Essays on Dynamic Macroeconomics: Debt, Taxation, and Policy Interaction

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Abstract

The macroeconomic theory of optimal fiscal and monetary policy based on the assumption of a 'benevolent dictator' has identified several key lessons which are thought to substantially improve the economic conditions of a nation (see Chari and Kehoe, 1999; Woodford, 2003): (i) Debt should be zero or negative in the long run, (ii) taxes on capital income should be zero in the long run or on average, and (iii) in the analysis of monetary policy, fiscal policy can largely be neglected. However, due to either distortions in the political process or market frictions beyond reach of policy makers, these optimal, welfare-enhancing policies are often not implemented as recommended by economic theory. The aim of this thesis is therefore twofold: First, to explain the gap between recommended and actually implemented policies and, second, to find mechanisms (or alternative policies) aimed at attenuating these deviations from optimality.

Chapter 2 studies welfare consequences of a soft borrowing constraint on sovereign debt which is modeled as a proportional fine per unit of debt exceeding some reference value. Debt is the result of myopic fiscal policy where the government is assumed to have a smaller discount factor than the private sector. In the absence of lump-sum taxation, debt reduces welfare. The chapter shows that the imposition of the soft borrowing constraint, which resembles features of the Stability and Growth Pact and which is taken into account by the policy maker when setting its instruments, prevents excessive borrowing. The constraint can be implemented such as to (i) control the long run level of debt, (ii) prevent debt accumulation, and (iii) induce debt consolidation. In all three cases the constraint enhances welfare and these gains outweigh the short run welfare losses of increasing the costs of using debt to smooth taxes over the business cycle by two orders of magnitude.

Why do governments tax capital in face of the benchmark of standard economic theory that capital ought to be untaxed? Chapter 3 provides a model of fiscal policy with endogenous labour, bonds, and capital in order to account for the observation that worldwide taxes on capital remain far from zero. It introduces policy myopia into an otherwise standard framework of optimal fiscal policy where the government can tax labour and capital income and shows, analytically for the case of quasi-linear preferences and numerically for the case of CRRA preferences, that policy myopia leads to empirically realistic tax rates on capital. Moreover, it is shown that the tax rate on capital increases as myopia increases. Finally, the chapter analyzes the effects of policy myopia on the conduct of fiscal policy over the business cycle.

Based on the theoretical analysis of Chapter 3, Chapter 4 presents empirical support for the hypothesis that higher political instability leads to an increase of the tax rate on capital income. The hypothesis is tested on a panel of annual observations for 13 OECD countries for the period 1964-1983. The main finding is that an increase of the index of political instability by one standard deviation leads to an increase of the tax rate on capital by about 1.8 percentage points. This effect is statistically and economically significant and robust against alternative sets of regressors and measures of the dependent variable, outlier correction, and alternative estimation strategies.

Chapter 5 (joint with Markus Kirchner) assesses the role of sovereign risk in explaining macroeconomic fluctuations in Turkey. We estimate two versions of a simple New Keynesian small open economy model on quarterly data for the period 1994Q3-2008Q2: A basic version and a version augmented by a default premium on government debt due to a perceived risk of sovereign debt default. Model comparisons clearly support the augmented version since it leads to stronger internal propagation and hence smaller shocks are required in order to reconcile the observed dynamics of nominal and real variables, leading to better forecasting performance. The results suggest that the augmented model may lead to a better understanding of macroeconomic fluctuations in emerging market economies that are subject to sovereign risk. In terms of policy implications, counterfactual experiments show that both more active monetary policy and stronger fiscal feedbacks from debt on taxes can lead to less volatile inflation and debt dynamics, but higher debt feedbacks on taxation additionally reduce expected default rates.

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Chapter 1

Introduction

In order to improve the economic well-being of a society, a central question in economics has always been how fiscal and monetary policy should be set over the business cycle and in the long run. With emergence of the New-Keynesian models, the macroeconomic profession has focused mainly on the role of monetary policy in managing fluctuations in demand and controlling inflation, leaving hardly any room for fiscal policy. As a result the literature on optimal taxation still seems of limited use for the study of many practical fiscal policy problems, which is in stark contrast to the usefulness of the literature on optimal monetary policy in the study of monetary policy problems.

The macroeconomic theory of optimal fiscal and monetary policy based on the assumption of a 'benevolent dictator' has identified several key lessons which, if followed by policy makers, are thought to substantially improve the economic conditions of a nation (see Chari and Kehoe, 1999; Woodford, 2003): (i) Debt should be zero or negative in the long run, (ii) taxes on capital income should be zero in the long run or on average, and (iii) in the analysis of monetary policy, fiscal policy can largely be neglected and an active interest rate policy stabilizes inflation. However, due to either distortions in the political process or market frictions beyond reach of policy makers, these optimal, welfare enhancing policies are often not implemented as recommended by economic theory. The aim of this thesis is therefore twofold: First, to explain discrepancies between recommended and actually implemented fiscal policies and, second, to find mechanisms (or alternative policies) aimed at attenuating these deviations from optimality. More precisely, the aim of the thesis is to answer the following four questions:

1. How can high levels of public debt and the associated welfare costs be reduced?
2. Why do governments tax capital in face of the benchmark of economic theory that capital ought to be untaxed?
3. Does political instability lead to capital income taxation?
4. What are the quantitative consequences of sovereign default believes for the fluctuations of emerging market economies?

Chapter 2 studies the welfare consequences of a sanction on excessive government debt. It shows that the introduction of such a sanction leads to welfare gains by preventing excessive borrowing in the long run. Chapter 3 provides a model of fiscal policy in an economy with capital. It shows that assuming a myopic government which sets the tax rates on labour and capital income leads to positive and empirically realistic capital tax rates. Chapter 4 provides empirical support for the hypothesis that political instability leads to capital taxation based on a panel of OECD countries. Using Bayesian methods, Chapter 5 assesses the quantitative role of sovereign default believes in explaining macroeconomic dynamics in Turkey, before Chapter 6 concludes.

The methodological framework in Chapters 2 and 3 is closely related. There has been a long debate among economists over the optimality of debt and taxes to finance government consumption. A widely used paradigm in this debate is that of the benevolent Ramsey planner, i.e. the planner who is fully benevolent and maximizes social welfare. The problem of the Ramsey planner is to choose the optimal sequences of taxes and transfers given that only distortionary tax instruments are available. However, key findings of this literature – zero debt and zero capital taxes in the long run – contrasts with the observed policies in most countries across the world where debt and capital taxes are positive and far from zero (see, for example, Mendoza, Razin, and Tesar, 1994; OECD, 2009).

In order to account for positive levels of government debt, in seminal contributions Persson and Svensson (1989) and Alesina and Tabellini (1990) show that if policy makers alter in office as the result of elections they will issue large amounts of debt. Chapters 2 and 3 build on the insights of this literature that political distortions can affect macroeconomic policy. The duration in power of real world governments is limited to several years, or at most decades. Hence, in both chapters the assumption is that the government is myopic which is modeled as a smaller government discount factor than that of the private sector. Policy myopia can be interpreted as an expected finite planning horizon of the government, as in Grossman and Van Huyck (1988). However, in both chapters the government is otherwise benevolent and applies the instantaneous utility function of the households. This set up allows working with the well developed analytical framework of the optimal taxation literature but provides a better understanding of actual fiscal policy outcomes.

In 2010 the average debt to GDP ratio of the OECD countries will reach 100%. In the absence of non-distortionary taxation, high levels of debt reduce social welfare due to the deadweight loss of the taxes needed to service that debt. Chapter 2 analyzes how debt and the associated welfare costs can be reduced. The model builds on Aiyagari, Marcet, Sargent, and Seppälä (2002) where, for the sake of realism, markets for government bonds are incomplete. The government is myopic which gives rise to a 'debt bias', following Kumhof and Yakadina (2007): The policy maker lowers tax rates in the near future which leads to positive levels of debt in the long run. To reduce the incentives for excessive borrowing, a soft borrowing constraint (SBC) on debt is introduced, as in Beetsma, Ribeiro, and Schabert (2008). It is modelled as a proportional fine per unit of debt exceeding some reference value and resembles features of the Stability and Growth Pact (SGP). The chapter shows that by setting the reference value to zero the long run level of debt can effectively be contained and it is possible to implement the same long run allocation as under the Ramsey planner-solution, leading to substantial welfare gains. The short run welfare costs of the SBC, due to a reduced flexibility of using debt debt to smooth taxes over the business cycle, are quantitatively negligible. These results reflect the conclusion of Lucas (2003) that welfare gains from improved long run policies exceed by far the potential from further improvements in short run policies. The chapter supports the proposals for maintaining or even strengthening the rules of the SGP. It also provides an argument for the inclusion of the debt break into the German Constitution or for the advocates of balanced budget rules.

While Beetsma, Ribeiro, and Schabert (2008) compare debt to deficit based constraints in a small open economy with a government which does not take into account the equilibrium reaction of the private sector when choosing policy, the main contribution of Chapter 2 is to show that a debt based constraint enhances welfare when the optimizing government takes into account both the existence of the constraint as well as the equilibrium reaction of the private sector. The chapter uses the well developed analytical framework of the Ramsey-planner which is used as a natural benchmark in order to compute the welfare consequences of the SBC, in the short run, during the period of transition, and in the long run.

While Chapter 2 focuses on debt and labour taxes, Chapter 3 analyzes fiscal policy with a focus on capital taxation. One of the most prominent results from the theory of optimal taxation in dynamic models is that capital income should not be taxed in the long run or on average (see Judd, 1985; Chamley, 1986; Zhu, 1992; Chari and Kehoe, 1999; Farhi, 2009). However, actual tax rates on capital income across the world remain far from zero. One possible explanations for this gap between theory and policy, put forward by Alesina and Rodrik (1994) in a model of endogenous growth, is redistribution of wealth. However, Perotti (1996) does not find empirical support for their hypothesis that higher inequality leads to higher taxes on capital income. In a model closely related to that of Chapter 2 but which now includes capital and capital income taxation, Chapter 3 introduces policy myopia as an alternative explanation for positive capital taxation. The main version of the model builds on Farhi (2009, forthcoming). In order to provide a realistic description of the instruments available to real world governments, the government can use only non-state-contingent bonds (as in Chapter 2) and capital taxes have to be set one period in advance, reflecting the implementation lag of fiscal policy. The model shows that if the government is myopic it levies a tax on capital income (which is zero under the Ramsey planner-solution). Intuitively, policy myopia implies that the government prefers nearby utility more than the private sector which in turn leads to short term oriented fiscal policies. It is well know that a tax on capital is equivalent to an ever-increasing tax on future consumption, depressing the long run stock of capital. At the heart of this explanation is one of the oldest principles in economics which has however not been considered in this context before: Myopic governments care less about intertemporal distortions.

While Chapter 2 and 3 are methodologically closely related, Chapter 4 is inspired by Chapter 3 with regard to its content. Since policy myopia is inherently difficult to measure, the chapter uses an index of political instability to test the hypothesis that political instability leads to capital income taxation on a panel of annual observations of 13 OECD countries for the period 1964-1983. It uses two standard measures: The index of political instability of Gupta (1990) and the effective average tax rate on capital income of Mendoza, Razin, and Tesar (1994). The index contains events such as anti-government demonstrations, political strikes, and riots. These are expressions of discontent by the population with actual policies implemented by the incumbent government and are thus intimately linked to the perceived probability of the incumbent government of loosing office, as a proxy for policy myopia. The specification of the econometric model closely follows Swank and Steinmo (2002). Given the time-series and cross-sectional properties of the data set, the estimation procedure uses the Prais-Winsten transformation to remove serial correlation of the errors and panel corrected standard errors, following Beck and Katz (1995), to correct for contemporaneously correlated and cross-sectionally heteroskedastic errors. In order to account for the implementation lag of fiscal policy the main identifying assumption is that all explanatory variables enter the model with their first lag. The chapter shows that, on average, an increase of the index of political instability by one standard deviation leads to a statistically significant increase of the tax rate on capital by about 1.8 percentage points. This effect is robust to a large set of sensitivity checks.

The main contribution of the paper is to identify empirically political instability as a determinant of the tax rate on capital and thereby suggest a new channel for the well documented effect from political instability on investment and growth (see, for example, Alesina and Perotti, 1996; Alesina, Özler, Roubini, and Swagel, 1996).

Chapter 5 (co-authored with Markus Kirchner) analyzes how the presence of sovereign default believes affects the dynamics of nominal and real variables in emerging market economies. Standard New Keynesian models imply that movements in the short rate are associated one-for-one with movements in the expected growth of the marginal utility of the representative consumer and expected inflation. However, the empirical shortcomings of the Euler equation have lead researchers to include ad hoc risk-premium shocks into the Euler equation in both closed and open economy models (see, for example, Adolfson, Laséen, Lindé, and Villani, 2007; Smets and Wouters, 2007; Christoffel, Kuester, and Linzert, 2009; Justiniano and Preston, 2010). Chapter 5 focuses instead on endogenous default premia in order to improve both the forecasting performance of the current generation of models and their usefulness for policy analysis. The chapter presents a mostly standard model of a small open economy, as in Galí and Monacelli (2005), but including a fiscal authority which follows a tax rule, as in Schmitt-Grohé and Uribe (2007), with at least some feedback from higher debt levels on taxation. Following the argument of Schabert and van Wijnbergen (2010), the feedback rule may imply perceived infeasible rates of taxation where in such cases the government defaults on (part of) its outstanding debt, giving rise to an endogenous default premium.

The chapter outlines two variants of the model which differ only with respect to the existence of the expected default rate in the Euler equation. Both versions are estimated on quarterly Turkish data for the period 1994Q3-2008Q2 using Bayesian methods. The estimated expected default rate is highly debt-elastic, indicating that default fears are a relevant concern. Formal model comparisons between the two models clearly support the augmented version. In the basic model, large shocks are required in order to reconcile the observed dynamics of nominal and real variables. Accounting for sovereign risk leads to stronger internal propagation and better forecasting performance. Counterfactual experiments show that higher fiscal feedbacks from debt on taxation lead to stable debt and inflation dynamics, by reducing expected default rates. The main contribution of the paper is to show the quantitative importance of (endogenous) default premia on sovereign debt in explaining dynamics in emerging market economies. Moreover, recent concerns about fiscal solvency in Greece, Portugal or Spain suggest that this result may also have implications for developed economies.

Chapter 2

Myopic Governments and Welfare-Enhancing Debt Limits

This chapter studies welfare consequences of a soft borrowing constraint on sovereign debt which is modeled as a proportional fine per unit of debt exceeding some reference value. Debt is the result of myopic fiscal policy where the government is assumed to have a smaller discount factor than the private sector. In the absence of lump-sum taxation, debt reduces welfare. The chapter shows that the imposition of the soft borrowing constraint, which resembles features of the Stability and Growth Pact and which is taken into account by the policy maker when setting its instruments, prevents excessive borrowing. The constraint can be implemented such as to (i) control the long run level of debt, (ii) prevent debt accumulation, and (iii) induce debt consolidation. In all three cases the constraint enhances welfare and these gains outweigh the short run welfare losses of increasing the costs of using debt to smooth taxes over the business cycle by two orders of magnitude.

2.1 Introduction

How can high levels of debt and the associated welfare costs be reduced? In 2010 the average debt to GDP ratio of the OECD countries reaches 100%. [1] In the Euro Area this ratio was 70% already before the outset of the financial crisis.[2] In the absence of lump-sum taxation, high levels of debt reduce social welfare due to the deadweight loss of the taxes needed to service that debt.[3] This paper analyzes how debt and the associated welfare costs can be reduced. It first measures these costs. Then, it

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[1] See OECD (2009).

[2] See ECB (2009).

[3] See, for example, Elmendorf and Mankiw (1999).

proposes a legal restriction on fiscal policy and shows how such a restriction leads to an enhancement of social welfare.

According to standard economic theory, a benevolent government will use debt only to smooth taxes in response to budget fluctuations. In the long run debt should be near zero or even negative.[4] However, this prescription contrasts with the observed levels of sovereign debt in most OECD countries. To account for this observation, in the model the government is assumed to have an objective which differs from that of the representative household.

The set-up of the model is as follows. There are two distortions in the economy. First, following the standard approach of optimal fiscal policy, the government has only access to distortionary taxation in order to finance an exogenously given stream of government consumption. Second, introducing a political distortion, the government is myopic, i.e. it has a lower discount factor than the private sector, giving rise to a 'debt bias'. Myopia can be interpreted as the result of an expected finite planning horizon of the government. These two distortions combined are the source of welfare costs and provide the motivation for an analysis of a debt constraint. More specifically, the paper proposes a constraint on debt but where full compliance by the government is not ensured. The government can violate the constraint but this violation is associated with the payment of a fine. Rather than a hard 0/1 constraint on sovereign debt, the proposed mechanism hence constitutes a 'soft borrowing constraint' (SBC). The SBC resembles features of the Stability and Growth Pact (SGP) which is a particular example of such a mechanism. In the limit, i.e. for very high fines associated with a violation of the constraint, the SBC implies a balanced budget rule. The main contribution of the paper is to show that the proposed SBC enhances welfare in an economy where the optimizing government takes into account this SBC as well as the equilibrium reactions of households.

The model builds on Aiyagari, Marcet, Sargent, and Seppälä (2002). The government has access to flat rate taxes on labour income and issues one-period non-state-contingent bonds. For the sake of realism, markets for government bonds are thus incomplete. The government has to finance an exogenously given and stochastic stream of government consumption. I include the following two features into this

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[4] See, for example, Aiyagari, Marcet, Sargent, and Seppälä (2002).

set up.

First, the government is myopic. Myopia is modeled as a lower discount factor of the government than that of the private sector. Myopia can be interpreted as the result of an expected finite planning horizon which corresponds to the prospective duration of the government's survival in power, as in Grossman and Van Huyck (1988) and Kumhof and Yakadina (2007). The difference between the discount factors creates a debt bias: The policy maker lowers tax rates in the near future by issuing debt. In the long run, this policy leads to a positive level of debt which in turn requires higher taxes to finance higher debt servicing costs. Persson and Svensson (1989) and Alesina and Tabellini (1990), among others, model the political process which gives rise to the debt bias as a political conflict between different interest groups.[5] However, in the analysis of this paper I follow Grossman and Van Huyck (1988) and assume that the government is myopic but otherwise benevolent. This allows staying conceptually close to the standard normative approach of the Ramsey planner which can then be used as a natural benchmark to compute the welfare consequences of the SBC.

Second, following Beetsma, Ribeiro, and Schabert (2008), I introduce a SBC which is modeled as a proportional fine per unit of debt exceeding some reference value.[6] The SBC includes a threshold on debt which is taken into account by the government when maximizing its objective. However, the constraint can be violated by the government which then has to pay the associated fine. The reference value of debt and the tightness of the SBC are treated as if controlled by a supranational institution and are thus taken as given by the government. I show that the proposed SBC can bring down debt to zero in the long run and thereby eliminates the main source of welfare costs, namely positive levels of debt in steady state.

In the following four scenarios I analyze the effects of the SBC on welfare: First, I consider a shift of the steady state of the economy, relative to the benchmark steady state under Ramsey-optimal policy, that is due to myopic fiscal policy. For illustrational purposes and to obtain a quantitative impression of both stochastic and non-stochastic steady state effects of myopic fiscal policy I here neglect the period

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[5] See Alesina and Perotti (1994) for a review of the political economy of budget deficits.

[6] While this specification resembles features of the SGP, the aim is not to model the precise deficit procedure prescribed by the rules of the SGP.

of transition. For the baseline calibration myopic fiscal policy implies a level of debt to GDP of about 100%. This is associated with welfare costs of 0.353%, as measured by the equivalent variation.[7] Using figures for per capita income in the Euro-zone in 2009, these costs amount to about 60 euros per person per annum. I show that by setting the tightness of the SBC appropriately it can be ensured that the policy maker refrains completely from violating the SBC. In the long run, the level of debt can then effectively be contained by the reference value of debt, as specified in the SBC. By setting this reference value to zero, it is possible to implement the same allocation as in the non-stochastic steady state of the Ramsey planner solution and thereby prevent welfare losses of 0.353%.

Second, I consider a transition under perfect foresight from the steady state under Ramsey-optimal policy to the steady state under myopic fiscal policy. This transition is associated with debt accumulation up to 100% of GDP and implies welfare costs of 0.141%. I show that the imposition of the SBC from period zero onwards prevents a transition to the high debt steady state and thereby completely prevents the associated welfare costs.

Third, I consider a debt consolidating transition under perfect foresight, induced by the imposition of the SBC, from the state under myopic fiscal policy without SBC to the new steady state under a SBC. I show that for the optimal tightness of the SBC it is possible to induce debt consolidation from 100% of GDP to zero and that this implies welfare gains of 0.079%.

Finally, I look at the short run dynamics of myopic fiscal policy under a SBC which are compared to Ramsey-optimal policy and to a balanced budget regime as an alternative means to prevent excessive borrowing. Welfare costs of the SBC amount to 0.0010% as compared to Ramsey-optimal policy because the SBC increases the costs of using debt to smooth taxes over the business cycle. However, the SBC is slightly preferable to a balanced budget regime which implies welfare costs of 0.0011%.

The magnitude of the welfare costs in the four considered scenarios reflect the conclusion of Lucas (2003) that welfare gains from improved long run policies ex-

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[7] The equivalent variation is defined as the percentage of the consumption stream under Ramsey-optimal policy that would leave the representative household indifferent between the superior allocation under Ramsey-optimal policy and the inferior allocation under myopic fiscal policy.

ceed by far the potential from further improvements in short run policies.[8] The next section lays out the model and the policy problem. Section 2.3 presents the calibration and the welfare measure. Section 2.4 provides the results. Section 2.5 discusses the results and their sensitivity to alternative assumptions before Section 2.6 concludes.

2.2 The model

In this section, I first describe the economy and define the competitive equilibrium for a given policy. Then, I set up the policy problem and define the equilibrium under optimizing fiscal policy. Finally, I analyze the equilibrium and its steady state.

2.2.1 Private sector

The private sector consists of households, firms, and a financial intermediary. There is no population growth and no technological progress. All agents have rational expectations.

Households

Households are identical, infinitely-lived, and of mass one. The objective of a representative household is given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, n_t\right), \tag{2.1}$$

where c_t denotes consumption, n_t working time, $\beta \epsilon (0,1)$ is the discount factor, and $u(c,n)$ is additively separable. The household's total amount of time is normalized to one and is divided between working time and leisure. It earns the wage rate w_t and has to pay a flat-rate tax τ_t on labour income. The household can invest in

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[8] The numbers in case four are smaller than in Stockman (2001) who finds larger welfare costs associated with a balanced budget regime. However, he derives his results from an economy with capital and complete markets. Further, the role of balanced budget rules as an additional source of instability, as suggested by Schmitt-Grohé and Uribe (1997), is not considered in my welfare analysis. Finally, I do not consider benefits of government debt for households as in Aiyagari and McGrattan (1998).

one-period non-state-contingent government bonds b_{t+1} at the period t price $1/R_t$, where R_t is the gross rate of return. For the sake of realism, markets are thus incomplete like in Aiyagari, Marcet, Sargent, and Seppälä (2002). The budget constraint reads:

$$c_t + \frac{b_{t+1}}{R_t} + \Phi_t \leq (1 - \tau_t)\, w_t n_t + b_t + \pi_t, \tag{2.2}$$

where Φ_t are transaction costs which have to be paid to a financial intermediary when the household enters the capital market. They are assumed to have the following functional form:

$$\Phi_t = \frac{\phi}{2} y_t \left(\frac{b_{t+1}}{y_t} \right)^2 . \tag{2.3}$$

They are quadratic in the ratio of bond holdings over per capita output and proportional to GDP. Positive transaction costs ensure the existence of a well defined steady state for all policy cases considered in this paper (see Section 2.2.4). The main advantage of this functional form, which follows Schmitt-Grohé and Uribe (2003), Neumeyer and Perri (2005), and Kumhof and Yakadina (2007), is its analytical tractability. The transaction costs imply that an increase of the level of debt to GDP leads to an increase of the interest rate on government bonds. This implication commands broad empirical support (see Gale and Orszag, 2003, Engen and Hubbard, 2004, or Laubach, 2009). The firms' and financial intermediary's profits π_t are redistributed to the household in a lump-sum way.

The household maximizes (2.1) subject to (2.2) and (2.3). The first order conditions can be combined to

$$\begin{aligned} (1 - \tau_t)\, w_t u_{c,t} &= -u_{n,t} \qquad (2.4) \\ u_{c,t} \left(\frac{1}{R_t} + \phi \frac{b_{t+1}}{y_t} \right) &= \beta E_t u_{c,t+1}. \qquad (2.5) \end{aligned}$$

Moreover, the transversality condition holds: $\lim_{t \to \infty} \beta^{t+1} E_0 \left[u_{c,t+1} b_{t+1} \right] = 0$. Equation (2.5) shows that an increase of the ratio of debt to GDP tends to increase the interest rate via an increase of transaction costs.

Firms and financial intermediary

Competitive firms produce with the linear production function $y_t = a_t n_t$, where a_t denotes productivity which follows an exogenously given stochastic process. They pay a wage rate equal to the marginal product of labour: $w_t = a_t$. The financial intermediary has zero marginal and fixed costs and since firms make zero profits $\Phi_t = \pi_t$ holds.

2.2.2 Government and resource constraint

The government has to finance an exogenously given and stochastic stream of government consumption g_t. It has access to flat-rate taxes on labour income and issues one-period non-state-contingent bonds. The government's objective is described in detail in the next subsection.

I introduce a constraint on the public debt which takes the form of a soft borrowing constraint (SBC). In particular, the government has to pay a fine to a supranational institution whenever beginning of period debt b_t exceeds a time-invariant reference value, denoted by b^{ref}. The debt based criterion of the SGP, which specifies that the level of total government debt should not exceed 60% of GDP, could be interpreted as an example of such a SBC. The tightness of the SBC is governed by the policy parameter κ. Let the SBC be denoted by f_t, it is given by

$$f_t = \kappa \left(b_t - b^{ref} \right) I \left[b_t ; b^{ref} \right], \tag{2.6}$$

where the indicator function is given by

$$I \left[b_t ; b^{ref} \right] = \begin{cases} 1 & if \quad b_t > b^{ref} \\ 0 & if \quad b_t \leq b^{ref} \end{cases}. \tag{2.7}$$

The fine has only to be paid if the level of debt exceeds the reference value b^{ref}. The government does not receive subsidies for levels of debt below b^{ref}. The SBC allows for transitory as well as permanent deviations from b^{ref}. For $\kappa \rightarrow \infty$ the SBC converges to a balanced budget rule. The policy parameters κ and b^{ref} are treated as if controlled by the supranational institution, like in case of the SGP. They are taken as given by the government. The aim of the following analysis is to assess the effects of the SBC and to determine the optimal values for κ and b^{ref}. The government budget constraint reads

$$g_t + b_t = \frac{b_{t+1}}{R_t} + \tau_t w_t n_t - f_t. \tag{2.8}$$

Since the fine payments are assumed to be made to the supranational institution, they are resource costs to the economy.[9] The resource constraint of the economy is given by

$$y_t = c_t + g_t + f_t. \tag{2.9}$$

Now, for a given government policy (which will be determined in detail below), a competitive equilibrium can be defined as follows:

Definition 2.1. *For a given government policy* $\{b_t, \tau_t\}_{t=0}^{\infty}$ *satisfying the government budget constraint (2.8), a competitive equilibrium is a set of sequences* $\{c_t, n_t, f_t, R_t, w_t, y_t, \Phi_t, \pi_t\}_{t=0}^{\infty}$ *satisfying (2.3)- (2.6), (2.9),* $y_t = a_t n_t$, $w_t = a_t$, $\Phi_t = \pi_t$, *and the transversality condition for given exogenous processes* $\{a_t, g_t\}_{t=0}^{\infty}$ *and an initial value* b_0.

2.2.3 Policy problem

Fiscal policy in the majority of OECD countries over the last few decades points to a 'debt bias'. One possible reason for the debt bias is that governments may not be reelected, and as a result may discount the future more heavily than the private sector. In order to account for this observation, I assume that the government is myopic, i.e. it has a smaller discount factor than the households, but that it is otherwise benevolent and applies the instantaneous utility function of the households. The objective of the government is then given by

$$E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \, u\left(c_t, n_t\right), \tag{2.10}$$

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[9] In Section 2.5, I discuss the alternative of introducing the fine at a national level (for example by changing the constitution by the required majority) and redistributing it to the household in a lump-sum way.

where $0 \leq \gamma \leq 1$. Myopia can be interpreted as the result of an expected finite planning horizon of the incumbent government corresponding to the expected duration in power, following Grossman and Van Huyck (1988). In a quarterly model, the term $h = 1/\left[4\left(1-\gamma\right)\right]$ can then be interpreted as the expected planning horizon in years.

If $\gamma = 1$, the objectives of the household and the government are identical (see 2.1 and 2.10) which gives the reference case of the fully benevolent Ramsey planner. If $\gamma < 1$ the two objectives differ and the government is myopic. A discount factor of $\gamma\beta < \beta$ makes the issuance of new debt relatively attractive for the government since it would be willing to pay a higher interest rate than that demanded by the household, giving rise to a debt bias. This framework is convenient for the purpose of this paper because it allows staying conceptually close to the standard approach of the Ramsey planner which can then be used as a natural benchmark to assess the welfare effects of the SBC.

The politically optimal plan of the government can then be derived as follows:

Definition 2.2. *To derive the politically optimal plan the government maximizes (2.10) over competitive equilibria by choosing sequences of tax rates* τ_t *and bonds* b_{t+1} *subject to the government budget constraint (2.8), given an initial value* b_0 *and exogenous processes* $\{a_t, g_t\}_{t=0}^{\infty}$.

There is a multiplicity of competitive equilibria indexed by different government policies. Definition 2.2 implies that the government picks the equilibrium which maximizes (2.10) and that the policy maker takes into account the existence of the SBC and the equilibrium reaction of the private sector.

To derive the politically optimal plan, I follow the methodology of the Ramsey primal approach. In particular, I derive a sequence of implementability constraints, following Aiyagari, Marcet, Sargent, and Seppälä (2002). To start, I substitute out prices R_t and w_t and taxes τ_t in the household's budget constraint (2.2) by using the household's first order conditions (2.4) and (2.5), which yields

$$c_t + b_{t+1}\left[\beta E_t \frac{u_{c,t+1}}{u_{c,t}} - \phi \frac{b_{t+1}}{y_t}\right] = \frac{-u_{n,t} n_t}{u_{c,t}} + b_t, \tag{2.11}$$

where I used that $\Phi_t = \pi_t$. Now, I iterate forward (2.11), apply the law of iterated expectations, and use the transversality condition which yields[10]

$$u_{c,t}b_t = E_t \sum_{j=0}^{\infty} \beta^j u_{c,t+j} \left[c_{t+j} + \frac{u_{n,t+j}n_{t+j}}{u_{c,t+j}} - \phi \frac{b^2_{t+1+j}}{y_{t+j}} \right]. \tag{2.12}$$

Incomplete markets imply that at the end of each period the government has to form new expectations, depending on the realization of shocks today, of the future state of the economy. This in turn implies that the price of debt R_t as well as the expected present value of the budget surplus depends on the formed expectations and the realization of shocks today.[11]

The reaction of the private sector to the government's policy is summarized by (2.12). Using (2.6) and $y_t = a_t n_t$, the resource constraint of the economy reads

$$a_t n_t = c_t + g_t + \kappa \left(b_t - b^{ref} \right) I \left[b_t ; b^{ref} \right]. \tag{2.13}$$

Equations (2.12) and (2.13) summarize the restrictions on the set of allocations the government can achieve.

Let η_t and α_t denote the Lagrange multipliers on the resource and implementability constraints, respectively. The policy maker maximizes (2.10) s.t. (2.12) and (2.13):

$$\begin{aligned} \mathcal{L} \;=\; & E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \left\{ u\left(c_t, n_t\right) \right. \qquad (2.14) \\ & + \eta_t \left(a_t n_t - c_t - g_t - \kappa \left(b_t - b^{ref} \right) I \left[b_t ; b^{ref} \right] \right) \\ & \left. + \, \alpha_t \left(E_t \sum_{j=0}^{\infty} \beta^j u_{c,t+j} \left[c_{t+j} + \frac{u_{n,t+j}n_{t+j}}{u_{c,t+j}} - \phi \frac{b^2_{t+1+j}}{a_{t+j}n_{t+j}} \right] - u_{c,t}b_t \right) \right\}. \end{aligned}$$

Since the problem in (2.14) exhibits a discontinuity due to the presence of the indicator function $I\left[b_t ; b^{ref}\right]$, I approximate the indicator function with a continuous

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[10] For a derivation of the sequence of implementability constraints see Appendix 2.A.

[11] In the case of complete markets, the debt payoff can be conditioned on the state of the economy such that the present value of the future surplus across different current states is known in advance and might differ across current states. This flexibility of the contract between the government and the household implies that it is possible to reduce the set of constraints in (2.12) to one single implementability constraint as of period zero. In other words, under complete markets the government can construct a state contingent plan which ensures solvency as of period zero. Under incomplete markets instead, the government has to adjust its plan, i.e. the present value of the surplus, each period in response to the realized state of the economy such as to ensure solvency.

transition function which allows applying standard local approximation methods.[12] In particular, I use the logistic function, which has been used in, for example, Bayoumi, Goldstein, and Woglom (1995) to model nonlinearities:

$$L_t \equiv L_t\left(\delta, b_t, b^{ref}\right) = \frac{1}{1+\exp\left(-\delta\left(b_t - b^{ref}\right)\right)}, \qquad \delta > 0, \tag{2.15}$$

with $L_t > 0$ and $\frac{\partial L_t}{\partial b_t} > 0$. For $\delta \rightarrow \infty$, $L_t\left(\delta, b_t, b^{ref}\right) \rightarrow I\left[b_t; b^{ref}\right]$.

Since the infinite double sum in (2.14) complicates the analysis of the policy problem, I rewrite the Lagrangian recursively, following Aiyagari, Marcet, Sargent, and Seppälä (2002). I define a new stochastic multiplier $\mu_t = \mu_{t-1}/\gamma + \alpha_t$, where $\mu_{-1} = 0$. The infinite double sum can then be written recursively as[13]

$$E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \alpha_t E_t \sum_{j=0}^{\infty} \beta^j s_{t+j} = E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \mu_t s_t, \tag{2.16}$$

where $s_{t+j} \equiv u_{c,t+j}\left(c_{t+j} + \frac{u_{n,t+j}n_{t+j}}{u_{c,t+j}} - \phi\frac{b^2_{t+j+1}}{a_{t+j}n_{t+j}}\right)$. Using (2.15) and (2.16), the Lagrangian in (2.14) can be written as

$$\begin{aligned} \mathcal{L} \ = \ & E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \left\{ u\left(c_t, n_t\right) \right. \\ & + \eta_t \left[a_t n_t - c_t - g_t - \kappa\left(b_t - b^{ref}\right) L_t\right] \\ & \left. + \mu_t \left[u_{c,t}c_t + u_{n,t}n_t - u_{c,t}\left(\phi\frac{b^2_{t+1}}{a_t n_t} + b_t\right)\right] + \frac{\mu_{t-1}}{\gamma} b_t u_{c,t} \right\}. \end{aligned} \tag{2.17}$$

---

[12] Moreover, a continuous transition function seems to be in accordance with reality where strict constraints usually do not exist. Consider, for example, the case of a debt contract. Usually, it is always possible to find some lender, no matter what the existing level of debt of the borrower or its capacity to pay-back the new debt are. To find such a lender is just a question of the size of the offered interest rate in the contract (which may indeed by a highly non-linear function in the level of debt or the capacity to pay-back that debt).

[13] For a derivation of (2.16) see Appendix 2.B.

The first order conditions to (2.17) w.r.t. c_t, n_t, and b_{t+1} are

$$\begin{aligned}
\eta_t &= u_{c,t} + \mu_t \left[u_{cc,t} c_t + u_{c,t} - u_{cc,t} \left(\phi \frac{b_{t+1}^2}{a_t n_t} + b_t \right) \right] + \frac{\mu_{t-1}}{\gamma} b_t u_{cc,t} && (2.18) \\
0 &= u_{n,t} + \eta_t a_t + \mu_t \left(u_{nn,t} n_t + u_{n,t} + u_{c,t} \phi \frac{b_{t+1}^2}{a_t n_t^2} \right) && (2.19) \\
0 &= \mu_t u_{c,t} \frac{2\phi b_{t+1}}{a_t n_t} + \gamma \beta E_t \left(\eta_{t+1} \frac{\partial \left[\kappa \left(b_{t+1} - b^{ref} \right) L_{t+1} \right]}{\partial b_{t+1}} + \mu_{t+1} u_{c,t+1} - \frac{\mu_t}{\gamma} u_{c,t+1} \right) && (2.20)
\end{aligned}$$

where

$$\frac{\partial \left[\kappa \left(b_{t+1} - b^{ref} \right) L_{t+1} \right]}{\partial b_{t+1}} = \kappa L_{t+1} \left(1 + \delta \left(b_{t+1} - b^{ref} \right) e^{-\delta \left(b_{t+1} - b^{ref} \right)} L_{t+1} \right). \quad (2.21)$$

Now, an equilibrium under the politically optimal plan can be defined as follows:

Definition 2.3. *An equilibrium under the politically optimal plan is a set of sequences* $\{b_t, c_t, n_t, \eta_t, \mu_t\}_{t=0}^{\infty}$ *satisfying (2.11), (2.13) with* $I\left[b_t; b^{ref}\right] \approx L_t$, *and (2.18)- (2.20) for given exogenous processes* $\{a_t, g_t\}_{t=0}^{\infty}$ *and initial values* b_0 *and* $\mu_{-1} = 0$.

For $\gamma = 1$, Definition 2.3 implies the optimal policy of the Ramsey planner. For $\gamma < 1$, fiscal policy is still optimizing but optimization occurs with respect to the policy maker's own objective. In the following analysis, I refer to the case of $\gamma = 1$ as Ramsey-optimal policy and to the case of $\gamma < 1$ as myopic fiscal policy. In both cases, the government adheres to commitments made in the past when choosing policy (see, for example, Chari and Kehoe, 1999).

2.2.4 Equilibrium and steady state analysis

In this subsection, I analyze the equilibrium properties under Ramsey-optimal policy and myopic fiscal policy in order to show the main differences between the two regimes and to illustrate the effects of the transaction costs and the SBC. The non-stochastic steady state is defined as the long-run equilibrium in absence of shocks and where all endogenous variables grow with a constant rate equal to zero. I drop the time subscript of a variable to denote its non-stochastic steady state, henceforth.

First, I illustrate the effects of γ and ϕ in the model without SBC, i.e. where $\kappa = 0$. In (2.20) we see how the policy maker equates the budget relaxing effect of issuing new debt to the associated higher expected fine and transaction costs. For the case of Ramsey-optimal policy and $\phi = 0$ (and $\kappa = 0$) equation (2.20) indicates the existence of a unit root as in Barro (1979):

$$\mu_t u_{c,t+1} = E_t \left[\mu_{t+1} u_{c,t+1}\right]. \tag{2.22}$$

Equation (2.22) shows that under incomplete markets and no transaction costs the allocation and in particular welfare depend on initial conditions and not only on policy. To remove the unit root from the system, I thus assume that $\phi > 0$. Then, the non-stochastic steady state is independent of initial conditions and it is possible to compare welfare under the different regimes.

Next, I consider the case of myopic fiscal policy and $\phi > 0$ (while $\kappa = 0$ throughout). Then, (2.20) can be used to illustrate the effect of γ and ϕ on the level of debt. In the non-stochastic steady state it implies

$$\frac{b}{y} = \frac{(1-\gamma)\beta}{2\phi}.$$

For $\gamma = 1 \Rightarrow b/y = 0$ which gives the reference case of Ramsey-optimal policy with zero debt. If $\gamma < 1 \Rightarrow b/y > 0$. Myopia leads the government to cut taxes and issue debt. This policy continues until the increase in transaction costs and the associated rise of the interest rate close the gap between the discount factors of the government and the household. In the long run this policy leads to a positive level of debt.[14] For $\phi \to 0 \Rightarrow b/y \to \infty$. Without the SBC, b/y is thus determined by the size of γ and ϕ. Accordingly, the second purpose of $\phi > 0$ (next to the elimination of the unit root) is to ensure a well defined steady state under myopic fiscal policy without SBC by preventing the path of debt to be explosive.

Now, I analyze the effects of the SBC, i.e. $\kappa > 0$. For the case of myopic fiscal policy under a SBC (and keeping $\phi > 0$), in the non-stochastic steady state (2.20) implies

$$\frac{b}{y} = \frac{(1-\gamma)\beta}{2\phi} - \frac{1}{2\phi}\left(\frac{\gamma\beta\eta}{\mu u_c}\right)\frac{\partial\left[\kappa\left(b - b^{ref}\right)L\right]}{\partial b}. \tag{2.23}$$

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[14] With positive debt in steady state fiscal policy needs to generate surpluses in order to finance permanent interest payments. This is the reason why I do not consider a deficit criterion in this model.

The second term on the RHS gives the effect of the SBC on b/y. Given that $\kappa > 0$, $\frac{\partial\left[\kappa\left(b-b^{ref}\right)L\right]}{\partial b} > 0$ for $b > b^{ref}$. Moreover, $\left(\frac{\gamma\beta\eta}{\mu u_c}\right) > 0$ since marginal utility u_c and the Lagrange multipliers η and μ are strictly positive for binding resource and implementability constraints. Hence, (2.23) shows that the introduction of the SBC reduces b/y. Given that $\frac{\partial\left[\kappa\left(b-b^{ref}\right)L\right]^2}{\partial b\partial\kappa} \geq 0$ (see 2.21), this effect is stronger for higher values of κ, i.e. for a tightening of the SBC. Hence, in choosing appropriate values of κ and b^{ref} the supranational institution can try to outweigh the effects of myopia and implement the allocation under Ramsey-optimal policy with zero debt.

Finally, I consider the case of $\kappa > 0$ and no transaction costs, i.e. $\phi = 0$. Equation (2.20) implies

$$E_t\left[\eta_{t+1}\frac{\partial\left[\kappa\left(b_{t+1}-b^{ref}\right)L_{t+1}\right]}{\partial b_{t+1}} + \mu_{t+1}u_{c,t+1} - \frac{\mu_t}{\gamma}u_{c,t+1}\right] = 0,$$

and in steady state

$$\eta\frac{\partial\left[\kappa\left(b-b^{ref}\right)L\right]}{\partial b} = \mu u_c\left(\frac{1}{\gamma}-1\right).$$

Even for $\gamma = 1$, the first equation shows that the SBC ensures independence of initial conditions by removing the unit root from the system. The second equation implicitly gives the level of debt in steady state and indicates that the introduction of the SBC rules out explosive paths of debt. However, to be able to numerically compare welfare under myopic fiscal policy before and after the introduction of the SBC, I maintain the assumption of positive transaction costs throughout the analysis.

Now, I turn to an interpretation of (2.18). To simplify the comparison between the two regimes, I consider the case of log-utility here. Then, in the non-stochastic steady state (2.18) implies

$$\eta = \frac{1}{c} + \left(1-\frac{1}{\gamma}\right)\mu\frac{b}{c^2} + \mu\frac{\phi b^2}{c^2 an}, \tag{2.24}$$

with $0 \leq \gamma \leq 1$. Equation (2.24) provides information on η which measures in terms of utility the value attributed to a relaxation of the resource constraint in the long run. For the limiting case of $\phi \to 0$ the last term on the RHS vanishes. Under Ramsey-optimal policy $\gamma = 1$ and (2.24) reads $\eta = \frac{1}{c} = u_c$. Relaxations of the budget and the resource constraint are valued identically by the household and the policy maker. Under myopic fiscal policy $\gamma < 1$ which implies that $\left(1 - \frac{1}{\gamma}\right) < 0$ so that $\eta < u_c$ (given that $b, c, \mu > 0$). This inequality implies that, due to myopia, a relaxation of the resource constraint in the long run is valued less by the policy maker than a relaxation of the budget constraint by the household.

2.3 Calibration and welfare measure

2.3.1 Calibration

This subsection describes the baseline calibration of the model. All parameters are calibrated to a quarterly frequency. Government spending g_t and productivity a_t are assumed to follow independent stationary AR(1) processes in their logarithms

$$\begin{aligned} \ln g_t &= (1-\rho^g)\ln \overline{g} + \rho^g \ln g_{t-1} + \varepsilon_t^g \\ \ln a_t &= \rho^a \ln a_{t-1} + \varepsilon_t^a, \end{aligned}$$

where ε_t^g and ε_t^a are *n.i.d.* with mean zero. Following Schmitt-Grohé and Uribe (2007), the standard deviations of the innovations are $\sigma_{\varepsilon^g} = 0.016$ and $\sigma_{\varepsilon^a} = 0.0064$ and $\rho^g = \rho^a = 0.9$.

I set the expected planning horizon of the government h to twelve years. This value corresponds to three legislative periods and is supposed to loosely reflect the time in office of an average member of the executive authority. From $h = 1/\left[4\left(1-\gamma\right)\right]$ it implies a value of $\gamma = 0.979$. The single period utility function is of the form

$$u\left(c_t, n_t\right) = \frac{c_t^{1-\sigma} - 1}{1-\sigma} - \frac{\nu n_t^{1+\varphi}}{1+\varphi}. \tag{2.25}$$

The weight for working time in utility is $\nu = 4$ and σ and φ are set to unity. These values imply an equal division of the total time endowment into working time and leisure, for convenience.[15] In Section 2.5.2, I discuss alternative values for σ and φ. The household's discount factor is $\beta = 0.99$.

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[15] Since the model does not explicitly consdier growth, I do not confine the analysis to growth-consistent preferences.

In order to try replicating Ramsey-optimal policy where debt is zero in steady state (see Section 2.2.4), I set the reference value of debt in the SBC to $b^{ref} = 0$. To assess the effectiveness of the SBC, the policy parameter κ varies between 0 an 0.016. Given a steady state value of $y = n = 0.5$, the upper bound implies a fine of about 3% of GDP per unit of debt exceeding b^{ref}. The parameter governing the size of the transaction costs ϕ is set to 0.01. In steady state, this value implies an increase of the interest rate (which equals $R = 1.02073$ under myopic fiscal policy) of about four basis points on an annual basis when b/y increases by one percent. It is well within the estimates for the effect of debt on the government's borrowing costs (see Gale and Orszag, 2003, Engen and Hubbard, 2004, or Laubach, 2009). The parameter in the logistic function is set to $\delta = 300$ which gives a smooth approximation of the indicator function, as shown by Franses and van Dijk (2000). The value of government consumption $\bar{g}$ is set to 0.1 such as to obtain a ratio of $\bar{g}/y = 0.2$ under Ramsey-optimal policy, corresponding to the average share of government consumption in GDP in the OECD countries (see OECD, 2009b). In Section 2.5, I discuss the alternative of fixing the ratio $\overline{g/y}$ instead of the absolute value of $\bar{g}$ itself. Table 2.1 summarizes the parameter values of the baseline calibration.

Table 2.1: Parameter values of the baseline calibration to a quarterly frequency.

Parameter	Value	Description
β	0.99	Household discount factor
γ	[0.979;1]	Myopia
ν	4	Weight of labour in utility
σ	1	Inverse intertemporal elasticity of substitution
φ	1	Inverse Frisch labor supply elasticity
ρ^g	0.9	Serial correlation government consumption
ρ^a	0.9	Serial correlation productivity
σ_{ε^g}	0.016	St. dev. of innovation to gov. consumption
σ_{ε^a}	0.0064	St. dev. of innovation to productivity
$\bar{g}/y$	0.2	Government consumption to GDP
κ	[0;0.016]	Tightness of the SBC
b^{ref}	0	Reference value of debt in the SBC
ϕ	0.01	Transaction cost parameter
δ	300	Smoothness of the logistic function

2.3.2 Welfare measure

Since the steady state of the economy depends on policy, I use two methods to compute the welfare effects of myopic fiscal policy and the SBC. The first method considers pure shifts of the steady state of the economy, while the second method accounts for the period of transition between these. In both cases welfare is based on the representative household's utility. Following Jonsson and Klein (2003), in the first case welfare is measured as expected lifetime utility while in the second case it is measured as lifetime utility under perfect foresight.

Welfare under uncertainty

The first measure illustrates the size of welfare effects associated with pure shifts of both the stochastic and non-stochasti steady state under each regime. To start, I define the variable

$$V_t \equiv E_t \sum_{j=0}^{\infty} \beta^j u\left(c_{t+j}, n_{t+j}\right). \tag{2.26}$$

Following Schmitt-Grohé and Uribe (2007) and based on household utility (see 2.1), I then define welfare under Ramsey-optimal policy, denoted by R, conditional on the state of the economy in period $j = 0$ being the non-stochastic steady state associated with that regime and remaining under that regime forever as

$$V^R = E_t \sum_{j=0}^{\infty} \beta^j u\left(c^R_{t+j}, n^R_{t+j}\right), \tag{2.27}$$

where c^R_{t+j} and n^R_{t+j} denote the particular plans for consumption and working time under regime R. In the same way, I define welfare under myopic fiscal policy, denoted by M, as

$$V^M = E_t \sum_{j=0}^{\infty} \beta^j u\left(c^M_{t+j}, n^M_{t+j}\right), \tag{2.28}$$

where now c^M_{t+j} and n^M_{t+j} are functions of myopia γ.

Now, let λ^M denote welfare costs of myopic fiscal policy in terms of consumption. It is defined as the fraction of the Ramsey consumption process that a household would be willing to give up to be as well off under policy M as under policy

R:

$$V^M = E_t \sum_{j=0}^{\infty} \beta^j u \left(\left(1 - \lambda^M\right) c^R_{t+j}, n^R_{t+j} \right). \tag{2.29}$$

Using (2.25) with $\sigma = 1$, $\varphi = 1$, and $\nu = 4$ and rearranging terms yields

$$\begin{aligned} V^M &= E_t \sum_{j=0}^{\infty} \beta^j \left(\log \left[\left(1 - \lambda^M\right) c^R_{t+j} \right] - 2 \left(n^R_{t+j} \right)^2 \right). \qquad (2.30) \\ &= E_t \sum_{j=0}^{\infty} \beta^j \left(\log \left(1 - \lambda^M\right) + \log c^R_{t+j} - 2 \left(n^R_{t+j} \right)^2 \right) \\ &= \frac{\log \left(1 - \lambda^M\right)}{1 - \beta} + V^R \end{aligned}$$

Solving for λ^M gives

$$\lambda^M = 1 - \exp \left[\left(V^M - V^R \right) (1 - \beta) \right]. \tag{2.31}$$

To compute λ^M, I use the approximated policy functions for V^M and V^R. In particular, the solution to the system of equations of Definition 2.3 and (2.26) gives V_t as a function of endogenous and exogenous state variables x_t and a parameter scaling the standard deviations of the exogenous shocks $\omega : V\left(x_t, \omega\right)$ (see Schmitt-Grohé and Uribe, 2004). Using perturbation methods, a second-order approximation to V_t around the non-stochastic steady state, denoted by $\bar{x}$, yields

$$\begin{aligned} V\left(x_t, \omega\right) \approx\; & V\left(\bar{x}, 0\right) + V_x\left(\bar{x}, 0\right)\left(x_t - \bar{x}\right) + V_\omega\left(\bar{x}, 0\right)\omega + V_{x\omega}\left(\bar{x}, 0\right)\omega\left(x_t - \bar{x}\right) \\ & + \frac{1}{2} V_{xx}\left(\bar{x}, 0\right)\left(x_t - \bar{x}\right)^2 + \frac{1}{2} V_{\omega\omega}\left(\bar{x}, 0\right)\omega^2, \end{aligned}$$

where V_x and V_{xx} denote the first and second derivative w.r.t x_t, respectively, and where I used that in the non-stochastic steady state $\omega = 0$. To compute welfare, I evaluate $V\left(x_t, \omega\right)$ assuming that the initial state x_0 is equal the non-stochastic steady state $\bar{x}$, i.e. $x_0 = \bar{x}$ and $\omega = 0$:

$$V = V\left(x_0, 0\right) \approx V\left(\bar{x}, 0\right) + V_\omega\left(\bar{x}, 0\right)\omega + \frac{1}{2} V_{\omega\omega}\left(\bar{x}, 0\right)\omega^2.$$

Schmitt-Grohé and Uribe (2004) show that certainty equivalence also holds for a first-order approximation when using perturbation methods which implies that $V_{\omega}\left(\bar{x},0\right)=0$, yielding

$$V\left(x_0,0\right)\approx V\left(\bar{x},0\right)+\frac{1}{2}V_{\omega\omega}\left(\bar{x},0\right)\omega^2. \tag{2.32}$$

Up to first order accuracy, welfare is given by its non-stochastic steady state value $V\left(\bar{x},0\right)$, as can be seen from the RHS of (2.32). The second term on the RHS of (2.32) gives the shift of the level of $V\left(x_0,0\right)$ due to uncertainty and hence gives the difference between the non-stochastic and the stochastic steady state of that variable. The size of the shift depends on ω which in turn depends on the standard deviation of the innovations to factor productivity and government consumption, as calibrated in Section 2.3.1.

