lindqvist and Östling, 2008). I use answers to the following question: 'How would you place your views on this scale? where 1 means agree completely with the left (People should take more responsibility to provide for themselves) and 10 means agree completely with the right (The government should take more responsibility)'. The measure of polarization is the standard deviation of responses per country.

Political Stability is obtained from Political Risk Services' (PRS) International Country Risk Guide dataset, the variable name is *G*overnment Stability'. I use the 1980-1990s average for this variable. Countries are assigned 'Government Stability' points based on an assessment of the governments ability to carry out its declared programs and its ability to stay in office using PRS' proprietary methodology.

Since data availability is not consistent across the four economic variables for individual countries, the period studied in each case reflects the longest time span for which I have complete data for that country. Sample lengths for each country are reported in Table A.1. I also dropped from the sample countries for which I had no Polarization data.

The data for chapter 2 uses the same sources as Barseghyan, Battaglini and Coate (2008). See their paper for a list of data sources and series construction techniques.

Table A.1: Sample lengths

Developed Economies		**Emerging Economies**	
Country	*Period*	*Country*	*Period*
Australia	1960-2003	Algeria	1969-2003
Austria	1965-2003	Bangladesh	1969-2003
Canada	1960-2003	Brazil	1977-2003
Finland	1965-2003	Chile	1966-2003
France	1970-2003	China	1981-2003
Germany	1979-2003	Dominican Republic	1969-2003
Ireland	1960-2003	Egypt	1969-2003
Italy	1965-2003	Indonesia	1969-2003
Japan	1960-2003	Iran	1969-2003
Netherlands	1960-2003	Jordan	1963-2003
New Zealand	1969-2003	Korea	1960-2003
Norway	1969-2003	Mexico	1969-2003
Portugal	1969-2003	Morocco	1969-2003
Spain	1969-2003	Pakistan	1963-2003
Switzerland	1969-2003	Peru	1969-2003
United Kingdom	1960-2003	Philippines	1969-2003
United States	1960-2003	South Africa	1966-2003
		Uganda	1982-2003
		Zimbabwe	1969-2003

Table A.2: Relative volatility of consumption, investment and public spending

Country	$\sigma(c)/\sigma(y)$	$\sigma(I)/\sigma(y)$	$\sigma(g_c)/\sigma(y)$	Polarization	Stability
Developed Economies:					
Australia	0.68	3.78	1.35	2.29	8.27
Austria	0.85	3.60	1.32	2.10	8.43
Canada	0.85	4.03	1.47	2.21	8.12
Finland	0.68	3.83	0.76	2.09	8.90
France	0.73	4.51	0.91	2.22	8.06
Germany	1.19	2.33	1.33	2.28	8.03
Ireland	1.11	4.10	1.58	2.28	8.88
Italy	0.96	3.58	1.96	2.21	7.15
Japan	0.56	2.69	2.01	1.85	8.06
Netherlands	1.23	3.64	1.58	1.86	8.62
New Zealand	1.20	3.75	1.73	2.27	7.88
Norway	1.81	4.8	1.58	1.91	8.04
Portugal	0.95	4.60	1.68	2.73	8.03
Spain	1.02	3.35	1.03	2.49	8.27
Switzerland	0.55	4.13	1.06	2.38	9.75
United Kingdom	1.15	4.39	1.37	2.19	8.26
United States	0.83	3.35	1.21	2.24	8.83
Mean	*0.96*	*3.79*	*1.41*	*2.21*	*8.33*
Emerging Economies					
Algeria	1.95	3.14	1.46	3.19	8.07
Bangladesh	1.03	1.53	3.60	3.35	5.88
Brazil	1.12	3.32	2.49	3.20	
Chile	1.20	5.85	1.99	2.80	7.30
China	1.22	2.29	1.19	2.87	8.38
Dominican Republic	1.31	3.39	7.51	3.17	6.76
Egypt	1.28	4.50	2.71	2.87	8.25
Indonesia	0.96	3.99	6.0	2.64	7.39
Iran	1.02	2.74	1.71	2.62	7.22
Jordan	1.16	2.60	4.19	2.95	8.16
Korea	1.00	4.18	2.28	2.39	7.70
Mexico	1.16	2.80	2.82	3.31	7.44
Morocco	1.04	3.98	2.40	3.51	8.77
Pakistan	1.53	4.08	2.64	1.65	7.20
Peru	0.91	3.11	2.74	2.86	6.06
Philippines	0.66	4.14	2.80	2.68	6.44
South Africa	1.93	5.03	3.99	3.06	7.73
Uganda	1.52	4.09	2.95	3.02	7.50
Zimbabwe	1.31	8.30	2.14	3.43	6.13
Mean	*1.23*	*3.85*	*3.03*	*2.92*	*7.39*

