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# Essays on commitment and government debt structure

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# Tiivistelmä

Valtionvelan määrä ja rakenne vaihtelevat suuresti eri maissa. Tämä tutkimus koostuu kolmesta esseestä, joissa tutkitaan valtionvelan rakenteen määräytymistä. Kaikkien esseiden yhteisenä tekijänä on se, että valtionvelan korkea määrä laskee velan efektiivistä maturiteettia. Lisäksi sekä poliittiset että institutionaaliset tekijät vaikuttavat valtionvelaan rakenteeseen. Esseissä johdettuja teoreettisia malleja testataan myös empiirisellä aineistolla.

Ensimmäisessä esseessä johdetaan malli, jossa tulevan hallituspuolueen identiteetti on epävarma. Kahdesta puolueesta kumpikaan ei pysty sitoutumaan alhaisen inflaation politiikkaan, vaikka se olisi hyvinvoinnin kannalta optimaalista. Ennen vaaleja hallituksessa oleva puolue pystyy vaikuttamaan vaalien jälkeisen hallituksen toimintaan valitsemalla valtionvelan efektiivisen maturiteetin oikein. Efektiivistä maturiteettia pystytään käyttämään alhaisen inflaation politiikkaan sitoutumiseen. Kun puolue, joka vieroksuu enemmän veroja, on hallituksessa, hallituksen vaihtumisen todennäköisyys nostaa valtionvelan suurinta mahdollista efektiivistä maturiteettia. Puoluekentän polarisoituminen laskee efektiivistä maturiteettia. Malli pystyy selittämään valtionvelan rakenteiden muutokset varsin hyvin 13 OECD-maan aineistossa.

Toisessa esseessä osittain itsenäinen keskuspankki auttaa osaltaan hallitusta sitoutumaan alhaisen inflaation politiikkaan. Tästä huolimatta valtionvelan rakenne säilyttää tärkeytensä sitoutumisinstrumenttina. Mallin mukaan maissa, joissa keskuspankki on hyvin itsenäinen, valtionvelan efektiivinen maturiteetti voi olla korkea, vaikka velkaa olisi paljon. Keskuspankin itsenäisyys on noussut selvästi useissa maissa 1990-luvun alusta lähtien, ja tämä antaa hyvän mahdollisuuden testata mallia empiirisesti. Kahdentoista OECD-maan aineisto osoittaakin, että keskuspankin itsenäisyys nostaa efektiivistä maturiteettia. Velan määrä itsessään laskee maturiteettia.

Kolmannessa esseessä rakenteelliset uudistukset vaikuttavat valtionvelan rakenteeseen. Onnistuneet rakenteelliset uudistukset voivat mm. laskea kotimaisen lainanoton hintaa, mutta tästä huolimatta rakennemuutosten ennustetaan nostavan ulkomaalaisen lainanoton osuutta. Tämä johtuu siitä, että hallitus ei voi uskottavasti sitoutua olemaan inflatoimatta kotimaista velkaa. Malli pystyy kuvaamaan varsin hyvin rakennemuutosten vaikutusta valtionvelan valuuttajakaumaan Latinalaisessa Amerikassa.

Asiasanat: valtionvelka, sitoutuminen, poliittinen taloustiede, paneelidata, keskuspankin itsenäisyys, rakenteelliset uudistukset

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Helsinki, June 2008
Iikka Korhonen

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# List of essays

A political economy model of government debt maturity (unpublished manuscript)

Central bank independence and government debt maturity (unpublished manuscript)

A model of structural reforms and government debt denomination (unpublished manuscript)

# 1 Introduction

Practically all sovereign countries of the world issue government debt. Over time different countries have accumulated very different levels of government debt (as share of GDP). Even within the European Union, a relatively homogenous economic region, indebtedness of countries differs widely. In 2003 the ratio of general government debt to GDP ranged from 5.4% in Luxembourg and 32.1% in Ireland to 100.7% in Belgium, 106.2% in Italy and 109.9% in Greece (Eurostat, 2004). Also, level of government debt can change quite significantly within one country over time. For example, as recently as in 1986 Ireland had a debt ratio of 114.3% (Missale, 1999).

Moreover, structure of government debt can also vary from one country to another, and over time within one country. For example, in 1980 Ireland had approximately 55% of its government debt denominated in foreign currencies. By 1995 that share had declined to 35% (Missale, 1999). Governments can issue debt with different maturities, ranging from very short-term paper to bonds with maturity of thirty years or even more. Interest rate on a particular bond may be fixed for the whole maturity, or it can be change as short-term interest rates change. Bonds can be issued in different currencies. Value of the bond can be linked to some other indicator, for example consumer price index. All of the aforementioned features (and many more, e.g. tax treatment of interest rate payments) can be combined in a myriad ways.

In the essays of this study we explore some factors which have an effect on the choice of government debt structure. As we will see, there are several potential factors affecting the debt structure. Some of the factors relate to the risks and costs associated with servicing and refinancing the debt. On the other hand, government debt structure may be used as a commitment device when a government is otherwise unable to commit to a specific policy such as low inflation.