Finally, to obtain λ^M, I evaluate $V^M\left(x_t,\omega\right)$ and $V^R\left(x_t,\omega\right)$ in the state of the economy in period $j=0$ being the non-stochastic steady state associated with the respective regime, yielding V^M and V^R. Identical non-stochastic steady states imply that $V^M(\bar{x},0)=V^R(\bar{x},0)$. This is the case in the analysis of Section 2.4.3 where only business cycle effects are considered. To obtain the first and second order approximations to the policy functions, I use the software package *Dynare 4.1* for MATLAB.[16]

Welfare under perfect foresight

It takes time for the economy to move from one steady state to another and the measure in (2.31) neglects welfare effects during this period of transition. Therefore, I use a second method to measure welfare which accounts for the transitional period. To give a preview, using (2.31) I find that more than 99.8% of the welfare costs of myopic fiscal policy are due to a distorted non-stochastic steady state (see Section 2.4.1). Following Jonsson and Klein (2003), the second method thus considers only welfare effects under perfect foresight.

I define welfare under regime R as the discounted sum of household period utility under perfect foresight conditional on the state of the economy in period $j=0$ being the non-stochastic steady state associated with that regime and staying there forever:

$$W^R=\sum_{j=0}^{\infty}\beta^j u\left(c_{t+j}^R,n_{t+j}^R\right),$$

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[16] The software package is available at http://www.dynare.org.

where c^R_{t+j} and n^R_{t+j} denote consumption and working time under policy R. Welfare under a transition from the superior regime R to the inferior regime M is then simply defined as the discounted sum of household period utility conditional on the state of the economy in period $j = 0$ being the non-stochastic steady state associated with regime R, changing permanently to regime M in period $j = 1$, and taking into account the period of transition:

$$W^{RM} = \sum_{j=0}^{\infty} \beta^j u\left(c^{RM}_{t+j}, n^{RM}_{t+j}\right),$$

where c^{RM}_{t+j} and n^{RM}_{t+j} denote consumption and working time under this scenario. Then, welfare costs Λ^{RM} (in terms of consumption under regime R) associated with a permanent change from regime R to regime M are defined as in (2.30) but for the case of perfect foresight. For the given utility function they are given by

$$\Lambda^{RM} = 1 - \exp\left[\left(W^{RM} - W^R\right)(1-\beta)\right]. \tag{2.33}$$

To obtain W^{RM}, I exogenously change γ from $\gamma = 1$ to $\gamma = 0.979$ in period $j = 1$ and compute the deterministic path of transition between the two regimes, using *Dynare 4.1*.

2.4 Numerical analysis of the soft borrowing constraint

In this section, I analyze the effects of the SBC on welfare under the following four scenarios: (i) A shift, due to myopic fiscal policy and relative to Ramsey-optimal policy, of both the non-stochastic steady state and the stochastic steady state, neglecting the period of transition, (ii) a debt accumulating transition under perfect foresight from the steady state under Ramsey-optimal policy to the steady state under myopic fiscal policy without SBC, (iii) a debt consolidating transition under perfect foresight, induced by the introduction of the SBC, from the steady state under myopic fiscal policy without SBC to the steady state under myopic fiscal policy with SBC, and (iv) short run welfare costs of myopic fiscal policy with SBC relative to Ramsey-optimal policy.

2.4.1 Long run effects of myopia and the soft borrowing constraint

In this first scenario, I analyze the long run welfare effects of the SBC by first setting $\kappa = 0$ and computing welfare costs of myopic fiscal policy without SBC. Then, I introduce the SBC by setting $\kappa > 0$ and show that this enhances welfare.

Myopic fiscal policy without SBC: $\kappa = 0$

This subsection presents results closely related to Kumhof and Yakadina (2007). These results illustrate the effects of myopia before the introduction of the SBC, i.e. here I set $\kappa = 0$. Figure 2.1 depicts the steady states of the model's key variables for different values of myopia γ. In particular, γ varies between 0.979 (the value implied by the baseline calibration of a planning horizon of twelve years) and 1 (which implies Ramsey-optimal policy as $h \to \infty$).

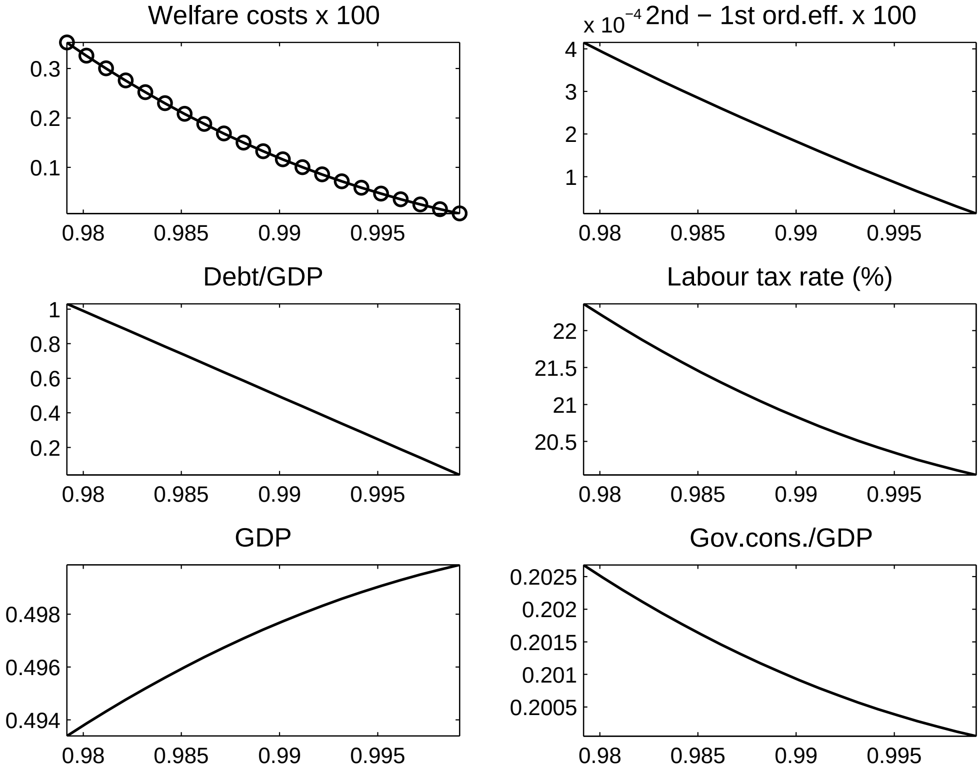

Figure 2.1: Effects of myopia on the steady state: $\gamma \in [0.979, 1]$. Upper left panel: solid line – non-stochastic steady state, circles – stochastic steady state.

The upper left panel shows welfare costs as defined in (2.31) and expressed as percentage: $\lambda^M \times 100$. As myopia increases welfare costs amount up to 0.353% of the Ramsey-optimal consumption stream. The solid line shows welfare costs when V^M and V^R are approximated up to first-order accuracy while the circles depict the approximation up to second-order accuracy. The two lines are virtually identical for the considered range of γ. The upper right panel depicts the difference between the two lines which increases as γ decreases. However, for the given calibration and $\kappa = 0.979$ the welfare costs due to a distorted stochastic steady state amount only to about 0.12% of total welfare costs. The utmost part of welfare costs, i.e. approximately 99.88%, is due to a distorted non-stochastic steady state. The other panels thus concentrate on the non-stochastic steady state.

In the middle left panel we see how the ratio of debt to GDP increases as myopia increases. For $\gamma = 0.979$ it amounts to 103%. As can be seen from the middle right panel, labour taxes increase from 20% to about 22% to finance the permanently higher debt servicing costs as debt increases.[17] This leads to an increase of the excess burden of taxation which reduces welfare. Higher tax rates depress working time and hence GDP (see lower left panel) and consumption. Since the level of government consumption is fixed, the ratio of government consumption to GDP increases.

In sum, a ratio of debt to GDP of 103% implies welfare costs of 0.353%. Second order welfare costs are negligible, as in Lucas (2003). Using figures for quarterly per capita income in the Euro-zone in 2009 and a share of 60% of final consumption in GDP, total welfare costs amount to about $7,000 \times 0.6 \times 0.00353 \approx 15$ euros per person per quarter. These numbers provide the rationale for the subsequent analysis finding the optimal κ.

Introducing the soft borrowing constraint: $\kappa > 0$

Now, I turn to an analysis of the long run welfare effects of the SBC by setting $\kappa > 0$. The aim is to determine the value for κ that reduces the long run level of debt and taxes, and hence welfare costs. I set the reference value of debt to $b^{ref} = 0$ in order to

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[17] Higher debt implies an increase of the interest rate. To illustrate that welfare costs are not only due to the increase of the interest rate, which is governed by the transaction cost parameter ϕ, I compute λ^M for the particular case of $\phi \rightarrow 0$. Holding the level of debt to GDP constant at the level implied by the baseline calibration, i.e. $b/y = 1.03$, and letting γ adjust endogenously, gives that for the limiting case of $\phi \rightarrow 0 \Rightarrow \lambda^M \rightarrow 0.162\%$ (where I set $\phi = 10^{-9}$ in the limit). Thus, in this particular case welfare costs are smaller as compared to the baseline calibration where $\lambda^M = 0.353\%$.

try replicating the non-stochastic steady state under Ramsey-optimal policy where $b = 0$ (see Section 2.2.4 and Figure 2.1), yielding the following parameterization of the SBC:

$$f_t = \kappa b_t L_t \left(\delta, b_t, b^{ref}\right) = \kappa b_t L_t \left(300, b_t, 0\right) = \frac{\kappa b_t}{1 + \exp\left(-300 b_t\right)}. \tag{2.34}$$

Figure 2.2 shows the steady states of the debt to GDP ratio, the tax rate, and the associated welfare costs for different values of $\kappa \in [0, 0.005]$, holding fixed $\gamma = 0.979$. As κ increases, welfare costs are reduced, as can be seen from the upper panel. As before, there is virtually no difference between first and second order approximations (depicted as a solid line and circles, respectively) to the policy functions of V^M and V^R.

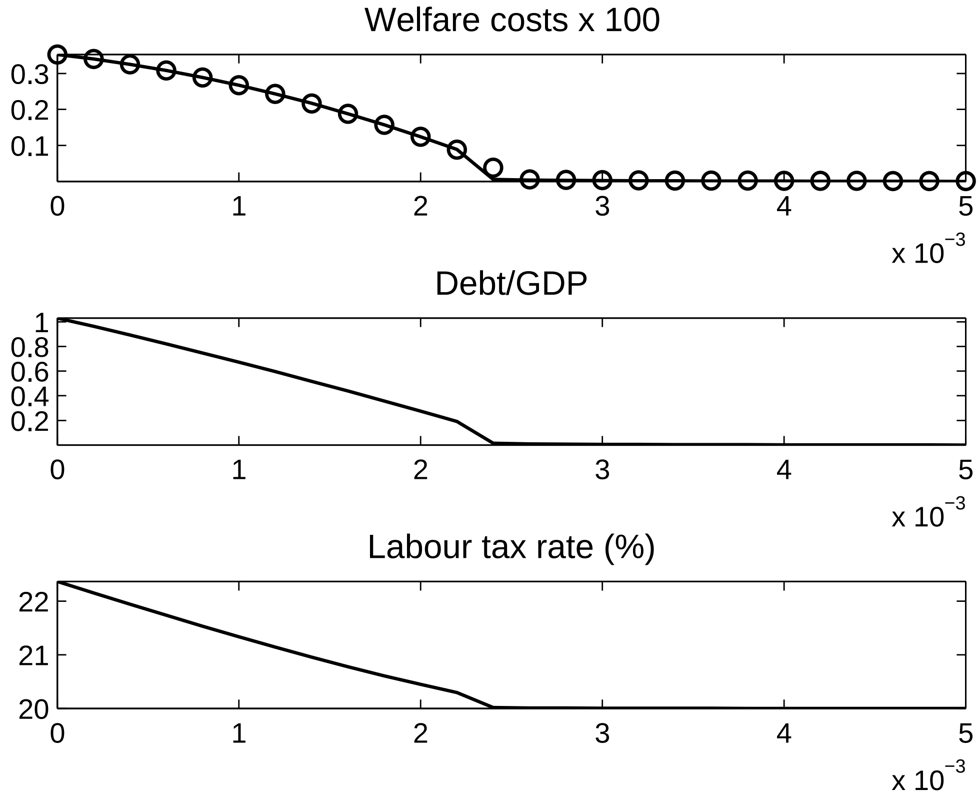

Figure 2.2: Effect of the tightness of the SBC on the steady state: $\kappa \in [0, 0.005]$.

A value of $\kappa > 0$ implies that the issuance of debt is associated with additional costs to the government which now has to pay a fine to the supranational institution for any $b > 0$. These costs increase as κ increases and induce a reduction of debt in steady state (see middle panel). In the lower panel we see that the tax rate can be reduced, and thus the deadweight loss, as steady state debt declines. The long run level of debt thus depends on the tightness of the SBC, i.e. on the value of κ. For the given calibration, $\kappa < 0.003$ is not sufficient to completely prevent excessive borrowing. However, for $\kappa \geq 0.003$ the incentive to reduce debt due to the presence of the SBC outweighs the effect of myopia. In particular, for $\kappa = 0.003$ the non-stochastic steady states under myopic fiscal policy under a SBC and under Ramsey-optimal policy are identical up to the third significant digit. This implies that 99.88% of the welfare costs associated with myopic fiscal policy can be prevented. Since GDP in steady state is approximately $y = n \approx 0.5$, a value of $\kappa = 0.003$ implies a fine on excessive debt of 0.6% of GDP per unit of debt exceeding b^{ref}. For any $\kappa \geq 0.003$ the steady state fine payments are zero because debt is at its reference value, i.e. $b = b^{ref} = 0$. In sum, the proposed SBC is an effective means to prevent excessive borrowing. It is possible to implement the same long run allocation as under Ramsey-optimal policy and thereby prevent the utmost part of the welfare costs of myopic fiscal policy.

2.4.2 Transitional dynamics under a soft borrowing constraint

Since it takes time for the economy to move from one steady state to another steady state, in this subsection I analyze how myopic fiscal policy and the SBC affect welfare when the period of transition is accounted for. I consider two scenarios: (i) A transition from Ramsey-optimal policy to myopic fiscal policy, and (ii) a transition from myopic fiscal policy without SBC to myopic fiscal policy under a SBC. The rationale for the analysis in (i) is to analyze the welfare consequences of myopic fiscal policy and the SBC with regard to the reference case of Ramsey-optimal policy when taking into account welfare effects during the debt accumulating period of transition. In (ii) the idea is to answer the following question: Given a level of debt to GDP of 103%, does the introduction of the SBC and the induced reduction of debt outweigh the costs of higher tax rates during the period of consolidation? Since welfare costs of a distorted stochastic steady state amount only to 0.12% of total welfare costs (see previous subsection), I consider a transition under perfect foresight in both cases, following Jonsson and Klein (2003). For the computations, I set $T = 5,000$.

Preventing debt accumulation

Figure 2.3 shows the debt accumulating transition from the steady state under Ramsey-optimal policy to the steady state under myopic fiscal policy. In period zero the economy operates under Ramsey-optimal policy with $\gamma = 1$. This regime is replaced by myopic fiscal policy with $\gamma = 0.979$ in periods $j = 1, \ldots, T$.

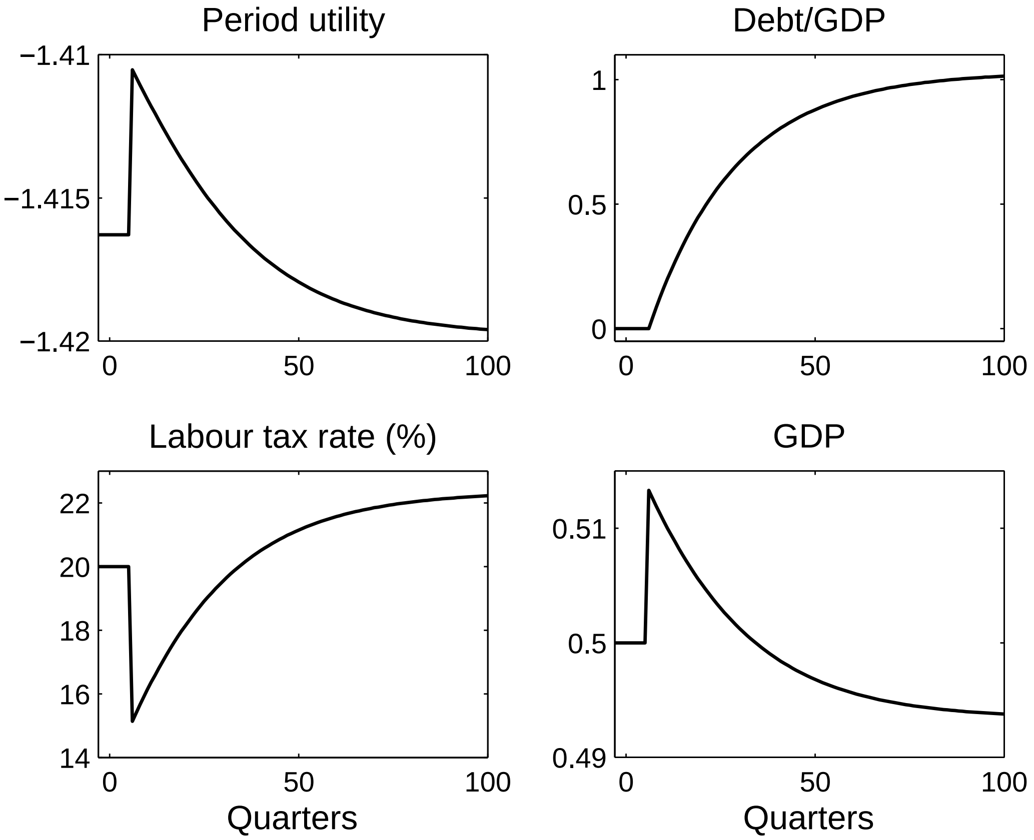

Figure 2.3: Transition under perfect foresight from the steady state under Ramsey-optimal policy (with $\gamma = 1$) to the steady state under myopic fiscal policy (with $\gamma = 0.979$).

As we can see from the figure, the transition is completed within about 25 years. At the beginning of the transition the government lowers tax rates and issues debt. This stimulates output and consumption and the household's period utility rises above its initial steady state for about 20 quarters. From then onwards, the tax rate is raised above its initial level to finance additional debt servicing costs as debt rises. In the long run, debt builds up to 103% of GDP.

The associated welfare costs of this transition under perfect foresight, as compared to staying under Ramsey-optimal policy, are defined in (2.33) and amount to

$$\Lambda^{RM} = \left(1 - \exp\left[\left(W^{RM} - W^{R}\right)(1-\beta)\right]\right) = 0.141\%.$$

This value is about half of the welfare costs as measured in the previous subsection where λ^M only considers steady state effects and does not account for the positive welfare effects in the first 20 quarters of the transitional period.

As the previous subsection showed, the long run level of debt is zero for $\kappa \geq 0.003$. Thus, by setting $\kappa \geq 0.003$ from period $j = 0$ onwards the supranational institution can ensure that the economy remains in the steady state under Ramsey-optimal policy.[18] There will be no transition to the steady state under myopic fiscal policy. Hence, in this scenario the introduction of the SBC avoids welfare losses of 0.141%.

Debt consolidation

Now, suppose that the ratio of debt to GDP is at its steady state value under myopic fiscal policy of 103%. This subsection addresses the question whether it is possible to increase welfare by imposing the SBC and thereby induce a consolidation of outstanding debt.

For three particular values of κ, Figure 2.4 shows the transition from the steady state under myopic fiscal policy without SBC (where $\kappa = 0$ and $\gamma = 0.979$) to the new steady state under myopic fiscal policy with SBC (where $\kappa > 0$ and $\gamma = 0.979$). In all three cases $b^{ref} = 0$ and $\kappa > 0$ from period $j = 1$ onwards. The figure shows the ratio of debt to GDP, the tax rate, and the fine payments (see 2.34) for the first 50 quarters. The time to reach the new steady state, the new steady state itself, and the shape of the transition path depend on the tightness of the SBC.

For $\kappa = 0.001$ (dashed line) the adjustment to the new steady state is smooth, tak-

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[18] This is numerically confirmed by setting $\kappa = 0.003$ for periods $j = 0, \ldots, T$ and $\gamma = 0.979$ for periods $j = 1, \ldots, T$.

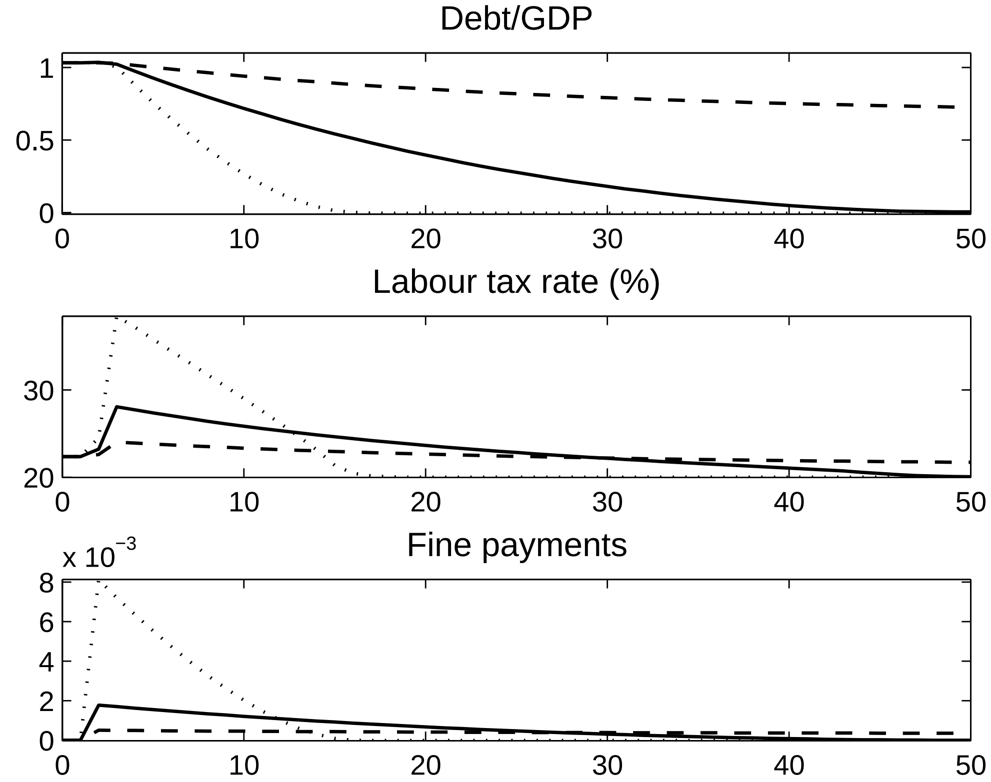

Figure 2.4: Debt consolidating transition from the steady state without SBC ($\kappa = 0$) to the steady state with SBC ($\kappa > 0$) for different values of κ: 0.001 (dashed line), 0.0035 (solid line), 0.016 (dotted line).

ing about 70 quarters. The level of debt remains at 67% in the long run because the incentive to reduce debt exerted by the SBC does not outweigh the effect of myopia. The tax rate increases slightly initially and a fraction of outstanding debt is paid back. The tax rate converges to a lower level in the long run. The fine payments to the supranational institution during the period of transition and in the long run are small due to the low value of κ. For $\kappa = 0.016$ (dotted line) the adjustment to the new steady state is completed within only 15 quarters. Debt is reduced to zero which implies a sharp increase of the tax rate. The fast pay-back of debt is induced by high fine payments. The solid line shows the consolidation for an intermediate value of κ. The question is, which is the welfare-enhancing value of κ that optimally weighs the induced short term costs of higher taxes during the period of consolidation to the long term benefits of lower taxes?

As before, I measure welfare costs of the inferior policy in terms of consumption of the superior policy. Since the conjecture is that welfare increases by introducing the SBC, welfare *costs* of remaining in the steady state without SBC and *not* consolidating are measured relative to a transition to the new steady state under a SBC. That is, positive welfare costs imply welfare gains of consolidation. Let welfare in the steady state without SBC be denoted by W^M and welfare under a particular path of consolidation be denoted by W^{sbc}, where M and sbc denote the respective regimes. W^M is defined as the discounted sum of household period utility under perfect foresight conditional on the state of the economy in period $j = 0$ being the steady state associated with regime M and remaining there forever:

$$W^M = \sum_{j=0}^{\infty} \beta^j u\left(c^M_{t+j}, n^M_{t+j}\right),$$

where c^M_{t+j} and n^M_{t+j} denote consumption and working time under regime M. Welfare of a transition from regime M to regime sbc is then defined as the discounted sum of household period utility conditional on the state of the economy in period $j = 0$ being the steady state associated with regime M, changing to regime sbc in periods $j = 1, \ldots, T$ and taking into account the period of transition:

$$W^{sbc} = \sum_{j=0}^{\infty} \beta^j u\left(c^{sbc}_{t+j}, n^{sbc}_{t+j}\right),$$

where c^{sbc}_{t+j} and n^{sbc}_{t+j} denote consumption and working time in case of consolidation. This definition implies that W^{sbc} is a function of κ. Then, for the given calibration, welfare costs of *not* consolidating are given by

$$\Lambda^{Msbc} = 1 - \exp\left[\left(W^M - W^{sbc}\right)(1-\beta)\right]. \tag{2.35}$$

Figure 2.5 plots $\Lambda^{Msbc} \times 100$ as a function of κ. The two intersections of this function with the x-axis are given at 0.0015 and 0.014, respectively, which implies that for any value in between not consolidating implies welfare costs. Put differently, the introduction of the SBC and the induced reduction of debt enhance welfare if the tightness of the SBC is set to $\kappa \in (0.0015, 0.014)$. The maximum welfare gain from a consolidation equals $\Lambda^{Msbc} = 0.079\%$ and is obtained for $\kappa = 0.0035$, which implies a fine of approximately 0.7% of GDP per unit of debt exceeding b^{ref}.

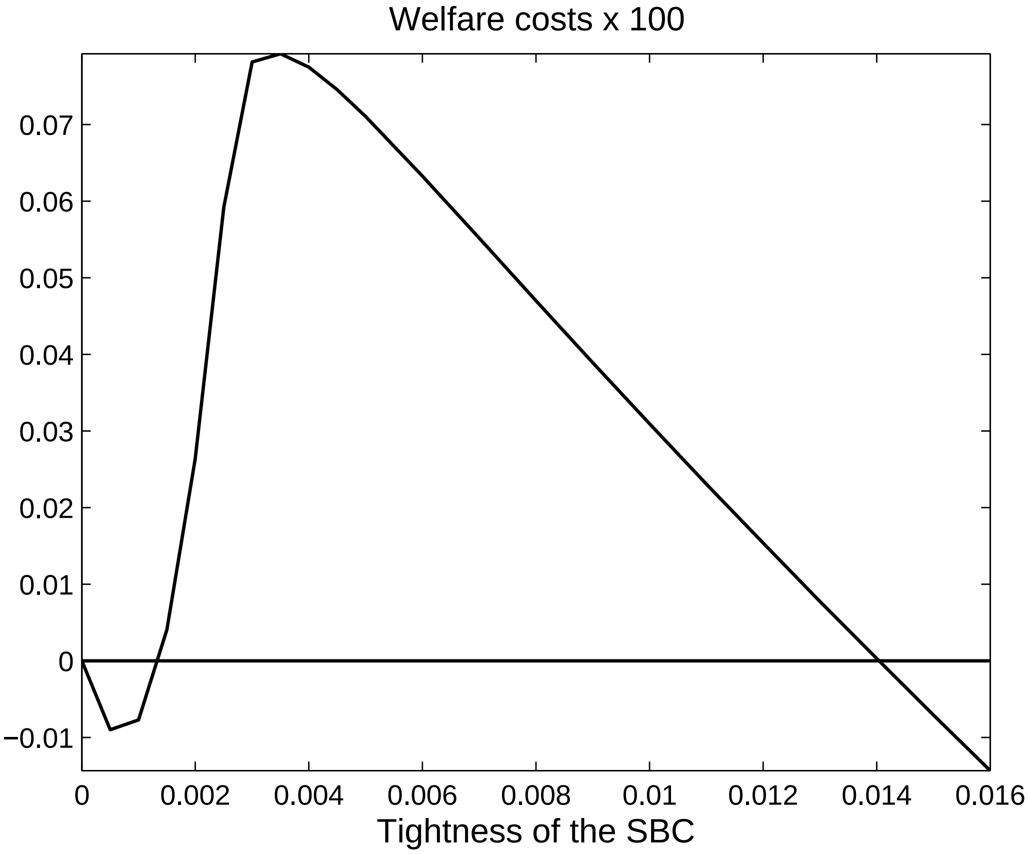

Figure 2.5: Welfare cost of *not* reducing debt $\Lambda^{Msbc} \times 100$ as a function of the tightness of the SBC: $\kappa \in [0, 0.016]$.

Returning to Figure 2.4, the solid line shows the transition path for this optimal κ. It takes about 50 quarters to reduce debt to zero. For $\kappa = 0.001$ (dashed line) welfare costs equal $\Lambda^{Msbc} = -0.008\%$ which implies that remaining in the steady state without SBC is preferable to a small debt reduction. For $\kappa = 0.016$ (dotted line), $\Lambda^{Msbc} = -0.014\%$. A very fast consolidation is also detrimental for welfare. However, there is a wide range of $\kappa \in (0.0015, 0.014)$ where the long run benefits from lower tax rates outweigh the short term costs of higher tax rates. In sum, the SBC should be implemented such as to induce a complete debt reduction in the long run but to allow smoothing taxes over several years.

2.4.3 Short run dynamics under a soft borrowing constraint

After showing that by imposing the SBC it is possible to eliminate distortions affecting the non-stochastic steady state of the economy, in this subsection I look at the short run welfare costs of myopic fiscal policy under a SBC, as compared to Ramsey-optimal policy.

Following Schmitt-Grohé and Uribe (2007), both regimes are calibrated to have the same non-stochastic steady state in order to concentrate on welfare costs of a distorted stochastic steady state. In particular, Ramsey-optimal policy is characterized by setting $\gamma = 1$ and $\kappa = 0$. As before, let this regime be denoted by R. Myopic fiscal policy under a SBC, denoted by SBC, is characterized by setting $\gamma = 0.979$, $\kappa = 0.005$, and $b^{ref} = 0$. These values imply zero debt in the non-stochastic steady state for a government which would otherwise accumulate debt up to 103% of GDP if the SBC was not imposed (see Section 2.4.1). The value for κ is the lowest possible value for this parameter that still implies the same allocation in the non-stochastic steady state under both regimes up to the fourth significant digit. All other parameters and functional forms are set according to the baseline calibration, in both regimes.

Based on (2.26), welfare under each regime $i = R, SBC$, conditional on the state of the economy in period $j = 0$ being the common non-stochastic steady state under both regimes, is given by

$$V_t^i \equiv E_t \sum_{j=0}^{\infty} \beta^j u\left(c_{t+j}^i, n_{t+j}^i\right), \tag{2.36}$$

where c_{t+j}^i and n_{t+j}^i denote the particular plans for consumption and working time under regime i. Using (2.36), the corresponding expression to (2.31) gives welfare costs of regime SBC relative to regime R as

$$\lambda^{sr} = 1 - \exp\left[\left(V^{SBC} - V^{R}\right)(1-\beta)\right].$$

To compute λ^{sr}, I use the policy functions for V_t^{SBC} and V_t^R approximated up to second order accuracy which I evaluate at the common non-stochastic steady state

$x_0 = \bar{x}$:

$$V^i(x_0, 0) \approx V^i(\bar{x}, 0) + \frac{1}{2} V^i_{\omega\omega}(\bar{x}, 0)\,\omega^2.$$

Identical non-stochastic steady states, i.e. $V^{SBC}(\bar{x}, 0) = V^R(\bar{x}, 0)$, imply that welfare costs are determined by the second derivatives of the policy functions with respect to uncertainty, $V^{SBC}_{\omega\omega}$ and $V^R_{\omega\omega}$, and the parameter scaling the standard deviations of the exogenous shocks ω :

$$\lambda^{sr} = 1 - \exp\left[\left(V^{SBC}_{\omega\omega} - V^R_{\omega\omega}\right)\frac{\omega^2}{2}(1-\beta)\right]. \tag{2.37}$$

For the standard deviations of the innovations given in the baseline calibration (see Section 2.3.1), short run welfare costs of myopic fiscal policy under a SBC amount to $\lambda^{sr} = 0.0010\%$. This value indicates that welfare costs associated with shifts of the stochastic steady state are quantitatively negligible since λ^{sr} is one to two orders of magnitude smaller than the welfare costs computed in the previous subsections (see λ^M, Λ^{RM}, and Λ^{Msbc}).[19] To illustrate the robustness of this result to the calibration, I artificially double the standard deviations of the innovations. The implied welfare costs remain small, although they increase to $\lambda^{sr} = 0.0040\%$. These figures show that, for the given calibration, it is welfare-enhancing to implement the SBC since the associated welfare gains of reducing distortions affecting the non-stochastic steady state by far outweigh the welfare costs of increasing the costs of using debt to smooth taxes over the cycle.

To further illustrate this finding, I also consider a balanced budget regime as a particular, well-known alternative to prevent debt accumulation. The balanced budget regime is characterized by letting the tax rate respond endogenously in a model without debt. The government budget constraint is then given by

$$g_t = \tau_t w_t n_t.$$

The calibration and functional forms of this regime are the same as for the other two regimes such that the non-stochastic steady state is the same under all three regimes.

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[19] Moreover, it indicates the limited gains of optimal fiscal policy over the cycle, as in Schmitt-Grohé and Uribe (2007).

Compared to Ramsey-optimal policy, a balanced budget regime is associated with welfare costs of 0.0011% and 0.0042% for the baseline calibration and the alternative calibration of the standard deviations, respectively. As before, these numbers illustrate the limited gains of optimal fiscal policy over the cycle as compared to improved long run policies. Moreover, they show that the SBC is slightly preferable in terms of welfare to a balanced budget regime since it allows for the use of debt to smooth taxes, but that quantitatively the two regimes are similar when looking only at short run effects.

To analyze the dynamics under regimes R and SBC, Figure 2.6 plots the impulse responses under both regimes to a government spending shock. It shows debt, the tax rate, the fine (as defined in (2.6) with $I\left[b_t; b^{ref}\right] \approx L_t$), and GDP. Debt and the fine are expressed as absolute deviations from their steady states (which are zero).

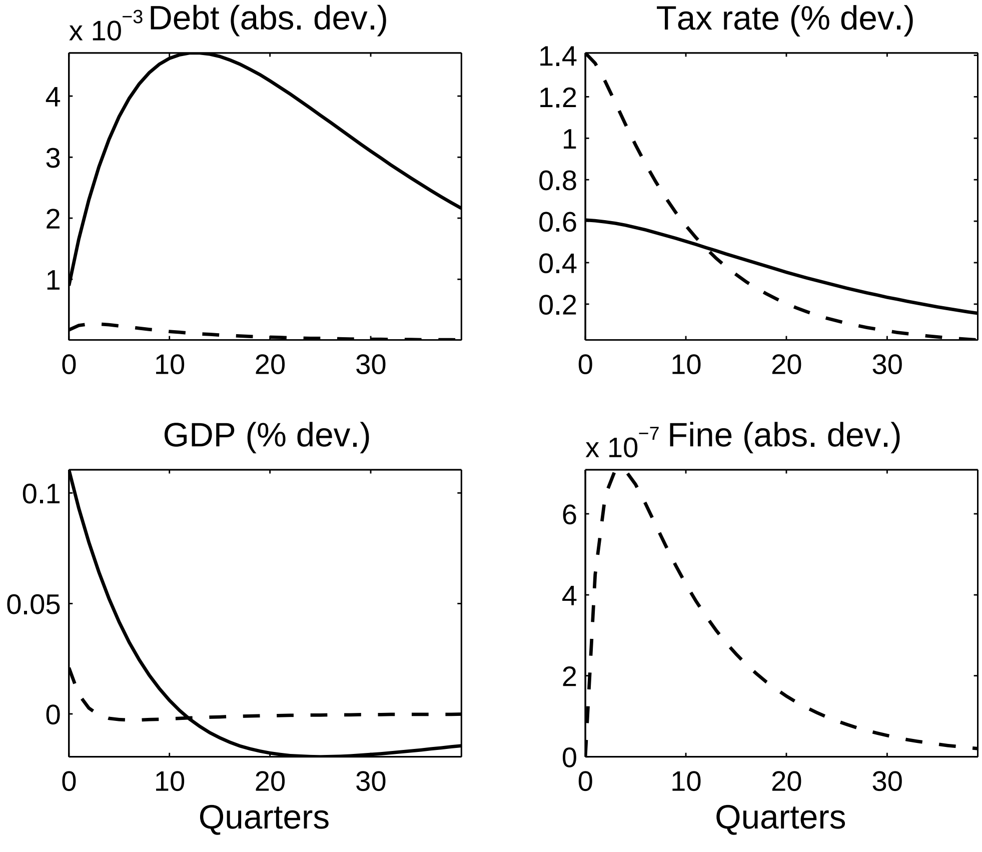

Figure 2.6: Impulse responses to a government spending shock under Ramsey-optimal policy (solid line) and myopic fiscal policy under a SBC (dashed line).

The solid line shows the impulse responses under Ramsey-optimal policy. We can see how the government uses debt to smooth labour taxes. The dashed line depicts myopic fiscal policy under a SBC. Again, the government uses both its instruments, debt and taxes. However, under a SBC the government largely refrains from using debt to smooth taxes (even though the fine payments are relatively small and only amount to about 7×10^{-7} at the maximum). In sum, this subsection shows that short run welfare costs of myopic fiscal policy under a SBC are relatively small as compared to the gains of the SBC from the elimination of distortions affecting the non-stochastic steady state.

2.5 Discussion

Before I analyze the sensitivity of the results to alternative parameterizations, I discuss three alternative assumptions on the structure of the model.

2.5.1 Welfare gains under alternative assumptions

The proposed SBC is assumed to be paid to a supranational institution to loosely reflect the arrangements of the SGP. This assumption implies that fine payments constitute social costs to the economy, as can be seen from the resource constraint (2.9). Accordingly, already small values for κ imply high costs of using debt and hence strong incentives to reduce excessive borrowing. Alternatively, I assume that the fine payments are private costs, i.e. they are redistributed to the household in a lump-sum way. This assumption reduces the costs of violating the SBC for a given value of κ. Then, to bring down debt to zero in steady state (from 103% of GDP for $\gamma = 0.979$), the tightness of the SBC has to increase to $\kappa \geq 0.02$ as compared to the base model where any $\kappa \geq 0.003$ implies zero debt in steady state. However, there is no natural upper bound for κ which can be set, for example, by changing the constitution. Hence, the alternative specification does not alter the general effectiveness of the SBC. Moreover, under the alternative assumption welfare in steady state is affected in the same way for $\kappa \geq 0.02$ because then steady state debt is zero such that there are no fine payments.

In the analysis of Section 2.4, I set the value of government consumption to $\bar{g} = 0.1$ such as to obtain a ratio of $\bar{g}/y = 0.2$ under Ramsey-optimal policy. This assumption implies that myopic fiscal policy leads to an increase of the ratio $\bar{g}/y$ because the steady state level of output y is an increasing function of γ, whereas $\bar{g}$ stays fixed. Thus, welfare costs of myopic fiscal policy include the increase of the share of government consumption (which here is a waste of resources) in GDP. To isolate the welfare costs of positive levels of debt from this composition effect of GDP the ratio $\overline{g/y}$ has to be constant across regimes. Following this alternative assumption, using the measure of welfare costs in (2.31), and approximating the policy functions up to second order accuracy yields that welfare costs amount to $\lambda^{M'} = 0.022\%$ (for $\gamma = 0.979$). This number is one order of magnitude smaller than the costs as computed in Section 2.4.1 (where $\lambda^{M} = 0.353\%$). However, the introduction of the SBC is as effective as before and more than 99% of these costs can be eliminated by preventing excessive borrowing. Moreover, this alternative specification implies economically implausible behavior of fiscal policy in the short run since it implies that fiscal policy is set such as to hold the ratio $\overline{g/y}$ constant in response to exogenous shocks.

Finally, the model's single endogenous state variable is debt. The main source of welfare costs of myopic fiscal policy stems from a distorted steady state of this variable. The specification of the SBC directly addresses this distortion as it is based on the level of debt. To assess the effects of a second endogenous state variable in the model, I analyze myopic fiscal policy and the introduction of the SBC in an economy with capital. Here, the government is restricted to have the same instruments, i.e. it can tax labour income and issue one-period non-state-contingent bonds. I assume the production function to be Cobb-Douglas using labour and capital as inputs and I set the production elasticity of capital to 0.34, the rate of depreciation to 0.025, and all other parameters and functional forms follow the baseline calibration. It turns out that welfare costs of myopic fiscal policy are larger in this alternative model. Using (2.31) and approximating the policy functions for the welfare measures up to second order accuracy, welfare costs for $\gamma = 0.979$ amount to $\lambda^{M''} = 1.43\%$. These costs are four times larger than the costs in the model without capital. Capital creates an additional channel through which myopic fiscal policy reduces welfare. Higher taxes on labour depress working time and thus the return on capital. This reduces the attractiveness of capital accumulation and hence the stock of capital in the long run. However, imposing the SBC with $\kappa = 0.005$ in this model brings down the steady state level of debt to zero, again eliminating more than 99% of these costs.

2.5.2 Sensitivity analysis

In this subsection, I first discuss the specification of the SBC before I analyze the sensitivity of the results to alternative parameters in the utility function. The SBC is specified in terms of the absolute level of debt b_t. Alternatively, I consider a specification of the SBC in terms of the ratio of debt to GDP b_t/y_t. This assumption leaves all the results virtually unchanged. Since there is no growth in the model, the specification in the absolute level of debt just simplifies the analysis.

There are two points to be addressed concerning the second order approximation of the logistic function: One with respect to the long run analysis and one with respect to the short run analysis. For the given calibration and $\kappa = 0.005$ (as in Section 2.4.3) the second order approximation to the policy function for f_t is given by:

$$f_t = 0.0026 b_t + 0.3748 b_t^2, \tag{2.38}$$

where the constant and the second derivative of the policy function with respect to uncertainty are zero. To reduce excessive borrowing in the long run it is sufficient that the coefficient in (2.38) multiplying b_t^2 is positive. This ensures that whenever the government would like to issue debt, which is the case for any $\gamma < 1$, it has to pay a positive fine. I checked that this coefficient is positive for all reasonable parameter combinations.[20]

Turning to the short run implications, (2.38) implies that for $b_t \in [-0.007; 0]$ the fine is negative, turning into a transfer to the economy. This sign reversion would not be the case if the logistic function was used instead and implies that the welfare costs of myopic fiscal policy under a SBC in the short run analysis of Section 2.4.3 are underestimated. However, since welfare costs of a distorted stochastic steady state amount only to $\lambda^{sr} = 0.0010\%$ and actual fine payments (and hence transfers) are

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[20] Notice that in the deterministic transition scenarios in Section 2.4.2 there is no need for an approximation of the logistic function since the absence of uncertainty allows using a Newton method to solve simultaneously all the original equations for all periods instead of using perturbation methods.

quantitatively negligible for the given calibration (see Figure 2.6) the approximation of the logistic function does not affect the main results of the analysis. Moreover, by using *Dynare++*, I checked up to a fifth order approximation to the policy functions for the model's endogenous variables that welfare costs are virtually identical to the case of a second order approximation, indicating the limited role of actual fine payments/ transfers for welfare.

Finally, I assess the sensitivity of the results to different values of σ and φ in the utility function (see 2.25). In all cases, the value of ν is chosen such as to obtain a value of working time of $n = 0.5$ in the non-stochastic steady state under Ramsey-optimal policy. Welfare costs are measured using the corresponding expressions to (2.31) and (2.33) for the case of general CRRA preferences, which are given by

$$\lambda^{gen} = 1 - \left(\frac{V^M - VN^R}{V^R - VN^R} \right)^{\frac{1}{1-\sigma}} \text{ and } \Lambda^{gen} = 1 - \left(\frac{W^{RM} - WN^R}{W^R - WN^R} \right)^{\frac{1}{1-\sigma}}, \qquad (2.39)$$

respectively, and where

$$VN^R = -E_t \sum_{j=0}^{\infty} \beta^j \left(\frac{\nu \left(n^R_{t+j} \right)^{1+\varphi}}{1+\varphi} + \frac{1}{1-\sigma} \right), WN^R = - \sum_{j=0}^{\infty} \beta^j \left(\frac{\nu \left(n^R_{t+j} \right)^{1+\varphi}}{1+\varphi} + \frac{1}{1-\sigma} \right),$$

and n^R_{t+j} denotes working time under Ramsey-optimal policy. The parameters and the results where λ^{gen} is approximated up to second order accuracy are summarized in Table 2.2. We can see that for both measures welfare costs decrease as σ and φ increase. However, in all cases the introduction of the SBC brings down debt to zero in the non-stochastic steady state and thus eliminates the main source of welfare costs.

2.6 Conclusions

The standard Ramsey approach to optimal taxation cannot account for the high and persistent levels of government debt that we observe in many OECD countries. Assuming a myopic policy maker implies empirically more realistic positive levels of

Table 2.2: Welfare costs for different parametes in the utility function.

Parameters				Welfare costs [a]	
n^R	ν	σ	φ	$\lambda^{gen} \times 100$	$\Lambda^{gen} \times 100$
0.5	1.78	0.5	0.5	0.806	0.314
0.5	4	1	1	0.353	0.141
0.5	20	2	2	0.166	0.067
0.5	100	3	3	0.108	0.044

a Welfare costs are defined in (2.39).

debt. In the absence of lump-sum taxation the associated allocation is inferior in terms of welfare to the allocation under Ramsey-optimal policy and implies welfare costs of up to 0.35% of the Ramsey consumption stream.

The paper proposes a legal restriction in the form of a soft borrowing constraint on sovereign debt which is modeled as a proportional fine on excessive debt and resembles features of the SGP. The constraint prevents excessive borrowing in the long run and thereby eliminates more than 99% of the welfare costs of myopic fiscal policy. The short run welfare costs of the soft borrowing constraint from increasing the cost of using debt to smooth taxes over the business cycle are quantitatively negligible. Thus, the paper supports the views of those who like to maintain or even strengthen the rules of the SGP. It also provides an argument for the inclusion of a debt break into the German constitution or for the advocates of balanced budget rules.

Conditioning the proportionality of the fine payments on some state of the economy, for example the level of output, could reduce the short run welfare cost of the SBC even further. On the other hand, in a medium- or large-scale macroeconomic model with nominal and real frictions the short run costs of the SBC might be larger. I leave both issues for future research.

2.A Derivation of the implementability constraint

This appendix shows in detail how to derive the sequence of implementability constraints. To start with, substitute out prices R_t and τ_t in the household's budget constraint (2.2) by using the household's first order conditions (2.4) and (2.5) to obtain

$$c_t + b_{t+1}\left[\beta E_t \frac{u_{c,t+1}}{u_{c,t}} - \phi \frac{b_{t+1}}{y_t}\right] = \frac{-u_{n,t}n_t}{u_{c,t}} + b_t, \tag{2.40}$$

where $\Phi = \pi_t$ was used. Rewrite (2.40) as

$$b_t = c_t + \frac{u_{n,t}n_t}{u_{c,t}} - \phi \frac{b_{t+1}^2}{y_t} + \beta E_t\left(\frac{u_{c,t+1}}{u_{c,t}}\right) b_{t+1}. \tag{2.41}$$

Note that b_t in (2.41) is non-state-contingent and thus the same for all future states of the economy.

For convenience, define $z_t = c_t + \frac{u_{n,t}n_t}{u_{c,t}} - \phi\frac{b_{t+1}^2}{y_t}$ in (2.41) which yields

$$b_t = z_t + \beta E_t\left(\frac{u_{c,t+1}}{u_{c,t}} b_{t+1}\right). \tag{2.42}$$

Then iterate forward (2.42), i.e. replace b_{t+1} in (2.42) by the right hand side of (2.42), with the time index adjusted one period ahead

$$\begin{aligned} b_t &= z_t + \beta E_t\left\{\left(\frac{u_{c,t+1}}{u_{c,t}}\right)\left[z_{t+1} + \beta E_{t+1}\left(\frac{u_{c,t+2}}{u_{c,t+1}}\right) b_{t+2}\right]\right\} \\ &= z_t + \beta E_t\left\{\left(\frac{u_{c,t+1}}{u_{c,t}}\right) z_{t+1} + \beta\left(\frac{u_{c,t+1}}{u_{c,t}}\right) E_{t+1}\left(\frac{u_{c,t+2}b_{t+2}}{u_{c,t+1}}\right)\right\} \\ &= z_t + \beta E_t\left\{\left(\frac{u_{c,t+1}}{u_{c,t}}\right) z_{t+1} + \beta\frac{1}{u_{c,t}} E_{t+1}\left(u_{c,t+2}b_{t+2}\right)\right\} \\ &= z_t + \beta E_t\left(\frac{u_{c,t+1}}{u_{c,t}} z_{t+1}\right) + \beta^2 E_t\left(\frac{u_{c,t+2}}{u_{c,t}} b_{t+2}\right), \end{aligned}$$

where the last equality used the law of iterated expectations. Repeating this substitution j times for future bond holdings b_{t+j} yields

$$b_t = z_t + \beta E_t\left(\frac{u_{c,t+1}}{u_{c,t}} z_{t+1}\right) + \beta^2 E_t\left(\frac{u_{c,t+2}}{u_{c,t}} z_{t+2}\right) + \ldots + \beta^{j+1} E_t\left(\frac{u_{c,t+j+1}}{u_{c,t}} b_{t+j+1}\right) \tag{2.43}$$

Let $j \to \infty$ and multiply by $u_{c,t}$

$$u_{c,t}b_t = E_t \sum_{j=0}^{\infty} \beta^j u_{c,t+j} z_{t+j} + \lim_{j\to\infty} \beta^{j+1} E_t\left(u_{c,t+j+1}b_{t+j+1}\right), \tag{2.44}$$

where, using the transversality condition, the last term on the RHS of (2.44) equals zero: $\lim\limits_{j\to\infty} \beta^{j+1} E_t\left(u_{c,t+j+1}b_{t+j+1}\right) = 0$.