Appendix B

Proofs

B.1 Proof of Proposition 1.4.1

With logarithmic utility agent optimization implies

$$\frac{1}{c} = \beta \mathbb{E}\left[\frac{r'(1-\tau')}{c'}\right]$$

where the expectation is over both realization of TFP and party in power. Competitive firm behavior gives

$$r = \frac{\alpha y}{k}, \quad y = rk + w.$$

Using the guess $c = s(1-\tau)y$ (which from agent budget constraint implies $k' = (1-s)(1-\tau)y$) we have

$$\frac{1}{s(1-\tau)y} = \beta \mathbb{E}\left[\frac{\frac{\alpha y'}{k'}(1-\tau')}{s(1-\tau')y'}\right].$$

Simple inspection reveals $s = 1 - \alpha\beta$. Since $g = \tau y$, substitution of s and τ give

$$c = (1-\alpha\beta)(y-g), \tag{B.1}$$

$$k' = \alpha\beta(y-g). \tag{B.2}$$

Given agent optimization the current government's problem is

$$\max_{g_i} \ (1-\lambda_i)ln(c) + \lambda_i ln(g) + \beta \mathbb{E}_z[pV_i(z',k') + (1-p)W_i(z',k')]$$

subject to (B.4), (B.5). Here the expectation is taken only over the realization of the TFP shock z. V_i and W_i are defined as in the text, they are the equilibrium continuation values of remaining in power and losing power respectively for a given party of type i. The government's first order condition can be written as

$$-\frac{(1-\lambda_i)}{y-g_i} + \frac{\lambda_i}{g_i} = \alpha\beta^2\mathbb{E}_z[pV'_{k,i} + (1-p)W'_{k,i}]. \tag{B.3}$$

The equilibrium continuation values use equilibrium policy for g_i. Assume (as is later confirmed) that the equilibrium policy for g_i is $g_i = \lambda_i \eta y$. The derivative of the $V_i(z,k)$ is then

$$V_{k,i} = \frac{(1-\lambda_i)}{c}(1-\alpha\beta)\frac{\alpha y}{k}(1-\lambda_i\eta) + \frac{\lambda_i}{g}\frac{\alpha y}{k}\lambda_i\eta + \beta\mathbb{E}_z[pV_{k,i} + (1-p)W_{k,i}]\alpha\beta\frac{\alpha y}{k}(1-\lambda_i\eta).$$

We use the government's FOC (government optimality must hold in equilibrium) to eliminate the $\mathbb{E}_z[pV'_{k,i} + (1-p)W'_{k,i}]$ term. After canceling terms and then updating one period we have

$$V_{k,i} = \frac{\alpha}{k}\frac{1}{\eta} \ \Rightarrow \ \mathbb{E}_z[V'_{k,i}] = \frac{\alpha}{k'}\frac{1}{\eta}.$$

The derivative of W is slightly more complex because the government's FOC cannot be used to directly cancel the value function derivatives next period. It is

$$W_{k,i} = \frac{(1-\lambda_i)}{c}(1-\alpha\beta)\frac{\alpha y}{k}(1-\lambda_j\eta) + \frac{\lambda_i}{g}\frac{\alpha y}{k}\lambda_j\eta + \beta\mathbb{E}_z[(1-p)V_{k,i} + pW_{k,i}]\alpha\beta\frac{\alpha y}{k}(1-\lambda_j\eta)$$

where $g_j = \lambda_j \eta$ is the policy of the opposing party j. We know the value of $\mathbb{E}_z[V_{k,i}]'$ and we can solve for $\mathbb{E}_z[W_{k,i}]'$ from (B.3). It is

$$\mathbb{E}_z[W'_{k,i}] = \left[\frac{1}{\alpha\beta^2}\left[-\frac{(1-\lambda_i}{y'(1-\lambda_i\eta)} + \frac{1}{\eta y'}\right] - p\mathbb{E}_z[V_{k,i}]\right]\frac{1}{1-p}.$$