## 1.1 Motivation for the study

It is not immediately obvious why the composition of government debt would matter for any relevant economic variable. In this study we examine some other reasons why the government might use the debt structure to affect e.g. inflation and inflation expectations. Also, we look at the interaction of some features of the political system and the debt structure in influencing e.g. inflation. The basic theme running through the models presented is the use of the government debt structure as a commitment device. For various reasons, governments can rarely make binding commitments concerning their future policies.

In macroeconomic context the most well-known example is perhaps the model by Barro and Gordon (1983), where the government can not ex ante commit to a policy of low (or non-existent) inflation. In the two-period Barro-Gordon model the government has an incentive to engineer surprise inflation in the second period after the inflation expectations have been formed, as this will temporarily lift output over its long-term potential level. As the private sector realises this when it is forming its inflation expectations, expectations are correspondingly set higher. In the second period the government has to engineer higher inflation to match these expectations (otherwise output would be lower than the long-run potential), but output will stay at its long-run level. Therefore inflation is higher without any additional benefits, which reduces social welfare.

Higher inflation can also be used to decrease the real value of the outstanding government debt. Quite naturally, this temptation is higher the larger the burden of government debt is, ceteris paribus. In all of the three essays we explore various ways in which this temptation affects the actions of government. When tested empirically, high debt levels have a clear effect on debt structure. In addition, institutional and political factors are found to affect debt structure. Our results are relevant for governments' debt management policies, and they can even offer some guidance as to the likely effects of some institutional reforms, e.g. higher central bank independence. While many other factors are obviously important as well, the empirical regularities seem to validate our models.

The effectiveness of surprise inflation in reducing the real level of government debt hinges crucially on the structure of government debt. If all government debt is denominated in foreign currencies, the government can not affect its real value by inflating (if we assume that purchasing power parity holds). But not only the currency denomination of the debt matters. The longer is the average maturity of the government debt, the more responsive the real value of the debt is to changes in the price level. Also some other features of the outstanding government bonds can influence the response of the debt's real value to surprise inflation. For example, if interest payments are fixed for the maturity of the bond, the real value of these payments can be changed through inflation. However, if the interest rate is linked to e.g. short-term market rates, the real value of future interest payments is less affected by inflation. Obviously, holders of debt and other private sector agents can observe the structure of government debt and presumably understand how the incentive to inflate is linked to the level and structure of government debt.

This gives rise to the opportunity to use the structure of government debt as a commitment instrument. For example, by issuing a larger share of the government debt in foreign currencies, ceteris paribus, a government can ex ante reduce its temptation to inflate. As a response to the larger share of foreign currency denominated government debt the private sector will reduce its inflation expectations. Consequently, the actual inflation will also be lower. If inflation has social costs, as is usually assumed, lower inflation will increase welfare.

This basic insight can be examined in various political and institutional settings. For example, it is possible that different political parties have different preferences concerning e.g. welfare costs of inflation. Therefore some variation in the structure of government debt might be linked to the fact that different political parties are in power at different points in time. Also, mere expectation that a party is about to gain (or maintain) executive power may lead to changes in the government debt structure.

Temptation to inflate can be alleviated also by institutional arrangements. In recent years, many countries have installed central banks with greater independence in conducting monetary policy. Altering the institutional set-up in such a way will also affect the optimal structure of government debt. In one of our models we explore how increasing central bank independence has changed the way governments choose their debt structures.

In addition, the structure of government debt can be used as a commitment device in conjunction with implementation of structural reforms Implementing such reforms may allow government to borrow more from domestic sources, if they are succesful, as risk premium on domestic borrowing decreases. However, ceteris paribus, this increases the temptation to inflate away the real value of government debt, and, consequently, private sector's inflation expectations increase. Government can shift borrowing to foreign currencies to counter-act this result. This result illustrates the fact that government debt structure can interact with other economic (and political factors) in surprising manners.

## 1.2 Structure of the study and contributions of the essays

The thesis consists of three essays. In addition, later on in this introduction we review the relevant literature in detail. (The essays contain small literature surveys of the most relevant papers.) In all of these essays a theoretical model of government debt structure is developed and then tested empirically. The common thread running across all the essays is that a government is unable to commit to any set of policies ex ante. This gives the debt structure a role to play as a commitment device. In our models the government can not commit itself to a policy of low (or non-existent) inflation, but of course the analysis would readily expand e.g. to exchange rate policy.

In the models developed in the essays, government's inability to commit interacts with different aspects of political process, institutional design or other factors. Therefore the models shed light on the phenomenon from different angles. Nevertheless, some results are common to all essays. High debt level makes the problem of time-inconsistency worse. To counteract this, government may change the structure of the debt, or delegate conduct of the monetary policy to a partially independent central bank. Even with delegation of monetary policy, the structure of government debt continues to have a role to play as commitment device.