Finally, replace z_{t+j} to obtain the *sequence* of implementability constraints (2.12) for the incomplete market case

$$u_{c,t}b_t = E_t \sum_{j=0}^{\infty} \beta^j u_{c,t+j} \left[c_{t+j} + \frac{u_{n,t+j} n_{t+j}}{u_{c,t+j}} - \phi \frac{b_{t+1+j}^2}{y_{t+j}} \right].$$

2.B Derivation of the infinite double sum

This appendix shows how the infinite double sum in (2.16) which is repeated here for convenience

$$E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \alpha_t E_t \sum_{j=0}^{\infty} \beta^j s_{t+j},$$

can be rewritten as

$$E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \mu_t s_t,$$

where $s_{t+j} = u_{c,t+j} \left(c_{t+j} + \frac{u_{n,t+j} n_{t+j}}{u_{c,t+j}} - \phi \frac{b_{t+j+1}^2}{y_{t+j}} \right)$, as above. To start, write out the sums on the LHS

$$\begin{aligned} LHS &= E_0 \left\{ \alpha_0 E_0 \sum_{j=0}^{\infty} \beta^j s_{0+j} \right\} + E_0 \left\{ \gamma\beta\alpha_1 E_1 \sum_{j=0}^{\infty} \beta^j s_{1+j} \right\} + \\ &\quad + E_0 \left\{ \gamma^2\beta^2\alpha_2 E_2 \sum_{j=0}^{\infty} \beta^j s_{2+j} \right\} + ... \\ &= E_0 \left\{ \alpha_0 E_0 \left[s_0 + \beta s_1 + \beta^2 s_2 + \beta^3 s_3 + ... \right] \right\} \\ &\quad + E_0 \left\{ \gamma\beta\alpha_1 E_1 \left[s_1 + \beta s_2 + \beta^2 s_3 + \beta^3 s_4 + ... \right] \right\} \\ &\quad + E_0 \left\{ \gamma^2\beta^2\alpha_2 E_2 \left[s_2 + \beta s_3 + \beta^2 s_4 + \beta^3 s_5 + ... \right] \right\} + ... \\ &= E_0 \{ \alpha_0 s_0 + \beta\alpha_0 s_1 + \beta^2\alpha_0 s_2 + \beta^3\alpha_0 s_3 + ... \\ &\quad + \gamma\beta\alpha_1 s_1 + \gamma\beta^2\alpha_1 s_2 + \gamma\beta^3\alpha_1 s_3 + \gamma\beta^4\alpha_1 s_4 + ... \\ &\quad + \gamma^2\beta^2\alpha_2 s_2 + \gamma^2\beta^3\alpha_2 s_3 + \gamma^2\beta^4\alpha_2 s_4 + \gamma^2\beta^5\alpha_2 s_5 + ... \Big\}, \end{aligned}$$

where the last equality used the law of iterated expectations. Then factor out the corresponding terms of s_t

$$\begin{aligned} LHS &= E_0 \left\{ \alpha_0 s_0 + (\beta\alpha_0 + \gamma\beta\alpha_1) s_1 + \left(\beta^2\alpha_0 + \gamma\beta^2\alpha_1 + \gamma^2\beta^2\alpha_2 \right) s_2 + ... \right\} \\ &= E_0 \left\{ \alpha_0 s_0 + \beta (\alpha_0 + \gamma\alpha_1) s_1 + \beta^2 \left(\alpha_0 + \gamma\alpha_1 + \gamma^2\alpha_2 \right) s_2 + ... \right\} \\ &= E_0 \left\{ [\alpha_0] s_0 + \gamma\beta \left[\frac{\alpha_0}{\gamma} + \alpha_1 \right] s_1 + \gamma^2\beta^2 \left[\frac{\alpha_0}{\gamma^2} + \frac{\alpha_1}{\gamma} + \alpha_2 \right] s_2 + ... \right\}. \end{aligned}$$

Now, express the square brackets recursively through the sequence of $\mu_t = \frac{\mu_{t-1}}{\gamma} + \alpha_t$, with $\mu_{-1} = 0$

$$\begin{aligned}
\mu_0 &= \frac{\mu_{-1}}{\gamma} + \alpha_0 = \alpha_0 \\
\mu_1 &= \frac{\mu_0}{\gamma} + \alpha_1 = \frac{\alpha_0}{\gamma} + \alpha_1 \\
\mu_2 &= \frac{\mu_1}{\gamma} + \alpha_2 = \frac{\alpha_0}{\gamma^2} + \frac{\alpha_1}{\gamma} + \alpha_2 \\
&\vdots \qquad \vdots .
\end{aligned}$$

The LHS can then be written as

$$\begin{aligned}
LHS &= E_0 \left\{ \mu_0 s_0 + \gamma\beta\mu_1 s_1 + \gamma^2\beta^2\mu_2 s_2 + \gamma^3\beta^3\mu_3 s_3 + ... \right\} \\
&= E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \mu_t s_t \\
&= RHS\textbf{.}
\end{aligned}$$

Chapter 3

Myopic Governments and Positive Capital Taxation

Why do governments tax capital in face of the benchmark of standard economic theory that capital ought to be untaxed? This chapter provides a model of fiscal policy with endogenous labour, bonds, and capital in order to account for the observation that worldwide taxes on capital remain far from zero. It introduces policy myopia into an otherwise standard framework of optimal fiscal policy where the government can tax labour and capital income and shows that policy myopia leads to empirically realistic levels of the tax rate on capital. First, assuming perfect foresight, the chapter shows analytically for the case of CRRA preferences that policy myopia leads to positive capital taxation. Then, this results is extended, analytically for the case of quasi-linear preferences and numerically for the case of CRRA preferences, to a stochastic setting where markets are incomplete. Moreover, it is shown that the tax rate on capital increases as myopia increases. Finally, the chapter analyzes the effects of policy myopia on the conduct of fiscal policy over the business cycle.

3.1 Introduction

Why do governments tax capital in face of the benchmark of economic theory that capital should not be taxed? One of the most prominent results from the theory of optimal taxation in dynamic models is that capital income should not be taxed in the long run or on average (see Judd, 1985; Chamley, 1986; Zhu, 1992; Chari and Kehoe, 1999; Farhi, 2009). This result has been qualified in many different ways but its strong underlying logic constitutes the benchmark for the prescription of how to divide the tax burden between labour and capital income. However, as pointed out by Mankiw, Weinzierl, and Yagan (2009), there remains a large gap between the prescriptions of economic theory and the actual tax rates on capital in most countries across the world which remain far from zero.[1]

To address this discrepancy between economic theory and the actual conduct of fiscal policy, I provide a model of capital taxation under policy myopia in this chapter. The main idea of the chapter is based on the observation that: "All the available evidence thus points to the same conclusion: countries with shorter lived governments tend to [...] rely on more inefficient forms of taxation (Alesina and Tabellini, 1992, P. 343)". As an illustration of this observation in the context of capital taxation consider the following examples: For the last 20 years Chile was one of the politically most stable countries in Latin America with one major coalition in office. At the same time Chile has very low tax rates on capital, or even capital subsidies. On the other hand, during the same period Argentina has suffered from frequent changes in the executive authority. As compared to Chile, Argentina has relatively high tax rates on capital.[2] In Europe, Italy has had over 50 different governments since 1945 leading to an average tenure of office of Italian governments of about one year. Also Belgium has repeatedly experienced periods of high rates of political turnover. At the same time both countries have relatively high tax rates on capital as compared to countries which tend to have longer lived governments as, for example, Germany and the Netherlands.[3]

These observations on the relationship between the time in office of governments and the tax structure of a country provide the rationale for the analysis of this chapter. In three versions of the base model, I analyze the effects of policy myopia on the tax structure of a country. Policy myopia captures the fact that the duration in power of real world governments is limited to several years, or at most decades. Myopia is modeled as a government discount factor which is smaller than that of the private sector. It can be interpreted as an expected finite planning horizon of the government, as in Grossman and Van Huyck (1988).[4] However, I assume that the

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[1] See, for example, Mendoza, Milesi-Ferretti, and Asea (1997) or Carey and Tchilinguirian (2000) for measures of effective average tax rates on capital income.

[2] See Barra and Jorratt (1998) or Soto (2005).

[3] See Nicodeme (2001) or Trabandt and Uhlig (2009).

[4] There is a broad literature which explicitly models the political distortions which lead to myopic policies: Among others, Persson and Svensson (1989), Alesina and Tabellini (1990), or more recently Devereux and Wen (1998), and Cuadra and Sapriza (2008). While the precise modeling strategies differ, in essence all these models imply that the policy maker discounts the future at higher rates,

government is otherwise benevolent and applies the instantaneous utility function of the households.

The first version of the model is a static two good-endowment economy. The simple set-up serves to illustrate how tax policy is affected when the objectives of the government and the representative household do not coincide. I show analytically that the government sets higher taxes on the good which it values less even though the household equally values both goods. The next two versions are dynamic and include government debt and capital. The government does not have access to lump-sum taxation. It can issue bonds and it can use flat-rate taxes on labour and capital income in order to finance an exogenously given stream of government consumption. As the main result of the chapter, I show that if the government discounts the future at higher rates than the private sector it levies a tax on capital income. From economic theory it is well know that a tax on capital is equivalent to an ever-increasing tax on future consumption.[5] This tax policy depresses the stock of capital in the long run. Intuitively, policy myopia implies that the government prefers nearby utility and cares less about intertemporal distortions which in turn leads to short term oriented fiscal policy.

In all three versions, I follow the methodology of the Ramsey approach to problems of optimal taxation. However, the optimal tax policy is only obtained as a special case where the objectives of the government and the household coincide. The first of the two dynamic versions is based on the textbook version of the models of Judd (1985) and Chamley (1986), as laid out in Ljungqvist and Sargent (2004). The representative household owns the firm which produces a consumption-capital good using capital and labour as inputs. Assuming certainty and a finite time horizon, I show analytically for the case of constant relative risk aversion (CRRA) preferences that a myopic government levies a positive tax on capital income.

The second of the two dynamic versions builds on Farhi (2009, forthcoming) who analyzes the stochastic properties of optimal fiscal policy in an economy with capital. This version allows for uncertainty. Here, capital taxes have to be set one period in advance and the government can issue only non-state-contingent bonds.

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leading to short term oriented policies.

[5] See, for example, Albanesi and Armenter (2009).

For the sake of realism, markets are thus incomplete. First, for the case of quasi-linear preferences, I show analytically that policy myopia leads to a positive tax on capital. Then, I show numerically that this result also holds for general CRRA preferences and that the tax rate on capital increases as myopia increases. Moreover, I show that, while the model implies empirically realistic levels of capital taxes, the quantitative effects of policy myopia on the conduct of fiscal policy over the business cycle are small.

The chapter is related to several strands of literature. The mechanism that leads myopic governments to tax capital is based on the same idea as the literature on the effects of political instability and macroeconomic policy. Edwards and Tabellini (1991), Cukierman, Edwards, and Tabellini (1992), and Aisen and Veiga (2006) find empirical support for the hypothesis that instability of the political system increases the size of seigniorage. Moreover, there is supportive evidence that higher political instability leads to higher deficits and debt (see Alesina and Tabellini, 1992, Alesina and Perotti, 1994, or Carmignani, 2003). In this literature the definition of political instability includes events such as government terminations and electoral surprises which are intimately linked to policy myopia. As well as inflation is a tax on money holdings and thus on future consumption, debt accumulation and excessive deficits imply higher tax rates in the future. So does a positive tax on capital income which is equivalent to a tax on future consumption.

In an economy without capital Kumhof and Yakadina (2007) analyze the effects of policy myopia on debt accumulation, business cycles, and labour taxation. They show that policy myopia leads to empirically realistic levels of debt. In an early contribution, Atkinson and Sandmo (1980) analyze efficiency aspects of capital and consumption tax schemes in a deterministic overlapping generations model. My result of positive capital taxation is reminiscent of their finding that savings are subsidized if the government attaches more weight than the individual to future consumption. Devereux and Wen (1998) study the relationship between political instability, capital taxation, and the size of governments in a linear endogenous growth model where, however, capital is the only factor of production. They find that higher political instability, which leads the government to value future utility less as in the case of policy myopia, implies higher taxes on this single production factor. In a model of endogenous growth, Alesina and Rodrik (1994) suggest redistributive purposes as an explanation of capital taxation. However, Perotti (1996) does not find empirical support for their hypothesis that higher inequality leads to higher taxes on capital income. Finally, Aiyagari (1995) provides an alternative explanation for positive capital taxation in a Bewely class model with incomplete insurance markets and borrowing constraints.

The structure of the chapter is as follows. The next section lays out the two deterministic versions of the model and presents the results based on these. Section 3.3 presents the stochastic version before Section 3.4 presents the results derived from this version. Section 3.5 concludes.

3.2 The deterministic model

In this section, I present two deterministic versions of the model in order to illustrate the basic mechanism of how tax policy is affected if the objectives of the government and the household differ. Moreover, assuming certainty allows deriving analytical results for the case of additively separable CRRA preferences. The first version is a simple endowment economy with two consumption goods which are equally valued by the household. I show that the government levies lower taxes on the good which it values more and that this tax structure leads to a decrease in welfare. The second version is dynamic and shows how the same mechanism applies in an economy with government debt and capital where the myopic government sets positive taxes on capital income since it values future utility less than the private sector.

3.2.1 Tax policy in a static version

The economy consists of a representative household and a government. There is no uncertainty.

Households

Households are identical, infinitely-lived, and of mass one. The preferences of the representative household are given by

$$U\left(c_1, c_2\right) = \log c_1 + \log c_2, \tag{3.1}$$

where c_1 and c_2 denote consumption of good 1 and 2, respectively. Its budget constraint reads

$$A = \left(1 + \tau_1\right) c_1 + \left(1 + \tau_2\right) c_2, \tag{3.2}$$

where A is an exogenously given endowment and τ_1 and τ_2 denote the tax rates on good 1 and 2, respectively. The household maximizes (3.1) s.t. (3.2) w.r.t. c_1 and c_2. Combining the first order conditions gives

$$\frac{c_1}{c_2} = \frac{1 + \tau_1}{1 + \tau_2}. \tag{3.3}$$

To derive the demand for both goods, I solve for c_1 and c_2 by using (3.2) and (3.3) which gives

$$c_1 = \frac{A}{2\left(1 + \tau_1\right)} \quad \text{and} \quad c_2 = \frac{A}{2\left(1 + \tau_2\right)} \tag{3.4}$$

as a function of policy.

Government

The preferences of the government are given by

$$V\left(c_1, c_2\right) = \log c_1 + \gamma \log c_2, \tag{3.5}$$

where $\gamma \in [0, 1]$ is the government's weight on consumption of good 2. If $\gamma < 1$ private and public preferences differ. The government's budget constraint is given by

$$g = \tau_1 c_1 + \tau_2 c_2, \tag{3.6}$$

where g is an exogenously given level of government consumption. The government can tax both consumption goods (at possibly different rates) in order to finance

g.

Now, a competitive equilibrium can be defined as follows:

Definition 3.1. *For a given government policy τ_1 and τ_2 satisfying the government budget constraint (3.6), a competitive equilibrium is an allocation c_1 and c_2 satisfying (3.4).*

Policy problem and tax structure

The two agents play a Stackelberg game where the government acts as the Stackelberg leader, i.e. it can credibly commit to its policy announcements. It announces a policy τ_1 and τ_2 which is taken as given by the household which in turn demands c_1 and c_1 according to (3.4). The government takes into account the equilibrium reaction of the household when choosing its policy. Then, using backward induction, the problem of the government is as follows:

Problem 1. *The government's problem is to maximize (3.5) over competitive equilibria.*

Note that the government maximizes its own objective (see 3.5) instead of private welfare (see 3.1). To solve Problem 1, I first substitute (3.4) into (3.5) and (3.6), respectively, which gives the Lagrangian to the policy maker's problem[6]

$$L = \log \frac{A}{2\left(1+\tau_1\right)} + \gamma \log \frac{A}{2\left(1+\tau_2\right)} + \lambda \left(\frac{\tau_1 A}{2\left(1+\tau_1\right)} + \frac{\tau_2 A}{2\left(1+\tau_2\right)} - g \right),$$

where λ denotes the Lagrange multiplier associated with (3.6), with c_1 and c_2 substituted out. Next, I derive the first order conditions w.r.t. τ_1 and τ_1 and simplify which yields

$$\tau_1 = \frac{\lambda A}{2} \quad \text{and} \quad \tau_2 = \frac{\lambda A}{\gamma 2}. \tag{3.7}$$

This leads to the following proposition:

Proposition 1. *Suppose that government preferences are given by (3.5) with $\gamma < 1$. Then $\tau_1 < \tau_2$.*

Proof. Combine (3.7) to obtain $\frac{\tau_1}{\tau_2} = \gamma$. If $\gamma \in [0,1) \Rightarrow \tau_1 < \tau_2$ □

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[6] The simple structure of the problem allows substituting out the allocation in the government's problem by using the household's first order conditions such that the government directly chooses the tax rates.

Proposition 1 illustrates the basic mechanism when the preferences of the government and the household differ. Even though the household values both goods equally, the tax rate on good 1 which is preferred by the government is lower than the tax rate on good 2. Further, $\tau_1 < \tau_2$ implies that $c_1 > c_2$ (see 3.4), i.e. consumption of good 1 is higher than consumption of good 2. Only if $\gamma = 1 \Rightarrow \tau_1 = \tau_2$. Identical tax rates on both goods imply lump-sum taxation which is identical to the optimal policy of the Ramsey planner, i.e. the planner which is fully benevolent. Appendix 3.A shows that private welfare declines as γ decreases.

Here, utility was obtained from two different consumption goods at the same moment in time. In the next two versions of the model the same logic as in Proposition 1 applies but for the case of consumption at different moments in time.

3.2.2 Capital taxation in a multi-period model with endogenous labour

In this subsection, I show analytically in a dynamic version of the model with bonds and capital that policy myopia leads to a positive capital taxation. The model is based on the textbook version of the models of Judd (1985) and Chamley (1986), as laid out in Ljungqvist and Sargent (2004, Ch. 15). The main difference with respect to the original model is that I allow for different discount factors between the government and the household. Moreover, I assume a finite time horizon for simplicity. The economy consists of households, firms, and the government. There is no population growth and no technological progress. All agents have perfect foresight.

Private sector

A representative household is characterized by time separable preferences and its objective is the sum of discounted utility under perfect foresight:

$$\sum_{t=0}^{T} \beta^t u\left(c_t, n_t\right), \tag{3.8}$$

where c_t denotes consumption, n_t working time, $\beta \in (0,1)$ is the discount factor, and $u(c,n)$ is additively separable. The household's total amount of time is normalized to one and is divided between working time and leisure. It earns the wage rate w_t and has to pay flat-rate taxes τ_t^n on labour income. The household can invest in one-period government bonds b_{t+1} at the period t price $1/R_t$, where R_t is the gross rate of return, and in capital k_{t+1}. It has to pay flat-rate taxes τ_t^k on the return on capital $(1+r_t-\delta)$, where r_t is the rental rate on capital and δ is the rate of depreciation. Its budget constraint reads

$$c_t + k_{t+1} + \frac{b_{t+1}}{R_t} \leq (1-\tau_t^n)\, w_t n_t + \left(1-\tau_t^k\right)(1+r_t-\delta)\, k_t + b_t. \tag{3.9}$$

The household maximizes (3.8) s.t. (3.9) w.r.t. c_t, n_t, k_{t+1}, and b_{t+1}. The first order conditions to the household's problem can be combined to

$$\begin{aligned} -u_{n,t} &= u_{c,t}\,(1-\tau_t^n)\, w_t, && (3.10)\\ u_{c,t} &= \beta u_{c,t+1} R_t, && (3.11)\\ u_{c,t} &= \beta u_{c,t+1}\left(1-\tau_{t+1}^k\right)(1+r_{t+1}-\delta)\,. && (3.12) \end{aligned}$$

Moreover, the terminal conditions hold:

$$\beta^T u_{c,T} k_{T+1} = 0 \quad \text{and} \quad \beta^T u_{c,T} b_{T+1}/R_T = 0.$$

The production technology $y_t = F(k_t, n_t)$ has constant returns to scale and uses labour and capital as inputs. Firms are perfectly competitive and maximize profits, taking the wage rate w_t and the rental rate on capital r_t as given. Their first-order conditions are

$$r_t = F_k(k_t, n_t) \quad \text{and} \quad w_t = F_n(k_t, n_t)\,, \tag{3.13}$$

where $F_k(k_t, n_t)$ and $F_n(k_t, n_t)$ denote the first derivatives w.r.t. k_t and n_t, respectively.

Government and resource constraint

The government has access to flat-rate taxes on capital and labour income in order to finance an exogenous sequence of government consumption $\{g_t\}_{t=0}^T$ and issues one-period discount bonds. Its budget constraint is

$$g_t + b_t = \tau_t^k (1 + r_t - \delta) k_t + \tau_t^n w_t n_t + \frac{b_{t+1}}{R_t}, \tag{3.14}$$

where the initial tax rate on capital τ_0^k is taken as given.[7] The resource constraint of the economy is given by

$$y_t = c_t + g_t + k_{t+1} - (1 - \delta) k_t, \tag{3.15}$$

For a given government policy (which will be determined in detail below), a competitive equilibrium can be defined as follows:

Definition 3.2. *For a given government policy $\{\tau_t^n, \tau_t^k, b_t\}_{t=0}^T$, a competitive equilibrium is a feasible allocation $\{c_t, k_t, n_t\}_{t=0}^T$ and a price system $\{w_t, r_t, R_t\}_{t=0}^T$, such that, given the price system and the government policy, the allocation solves the problems of the household and of the firms, and the government policy satisfies the sequence of government budget constraints (3.14), for an exogenously given sequence of government consumption $\{g_t\}_{t=0}^T$ and initial values b_0, k_0, and τ_0^k.*

As in Section 3.2.1, there is a multiplicity of competitive equilibria indexed by different government policies.

Policy problem

A salient feature of most political systems is that the duration of the government in power is limited to several years, or at most decades. In order to account for this feature, I assume that the government is myopic. Myopia is modeled as a government discount factor which is smaller than that of the private sector.[8] It can be

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[7] In order to make the problem interesting, this assumption rules out non-distortionary taxation since in period zero the stock of capital is inelastically supplied (see, for example, Chari and Kehoe, Chari and Kehoe, 1999, or Ljungqvist and Sargent, 2004, Ch. 15).

[8] There is a broad literature which explicitly models the political distortions which can lead to policy myopia: Among others, Persson and Svensson (1989), Alesina and Tabellini (1990), or more

interpreted as an expected finite planning horizon of the government, as in Grossman and Van Huyck (1988). However, I assume that the government is otherwise benevolent and applies the instantaneous utility function of the households. The objective of the government is thus given by

$$\sum_{t=0}^{T} (\gamma\beta)^t \, u \left(c_t, n_t\right), \tag{3.16}$$

where $\gamma \in (0,1]$. A value of $\gamma < 1$ implies that the government values future consumption less than the private sector (see 3.8) and is tempted to shift tax collection to the future. One possible way to achieve this is to set a positive tax rate on capital which is equivalent to a tax on future consumption. Hence, the empirically realistic assumption of policy myopia is convenient for the purpose of this chapter because it allows staying conceptually close to the standard approach of the Ramsey planner and shows that already small differences between the discount factors lead to positive capital taxation. The problem of the government can then be defined as follows:

Problem 2. *The problem of the government is to maximize (3.16) over competitive equilibria by choosing sequences of tax rates and bonds* $\{\tau_t^n, \tau_t^k, b_t\}_{t=0}^T$ *subject to the government budget constraint (3.14), given initial values* k_0, b_0, *and* τ_0^k *and an exogenous process* $\{g_t\}_{t=0}^T$.

As in the previous subsection, the two agents play a Stackelberg game where the policy maker acts as the Stackelberg leader. When choosing its policy it anticipates the equilibrium reaction of the private sector. To solve Problem 2, I follow the methodology of the Ramsey approach to problems of optimal taxation where the competitive equilibrium is summarized by the so-called implementability constraint (see, for example, Chari and Kehoe, 1999). The implementability constraint together with the resource constraint pose restrictions on the set of allocations the government can achieve.

To derive the implementability constraint, I first eliminate prices and taxes from (3.9) by using the private sector's first-order conditions (3.10)- (3.13). Then, I iterate

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recently Devereux and Wen (1998), and Cuadra and Sapriza (2008). While the precise modeling strategies differ, in essence all these models imply that the policy maker discounts the future at higher rates, leading to short term oriented policies.

forward by substituting out bonds and use the terminal conditions for bonds and capital, yielding

$$\sum_{t=0}^{T} \beta^t \left[u_{c,t}c_t + u_{n,t}n_t\right] = u_{c,0}A(b_0, k_0, n_0, \tau_0^k),$$

where A summarizes terms which depend on the allocation and the tax rate in period $t = 0 : A(b_0, k_0, n_0, \tau_0^k) = \{(1 - \tau_0^k)(F_k(n_0, k_0) + 1 - \delta) k_0 + b_0\}$. Let η_t and Ψ denote the Lagrange multipliers on the resource and implementability constraint, respectively. The Lagrangian to the government's optimization problem is then given by

$$\begin{aligned} L \;=\; & \sum_{t=0}^{T} (\gamma\beta)^t \left(u\left(c_t, n_t\right) + \eta_t \left(F\left(k_t, n_t\right) + (1-\delta) k_t - c_t - g_t - k_{t+1}\right)\right) \\ & + \Psi \left(\sum_{t=0}^{T} \beta^t \left[u_{c,t}c_t + u_{n,t}n_t\right] - u_{c,0}A(b_0, k_0, n_0, \tau_0^k) \right). \end{aligned} \tag{3.17}$$

Notice that the implementability constraint is associated with a single time-invariant Lagrange multiplier Ψ.[9]

Positive capital taxation

Since the government is myopic but otherwise benevolent, I here first look at the case where the government taxes capital when households are easily willing to substitute consumption at different dates, i.e. when they have a high elasticity of intertemporal substitution $1/\sigma$. In the next section I consider the case when households are more reluctant to substitute consumption at different dates. To facilitate an analytical solution to the Lagrangian in (3.17), I will thus use the following assumption:

Assumption 1. *The instantaneous utility function has the following form:*

$$u\left(c_t, n_t\right) = \left\{ \frac{c_t^{1-\sigma} - 1}{1-\sigma} - V\left(n_t\right), \quad \sigma \le 1, \right.$$

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[9] Moreover, notice that maximization over τ_0^k would be the same as using a non-distortionary tax since k_0 is given.

where $V' > 0$ and $V'' > 0$.

With Assumption 1 it is not necessary to solve for the complete equilibrium to show that the tax rate on capital is positive. Instead, it is sufficient to consider the first-order conditions to (3.17) w.r.t. c_t and k_{t+1}. Given the preferences in Assumption 1, for $1 \leq t < T$ they are

$$\begin{aligned} \gamma^t \eta_t &= c_t^{-\sigma} \left[\gamma^t + \Psi (1-\sigma) \right] && (3.18) \\ \eta_t &= \gamma \beta \eta_{t+1} \left(1 + F_k \left(k_{t+1}, n_{t+1} \right) - \delta \right). && (3.19) \end{aligned}$$

This leads to the following proposition:

Proposition 2. *Suppose that the objective of the government is given by (3.16) with $\gamma < 1$ and that the instantaneous utility function satisfies Assumption 1. Then, the tax rate on capital is positive: $\tau_t^k > 0$.*

Proof. Multiply (3.19) by γ^t. Use (3.18) to replace $\gamma^t \eta_t$ and (3.18) in period $t+1$ to replace $\gamma^{t+1} \eta_{t+1}$ in (3.19). This yields

$$1 = \beta \left(\frac{c_t}{c_{t+1}} \right)^{\sigma} \left(1 + F_k \left(k_{t+1}, n_{t+1} \right) - \delta \right) \frac{\gamma^{t+1} + \Psi (1-\sigma)}{\gamma^t + \Psi (1-\sigma)}.$$

Now, combine this equation with (3.12) for the utility function defined in Assumption 1 and (3.13) and adjust the time index to obtain $1 - \tau_t^k = \frac{\gamma^t + \Psi(1-\sigma)}{\gamma^{t-1} + \Psi(1-\sigma)}$. For a binding implementability constraint, i.e. $\Psi > 0$, and $\sigma \leq 1$, it follows that $1 > \frac{\gamma^t + \Psi(1-\sigma)}{\gamma^{t-1} + \Psi(1-\sigma)} > 0$ for $\gamma < 1$. Hence, $1 - \tau_t^k < 1 \Leftrightarrow \tau_t^k > 0$ □

Proposition 2 shows that if the policy maker cares less about future utility than the household it will drive a wedge between the rate of substitution and the rate of transformation of consumption at different dates by setting a positive tax on capital.[10] This can be seen from (3.12) for the preferences given in Assumption 1:

$$\left(1 - \tau_{t+1}^k \right) = \frac{\left(c_{t+1} / c_t \right)^{\sigma}}{\beta \left(1 + F_k \left(k_{t+1}, n_{t+1} \right) - \delta \right)}. \qquad (3.20)$$

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[10] In period $t = 1$ the tax rate on capital is positive even for $\gamma = 1$ because it also depends on A_0 and c_0 which are both positive (for $b_0 \geq 0$): $1 - \theta_1 = \frac{\gamma + \Psi(1-\sigma)}{1 + \Psi(1-\sigma) + \Psi \sigma A_0 / c_0}$.

Policy myopia leads to capital taxation and tends to decrease consumption growth (see 3.20). [11] In sum, if there exist distortions in the political process which lead the government to have more short-sighted objectives than the society as a whole, then tax rates on capital are positive like in many countries around the world.

3.3 The stochastic model

The last section showed that policy myopia leads to capital taxation under perfect foresight and when household have a high elasticity of intertemporal substitution. This section extends this result to a stochastic setting where markets are incomplete and shows that the government will tax capital even if households have a low elasticity of intertemporal substitution. To analyze the case of incomplete markets is important because neither state-contingent bonds nor state-contingent capital taxes are available to most real world governments. Further, introducing uncertainty allows analyzing how the introduction of myopia alters the response of fiscal policy to exogenous shocks.

3.3.1 The model with financial intermediary and incomplete markets

In this version of the model, I make the following new assumptions: (i) Introduction of uncertainty and an infinite time horizon, (ii) introduction of a financial intermediary, (iii) the tax rate on capital τ_t^k is levied on the net return of capital r_t, and (iv) the tax rate on capital is set one period in advance. The economy consists of households, firms, a government, and a financial intermediary. All agents have rational expectations.

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[11] Appendix 3.A shows that policy myopia also implies that the tax rate on labour increases as t increases. Moreover, it can be shown that $\tau_t^k = \frac{\gamma^{t-1}(1-\gamma)}{\gamma^{t-1}+\Psi(1-\sigma)} \rightarrow 0$ for $\gamma < 1, t \rightarrow \infty$ which implies that the tax rate on capital decreases over time. Hence, while this version of the model only shows that the tax on capital is positive for any $t < \infty$, in the next version of the model capital will also be taxed in the long run.

Private sector

Household preferences are now given by the corresponding expression to (3.8) accounting for uncertainty

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, n_t\right), \tag{3.21}$$

where $u\left(c, n\right)$ is additively separable. For the sake of realism, markets for government bonds are incomplete like in Aiyagari, Marcet, Sargent, and Seppälä (2002) and hence the return on bonds $1/R_t$ is non-state-contingent. The budget constraint reads:

$$\begin{aligned} c_t + \frac{b_{t+1}}{R_t} + k_{t+1} + \Phi_t \quad \leq \quad & \left(1 - \tau_t^n\right) w_t n_t \\ & + \left[1 + \left(1 - \tau_t^k\right) r_t - \delta\right] k_t + b_t + \pi_t, \end{aligned} \tag{3.22}$$

where Φ_t are transaction costs which have to be paid to a financial intermediary when the household engages in the capital market. They are assumed to have the following form:

$$\Phi_t = \frac{\phi}{2} y_t \left(\frac{b_{t+1}}{y_t}\right)^2. \tag{3.23}$$

They are quadratic in the ratio of bond holdings over per capita output and proportional to GDP. The transaction costs ensure a well defined steady state of the model by preventing the path of debt to be explosive (see Section 3.3.2). The main advantage of this functional form, which follows Schmitt-Grohé and Uribe (2003), Neumeyer and Perri (2005), and Kumhof and Yakadina (2007), is its analytical tractability. The transaction costs imply that an increase of the level of debt to GDP leads to an increase of the interest rate on government bonds. This implication commands broad empirical support (see Gale and Orszag, 2003, Engen and Hubbard, 2004, or Laubach, 2009). The firms' and financial intermediary's profits π_t are redistributed to the household in a lump-sum way. Moreover, notice that, in order facilitate an analytical analysis for the case of quasi-linear preferences (see Section 3.4.1 below), now the tax is levied on the net return on capital r_{t+1} .

The household maximizes (3.21) s.t. (3.22) and (3.23) which can be combined to

$$\begin{aligned} -u_{n,t} &= u_{c,t}\left(1-\tau_t^n\right)w_t && (3.24)\\ u_{c,t}\left(\frac{1}{R_t}+\phi\frac{b_{t+1}}{y_t}\right) &= \beta E_t u_{c,t+1} && (3.25)\\ u_{c,t} &= \beta E_t\left[u_{c,t+1}\left(1+\left(1-\tau_{t+1}^k\right)r_{t+1}-\delta\right)\right]. && (3.26)\end{aligned}$$

Moreover, the transversality conditions hold:

$$\lim_{t\to\infty}\beta^{t+1}E_0 u_{c,t+1}b_{t+1}=0 \quad\text{and}\quad \lim_{t\to\infty}\beta^{t}E_0 u_{c,t}k_{t+1}=0. \tag{3.27}$$

Equation (3.25) shows that an increase of the ratio of debt to GDP tends to increase the interest rate via and increase of transaction costs. Combining (3.25) and (3.26) to an arbitrage-freeness condition shows that the interest rate on bonds will then exceed the net return on capital.

The production function of competitive firms is given by $y_t = F\left(a_t, k_t, n_t\right)$ where now total factor productivity a_t follows an exogenous stochastic process (see below). The firms' first-order conditions are given by the corresponding expressions to (3.13). The financial intermediary has zero marginal and fixed costs and since firms make zero profits $\Phi_t = \pi_t$ holds.

Government

The government has to finance a given stream of government consumption g_t which now follows a stochastic process (see below). It has access to flat-rate taxes on labor income τ_t^n and on the net return on capital τ_t^k and can issue one-period non-state-contingent bonds. In order to account for inertia in the legislative process, I assume that capital taxes have to be set one period in advance, following Farhi (2009, forthcoming). By ruling out that the tax rate on capital is state-contingent this assumption preserves the incomplete market structure and thus provides a realistic description of the instruments available to real world governments. The government's budget constraint is given by

$$g_t + b_t = \tau_t^n w_t n_t + \tau_t^k r_t k_t + \frac{b_{t+1}}{R_t}, \tag{3.28}$$

where τ_0^k is exogenously fixed. The resource constraint of the economy is given by the corresponding expression to (3.15) where now $y_t = F(a_t, k_t, n_t)$.

Then, for a given government policy (which will be determined in detail below), a competitive equilibrium can be defined as follows:

Definition 3.3. *For a given government policy* $\{b_t, \tau_t^n, \tau_t^k\}_{t=0}^{\infty}$ *satisfying the government budget constraint (3.28), a competitive equilibrium is a set of sequences* $\{c_t, k_t, n_t, R_t, r_t, w_t, y_t, \Phi_t, \pi_t\}_{t=0}^{\infty}$ *satisfying (3.23)- (3.26), the firm's first order conditions, the resource constraint,* $y_t = F(a_t, k_t, n_t)$*,* $\Phi_t = \pi_t$*, and the transversality conditions for given exogenous processes* $\{a_t, g_t\}_{t=0}^{\infty}$ *and initial conditions* b_0*,* k_0*, and* τ_0^k*.*

3.3.2 Policy problem

Accounting for uncertainty, the objective of the government corresponding to (3.16) is given by:

$$E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \, u(c_t, n_t), \tag{3.29}$$

The problem of the government can be defined as follows:

Problem 3. *The problem of the government is to maximize (3.29) over competitive equilibria by choosing sequences of tax rates and bonds* $\{\tau_t^n, \tau_t^k,\ b_t\}_{t=0}^{\infty}$*, subject to the government budget constraint (3.28) and given initial values* b_0*,* k_0*, and* τ_0^k*, and exogenous processes* $\{a_t, g_t\}_{t=0}^{\infty}$ *.*

As opposed to the previous section, under incomplete markets it is not possible to construct a single implementability constraint as of period zero. To solve Problem 3, I thus follow Aiyagari, Marcet, Sargent, and Seppälä (2002) and derive a sequence of implementability constraints. To start, I substitute out prices w_t and R_t and the labour tax rate τ_t^n in the household's budget constraint (3.22) by using (3.24) and (3.25), yielding

$$\begin{aligned} c_t + b_{t+1}\left[\beta E_t \frac{u_{c,t+1}}{u_{c,t}} - \phi \frac{b_{t+1}}{y_t}\right] + k_{t+1} &= -\frac{u_{n,t} n_t}{u_{c,t}} + b_t \\ &\quad + \left[1 + \left(1 - \tau_t^k\right) r_t - \delta\right] k_t, \end{aligned} \tag{3.30}$$

where I used that $\Phi_t = \pi_t$. Now, I iterate forward (3.30), use (3.26), apply the law of iterated expectations, and use the transversality conditions (3.27) which gives[12]

$$\begin{aligned} & u_{c,t}\left(b_t + \left[1 + \left(1-\tau_t^k\right) r_t - \delta\right] k_t\right) \\ = \quad & E_t \sum_{j=0}^{\infty} \beta^j u_{c,t+j} \left[c_{t+j} + \frac{u_{n,t+j} n_{t+j}}{u_{c,t+j}} - \phi \frac{b_{t+1+j}^2}{y_{t+j}}\right]. \end{aligned} \tag{3.31}$$

Neither the debt payoff nor the tax rate on capital are conditional on the state of the economy. The only two instruments available to the government within a given period are non-state-contingent bonds and the tax rate on labour. Incomplete markets imply that (3.31) has to hold in every period separately. At the end of each period the government has to form new expectations, depending on the realization of shocks today, of the future state of the economy and set its instruments such that expected future surpluses can pay back outstanding debt.

The gross return on capital, and hence the tax rate on capital, can not completely be eliminated from the sequence of implementability constraints (see LHS of 3.31). Further, accounting for the resource constraint with $y_t = F(a_t, k_t, n_t)$, the Lagrangian to the policy maker's problem is given by

$$\begin{aligned} L \quad = \quad & E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \left\{ u(c_t, n_t) \right. \\ & + \eta_t \left(F(a_t, k_t, n_t) + (1-\delta) k_t - c_t - g_t - k_{t+1}\right) \\ & + \psi_t \left(\begin{array}{c} E_t \sum_{j=0}^{\infty} \beta^j u_{c,t+j} \left(c_{t+j} + \frac{u_{n,t+j} n_{t+j}}{u_{c,t+j}} - \phi \frac{b_{t+1+j}^2}{F\left(a_{t+j}, k_{t+j}, n_{t+j}\right)}\right) \\ - u_{c,t}\left(b_t + \left[1 + \left(1-\tau_t^k\right) F_k(a_t, k_t, n_t) - \delta\right] k_t\right) \end{array} \right) \\ & \left. + \chi_t \left(E_t\left[\frac{u_{c,t+1}}{u_{c,t}}\left(1 + \left(1-\tau_{t+1}^k\right) F_k(a_{t+1}, k_{t+1}, n_{t+1}) - \delta\right)\right] - \frac{1}{\beta}\right) \right\} \end{aligned} \tag{3.32}$$

Now, the multipliers on the implementability constraints ψ_t are time dependent. Moreover, the infinite double sum in (3.32) complicates the analysis of the policy problem. Therefore, I re-write the policy problem recursively. Following Aiyagari, Marcet, Sargent, and Seppälä (2002), I define a new stochastic multiplier $\mu_t = \frac{\mu_{t-1}}{\gamma} +$

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[12] For a derivation of the sequence of implementability constraints see Appendix 3.B.

ψ_t, with $\mu_{-1} = 0$. The infinite double sum in (3.32) can then be written as

$$E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \psi_t E_t \sum_{j=0}^{\infty} \beta^j s_{t+j} = E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \mu_t s_t, \tag{3.33}$$

where $s_{t+j} \equiv u_{c,t+j}\left(c_{t+j} + \frac{u_{n,t+j} n_{t+j}}{u_{c,t+j}} - \phi \frac{b_{t+j+1}^2}{F\left(a_{t+j}, k_{t+j}, n_{t+j}\right)}\right)$.[13] Using (3.33) the Lagrangian in (3.32) can be written as

$$\begin{aligned} L = {} & E_0 \sum_{t=0}^{\infty} (\gamma\beta)^t \{u(c_t, n_t) \\ & + \eta_t (F(a_t, k_t, n_t) + (1-\delta) k_t - c_t - g_t - k_{t+1}) \\ & + \mu_t \left(u_{c,t} c_t + u_{n,t} n_t - u_{c,t} \frac{\phi b_{t+1}^2}{F(a_t, k_t, n_t)}\right) \\ & - \psi_t u_{c,t} \left(b_t + \left[1 + \left(1 - \tau_t^k\right) F_k(a_t, k_t, n_t) - \delta\right] k_t\right) \\ & + \chi_t \left(E_t \left[\frac{u_{c,t+1}}{u_{c,t}} \left(1 + \left(1 - \tau_{t+1}^k\right) F_k(a_{t+1}, k_{t+1}, n_{t+1}) - \delta\right)\right] - \frac{1}{\beta}\right)\right\}. \end{aligned}$$

I define $R_t^k = \left[1 + \left(1 - \tau_t^k\right) F_k(k_t, n_t) - \delta\right]$ and I suppress the arguments of the production function in the following equations. The first-order conditions to the Lagrangian for $t \geq 1$ w.r.t. $c_t, n_t, k_{t+1}, b_{t+1}$, and τ_{t+1}^k are given by

$$\begin{aligned} \eta_t + \chi_t E_t \left[\frac{u_{c,t+1}}{u_{c,t}^2 u_{cc,t}} R_{t+1}^k\right] = {} & u_{c,t} + \mu_t \left[u_{cc,t} c_t + u_{c,t} - u_{cc,t} \frac{\phi b_{t+1}^2}{F(t)}\right] \\ & - \psi_t \left(u_{cc,t} b_t + R_t^k k_t\right) + \frac{\chi_{t-1}}{\gamma\beta} \frac{u_{cc,t}}{u_{c,t-1}} R_t^k \end{aligned} \tag{3.34}$$

$$\begin{aligned} \psi_t u_{c,t} \left(1 - \tau_t^k\right) F_{kn}(t) k_t = {} & u_{n,t} + \eta_t F_n(t) \\ & + \mu_t \left[u_{nn,t} n_t + u_{n,t} + u_{c,t} \frac{\phi b_{t+1}^2}{F^2(t) F_n(t)}\right] \\ & + \frac{\chi_{t-1}}{\gamma\beta} \frac{u_{c,t}}{u_{c,t-1}} \left(1 - \tau_t^k\right) F_{kn}(t) \end{aligned} \tag{3.35}$$

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[13] For a derivation of (3.33) see Appendix 2.B.

$$\begin{aligned}\eta_t &= \chi_t E_t\left[\frac{u_{c,t+1}}{u_{c,t}}\left(1-\tau^k_{t+1}\right)F_{kk}\left(t+1\right)\right] \\ &+\gamma\beta E_t\left\{\eta_{t+1}\left(F_k\left(t+1\right)+1-\delta\right)+\mu_{t+1}u_{c,t+1}\frac{\phi b^2_{t+2}}{F^2\left(t\right)F_k\left(t+1\right)}\right. \\ &\left.-\psi_{t+1}u_{c,t+1}\left(\left(1-\tau^k_{t+1}\right)F_{kk}\left(t+1\right)k_{t+1}+R^k_{t+1}\right)\right\}\end{aligned} \tag{3.36}$$

$$\mu_t u_{c,t}\frac{2\phi b_{t+1}}{F\left(t\right)}+\gamma\beta E_t\left[\psi_{t+1}u_{c,t+1}\right]=0 \tag{3.37}$$

$$\chi_t E_t\left[\frac{u_{c,t+1}}{u_{c,t}}F_k\left(t+1\right)\right]=\gamma\beta E_t\left[\psi_{t+1}u_{c,t+1}F_k\left(t+1\right)k_{t+1}\right]. \tag{3.38}$$

An equilibrium under the politically optimal plan can be defined as follows:

Definition 3.4. *An equilibrium under the politically optimal plan is a set of sequences* $\{b_t, c_t, n_t, k_t, R^k_t, y_t, \eta_t, \mu_t, \tau^k_t, \chi_t, \psi_t\}_{t=0}^{\infty}$ *satisfying the resource constraint,* $y_t = F\left(a_t, k_t, n_t\right)$*, (3.26), (3.30), (3.34)- (3.38),* $\mu_t = \frac{\mu_{t-1}}{\gamma} + \psi_t$*,* $R^k_t = \left[1 + \left(1-\tau^k_t\right)F_k\left(a_t, k_t, n_t\right) - \delta\right]$*, for given exogenous processes* $\{a_t, g_t\}_{t=0}^{\infty}$ *and initial values* b_0*,* k_0*,* τ^k_0*, and* $\mu_{-1} = 0$*.*

For $\gamma = 1$ Definition 3.4 implies the same set of sequences as under the Ramsey planner. For $\gamma < 1$, fiscal policy is still optimizing but optimization occurs with respect to the policy maker's own objective. In both cases, the government adheres to commitments made in the past when choosing policy (see, for example, Chari and Kehoe, 1999). Henceforth, I refer to the case of $\gamma = 1$ as Ramsey-optimal policy and to the case of $\gamma < 1$ as myopic fiscal policy.

Steady state analysis

Here, I characterize the non-stochastic steady state of the economy under Ramsey-optimal policy and myopic fiscal policy in order to show the differences between the two regimes and to illustrate the effect of the transaction costs. The non-stochastic steady state is defined as the non-stochastic long-run equilibrium allocation where all endogenous variables grow with a constant rate. Due to the neoclassical production function, using that the sequence of factor productivity is stationary, and given that there are no other sources of exogenous growth in the model, the non-stochastic steady state of the model is characterized by a common growth rate of the model's endogenous variables equal to zero.

In (3.37) we see how the policy maker equates the budget relaxing effect of issuing new debt to the associated higher transaction costs. This equation can be used to illustrate the effects of γ and ϕ on the level of debt. In the non-stochastic steady state together with $\psi = (1 - 1/\gamma)\,\mu$ it implies

$$\frac{b}{y} = \frac{(1-\gamma)\,\beta}{2\phi},$$

where I dropped the time subscript to denote the non-stochastic steady state of a variable. For $\gamma = 1 \Rightarrow b/y = 0$ which gives the reference case of Ramsey-optimal policy. If $\gamma < 1 \Rightarrow b/y > 0$. Myopia leads the government to cut taxes and issue debt until the increase of transaction costs and the associated rise of the interest rate close the gap between the discount factors of the government and the household. In the long run this policy leads to a positive level of debt. For a given value of $\gamma < 1$, the limiting case of $\phi \to 0$ implies that $b/y \to \infty$. Hence, the transaction costs serve as a continuous debt limit and prevent the path of debt to explode.

Equation (3.38) illustrates the trade-off the policy maker faces when setting the tax rate on capital for the next period. It equates the effect of an increase of the tax rate on capital on household savings on the LHS to the budget relaxing effect of higher tax revenues on the RHS. In steady state (3.38) implies

$$\chi = \gamma\beta\psi u_c k \Longleftrightarrow \gamma\beta = \frac{\chi}{\psi u_c k}.$$

A decrease of γ implies a decrease of $\chi/\psi u_c k$. The policy maker values the budget relaxing effect of a higher tax rate on capital (in the denominator) relatively more than the effect on savings (in the numerator), indicating a higher preference for current consumption relative to future consumption.

3.4 Positive capital taxation under uncertainty

In this section, I first show analytically for the case of quasi-linear preferences that policy myopia leads to capital taxation. Then, I present the calibration of the model, before I numerically evaluate its steady state for general CRRA preferences, showing that the tax rate on capital increases as myopia increases. Finally, I analyze the short run dynamics of myopic fiscal policy as compared to Ramsey-optimal policy.

3.4.1 The quasi-linear case

In this subsection, I make the following assumptions which allow deriving analytical results:

Assumption 2. *The instantaneous utility function in (3.21) has the following form:*

$$u\left(c_t, n_t\right) = c_t - V\left(n_t\right),$$

where $V' > 0$ *and* $V'' > 0$*. Moreover, the rate of depreciation equals 100%,* $\delta = 1$*, and the parameter in the transaction cost specification* $\phi \to 0$*, such that in (3.35)* $u_{c,t}\frac{\phi b_{t+1}^2}{F^2(t)F_n(t)} \to 0$ *and in (3.36)* $\mu_{t+1}u_{c,t+1}\frac{\phi b_{t+2}^2}{F^2(t)F_k(t+1)} \to 0$.

The assumption of quasi-linear preference eliminates intertemporal prices which implies that $u_{c,t} = E_t u_{c,t+1} = 1$. Then, I have the following proposition:

Proposition 3. *Suppose that the instantaneous utility function, the rate of depreciation, and the transaction costs satisfy Assumption 2. If a steady state exists, the tax rate on capital is positive in the non-stochastic steady state:* $\tau^k > 0$ *for* $\gamma < 1$.

Proof. See Appendix 3.C.1. □

Proposition 3 assumes the existence of a steady state. Given the high non-linearity of the equilibrium conditions, it is not possible to analytically proof its existence. However, the set of equilibrium conditions implied by Definition 3.4 in steady state can be reduced to the following two equations in k and n:[14]

$$\begin{aligned} \left(\gamma - n\right) V'\left(n\right) &= V\left(n\right) - \left(1-\gamma\right) F_n\left(k, n\right) \\ &\quad -\gamma\beta F_k\left(k, n\right)\left[V'\left(n\right)\left(n-1\right) + V\left(n\right)\right] \\ DF\left(k, n\right) &= \nu n^2 + k\beta^{-1} + g, \end{aligned}$$

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[14] See Appendix 3.C.1 for the full set of steady state conditions and Appendix 3.C.2 for the reduction of this system to a system of two equations in k and n.

where $D = D(\beta, \gamma, \phi)$ is a function of parameters only (see Appendix 3.C.2). These two equations implicitly define k and n. In order to show that a steady state exists for a particular set of parameter values, I assume the following functional forms:

$$V(n_t) = \nu \frac{1}{2} n_t^2 \quad \text{and} \quad F(a_t, k_t, n_t) = a_t k_t^{\alpha} n_t^{1-\alpha}.$$

Based on these these functional forms, Figure 3.1 plots the two equations in the k/n plane with capital as an implicit function of labour.[15]

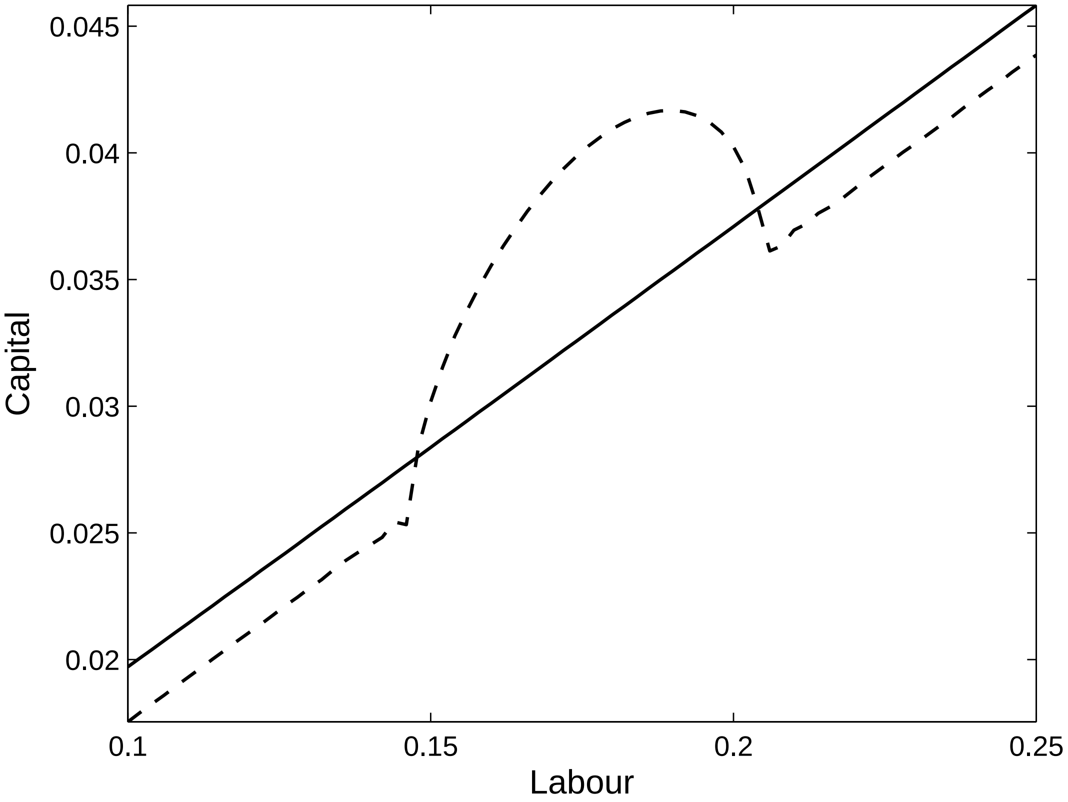

Figure 3.1: Capital as an implicit function of labour in steady state as implied by the two-equation system: Solid line – first equation; dashed line – second equation.

Figure 3.1 shows that there exist two steady states, illustrating the existence of a 'Laffer-curve' as is common in many problems of optimal fiscal policy. The solution to the left is associated with high taxes on labour and negative taxes on capital while the solution to the right is associated with lower taxes on labour and positive taxes

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[15] To solve the two-equation system, I use the following parameter values: $\phi = 0.01$, $g = 0.03$, $\beta = 0.97$, $\gamma = 0.98$, $\nu = 1$, and $\alpha = 0.34$.

on capital. However, the solution to the left is clearly inferior in terms of social welfare (as measured by 3.21) which is about 30% lower. Hence, I follow the usual approach in the literature and concentrate on the superior steady state in terms of welfare such that Proposition 3 applies.