After some algebra this becomes

$$\mathbb{E}_z[W'_{k,i}] = \frac{1}{k'}\frac{1}{1-p}\left[\frac{1-\eta-p\alpha\beta}{\beta}\right].$$

Returning to $W_{k,i}$ and simplifying the first two terms we can write

$$W_{k,i} = \frac{\alpha}{k} + \beta\left[\frac{1}{k'}\frac{p}{(1-p)}\left[\frac{1-\eta-p\alpha\beta}{\beta}\right] + \frac{1}{k'}(1-p)\frac{\alpha}{\eta}\right]\alpha\beta\frac{\alpha y}{k}(1-\lambda_j\eta).$$

We have a closed form expression for k' when party j is in power, $k' = \alpha\beta(1-\lambda_j\eta)y$. Inserting this into the above equation allows us to simplify $W_{k,i}$ to

$$W_{k,i} = \frac{\alpha}{k}\left[1 + \frac{\alpha\beta(1-2p)}{(1-p)\eta} + \frac{p}{1-p}\frac{1-\eta}{\eta}\right].$$

Just like $V_{k,i}$ this can be updated by simply replacing k with k'; no expectation operator is necessary. The government's first order condition (B.3) using the equilibrium policy rule can then be written as

$$-\frac{(1-\lambda_i)}{(1-\lambda_i\eta)y} + \frac{\lambda_i}{\lambda_i\eta y} =$$
$$\alpha\beta^2\left[p\frac{\alpha}{\alpha\beta(1-\lambda_i\eta)\eta y} + (1-p)\frac{\alpha}{\alpha\beta(1-\lambda_i\eta)y}\left[1 + \frac{\alpha\beta(1-2p)}{(1-p)\eta} + \frac{p}{1-p}\frac{(1-\eta)}{\eta}\right]\right].$$

Notice here everything cancels except the primitives α, β, and p. After some more brief algebra we arrive at

$$\eta = \frac{1-2\alpha\beta p - \alpha^2\beta^2(1-2p)}{1-\alpha\beta(1-2p)}.$$

B.2 Proof of Proposition 1.4.2

Defining $\hat{c}_t = ln(c_t)$ and $\hat{y}_t = ln(y_t)$ we want to show that in this environment $Var(\hat{c}_t) > Var(\hat{y}_t)$. We know from above that

$$c_t = (1-\alpha\beta)(1-\lambda_t\eta)y_t, \tag{B.4}$$

$$k_{t+1} = \alpha\beta(1-\lambda_t\eta)y_t \tag{B.5}$$

where λ_t is the realization of the political shock in period t. Taking logs of equation (B.4) gives

$$ln(c_t) = ln(1-\alpha\beta) + ln(1-\lambda_t\eta) + ln(y_t),$$
$$\hat{c}_t = ln(1-\alpha\beta) + \hat{x}_t + \hat{y}_t.$$

with $\hat{x}_t = ln(1-\lambda_t\eta)$. Then

$$Var(\hat{c}_t) = Var(\hat{y}_t) + Var(\hat{x}_t) + 2Cov(\hat{x}_t, \hat{y}_t). \tag{B.6}$$

Using (B.5) and initial production y_0, $\hat{y}_t$ can be written as

$$\hat{y}_t = ln(z_t) + \alpha^t\hat{y}_0 + \sum_{k=1}^{t} \alpha^k ln(z_{t-k}) + \alpha^k ln(\alpha\beta) + \alpha^k\hat{x}_{t-k}.$$

Using this expression it is apparent that

$$Cov(\hat{x}_t, \hat{y}_t) = \sum_{k=1}^{t} \alpha^k Cov(\hat{x}_t, \hat{x}_{t-k}).$$

Now using

$$Cov(\hat{x}_t, \hat{x}_{t-k}) = \mathbb{E}[\hat{x}_t\hat{x}_{t-k}] - \mathbb{E}[\hat{x}_t)\mathbb{E}(\hat{x}_{t-k}[$$

and a symmetric two state process for λ (which implies $\hat{x}_t \in \{\hat{x}_H, \hat{x}_L\}$) we know the unconditional expectation for $\hat{x}_t$ is

$$\mathbb{E}[\hat{x}_t] = \mathbb{E}[\hat{x}_{t-k}] = 0.5\hat{x}_L + 0.5\hat{x}_H.$$

The joint expectation depends on the path from $t-k$ to t.

$$\mathbb{E}[\hat{x}_t\hat{x}_{t-k}] = \sum_i \sum_j Prob(\hat{x}_{t-k} = \hat{x}_j) Prob(\hat{x}_t = \hat{x}_i | \hat{x}_{t-k} = \hat{x}_j)\hat{x}_j\hat{x}_i.$$

Defining P as the transition matrix for $\hat{x}$, this expression becomes

$$\mathbb{E}[\hat{x}_t\hat{x}_{t-k}] = \sum_i \sum_j \; 0.5 \; P^k_{i,j} \; \hat{x}_j\hat{x}_i.$$

Where $P^k_{i,j}$ is the $\{i,j\}$ element of the transition matrix to the kth power. With re-election probability p the transition matrix[1]

$$P = \begin{pmatrix} p & 1-p \\ 1-p & p \end{pmatrix}, \qquad P^k = \frac{1}{2}\begin{pmatrix} 1+(2p-1)^k & 1-(2p-1)^k \\ 1-(2p-1)^k & 1+(2p-1)^k \end{pmatrix}.$$

Thus

$$\mathbb{E}[\hat{x}_t\hat{x}_{t-k}] = 0.5(\hat{x}_H^2 + \hat{x}_L^2)0.5[1+(2p-1)^k] - \hat{x}_H\hat{x}_L[(1-(2p-1)^k]0.5$$

Rearranging terms

$$Cov(\hat{x}_t, \hat{x}_{t-k}) = 0.5^2(2p-1)^k(\hat{x}_H - \hat{x}_L)^2$$

So we can rewrite (B.6) as

$$Var(\hat{c}_t) = Var(\hat{y}_t) + Var(\hat{x}_t) + 2\sum_{k=1}^{t} \alpha^k 0.5^2(2p-1)^k(\hat{x}_H - \hat{x}_L)^2.$$

[1] From Hamilton, J.D., 1994, *Time Series Analysis*, Princeton University Press.

B.3 Proof of Lemma 2.3.1

Starting with a statement of the problem derive government optimality conditions, using the expression for $V_b(b)$ from the text

$$\max_{b,\tau} \, (1-\lambda)[0.5(1-\tau)^2 z^2 - \beta b] + \lambda(\tau(1-\tau)z^2 + \beta b) + \beta V(b),$$

$$\text{F.O.C. } b: \quad -(1-\lambda) + \lambda - 4(1-\lambda')\left(\frac{z'^2 + \sqrt{z'^2 - 4b}}{z'^2\sqrt{z'^2-4b}} + \frac{1}{4}\right) = 0,$$

$$\text{F.O.C. } \tau: \quad -(1-\lambda)(1-\tau) + \lambda(1-2\tau) = 0.$$

These equations solve implicitly government policy b, τ. Notice debt only appears in the first order condition with respect to debt. Insert the persistence conditions $\lambda' = \lambda$ and $z' = z$ into this equation and then take the derivative of it with respect to the primitives z and λ,

$$-2 - 4\left(\frac{z'^2 + \sqrt{z'^2 - 4b}}{z'^2\sqrt{z'^2-4b}} + \frac{1}{4}\right) + 8(1-\lambda)(z^2-4b)^{-3/2}\frac{\delta b}{\delta \lambda} = 0$$

$$-\frac{2}{z^3} - \frac{1}{2}(z^2-4b)^{-3/2}(2z - 4\frac{\delta b}{\delta z}) = 0$$

Solving these for the unknown derivatives gives

$$\frac{\delta b}{\delta \lambda} = \frac{2z^{-3} + z(z^2-4b)^{-3/2}}{2(z^2-4b)^{-3/2}}, \tag{B.7}$$

$$\frac{\delta b}{\delta z} = \frac{1 + 2\left(\frac{z'^2+\sqrt{z'^2-4b}}{z^2\sqrt{z^2-4b}} + \frac{1}{4}\right)}{4(1-\lambda)(z^2-4b)^{-3/2}}. \tag{B.8}$$

Both (B.7) and (B.8) are positive. Recall that if there is a solution then is must be that $z'^2 - 4b > 0$. Thus any power of this value must also be positive. The value for z being positive and $\lambda \in 0, 1$ then imply that every element in the numerator and denominator of both equations is positive.