The economic interpretation of the results for the case of quasi-linear preferences follows the intuition of the previous section. Myopic fiscal policy leads to capital taxation. Already small differences between the discount rates of the government and the private sector, i.e. any $\gamma < 1$, imply positive capital taxation. Given Assumption 2, in steady state (3.26) reads

$$1 = \beta \left(1 - \tau^k\right) F_k.$$

For a given value of β, $\tau^k > 0$ implies that F_k has to increase as compared to the steady state under Ramsey-optimal policy where $\gamma = 1$ and hence $\tau^k = 0$ (see 3.54). A higher marginal product of capital indicates that the long run stock of capital is lower, reflecting the short term orientation of the government.

3.4.2 Calibration

All parameters are calibrated to a yearly frequency. This frequency reflects inertia in fiscal policy which, unlike monetary policy, is subject to implementation lags. Due to the legislative process, fiscal policy is usually not able react to economic conditions at a quarterly frequency.

Government spending g_t and total factor productivity a_t follow independent AR(1) processes of the form:

$$\begin{aligned} \ln g_t &= (1-\rho^g)\ln g + \rho^g \ln g_{t-1} + \varepsilon_t^g, \\ \ln a_t &= \rho^a \ln a_{t-1} + \varepsilon_t^a, \end{aligned}$$

where ε_t^g and ε_t^a are *n.i.d.* with mean zero. Following Farhi (2009, forthcoming), I set $\rho^g = 0.89$, $\rho^a = 0.81$, $\sigma_{\varepsilon^g} = 0.07$, and $\sigma_{\varepsilon^a} = 0.04$.

In a yearly model, the term $h = 1/(1-\gamma)$ can be interpreted as the expected planning horizon of the government, following Grossman and Van Huyck (1988). I set $h = 50$ years which implies that $\gamma = 0.98$. This expected planning horizon is longer than the usual time in office of most governments and is supposed to give a conservative estimate of the effects of myopia on the tax rate on capital by showing that already mildly myopic governments tax capital. The instantaneous utility function is of the general CRRA form:

$$u\left(c_t, n_t\right) = \frac{c_t^{1-\sigma} - 1}{1-\sigma} - \nu \frac{n_t^{1+\varphi}}{1+\varphi}. \tag{3.39}$$

In the baseline calibration σ and φ are set to unity. The weight for working time in utility ν is calibrated such as to obtain 30% of the household's total time endowment dedicated to working time under Ramsey-optimal policy. The household's discount factor equals $\beta = 0.98$.

The parameter governing the size of the transaction costs ϕ is set to 0.01. This value implies an increase of R of about one basis point on an annual basis when b/y increases by one percent. It is at the lower end of the estimates for the effect of debt on the government's borrowing costs (see Gale and Orszag, 2003, Engen and Hubbard, 2004, or Laubach, 2009). The production elasticity of capital and the rate of depreciation are set to $\alpha = 0.34$ and $\delta = 0.1$, respectively. The value of government consumption $\bar{g}$ is set such as to obtain a ratio of $\bar{g}/y = 0.2$ under Ramsey-optimal policy. This value reflects the average of the OECD countries (see OECD, 2009b). Table 3.1 summarizes the parameters of the baseline calibration.

Unlike before, for the numerical analysis I assume that taxes are paid on the return of capital net of depreciation. This facilitates comparison with previous theoretical studies on capital taxation (see Chari and Kehoe, 1999, and Farhi, 2009, forthcoming) and previous empirical studies on capital taxation (see Mendoza, Milesi-Ferretti, and Asea, 1997, and Carey and Tchilinguirian, 2000).

3.4.3 Steady state analysis for CRRA preferences

In this subsection, I analyze numerically the effect of policy myopia on the steady state of the model. First, I show that for the given calibration the tax rate on cap-

Parameter	Value	Description
β	0.98	Household discount factor
γ	[0.98;1]	Myopia
n	0.3	Labour in steady state
σ	1	Inverse intertemporal elasticity of substitution
φ	1	Inverse Frisch labor supply elasticity
ρ^g	0.89	Serial correlation government consumption
ρ^g	0.81	Serial correlation total factor productivity
σ_{ε^g}	0.07	St. dev. of innovation to government consumption
σ_{ε^a}	0.04	St. dev. of innovation to productivity
$\bar{g}/y$	0.2	Government consumption to GDP
ϕ	0.01	Transaction costs parameter
α	0.34	Production elasticity of capital
δ	0.1	Rate of depreciation

Table 3.1: Parameter values of the baseline calibration to a yearly frequency.

ital is positive and increases as government myopia increases. Then, I assess the sensitivity of this result to alternative parameters in the utility function.

Positive and increasing capital taxes

For the baseline calibration of $\sigma = \varphi = 1$, Figure 3.2 shows the effect of policy myopia on the steady state. Myopia varies between 0.98 and 1, where the latter value implies Ramsey-optimal policy. The upper two panels depict the tax rates on capital and labour, expressed as percentage. The third panel shows the ratio of debt to GDP. The other panels show consumption, labour, and capital, expressed as percentage deviations from their steady state values under Ramsey-optimal policy.

In the upper two panels we can see that under Ramsey-optimal policy the government uses only labor taxes to finance government expenditures. In line with Judd (1985) and Chamley (1986), the tax rate on capital is set to zero. To avoid transaction costs, debt also equals zero. The first panel shows the two central findings of this chapter: First, the tax rate on capital is positive for $\gamma < 1$. This finding extends the analytical result of the previous subsection for the case of quasi-linear preferences to the case of general CRRA preferences. Second, the tax rate on capital increases as myopia increases. For $\gamma = 0.98$ it exceeds 40%. For the labour tax rate we observe a U-shape. While a mildly myopic government uses revenues from capital taxation to lower the distortions in the labor market, a strongly myopic government

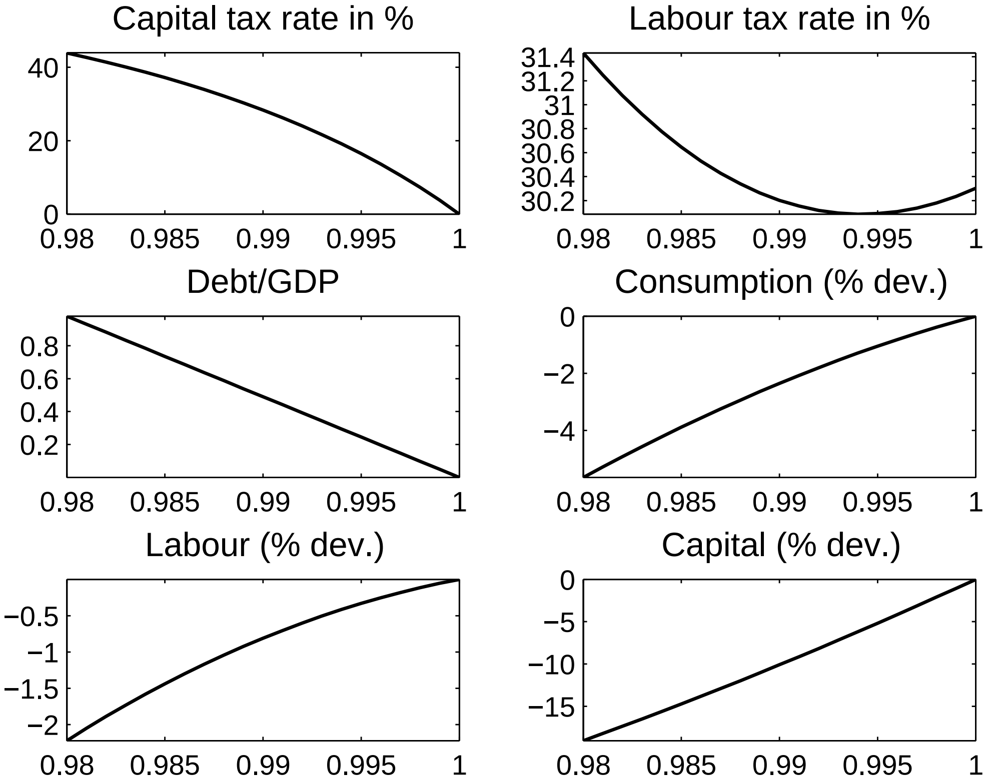

Figure 3.2: Effects of myopia on the steady state of the economy: $\gamma \in [0.98, 1]$. Consumption, labour, and capital are expressed as percentage deviations from the steady state under Ramsey-optimal policy.

also increases labour taxes to raise government revenues since pre-tax labour income declines as the wage rate decreases due to a lower stock of capital. However, as compared to the tax rate on capital, the quantitative effects of myopia on the tax rate on labour are small. For $\gamma = 0.98$ the tax rate on labour is about one percentage point higher than under Ramsey-optimal policy. In the middle left panel we see that the level of debt to GDP increases as policy myopia increases. Higher debt implies an increase of transaction costs which raises the gross interest rate. For $\gamma = 0.98$ and $\phi = 0.01$ the ratio of debt to GDP equals about 100%. In sum, the numerical analysis shows that introducing policy myopia into an otherwise standard problem of fiscal policy implies empirically realistic levels of the tax rates on capital and labour (see Mendoza, Milesi-Ferretti, and Asea, 1997, and Carey and Tchilinguirian, 2000) and the level of debt to GDP (see OECD, 2009).

The other panels show that consumption, labour, and capital decline relative to their steady state values under Ramsey-optimal policy. This is the result of an increasing tax rate on capital. In particular, there is a pronounced deterioration of the stock of capital as the tax rate on capital increases. For $\gamma = 0.98$ capital in steady state is about 20% lower than under Ramsey-optimal policy.

Sensitivity analysis

Next, I analyze the sensitivity of the previous numerical results to variations of the preference parameters σ and φ. Figure 3.3 shows the tax rates on capital and labour in steady state for different values of σ and φ, respectively. As in Figure 3.2, γ varies between 0.98 and 1. In all panels the solid line show the base case of $\sigma = \varphi = 1$. In the left column the coefficient of relative risk aversion σ varies between zero and three while the inverse of the Frish labour supply elasticity and labour are held constant at the baseline calibration of $\varphi = 1$ and $n = 0.3$, respectively. The dashed line depicts the case $\sigma = 0$, the dash-dotted line the case $\sigma = 2$, and the dotted line the case $\sigma = 3$. In the upper panel, we can see that for all considered values of σ and the given range of γ the relationship between policy myopia and the tax rate on capital is monotonic and positive. For the tax rate on labour (see lower panel) we observe a U-shape for all four cases, being more pronounced for higher values of σ. In fact, for $\sigma = 2$ or $\sigma = 3$, labour taxes are lower for all $\gamma \in [0.98; 1]$ than under Ramsey-optimal policy (see dotted and dash-dotted line, respectively). For a given γ, the tax rate on capital increases in σ whereas the tax rate on labour decreases in σ.

In the right column, now the inverse of the Frish labour supply elasticity φ varies between zero and three while the coefficient of relative risk aversion is held constant at the baseline calibration of $\sigma = 1$ (and, as before, labour is held constant at $n = 0.3$ and the line types correspond to the same values as when varying σ). We observe a similar picture as before at slightly different levels. For all considered values of φ and γ the relationship between policy myopia and the tax rate on capital is monotonic and positive. For a given γ, the tax rate on capital increases with higher values of φ whereas the tax rate on labour decreases. In sum, the sensitivity analysis shows that the positive relationship between policy myopia and the tax rate on capital is

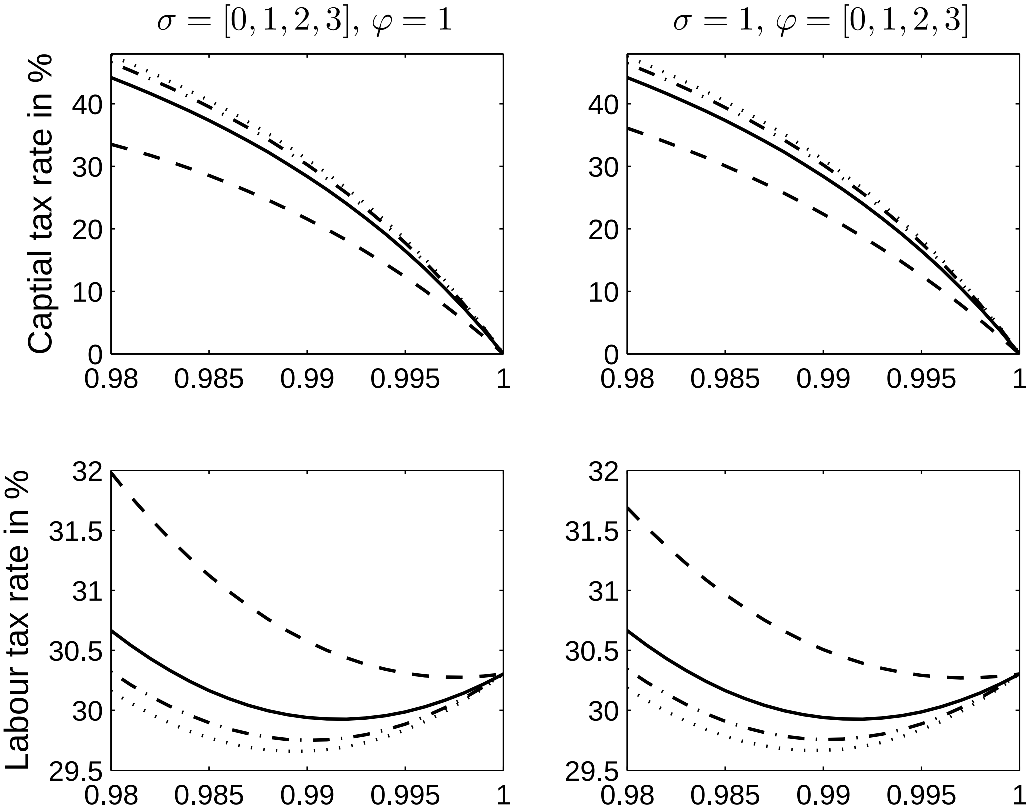

Figure 3.3: Steady state effects of myopia on the tax rates on capital and labour for different parameterizations of the utility function: $\sigma = [0, 1, 2, 3]$, $\varphi = 1$ and $\sigma = 1$, $\varphi = [0, 1, 2, 3]$ (0 – dashed line, 1 – solid, 2 – dash-dotted, 3 – dotted).

robust to alternative parameters σ and φ in the utility function.

3.4.4 Short run dynamics

In this subsection, I compare the impulse responses of fiscal policy to a government spending shock under Ramsey-optimal policy and myopic fiscal policy. I set $\gamma = 0.98$ for the case of myopic fiscal policy and $\gamma = 1$ for the case of Ramsey-optimal policy. Figure 3.4 shows the tax rates on capital and labour, debt, consumption, labour, capital, output, the interest rate on debt, and the net interest rate on capital in response to an innovation to government consumption of one standard deviation. Debt and the tax rate on capital are expressed as absolute deviations from steady state since their steady state values are zero under Ramsey-optimal policy. The remaining variables are expressed as percentage deviations from steady state.

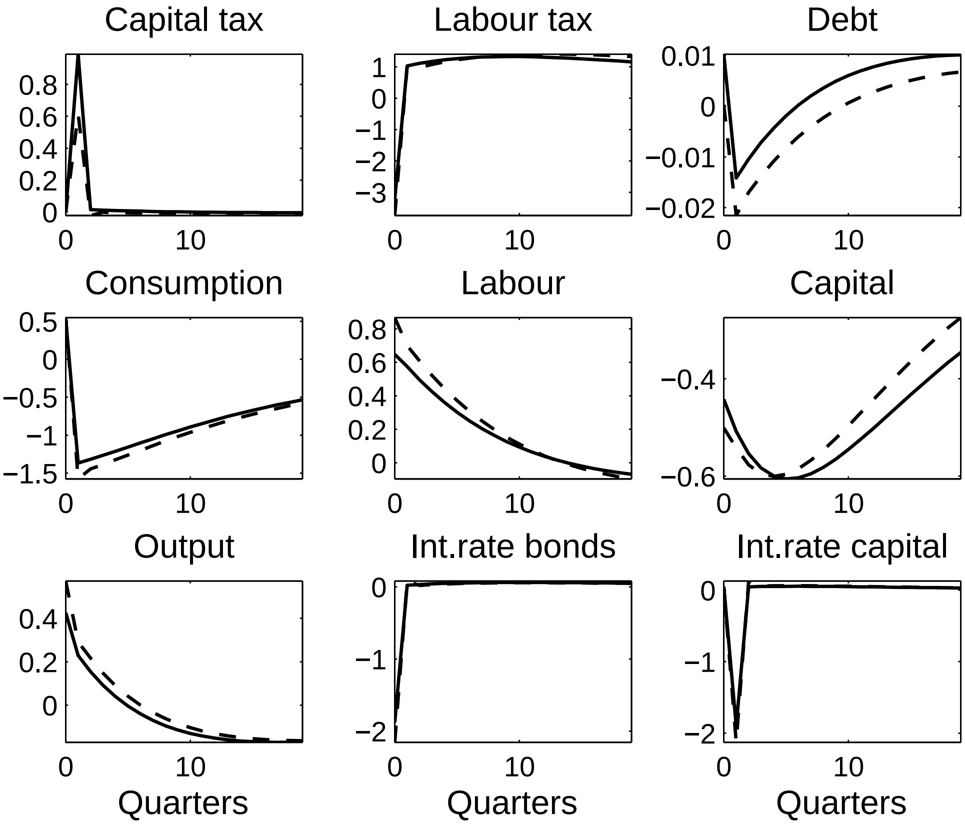

Figure 3.4: Impulse responses to a government spending shock under Ramsey-optimal policy (solid line) and myopic fiscal policy (dashed line).

The figure shows that the conduct of fiscal policy under both regimes are qualitatively and quantitatively similar. Only for debt and capital the differences are somewhat more pronounced. The first row shows how the government uses its instruments. The tax rate on capital τ_t^k spikes in the first period and then returns to zero. Capital taxes serve two purposes. First, they directly collect revenues and thus help to absorb budget fluctuations. Second, they are used to manipulate the interest rates which lowers the costs of issuing new debt. Debt in turn first helps to absorb the expenditure shock while profiting from the low interest rate. Then it drops below its steady state level for several periods relaxing the budget constraint through lower interest payments. The tax rate on labour shows only little variation after the decline on impact. This behavior illustrates the tax smoothing motive. The initial drop can be understood through a savings argument. Anticipating the sharp increase in the tax rate on capital tomorrow, the household would work less today, building less capital and consuming more out of the existing capital stock (a tendency which can also be seen from the reaction of consumption). To prevent the deterioration of tomorrows tax base the government lowers the tax rate on labour today, inducing an increase in labour and output. Even though output increases, higher government consumption crowds out capital and private consumption.

Under myopic fiscal policy the initial response of the tax rate on capital and debt are lower than under Ramsey-optimal policy. This differences is due to the fact that under myopic fiscal policy the steady state level of both variables is higher than under Ramsey-optimal policy (see Figure 3.2). Hence, the tax revenue from further increases of the tax rate on capital are relatively smaller and the distortions are higher. Equally, the ratio of debt to GDP under myopic fiscal policy is already at 100% such that new debt is only held by households at a higher interest rate (due to transaction costs). The impulse response to a shock to total factor productivity are just the mirror image of Figure 3.4 (except for labour and output) and are therefore relegated to Appendix 3.D. However, they also show that the differences between the impulse responses under both regimes are quantitatively small. In sum, this subsection shows that while policy myopia implies empirically realistic levels of the tax rates and debt the quantitative effects on the response of fiscal policy to exogenous shocks is small.

3.5 Conclusions

This chapter provides a model of fiscal policy under policy myopia. The model accounts for the observation that capital is taxed in most countries although this tax policy conflicts with the prescriptions of economic theory that capital ought to be untaxed. The chapter introduces policy myopia into an otherwise standard framework of optimal fiscal policy. Policy myopia reflects an expected finite planning horizon of the government which corresponds to the prospective duration of the government's survival in power. The government discounts the future at higher rates than the household which leads to short-sighted policies. In particular, the chapter shows that this assumption implies empirically realistic positive levels of the tax rate on capital in steady state. The quantitative effects of policy myopia on the conduct of fiscal policy over the business cycle are small.

3.A Welfare effects and labour taxation

Welfare effects

Use (3.4), (3.6) and (3.7) to solve for τ_1 and τ_2, which gives $\tau_1 = \frac{A}{A-g}\frac{1+\gamma}{2}$ and $\tau_2 = \frac{A}{A-g}\frac{1+\gamma}{2\gamma}$. Use this solution in (3.4) to obtain $c_1 = \frac{A-g}{1+\gamma}$ and $c_2 = \gamma\frac{A-g}{1+\gamma}$. Use this solution in (3.1) and calculate the first and second derivative w.r.t. γ which gives $\frac{\partial U(c_1,c_2)}{\partial\gamma} = \frac{1-\gamma}{1+\gamma} > 0$ and $\frac{\partial^2 U(c_1,c_2)}{\partial\gamma^2} = \frac{-2}{1+\gamma} < 0$. Hence, a decrease in γ reduces welfare.

Labour taxation

This appendix shows that under government myopia the tax rate on labour increases as t increases. In order to facilitate an analytical analysis, I assume that $V(n_t) = \nu n_t^{1+\varphi} / (1+\varphi)$. The first order condition to the Lagrangian in (3.17) for $1 \leq t < T$ w.r.t. n_t is

$$\gamma^t \eta_t F_n(k_t, n_t) = \gamma^t \nu n_t^{\varphi} + \Psi(1+\varphi)\nu n_t^{\varphi}.$$

Combining this expression with the first order condition to the Lagrangian in (3.17) for consumption (3.18) and rearranging terms gives

$$\frac{\gamma^t + \Psi(1-\sigma)}{\gamma^t + \Psi(1+\varphi)} = \frac{c_t^{\sigma}\nu n_t^{\varphi}}{F_n(k_t, n_t)}.$$

This expression can be combined with the household's and firms' first order conditions (3.10) and (3.13) for the given utility function, yielding an expression for the tax rate on labour

$$(1-\tau_t^n) = \frac{\gamma^t + \Psi(1-\sigma)}{\gamma^t + \Psi(1+\varphi)}.$$

The first derivative of this expression with respect to t is given by

$$\frac{\partial(1-\tau_t^n)}{\partial t} = \frac{\gamma^t \log\gamma(\sigma+\varphi)}{\left[\gamma^t + \Psi(1+\varphi)\right]^2} < 0 \quad \text{for} \quad \gamma < 1.$$

Additional to taxing future consumption by levying a tax on capital, myopia leads the government to increase the tax on labour as t increases.

3.B Derivation of the implementability constraint

This appendix shows how to derive the sequence of implementability constraints (3.31). To start with, I substitute out prices R_t and $(1-\tau_t^n)w_t$ in the household's budget constraint

(3.22) by using the household's first order conditions (3.24) and (3.25) to obtain

$$c_t + b_{t+1}\left[\beta E_t \frac{u_{c,t+1}}{u_{c,t}} - \phi \frac{b_{t+1}}{y_t}\right] + k_{t+1} = -\frac{u_{n,t}n_t}{u_{c,t}} + b_t + R_t^k k_t, \tag{3.40}$$

where I used that $\Phi = \pi_t$ and $R_t^k = \left[1 + \left(1 - \tau_t^k\right) r_t - \delta\right]$. Now, I re-write (3.40) as

$$b_t + R_t^k k_t = c_t + \frac{u_{n,t}n_t}{u_{c,t}} - \phi \frac{b_{t+1}^2}{y_t} + k_{t+1} + \beta E_t \left(\frac{u_{c,t+1}}{u_{c,t}}\right) b_{t+1}. \tag{3.41}$$

Notice that b_t in (3.41) is non-state-contingent. I define $z_t \equiv c_t + \frac{u_{n,t}n_t}{u_{c,t}} - \phi \frac{b_{t+1}^2}{y_t}$ in (3.41) which yields

$$b_t + R_t^k k_t = z_t + k_{t+1} + \beta E_t \left(\frac{u_{c,t+1}}{u_{c,t}} b_{t+1}\right). \tag{3.42}$$

Then, I iterate forward (3.42), i.e. I replace b_{t+1} in (3.42) by the right hand side of (3.42), with the time index adjusted one period ahead and use the consumption-Euler equation for capital (3.26) to eliminate capital

$$\begin{aligned}
b_t + R_t^k k_t &= z_t + k_{t+1} + \beta E_t \left\{ \left(\frac{u_{c,t+1}}{u_{c,t}}\right) \left[\begin{array}{c} z_{t+1} - R_{t+1}^k k_{t+1} \\ +k_{t+2} + \beta E_{t+1} \left(\frac{u_{c,t+2}}{u_{c,t+1}}\right) b_{t+2} \end{array} \right] \right\} \\
&= z_t + \left[1 - \beta E_t \left(\frac{u_{c,t+1}}{u_{c,t}} R_{t+1}^k\right)\right] k_{t+1} \\
&\quad + \beta E_t \left\{ \left(\frac{u_{c,t+1}}{u_{c,t}}\right) \left[z_{t+1} + k_{t+2} + \beta E_{t+1} \left(\frac{u_{c,t+2} b_{t+2}}{u_{c,t+1}}\right) \right] \right\} \\
&= z_t + \beta E_t \left\{ \left(\frac{u_{c,t+1}}{u_{c,t}}\right) \left[z_{t+1} + k_{t+2}\right] + \beta \frac{1}{u_{c,t}} E_{t+1} \left(u_{c,t+2} b_{t+2}\right) \right\} \\
&= z_t + \beta E_t \left(\frac{u_{c,t+1}}{u_{c,t}} \left[z_{t+1} + k_{t+2}\right]\right) + \beta^2 E_t \left(\frac{u_{c,t+2}}{u_{c,t}} b_{t+2}\right),
\end{aligned}$$

where in the last equality I used the law of iterated expectations. Repeating this substitution j times for future bondholdings b_{t+j} yields

$$\begin{aligned}
b_t + R_t^k k_t &= z_t + \beta E_t \left(\frac{u_{c,t+1}}{u_{c,t}} z_{t+1}\right) + E_t \left\{ \left[1 - \beta E_{t+1} \left(\frac{u_{c,t+2}}{u_{c,t+1}} R_{t+2}^k\right)\right] k_{t+2} \right\} \\
&\quad + \beta^2 E_t \left(\frac{u_{c,t+2}}{u_{c,t}} z_{t+2}\right) + E_t \left\{ \left[1 - \beta E_{t+2} \left(\frac{u_{c,t+3}}{u_{c,t+2}} R_{t+3}^k\right)\right] k_{t+3} \right\} \\
&\quad + \ldots \\
&\quad + \beta^j E_t \left(\frac{u_{c,t+j}}{u_{c,t}} k_{t+j+1}\right) + \beta^{j+1} E_t \left(\frac{u_{c,t+j+1}}{u_{c,t}} b_{t+j+1}\right)
\end{aligned}$$

Let $j \rightarrow \infty$ and multiply both sides by $u_{c,t}$

$$\begin{aligned} u_{c,t}\left(b_t + R_t^k k_t\right) &= E_t \sum_{j=0}^{\infty} \beta^j u_{c,t+j} z_{t+j} \\ &\quad + \lim_{j \rightarrow \infty} \beta^j E_t u_{c,t+j} k_{t+j} \\ &\quad + \lim_{j \rightarrow \infty} \beta^{j+1} E_t \left(u_{c,t+j+1} b_{t+j+1}\right). \end{aligned} \tag{3.43}$$

Using (3.27), the last two terms on the RHS of (3.43) equal zero.

Finally, I replace z_{t+j} and R_t^k to obtain the sequence of implementability constraints (3.31) for the incomplete market case

$$\begin{aligned} & u_{c,t}\left(b_t + \left[1 + \left(1 - \tau_t^k\right) r_t - \delta\right] k_t\right) \\ = \;& E_t \sum_{j=0}^{\infty} \beta^j u_{c,t+j} \left[c_{t+j} + \frac{u_{n,t+j} n_{t+j}}{u_{c,t+j}} - \phi \frac{b_{t+1+j}^2}{y_t}\right]. \end{aligned}$$

3.C Steady state analysis under Assumption 2

3.C.1 Proof of Proposition 3

Given Definition 3.4 and Assumption 2, the set of steady state equilibrium conditions for $\{b, c, k, n, \eta, \tau^k, \mu, \chi, \psi\}$ are given by:

$$1 + \mu = \eta \tag{3.44}$$

$$\begin{aligned} \eta F_n &= V'(n) + \mu\left[V'(n) n + V(n)\right] \\ &\quad + \psi\left(1 - \tau^k\right) F_{kn} k - \frac{\chi}{\beta\gamma}\left(1 - \tau^k\right) F_{kn} \end{aligned} \tag{3.45}$$

$$\eta = \chi\left(1 - \tau^k\right) F_{kk} + \gamma\beta\left(\eta F_k - \psi\left(1 - \tau^k\right)\left[F_{kk} k + F_k\right]\right) \tag{3.46}$$

$$\frac{b}{F(k,n)} = \frac{(1-\gamma)\beta}{2\phi} \tag{3.47}$$

$$\chi = \gamma\beta\psi k \tag{3.48}$$

$$\mu = \frac{\mu}{\gamma} + \psi \tag{3.49}$$

$$F(k,n) = c + g + k \tag{3.50}$$

$$c = V(n) n + b\left(1 - \beta + \frac{\phi b}{y}\right) + k\left(\beta^{-1} - 1\right) \tag{3.51}$$

$$1 = \beta\left(1 - \tau^k\right) F_k, \tag{3.52}$$

where I suppress the arguments of the derivatives of $F(k,n)$ to save notation. Now, I use (3.48) to replace χ in (3.46) and simplify, to obtain:

$$\eta + \psi\gamma\beta\left(1 - \tau^k\right) F_k = \gamma\beta\eta F_k. \tag{3.53}$$

I use (3.52) to simplify (3.53):

$$\eta + \psi\gamma = \frac{\gamma\eta}{1-\tau^k}.$$

Then, I replace η and ψ by using (3.44) and (3.49), respectively, and solve for $\left(1-\tau^k\right)$:

$$1-\tau^k = \frac{\gamma+\gamma\mu}{1+\gamma\mu}. \tag{3.54}$$

Ruling out non-distortionary taxation in the first period, the Lagrange multiplier on the implementability constraint μ is positive. Hence, $1-\tau^k < 1$ for $\gamma < 1$**.**

3.C.2 Reduction of the steady state conditions

This appendix shows how to reduce the steady state conditions given in Appendix 3.C.1 to two equations in k and n. To obtain the first of the two equations, I eliminate τ^k, η, ψ, χ, and μ. I Start by using (3.48) to replace χ in (3.45) and simplify to obtain:

$$\eta F_n = V'(n) + \mu\left[V'(n)\,n + V(n)\right]. \tag{3.55}$$

Then, I use (3.49) and (3.52) in (3.53) to first replace ψ and then $\beta\left(1-\tau^k\right)F_k$, respectively, to obtain

$$\eta = \gamma\beta\eta F_k + \mu\left(1-\gamma\right). \tag{3.56}$$

Now, I use (3.44) to replace η in (3.56), simplify, and solve for μ:

$$\mu = \frac{\gamma\beta F_k - 1}{\gamma\left(1-\beta F_k\right)}.$$

Using (3.49) to replace η in (3.55) and solving for μ:

$$\mu = \frac{V'(n) - F_n}{F_n - \left[V'(n)\,n + V(n)\right]}.$$

I combine the two equations to eliminate μ and simplify. This gives the first of the two equations:

$$\begin{aligned} & V(n) - \gamma\beta F_k(k,n)\left[V'(n)(n-1) + V(n)\right] \\ = \quad & (\gamma - n)\,V'(n) + (1-\gamma)\,F_n(k,n). \end{aligned}$$

To obtain the second of the two equations, I eliminate b and c. I start by combining (3.50) and (3.51) to eliminate c:

$$F(k,n) = V'(n)\,n + b\left(1-\beta+\frac{\phi b}{y}\right) + k\left(\beta^{-1}-1\right) + g + k.$$

Now, I use (3.47) to eliminate b, simplify, and collect terms on $F(k,n)$. This gives the second of the two equations in k and n:

$$DF(k,n) = V'(n)\,n + k\beta^{-1} + g,$$

where $D = 1 - \frac{\beta(1-\gamma)(1-\beta)}{2\phi} - \left(\frac{\beta(1-\beta)}{2}\right)^2$.

3.D Impulse response to a shock to total factor productivity

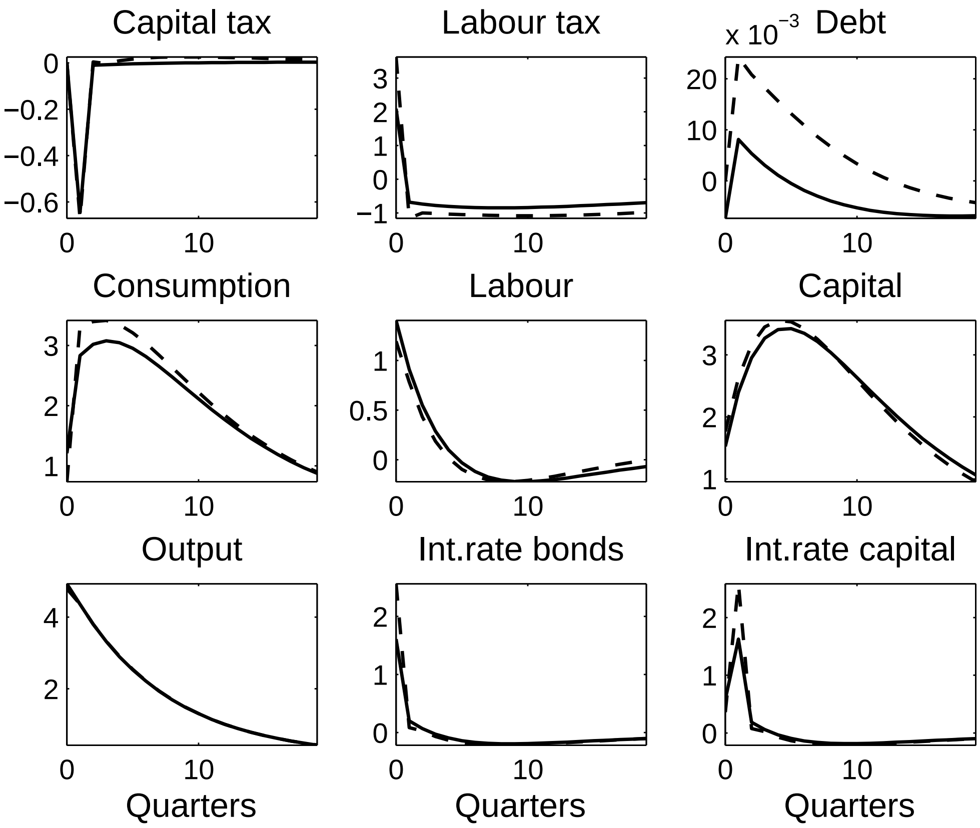

Figure 3.5: Impulse response to a shock to total factor productivity under Ramsey-optimal policy (solid line) and myopic fiscal policy (dashed line).

Chapter 4

Political Instability and Capital Taxation: Evidence from a Panel of OECD Countries

The level of capital taxation plays a crucial role in the optimal, welfare-enhancing design of macroeconomic policies. However, there remains a large gap between the prescriptions of economic theory, recommending a zero tax rate on capital, and actual tax rates on capital, remaining far from zero. In order to account for this gap, this chapter presents empirical support for the hypothesis that higher political instability leads to an increase of the tax rate on capital income. The hypothesis is tested on a panel of annual observations for 13 OECD countries for the period 1964-1983. The main finding is that an increase of the index of political instability by one standard deviation leads to an increase of the tax rate on capital by about 1.8 percentage points. This effect is statistically and economically significant and robust against alternative sets of regressors and measures of the dependent variable, outlier correction, and alternative estimation strategies.

4.1 Introduction

Since taxes play a crucial role in the optimal, welfare enhancing design of macroeconomic policies, a central question in economics has always been the determination of the optimal level of capital taxation (see Chari and Kehoe, 1999). One of the most prominent results from the theory of optimal taxation in dynamic models with a representative agent is that capital income should not be taxed in the long run or on average (see, for example, Judd, 1985, Chamley, 1996, Zhu, 1992, or Farhi, 2009). However, there remains a large gap between economic theory and the actual tax rates on capital in most countries across the world which remain far from zero.[1] There have been several attempts to explain this discrepancy (see, for example, Alesina and Rodrik, 1994, or Aiyagari, 1995). In this chapter, I present an alternative explanation for positive capital taxation based on a well know phenomenon in the macroeconomic literature: Political instability. The theoretical argument for a relationship between political instability and capital taxation is based on the analysis of the previous chapter where I showed that policy myopia leads to capital taxation. However, since the discount factor of the government is inherently difficult to measure, I use political instability as a measure for the perceived probability of the incumbent government of loosing office.

The main idea of this chapter is the following: By increasing the probability of loosing office, higher political instability shortens the planning horizon of governments. As a consequence they implement more short sighted policies, setting a positive tax on capital income. Since this tax is equivalent to an ever-increasing tax on future consumption it postpones tax collection into the future but depresses the long run stock of capital. More technically speaking, short sighted governments have stronger preferences for nearby consumption and thus care less about intertemporal distortions. Hence, the main hypothesis of this chapter is that higher political instability leads to an *increase* of the tax rate on capital income. This hypothesis is consistent with previous studies which find that political instability tends to reduce investment (see, for example, Alesina and Perotti, 1996) and growth (see, for example, Alesina, Özler, Roubini, and Swagel, 1996) and suggests that one possible channel from political instability on investment and growth is that via capital taxation.

The hypothesis that political instability leads to capital taxation is tested on a panel of annual observations of 13 OECD countries for the period 1964-1983 using two standard measures. To measure political instability, I use the index of Gupta (1990) who addresses in detail the problem of representing a multidimensional phenomenon by a single variable. For the given sample, the index is basically driven by

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[1] See, for example, Mendoza, Milesi-Ferretti, and Asea (1997) or Carey and Tchilinguirian (2000) for measures of effective average tax rates on capital income.

events such as anti-government demonstrations, political strikes, and riots which are a manifestation of discontent of the population with the policies implemented by the incumbent government and thus captures the perceived probability of loosing office. The index has been used in similar contexts by Venieris and Gupta (1986), Benhabib and Spiegel (1994), and Perotti (1996). To measure the tax rate on capital income, I use the estimates of Mendoza, Milesi-Ferretti, and Asea (1997) which are based on the methodology proposed in Mendoza, Razin, and Tesar (1994) for computing aggregate tax rates which correspond to the average effective tax rates in macroeconomic, representative household models. These estimates have been used in many studies on capital taxation, among others, by Bretschger and Hettich (2002), Garrett and Mitchell (2001), Swank and Steinmo (2002), and Dreher (2006).

The data set contains pooled time-series cross-sectional (TSCS) observations. This data structure is typically characterized by having contemporaneously correlated, cross-sectionally heteroskedastic, and serially correlated errors. In the empirical analysis, I thus first use the Prais-Winsten transformation to remove the serial correlation of the errors and obtain estimates of the coefficients of the model. Then, I use panel corrected standard errors (PCSE) which correct for contemporaneously correlated and cross-sectionally heteroskedastic errors, following Beck and Katz (1995). With regard to the control variables, I closely follow the specification of Swank and Steinmo (2002) and include four broad categories of controls: Internationalization, domestic economic conditions, budgetary pressures, and general model/ control variables. In order to account for the implementation lag of fiscal policy and to identify the discretionary part of fiscal policy all explanatory variables, including the index of political instability, enter the empirical model with their first lag.

The main finding of the empirical analysis is that higher political instability leads to an increase of the tax rate on capital. On average, an increase of the index of political instability by one standard deviation leads to a statistically significant increase of the tax rate on capital by about 1.8 percentage points. If the most stable country in the sample (according to the mean of the index over the sample period), Finland, would exhibit the same instability as the most unstable country, Spain, its tax rate on capital would be approximately 3.4 percentage points higher. For the average country (according to the mean across countries for a given year), an increase of the index of political instability by one standard deviation in a given year leads to an increase of the tax rate on capital by approximately 0.3 percentage points in the following year. This effect holds for a broad set of considered specifications using alternative sets of control variables. Moreover, it is robust against the following sensitivity checks and alternative estimation approaches: Inclusion of the lagged dependent variable as an additional explanatory variable, several ways to correct for outliers, an alternative measure of the dependent variable, and alternative assumptions on the error process.

There are several related strands of literature. The first strand is related with respect to the dependent variable, the tax rate on capital. Swank and Steinmo (2002) analyze the role of internationalization for the tax structure of capitalist democracies. Using panel data on 14 countries for the period 1981-1995 they find that, while statuary corporate tax rates tend to decline with internationalization, the effective tax rate on capital remains unaffected. The basic idea in the literature on how internationalization affects policies is that the former induces capital to migrate to countries with lower tax rates, leading to a 'race to the bottom' of capital tax rates. Empirical evidence on the relationship between internationalization and the tax rate on capital is mixed: While Rodrik (1997), Bretschger and Hettich (2002), and Hansson and Olofsdotter (2003) find the hypothesized negative relationship, Garrett (1995) and Dreher (2006) find a positive relationship.

A general perception among economists is that political instability is harmful to the economic performance of a country.[2] High degrees of instability are likely to shorten the planning horizon of policy makers, leading to short term oriented macroeconomic policies. This effect is well known and documented in the context of monetary policy, both theoretically and empirically, where higher political instability is associated with higher inflation.[3] In a seminal work Cukierman, Edwards, and Tabellini (1992) show that countries with higher political instability rely more heavily on seigniorage. Aisen and Veiga (2006) confirm this finding. In the context of fiscal policy, there is supportive evidence that higher instability leads to higher deficits and debt (see Alesina and Tabellini, 1992, or Alesina and Perotti,

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[2] For an overview of the literature on the effects of political instability and macroeconomic policy, see Persson and Tabellini (1999) or Carmignani (2003).

[3] For a survey of the models, see Alesina, Roubini, and Cohen (1997) or Drazen (2000).

1994). Despite this widely accepted view that political distortions may essentially affect macroeconomic policy, the effect of political instability on the tax structure of a country has attained less attention in the literature.[4]

Another strand of literature analyzes the effects of political instability on growth and investment. Easterly and Rebelo (1993) and Alesina, Özler, Roubini, and Swagel (1996) show that growth is significantly lower in countries with higher political instability. While Easterly and Rebelo (1993) present cross-country regressions for data averaged over nearly two decades, Alesina, Özler, Roubini, and Swagel (1996) estimate a model on annual data where economic growth and political instability are jointly determined. In a related study, Alesina and Perotti (1996) show that political instability, by creating uncertainty in the politico-economic environment, reduces investment.

4.2 Theoretical determinants of capital tax rates

In this section, I discuss the factors which, according to economic theory, determine the discretionary part of fiscal policy and in particular the level of the tax rate on capital income across countries and over time.[5] [6] I start with the main variable of interest, political instability. Based on the analysis of Chapter 3, the theoretical argument for a positive causal relationship between political instability and the tax rate on capital income is of as follows: Governments are unsure about their time in office because there is a non-zero probability of loosing office in any future period. Political instability, which comprises events such as anti-government demonstrations and political strikes, is an expression of discontent of the population with the polices implemented by the incumbent government. It increases the perceived probability of loosing office which shortens the planning horizon of the incumbent government

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[4] See Volkerink and Haan (1999) for an analysis of the tax mix focusing on direct and indirect taxation and a short overview of some previous studies on this relationship.

[5] Notice that the term 'discretionary' follows the empirical literature on fiscal policy which usually distinguishes between the discretionary part of fiscal policy as the result of the decision of the government to change the tax rate as opposed to automatic stabilizers which work without the explicit action of the government, for example due to the progressivity of the tax system. Thus, the term does not refer to the theoretical literature on fiscal policy which usually distinguishes between discretionary policy and policy under commitment.

[6] Here, I only discuss the theoretical predictions. In Section 4.3.1, I discuss the data to measure the respective variables.

and leads to the implementation of more short-sighted policies. In particular, the government will set a positive tax on capital income which is equivalent to an ever-increasing tax on *future* consumption (see, for example, Mankiw, Weinzierl, and Yagan, 2009, or Albanesi and Armenter, 2009) where the latter is valued less by the incumbent government when faced with a high probability of loosing office. Put differently, short-sighted governments care less about intertemporal distortions and taxing capital allows shifting tax collection partly into the future. The outlined argument leads to the main hypothesis of the chapter: Higher political instability leads to an *increase* of the tax rate on capital income.

Now, I turn to a discussion of the set of control variables, which closely follows Swank and Steinmo (2002), and their hypothesized effects on the tax rate on capital. There is a long and intensive discussion in the literature on how internationalization affects policies, and in particular the tax rates on capital and labour. According to economic theory, internationalization reduces the tax rate on capital (see, for example, Gordon, 1986, or Razin and Sadka, 1991). Higher economic integration and the removal of restrictions to international capital flows induces mobile factor of production, namely capital, to migrate to countries with lower tax rates on capital. This process induces national governments to engage in tax competition in order to maintain their tax bases, leading to a 'race to the bottom'. Thus, the hypothesis is that higher internationalization leads to a decrease of the tax rate on capital income. The next set of control variables includes measures of domestic economic conditions and budgetary needs of the government. If the government follows anti-cyclical fiscal policies, an improvement in domestic economic conditions leads to a decrease of the tax rate on capital income. A positive shock to the government's budget affects the tax rate in the same way. The last set of control variables includes measures of the political orientation of the incumbent government. Here, the tax rate on capital is expected to be higher when left wing governments hold office, following Swank and Steinmo (2002) and Dreher (2006).

These factors are supposed to influence the discretionary part of fiscal policy, as opposed to some form of automatic adjustments of the tax rate (say, implied by the tax code) or automatic stabilizers (say, due to the progressivity of the tax system). Given the complexity of many political systems, the administrative and political processes that precede adjustments in tax rates take time. Thus, in order to account for the implementation lag of fiscal policy and to identify the discretionary part of fiscal policy, I assume that all explanatory variables affect the tax rate on capital with a lag of one year.[7]

4.3 Data and basic statistics

4.3.1 Data

The data include an unbalanced panel of annual observations for 17 OECD member countries for the period 1964-1983. The number of observations is constrained by the simultaneous availability of the index of political instability and data on the tax rate on capital. The index of political instability is available for over 100 countries for the period 1948-1982. Data on capital income tax rates cover the period 1965-1992 for OECD countries.

To measure political instability, I use the index of Gupta (1990). The author addresses in detail the classical problem of representing a multidimensional phenomenon with a single variable.[8] Since his analysis covers over 100 countries including many different political regimes, he considers three broad classes of protest against the regime. However, for the given sample of OECD countries the only relevant class is that of 'collective rebellion'. It comprises political strikes, riots, and anti-government demonstrations in the subclass of 'anomic violence' and death, armed attacks, and assassinations in the subclass of 'internal war'.[9] Gupta points out that, among these two subclasses, the latter becomes progressively less important when countries become more developed.

The main advantage of the index is that it captures many dimensions of political instability and thus proxies for the perceived probability of the government of loosing office which is difficult to measure by one single dimension. Moreover, it has the

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[7] Moreover, this assumption mitigates potential problems of endogeneity because it implies that only expected, but not actual increases of the tax rate on capital can affect the level of political instability today.

[8] For a detailed description of the index creation see Gupta (1990, Ch. 7).

[9] The other two classes are 'violence by the regime' and 'violence within the regime'. For the former there is only one observations for UK in 1975, for the latter there are no occurrences in the sample. See Appendix 4.A.1 for a further description of the index.

advantage of not using purely (and thus to some extent arbitrary) qualitative judgment, erroneous variables, or redundant variables. Further, since most dimensions of political instability are highly correlated it is not viable to include them all at the same time in one regression. On the other hand, leaving out certain dimensions of political instability leads to biased estimates. Thus, for the purpose of this chapter it is preferable to use an aggregate index.[10] Moreover, the index is used in related contexts, among others, in Venieris and Gupta (1986), Benhabib and Spiegel (1994), and Perotti (1996) to study the effects of political instability on savings or growth.

To measure the dependent variable, I use the estimates of average tax rates on capital, labour, and consumption of Mendoza, Milesi-Ferretti, and Asea (1997). The estimates are based on the methodology proposed in Mendoza, Razin, and Tesar (1994) and reflect the wedges distorting the economic decisions of agents in standard dynamic macroeconomic models of fiscal policy. A brief description of how to construct these estimates is provided in Appendix 4.A.2.[11] For the purpose of this chapter, the main advantage of the estimates is twofold: (i) They facilitate a comparison across countries, and (ii) they allow separating taxes on capital from taxes on labour and consumption. Regarding (i), several studies focus on the details of a particular tax system, combining information on tax codes, tax returns, and statuary tax rates with data on income distribution to construct precise measures of effective marginal taxes. However, the complexity and diversity of worldwide tax systems and the limitations on data availability make this approach not viable in the context of cross-country comparisons. Regarding (ii), many studies use only aggregate measures, such as the ratio of total tax revenues to GDP or the ratio of direct and indirect taxes, respectively, to total tax revenue or relative to GDP. While this approach facilitates comparisons across countries, it does not allow isolating tax rates on capital income from taxes on labour income which is necessary in order

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[10] Another advantage of the index is that it is provided on an annual basis. In the empirical literature on the determinants of growth, political instability is often perceived as a long-term phenomenon. Since these studies usually cover all different kinds of political regimes, instability largely reflects infrequent major events such as political executions and (attempted) coup d'états. For the given sample of OECD countries, the index is mostly driven by more frequent events of 'collective rebellion' such that an annual frequency still provides sufficient variation over time.

[11] One of the main difficulties in empirical research on the determinants of tax rates is the construction of an accurate measure that corresponds to the tax rates in theoretical models. For a discussion of the different methodological approaches see Volkerink and de Haan (2001).

to distinguish between inter- and intratemporal distortionary effects of particular taxes. Previous cross-countries studies on capital taxation using these estimates are, among others, Bretschger and Hettich (2002), Garrett and Mitchell (2001), Swank and Steinmo (2002), and Dreher (2006).

The sources of the other economic and political data for the control variables are Penn World Table 6.3 (PWT), Quinn (1997), OECD, the *Comparative Parties Data Set,* and the data set of Alesina, Özler, Roubini, and Swagel (1996).[12] The first category of controls – internationalization – includes a measure of policy restrictions on the international mobility of capital and a measure of the openness of the economy. The former is an index for international restrictions on payments and receipts of capital constructed by Quinn (1997). It is on a 0-4 scale, where 4 represents the absence of capital controls. Openness is measured as exports plus imports divided by GDP (all in constant prices) which gives the total trade as a percentage of GDP.

The second category – domestic economic conditions – includes a measure of unemployment. I use the unemployment rate as percentage of the civilian labour force, all persons. This control variable slightly differs from the one used by Swank and Steinmo (2002) who use data on structural unemployment. However, those data are only available from the 1970s onwards which would considerably reduce the number of observations.[13]

The third category – budgetary pressures – includes government consumption and the share of elderly people in the population. Government consumption is measured as the government's share of real GDP in constant prices. The share of elderly is measured as the percentage of the population which is 65 years and older.

The general control variables include the growth rate of GDP and two variables measuring the political orientation of the government. The growth rate of real GDP is measured as the percentage change to the previous year. The political variables measure the left and right parties' cabinet portfolios, respectively, as a percent of all cabinet portfolios and are obtained from the *Comparative Parties Data Set* provided

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[12] See Appendix 4.A.3 for a description of the data and their sources.

[13] Moreover, structural unemployment is a characteristic of the labour market only after the 1970s such that the unemployment rate provides a measures for domestic economic conditions over the full sample period.

by Duane Swank.[14] Depending on the precise specification of the model, additional control variables are the share of the labour force in the agricultural sector, investment in GDP, and government debt to GDP.

4.3.2 Basic statistics

In this subsection, I provide some basic statistics for the main variables and a graphical illustration for the index of political instability and the tax rate on capital income. Table 4.1 provides summary statistics on the latter two variables.

	— Index of Political Instability —					— Tax Rate on Capital Income —				
	Obs	Mean	Sd	Min	Max	Obs	Mean	Sd	Min	Max
Australia	19	0.014	0.029	0.00	0.13	19	38.319	6.344	29.28	50.63
Austria	19	0.008	0.030	0.00	0.13	14	20.168	1.934	17.34	23.43
Belgium	19	0.008	0.010	0.00	0.03	14	33.406	6.445	22.26	40.58
Canada	19	0.027	0.044	0.00	0.15	19	40.993	3.197	36.06	46.55
Denmark	19	0.002	0.005	0.00	0.02	3	32.380	1.321	31.48	33.90
Finland	19	0.000	0.000	0.00	0.00	19	29.817	6.140	21.61	42.71
France	19	0.216	0.284	0.00	1.20	14	22.376	4.727	16.10	29.44
Germany	19	0.081	0.091	0.01	0.38	19	25.912	4.367	20.48	32.21
Italy	19	0.425	0.675	0.01	2.55	4	23.722	3.061	20.01	27.12
Japan	19	0.025	0.030	0.00	0.10	19	28.725	7.020	19.50	40.29
New Zealand	19	0.014	0.029	0.00	0.13	2	34.540	4.117	31.63	37.45
Norway	19	0.002	0.003	0.00	0.01	9	38.344	6.161	27.32	46.42
Spain	19	1.249	0.338	0.93	1.93	4	13.378	0.825	12.68	14.56
Sweden	19	0.011	0.032	0.00	0.14	14	46.803	7.760	38.14	62.19
Switzerland	19	0.011	0.031	0.00	0.14	19	21.614	4.698	13.94	27.38
UK	19	1.097	1.398	0.01	5.91	19	55.183	10.398	39.26	74.33
US	19	0.445	0.308	0.06	1.15	19	43.524	3.209	36.80	48.84
Total	323	0.214	0.543	0.00	5.91	230	33.808	12.018	12.68	74.33

Table 4.1: Summary statistics by country: Index of political instability and tax rate on capital income. *Notes*. (1) Data sources: Gupta (1990) and Mendoza et al. (1997). (2) Sample capital tax rate: 1965 - 1983. (3) Sample political instability: 1964-1982.

The first set of columns provides summary statistics on the index of political instability. The first column shows that there are no missing observations for the index: It is available from 1964-1982, yielding 19 observations per country. The sample mean is 0.21 with standard deviation of 0.54. Even though the sample includes only OECD members, the country means vary considerably. The countries can broadly

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[14] Notice that these two variables are not mutually exclusive, i.e. perfectly negatively correlated, as for example in case of male and female dummies. That is, including both variables in the estimation does not create problems of collinearity. This is verified by excluding either one of them which leaves all results virtually unchanged.

be classified into three categories. For 12 countries the mean is smaller than 0.1. Three countries have means in the range 0.1 to 1, and two countries have a mean greater than one. For all countries the index varies over time, as can be seen from the respective standard deviations in the third column.[15] The countries with the lowest means are Finland and Denmark with zero (which is the lower bound of the index by construction, see Appendix 4.A.1) and 0.002, respectively. The countries with the highest means are the UK and Spain with 1.097 and 1.249, respectively. Most countries have experienced years without instability, as can be seen from their minimum values in column four. The maximum value in the sample is 5.909 which corresponds to the UK in 1973.

The second set of columns provides summary statistics on the tax rate on capital income. The respective first column shows that for many countries the data do not cover the complete sample period 1965-1983. Thus, the panel is unbalanced which reduces the total number of observations to 230. However, there are no gaps in the individual series which is important for the time-series properties of the model. The mean tax rate differs substantially across countries. Spain and Austria have the lowest tax rates of 13% and 20%, respectively, while Sweden and the UK have the highest tax rates of 47% and 55%, respectively. Moreover, the individual tax rates show considerable variation over time, as can be seen from their respective standard deviations.

Figure 4.1 shows the means (across countries) of the index of political instability and the tax rate on capital over the sample period. The mean of the index more than doubles from 0.1 to 0.26 over this period (right scale). The mean of the tax rate on capital increases by about eight percentage points. Both series show a similar upward trend. The spike of the index of political instability in 1973 is driven by the high value for the UK. In sum, both variables show variation across countries and over time such that they can be used to test the main hypothesis of this chapter.

Table 4.2 shows the correlation of the tax rate on capital income with the main control variables. The first column shows the contemporaneous correlation. In the second column, all explanatory variables are lagged one period. Since the tax rate

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[15] The mean and standard deviation of the index for Finland exceed zero at the fourth significant digit.

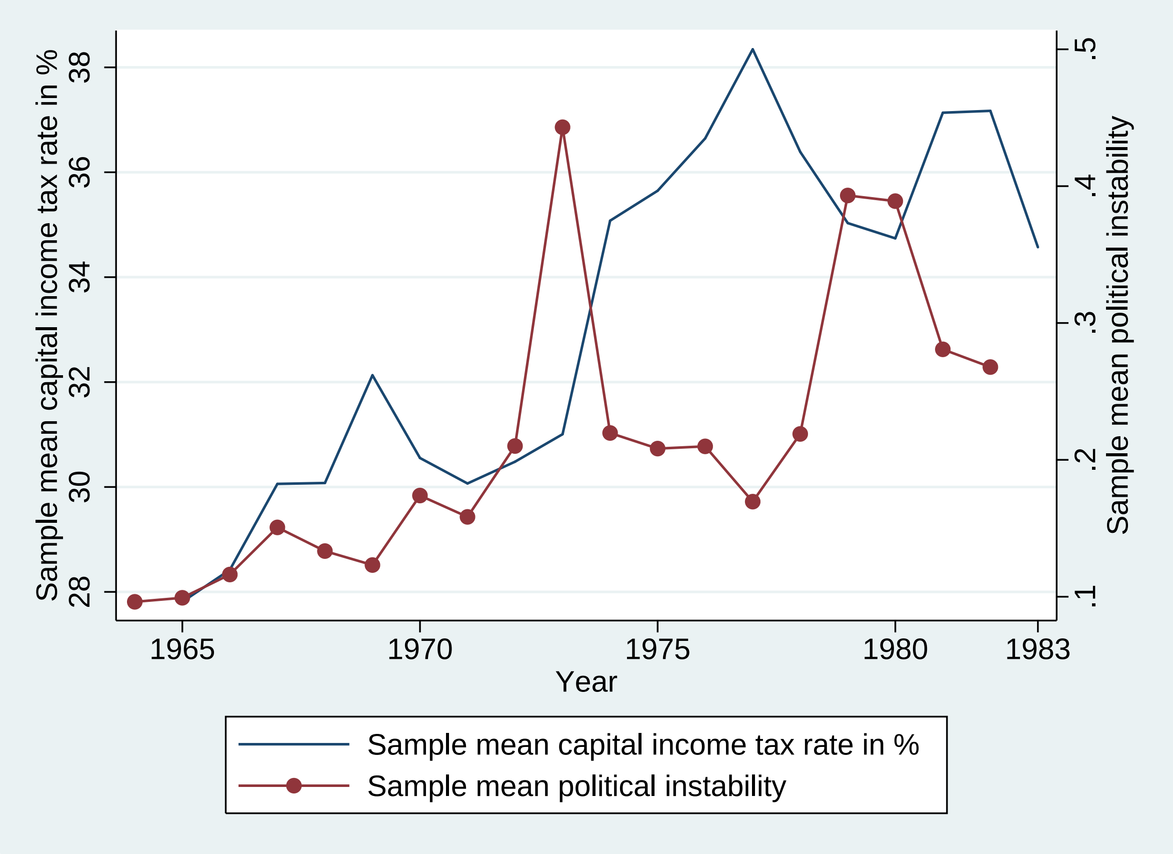

Figure 4.1: Sample means of the tax rate on capital income (solid line, left scale) and the index of political instability (circles, right scale) for the years 1964-1983.

is highly persistent, as can be seen from the last row, the cross-correlations in the two columns are similar. In the first row, we see that political instability and the tax rate on capital are positively correlated with 0.27 and 0.29, respectively. This value is among the highest correlations. The highest correlation is found for government consumption. The growth rate of GDP is strongly negatively correlated with the tax rate. These three co-movements are consistent with the theoretical consideration of Section 4.2. All other variables, except unemployment, are only weakly correlated with the tax rate.

4.4 Empirical analysis of political instability and capital taxation

In this section, I first discuss the estimation strategy and then present the main results.

	Correlation	
	$Corr(\tau_t^k, x_t)$	$Corr(\tau_t^k, x_{t-1})$
Political instability	0.27	0.29
Capital controls	-0.03	-0.02
Trade openness	-0.05	-0.04
Unemployment	0.26	0.25
Elderly	0.05	0.05
(Gov. cons.)/GDP	0.58	0.57
Growth rate	-0.30	-0.28
Left gov.	-0.11	-0.03
Right gov.	0.05	-0.00
Linear trend	0.21	0.21
Capital tax rate	-	0.95

Table 4.2: Table of correlation between the tax rate on capital income and the main control variables. *Notes.* First column – Contemporaneous correlation. Second column – All control variables are lagged one period. Sample 1964-1983, all countries.

4.4.1 Methodology for time-series cross-sectional data

The data set contains pooled time-series cross-sections (TSCS) of 1964-1983 annualized data for 17 countries. The empirical model for the tax rate on capital can be summarized as follows:

$$\tau_{i,t}^k = \alpha PI_{i,t-1} + x_{i,t-1}\beta + u_{i,t}, \qquad i = 1, ..., N, \qquad t = 1, ..., T, \tag{4.1}$$

where $\tau_{i,t}^k$ denotes the tax rate on capital and PI the index of political instability, $x_{i,t-1}$ is a k vector of exogenous variables and observations are indexed by both country (i) and time (t).[16] The exogenous variables in $x_{i,t-1}$ include a constant, measures of political instability, capital controls, trade openness, unemployment, elderly, government consumption to GDP, the growth rate, and the political orientation of the government. I denote the $NT \times NT$ covariance matrix of the errors as Ω, with typical element being $E\left(u_{i,t}, u_{j,s}\right)$. The parameter of interest is α.

TSCS data are characterized by having a relatively small number of units and a relatively large number of observations per unit (small N, large T), as opposed to typical microeconomic data sets with few repeated observations for a large number of units (large N, small T). Given the structure of TSCS data, I expect contemporaneously correlated errors, cross-sectionally heteroskedastic errors, and serially corre-

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[16] Notice that the pooling assumption implies that $\alpha_i = \alpha$ and $\beta_i = \beta$.

lated errors, as in, for example, Swank and Steinmo (2002) and Dreher (2006). Panel heteroskedasticity is likely to arise in a cross-country panel study where the level of the tax rate on capital differs substantially across countries. Hence, I do not assume spherical errors but allow for panel heteroskedasticity:

$$Var\left(u_{i,t}^{2}\right)=\sigma_{i}^{2}, \tag{4.2}$$

where the variance of the errors σ_i^2 may differ across countries. Moreover, contemporaneous correlation is likely to arise in cross-country studies where, for example, France and Germany are affected by correlated shocks. Hence, the errors may be contemporaneously correlated:

$$\begin{aligned} E\left(u_{i,t},u_{j,t}\right) &= \sigma_{ij}, \\ E\left(u_{i,t},u_{j,s}\right) &= 0, \qquad \text{for } t\neq s, \end{aligned} \tag{4.3}$$

such that errors for country i at time t will be correlated with errors for country j at time t. Finally, given the time-series properties of the data, autocorrelation may arise as the result of missing unobservable explanatory variables, such that I allow for serial correlation in the error term $u_{i,t}$:

$$u_{i,t}=\rho u_{i,t-1}+\varepsilon_{i,t}, \tag{4.4}$$

where $\varepsilon_{i,t}$ are independent, identically distributed, zero-mean random shocks.[17]

The autocorrelation and the cross-sectional correlation of the errors can be treated independently. I address dynamics first. Visual inspection shows that the residuals of a least squares country-specific dummy variables estimation exhibit considerable persistence. I formally test for autocorrelation using a Lagrange-multiplier test, following Greene (2008, p. 655). In the absence of reasons that suggest a specific model for the serial correlation of the error process, this test is based on the AR(1) model of (4.4). The null hypothesis that $\rho=0$ is clearly rejected. Equation (4.1) with errors given by (4.4) can be estimated by OLS. The residuals from this regression yield an estimate of ρ. The estimated autocorrelation of the errors, $\hat{\rho}$, can then be used to

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[17] Notice that I assume that $\rho_i=\rho$.

transform the original observations using the Prais-Winsten transformation (see, for example, Greene, 2008, P. 653) which produces serially uncorrelated errors.

Now, I turn to the cross-section structure of the error matrix. Following Beck and Katz (1995), I use panel corrected standard errors (PCSE) to account for panel heteroskedasticity (see 4.2), and contemporaneous correlation (see 4.3). For TSCS data, the authors recommend to retain OLS or Prais-Winsten parameter estimates but to replace the standard errors with PCSE. Beck and Katz (1995) show that these estimates provide accurate measures of the sampling variability, even for the complicated error structure which is typically found in TSCS data. They further show that these estimates are superior to the standard errors using the more complicated GLS approach which in turn may severely understate the variability of the estimates. The $NT \times NT$ block diagonal covariance matrix of the errors, Ω, is given by

$$\Omega = \Sigma \otimes I_T,$$

where Σ is the $N \times N$ matrix of contemporaneous covariances, with typical element satisfying (4.3).[18] Since Σ is unknown, it needs to be estimated. Let E denote the $N \times T$ matrix of Prais-Winsten residuals, then Σ can be estimated by

$$\hat{\Sigma} = \frac{E'E}{T},$$

which gives an estimate of Ω:

$$\hat{\Omega} = \frac{E'E}{T} \otimes I_T.$$

Then, PCSE are computed as the square root of the diagonal elements of

$$\left(X'X\right)^{-1} X'\hat{\Omega}X \left(X'X\right)^{-1},$$

where X denotes the matrix of regressors for all observations.

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[18] For example, consider the case of $N = 2$ and $T = 3$. Then, Ω is given by $\Omega = \begin{pmatrix} \sigma_1^2 & 0 & 0 & \sigma_{12} & 0 & 0 \\ 0 & \sigma_1^2 & 0 & 0 & \sigma_{12} & 0 \\ 0 & 0 & \sigma_1^2 & 0 & 0 & \sigma_{12} \\ \sigma_{12} & 0 & 0 & \sigma_2^2 & 0 & 0 \\ 0 & \sigma_{12} & 0 & 0 & \sigma_2^2 & 0 \\ 0 & 0 & \sigma_{12} & 0 & 0 & \sigma_2^2 \end{pmatrix}.$

Since the panel is unbalanced, it must be decided which observations should be used to estimate $\hat{\Omega}$. I estimate each pairwise covariance, σ_{ij}, using all available periods that are common to the two countries contributing to this covariance. This procedure ensures that the maximum number of observations are used to compute each σ_{ij}. The alternative of using only the periods which are available for all countries would considerably reduce the number of periods. For the computations, I use *STATA* Version 10.

4.4.2 Main results on political instability and capital taxation

In this section, I conduct the econometric analysis of the relationship between political instability and the tax rate on capital. In the main regressions, I exclude Denmark, Italy, New Zealand, and Spain because the number of observations per country is four or less and it is difficult to obtain accurate estimates of the pairwise covariances with this small number of observations.[19]

Table 4.3 shows the regression results for equation (4.1). The dependent variable is the tax rate on capital and all models include a constant (not reported in the table). One period lagged regressors are denoted by L. The level of significance of the coefficients is denoted by one, two, and three stars for the 10%, 5%, and 1% level, respectively. The panel corrected standard errors of the estimated coefficients are in parentheses. The coefficient on the variable of interest, political instability, is given in the first row. Columns (1)-(3) show the results using the Prais-Winsten transformation and assuming a common serial correlation of the error process ρ. Columns (4) and (5) show the results of OLS regressions with the lagged endogenous variable (see below).

Column (1) shows the baseline specification with the set of regressors discussed in Section 4.2. The coefficient on political instability, α, is statistically significant at the 1% level and has the predicted positive sign. On average, an increase of the index by one half of a standard deviation, i.e. by 0.25, (say, as the result of approximately 30 more political demonstrations in a given year) leads to an increase of the tax rate on capital by approximately one percentage point. The estimated autocor-

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[19] In the sensitivity analysis, I include these countries and show that the main results are unaffected.

Table 4.3: **— Main results — Dependent varariable: Tax rate on capital income (percent).** Panel data for 13 OECD countries for 1964-1983. Models (1)-(3) use Prais-Winsten transformations and models (4) and (5) use OLS. In all cases panel corrected standard errors are reported. All regressions include a constant.

	– Prais-Winston regr. with PCSE –			– OLS-PCSE –	
	(1)	(2)	(3)	(4)	(5)
L.Political instability	3.53***	2.44***	3.04***	2.44**	2.75**
	(1.16)	(0.90)	(1.10)	(1.14)	(1.15)
L.Capital controls	3.02***	2.40***	1.77*	0.87	1.07
	(1.02)	(0.89)	(0.99)	(0.70)	(0.77)
L.Trade openness	0.00	-0.03	-0.00	0.03***	0.03
	(0.03)	(0.11)	(0.04)	(0.01)	(0.02)
L.Unemployment	-0.22	-1.42***	-0.88**	-0.36**	-0.49***
	(0.35)	(0.32)	(0.37)	(0.17)	(0.17)
L.Elderly	-1.20**	-2.63***	-1.79***	-0.42	-0.31
	(0.47)	(0.94)	(0.49)	(0.29)	(0.27)
L.(Gov. cons.)/GDP	1.87***	0.84*	1.88***	0.19	
	(0.21)	(0.43)	(0.21)	(0.13)	
L.Growth rate	-0.22	-0.18	-0.05	0.22*	0.24*
	(0.16)	(0.13)	(0.14)	(0.12)	(0.14)
L.Left gov.	0.03	-0.00	0.02	0.02	0.01
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
L.Right gov.	0.04*	-0.00	0.03	0.01	-0.00
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
L.Agricultur			-0.74***		
			(0.19)		
L.Capital tax rate				0.93***	0.94***
				(0.04)	(0.05)
L.Investment/GDP					0.08
					(0.09)
Gov. debt					0.02
					(0.03)
Country effects		yes			
Year effects		yes			
Observations	211	211	211	199	150
Countries	13	13	13	13	11
R^2	0.35	0.84	0.42	0.92	0.91
$\hat{\rho}$	0.61	0.41	0.65	.	.

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

relation of the residuals is $\hat{\rho} = 0.61$, indicating high persistence in the error process. The coefficient on capital controls is also statistically significant and positive at the 1% level which is at odds with the theoretical predictions but in line with previous findings (see Rodrik, 1997; Garrett and Mitchell, 2001; Devereux, Lockwood, and Redoano, 2008). Agglomeration effects stemming from increased internationalization which outweigh the costs of higher tax rates on capital for foreign investors or increased economic integration which lead to better policy coordination preventing the 'race to the bottom' of capital tax rates could explain this finding. At odds with the theoretical predictions, the tax rate on capital decreases statistically significantly with the share of elderly people in the population. One explanation for the negative coefficient could be that in most developed countries elderly people are usually owners of capital. With an increasing share of voters being capital owners, the government might try to shift the tax burden away from this group and thereby increase voter approval. Finally, in line with the theoretical predictions, the ratio of government consumption to GDP is positively related to the tax rate on capital and statistically significant.

In column (2), I include a full set of country and year dummy variables into the model in order to control for country and temporal fixed effects, following, for example, Garrett and Mitchell (2001), Swank and Steinmo (2002), or Dreher (2006). The variables are jointly significant by group and all variables of both groups jointly are significant. The coefficient on political instability remains positive and significant at the 1% level but drops in size from 3.5 to 2.4. The coefficients on capital controls and government consumption remain significant. As expected, the estimated autocorrelation of the residuals declines as the country fixed effects absorb part of the persistence of the error process. To save degrees of freedom, I exclude the country and year dummies from the next regressions.

In column (3), I include the (first lags of the) share of the labour force in the agricultural sector as an additional economic structural variable, following Cukierman, Edwards, and Tabellini (1992) and Aisen and Veiga (2006). It is supposed to reflect the characteristics of the country which affect its capacity to raise taxes. The estimated coefficient on political instability remains positive and statistically significant at the 1% level while the coefficient on the share of the labour force in the agricultural sector is significant at the 1% level with value –0.7.

One prominent alternative to address the dynamics inherent in TSCS data is proposed by Beck and Katz (1996) who recommend including a lagged dependent variable into the model. Based on Monte Carlo experiments, they show that this specification will produce serially uncorrelated errors. Studies on the determinants of capital taxation following this approach usually refer to the existence of some form of tax adjustment costs which leads to tax smoothing.[20] In the last two columns, I thus include the lagged endogenous variable as additional regressor and report the OLS coefficient estimates while retaining the PCSE. In column (4), I add the lagged endogenous variable to the specification of column (1). As already expected from the high autocorrelation (see Table 4.2), the estimated coefficient on the lagged tax rate is large with value of 0.9 and significant at the 1% level. In column (5), I estimate the same model as Swank and Steinmo (2002), but include the index of political instability as an additional control variable.[21] With respect to column (1), I exclude the share of government consumption in GDP and I include the lagged endogenous variable, the share of investment in GDP, and gross government debt as a percentage of GDP. In both cases (columns 5 and 6), the estimated coefficient on political instability remains positive and statistically significant at the 5% level.[22]

In sum, Table 4.3 provides supportive evidence for the hypothesis that political instability leads to capital taxation. Higher political instability increases the perceived probability of loosing office and governments become more short sighted. They value future consumption less and thus care less about intertemporal distortions. Accordingly, they tax future consumption by setting a positive tax rate on capital. This result holds for a large set of control variables and irrespective of the

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[20] See, for example, Bretschger and Hettich (2002), Dreher (2006), or Devereux, Lockwood, and Redoano (2008).

[21] There is one subtle difference with respect to their specification. Due to data limitations, the percent change of real profits is not included.

[22] I do not include debt and the share of investment into the baseline specification of column (1) since these two variables should rather be treated as endogenous, following the reasoning of the theoretical arguments outlined in Section 4.2 and the cited literature on political distortions and fiscal policy. They are thought to be determined, jointly with the tax rate on capital, by the level of political instability and other structural explanatory variables. Thus, the specification of column (1) is aimed at answering the deeper question which is why countries differ on the way they conduct fiscal policy. It follows the lines of Aisen and Veiga (2006) who exclude money growth and deficits from their baseline model of inflation and political instability in order to search for the deeper determinants of inflation.

methodology applied to account for serial correlation in the error terms.

4.5 Discussion of main results

In this section, I first conduct several sensitivity checks, then I analyze an alternative measure of the dependent variable, before I discuss several alternative estimation strategies and their results.

4.5.1 Sensitivity analysis

The main result that political instability leads to an increase of the tax rate on capital income is robust to several sensitivity checks. First, I include the four countries with four or less observations before 1983 into the sample and estimate the same models as in Table 4.3. The number of observations increases to 223. All the results are virtually unchanged. The index of political instability is statistically significant at the 5% level for models 1, 2, and 4 and at the 1% level for models 3 and 5. The estimated coefficients on the index are of similar size as before, i.e. they are in the range 1.9 to 3.2.[23]

Second, I control for outliers. Here, I use two criteria to detect outliers: one is based on the residuals and one on the index of political instability. Following Mendoza, Milesi-Ferretti, and Asea (1997), the first criterion defines outliers as observations that yield residuals larger than 1.5 standard errors of a full sample regression (of the baseline models of column (1) in Table 4.3). Since outliers cannot be excluded from the sample due to the time-series properties of the data, I include a dummy variable with value 1 for the 38 identified outliers, and 0 otherwise. I construct a similar dummy for residuals larger than two standard errors of a full sample regression (for four identified observations). The inclusion of neither of the two dummy variables into the models of Table 4.3 affects the main results. In all five regressions the estimated coefficient on the index of political instability remains positive, sim-

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[23] From a cross-country perspective, the data for Spain run counter the main hypothesis in that taxes on capital are relatively low (with mean of 13%) and the index of political instability is relatively high (with mean of 1.2). However, Spain is a case apart in the sample because it only became a democracy in the mid-seventies after the turmoils of the end of the Franco-area. All other countries in the sample have been democracies for at least a decade before the first observation.

ilar in size, and significant at least at the 5% level. As a further check, I construct dummy variables for outliers defined as observations that yield residuals in the 90-, 95- and 99-percentiles of the error distribution, respectively. Again, the inclusion of neither of these three dummies into the five regressions affects the main results.

The second criterion defines outliers based on the index of political instability. I construct a first dummy variable for the observation for the UK in 1973. In this year, the index of political instability exceeds its mean by more than ten times its standard deviation. Visual inspection of the data detects this observation as an obvious candidate. I construct a second dummy variable for all observations where the value of the index exceeds two times its standard deviation (which occurs in 11 cases). Including the first dummy leaves the results basically unaffected. The coefficient on political instability remains positive and significant in all cases (at the 1% level in three cases and at the 5% level in two cases). In some cases its size drops slightly. Including the second dummy does not alter the main results, either. In three cases the coefficient is significant at the 1% level while it is significant at the 5% level in the remaining two cases. In some of the models the estimated coefficient is smaller (by about 0.5).

4.5.2 Alternative measure for dependent variable

The hypothesis outlined in Section 4.2 is that more short sighted governments tax capital since they care less about intertemporal distortions and value less future consumption. This argument leads to the conjecture that the ratio of taxes distorting intertemporal decisions relative to taxes distorting intratemporal decisions increases with political instability.[24] To shed light on this issue and given the data availability (from Mendoza, Milesi-Ferretti, and Asea, 1997), I use as an alternative dependent variable the tax ratio, defined as:

$$\text{Tax ratio} = \frac{\text{Tax rate on capital income}}{\text{Tax rate on consumption + Tax rate on labour income}} \times 100.$$

The mean of this variable is 90 with standard deviation of 46 and minimum and

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[24] Notice that the hypothesis is not that political instability leads to a decrease of labour and/ or consumption taxes.

maximum values of 32 and 202, respectively. The correlation of the tax ratio and the index of political instability is 0.22. Table 4.4 shows the results from the estimation of the same five models as in Table 4.3, but where now the dependent variable is the tax ratio.

The results are similar to the ones obtained in Table 4.3. The estimated coefficient on political instability has the predicted positive sign with range of 4.5 to 9.1. The coefficient is statistically significant at the 5% level in three of the five models and significant at the 1% and 10% level in the other two models, respectively. On average an increase of the index of political instability by one standard deviation leads to an increase of the tax ratio in the range of 2.3 to 4.5 percentage points. The evidence on the effects of the other control variables is mixed. A dismantling of restrictions on international capital flows and an increase of government consumption tend to increase the tax ratio. An increase of trade openness and of the share of elderly people tend to decrease the tax ratio. In columns (4) and (5) we can see that the tax ratio shows high persistence. In sum, Table 4.4 provides supportive evidence for the hypothesis that higher political instability leads to a shift from intra- to intertemporal distortionary taxes, reflecting the short term orientation of the government.

4.5.3 Methodological aspects

In this subsection, I discuss alternative estimation strategies. In particular, I assess the sensitivity of the estimation results from the baseline specification of column (1) of Table 4.3 to alternative assumptions on the error process and fixed effects estimation. Table 4.5 shows five models addressing these alternative estimation approaches.

For comparison, column (1) replicates the baseline specification of column (1) of Table 4.3, based on the Prais-Winsten transformation and PCSE. Column (2) estimates the same model using the Prais-Winsten transformation but computes the PCSE only on those periods that are available for all countries. Thus, while the estimated coefficients are the same, the standard errors are somewhat different. In particular, the level of significance of the coefficient of political instability drops to the 5% level. Column (3) presents results for the same model as in column (1), but

Table 4.4: **Alternative measure of dependent variable: Tax ratio = Tax rate on capital income/(Tax rate on labour + Tax rate on consumption), percent;** Panel data for 13 OECD countries for 1964-1983. Models (1)-(3) use Prais-Winsten transformations and models (4) and (5) use OLS. In all cases panel corrected standard errors are reported. All regressions include a constant.

	– Prais-Winston regr. with PCSE –			– OLS-PCSE –	
	(1)	(2)	(3)	(4)	(5)
L.Political instability	9.11**	6.71***	7.05**	4.51*	6.08**
	(3.72)	(2.22)	(3.14)	(2.49)	(2.78)
L.Capital controls	8.93***	5.25**	5.21*	0.83	1.05
	(2.93)	(2.37)	(2.99)	(1.47)	(1.51)
L.Trade openness	-0.41***	0.11	-0.37***	0.04*	0.00
	(0.11)	(0.30)	(0.12)	(0.03)	(0.06)
L.Unemployment	-0.58	-3.66***	-2.92**	-0.76*	-0.94***
	(1.06)	(0.77)	(1.14)	(0.39)	(0.35)
L.Elderly	-9.15***	-4.35	-11.34***	-0.29	-0.88
	(1.28)	(2.95)	(1.53)	(0.60)	(0.60)
L.(Gov. cons.)/GDP	2.70***	0.58	2.67***	0.08	
	(0.57)	(1.25)	(0.61)	(0.24)	
L.Growth rate	-0.40	-0.47	0.15	1.04***	0.88***
	(0.45)	(0.38)	(0.38)	(0.23)	(0.29)
L.Left gov.	0.09	0.00	0.05	0.02	0.01
	(0.07)	(0.05)	(0.06)	(0.03)	(0.03)
L.Right gov.	0.16***	-0.02	0.11**	0.02	0.02
	(0.06)	(0.05)	(0.05)	(0.02)	(0.02)
L.Agricultur			-2.25***		
			(0.59)		
L.Tax ratio				0.97***	0.90***
				(0.03)	(0.06)
L.Investment/GDP					0.06
					(0.16)
Gov. debt					0.08
					(0.08)
Country effects		yes			
Year effects		yes			
Observations	200	200	200	188	143
Countries	13	13	13	13	11
R^2	0.50	0.92	0.55	0.96	0.97
$\hat{\rho}$	0.65	0.43	0.75	.	.

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.5: **— Methodological aspects — Dependent vararaible: Tax rate on capital income (percent);** Panel data for 13 OECD countries for 1964-1983. (1) Prais-Winston regression with panel corrected standard errors (same as column (1) of Table 4.3); (2) Same as (1), but PCSE computed only on observations available for all countries; (3) Same as (1), but based on country specific estimates of AR(1) coefficient of error process; (4) OLS including lagged endogenous variable; (5) Fixed effects including lagged endogenous variable.

	— Panel corrected SE —			— Regular SE —	
	(1) BASE	(2) CASEW	(3) RHOi	(4) LEV	(5) FE
L.Political instability	3.53***	3.53**	2.99***	2.44**	2.90***
	(1.16)	(1.37)	(1.07)	(1.14)	(0.59)
L.Capital controls	3.02***	3.02***	2.70***	0.87	0.83
	(1.02)	(1.03)	(0.83)	(0.70)	(0.71)
L.Trade openness	0.00	0.00	-0.07**	0.03***	0.17**
	(0.03)	(0.03)	(0.03)	(0.01)	(0.07)
L.Unemployment	-0.22	-0.22	0.10	-0.36**	-0.65***
	(0.35)	(0.36)	(0.30)	(0.17)	(0.19)
L.Elderly	-1.20**	-1.20***	-0.63	-0.42	0.86*
	(0.47)	(0.47)	(0.41)	(0.29)	(0.51)
L.(Gov. cons.)/GDP	1.87***	1.87***	1.76***	0.19	-0.31
	(0.21)	(0.22)	(0.23)	(0.13)	(0.33)
L.Growth rate	-0.22	-0.22	-0.18	0.22*	0.00
	(0.16)	(0.14)	(0.14)	(0.12)	(0.12)
L.Left gov.	0.03	0.03	0.02	0.02	0.03
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
L.Right gov.	0.04*	0.04*	0.02	0.01	0.00
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
L.Capital tax rate				0.93***	0.70***
				(0.04)	(0.07)
Observations	211	211	211	199	199
Countries	13	13	13	13	13
overall R^2	0.35	0.35	0.83	0.92	0.55

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

where now the AR(1) coefficient of the error process, ρ_i, is allowed to vary across countries: $u_{i,t} = \rho_i u_{i,t-1} + \varepsilon_{i,t}$. The additional flexibility of the model improves the overall fit (from 0.35 to 0.83), but leaves the main result basically unchanged.[25]

Columns (4)-(5) include the lagged endogenous variable in order to account for dynamics and standard errors are computed based on the assumption of spherical errors. Column (4) reports results from the same specification as in column (4) of Table 4.3, but assuming spherical errors. While the estimated coefficients are the same, the estimated standard errors decrease, in line with Beck and Katz (1995). Column (5) reports results from a country-fixed effects model including the lagged endogenous variable.[26] In both models (column 4 and 5) the coefficient on political instability is positive and statistically significant.

In order to address potential problems of endogeneity, I instrument the index of political instability by its own (second) lag and conduct a two stage least squares estimation (not reported in the table), including fixed effects.[27] The correlation between the instrumented variable and the instrument, i.e. the autocorrelation of the index, is 0.71. The coefficient on the index of political instability increases slightly. However, the F-value of the first stage regression is 7.7 and thus smaller than 10, indicating a problem of weak instruments. In sum, Table 4.5 provides evidence for the robustness of the main results to different estimation strategies.

4.6 Conclusions

In this chapter, I present empirical support for the hypothesis that higher political instability leads to an increase of the tax rate on capital income. The hypothesis is tested on a panel of annual observations for 13 OECD countries for the period 1964-

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[25] The assumption that $\rho_i = \rho$ in the baseline model is based on the argument that the coefficients of interest (α and β) are assumed to be the same across countries, which allows the pooling of the data. Assuming country-specific autocorrelation of the error process conflicts with this assumption (see Beck and Katz (1995) for this argument).

[26] Since the Hausman-test clearly rejects a random effects model, I do not report the results here. However, they are similar to the results of column (4).

[27] Since the index enters the main specification with its first lag, it only remains to address expectations about the future tax rate on capital. For the given sample, the index is driven by political demonstrations, riots, and strikes which are more likely to be conducted by workers/ wage earners rather than by capitalists/ capital owners. Thus, expecting future increases of the tax rate on capital could lead to a decrease of political instability today. If such expectations exist, the coefficient on political instability would be biased toward zero.

1983. Political instability is measured by the index of Gupta (1990). The tax rates on capital income, labour income, and consumption are measured using the estimates of Mendoza, Milesi-Ferretti, and Asea (1997). In the empirical model, I follow Beck and Katz (1995) and use PCSE which correct for contemporaneously correlated and cross-sectionally heteroskedastic errors. The specification of the baseline model closely follows Swank and Steinmo (2002).

The main finding is that, on average, an increase of the index of political instability by one standard deviation leads to an increase of the tax rate on capital by about 1.8 percentage points and to an increase of the ratio of capital to consumption and labour taxes of 4.5 percentage points. These effects are statistically and economically significant and robust against alternative sets of regressors, outlier correction, an alternative measure of the dependent variables, and alternative estimation strategies.

High degrees of political instability lead to short term oriented macroeconomic policies. While this effect is well known in the context of inflation and government deficits and debt, the main contribution of this chapter is to show that political instability also affects the tax structure of a country. Since capital taxation is likely to have a detrimental effect on investment and growth, it would be interesting to re-address the question of how political instability affects investment and growth when controlling for capital taxation. I leave this for future research.

4.A Data and sources

4.A.1 Index of political instability

This appendix gives a brief description of the construction of the index of political instability in Gupta (1990). In a first step, he calculates the Euclidean distance of each country from a hypothetical country of 'political stability' using cluster analysis. 'Political stability' is defined as zero occurrences of incidents of political instability. He then classifies the countries into groups according to their relative levels of political instability. In a second step he uses discriminant analysis to find the manifest variables which account for the classification of step one. In particular, he obtains the following equation

$$\begin{aligned} PI &= 1.14 + 0.0007\,PD + 0.0049\,RT + 0.0086\,PS \\ &\quad +0.43 * 10^{-5}\,D + 0.13\,AS + 0.0008\,AA + 0.0033\,PX, \end{aligned} \tag{4.5}$$

where

PI = Political instability
PD = Number of political demonstrations
RT = Number of riots
PS = Number of political strikes
D = Number of deaths from political violence
AS = Number of assassinations
AA = Number of armed attack events
PX = Number of political executions.

In reporting (4.5), I dropped three arguments from the original equation of Gupta: A democracy dummy and two dummies for successful and attempted coup d'états. These dummies are redundant in the given sample because all countries are democracies and there were neither successful nor attempted coup d'états in the sample period.

4.A.2 Tax rate on capital income

This appendix briefly describes the methodology of Mendoza, Milesi-Ferretti, and Asea (1997) how to construct average effective tax rates on capital income. The authors use data from revenue statistics and national accounts to construct effective tax rates for a sample of OECD countries for the period 1965-1992. In a first step, all tax revenues at the general government level are classified into the following three groups of taxes: consumption, capital, and labour. Then, these estimated revenues are expressed as a fraction of an estimate of the corresponding tax base, yielding an estimate of the ad valorem tax rate.[28] This approach avoids the problem that data on pre- and post-tax prices are usually not available which could otherwise be used to compute the tax rate per unit of the respective good. To calculate the effective tax rate on capital income, the authors assume that all sources of the households' income are taxed uniformly, that net profits are zero, and that the aggregate technology has constant returns to scale. The tax revenues include households' payments of capital income taxes, the payment of capital income taxes made by corporations, taxes on immovable property, and revenue from specific taxes on financial and capital transactions. The tax base is the operating surplus of the private sector in the economy.

4.A.3 Other data and sources

This appendix describes the data with their sources.

Capital income tax rate: The estimates for 17 OECD countries are used in the article "On the Ineffectiveness of Tax Policy in Altering Long-run Growth," by Mendoza, Milesi-Ferretti, and Asea (1997). The estimates were constructed using the methodology

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[28] For details on how to construct the tax rate see Mendoza, Razin, and Tesar (1994, p. 301).

developed by Mendoza, Razin, and Tesar (1994). The data in pdf-format can be found at Enrique G. Mendoza's webpage *http://econweb.umd.edu/~mendoza/published%20papers.html.*

Index of political instability: This index is constructed by Dipak A. Gupta and provided in the Appendix of his book "The Economics of Political Violence" (1990). This index of political instability is provided for over 104 noncommunist countries for the years 1948- 1982 on an annual basis.

Capital controls: Index for international restrictions on payments and receipts of capital constructed by Quinn (1997). It is on a 0-4 scale, where 4 represents the absence of capital controls. The data are available from the *Comparative Political Data Set I, 1960-2007*, compiled by Klaus Armingeon, Panajotis Potolidis, Marlène Gerber, Philipp Leimgruber and can be downloaded at *http://www.ipw.unibe.ch/content/team/klaus_armingeon/comparative_political_data_sets/index_ger.html.*

Openness: Exports plus imports divided by GDP (all in constant prices) which gives the total trade as a percentage of GDP. It is obtained from PWT 6.3.

Unemployment: Unemployment rate as percentage of the civilian labour force, all persons. It is taken from the OECD Population and labour force statistics.

Government consumption: Government's share of real GDP, per capita, in constant prices, obtained from PWT 6.3.

Government debt: Gross government debt (financial liabilities) is measured as a percentage of GDP and is taken from the OECD Economic Outlook Database.

Elderly population: Percentage of the population which is 65 years and older. The data source is the OECD Employment and Labour Market Statistics, Labour force statistics - Summary tables.

Growth rate of GDP: Growth of real GDP as the percentage change from the previous year and is taken from the OECD Economic Outlook Database.

Total investment: Investment share of GDP, both in constant prices, obtained from the PWT 6.3.

Left and right cabinet portfolios: Left and right parties cabinet portfolios, respectively, as a percent of all cabinet portfolios, obtained from the *Comparative Parties Data Set* provided by Duane Swank which can be downloaded from *http://www.marquette.edu/polisci/faculty_swank.shtml*.

Additional control variables: GDP per capita in 1960, the share of the population enrolled in secondary school, the average rate of growth of the G7 countries, the share of the labour force in the agricultural sector, and the long term interest rate, obtained from Alesina, Özler, Roubini, and Swagel (1996)

Chapter 5

Sovereign Risk and Macroeconomic Fluctuations in an Emerging Market Economy

This chapter assesses the role of sovereign risk in explaining macroeconomic fluctuations in Turkey. We estimate two versions of a simple New Keynesian small open economy model on quarterly data for the period 1994Q3-2008Q2: A basic version and a version augmented by a default premium on government debt due to a perceived risk of sovereign debt default. Model comparisons clearly support the augmented version since it leads to stronger internal propagation and hence smaller shocks are required in order to reconcile the observed dynamics of nominal and real variables, leading to better forecasting performance. The estimated default probability is highly debt-elastic, indicating that default fears are a relevant concern. The results suggest that the augmented model may lead to a better understanding of macroeconomic fluctuations in emerging market economies that are subject to sovereign risk. In terms of policy implications, counterfactual experiments show that both more active monetary policy and stronger fiscal feedbacks from debt on taxes can lead to less volatile inflation and debt dynamics, but higher debt feedbacks on taxation additionally reduce expected default rates.

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5.1 Introduction

This chapter investigates the role of sovereign risk in explaining macroeconomic fluctuations in emerging market economies. While there is a growing empirical literature on new open-economy macroeconomic (NOEM) models for developed countries (see, for example, Lubik and Schorfheide, 2005, 2007, or Justiniano and Preston, 2010), the evidence for less developed countries is still scarce. One possible reason for this lack of studies is that emerging market economies are often characterized by dynamics of nominal and real variables that are difficult to reconcile with standard New Keynesian small open economy models. In particular, many less developed countries are characterized by high inflation rates, high nominal interest rates and a (perceived) risk of sovereign debt default, combined with the inability to borrow from abroad in their own currency. Examples are Argentina, Brazil, Mexico, Russia, or Turkey. In the analysis of business cycles in developed economies sovereign risk is usually neglected. While this might be a good approximation for developed countries, sovereign risk may be an important element of business cycles in less developed countries. We therefore assess the quantitative importance of sovereign risk in explaining the fluctuations of nominal and real variables in Turkey, which is taken as a typical example of an emerging market economy.

We set up a mostly standard model of a small open economy following Galí and Monacelli (2005) but including a fiscal authority. The government borrows in domestic currency at home and in foreign currency abroad. Rigidities in domestic producer prices are the only nominal friction. Unlike Galí and Monacelli (2005) we use CPI inflation stabilization as the central bank's target which is in line with the actual behavior of the Central Bank of the Republic of Turkey (CBRT) (see Ersel and Ozatay, 2008). The government follows a tax rule, as in Schmitt-Grohé and Uribe (2007), with at least some feedback from higher debt levels on taxation. Following Schabert and van Wijnbergen (2010), we argue that the feedback rule may imply perceived infeasible rates of taxation where in such cases the government defaults on (part of) its outstanding debt. The presence of sovereign default believes leads to an endogenous default premium on government debt as a function of total real government liabilities. If the monetary authority follows an active interest rate policy, increases in inflation imply high nominal rates and an associated increase in debt service burden which in turn may lead to higher fears of default. The negative feedback from debt on its return implies that current savings tends to be lower, putting pressure on the real exchange rate, further increasing the need for the monetary authority to raise nominal interest rates. This destabilizing effect of active monetary policy in the presence of fears of default has been pointed out by Blanchard (2005) in the context of Brazil.

We outline two variants of the model which differ only with respect to the existence of the expected default rate in the Euler equation. More specifically, the basic model without sovereign risk is a special case of the augmented model with sovereign risk but where the expected default rate in the Euler equation is restricted to equal zero. Then, the model reduces to a standard New Keynesian small open economy model where the level of debt is irrelevant for the dynamics of inflation, the nominal interest rate and consumption.

We estimate both versions of the model on quarterly Turkish data for the period 1994Q3-2008Q2 using Bayesian methods. We find that the estimated expected default rate is highly debt-elastic, indicating that default fears are a relevant concern. Formal model comparisons between the two models clearly support the proposed modification of the Euler equation in the augmented version. We find that in the basic model, large shocks are required in order to reconcile the observed dynamics of nominal and real variables. In turn, accounting for sovereign risk leads to stronger internal propagation and better forecasting performance. In terms of policy implications, counterfactual experiments show that higher fiscal feedbacks from debt on taxation lead to stable debt and inflation dynamics, by reducing expected default rates. On the other hand, more active monetary policy is also an effective stabilization device for inflation and debt, but it does not reduce expected default rates.

Turkey is an illustrative example to study the role of sovereign risk in emerging market economies. The country was hit by two financial crises in the last decades. The last crisis burst in November 2000 when interest rates on Turkish government bonds shot up, accompanied by a downgrading of Turkey's debt to below investment grade, indicating that fears of sovereign default played an important role. This view is supported by several studies (see Basci and Ekinci, 2005, Aktas, Kaya, and Ozlale, 2005, or Budina and van Wijnbergen, 2008). The presence of sovereign risk and the associated default premia are therefore imminent explanations for the observed variations in nominal interest rates on Turkish debt.[1] Moreover, good

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[1] Recent concerns about fiscal solvency in euro area countries such as Greece, Portugal or Spain

data availability in the case of Turkey, compared to many other emerging market economies, means that we can estimate the model on a relatively large number of macroeconomic time series for a relatively long sample.

Our study is related to several strands of literature in addition to the above cited literature on the estimation of NOEM models. First, several studies explore the role of different driving forces of real business cycle in small open economy models for less developed countries. Aguiar and Gopinath (2007) argue that a stochastic productivity trend - rather than transitory fluctuations around a stable trend - goes a long way towards explaining several empirical regularities of emerging market economies and in particular the high volatility of consumption relative to output. Neumeyer and Perri (2005) and Uribe and Yue (2006) show that foreign interest rate shocks amplified by financial frictions (for example working capital requirements) are consistent with the counter-cyclicality of interest rates and output in emerging market economies. Chang and Fernández (2010) encompass both approaches into one model and evaluate the fit of each model using Bayesian methods. Formal model comparisons attribute a larger role to interest rates and financial frictions in generating aggregate fluctuations as opposed to permanent technology shocks. Our analysis is partly inspired by this finding on the importance of interest rates in understanding fluctuations in emerging market economies, but we assess their role in a model with nominal frictions.

Second, models of monetary policy start from the assumption that the central bank controls the short rate as its policy instrument. It is linked to the economy through the consumption Euler equation. Thus, standard New Keynesian models imply that movements in the short rate are associated one-for-one with movements in the expected growth of the marginal utility of the representative consumer and expected inflation. However, the empirical shortcomings of the Euler equation have lead researchers to include ad hoc risk-premium shocks into the Euler equation in both closed and open economy models (see, for example, Adolfson, Laséen, Lindé, and Villani, 2007; Smets and Wouters, 2007; Christoffel, Kuester, and Linzert, 2009; Justiniano and Preston, 2010). We focus instead on internal propagation

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suggest that our results may also have implications for developed economies, both in terms of business cycle analysis and policy recommendations.

mechanisms in order to improve both the forecasting performance of the current generation of models and their usefulness for policy analysis.

Third, based on the seminal contribution of Eaton and Gersovitz (1981), many papers analyze the role of strategic default of the government and fluctuations in emerging economies. Most prominently, Arellano (2008) focuses on the terms of international loans which are endogenous to domestic fundamentals and depend on the incentives to default in order to explain co-movements between real interest rates and output. While this literature focuses on the strategic incentives for the government to default in order to smooth consumption, in our model their is no strategic motive for the government which follows a simple fiscal feedback rule. Default premia are instead determined by investors' beliefs that infeasible rates of taxation implied by this rule *force* the government to default on its debt.

The remainder of the chapter is organized as follows. In the next section we lay out the model. In Section 5.3 we discuss the empirical implementation and in Section 5.4 we present the results. In particular, we compare the basic and the augmented model in terms of business cycle moments, forecasting performance, marginal data densities and variance decompositions, and we implement counterfactual experiments based on the estimated augmented model. Section 5.5 concludes.

5.2 A small open economy model

In this section we set up a small open economy model with sticky prices based on Galí and Monacelli (2005). The model considers expectations about sovereign default, following Schabert and van Wijnbergen (2010). We allow for foreign currency denominated debt in order to provide a realistic description of the conduct of fiscal policy in Turkey. While the Turkish government can borrow from domestic households in terms of its own currency, it cannot borrow from abroad in Turkish lira. Eichengreen and Hausmann (1999) and Eichengreen, Hausmann, and Panizza (2007) call this inability the 'original sin' , which typically characterizes emerging market economies. Due to the presence of foreign currency denominated debt, changes in the real exchange rate have a direct impact on expected sovereign default rates.

5.2.1 The public sector

The public sector consists of a government and a central bank. The price of domestic bonds is set by the central bank, and since government bonds are subject to perceived default risk, the central bank's policy instrument is an interest rate on an asset which exhibits a contingent pay-off. Thus, even if one interprets the policy instrument as a short-term interest rate, it carries a risk component that will be reflected in equilibrium (see Schabert and van Wijnbergen, 2006).[2]

Fiscal policy

The government issues one-period discount bonds denominated in domestic and foreign currency $B_{H,t}$ and $B_{F,t}$, respectively.[3] It also levies lump-sum taxes $P_t\tilde{\tau}_t$ on domestic households and it purchases domestic goods $P_{H,t}g_t$, where P_t and $P_{H,t}$ denote the consumer price level and the price of domestically produced goods, respectively. The assumption that government purchases are fully allocated to domestically produced goods seems reasonable in view of empirical evidence for OECD countries of a strong home bias in government procurement, over and above that observed in private consumption (see e.g. Trionfetti, 2000; Brulhart and Trionfetti, 2004). The central bank sets the domestic currency price $1/R_{H,t}$ of domestic bonds, whereas the foreign currency price $1/R_{F,t}$ of foreign bonds is endogenously determined in equilibrium.

The government is assumed to follow a simple tax feedback rule, adjusting lump-sum taxes in response to the outstanding stock of debt,

$$P_t\tilde{\tau}_t = \kappa\left(B_{H,t-1} + X_t B_{F,t-1}\right) + P_t \exp(\varepsilon_{\tau,t}), \qquad \varepsilon_{\tau,t} \sim NID(0, \sigma_\tau^2), \tag{5.1}$$

where $\varepsilon_{\tau,t}$ is a fiscal policy shock or implementation error in the conduct of policy and X_t denotes the domestic currency price of one unit of foreign currency. Follow-

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[2] In fact, in his discussion of Blanchard (2005), Loyo (2005) argues that even an overnight rate (specifically, the Brazilian Selic) contains a risk premium.

[3] Throughout, nominal (real) variables are denoted by capital (lower) letters, asterisks denote foreign variables and variables without time subscript denote non-stochastic steady state values.

ing Bohn (1992), a tax rule of this type ensures fiscal solvency as long as $\kappa > 0$, for any finite initial level of debt. However, it may imply politically infeasible levels of taxation as discussed next.

Investors' beliefs

Following Schabert and van Wijnbergen (2010), according to domestic and foreign investors' beliefs, the government defaults when debt service would demand a politically infeasible level of taxation $\overline{T}$. Lenders do not know the exact value of $\overline{T}$, but they have a prior on its distribution, $h(\overline{T})$. Given that tax revenues are set according to (5.1), the perceived probability of default δ_t then equals the probability that the tax rule implies a level of $\tilde{\tau}_t$ exceeding $\overline{T}$:

$$\delta_t = \int_0^{\tilde{\tau}_t} h(\overline{T}) d\overline{T}. \tag{5.2}$$

For a differentiable distribution function $h(\cdot)$ the impact of total real debt

$$b_t = \left(B_{H,t-1} + X_t B_{F,t-1}\right) / P_t = b_{H,t-1} \pi_t^{-1} + q_t b_{F,t-1} \pi_t^{*-1},$$

where b_t is not predetermined due to the presence of the exchange rate, on the probability of default is given by

$$\frac{\partial \delta_t(\cdot)}{\partial b_t} = \kappa h(\kappa b_t) > 0.$$

Thus, the perceived default probability strictly increases with the real value of total debt. For the local analysis of the model we use the product of the default elasticity with respect to the real value of total debt evaluated at the steady state with the ratio $\frac{b_H/\pi}{1-\delta}$, where $\delta = \delta(b) < 1$:

$$\Phi = \frac{b_H/\pi}{1-\delta} \left(\frac{\partial \delta_t(\cdot)}{\partial b_t} \, |_{b_t=b} \right). \tag{5.3}$$

We refer to Φ as the default elasticity, and we treat it as a structural parameter in the empirical implementation. Note that $\Phi > 0$ if the steady state satisfies $b_H/\pi > 0$

(see 5.3).[4] This structure of the default elasticity has broad empirical support; see, for instance, Edwards (1994), Cantor and Packer (1996), Min (1998), Eichengreen and Mody (1998) and Ferucci (2003).