B.4 Proof of Lemma 2.3.2

From the proof of Proposition 1 the first order condition with respect to the tax rate τ is

$$-(1-\lambda)(1-\tau)+\lambda(1-2\tau)=0.$$

This allows a closed form expression for τ as

$$\tau=\frac{2\lambda-1}{3\lambda-1}.$$

Taxes are positive if and only if both numerator and denominator have the same sign. This occurs when $\lambda<1/3$ and $\lambda>1/2$ This expression for τ is then combined with the closed form for output from the labor supply relationship, $y=zl=z^2(1-\tau)$, to state output as a function of z and λ,

$$y=z^2\frac{\lambda}{3\lambda-1}.$$

With derivatives

$$\begin{aligned}\frac{\delta y}{\delta\lambda}&=-z^2\frac{1}{(3\lambda-1)^2},\\ \frac{\delta y}{\delta z}&=2z\frac{\lambda}{3\lambda-1}.\end{aligned}$$

Simple inspection reveals $\delta y/\delta\lambda$ is always negative. For $\delta y/\delta z$ to be positive all that is required is $(1-\tau)>0$. This however must be the case at an interior solution as $l>0\Rightarrow(1-\tau)>0$.

Appendix C

Numerical Implementation

The numerical implementation for the full models presented in chapters 1 and 2 consists of finding a fixed-point in the two equilibrium policy rules, i.e. $\mathcal{G}_i(z,k)$ and $\mathcal{H}_i(z,k)$ for chapter 1. Because of asymmetric preferences, stochastic productivity, and the importance of the transitional dynamics in determining the simulated moments of the model it is not enough to solve at steady states as in Klein, Krusell and Rios-Rull (2008). I require a global solution for the equilibrium rules. To accomplish this I make guesses at these rules and iterate on them using the agents' and government's first order conditions until convergence. Here discussion is limited to the model of chapter 1, however the solution method generalizes to the model without capital of chapter 2. The algorithm proceeds as follows:

1. Start with a sufficiently large grid for k and g.

2. Make "good" guesses for the functions $\mathcal{G}_i^N(z,k)$ and $\mathcal{H}_i^N(z,k)$ for each of the points on the grid of k, the realization of the shock z, and the party in power i. I use cubic spline interpolation to determine policy for off-grid values of k and also the derivatives of the policy functions that appear in the government's optimality condition.

3. Using these guesses and the current state solve the agent's Euler equation for k' at each state $\{k, z, i\}$ as well as level of g. This gives the function $H_i(z, k, g) = k'$.

4. The government of takes agent optimization H_i in the current period as given. The next step is to solve the government's first order condition for g given future policy $\mathcal{G}^N$ and $\mathcal{H}^N$ and current agent optimization H_i. The solution to this problem gives the updated guess for g policy, $\mathcal{G}_i^{N+1}(z, k) = g$.

5. Update the guess at equilibrium savings policy; $\mathcal{H}_i^{N+1}(z, k) = H_i(z, k, \mathcal{G}_i^{N+1}(z, k))$.

6. Repeat this process until $\max\{|\mathcal{G}_i^{N+1}(z, k) - \mathcal{G}_i^N(z, k)|, |\mathcal{H}_i^{N+1}(z, k) - \mathcal{H}_i^N(z, k)|\}$ is small enough.

Time-consistency introduces particular challenges to computation of the equilibrium. The government's problem is not in general a contraction and has significant non-convexities. To overcome the lack of contraction in a similar framework Ilzetski (2010) solves the finite horizon problem for a long horizon. I do not need to resort to this; in practice our program converges relatively quickly given our "good" initial guesses.

The advantage I have in solving the problem is the "good" initial guess of having a closed form solution given Assumption 1. Starting with an exact solution for the policy functions the parameters can be slowly adjusted to the desired calibration. This adjustment is done at times extremely slowly to maintain a contraction in the government's problem. For a grid of 60 points for k and 30 points for g I consistently achieve convergence of 1e-7.

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