In order to pin down the division of total debt among domestic debt and foreign debt, which is under the discretion of the government, we assume that the government issues foreign currency denominated debt as a time-varying fraction $f_t \geq 0$ of domestic debt:

$$X_t \frac{B_{F,t}}{R_{F,t}} = f_t \frac{B_{H,t}}{R_{H,t}},$$

where f_t follows an AR(1) process in logs:

$$\log(f_t/\bar{f}) = \rho_f \log(f_{t-1}/\bar{f}) + \varepsilon_{f,t}, \qquad \varepsilon_{f,t} \sim NID(0, \sigma_f^2).$$

We assume that the savings of default, $\delta_t \left(B_{H,t-1} + X_t B_{F,t-1}\right)$, are handed out in a lump-sum fashion to domestic households. Given the specification (5.2), the period-by-period expected government budget constraint for any period t reads:

$$\frac{B_{H,t}}{R_{H,t}} + X_t \frac{B_{F,t}}{R_{F,t}} + P_t \tau_t = P_{H,t} g_t + (1 - \delta_t) \left(B_{H,t-1} + X_t B_{F,t-1}\right),$$

where $P_t \tau_t = P_t \tilde{\tau}_t - \delta_t \left(B_{H,t-1} + X_t B_{F,t-1}\right)$ and g_t follows an AR(1) process in logs:

$$\log(g_t/\bar{g}) = \rho_g \log(g_{t-1}/\bar{g}) + \varepsilon_{g,t}, \qquad \varepsilon_{g,t} \sim NID(0, \sigma_g^2).$$

Monetary policy

The central bank sets the domestic currency price of domestic bonds according to a CPI based Taylor rule:

$$\frac{R_{H,t}}{R_H} = \left(\frac{\pi_t}{\pi}\right)^{\alpha_\pi} \exp(\varepsilon_{R,t}), \qquad \varepsilon_{R,t} \sim NID(0, \sigma_R^2), \tag{5.4}$$

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[4] Appendix 5.C shows that, while we compute $\frac{\partial \delta_t(\cdot)}{\partial b_t}$ at $b_t = b$, the log-linearization of the model's equilibrium conditions and simplification leads to an expression for Φ in terms of b_H/π. This expression implies a positive default premium if the real stock of Turkish lira debt is positive in steady state.

where the interest rate and inflation targets of the central bank are assumed to be consistent with steady state values. Before the economic reforms introduced in 2001, the central bank actually followed a crawling peg exchange rate targeting strategy (see Gormez and Yilmaz, 2007). In order to account for this fact, we check in Section 5.4.3 the sensitivity of the estimation results to the introduction of an exchange rate stabilization term in the Taylor rule. Since we are primarily interested in the interaction between an inflation targeting monetary authority and fiscal policy we do not include the output gap into the Taylor rule. Moreover, since visual inspection of the data on the nominal interest shows that interest rate smoothing seemed not to be a primary goal of the CBRT - at least for the first half of the sample - we do not include a smoothing term into the Taylor rule. Finally, specifying the most simplest Taylor rule helps achieving better identification of the parameters of interest in the estimation step by reducing the number of estimated parameters to a necessary minimum.[5] Finally, define the nominal rate of depreciation as

$$\pi_{X,t} = \frac{X_t}{X_{t-1}} = \left(\frac{q_t}{q_{t-1}}\right)\frac{\pi_t}{\pi_t^*},$$

where $q_t = X_t P_t^* / P_t$ denotes the real exchange rate.

5.2.2 The private sector

Domestic households

The domestic economy is inhabited by a continuum of infinitely lived households, with identical asset endowments and identical preferences. A representative domestic household chooses consumption c_t, hours worked n_t, and the asset portfolio described below, so as to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\exp(\varepsilon_{c,t}) \frac{c_t^{1-\sigma}}{1-\sigma} - \frac{n_t^{1+\eta}}{1+\eta} \right), \qquad \sigma > 0, \quad \eta \geq 0, \tag{5.5}$$

where $\beta \in (0,1)$ denotes the time discount factor, σ is the inverse of the intertemporal elasticity of substitution in consumption, η denotes the inverse of the Frisch

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[5] In Section 5.4.3 we check the sensitivity of our results to an inclusion of an output gap and smoothing term into the Taylor rule.

elasticity of labor supply and $\varepsilon_{c,t} \sim NID(0, \sigma_c^2)$ is a demand shock.[6]

We assume that domestic households invest in domestic and foreign currency denominated Turkish government bonds and in a complete set of state-contingent securities which are traded internationally. Let $\Gamma_{t,t+1}$ denote the stochastic discount factor for a one-period ahead nominal payoff S_{t+1} in foreign currency. Optimization occurs subject to a no-Ponzi game condition and the perceived flow budget constraint, which takes into account the households' default beliefs,

$$\begin{aligned} & P_t c_t + P_t \tau_t + E_t \left(X_t \Gamma_{t,t+1} S_{t+1} \right) + \frac{B_{H,t}}{R_{H,t}} + \frac{X_t B_{F,t}}{R_{F,t}} \\ \leq \quad & X_t S_t + (1 - \delta_t) \left(B_{H,t-1} + X_t B_{F,t-1} \right) + P_t w_t n_t + \Sigma_t \end{aligned} \tag{5.6}$$

for given initial wealth endowments $B_{H,-1}$ and S_0. Here, w_t is the real wage rate and Σ_t collects dividends received from the ownership of firms, which are both taken as given by the household.

The representative household's consumption basket is an aggregate of domestically produced goods $c_{H,t}$ and goods of foreign origin $c_{F,t}$:

$$c_t = \gamma \left(c_{H,t} \right)^{1-\vartheta} \left(c_{F,t} \right)^{\vartheta},$$

where $\vartheta \in [0, 1]$ denotes the import share and $\gamma = \left[\vartheta^{\vartheta} \left(1 - \vartheta \right)^{1-\vartheta} \right]^{-1}$. The optimal allocation of consumption among $c_{H,t}$ and $c_{F,t}$ yields the demand functions

$$c_{H,t} = (1 - \vartheta) \left(\frac{P_{H,t}}{P_t} \right)^{-1} c_t, \qquad c_{F,t} = \vartheta \left(\frac{P_{F,t}}{P_t} \right)^{-1} c_t,$$

where $P_{H,t}$ and $P_{F,t}$ are the prices of domestic and foreign goods, respectively. The composite consumption price index (CPI) is

$$P_t = P_{H,t}^{1-\vartheta} P_{F,t}^{\vartheta}. \tag{5.7}$$

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[6] We do not specify an AR(1) process for $\varepsilon_{c,t}$ in order to reduce the amount of exogenous persistence in the consumption Euler equation (see below).

The first-order conditions from the maximization of (5.5) subject to (5.6) are

$$
\begin{aligned}
\lambda_t &= \exp(\varepsilon_{c,t}) c_t^{-\sigma} && (5.8)\\
n_t^{\eta} &= \lambda_t w_t && (5.9)\\
\lambda_t &= R_{H,t} \beta E_t \left[(1-\delta_{t+1}) \lambda_{t+1} \pi_{t+1}^{-1} \right] && (5.10)\\
\Gamma_{t,t+1} &= \beta \frac{X_{t+1}\lambda_{t+1}}{X_t \lambda_t} \pi_{t+1}^{-1} && (5.11)\\
\lambda_t q_t &= R_{F,t} \beta E_t \left[(1-\delta_{t+1}) \lambda_{t+1} q_{t+1} \pi_{t+1}^{*-1} \right] && (5.12)
\end{aligned}
$$

where λ_t denotes the Lagrangian multiplier associated with (5.6), $\pi_t = P_t/P_{t-1}$ denotes the gross CPI inflation rate. The budget constraint holds with equality and the transversality conditions are satisfied.

The first equation equates the marginal utility gain of additional consumption and the shadow price of wealth. The second equation says that the marginal rate of substitution has to equal the real wage. The last two equations equate the intertemporal terms of trade using the available assets. Combining (5.10) and (5.11), it follows that higher expected default leads investors to demand a higher interest rate on domestic bonds for a given expected rate of nominal depreciation and a given stochastic discount factor:

$$R_{H,t}^{-1} = E_t \left[(1-\delta_{t+1}) \pi_{X,t+1}^{-1} \Gamma_{t,t+1} \right].$$

Foreign households

The foreign economy is inhabited by a continuum of infinitely lived households with identical asset endowments, which have qualitatively the same preferences as domestic households. A representative foreign household's demand for domestically produced consumption goods $c_{H,t}^*$ satisfies

$$c_{H,t}^* = \vartheta^* \left(\frac{P_{H,t}^*}{P_t^*} \right)^{-1} c_t^*, \tag{5.13}$$

where $\vartheta^* \in (0,1)$ and c_t^* is aggregate foreign consumption. The foreign households invest in state-contingent securities S_t and foreign currency denominated bonds issued by the domestic government $B_{F,t}$. The first order conditions are given by

$$\begin{aligned} \Gamma_{t,t+1} &= \beta \frac{\lambda^*_{t+1}}{\lambda^*_t} \pi^{*-1}_{t+1} && (5.14) \\ \lambda^*_t &= R_{F,t} \beta E_t \left[(1-\delta_{t+1}) \lambda^*_{t+1} \pi^{*-1}_{t+1} \right], && (5.15) \end{aligned}$$

where $\lambda^*_t = c_t^{*-\sigma}$. Note that (5.14) (together with 5.11) allows perfect international risk sharing (see below). Since the foreign economy is exogenous to the domestic economy, we assume for simplicity that foreign consumption and foreign inflation are determined according to an (identified) vector autoregression of order 4, specified in logs (see Section 5.3.3).

Final goods producers

The final domestic good $y_{H,t}$ is assembled by a perfectly competitive final goods sector from intermediate goods $y^i_{H,t}$, for $i \in [0,1]$, through the technology

$$y_{H,t} = \left(\int_0^1 \left(y^i_{H,t} \right)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}},$$

where ϵ denotes the elasticity of substitution among intermediate goods.

The final goods producer maximizes profits over input demands taking as given all intermediate goods prices $P^i_{H,t}$ and the final goods price $P_{H,t}$:

$$\max_{y^i_{H,t}} P_{H,t} y_{H,t} - \int_0^1 P^i_{H,t} y^i_{H,t} di$$

which yields the input demand functions

$$y^i_{H,t} = \left(\frac{P^i_{H,t}}{P_{H,t}} \right)^{-\epsilon} y_{H,t} \quad \text{for all } i, \tag{5.16}$$

where we have used the zero profit condition in the final goods sector, i.e. $P_{H,t} y_{H,t} = \int_0^1 P^i_{H,t} y^i_{H,t} di$.[7]

The price index for domestic goods $P_{H,t}$ follows from substituting (5.16) into the

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[7] The first-order conditions corresponding to the solution of the final goods producer's profit max-

zero profit condition stated above:

$$P_{H,t} = \left(\int_0^1 \left(P^i_{H,t}\right)^{1-\epsilon} di\right)^{\frac{1}{1-\epsilon}}.$$

Intermediate goods producers

Intermediate goods production is done by a continuum of monopolistically competitive firms. Each firm i uses the technology

$$y^i_{H,t} = a_t n^i_t,$$

where a_t is common factor productivity which follows an AR(1) process in logs

$$\log a_t = \rho_a \log a_{t-1} + \varepsilon_{a,t}, \qquad \varepsilon_{a,t} \sim NID(0, \sigma_a^2).$$

Intermediate goods producers solve a two-stage problem. In the first stage, taking the input price w_t as given, firms hire labor in order to minimize costs independently of the output price $P^i_{H,t}$:

$$\min_{n^i_t} P_t w_t n^i_t \qquad \text{s.t.} \quad y^i_{H,t} = a_t n^i_t.$$

Assuming an interior solution, the first-order conditions are

$$P_t w_t = MC^i_t a_t \quad \text{for all } i,$$

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imization problem are

$$P^i_{H,t} = P_{H,t}\left(y^i_{H,t}\right)^{\frac{\epsilon-1}{\epsilon}-1}\left(\int_0^1 \left(y^i_{H,t}\right)^{\frac{\epsilon-1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}-1} \qquad \text{for all } i.$$

Dividing the first-order conditions for two types of goods i and j by each other gives

$$P^i_{H,t} y^i_{H,t} = P^j_{H,t}\left(y^j_{H,t}\right)^{\frac{1}{\epsilon}}\left(y^i_{H,t}\right)^{\frac{\epsilon-1}{\epsilon}}.$$

Integrating over all intermediate goods yields

$$\int_0^1 P^i_{H,t} y^i_{H,t} di = P^j_{H,t}\left(y^j_{H,t}\right)^{\frac{1}{\epsilon}} y_{H,t}^{\frac{\epsilon-1}{\epsilon}} = P_{H,t} y_{H,t},$$

where the last equality follows from the zero profit condition.

where MC_t^i denotes the Lagrangian multiplier associated with the technology constraint, i.e. nominal marginal costs. Marginal costs are seen to be common across domestic firms, $MC_t^i = MC_t$, since all firms face the same input prices and use the same technology. Expressing real marginal costs in terms of domestic prices, $mc_t = MC_t / P_{H,t}$, then yields the labor demand function

$$w_t = \frac{P_{H,t}}{P_t} mc_t a_t,$$

In the second stage of the intermediate goods producers' problem, given real marginal costs, they choose prices $P_{H,t}^i$ in order to maximize discounted real profits. Following Calvo (1983) and Yun (1996), in each period a fraction $1 - \phi$ of randomly selected firms is allowed to set a new price $\check{P}_{H,t}^i = \check{P}_{H,t}$, by symmetry. The remaining firms change their prices along with steady state producer price inflation π_H. Each firm i which receives permission to optimally reset its price maximizes the expected sum of discounted profits subject to the demand function (5.16):

$$\begin{aligned} \max \qquad & E_t \sum_{s=0}^{\infty} \phi^s X_t \Gamma_{t,t+s} \left[P_{H,t}^i - P_{H,t+s} mc_{t+s} \right] y_{H,t+s}^i \\ \text{s.t.} \quad y_{H,t}^i &= \left(\frac{P_{H,t+s}^i}{P_{H,t+s}} \right)^{-\epsilon} y_{H,t+s}, \\ \text{where} \quad P_{H,t+s}^i &= \check{P}_{H,t} \pi_H^s \quad \text{for } s = 1, 2, \ldots \end{aligned}$$

The first-order condition is

$$0 = E_t \sum_{s=0}^{\infty} \phi^s X_t \Gamma_{t,t+s} y_{H,t+s}^i \left[(1 - \epsilon) \pi_H^s \check{P}_{H,t} + \epsilon P_{H,t+s} mc_{t+s} \right].$$

The price index of domestic goods follows as

$$P_{H,t} = \left[(1 - \phi) \check{P}_{H,t}^{1-\epsilon} + \phi \left(\pi_H P_{H,t-1} \right)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}.$$

5.2.3 Market clearing

Market clearing requires that the demand for labor services is equal to labor supply:

$$\int_0^1 n_t^i di = n_t.$$

Integrating $y_{H,t}^i = a_t n_t^i$ over all i, it then follows that

$$\int_0^1 y_{H,t}^i di = a_t n_t$$

or, using the demand functions (5.16):

$$y_{H,t} v_t = a_t n_t,$$

where $v_t = \int_0^1 \left(\frac{P_{H,t}^i}{P_{H,t}} \right)^{-\epsilon} di$ is a price dispersion term.

We assume the domestic economy to be small relative to the foreign economy, implying that the foreign producer price level $P_{F,t}^*$ is identical to the foreign consumption price index P_t^*. Furthermore, the law of one price is assumed to hold separately for each good such that $P_{F,t} = X_t P_{F,t}^*$ and $P_{H,t} = X_t P_{H,t}^*$, where $P_{H,t}^*$ is the price of domestic goods expressed in foreign currency. Using (5.7), foreign demand for domestic goods (5.13) can then be re-written as

$$c_{H,t}^* = \vartheta^* q_t^{\frac{1}{1-\vartheta}} c_t^*$$

and domestic demand $c_{H,t} = (1-\vartheta) \left(\frac{P_{H,t}}{P_t} \right)^{-1} c_t$ can be re-written as

$$c_{H,t} = (1-\vartheta) q_t^{\frac{\vartheta}{1-\vartheta}} c_t,$$

where we have used that $\frac{P_{H,t}}{P_t} = \left(\frac{P_{F,t}}{P_t} \right)^{-\frac{\vartheta}{1-\vartheta}} = \left(\frac{X_t P_t^*}{P_t} \right)^{-\frac{\vartheta}{1-\vartheta}} = q_t^{-\frac{\vartheta}{1-\vartheta}}$.

Goods market clearing requires that aggregate supply equals aggregate demand:

$$y_{H,t} = c_{H,t} + c_{H,t}^* + g_t.$$

Using the demand functions, the goods market clearing condition can be re-written as

$$y_{H,t} = (1-\vartheta)\, q_t^{\frac{\vartheta}{1-\vartheta}} c_t + \vartheta^* q_t^{\frac{1}{1-\vartheta}} c_t^* + g_t.$$

Further, the CPI inflation rate can be expressed in terms of producer price inflation as follows:

$$\pi_t = \pi_{H,t} (q_t / q_{t-1})^{\frac{\vartheta}{1-\vartheta}} \quad \text{for all } t \geq 1.$$

Combining (5.11) and (5.14) yields

$$\frac{\lambda_{t+1}^*}{\lambda_t^*} = \frac{q_{t+1}}{q_t} \frac{\lambda_{t+1}}{\lambda_t}.$$

This condition determines the relation between the levels of domestic and foreign marginal utility and the real exchange rate up to a constant ξ (which depends on initial endowments):

$$\lambda_t^* = \xi q_t \lambda_t.$$

5.2.4 Log-linearized equilibrium

For the empirical implementation we employ a log-linear approximation to the model's equilibrium conditions around the non-stochastic steady state. The latter is described in Appendix 5.B. Thus, define the log deviation of a variable x_t from its steady state x as $\hat{x}_t \equiv \log(x_t/x) \approx (x_t - x)/x$, such that $100 \times \hat{x}_t$ is approximately the percentage deviation of x_t from x. Furthermore, we denote as $\tilde{x}_t = x\hat{x}_t$ the absolute deviation of x_t from x. Using these relations, the following log-linearized system of equilibrium equations is derived in Appendix 5.C.[8]

Domestic households.

$$\hat{\lambda}_t = \varepsilon_{c,t} - \sigma \hat{c}_t \tag{5.17}$$

$$\eta \hat{n}_t = \hat{\lambda}_t + \hat{w}_t \tag{5.18}$$

Foreign households.

$$\hat{\lambda}_t^* = -\sigma \hat{c}_t^* \tag{5.19}$$

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[8] Variables with bars denote steady state values which we take as given.

Production and pricing.

$$\hat{y}_{H,t} = \hat{a}_t + \hat{n}_t \tag{5.20}$$

$$\widehat{mc}_t = \frac{\vartheta}{1-\vartheta}\hat{q}_t + \hat{w}_t - \hat{a}_t \tag{5.21}$$

$$\hat{\pi}_{H,t} = \frac{(1-\phi)(1-\phi\beta)}{\phi}\widehat{mc}_t + \beta E_t \hat{\pi}_{H,t+1} \tag{5.22}$$

$$\hat{\pi}_t = \hat{\pi}_{H,t} + \frac{\vartheta}{1-\vartheta}(\hat{q}_t - \hat{q}_{t-1}) \tag{5.23}$$

Capital market.

$$\hat{\lambda}_t^* = \hat{q}_t + \hat{\lambda}_t \tag{5.24}$$

$$\hat{\lambda}_t = E_t\hat{\lambda}_{t+1} + R_{H,t} - E_t\hat{\pi}_{t+1} - \frac{1}{1-\bar{\delta}}E_t\tilde{\delta}_{t+1} \tag{5.25}$$

$$\hat{\lambda}_t^* = E_t\hat{\lambda}_{t+1}^* + \hat{R}_{F,t} - E_t\hat{\pi}_{t+1}^* - \frac{1}{1-\bar{\delta}}E_t\tilde{\delta}_{t+1} \tag{5.26}$$

$$E_t\tilde{\delta}_{t+1} = \Phi\left(1-\bar{\delta}\right)\left(1+\bar{f}\right)E_t\hat{b}_{t+1} \tag{5.27}$$

Policy.

$$\hat{q}_t + \hat{b}_{F,t} - \hat{R}_{F,t} = \hat{f}_t + \hat{b}_{H,t} - \hat{R}_{H,t} \tag{5.28}$$

$$\left(1+\bar{f}\right)\hat{b}_t = \hat{b}_{H,t-1} - \hat{\pi}_t + \bar{f}\left(\hat{q}_t + \hat{b}_{F,t-1} - \hat{\pi}_t^*\right) \tag{5.29}$$

$$\begin{aligned}\hat{b}_{H,t} - \hat{R}_{H,t} + \bar{f}\left(\hat{q}_t + \hat{b}_{F,t} - \hat{R}_{F,t}\right) &= \frac{(1-\kappa)(1+\bar{f})}{\beta\left(1-\bar{\delta}\right)}\hat{b}_t - \varepsilon_{\tau,t} \\ &\quad + \frac{\kappa + \beta\left(1-\bar{\delta}\right) - 1}{\beta\left(1-\bar{\delta}\right)\left(1+\bar{f}\right)^{-1}}\left(\hat{g}_t - \frac{\vartheta}{1-\vartheta}\hat{q}_t\right)\end{aligned} \tag{5.30}$$

$$\hat{R}_{H,t} = \alpha_\pi\hat{\pi}_t + \varepsilon_{R,t} \tag{5.31}$$

Market clearing.

$$\begin{aligned}\hat{y}_{H,t} &= (1-\vartheta)\,\bar{s}_c\hat{c}_t + \left[1-(1-\vartheta)\,\bar{s}_c - \bar{s}_g\right]\hat{c}_t^* \\ &\quad + \left(\vartheta\bar{s}_c + \frac{1-(1-\vartheta)\,\bar{s}_c - \bar{s}_g}{1-\vartheta}\right)\hat{q}_t + \bar{s}_g\hat{g}_t\end{aligned} \tag{5.32}$$

Stochastic processes.

$$\hat{a}_t = \rho_a \hat{a}_{t-1} + \varepsilon_{a,t} \tag{5.33}$$

$$\hat{g}_t = \rho_g \hat{g}_{t-1} + \varepsilon_{g,t} \tag{5.34}$$

$$\hat{f}_t = \rho_f \hat{f}_{t-1} + \varepsilon_{f,t} \tag{5.35}$$

$$\begin{aligned} \rho^{cc}_{0*} \hat{c}^*_t = {} & \rho^{cc}_{1*} \hat{c}^*_{t-1} + \rho^{c\pi}_{1*} \hat{\pi}^*_{t-1} + \rho^{cc}_{2*} \hat{c}^*_{t-2} + \rho^{c\pi}_{2*} \hat{\pi}^*_{t-2} \\ & + \rho^{cc}_{3*} \hat{c}^*_{t-3} + \rho^{c\pi}_{3*} \hat{\pi}^*_{t-3} + \rho^{cc}_{4*} \hat{c}^*_{t-4} + \rho^{c\pi}_{4*} \hat{\pi}^*_{t-4} + \varepsilon_{c^*,t} \end{aligned} \tag{5.36}$$

$$\begin{aligned} \rho^{\pi\pi}_{0*} \hat{\pi}^*_t + \rho^{\pi c}_{0*} \hat{c}^*_t = {} & \rho^{\pi\pi}_{1*} \hat{\pi}^*_{t-1} + \rho^{\pi c}_{1*} \hat{c}^*_{t-1} + \rho^{\pi\pi}_{2*} \hat{\pi}^*_{t-2} + \rho^{\pi c}_{2*} \hat{c}^*_{t-2} \\ & + \rho^{\pi\pi}_{3*} \hat{\pi}^*_{t-3} + \rho^{\pi c}_{3*} \hat{c}^*_{t-3} + \rho^{\pi\pi}_{4*} \hat{\pi}^*_{t-4} + \rho^{\pi c}_{4*} \hat{c}^*_{t-4} + \varepsilon_{\pi^*,t} \end{aligned} \tag{5.37}$$

We then have the following definition: *A rational expectations equilibrium is a set of sequences* $\{\hat{c}_t, \hat{c}^*_t, \hat{\lambda}_t, \hat{\lambda}^*_t, \hat{n}_t, \hat{w}_t, \hat{a}_t, \hat{y}_{H,t}, \widehat{mc}_t, \hat{q}_t, \hat{\pi}_{H,t}, \hat{\pi}_t, \hat{\pi}^*_t, \hat{b}_t, \hat{b}_{H,t}, \hat{b}_{F,t}, \hat{f}_t, \hat{g}_{t,}, \hat{R}_{H,t}, \hat{R}_{F,t}, \tilde{\delta}_t\}^{\infty}_{t=0}$ *satisfying (5.17)-(5.37) and the transversality conditions, for given initial asset endowments* $B_{H,-1}$ *and* $B_{F,-1}$ *and initial price levels* $P_{H,-1}$ *and* $P_{F,-1}$*. The i.i.d. innovations are* $\{\varepsilon_{a,t}, \varepsilon_{c,t}, \varepsilon_{f,t}, \varepsilon_{g,t}, \varepsilon_{R,t}, \varepsilon_{\tau,t}, \varepsilon_{c^*,t}, \varepsilon_{\pi^*,t}\}^{\infty}_{t=0}$.

5.3 Empirical implementation using Bayesian methods

The linearized model is estimated using Bayesian methods as described in An and Schorfheide (2007).[9] We apply full information estimation techniques since they provide a natural framework for formal model comparisons. To our knowledge, this is the first study which estimates a dynamic stochastic general equilibrium model for Turkey. As a consequence we hardly have access to prior information on the model's deep structural parameters. Therefore, we use uniform priors for those parameters as we would with restricted maximum likelihood estimation. However, the standard deviations of the shocks turned out to be weakly identified especially for the model without default risk, which may be a consequence of possible model misspecification. In order to avoid implausible estimates for those parameters, we elicit (diffuse) priors centered on values which we deem reasonable, as described below.

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[9] We use version 4.1.1 of the Dynare toolbox for MATLAB for the computations.

5.3.1 Econometric methodology

Formally, let $P(\theta_{M_i}|M_i)$ denote the prior distribution of the vector of structural parameters θ_{M_i} for model M_i, and let $L(Y^T|\theta_{M_i}, M_i)$ denote the likelihood function for the observed data $Y^T = Y_1, \ldots, Y_T$. Collect the model variables in the vector x_t, and let ε_t and ζ_t denote the vectors of structural shocks and expectational errors, respectively. The log-linearized model

$$Ax_t = Bx_{t-1} + C\varepsilon_t + D\zeta_t$$

is solved using standard perturbation techniques, which yields as solution the linear state-space representation

$$\begin{aligned} x_t &= Fx_{t-1} + G\varepsilon_t, \qquad \varepsilon_t \sim NID(0, \Sigma_\varepsilon) \\ Y_t &= Hx_t + u_t, \qquad u_t \sim NID(0, \Sigma_u) \end{aligned}$$

for $t = 1, \ldots, T$. The first equation is the state transition equation and the second equation is the observation equation with measurement errors collected in u_t.

The Kalman filter is applied to evaluate the likelihood of the observables.[10] The posterior distribution of the vector of parameters is obtained using Bayes' rule:

$$P(\theta_{M_i}|Y^T, M_i) = \frac{L(Y^T|\theta_{M_i}, M_i)P(\theta_{M_i}|M_i)}{\int L(Y^T|\theta_{M_i}, M_i)P(\theta_{M_i}|M_i)d\theta_{M_i}} \propto L(Y^T|\theta_{M_i}, M_i)P(\theta_{M_i}|M_i).$$

In order to evaluate the posterior, the Random Walk Metropolis (RWM) algorithm is used. In short, this algorithm constructs a Gaussian approximation around the mode of the posterior kernel $L(Y^T|\theta_{M_i}, M_i)P(\theta_{M_i}|M_i)$ and uses a scaled version of the asymptotic covariance matrix as the covariance matrix for a proposal distribution.[11] Using rejection sampling, the algorithm then generates a sequence of draws from the posterior that can be averaged to approximate posterior moments of interest, such as location measures and measures of dispersion.[12]

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[10] Since x_t is stationary, the Kalman filter is initialized with the unconditional distribution of x_t.

[11] The (log) posterior kernel is maximized using Chris Sim's version of the BFGS quasi-Newton algorithm, which uses a line search and randomly perturbs the search direction if it reaches regions of non-existence or non-uniqueness of a stable rational expectations solution.

[12] Let $\tilde{\Sigma}_{M_i}$ denote the negate inverse Hessian at the posterior mode $\tilde{\theta}_{M_i}$. A starting value $\theta_{M_i}^{(0)}$

We assess the evidence of model M_i over an alternative model M_j using posterior odds comparison. The ratio of the posterior probabilities of the two models is

$$\frac{P(M_i|Y^T)}{P(M_j|Y^T)} = \frac{P(M_i)}{P(M_j)}\frac{p(Y^T|M_i)}{p(Y^T|M_j)}.$$

The first term on the right-hand side is the prior odds ratio in favor of model M_i. The second term is the Bayes factor summarizing the sample evidence in favor of model M_i. Here, the marginal data density $p(Y^T|M_i) \equiv \int L(Y^T|\theta_{M_i}, M_i)P(\theta_{M_i}|M_i)d\theta_{M_i}$ indicates the likelihood of model M_i conditional on the observed data, and similarly for model M_j.[13] Throughout the analysis, we set the prior odds ratio to 1.

Finally, for $t = 1, \ldots, T$ the smoothed structural shocks $\varepsilon_{t|T}$ which, according to the model, have generated the observed data are recovered by an application of the Kalman filter at the posterior mean estimates of the model parameters. This step also yields smoothed estimates $x_{t|T}$ of the (unobserved) model variables. In order to evaluate the forecasting performance of alternative models, one-step ahead forecasts are computed as the estimates of the observed variables conditional on period t information: $Y_{t+1|t} = Hx_{t+1|t}$, where $x_{t+1|t}$ is computed as $x_{t+1|t} = Fx_{t|t}$ and $x_{t|t}$ denotes the updated variables obtained from the application of the Kalman filter.

5.3.2 Data description

We use quarterly data on real Turkish output (GDP$_t$), real private consumption (CONS$_t$), the annual consumer price inflation rate (INF$_t$), the nominal interest rate

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is drawn from $N(\tilde{\theta}_{M_i}, c_0\tilde{\Sigma}_{M_i})$. For $s = 1, \ldots, S$, a candidate vector $\breve{\theta}_{M_i}$ is drawn from the proposal distribution $N(\theta^{(s)}_{M_i}, c\tilde{\Sigma}_{M_i})$. The jump from $\theta^{(s-1)}_{M_i}$ is accepted ($\theta^{(s)}_{M_i} = \breve{\theta}_{M_i}$) with probability $\min\{1, r(\theta^{(s-1)}_{M_i}, \breve{\theta}|Y^T)\}$ and rejected ($\theta^{(s)}_{M_i} = \theta^{(s-1)}_{M_i}$) otherwise, where

$$r(\theta^{(s-1)}_{M_i}, \breve{\theta}|Y^T) = \frac{L(Y^T|\breve{\theta}_{M_i}, M_i)P(\breve{\theta}_{M_i}|M_i)}{L(Y^T|\theta^{(s-1)}_{M_i}, M_i)P(\theta^{(s-1)}_{M_i}|M_i)}$$

In practice, we use $S = 500,000$ and drop the first $250,000$ draws to let the Markov chain produced by the RWM algorithm converge. The scaling factor c_0 is set to $2c$, and we produce five chains with different starting values in order to assess convergence based on the diagnostics suggested by Brooks and Gelman's (1998). The scaling factor c is set in order to achieve an average acceptance rate per chain of approximately 25%.

[13] The marginal data density is estimated using Geweke's (1999) modified harmonic mean estimator.

on 3-month Turkish lira denominated treasury bills (INT_t), the real effective exchange rate (REER_t), real government consumption (GOV_t), real Turkish lira denominated domestic government debt (DEBT_t), real foreign consumption (CONS_t^*) and the foreign consumer price inflation rate (INF_t^*). The variables of the foreign economy (CONS_t^* and INF_t^*) are computed as a trade-weighted average of the U.S. and the Euro area, which are Turkey's main trading partners.[14]

The sample period is 1994:3-2008:2 ($T = 56$ observations). The starting point is chosen to reduce the impact of high inflation during the crisis period in the first two quarters of 1994. In these quarters, annual inflation rates reached values up to 150 percent but they returned to about 60 percent in the third quarter of 1994. The annual interest rate was almost 300 percent in 1994:2 but it returned to around 122 percent in 1994:3. Although such high inflation and interest rates could potentially be explained by large shocks, it seems unlikely that our assumptions on the statistical properties of the stochastic processes such as their AR(1) structure and normality of the disturbances, which we make to simplify econometric inference, are adequate to describe such crisis episodes.

Nominal variables are demeaned consistent with their steady state values. Real variables are in natural logarithms and they are detrended using a linear trend, since our model does not explicitly consider growth.[15] Details on data definitions and the construction of the foreign variables are provided in Appendix 5.A. Domestic and foreign inflation (INF_t and INF_t^*) and the domestic interest rate (INT_t) are related to the model variables through the measurement equations

$$\begin{aligned}
\text{INF}_t &= 4\bar{\pi}\hat{\pi}_t \\
\text{INF}_t^* &= 4\bar{\pi}^*\hat{\pi}_t^* \\
\text{INT}_t &= 4\bar{R}_H\hat{R}_{H,t}.
\end{aligned}$$

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[14] We include domestic currency denominated debt as an observed variable since Turkey issues external (U.S. dollar and Euro denominated) debt only at maturities longer than 3 months. In addition, the observed nominal interest rate also refers to domestic currency denominated debt.

[15] We have verified that our results are robust to the use of alternative trends, such as linear-quadratic or Hodrick-Prescott filtered trends, by estimating the basic and the augmented model on the alternatively detrended data. The estimates of the model's deep structural parameters are similar to the ones obtained with a linear trend, while the estimated shock variances tend to decrease.

Furthermore, since the available data for the real effective exchange rate REER_t is constructed as a trade-weighted average of all trading partners of Turkey it is not exactly equivalent to the model-implied real exchange rate, given that we construct the foreign variables CONS_t^* and INF_t^* as a trade-weighted average of the U.S. and the Euro area. Thus, we include an error in the measurement equation for the real exchange rate:

$$\text{REER}_t = \hat{q}_t + u_{q,t},$$

where $u_{q,t} \sim NID(0, \sigma_q^2)$. The remaining observed variables are equal to the model variables, i.e. $\text{GDP}_t = \hat{y}_{H,t}$, $\text{CONS}_t = \hat{c}_t$, $\text{GOV}_t = \hat{g}_t$, $\text{DEBT}_t = \hat{b}_{H,t}$ and $\text{CONS}_t^* = \hat{c}_t^*$. All observed variables are shown in Figure 5.1.

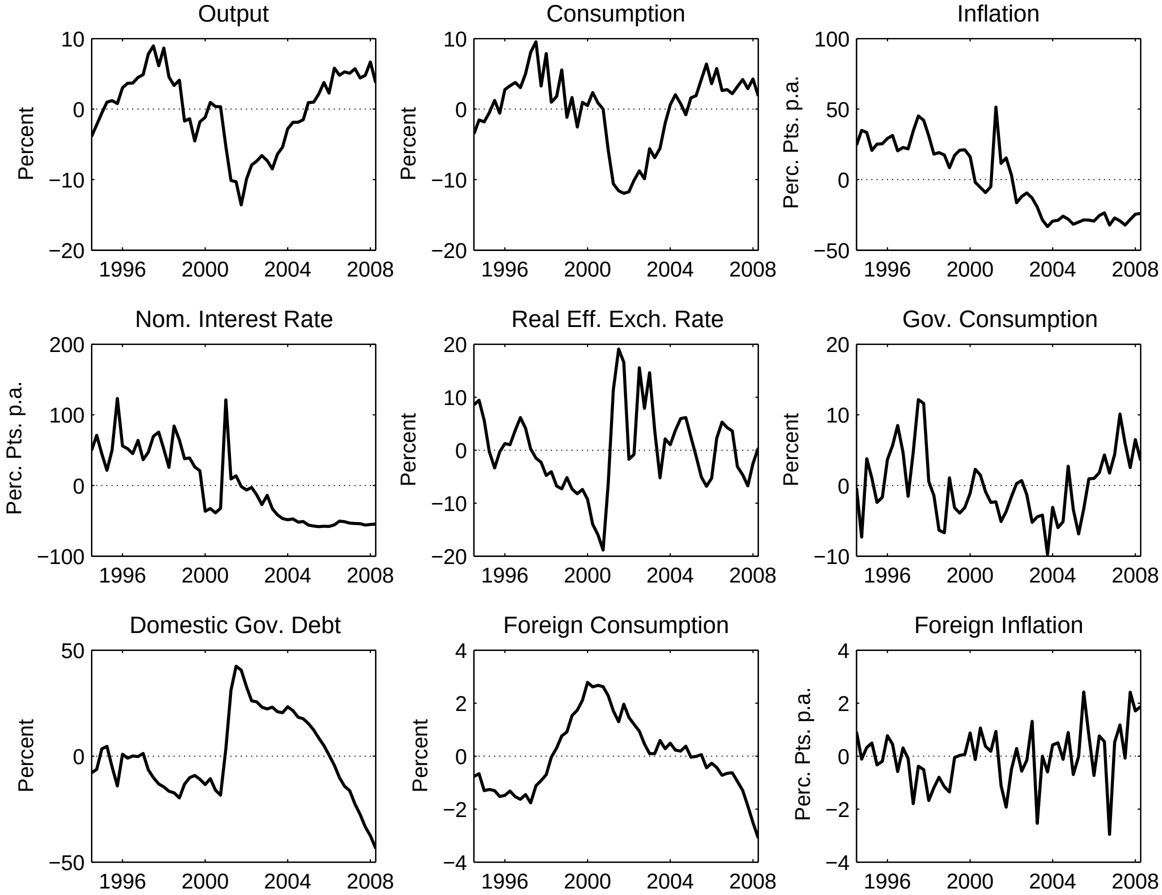

Figure 5.1: Data used in the estimation. *Notes.* Quarterly data, 1994:3-2008:2; real variables are measured in percentage deviations from a linear trend, nominal variables are demeaned and in annualized percentage terms.

5.3.3 Calibrated parameters

The steady state values are calibrated consistent with sample averages. The average annual Turkish inflation rate over the period 1994:3-2008:2 was 37.2 percent. In order to match this value, we set the quarterly steady state inflation rate to $\pi = \bar{\pi} = 1.093$. The average annualized 3-month treasury bill rate was approximately 72.4 percent, so we set the quarterly steady state interest rate to $R_H = \bar{R}_H = 1.181$. Further, we set the shares of private and government consumption in GDP s_c and s_g, respectively, to their empirical counterparts. That is, $s_c = \bar{s}_c = 0.683$ and $s_g = \bar{s}_g = 0.108$. The steady state share of foreign currency denominated debt over domestic currency denominated debt is also set to its empirical counterpart, i.e. $f = \bar{f} = 0.829$.

The parameters of the stochastic process for the foreign variables are calibrated by fitting an identified VAR(4) process to detrended (log) real foreign consumption and the demeaned annual foreign inflation rate:

$$\begin{aligned}\begin{bmatrix}\log c_t^* \\ \log \pi_t^*\end{bmatrix} &= (I - \Phi_{1*} - \Phi_{2*} - \Phi_{3*} - \Phi_{4*})\begin{bmatrix}\log \bar{c}^* \\ \log \bar{\pi}^*\end{bmatrix} + \Phi_{1*}\begin{bmatrix}\log c_{t-1}^* \\ \log \pi_{t-1}^*\end{bmatrix} \\ &\quad + \Phi_{2*}\begin{bmatrix}\log c_{t-2}^* \\ \log \pi_{t-2}^*\end{bmatrix} + \Phi_{3*}\begin{bmatrix}\log c_{t-3}^* \\ \log \pi_{t-3}^*\end{bmatrix} + \Phi_{4*}\begin{bmatrix}\log c_{t-4}^* \\ \log \pi_{t-4}^*\end{bmatrix} + \begin{bmatrix}v_{c^*,t} \\ v_{\pi^*,t}\end{bmatrix},\end{aligned}$$

where $[v_{c^*,t}, v_{\pi^*,t}]' \sim NID(0, \Sigma_*)$. Our identifying assumption is that foreign consumption affects foreign inflation within a quarter but not vice versa. We apply a recursive Cholesky identification scheme: $\Sigma_* = C_* C_*'$, where C_* is a non-singular lower triangular matrix, which yields the structural shocks $[\varepsilon_{c^*,t}, \varepsilon_{\pi^*,t}]' \sim NID(0, I)$ as a linear combination of the reduced-form innovations, i.e. $[\varepsilon_{c^*,t}, \varepsilon_{\pi^*,t}]' = C_*^{-1}[v_{c^*,t}, v_{\pi^*,t}]'$.

We calibrate steady state foreign inflation $\pi^* = \bar{\pi}^*$ to match an average quarterly foreign inflation rate of 0.6 percent over the period 1994:3-2008:2, or an average annual inflation rate of 2.4 percent. Foreign consumption and inflation are then included in the actual estimation step (calibrating the VAR parameters) in order to recover the shocks of foreign origin.

We also calibrate a small number of additional parameters that are inherently difficult to identify. This concerns the inverse of the Frisch elasticity of labor supply η which we set to 2, implying a labor supply elasticity of $1/2$ in line with the range of available estimates (see Christoffel, Coenen, and Warne, 2008). The subjective discount factor β is set to 0.99, which implies a steady state default probability $\delta = \bar{\delta} = 1 - \bar{\pi}/\bar{R}_H/\beta = 0.065$, in accordance with the average EMBIG spread on Turkish governments bonds over the sample period.[16] Furthermore, the foreign degree of openness towards the domestic economy ϑ^* is set to 0.004, which is approximately equal to the weighted average, according to the trade weights used to construct foreign variables, of the shares of imports from Turkey in GDP of the Euro area and the U.S.[17]

5.3.4 Prior distributions

Our priors are summarized in Table 5.1. The prior distributions are assumed to be independent across parameters. We elicit uniform priors, restricted to theoretically plausible ranges, on all deep structural parameters. In particular, the inverse elasticity of intertemporal substitution σ and the inflation feedback in the Taylor rule α_π obtain a lower bound of 0 and upper bounds of 20 and 10, respectively. The Calvo probability ϕ and the domestic degree of openness ϑ are restricted to the range [0,1], consistent with their theoretically feasible values. In order to ensure a positive default elasticity, which is the case if steady state domestic debt is positive, the debt response κ in the fiscal policy rule is restricted to be larger than $1 - \beta(1 - \bar{\delta})$, and we impose an upper bound of 10.[18]

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[16] In Section 5.4.3 we check the sensitivity of our results to alternative values for β.

[17] This weighted average is calculated as follows, taking as reference year the year 2007 due to data availability. The main Turkish exports markets in 2007 were the European Union (56.4%), Russia (4.4%), the U.S. (3.9%), Romania (3.4%), the United Arab Emirates (3.0%) and Iraq (2.6%) (see http://ec.europa.eu/trade/creating-opportunities/bilateral-relations/countries/turkey). The total goods exports volume of Turkey was approximately 107.2 billion U.S. dollars in 2007 (see the country statistical profile for Turkey on http://stats.oecd.org). Total nominal U.S. private consumption in 2007 was 39,752.5 billion U.S. dollars, such that the share of imports from Turkey in U.S. private consumption can be calculated as $\vartheta^{US} = \frac{0.039 \times 107.2}{39752.5} \simeq 0.000105 = 0.0105\%$. Similarly, total nominal Euro area private consumption in 2007 was 5,058.8 billion Euros, or 6,922.7 billion U.S. dollars given an average Euro per U.S. dollar nominal exchange rate of 0.731 in 2007. The share of imports from Turkey in Euro area private consumption can thus be calculated as $\vartheta^{EA} = \frac{0.564 \times 107.2}{6922.7} \simeq 0.008734 = 0.8734\%$. Hence, we obtain the foreign degree of openness towards the domestic economy as $\vartheta^* = \frac{\mu^{EA}\vartheta^{EA} + \mu^{US}\vartheta^{US}}{\mu^{EA} + \mu^{US}} \simeq 0.003858$, where the weights are $\mu^{EA} = 0.77$ and $\mu^{US} = 1$ (see Appendix 5.A).

[18] Note that $\frac{b_H}{\pi} = \frac{g(1+\bar{f})^{-1}}{\kappa + \beta(1-\delta) - 1}$ as shown in Appendix 5.C, and therefore $\Phi > 0$ when $\frac{b_H}{\pi} > 0$, which is the case if $\kappa > 1 - \beta(1 - \bar{\delta})$ since $g, \bar{f} > 0$.

Table 5.1: Prior distributions and posterior estimates.[a]

Parameter	Definition	Domain	Prior[b]	*With sovereign risk (M_1)*		*No sovereign risk (M_2)*	
				Post. mean	90% int.	Post. mean	90% int.
σ	Inv. elast. of intertemp. subst.	$\mathbb{R}^+$	$U(0, 20)$	0.59	[0.44, 0.75]	15.85	[13.82, 17.84]
ϕ	Calvo price stickiness	[0,1]	$U(0, 1)$	0.19	[0.00, 0.33]	0.72	[0.67, 0.78]
ϑ	Degree of openness	[0,1]	$U(0, 1)$	0.42	[0.29, 0.54]	0.03	[0.00, 0.05]
α_π	Taylor rule inflation response	$\mathbb{R}$	$U(0, 10)$	2.10	[1.81, 2.40]	1.25	[1.16, 1.33]
κ	Tax rule debt response	$\mathbb{R}$	$U(\kappa_L, 10)$[c]	0.53	[0.46, 0.60]	0.10	[0.08, 0.11]
Φ	Default elasticity	$\mathbb{R}^+$	$U(0, 10)$	0.25	[0.21, 0.28]	–	–
ρ_a	AR(1) technology	[0,1)	$U(0, 1)$	0.91	[0.84, 0.99]	0.64	[0.54, 0.74]
ρ_g	AR(1) gov. consumption	[0,1)	$U(0, 1)$	0.50	[0.32, 0.67]	0.79	[0.71, 0.88]
ρ_f	AR(1) foreign debt ratio	[0,1)	$U(0, 1)$	0.86	[0.77, 0.96]	0.66	[0.24, 1.00]
σ_a	Std. dev. technology shocks	$\mathbb{R}^+$	$IG(0.05, \infty)$	0.02	[0.02, 0.03]	0.06	[0.03, 0.08]
σ_g	Std. dev. gov. consumption shocks	$\mathbb{R}^+$	$IG(0.05, \infty)$	0.04	[0.03, 0.05]	0.23	[0.18, 0.27]
σ_f	Std. dev. foreign debt ratio shocks	$\mathbb{R}^+$	$IG(0.05, \infty)$	0.31	[0.26, 0.36]	0.04	[0.01, 0.09]
σ_τ	Std. dev. fiscal policy shocks	$\mathbb{R}^+$	$IG(0.05, \infty)$	0.10	[0.08, 0.13]	0.12	[0.09, 0.16]
σ_R	Std. dev. interest rate shocks	$\mathbb{R}^+$	$IG(0.05, \infty)$	0.07	[0.06, 0.08]	0.06	[0.05, 0.07]
σ_c	Std. dev. demand shocks	$\mathbb{R}^+$	$IG(0.05, \infty)$	0.02	[0.01, 0.02]	0.83	[0.67, 0.99]
σ_q	Std. dev. meas. error on $REER_t$	$\mathbb{R}^+$	$IG(0.05, \infty)$	0.09	[0.08, 0.10]	0.21	[0.17, 0.25]
$\log p(Y^T \mid M_i)$	Log marginal data density[d]			873.67		704.64	

[a] The estimation results are based on 500,000 accepted draws from the RWM sampler, dropping the first 250,000 draws.

[b] $U(a, b)$ refers to the continuous uniform distribution with lower bound a and upper bound b; $IG(c, d)$ refers to the inverse gamma distribution with mean c and std. deviation d.

[c] The lower bound is $\kappa_L = 1 - \beta(1 - \bar{\delta})$, which ensures that steady state domestic debt b_H / π is positive such that $\Phi > 0$ (see Appendix 5.C).

[d] The marginal data density is estimated using Geweke's (1999) modified harmonic mean estimator.

We also use uniform priors on the range [0,1] for the AR(1) coefficients of the stochastic processes. However, as discussed above, in order to rule out implausible estimates for the standard deviations of the innovation components for any version of the model, we impose tighter priors on those parameters. That is, we elicit inverse gamma priors with mean 0.05 and an infinite standard deviation, implying that a larger portion of the probability mass tends to fall on existing estimates for small open economies (see e.g. Adolfson, Laséen, Lindé, and Villani, 2007; Lubik and Schorfheide, 2007; Justiniano and Preston, 2008) while still covering all of the theoretically feasible range.

5.4 Estimation results

We organize the discussion of results as follows. Section 5.4.1 compares the basic model without perceived default risk and the augmented model in terms of parameter estimates, posterior odds comparisons, model-implied shocks, business cycle moments, forecasting performance, and variance decompositions. Section 5.4.2 implements several counterfactual experiments based on the estimated model, in order to understand the role of perceived default risk and to assess policy implications and presents estimated impulse responses. Robustness checks are deferred to Section 5.4.3.

5.4.1 Model comparison: Basic vs. augmented model

Parameter estimates and marginal data densities

The estimation results for both the basic and the augmented model are summarized in Table 5.1. The table reports the posterior means of the estimated parameters, their 90% probability intervals and the (log) marginal data densities associated with the two models. Several results stand out. The estimated deep structural parameters, inverse intertemporal substitution elasticity σ, price stickiness ϕ and degree of openness ϑ, are broadly in line with existing estimates for small open economies (see, for example Lubik and Schorfheide, 2007; Justiniano and Preston, 2008) but, most notably, the model without sovereign risk implies a significantly higher σ. We provide an interpretation of this result below.

The estimated default elasticity Φ in the model with sovereign risk is 0.25, such that the expected default rate is highly debt-elastic. This result confirms the findings in Budina and van Wijnbergen (2008) who show that higher debt service obligations lead to stronger expectations that these debt obligations might not be met. Furthermore, both the Taylor rule inflation response α_π and the tax feedback κ are larger in the model with sovereign risk but in line with existing estimates (see Yazgan and Yilmazkuday, 2007). All three policy parameters are well identified. The fact that a positive default elasticity implies a relatively high tax feedback is not surprising, since this is required – by prior assumption – in order to prevent the unstable equilibrium dynamics suggested by Blanchard (2005) and analyzed in Schabert and van Wijnbergen (2010).

Third, the standard deviations of the structural innovations are significantly larger in the basic model, whereas the model with sovereign risk requires much smaller shocks in order to describe the data. An exception is the standard deviation of the foreign debt share, which is however not well identified in the model without sovereign risk. The remaining standard deviations are also better identified in the model with sovereign risk. A formal model comparison based on the marginal data density clearly supports the model with sovereign risk. The Bayes factor in favor of this model (M_1) over the model without sovereign risk (M_2) is

$$\frac{p(Y^T|M_1)}{p(Y^T|M_2)} = \frac{\exp(873.67)}{\exp(704.64)} \approx 2.6 \times 10^{73}$$

indicating strong support for the model with sovereign risk, conditional on the observed data.

Estimated default rate and EMBIG spreads

How do the size and dynamics of the estimated expected default rate compare to existing estimates of sovereign risk in Turkey? Figure 5.2 plots the expected default rate $E_t\tilde{\delta}_{t+1}$, as implied by the Kalman smoother at the posterior mean, against the J.P. Morgan Emerging Market Bond Index Global (EMBIG) spreads on (i) Turkish bonds denominated in U.S. dollar over U.S. treasury bonds and (ii) Euro denominated

Turkish bonds over German bunds.[19] In general there is a strong co-movement, although the EMBIG indicates somewhat smaller default rates before and during the 2000-2001 crisis and larger rates thereafter. The correlations between the model-implied expected default rate and (i) and (ii) are 0.66 and 0.56, respectively. Given the degree of abstraction of the theoretical model, based on this evidence one may nevertheless conclude that it provides a realistic description of sovereign risk in Turkey.

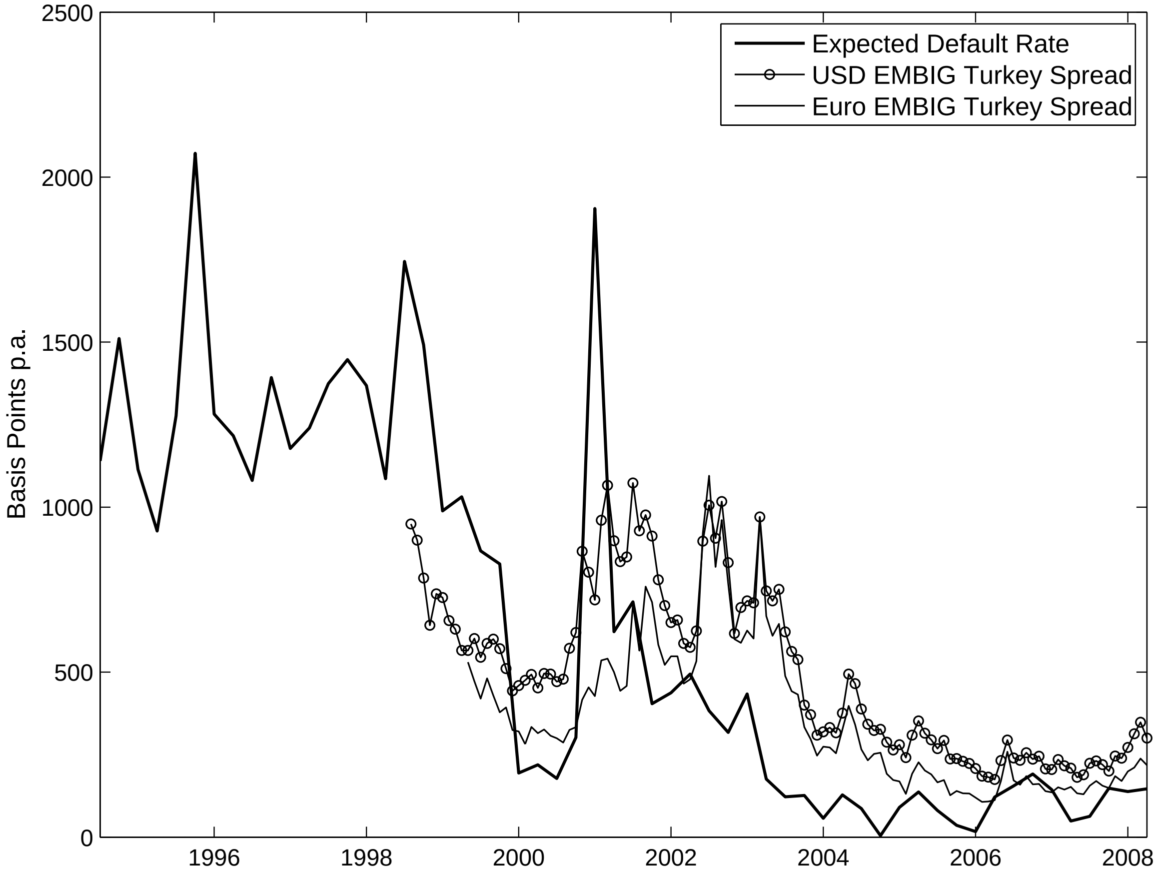

Figure 5.2: Estimated expected default rate ($E_t\tilde{\delta}_{t+1}$) and J.P. Morgan EMBIG Turkey spreads. *Notes.* The default rate is the estimate implied by the Kalman smoother at the posterior mean (1994:3-2008:2); source of EMBIG spreads (monthly data): J.P. Morgan and Bloomberg; 'USD' indicates spreads on U.S. dollar Brady bonds and loans over U.S. treasury bonds (08/1998-06/2008); 'Euro' indicates spreads on euro denominated bonds and loans over German bunds (05/1999-06/2008).

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[19] All variables are reported in basis points, and the steady state value $\bar{\delta}$ is added to the estimated default rate in absolute deviations from steady state, $E_t\tilde{\delta}_{t+1}$, in order to obtain the actual estimated default rate $E_t\delta_{t+1}$.

Business cycle moments

In order to provide a first intuition on the factors underlying the support for the model with sovereign risk, we discuss the business cycle implications of the two estimated models in terms of selected moments. Table 5.2 compares the standard deviations, correlations with output and autocorrelations of the observed data with the corresponding model-implied moments. These moments are computed at the posterior mean conditional on all structural shocks. The results show that the basic model overpredicts the volatility of domestic output, the real exchange rate and the fiscal variables but significantly underpredicts the volatility of inflation (by a factor of 26) and the nominal interest rate. The model with sovereign risk comes closer in terms of the volatility of output, the real exchange rate and also inflation. It overstates the latter, but only by a factor of 2.5. In sum, the augmented model tends to overpredict the variability of nominal variables and debt. We provide a discussion on this in Section 5.4.2. When comparing the relative volatility of the components of output, the next two columns of Table 5.2 show that the augmented model also more closely matches the relative volatility of domestic private and government consumption relative to output.

Both versions of the model have trouble in matching the observed correlations with domestic output, but it stands out that the cyclicality of domestic consumption is significantly understated by the basic model whereas the augmented model implies a perfect match. Also in terms of autocorrelation patterns, the model with sovereign risk implies a better fit although there are some exceptions such as the real exchange rate. Most notably, however, the autocorrelations of domestic output and consumption are matched significantly more closely by the augmented model. Overall, we conclude that the proposed modification of the basic model leads to a better description of the observed data in terms of business cycle facts.

Model-implied shocks

Next, in order to illustrate the differences in terms of the size of shocks required to fit the data, Figure 5.3 shows the estimated structural innovations implied by the Kalman smoother at the posterior mean according to both model versions. The

Table 5.2: Selected moments of observed data and model-implied moments.[a]

	Standard deviation		Std. deviation rel. to output		Correlation with output		Autocorrelation of order 1		Autocorrelation of order 4	
	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
With sovereign risk										
Output	0.05	0.06	1.00	1.00	1.00	1.00	0.92	0.91	0.61	0.68
Consumption	0.05	0.06	0.97	1.02	0.94	0.94	0.86	0.78	0.55	0.59
Inflation	0.26	0.64	–	–	0.04	-0.39	0.90	0.93	0.76	0.81
Interest rate	0.52	1.42	–	–	0.05	-0.40	0.79	0.96	0.71	0.84
Real exch. rate	0.08	0.10	–	–	-0.41	0.31	0.71	0.11	-0.02	0.09
Gov. consumption	0.05	0.05	0.89	0.80	0.58	0.03	0.60	0.50	0.23	0.06
Domestic debt	0.19	0.57	–	–	-0.76	-0.33	0.94	0.94	0.58	0.77
For. consumption	0.01	0.03	0.26	0.52	-0.60	0.04	0.97	0.99	0.75	0.87
For. inflation	0.01	0.01	–	–	0.11	-0.39	0.17	0.26	-0.06	0.03
Default rate	–	0.15	–	–	–	-0.35	–	0.96	–	0.84
No sovereign risk										
Output	0.05	0.08	1.00	1.00	1.00	1.00	0.92	0.76	0.61	0.60
Consumption	0.05	0.05	0.97	0.65	0.94	0.26	0.86	0.04	0.55	0.03
Inflation	0.26	0.01	–	–	0.04	0.63	0.90	0.83	0.76	0.57
Interest rate	0.52	0.43	–	–	0.05	0.41	0.79	0.61	0.71	0.42
Real exch. rate	0.08	0.38	–	–	-0.41	0.65	0.71	0.66	-0.02	0.57
Gov. consumption	0.05	0.37	0.89	4.50	0.58	0.37	0.60	0.79	0.23	0.40
Domestic debt	0.19	0.44	–	–	-0.76	0.12	0.94	0.98	0.58	0.93
For. consumption	0.01	0.03	0.26	0.35	-0.60	-0.77	0.97	0.99	0.75	0.87
For. inflation	0.01	0.01	–	–	0.11	0.07	0.17	0.26	-0.06	0.03

[a] The model-implied moments are computed from the solution of the model at the posterior mean.

[b] The standard deviations of inflation and the interest rate are in annual terms, the remaining standard deviations are in quarterly terms.

model without sovereign risk generates much larger domestic demand shocks and government consumption shocks, and also larger technology shocks and measurement errors on the real exchange rate. Overall, the model with sovereign risk requires significantly smaller shocks. An exception is the foreign debt ratio. Importantly, the estimated innovations from the model without sovereign risk can hardly be defended to satisfy the properties of the assumed underlying stochastic processes, i.e. no autocorrelation.[20] The model with sovereign risk, on the other hand, comes closer to those assumptions except for occasional spikes during the financial crisis of 2000-2001.

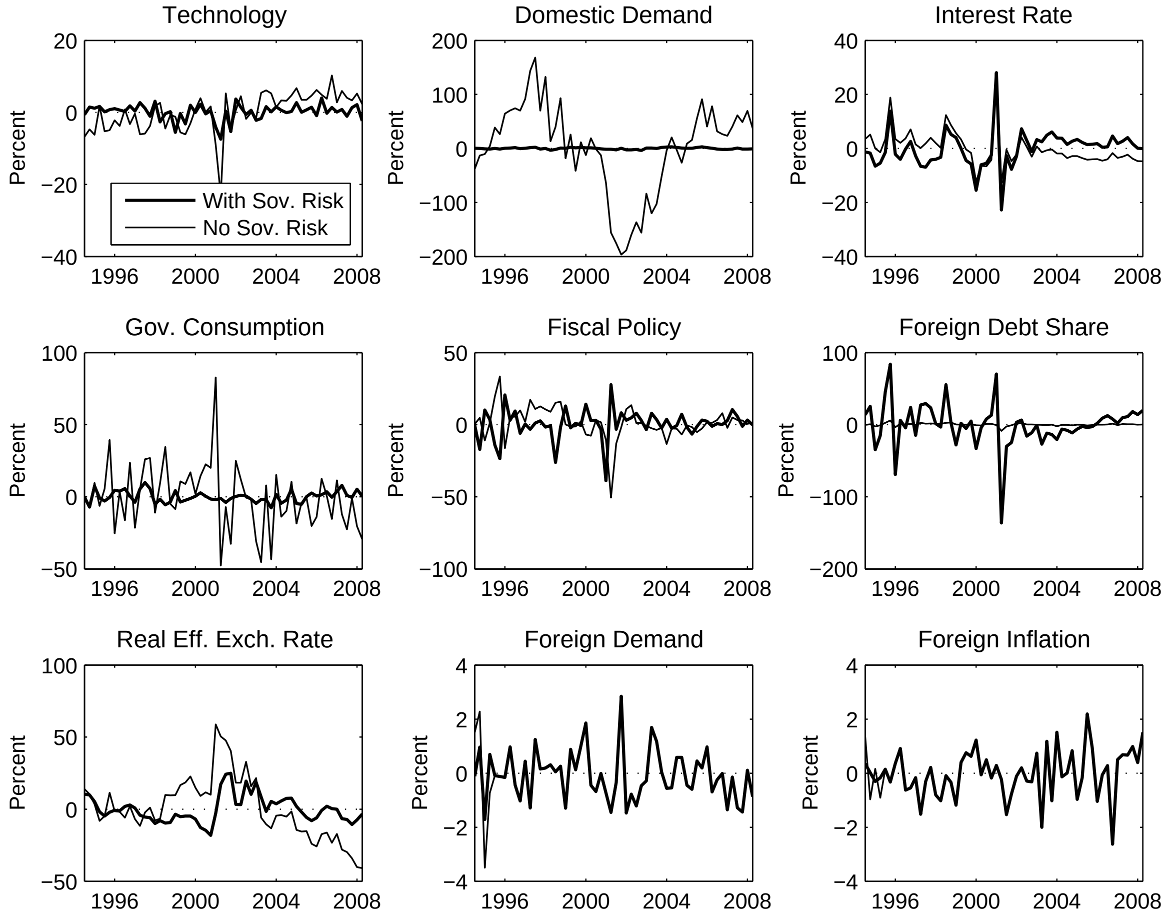

Figure 5.3: Estimated structural innovations with and without sovereign risk (percentage points). *Notes.* The innovations are estimates implied by the Kalman smoother at the posterior mean.

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[20] In the augmented model the hypothesis of no autocorrelation cannot be rejected at the 1% level in case of two shocks while in the basic model it cannot be not rejected in case of five shocks.

Forecasting performance

Figure 5.4 compares the observed variables and their one-step ahead forecasts implied by the two estimated models. The one-step ahead forecasts are computed by applying the Kalman filter at the respective posterior mean estimates. From visual inspection, while both models forecast output, inflation and government debt fairly well, it is obvious that the model with sovereign risk implies better forecasts of private consumption and government consumption in particular, but also of the real exchange rate and the nominal interest rate.

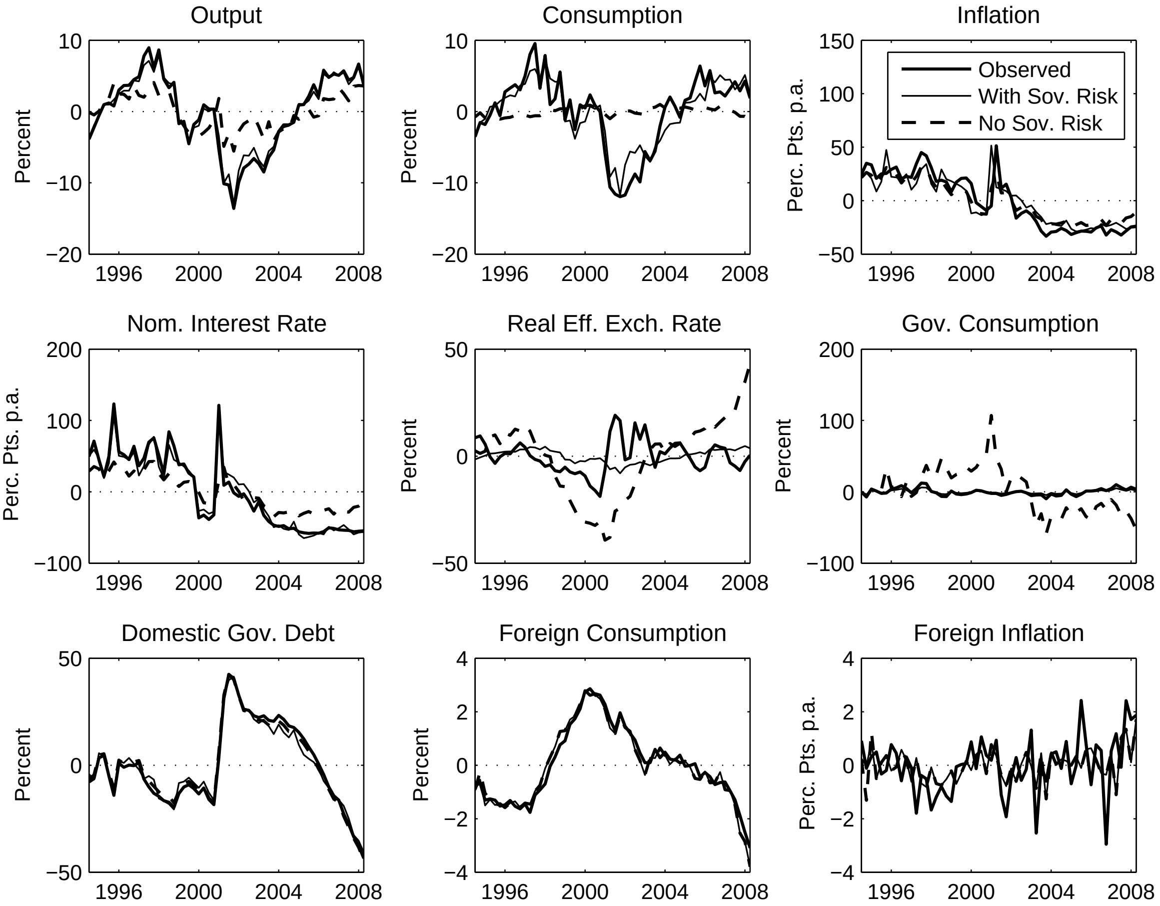

Figure 5.4: Observed data and one-step ahead forecasts from the models with and without sovereign risk. *Notes.* Quarterly data, 1994:3-2008:2; one-step ahead forecasts are estimates implied by the Kalman filter at the posterior mean; real variables are measured in percentage deviations from a linear trend, nominal variables are demeaned and in annualized percentage terms.

The obtained fit of the basic model in some directions thus comes at the cost of inferior forecasts in other directions. For example, large demand shocks may help to match the dynamics of the real interest rate (as discussed below), but they imply bad forecasts for consumption. The reason is that expected consumption repeatedly underpredicts actual consumption if there are long sequences of unexpected positive demand shocks. The basic model also generates large government consumption shocks (see Figure 5.3) in order to match the dynamics of inflation and the nominal interest rate, which works through the inflationary impact of expansionary fiscal shocks. However, this comes at the cost of bad forecasts of government consumption.

Table 5.3 reports mean forecast errors (MFE) and root mean squared forecast errors (RMSFE) which were computed based on the one-step ahead forecasts.[21] The RMSFE are useful to judge the overall predictive performance of the two model versions. The MFE help to judge whether any variable is repeatedly over- or underpredicted. The latter indicate that the basic model tends to underpredict domestic consumption, inflation and the real exchange rate, but overpredicts government consumption. The mean forecast errors are however much closer to zero in the augmented model, for almost all variables. Similarly, the RMSFE of the augmented model are (significantly) smaller for almost all variables. As for the business cycle moments, exceptions are in case of the MFE the interest rate and in case of the RMSFE inflation and debt. We postpone the interpretation of these results to Section 5.4.2. In sum, the model with sovereign risk is clearly preferable in terms of forecasting performance to the underlying basic model.

Default premia and effective interest rates

Why does the model with sovereign risk provide a significantly better fit to the observed data or, conversely, why does the data clearly reject the basic model? In order to provide an intuition, notice that combining equations (5.17) and (5.25) yields

$$\varepsilon_{c,t} - \sigma \hat{c}_t = E_t(\varepsilon_{c,t+1} - \sigma \hat{c}_{t+1}) + \hat{R}_{H,t} - E_t \hat{\pi}_{t+1} - \frac{1}{1-\bar{\delta}} E_t \tilde{\delta}_{t+1}$$

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[21] The formulas are MFE $= T^{-1}\sum_{t=1}^{T} F_t$ and RMSFE $= \sqrt{T^{-1}\sum_{t=1}^{T} F_t^2}$, where F_t is the one-step ahead forecast error.

Table 5.3: One-step ahead forecast errors.[a]

	Mean forecast error MFE[b]		Root mean squared forecast error RMSFE[c]	
	With sov. risk	No sov. risk	With sov. risk	No sov. risk
Output	-0.00	0.00	0.75	3.66
Consumption	0.00	0.04	2.14	5.23
Inflation	0.05	0.08	13.26	8.90
Interest rate	0.12	0.11	8.96	30.33
Real exch. rate	-0.02	0.40	8.97	18.91
Gov. consumption	0.00	-1.19	2.42	23.43
Domestic debt	0.03	-0.06	3.14	1.81
For. consumption	0.03	0.01	0.27	0.28
For. inflation	-0.01	0.01	0.98	1.00

[a] The forecast errors F_t are computed as the difference between the observed variable Y_t and its one-step ahead forecast Y_t^f as $F_t = Y_t - Y_t^f$, where Y_t and Y_t^f are measured in percentage terms.

[b] The mean forecast errors are computed according to the formula MFE $= T^{-1} \sum_{t=1}^{T} F_t$.

[c] The mean squared forecast errors are computed according to the formula RMSFE $= \sqrt{T^{-1} \sum_{t=1}^{T} F_t^2}$.

or, using that $E_t \varepsilon_{c,t+1} = 0$ and re-writing:

$$\sigma(E_t \hat{c}_{t+1} - \hat{c}_t) = \hat{R}_{H,t} - E_t \hat{\pi}_{t+1} - \frac{1}{1-\bar{\delta}} E_t \tilde{\delta}_{t+1} - \varepsilon_{c,t} \tag{5.38}$$

Suppose that expected consumption growth $E_t \hat{c}_{t+1} - \hat{c}_t$ shows "different" dynamics than the expected real interest rate $\hat{R}_{H,t} - E_t \hat{\pi}_{t+1}$. Indeed, according to both models, estimated consumption growth was low in the first half of the sample whereas the real interest rate was relatively high (compare Figure 5.5 and Figure 5.7). In principle, there are three ways in which such dynamics could be reconciled with (5.38):

1. Suppose that $E_t \tilde{\delta}_{t+1} = 0$ for all t. Positive demand shocks $\varepsilon_{c,t}$ could make (5.38) hold if $E_t \hat{c}_{t+1} - \hat{c}_t$ is temporarily low relative to $\hat{R}_{H,t} - E_t \hat{\pi}_{t+1}$. For example, in the case of a positive demand shock, households would save less even if the real interest rate is high since they have a temporary preference for higher consumption.

2. Alternatively, set both $E_t \tilde{\delta}_{t+1} = 0$ and $\varepsilon_{c,t} = 0$ for all t. A relatively large value on the inverse intertemporal substitution elasticity σ would increase the households' preferences for a smooth consumption path, even if the real inter-

est rate is not smooth.

3. Finally, with relatively small demand shocks and a moderate value of σ, a high expected default rate can balance (5.38). Households would invest less when the real interest rate is high due to higher default fears, and vice versa.

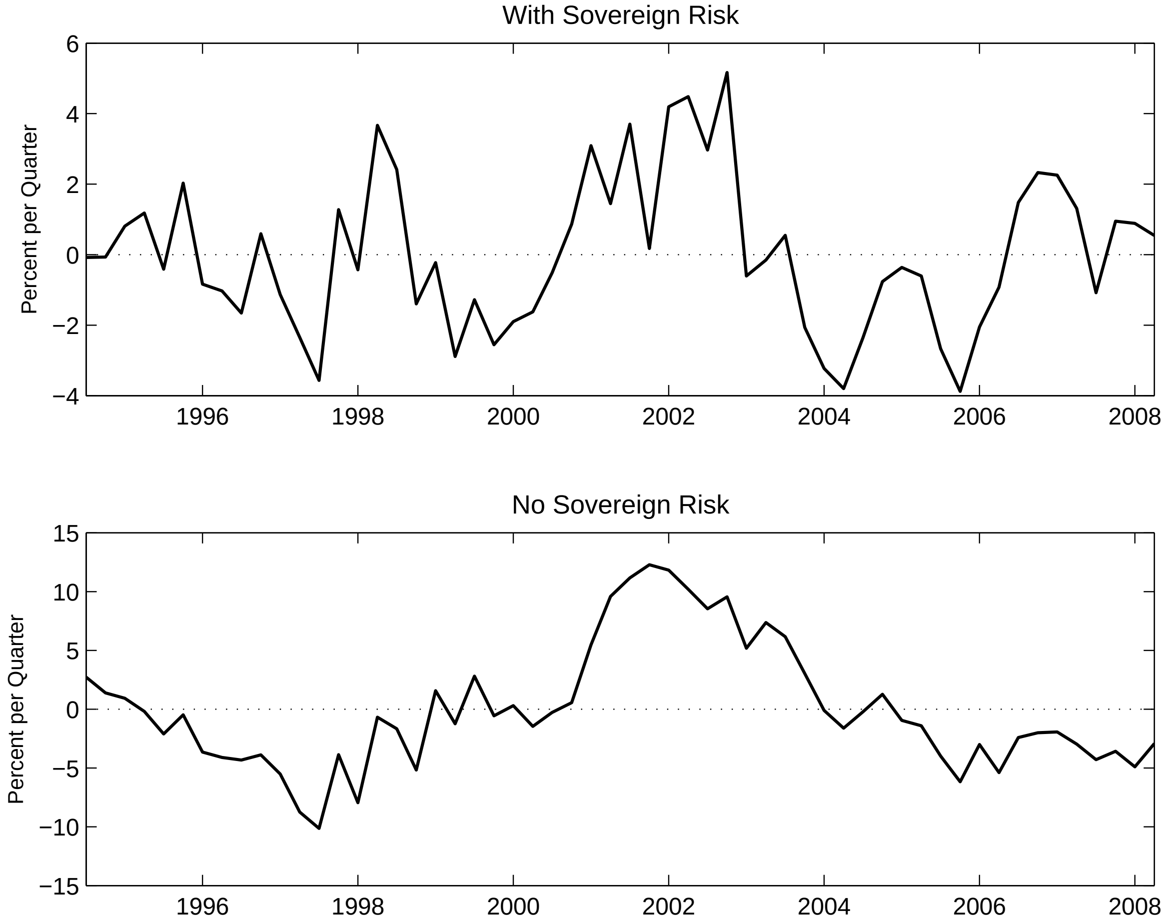
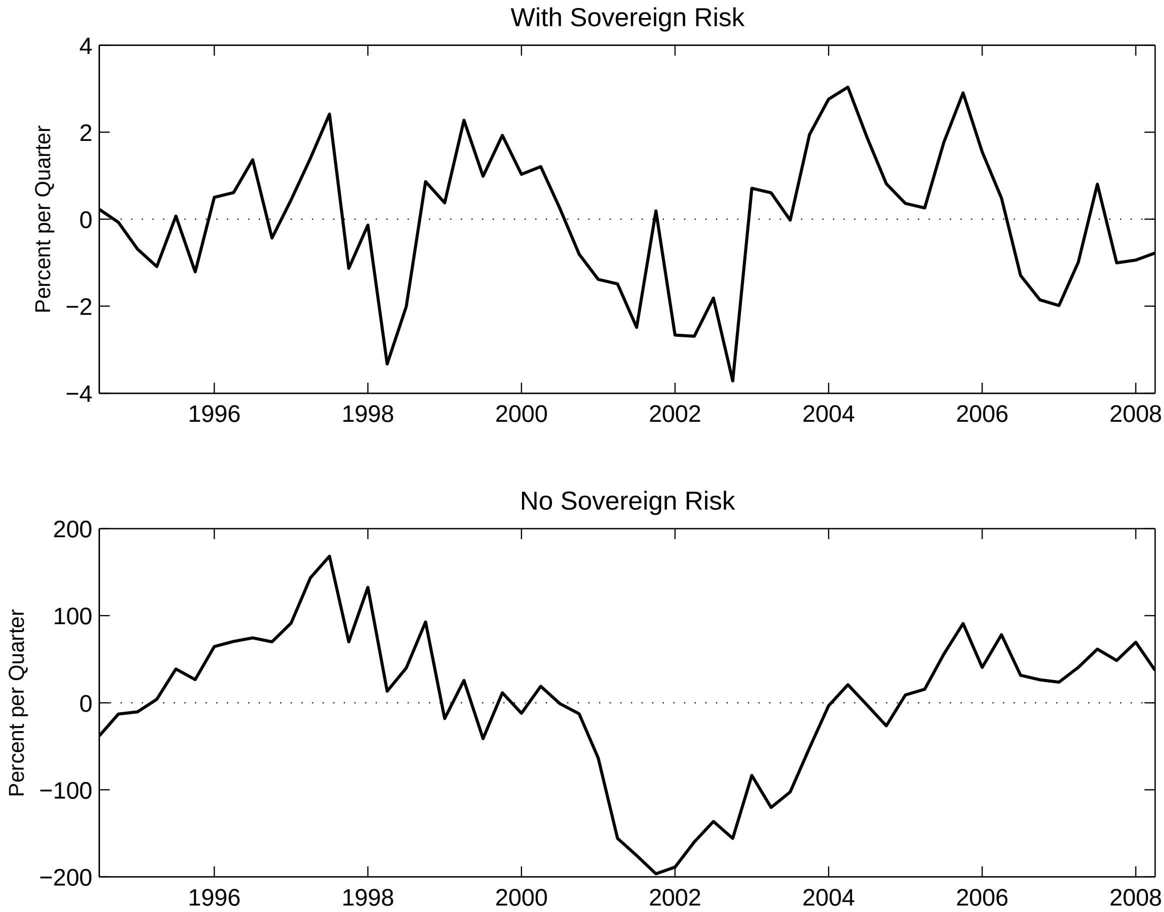


Figure 5.5: Estimated expected consumption growth with and without sovereign risk (in percentage deviations from steady state). *Notes.* Expected consumption growth $E_t\hat{c}_{t+1} - \hat{c}_t$ is estimated using the Kalman smoother at the posterior mean.

A combination of all three explanations seems relevant for understanding our estimation results. First, large demand shocks occur in the model without sovereign risk whereas the model with sovereign risk requires much smaller shocks, as indicated by Figure 5.6, which shows the smoothed demand shocks from both models. Second, the estimated value of σ is more than 25 times higher in the model without sovereign risk. And third, we conclude from Figure 5.7 that default premia were relatively high before the monetary reforms in 2001 but they have declined since then. Therefore, the effective real interest rate net of default risk $\hat{R}_{H,t} - E_t\hat{\pi}_{t+1} - E_t\tilde{\delta}_{t+1}/(1-\bar{\delta})$ shows much smoother dynamics than the actual real rate, which are easier to reconcile with the expected consumption growth.


With Sovereign Risk

No Sovereign Risk

Figure 5.6: Estimated demand shocks $\varepsilon_{c,t}$ with and without sovereign risk. *Notes.* The shocks are estimates implied by the Kalman smoother at the posterior mean.

Variance decomposition

The importance of alternative structural shocks in driving the variation of the observed data as well as the (estimated) expected default rate is analyzed next. Table 5.4 reports their unconditional posterior variance decomposition, distinguishing between economic shocks and policy shocks.[22]

The results show that economic shocks are the main driving force of output, private consumption and the real exchange rate in both versions of the model. However, overall the economic shocks are more important in the model without sovereign

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[22] The economic shocks are $\{\varepsilon_a, \varepsilon_c, \varepsilon_{c^*}, \varepsilon_{\pi^*}, \varepsilon_q\}$ and the policy shocks are $\{\varepsilon_R, \varepsilon_\tau, \varepsilon_g\}$.

Table 5.4: Posterior variance decomposition of observed variables and estimated default rate.[a]

	Output	Cons.	Inflation	Int. rate	Exch. rate	Gov. cons.	Dom. debt	For. cons.	For. infl.	Default rate
With sovereign risk: economic shocks										
Technology ε_a	98.9	83.0	35.6	36.6	10.1	0.0	26.8	0.0	0.0	33.8
Dom. demand ε_c	0.6	14.9	0.2	0.2	0.2	0.0	0.1	0.0	0.0	0.2
For. demand ε_{c^*}	0.1	1.1	3.0	3.1	1.3	0.0	2.3	73.1	15.0	3.0
For. prices ε_{π^*}	0.1	0.4	1.2	1.2	0.5	0.0	1.0	26.8	85.0	1.2
Exch. rate ε_q	0.0	0.0	0.0	0.0	87.8	0.0	0.0	0.0	0.0	0.0
Total[b]	99.7	99.4	40.0	41.1	99.9	0.0	30.2	99.9	100.0	38.2
With sovereign risk: policy shocks										
Int. rate ε_R	0.3	0.2	4.2	1.4	0.0	0.0	1.1	0.0	0.0	1.4
Gov. cons. ε_g	0.1	0.3	20.3	20.9	0.0	100.0	15.9	0.0	0.0	20.9
Fiscal policy ε_τ	0.0	0.0	35.6	36.6	0.0	0.0	28.9	0.0	0.0	39.5
For. debt share ε_f	0.0	0.0	0.0	0.0	0.0	0.0	23.9	0.0	0.0	0.0
Total[b]	0.4	0.5	60.1	48.9	0.0	100.0	69.8	0.0	0.0	61.8
No sovereign risk: economic shocks										
Technology ε_a	4.4	0.5	30.4	22.0	2.4	0.0	1.7	0.0	0.0	–
Dom. demand ε_c	15.8	95.2	0.9	0.7	0.0	0.0	0.0	0.0	0.0	–
For. demand ε_{c^*}	45.5	2.8	43.6	31.5	47.0	0.0	19.6	73.2	15.0	–
For. prices ε_{π^*}	17.1	1.0	17.2	12.4	17.5	0.0	3.0	26.8	85.0	–
Exch. rate ε_q	0.0	0.0	0.0	0.0	30.6	0.0	0.0	0.0	0.0	–
Total	82.8	99.5	92.1	66.6	97.5	0.0	24.3	100.0	100.0	–
No sovereign risk: policy shocks										
Int. rate ε_R	3.3	0.4	2.8	29.7	1.7	0.0	13.6	0.0	0.0	–
Gov. cons. ε_g	13.9	0.1	5.2	3.7	0.7	100.0	10.5	0.0	0.0	–
Fiscal policy ε_τ	0.0	0.0	0.0	0.0	0.0	0.0	51.4	0.0	0.0	–
For. debt share ε_f	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	–
Total	17.2	0.5	8.0	33.4	2.4	100.0	75.9	0.0	0.0	–

[a] Table entries refer to contribution to unconditional variance (in percent) at the posterior mean.

[b] Some of the totals do not sum up to 100% due to rounding errors.

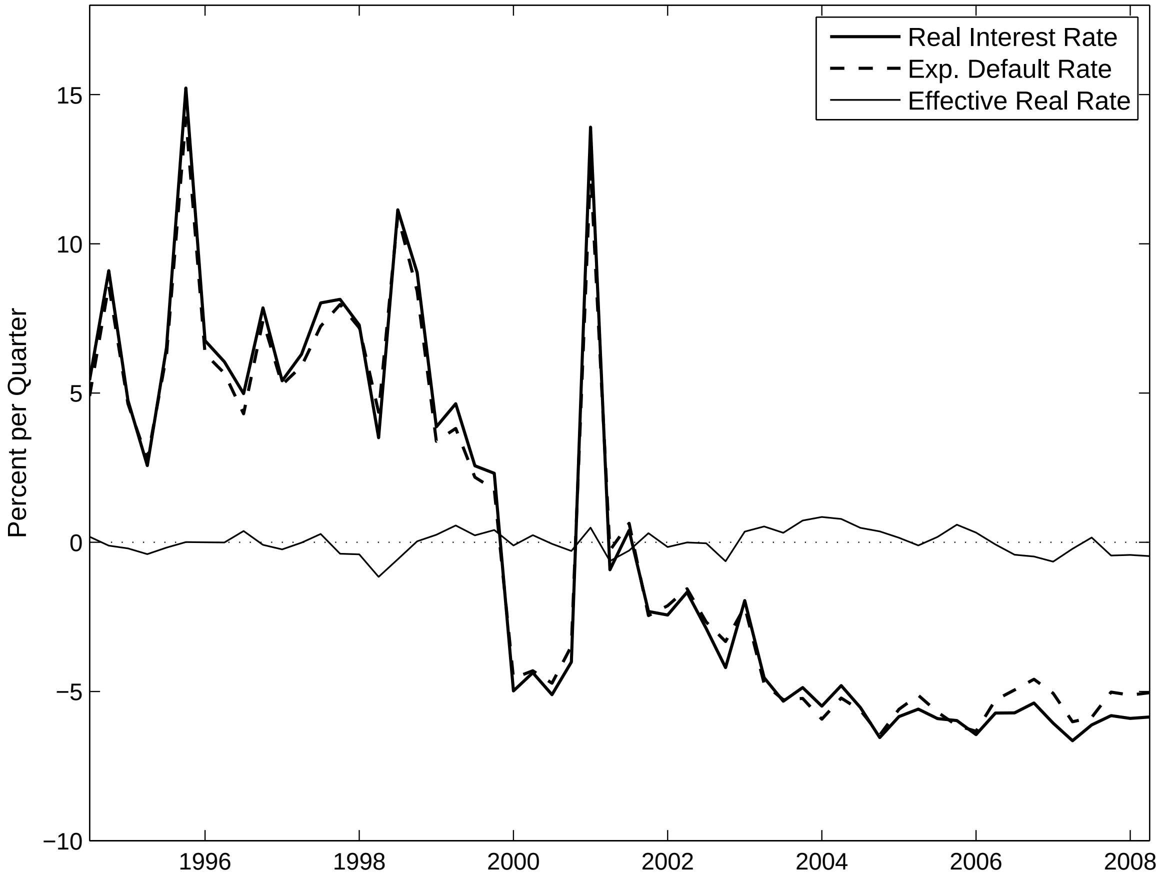

Figure 5.7: Estimated expected real interest rate ($\hat{R}_{H,t} - E_t\hat{\pi}_{t+1}$), expected default rate ($E_t\tilde{\delta}_{t+1}$) and effective real interest rate ($\hat{R}_{H,t} - E_t\hat{\pi}_{t+1} - (1-\bar{\delta})^{-1}E_t\tilde{\delta}_{t+1}$). *Notes.* The variables are estimates implied by the Kalman smoother at the posterior mean; the real interest rate and the real effective interest rate are reported as quarterly percentage deviations from steady state; the default rate is measured in absolute deviations (in percentage points) from its steady state value.

risk. With sovereign risk, about 50-60% of the variation in inflation and the nominal interest rate is attributed to policy shocks, and here especially the fiscal policy shock ε_τ and the government consumption shock ε_g, whereas the basic model does not assign a dominant role to those shocks. The interest rate shock ε_R, on the other hand, becomes less important in explaining variation in the nominal interest rate in the model with sovereign risk.

In terms of the driving forces of the expected default rate, it turns out that economic shocks contribute 38% and policy shocks contribute 62% to its variation. Among the economic shocks, technology shocks are again most important. Among the policy shocks, the fiscal policy shocks contributes most variation, about 40%, whereas the government consumption and the interest rate shock contribute about

21% and 1%, respectively. These results indicate that a reduction in the volatility of policy shocks (especially fiscal shocks) has helped to reduce the variability of expected default rates over time (compare Figures 5.3 and 5.7).

5.4.2 Counterfactual experiments and amplification of shocks

In this subsection we first present several counterfactual experiments in order to investigate the importance of (and to gain intuition for) particular elements of the model in explaining the dynamics of the model and hence the observed data. Moreover, we analyze the implications of alternative fiscal and monetary policies. Then we present the estimated impulse response functions from the basic and the augmented model computed at the posterior mean estimates of the structural parameters which here jointly differ across the two models. In all cases, we compare the impulse responses of selected variables to a unitary negative technology shock where the shock is normalized to have the estimated persistence from the model with sovereign risk in order to ensure comparability.[23]

Counterfactual experiments

All experiments are based on the estimated model with sovereign risk, which we refer to as the benchmark model.[24] We change one structural parameter at a time. In particular, (i) the default elasticity Φ is set to zero, (ii) the degree of openness ϑ is set to zero, (iii) the foreign debt share $\bar{f}$ is set to zero, (iv) the inverse intertemporal substitution elasticity σ is set to 15.85, its posterior mean estimate in the basic model, (v) the fiscal feedback κ is doubled and (vi) the monetary feedback α_π is doubled. For expositional purposes, we first discuss experiment (i), the model without sovereign risk, before we turn to the benchmark model with sovereign risk.

Figure 5.8 shows the impulse responses for experiments (i), (ii), (iii) and (iv). When the default elasticity Φ is set to zero (experiment (i), thick dashed line) there is no expected default (i.e. Ricardian equivalence holds). The negative technology

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[23] The parameter ρ_a is thus set to 0.91 in all models.

[24] We choose the augmented model as the benchmark since the basic model is clearly rejected by the data. Moreover, the augmented model allows analyzing the effects of foreign currency denominated debt and changes of the policy parameters, both in the presence of sovereign risk.

shock causes a rise in intermediate goods firms' marginal costs. The firms react by increasing prices, which leads to an appreciation of the real exchange rate. Domestic consumption therefore falls, due to international risk sharing and expenditure switching of domestic and foreign households, and so does domestic output. The monetary authority reacts to higher inflation by increasing the nominal interest rate. Government debt falls initially, due to the direct beneficial exchange rate effect on foreign debt and the fact that government purchases of domestic goods become cheaper due to the real appreciation. Thereafter, government debt shows a persistent increase due to higher debt service obligations resulting from the higher nominal interest rate.

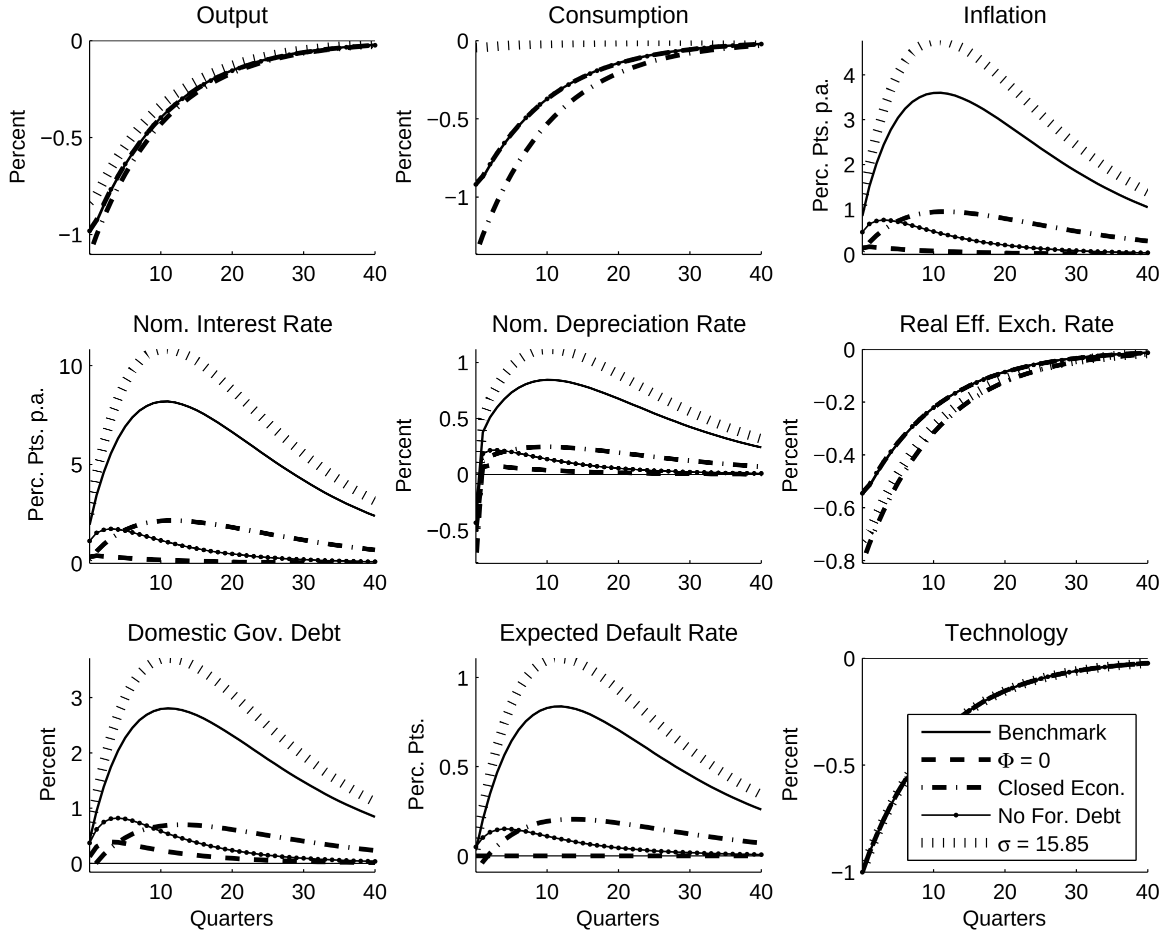

Figure 5.8: Estimated and counterfactual impulse responses due to a technology shock based on the model with sovereign risk. *Notes.* Technology shock is normalized to 1%; estimated impulse responses are calculated at the posterior mean and counterfactual impulse responses are calculated by changing one parameter at a time; real variables are measured in percentage deviations from steady state, nominal variables in absolute (annual) percentage point deviations from steady state.

Under sovereign risk (benchmark model, solid line) the real value of debt affects the effective rate of return and thus alters those dynamics through various channels. As in case (i), higher inflation leads to higher nominal interest rates and hence to higher debt service obligations and debt. However, savings tend to be lower and current domestic consumption tends to be higher than in case (i) due to the negative feedback from debt on its return (see equations 5.25 and 5.27), spurring inflationary pressures. In order to contain inflation, the central bank needs to increase the nominal interest rate by more than in case (i), which then reduces the tendency of current domestic consumption to rise. Higher nominal rates in turn imply higher debt servicing costs, higher debt levels and thus increasing expected default rates which tend to lower the expected return on debt and hence eventually lead to further pressures on demand and inflation. Hence, the initial increase of inflation is amplified via the negative feedback from debt on its return, pushing up nominal variables and debt.

In an open economy, demand and inflationary pressures are even larger due to the presence of the exchange rate channel. Here, the pressure on domestic current consumption from the negative feedback from debt on its return feeds into pressures on the real exchange rate due to international risk sharing (see equation 5.24). A real depreciation would lead to expenditure switching of domestic households and increasing demand of foreign households for home goods. Moreover, domestic households would demand a higher nominal wage since the price level of aggregate consumption rises due to higher prices of imported goods. Hence, in a open economy the central bank has to raise nominal interest rate by more than in a closed economy in order to maintain the additional demand pressures from depreciationary effects of the real exchange rate.

The benchmark model and experiment (i) show that the presence of sovereign risk in an open economy may considerably amplify the fluctuations of nominal variables and debt. In addition to improving the fit of the consumption Euler equation (see Section 5.4.1), including sovereign risk into the model thus helps to account for the high volatility of nominal variables and debt in the data. Put differently, it is not only the variability of the default premium which helps to improve the fit of the model but also its pure existence.

In a closed economy (experiment (ii), dash-dotted line) the impact of the technology shock on the inflation and the nominal interest rate is significantly muted, such that the debt response and the reaction of the default rate are also smaller.[25] The reason is that the additional pressure on aggregate demand via the exchange rate is shut down in that case. This experiment shows that the presence of sovereign risk also alters the dynamics of a closed economy, but that the effects of sovereign risk are amplified in an open economy via the exchange rate channel.

Similarly, without foreign debt (experiment (iii), solid line with dots) the increase in inflation, the nominal interest rate and debt is muted. Without foreign currency denominated debt, the pressure on the real exchange rate does not trigger additional fears of default due to fears of debt revaluation (see equations 5.25, 5.27 and 5.29). Moreover, the devaluating effect of increases of domestic inflation on the stock of real debt is more pronounced if debt is only denominated in domestic currency. Interestingly, the dynamics without foreign debt are quantitatively more similar to the dynamics without sovereign risk (experiment i) than to the benchmark model, for the given parameter values.

For high values of the inverse intertemporal substitution elasticity σ (experiment (iv), bars) the response of consumption to an increase of the nominal interest rate is substantially muted since households have strong preferences for a smooth consumption path. The effectiveness of high nominal rates to maintain pressures on aggregate demand is reduced such that higher nominal rates are required. Higher nominal rates in turn imply higher actual debt service obligations and hence expected default rates, explaining the amplified responses for high values of σ.

A priori, it is not clear which policy is superior in terms of stabilizing nominal variables, debt and expected default rates, stronger fiscal or stronger monetary feedbacks. A stronger fiscal feedback is expected to lead to a faster reduction in government debt at the cost of approaching critical tax levels. The impact on the expected default rate is therefore ambiguous. A stronger monetary feedback may better contain demand pressures, but they imply higher actual debt service obligations and hence fears of default.

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[25] Notice that the definitions of the nominal depreciation rate and the real exchange rate become meaningless for $\vartheta = 0$.

The results reported in Figure 5.9 show that due to an increase in the fiscal feedback coefficient κ from 0.53 to 1.06 (experiment (v), solid line with dots) the reduction in government debt via higher taxes occurs faster. The increase in the expected default rate is therefore weaker, which leads to lower demand pressure and inflation and thus a smaller increase in the nominal interest rate. Under a higher monetary feedback, i.e. an increase of α_π from 2.1 to 4.2 (experiment (vi), solid-dotted line) inflation expectations are contained. Hence, demand pressures do not feed into higher inflation which reduces the need for the central bank to raise actual nominal interest rates.[26] However, there is no reduction in the response of the default rate but rather a slight increase since the devaluating effect of inflation on the real stock of debt is smaller.

We conclude that the destabilizing dynamics of sovereign risk discussed by Blanchard (2005) and Schabert and van Wijnbergen (2010) do have practical relevance. However, both more active monetary and higher fiscal debt feedbacks on taxes can have stabilizing effects on nominal interest rates, inflation and government debt. A more active stance of monetary policy, by maintaining inflation expectations, reduces the need for high nominal interest rates. Default premia can however be larger under more active monetary policy whereas they unambiguously decline with higher fiscal feedbacks. Hence, if an economy is subject to sovereign risk solid fiscal policy is an effective device for stabilizing nominal interest rates, inflation and debt, and the clearly preferable policy for stabilizing expected default rates.

Amplification of shocks

After analyzing particular elements of the model in isolation, we now discuss the estimated impulse response functions from both models computed at the posterior mean estimates of the structural parameters which now jointly differ across models. The dashed line in Figure 5.10 shows the impulse responses due to a unitary negative technology shock of the basic model without sovereign risk. As above, the negative technology shock causes a rise in inflation and an appreciation of the real exchange rate. Domestic consumption and output fall. The monetary authority in-

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[26] The same holds in a closed economy setting, not reported here.

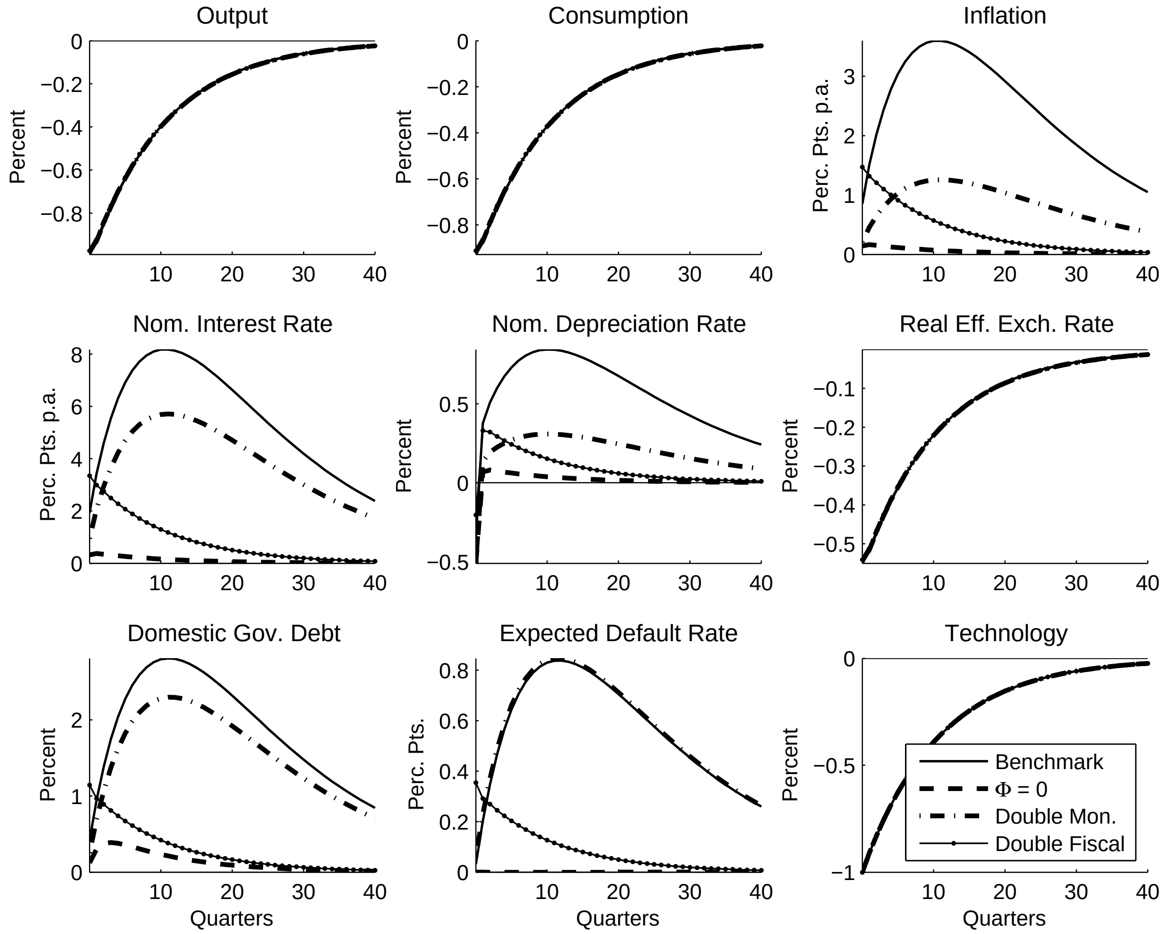

Figure 5.9: Estimated and counterfactual impulse responses due to a technology shock based on the model with sovereign risk, policy feedbacks. *Notes.* Technology shock is normalized to 1%; estimated impulse responses are calculated at the posterior mean and counterfactual impulse responses are calculated by changing one parameter at a time; real variables are measured in percentage deviations from steady state, nominal variables in absolute (annual) percentage point deviations from steady state.

creases the nominal interest rate, government debt falls initially and then shows a persistent increase due to higher debt service obligations resulting from the higher interest rate.

Under sovereign risk (solid line), the real value of debt affects the effective rate of return, as discussed above. In particular, the amplification of the responses of inflation, the nominal interest rate, domestic debt and the expected default rate can mainly be attributed to the presence of sovereign risk, i.e. to the fact that $\Phi > 0$. The different responses of consumption, output and the real exchange rate seem to be mainly driven by the lower value of the inverse intertemporal substitution elasticity

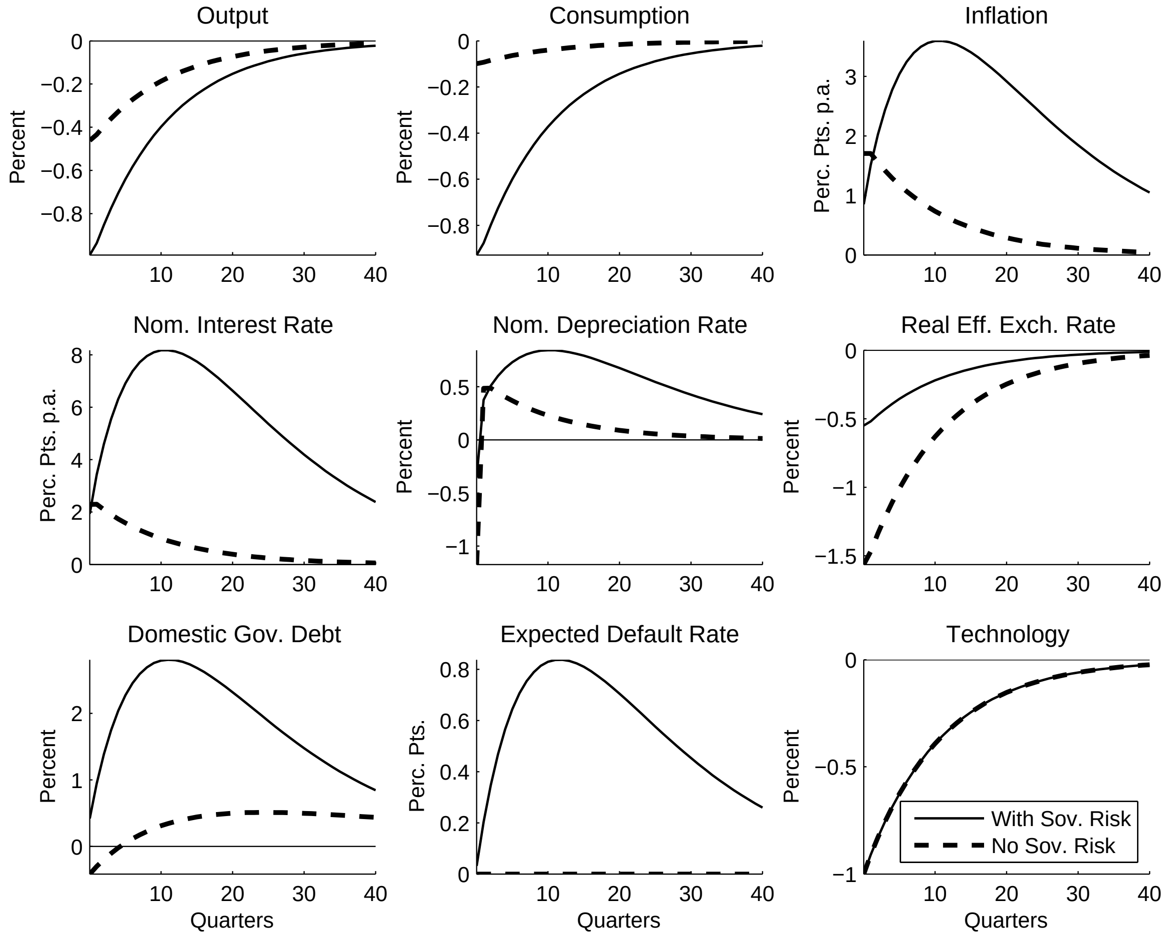

Figure 5.10: Estimated impulse responses due to technology shocks in the models with and without sovereign risk. *Notes.* Technology shock is normalized to 1% and to have persistence as estimated in the model with sovereign risk; impulse responses are calculated at the posterior mean; real variables are measured in percentage deviations from steady state, nominal variables in absolute (annual) percentage point deviations from steady state.

σ. A low value for σ implies a more pronounced response of consumption to movements in the real effective interest rate. However, the effect on the real exchange rate is muted since variations in domestic consumption only feed into small variations of the real exchange rate, given the low value of σ (as can be seen from equations 5.17 and 5.24). Finally, the higher share of imports tends to amplify both the effects of sovereign risk on nominal variables and government debt and the response of consumption.

In sum, comparing these results to the impulse responses in Figures 5.8 and 5.9 shows that the differences between the dynamics of the estimated basic and the estimated augmented model are due to the fact that all parameters differ across estimated models but not from the addition of sovereign risk in isolation.

5.4.3 Sensitivity checks

As a final step of the analysis, we estimate alternative versions of the benchmark model with sovereign risk. Table 5.5 compares the parameter estimates. First, instead of estimating the standard deviation of the measurement error on the real effective exchange rate σ_q, it is calibrated to 0.05, i.e. its prior mean.[27] The estimated inverse intertemporal substitution elasticity σ, the degree of openness ϑ, and the degree of price stickiness ϕ change slightly, but the remaining estimates remain almost unaffected.

Second, an exchange rate stabilization term is introduced in the monetary authority's reaction function. The reason is that the CBRT only moved to explicit inflation targeting with the economic reforms introduced in 2001. Before that, it pursued a crawling peg exchange rate targeting policy (see Gormez and Yilmaz, 2007). We attempt to capture this fact by the following modification of (5.4):

$$\frac{R_{H,t}}{R_H} = \left(\frac{\pi_t}{\pi}\right)^{\alpha_\pi} \left(\frac{q_t}{q}\right)^{\alpha_q} \exp(\varepsilon_{R,t}),$$

where again $\varepsilon_{R,t} \sim NID(0, \sigma_R^2)$ and the feedback α_q indicates the strength of the monetary authority's reaction to exchange rate movements.[28] As the inflation feedback, the exchange rate feedback is assumed to be non-negative, i.e. the monetary authority reacts to a real depreciation by increasing the nominal interest rate.[29] The exchange rate feedback is motivated by Lubik and Schorfheide's (2007) observation that many central banks in small open economies do target exchange rate movements via a Taylor rule. The estimation results in Table 5.5 indicate that the exchange rate feedback is fairly large, but the marginal likelihood does not provide support for this specification, compared to the benchmark model. Importantly, the estimates

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[27] This exercise shows whether, if we restrict the estimation procedure in one dimension (here measurement error) where there is some discrepancy between the model and the data, first, the model can still explain the data, i.e. whether we obtain convergence in the mode maximization step, and second, whether estimation of the restricted model leads to reasonable estimates of the structural parameters and remaining shock variances.

[28] The exchange rate target is assumed to be consistent with steady state values.

[29] A $U(0, 10)$ prior is applied similar to the prior for α_π.

Table 5.5: Sensitivity of parameter estimates.[a]

Parameter	Definition	Prior[b]	Benchmark model	Smaller meas. error[c]	Taylor exch. rate	Habit formation	Smaller debt shocks[d]
σ	Inv. elast. of intertemp. subst.	$U(0,20)$	0.59	0.43	0.58	1.24	1.33
h	Degree of habit formation	$U(0,1)$	–	–	–	0.58	–
ϕ	Calvo price stickiness	$U(0,1)$	0.19	0.14	0.19	0.54	0.64
ϑ	Degree of openness	$U(0,1)$	0.42	0.57	0.42	0.14	0.12
α_π	Taylor rule inflation response	$U(0,10)$	2.10	2.13	2.12	1.80	1.58
α_q	Taylor rule ex. rate response	$U(0,10)$	–	–	0.24	–	–
κ	Tax rule debt response	$U(\kappa_L,10)$[e]	0.53	0.53	0.53	0.42	0.41
Φ	Default elasticity	$U(0,10)$	0.25	0.24	0.25	0.19	0.18
ρ_a	AR(1) technology	$U(0,1)$	0.91	0.91	0.91	0.95	0.97
ρ_g	AR(1) gov. consumption	$U(0,1)$	0.50	0.51	0.50	0.42	0.28
ρ_f	AR(1) foreign debt ratio	$U(0,1)$	0.86	0.86	0.86	0.90	0.93
σ_a	Std. dev. technology shocks	$IG(0.05,\infty)$	0.02	0.02	0.02	0.04	0.05
σ_g	Std. dev. gov. consumption shocks	$IG(0.05,\infty)$	0.04	0.04	0.04	0.04	0.04
σ_f	Std. dev. foreign debt ratio shocks	$IG(0.05,\infty)$	0.31	0.32	0.31	0.26	–
σ_τ	Std. dev. fiscal policy shocks	$IG(0.05,\infty)$	0.10	0.11	0.10	0.08	0.07
σ_R	Std. dev. interest rate shocks	$IG(0.05,\infty)$	0.07	0.07	0.07	0.06	0.06
σ_c	Std. dev. demand shocks	$IG(0.05,\infty)$	0.02	0.01	0.02	0.09	0.05
σ_q	Std. dev. meas. error on $REER_t$	$IG(0.05,\infty)$	0.09	–	0.09	0.11	0.11
$\log p(Y^T\|M_i)$	Log marginal data density[f]		873.67	849.86	870.47	880.67	854.00

[a] The estimation results are based on 500,000 accepted draws from the RWM sampler, dropping the first 250,000 draws.

[b] $U(a,b)$ refers to the continuous uniform distribution with lower bound a and upper bound b; $IG(c,d)$ refers to the inverse gamma distribution with mean c and std. deviation d.

[c] For the specification with smaller measurement errors, the standard deviation σ_q is calibrated to 0.05.

[d] For the specification with smaller debt shocks, the standard deviation σ_f is calibrated to 0.15.

[e] The lower bound is $\kappa_L = 1 - \beta(1-\bar{\delta})$, which ensures that steady state domestic debt b_H/π is positive such that $\Phi > 0$ (see Appendix 5.C).

[f] The marginal data density is estimated using Geweke's (1999) modified harmonic mean estimator.

of the remaining model parameters change very little.[30]

Further, we add external habit formation in consumption to the estimated model, like in Adolfson, Laséen, Lindé, and Villani (2007) or Justiniano and Preston (2010). That is, the (domestic and foreign) households' preferences are modified accordingly:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\exp(\varepsilon_{c,t}) \frac{(c_t - h\breve{c}_{t-1})^{1-\sigma}}{1-\sigma} - \frac{n_t^{1+\eta}}{1+\eta} \right)$$

where $h \in (0,1)$ and $\breve{c}_{t-1}$ denotes aggregate domestic consumption, which is taken as exogenous by the individual households.[31] The first-order conditions for (domestic and foreign) consumption become

$$\begin{aligned} \lambda_t &= \exp(\varepsilon_{c,t}) \left(c_t - hc_{t-1}\right)^{-\sigma} \\ \lambda_t^* &= \left(c_t^* - hc_{t-1}^*\right)^{-\sigma} \end{aligned}$$

where the equilibrium conditions $c_t = \breve{c}_t$ and $c_t^* = \breve{c}_t^*$ have been imposed for all t. The introduction of habit formation is motivated by the idea that, if this is a salient feature of the data (see, for example, Adolfson, Laséen, Lindé, and Villani, 2007; Smets and Wouters, 2007; Justiniano and Preston, 2010), the associated modification of the consumption Euler equation may alter the importance of sovereign risk in explaining macroeconomic dynamics as well. The estimation results in Table 5.5 show that, although h is fairly large with an estimated value of 0.58 and the marginal data density improves by 7 log points, the estimated default elasticity and the policy coefficients remain sufficiently close to the baseline estimates.[32] The default elasticity drops from 0.25 to 0.19.

Next, the largest estimated standard deviation (of the debt issuance shock) σ_f is calibrated to 0.15, i.e. half of the benchmark estimate. This shock only has an impact on the division among domestic and foreign debt, but no effect on the real vari-

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[30] Alternatively, we included a real exchange rate depreciation term $(q_{t+1} - q_t)$ in the Taylor rule with prior $\mathcal{N}(0.5, 0.5^2)$ on its reaction coefficient. However, the reaction coefficient was not identified by the estimation. Moreover, we included the output gap (in deviations from steady state output) with prior $\mathcal{N}(0.5, 0.5^2)$ on its reaction coefficient into the Taylor rule. The estimated reaction coefficient is close to zero (0.03). All other parameter values and the marginal likelihood remain virtually unchanged.

[31] A $U(0,1)$ prior is elicited on h consistent with its theoretical domain.

[32] We have not introduced habit formation in the basic model without sovereign risk since we here faced convergence problems in the mode optimization step.

ables and the estimated default rate (see Table 5.4). With a smaller value of its standard deviation the model is restricted to explain more variation in domestic debt by the remaining structural shocks via cross-equation restrictions. The estimated persistence of government consumption decreases and there are also some significant changes in the remaining estimates compared to the benchmark case (notably σ, ϕ, ϑ and α_π). Most importantly, however, the estimated default elasticity of 0.18 still indicates a highly debt-elastic default rate.

We have also attempted to estimate the benchmark model by constrained maximum likelihood (ML), where we restricted the model parameters on their theoretically feasible range according to the domains in Table 5.1. It turned out that ML estimation was only feasible (in terms of convergence of the optimizer) when we calibrated the degree of price stickiness ϕ to its benchmark value of 0.19. The estimation results for the remaining parameters show that only σ and ϑ change significantly to 0.26 and 0.74, respectively, whereas the other parameters remain close to the benchmark values. Again, the default elasticity is estimated to be highly debt-elastic (with a value of 0.23).

Finally, the estimated expected default rates from all estimated versions of the model are compared in Figure 5.11. The results are very similar across models, the only exceptions being the models with habit formation and smaller debt issuance shocks for which the default rate is somewhat less volatile, smaller during the first half of the sample and larger during the second half. However, even in those two cases the estimated default rate remains close to the estimate from the benchmark model. Setting the discount factor β to alternative values of 0.97 and 0.999 leaves all the estimation results virtually unchanged. The standard deviation of the model-implied default premium is only affected at the third significant digit when changing β while the correlation with the default premium for $\beta = 0.99$ is one in both cases.

5.5 Conclusions

We set up a mostly standard dynamic stochastic general equilibrium model of a small open economy where rigidities in domestic producer prices are the only nomi-

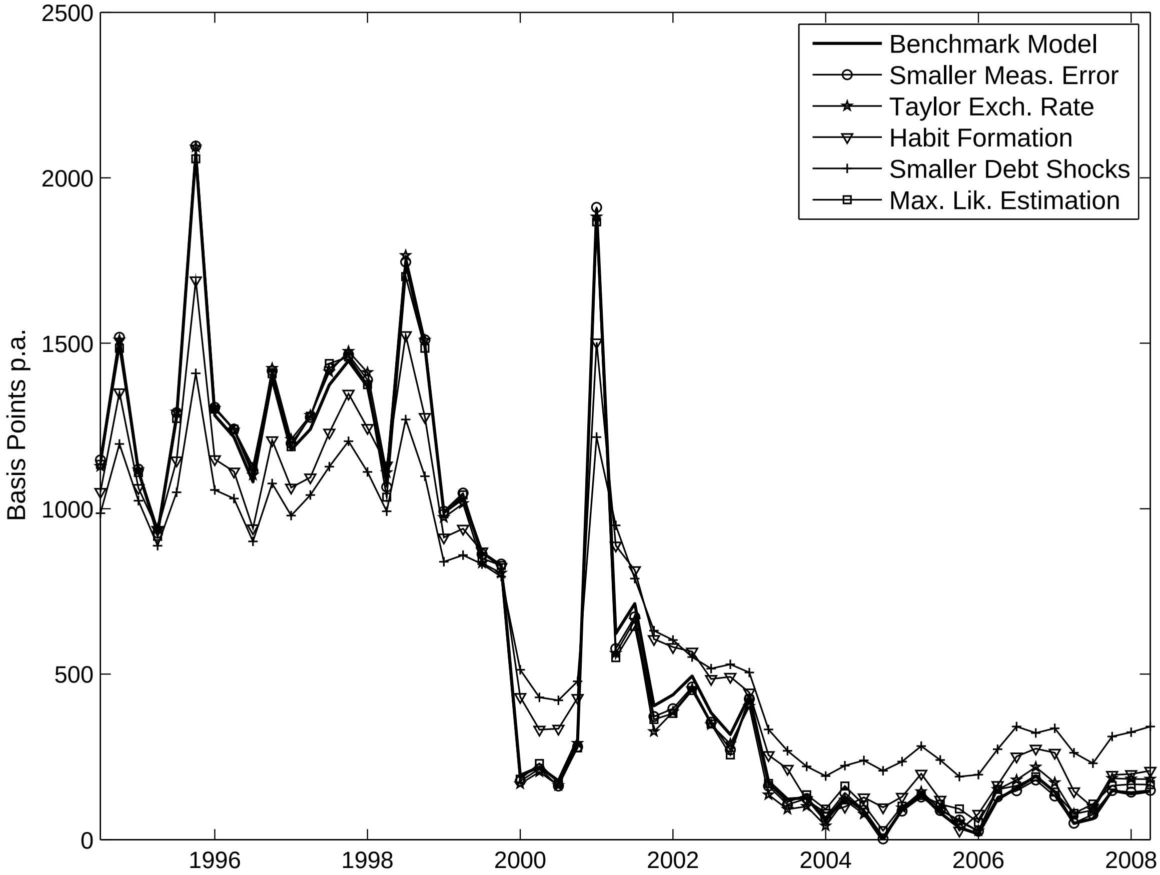

Figure 5.11: Estimated expected default rate ($E_t\tilde{\delta}_{t+1}$) according to alternative models. *Notes.* The default rate is the estimate implied by the Kalman smoother at the posterior mean.

nal friction. A perceived possibility of sovereign debt default implies a time-varying default premium on government bonds which depends on the stock of real total debt and which we include into this otherwise standard NOEM model. We outline two main variants of the model which differ only with respect to the inclusion of the expected default rate. More specifically, the model without sovereign risk is a special case of the general model with sovereign risk where the parameter on the expected default rate in the Euler equation for government bonds is restricted to equal zero.

Using Bayesian estimation methods we find that the estimated expected default rate is highly debt-elastic and depends on fiscal policy, indicating that default fears are a relevant concern. Model comparisons clearly support the model with expected default rate as compared the standard New Keynesian small open economy model where the level of debt is irrelevant for the dynamics of nominal variables. We find that in the latter, large shocks are required in order to reconcile the observed dynamics of the nominal interest rate, the real exchange rate, government debt and aggregate demand. Accounting for sovereign risk leads to stronger internal propagation and better forecasting performance. In terms of policy implications, counterfactual experiments show that solid fiscal policy leads to less volatile debt and inflation dynamics, by reducing expected default rates. On the other hand, more active monetary policy is also an effective stabilization device for inflation and debt, but it does not reduce expected default rates.

Finally, there is empirical evidence that the relationship between government debt and default premia may contain non-linear elements (see Alesina, Broeck, Prati, Tabellini, Obstfeld, and Rebelo, 1992; Bayoumi, Goldstein, and Woglom, 1995) such that the linear estimation approach followed in this chapter provides only an incomplete picture of this relationship. However, non-linear estimation methods are still not readily available. They might become a viable avenue in future research. Moreover, the linear model seems to provide a reasonable description of expected default rates (see the EMBIG Turkey spread in Figure 5.2).

5.A Data Definitions

This appendix provides details on data definitions, data sources and the construction of the foreign variables. All data are seasonally adjusted and the consumer price index is used to construct real variables with base year 1998, if they are only available in nominal terms from the original source. The domestic variable definitions and their sources are as follows:

- GDP_t: Real gross domestic product, Central Bank of the Republic of Turkey.
- CONS_t: Real private consumption expenditure, Central Bank of the Republic of Turkey.
- GOV_t: Real government consumption expenditure, Central Bank of the Republic of Turkey.
- DEBT_t: Domestic debt position of the treasury, Central Bank of the Republic of Turkey.
- INT_t: Annual net interest rate for 3-month treasury bills, constructed from data obtained from the Central Bank of the Republic of Turkey; if 3-month bills were not issued in some quarter, we use the closest maturity available.
- INF_t: Annualized rate of change of the quarterly CPI, State Institute of Statistics Turkey.

- REER_t: Real CPI-based effective exchange rate, OECD main economic indicators.

The foreign variables are constructed from euro area real private consumption and the annual inflation rate according to the Harmonized Index of Consumer Prices obtained from the Area-Wide Model database (Fagan, Henry, and Mestre, 2005), and real U.S. personal consumption and the CPI-based U.S. inflation rate (all urban sample, all items) obtained from the U.S. Bureau of Economic Analysis. Aggregate foreign consumption CONS_t^* and foreign inflation INF_t^* are computed according to the trade weights in the basket targeted by the Turkish central bank during the exchange rate targeting period (see Gormez and Yilmaz, 2007). That is, the euro area obtains a weight of 0.77 and the U.S. obtains a weight of 1.

5.B Steady State Properties

In this appendix we derive a partial solution for the non-stochastic steady state of the model, which is sufficient for its implementation. We take as given the steady state interest rate $R_H = \bar{R}_H$, steady state marginal costs $mc = \overline{mc}$, the average foreign inflation CPI rate $\bar{\pi}^*$, the average domestic CPI inflation rate $\pi = \bar{\pi}$, and the shares $s_c = \bar{s}_c$ and $s_g = \bar{s}_g$. Furthermore, the steady state is assumed to satisfy the purchasing power parity (PPP) condition, i.e. the steady state real exchange rate equals unity ($q = 1$). While usually not taken seriously as a short-term proposition, empirical evidence supports the usefulness of PPP as a long-run anchor for real exchange rates (Rogoff, 1996).[33] In order to obtain a well-defined equilibrium, we set the values of $\bar{\delta}$, $\overline{mc}$, $\bar{\pi}^*$, $\bar{\pi}_X$, $\bar{c}^*$, $\bar{g}$ and ξ accordingly, as follows.

First, the process for productivity implies that

$$(1 - \rho_a) \log a = 0$$

or $a = 1$. Similarly, the remaining stochastic processes imply that $g = \bar{g}$ and $f = \bar{f}$. The foreign VAR process implies that

$$(I - \Phi_{1*} - \Phi_{2*} - \Phi_{3*} - \Phi_{4*}) \begin{bmatrix} \log c^* \\ \log \pi^* \end{bmatrix} = (I - \Phi_{1*} - \Phi_{2*} - \Phi_{3*} - \Phi_{4*}) \begin{bmatrix} \log \bar{c}^* \\ \log \bar{\pi}^* \end{bmatrix}$$

and therefore, assuming stability of the VAR such that $(I - \Phi_{1*} - \Phi_{2*} - \Phi_{3*} - \Phi_{4*})$ is non-singular, $c^* = \bar{c}^*$ and $\pi^* = \bar{\pi}^*$ can be taken as given.

Second, the central bank is assumed to achieve its target rate of nominal depreciation in the steady state, i.e.

$$\pi_X = \bar{\pi}_X = \pi / \bar{\pi}^*.$$

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[33] In particular, the estimated half-life of deviations from PPP in OECD countries is about three years (see Abuaf and Jorion, 1996).

Therefore, we can take $\pi = \bar{\pi} = \bar{\pi}_X \bar{\pi}^*$ as given.

Third, the steady state interest rate satisfies

$$R_H = \bar{R}_H = \frac{\bar{\pi}}{\beta\left(1-\bar{\delta}\right)}$$

such that $\bar{\delta}$ is given by

$$\bar{\delta} = 1 - \frac{\bar{\pi}/\bar{R}_H}{\beta} < 1.$$

Fourth, the intermediate goods firms' first-order conditions for price setting imply that

$$mc = \frac{\epsilon - 1}{\epsilon}$$

so we can take $mc = \overline{mc}$ as given by calibrating ϵ accordingly.

Fifth, we set the constant ξ (which depends on initial endowments) such that $q = 1$. In order to see this, notice that the international risk sharing condition yields

$$\lambda^* = \xi q \lambda$$

or, substituting out $\lambda^* = \bar{c}^{*-\sigma}$ and $\lambda = c^{-\sigma}$ and solving for q:

$$q = \frac{1}{\xi}\left(\frac{c}{\bar{c}^*}\right)^{\sigma}.$$

In order to obtain an expression for the steady state real exchange rate in terms of the given values for s_c and s_g, solve the market clearing equation in steady state for s_{c^*}:

$$y_H = \left(1-\vartheta\right) q^{\frac{\vartheta}{1-\vartheta}} c + \vartheta^* q^{\frac{1}{1-\vartheta}} c^* + g$$

or

$$s_{c^*} = \frac{1 - \left(1-\vartheta\right) q^{\frac{\vartheta}{1-\vartheta}} \bar{s}_c - \bar{s}_g}{q^{\frac{1}{1-\vartheta}} \vartheta^*}.$$

Therefore, we have

$$q = \frac{1}{\xi}\left(\frac{\bar{s}_c}{s_{c^*}}\right)^{\sigma} = \frac{1}{\xi}\left(\frac{q^{\frac{1}{1-\vartheta}} \vartheta^* \bar{s}_c}{1 - \left(1-\vartheta\right) q^{\frac{\vartheta}{1-\vartheta}} \bar{s}_c - \bar{s}_g}\right)^{\sigma}.$$

In order to fix $q = 1$, we can set the constant ξ accordingly:

$$\xi = \left(\frac{\vartheta^* \bar{s}_c}{1 - \left(1-\vartheta\right) \bar{s}_c - \bar{s}_g}\right)^{\sigma}.$$

Finally, we need to fix values $\bar{c}^*$ and $\bar{g}$ in order to match $s_c = \bar{s}_c$ and $s_g = \bar{s}_g$. For $q = 1$ it follows from the international risk sharing condition that

$$c = \xi^{1/\sigma} c^* = \xi^{1/\sigma} \bar{c}^*.$$

Furthermore, the steady state real wage rate is equal to steady state marginal costs,

$$w = \overline{mc}.$$

Then the domestic households' first-order condition for labor supply implies that

$$c^\sigma n^\eta = w = \overline{mc}$$

or

$$y_H = \left(\frac{\overline{mc}}{c^\sigma}\right)^{1/\eta} = \left(\frac{\overline{mc}/\xi}{\bar{c}^{*\sigma}}\right)^{1/\eta}$$

since $y_H = n$ in the steady state. We then obtain the desired values for $\bar{c}^*$ and $\bar{g}$ from

$$\bar{c}^* = c^* = s_{c^*} y_H = s_{c^*} \left(\frac{\overline{mc}/\xi}{\bar{c}^{*\sigma}}\right)^{1/\eta}$$

or

$$\bar{c}^* = \left(\overline{mc}/\xi\right)^{\frac{1/\sigma}{\eta/\sigma+1}} \left(\frac{1-(1-\vartheta)\,\bar{s}_c - \bar{s}_g}{\vartheta^*}\right)^{\frac{\eta/\sigma}{\eta/\sigma+1}}$$

and

$$\bar{g} = g = s_g y_H = \bar{s}_g \left(\frac{\overline{mc}/\xi}{\bar{c}^{*\sigma}}\right)^{1/\eta}$$

or

$$\bar{g} = \frac{\bar{s}_g \left(\overline{mc}/\xi\right)^{\frac{1/\sigma}{\eta/\sigma+1}}}{\left(\frac{1-(1-\vartheta)\bar{s}_c-\bar{s}_g}{\vartheta^*}\right)^{\frac{1}{\eta/\sigma+1}}}.$$

In the implementation of the model, we need to verify that $\bar{c}^* > 0$ and $\bar{g} > 0$.

In addition, we derive some steady state expressions which are used in the log-linearization step below. The debt issuance rule implies that(since $f = \bar{f}$):

$$\frac{b_F}{R_F} = \bar{f}\frac{b_H}{R_H}$$

or

$$\frac{b_F}{\pi^*} = \bar{f}\frac{b_H}{\pi}.$$

where we have used the domestic and foreign households' consumption Euler equations in steady state:

$$R_H = \frac{\pi}{\beta\,(1-\delta)}, \quad R_F = \frac{\pi^*}{\beta\,(1-\delta)}.$$

Furthermore, steady state total debt is defined by

$$b = b_H/\pi + b_F/\pi^*.$$

5.C Log-Linearization

In this appendix we log-linearize the equilibrium conditions around the non-stochastic steady state. In a neighborhood of the steady state, the rational expectations solution of the model is then approximated by the solution of the linearized system.

1. First-order condition for domestic consumption:

   $$\lambda_t = \exp(\varepsilon_{c,t}) c_t^{-\sigma}.$$

   Taking logs and subtracting steady state values yields the log-linearized version:

   $$\begin{aligned} \log \lambda_t &= \varepsilon_{c,t} - \sigma \log c_t \\ \log \lambda_t - \log \lambda &= \varepsilon_{c,t} - \sigma \left(\log c_t - \log c\right) \\ \hat{\lambda}_t &= \varepsilon_{c,t} - \sigma \hat{c}_t. \end{aligned}$$

2. First-order condition for labor supply:

   $$n_t^{\eta} = \lambda_t w_t.$$

   Similarly as above, taking logs and subtracting steady state values yields the log-linearized version:

   $$\eta \hat{n}_t = \hat{\lambda}_t + \hat{w}_t.$$

3. First-order condition for foreign consumption:

   $$\lambda_t^* = c_t^{*-\sigma}.$$

   The log-linearized version is

   $$\hat{\lambda}_t^* = -\sigma \hat{c}_t^*.$$

4. Domestic production:

   $$y_{H,t} v_t = a_t n_t.$$

   It can be shown that, in a neighborhood of the steady state, the price dispersion term $v_t = \int_0^1 \left(\frac{P_{H,t}^i}{P_t}\right)^{-\epsilon} di$ is equal to zero up to a first-order approximation (Yun, 1996), i.e.

$\hat{v}_t = 0$. Log-linearizing thus yields

$$\hat{y}_{H,t} = \hat{a}_t + \hat{n}_t.$$

5. Labor demand function:

$$w_t = \frac{P_{H,t}}{P_t} mc_t a_t.$$

Since $P_{H,t}/P_t = q_t^{\frac{\vartheta}{\vartheta-1}}$, the log-linearized version is

$$\widehat{mc}_t = \frac{\vartheta}{1-\vartheta}\hat{q}_t + \hat{w}_t - \hat{a}_t.$$

6. Domestic inflation:

Following (Yun, 1996), log-linearizing the intermediate goods producers' first-order condition for pricing yields the open economy Phillips curve

$$\hat{\pi}_{H,t} = \frac{(1-\phi)(1-\phi\beta)}{\phi}\widehat{mc}_t + \beta E_t \hat{\pi}_{H,t+1}.$$

7. CPI inflation:

$$\pi_t = \pi_{H,t}(q_t/q_{t-1})^{\frac{\vartheta}{1-\vartheta}}.$$

The log-linearized version is

$$\hat{\pi}_t = \hat{\pi}_{H,t} + \frac{\vartheta}{1-\vartheta}(\hat{q}_t - \hat{q}_{t-1}).$$

8. International risk sharing:

$$\lambda_t^* = \xi q_t \lambda_t,$$

where ξ is a constant which depends on initial endowments. Taking logs and subtracting steady state values yields

$$\hat{\lambda}_t^* = \hat{q}_t + \hat{\lambda}_t.$$

9. Taylor rule:

$$\frac{R_{H,t}}{R_H} = \left(\frac{\pi_t}{\pi}\right)^{\alpha_\pi} \exp(\varepsilon_{R,t}).$$

Taking logs yields the log-linearized version

$$\hat{R}_{H,t} = \alpha_\pi \hat{\pi}_t + \varepsilon_{R,t}.$$

10. Market clearing:

$$y_{H,t} = (1-\vartheta)\, q_t^{\frac{\vartheta}{1-\vartheta}} c_t + \vartheta^* q_t^{\frac{1}{1-\vartheta}} c_t^* + g_t.$$

The market clearing condition can be log-linearized as follows:

$$\begin{aligned} y_H \hat{y}_{H,t} &= (1-\vartheta)\, c \left(\frac{\vartheta}{1-\vartheta} \hat{q}_t + \hat{c}_t \right) + \vartheta^* c^* \left(\frac{1}{1-\vartheta} \hat{q}_t + \hat{c}^*_t \right) + g \hat{g}_t \\ &= (1-\vartheta)\, c \hat{c}_t + \vartheta^* c^* \hat{c}^*_t + \left(\vartheta c + \frac{\vartheta^*}{1-\vartheta} c^* \right) \hat{q}_t + g \hat{g}_t \end{aligned}$$

or

$$\hat{y}_{H,t} = (1-\vartheta)\, s_c \hat{c}_t + \vartheta^* s_{c^*} \hat{c}^*_t + \left(\vartheta s_c + \frac{\vartheta^*}{1-\vartheta} s_{c^*} \right) \hat{q}_t + s_g \hat{g}_t.$$

where $s_c = c/y_H$, $s_g = g/y_H$ and $s_{c^*} = c^*/y_H$ denote the shares of domestic consumption, government consumption and foreign consumption over domestic output. In steady state, we have (see Appendix 5.B)

$$s_{c^*} = \frac{1 - (1-\vartheta)\, s_c - s_g}{\vartheta^*}.$$

We take $s_c = \bar{s}_c$ and $s_g = \bar{s}_g$ as given so that

$$\begin{aligned} \hat{y}_{H,t} &= (1-\vartheta)\, \bar{s}_c \hat{c}_t + \left[1 - (1-\vartheta)\, \bar{s}_c - \bar{s}_g \right] \hat{c}^*_t \\ &\quad + \left(\vartheta \bar{s}_c + \frac{1 - (1-\vartheta)\, \bar{s}_c - \bar{s}_g}{1-\vartheta} \right) \hat{q}_t + \bar{s}_g \hat{g}_t. \end{aligned}$$

11. Debt issuance

$$X_t \frac{B_{F,t}}{R_{F,t}} = f_t \frac{B_{H,t}}{R_{H,t}}.$$

In real terms:

$$q_t \frac{b_{F,t}}{R_{F,t}} = f_t \frac{b_{H,t}}{R_{H,t}}.$$

Taking logs and subtracting steady state values yields

$$\hat{q}_t + \hat{b}_{F,t} - \hat{R}_{F,t} = \hat{f}_t + \hat{b}_{H,t} - \hat{R}_{H,t}.$$

12. Total debt:

$$\begin{aligned} b_t &= \left(B_{H,t-1} + X_t B_{F,t-1} \right) / P_t \\ &= b_{H,t-1} \pi_t^{-1} + q_t b_{F,t-1} \pi_t^{*-1}. \end{aligned}$$

A first-order Taylor expansion around the steady state yields

$$\begin{aligned} b_t - b &= \frac{1}{\pi} \left(b_{H,t-1} - b_H \right) - \frac{b_H}{\pi^2} \left(\pi_t - \pi \right) \\ &\quad + \frac{b_F}{\pi^*} \left(q_t - q \right) + \frac{1}{\pi^*} \left(b_{F,t-1} - b_F \right) - \frac{b_F}{\pi^{*2}} \left(\pi^*_t - \pi^* \right) \end{aligned}$$

or

$$b\hat{b}_t = \frac{b_H}{\pi}\left(\hat{b}_{H,t-1} - \hat{\pi}_t\right) + \frac{b_F}{\pi^*}\left(\hat{q}_t + \hat{b}_{F,t-1} - \hat{\pi}_t^*\right).$$

Using $b = b_H/\pi + b_F/\pi^*$ and $b_F/\pi^* = \bar{f}\left(b_H/\pi\right)$ (see Appendix 5.B):

$$\left(1+\bar{f}\right)\hat{b}_t = \hat{b}_{H,t-1} - \hat{\pi}_t + \bar{f}\left(\hat{q}_t + \hat{b}_{F,t-1} - \hat{\pi}_t^*\right).$$

13. Government budget:

$$\frac{B_{H,t}}{R_{H,t}} + X_t\frac{B_{F,t}}{R_{F,t}} + P_t\tau_t = P_{H,t}g_t + B_{H,t-1} + X_tB_{F,t-1}.$$

In real terms:

$$\begin{aligned}\frac{b_{H,t}}{R_{H,t}} + q_t\frac{b_{F,t}}{R_{F,t}} + \kappa\left(b_{H,t-1}\pi_t^{-1} + q_tb_{F,t-1}\pi_t^{*-1}\right) + \exp(\varepsilon_{\tau,t}) \\ = \frac{P_{H,t}}{P_t}g_t + b_{H,t-1}\pi_t^{-1} + q_tb_{F,t-1}\pi_t^{*-1}\end{aligned}$$

or, substituting out $b_t = b_{H,t-1}\pi_t^{-1} + q_tb_{F,t-1}\pi_t^{*-1}$ and $P_{H,t}/P_t = q_t^{\frac{\vartheta}{\vartheta-1}}$:

$$\frac{b_{H,t}}{R_{H,t}} + q_t\frac{b_{F,t}}{R_{F,t}} = q_t^{\frac{\vartheta}{\vartheta-1}}g_t + (1-\kappa)b_t - \exp(\varepsilon_{\tau,t}).$$

In steady state, we have

$$\frac{b_H}{R_H} + \frac{b_F}{R_F} = g + (1-\kappa)b$$

or, using $R_H = \frac{\pi}{\beta(1-\delta)}$, $R_F = \frac{\pi^*}{\beta(1-\delta)}$, $b = b_H/\pi + b_F/\pi^*$ and $b_F/\pi^* = \bar{f}\left(b_H/\pi\right)$:

$$\frac{b_H}{\pi} = \frac{g(1+\bar{f})^{-1}}{\kappa + \beta\left(1-\delta\right) - 1}.$$

The budget constraint can then be log-linearized as follows:

$$\begin{aligned}\frac{b_H}{R_H}\left(\hat{b}_{H,t} - \hat{R}_{H,t}\right) + \frac{b_F}{R_F}\left(\hat{q}_t + \hat{b}_{F,t} - \hat{R}_{F,t}\right) \\ = g\left(\hat{g}_t - \frac{\vartheta}{1-\vartheta}\hat{q}_t\right) + (1-\kappa)b\hat{b}_t - \varepsilon_{\tau,t}\end{aligned}$$

or, substituting out steady state values,

$$\begin{aligned}\frac{b_H}{\pi}\beta\left(1-\delta\right)\left[\hat{b}_{H,t} - \hat{R}_{H,t} + \bar{f}\left(\hat{q}_t + \hat{b}_{F,t} - \hat{R}_{F,t}\right)\right] \\ = g\left(\hat{g}_t - \frac{\vartheta}{1-\vartheta}\hat{q}_t\right) + \frac{b_H}{\pi}(1-\kappa)(1+\bar{f})\hat{b}_t - \varepsilon_{\tau,t}.\end{aligned}$$

Dividing through by $\frac{b_H}{\pi}\beta\left(1-\delta\right)$ yields

$$\begin{aligned}&\hat{b}_{H,t}-\hat{R}_{H,t}+\bar{f}\left(\hat{q}_t+\hat{b}_{F,t}-\hat{R}_{F,t}\right)-\frac{(1-\kappa)(1+\bar{f})}{\beta\left(1-\delta\right)}\hat{b}_t\\&\qquad=\frac{g}{\frac{b_H}{\pi}\beta\left(1-\delta\right)}\left(\hat{g}_t-\frac{\vartheta}{1-\vartheta}\hat{q}_t\right)-\frac{1}{\frac{b_H}{\pi}\beta\left(1-\delta\right)}\varepsilon_{\tau,t}.\end{aligned}$$

or, using $\frac{b_H}{\pi}=\frac{g(1+\bar{f})^{-1}}{\kappa+\beta(1-\delta)-1}$ and normalizing the fiscal policy shock $\varepsilon_{\tau,t}$ such that the normalized shock has variance σ_τ^2:

$$\begin{aligned}&\hat{b}_{H,t}-\hat{R}_{H,t}+\bar{f}\left(\hat{q}_t+\hat{b}_{F,t}-\hat{R}_{F,t}\right)-\frac{(1-\kappa)(1+\bar{f})}{\beta\left(1-\bar{\delta}\right)}\hat{b}_t\\&\qquad=\frac{\kappa+\beta\left(1-\bar{\delta}\right)-1}{\beta\left(1-\bar{\delta}\right)\left(1+\bar{f}\right)^{-1}}\left(\hat{g}_t-\frac{\vartheta}{1-\vartheta}\hat{q}_t\right)-\varepsilon_{\tau,t}.\end{aligned}$$

Recall that we take $\delta=\bar{\delta}$ as given.

14. Domestic Euler equation:

$$\lambda_t=R_{H,t}\beta E_t\left[(1-\delta_{t+1})\lambda_{t+1}\pi_{t+1}^{-1}\right].$$

Defining $\Xi_t=1-\delta_t$, the log-linearized version is

$$\hat{\lambda}_t=E_t\hat{\lambda}_{t+1}+\hat{R}_{H,t}-E_t\hat{\pi}_{t+1}+E_t\widehat{\Xi}_{t+1}.$$

A first-order Taylor expansion of Ξ_t at the steady state furthermore yields (where we use $\frac{b_F}{\pi^*}=\bar{f}\frac{b_H}{\pi}$):

$$\begin{aligned}\Xi_t&=\Xi-\left(\frac{\partial\delta_t(\cdot)}{\partial b_t}\,|_{b_t=b}\right)\begin{bmatrix}\pi^{-1}\left(b_{H,t-1}-b_H\right)-b_H\pi^{-2}\left(\pi_t-\pi\right)\\+\pi^{*-1}\left(b_{F,t-1}-b_F\right)+b_F\pi^{*-1}(q_t-1)\\-b_F\pi^{*-2}\left(\pi_t^*-\pi^*\right)\end{bmatrix}\\&=\Xi-\left(\frac{\partial\delta_t(\cdot)}{\partial b_t}\,|_{b_t=b}\right)\begin{bmatrix}b_H\pi^{-1}\hat{b}_{H,t-1}-b_H\pi^{-1}\hat{\pi}_t\\+b_F\pi^{*-1}\hat{b}_{F,t-1}+b_F\pi^{*-1}\hat{q}_t\\-b_F\pi^{*-1}\hat{\pi}_t^*\end{bmatrix}\\&=\Xi-\left(\frac{\partial\delta_t(\cdot)}{\partial b_t}\,|_{b_t=b}\right)\left(\frac{b_H}{\pi}\right)\left[\hat{b}_{H,t-1}-\hat{\pi}_t+\bar{f}\left(\hat{q}_t+\hat{b}_{F,t-1}-\hat{\pi}_t^*\right)\right]\end{aligned}$$

or, since $\Xi=1-\delta$:

$$\begin{aligned}\widehat{\Xi}_t&=-\frac{b_H/\pi}{1-\delta}\left(\frac{\partial\delta_t(\cdot)}{\partial b_t}\,|_{b_t=b}\right)\left[\hat{b}_{H,t-1}-\hat{\pi}_t+\bar{f}\left(\hat{q}_t+\hat{b}_{F,t-1}-\hat{\pi}_t^*\right)\right]\\&=-\Phi\left[\hat{b}_{H,t-1}-\hat{\pi}_t+\bar{f}\left(\hat{q}_t+\hat{b}_{F,t-1}-\hat{\pi}_t^*\right)\right]\\&=-\Phi\left(1+\bar{f}\right)\hat{b}_t.\end{aligned}$$

The log-linearized default probability is

$$\delta\hat{\delta}_t = -\Xi\widehat{\Xi}_t = \Phi\left(1-\delta\right)\left(1+\bar{f}\right)\hat{b}_t$$

or, in absolute deviations from steady state, taking $\delta = \bar{\delta}$ as given:

$$\tilde{\delta}_t = \Phi\left(1-\bar{\delta}\right)(1+\bar{f})\hat{b}_t.$$

Hence, we obtain the following log-linearized consumption Euler equation:

$$\begin{aligned}\hat{\lambda}_t &= E_t\hat{\lambda}_{t+1} + \hat{R}_{H,t} - E_t\hat{\pi}_{t+1} - \Phi\left(1+\bar{f}\right)E_t\hat{b}_{t+1} \\ &= E_t\hat{\lambda}_{t+1} + \hat{R}_{H,t} - E_t\hat{\pi}_{t+1} - \frac{1}{1-\bar{\delta}}E_t\tilde{\delta}_{t+1}.\end{aligned}$$

15. Foreign Euler equation:

$$\lambda^*_t = R_{F,t}\beta E_t\left[(1-\delta_{t+1})\lambda^*_{t+1}\pi^{*-1}_{t+1}\right].$$

Similarly as above, the log-linearized version is

$$\hat{\lambda}^*_t = E_t\hat{\lambda}^*_{t+1} + \hat{R}_{F,t} - E_t\hat{\pi}^*_{t+1} - \frac{1}{1-\bar{\delta}}E_t\tilde{\delta}_{t+1}.$$

16. Productivity shock:

$$\log a_t = \rho_a \log a_{t-1} + \varepsilon_{a,t}.$$

Since $a = 1$, the log-linearized version is

$$\begin{aligned}\log a_t - \log a &= \rho_a\left(\log a_{t-1} - \log a\right) + \varepsilon_{a,t} \\ \hat{a}_t &= \rho_a\hat{a}_{t-1} + \varepsilon_{a,t}.\end{aligned}$$

17. Government goods purchases:

$$\log(g_t/\bar{g}) = \rho_g \log(g_{t-1}/\bar{g}) + \varepsilon_{g,t}.$$

Since $g = \bar{g}$, the log-linearized version is

$$\hat{g}_t = \rho_g\hat{g}_{t-1} + \varepsilon_{g,t}.$$

18. Foreign debt share:

$$\log(f_t/\bar{f}) = \rho_f \log(f_{t-1}/\bar{f}) + \varepsilon_{f,t}.$$

Since $f = \bar{f}$, the log-linearized version is

$$\hat{f}_t = \rho_f \hat{f}_{t-1} + \varepsilon_{f,t}.$$

19. Foreign variables:

$$\begin{aligned}\begin{bmatrix} \log c_t^* \\ \log \pi_t^* \end{bmatrix} &= (I - \Phi_{1*} - \Phi_{2*} - \Phi_{3*} - \Phi_{4*}) \begin{bmatrix} \log \bar{c}^* \\ \log \bar{\pi}^* \end{bmatrix} + \Phi_{1*} \begin{bmatrix} \log c_{t-1}^* \\ \log \pi_{t-1}^* \end{bmatrix} \\ &+\Phi_{2*} \begin{bmatrix} \log c_{t-2}^* \\ \log \pi_{t-2}^* \end{bmatrix} + \Phi_{3*} \begin{bmatrix} \log c_{t-3}^* \\ \log \pi_{t-3}^* \end{bmatrix} + \Phi_{4*} \begin{bmatrix} \log c_{t-4}^* \\ \log \pi_{t-4}^* \end{bmatrix} + \begin{bmatrix} v_{c^*,t} \\ v_{\pi^*,t} \end{bmatrix},\end{aligned}$$

where

$$[v_{c^*,t}, v_{\pi^*,t}]' \sim NID(0, \Sigma_*).$$

Since $c^* = \bar{c}^*$ and $\pi^* = \bar{\pi}^*$, the log-linearized version is

$$\begin{aligned}\begin{bmatrix} \hat{c}_t^* \\ \hat{\pi}_t^* \end{bmatrix} &= \Phi_{1*} \begin{bmatrix} \hat{c}_{t-1}^* \\ \hat{\pi}_{t-1}^* \end{bmatrix} + \Phi_{2*} \begin{bmatrix} \hat{c}_{t-2}^* \\ \hat{\pi}_{t-2}^* \end{bmatrix} \\ &+\Phi_{3*} \begin{bmatrix} \hat{c}_{t-3}^* \\ \hat{\pi}_{t-3}^* \end{bmatrix} + \Phi_{4*} \begin{bmatrix} \hat{c}_{t-4}^* \\ \hat{\pi}_{t-4}^* \end{bmatrix} + \begin{bmatrix} v_{c^*,t} \\ v_{\pi^*,t} \end{bmatrix}.\end{aligned}$$

Our identifying assumption is that foreign consumption affects foreign inflation within a quarter but not vice versa. Thus, we apply a recursive Cholesky identification scheme: $\Sigma_* = C_* C_*'$, where C_* is a non-singular lower triangular matrix. Then we can write the identified foreign VAR process as follows:

$$\begin{aligned}C_*^{-1} \begin{bmatrix} \hat{c}_t^* \\ \hat{\pi}_t^* \end{bmatrix} &= C_*^{-1}\Phi_{1*} \begin{bmatrix} \hat{c}_{t-1}^* \\ \hat{\pi}_{t-1}^* \end{bmatrix} + C_*^{-1}\Phi_{2*} \begin{bmatrix} \hat{c}_{t-2}^* \\ \hat{\pi}_{t-2}^* \end{bmatrix} \\ &+C_*^{-1}\Phi_{3*} \begin{bmatrix} \hat{c}_{t-3}^* \\ \hat{\pi}_{t-3}^* \end{bmatrix} + C_*^{-1}\Phi_{4*} \begin{bmatrix} \hat{c}_{t-4}^* \\ \hat{\pi}_{t-4}^* \end{bmatrix} + \begin{bmatrix} \varepsilon_{c^*,t} \\ \varepsilon_{\pi^*,t} \end{bmatrix},\end{aligned}$$

where

$$[\varepsilon_{c^*,t}, \varepsilon_{\pi^*,t}]' \sim NID(0, I),$$

or, in simultaneous equations form (since C_*^{-1} is a lower triangular matrix):

$$\begin{aligned}\rho_{0*}^{cc}\hat{c}_t^* &= \rho_{1*}^{cc}\hat{c}_{t-1}^* + \rho_{1*}^{c\pi}\hat{\pi}_{t-1}^* + \rho_{2*}^{cc}\hat{c}_{t-2}^* + \rho_{2*}^{c\pi}\hat{\pi}_{t-2}^* \\ &+\rho_{3*}^{cc}\hat{c}_{t-3}^* + \rho_{3*}^{c\pi}\hat{\pi}_{t-3}^* + \rho_{4*}^{cc}\hat{c}_{t-4}^* + \rho_{4*}^{c\pi}\hat{\pi}_{t-4}^* + \varepsilon_{c^*,t} \\ \rho_{0*}^{\pi\pi}\hat{\pi}_t^* + \rho_{0*}^{\pi c}\hat{c}_t^* &= \rho_{1*}^{\pi\pi}\hat{\pi}_{t-1}^* + \rho_{1*}^{\pi c}\hat{c}_{t-1}^* + \rho_{2*}^{\pi\pi}\hat{\pi}_{t-2}^* + \rho_{2*}^{\pi c}\hat{c}_{t-2}^* \\ &+\rho_{3*}^{\pi\pi}\hat{\pi}_{t-3}^* + \rho_{3*}^{\pi c}\hat{c}_{t-3}^* + \rho_{4*}^{\pi\pi}\hat{\pi}_{t-4}^* + \rho_{4*}^{\pi c}\hat{c}_{t-4}^* + \varepsilon_{\pi^*,t}.\end{aligned}$$

Chapter 6

Conclusions

The standard Ramsey approach to optimal taxation cannot account for the high and persistent levels of government debt and capital taxation that we observe in many countries. The assumption of policy myopia, reflecting an expected finite planning horizon of the government which corresponds to the prospective duration of the government's survival in power, leads to empirically more realistic positive levels of debt and capital tax rates.

Chapter 2 proposes a legal restriction in the form of a soft borrowing constraint on government debt which prevents excessive borrowing by myopic governments. The associated long run welfare gains by far exceed the welfare costs of the reduced flexibility to use debt to smooth taxes over the business cycle. Thus, the chapter supports the views of those who like to maintain or even strengthen the rules of the SGP. It also provides an argument for the inclusion of a debt break into the German Constitution or for the advocates of balanced budget rules.

Chapter 3 provides a model of fiscal policy under policy myopia that accounts for the observation that capital is taxed in most countries across the world although this tax policy conflicts with the recommendations of economic theory that capital ought to be untaxed. It thus provides a more realistic description of actual tax policies pursued by real world governments.

Motivated by the theoretical predictions of Chapter 3, Chapter 4 presents empirical support for the hypothesis that higher political instability leads to an increase of the tax rate on capital income. The hypothesis is tested on a panel of annual observations for 13 OECD countries for the period 1964-1983. Since capital taxation is likely to have a detrimental effect on investment and growth, the chapter suggests a new channel how political distortions may affects economic welfare of a society.

Finally, using Bayesian estimation methods and quarterly Turkish data, Chapter 5 estimates two variants of a New Keynesian open economy model which differ only with respect to the inclusion of an (endogenous) expected default rate in the Euler equation for government bonds. It shows that that the estimated expected default rate is highly debt-elastic and that model comparisons clearly support the model with the expected default rate. Accounting for sovereign risk leads to stronger internal propagation and better forecasting performance. In terms of policy implications, counterfactual experiments show that solid fiscal policy leads to less volatile debt and inflation dynamics, by reducing expected default rates.

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Eidesstattliche Erklärung

Hiermit erkläre ich an Eides statt, dass ich die vorliegende Arbeit selbständig und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Die aus fremden Quellen direkt oder indirekt entnommenen Gedanken sind als solche kenntlich gemacht.

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