In all of the essays, the empirical results support the predictions of theoretical models. The first two essays use data from OECD countries, while the empirical part of the last essay deals with structural reforms and debt structure in a sample of Latin American countries. Although the models are by necessity quite stylised, it is remarkable that their predictions are broadly confirmed in different data samples.

Next, we shall review the contributions of the essays individually.

### 1.2.1 Political economy model of government debt maturity

In the first essay we present a political economy model of government debt structure and extensively test the effect of various political variables on government debt maturity. Even though there are various models linking political factors and debt maturity, such extensive empirical testing of various political factors has not been attempted in the literature before. In the model there are two political parties which have possibility of being in power after the first period. The incumbent party can use the effective maturity of government debt to signal its commitment to a policy of low (or non-existent) inflation. How much it needs to do this depends on the preferences of the party. Also, the maturity chosen will have an effect on the next government's actions. Furthermore, the probability of government change is also found to affect the effective maturity. All of these are novel results to the literature. In addition, we are able to test the derived results with an extensive panel data set consisting of most OECD countries. Predictions of the model are found to be broadly consistent with the data.

In the model, two parties have different preference concerning the potential trade-off between inflation and taxation. Possibility of such a trade-off arises from the fact that a government may try to use surprise inflation to reduce the real value of its outstanding debt stock. Surprise inflation will decrease the need for tax revenues in all future periods. However, private sector understands the temptation the government faces, and adjusts its behaviour correspondingly. If the government inflates in any one period, it will lose its credibility for all future periods as well, and the private sector will always expect its inflation to be higher than zero, i.e. the private sector follows a trigger strategy. An added feature of the model is that if the incumbent party decides to inflate, it is punished and it will be out of office for sure in the next period. Also, in the coming periods there will a possibility for it to be out of the office, whereas not inflating ensures the party is in power forever. This is important, because governments receive disutility from being out of office. The structure of government debt is significant for the decision, because debt stocks with different maturities will react differently to surprise inflation. If the effective maturity[1] of the debt stock is high, its real value will decrease more for any given surprise inflation.

In the model we can derive the maximum effective maturity consistent with an equilibrium where the incumbent party does not want to inflate. It can be shown that whether the incumbent party is more

[1]Missale and Blanchard (1994) define effective maturity as the effect of an unexpected inflation on the real value of the government debt. Therefore it is not the same thing as the average maturity of government debt. It is assumed that foreign currency denominated debt has an effective maturity of zero, because the government can not change its real value by engineering an inflation. If there is inflation, the nominal exchange rate will depreciate (restoring the purchasing power parity between the home country and the rest of the world) and the real value of the foreign currency denominated bond remains unchanged. Nominal domestic bonds contribute to the effective maturity with their ordinary maturity.

or less tax averse, the probability of a more tax-averse government being in power decreases the effective maturity, given a right constellation of parameter values. Also, we can show a similar result to many other studies in the field in that high level of debt itself will decrease the maximum effective maturity consistent with the low inflation equilibrium.

As is usual, the model employed is highly stylised and artificial. The parameter values have to be constrained somewhat to ensure that the solutions are well-defined. However, these constraints are perhaps not too strict, especially given the economic problem we are studying.

Even though the model is by necessity highly stylised, its predictions are borne out by the data, perhaps surprisingly well. To our knowledge, this is the first time such a political economy model has been tested so extensively. Debt ratio does have negative and statistically significant influence on the effective maturity of government debt. This result is robust across many different empirical specifications. Previous empirical evidence on the effect of debt ratio on maturity has been somewhat contradictionary, but our results offer clear support for the view that high debt ratio is associated with lower debt maturity. When a more tax-averse government in in power, higher probability of government change does increase the effective maturity,

Furthermore, it seems clear that political fragmentation (or polarisation) is associated with lower effective maturity. However, the effect is not entirely straightforward. Having more parties than one in the government actually increases the maturity, but having a minority government decreases it. We speculate that having a broad-based government, ceteris paribus, increases the general credibility of economic policies and reduces the risk of policy reversals in the case of government change.

As a robustness check we experimented with a different dependent variable (the average maturity of government's fixed-term bonds). Results were mostly qualitatively unaffected. Furthermore, we added inflation as a control variable to the regressions. Inflation does seem to affect the effective maturity, and its inclusion also changes other results somewhat. When debt level is high, moderate inflation reduces the effective maturity. However, when inflation is high enough, it increases the effective maturity, presumably because it reduces the future cost of debt servicing. Taken together, our empirical results give clear support to the idea that political variables do affect structure of government debt, although their influence may depend e.g. on the debt level.

### 1.2.2 Central bank independence and government debt structure

In the second essay we introduce a model where two commitment instruments interact. As in the previous model, the government can not commit itself to a policy of low inflation because of the familiar time inconsistency problems. In the second essay a central bank with some degree of independence can alleviate the time inconsistency problem. However, also the structure of government debt can still be used for the same purpose.

In the model, the central bank has different loss function from that of the government/fiscal authority, and, therefore, allowing it more independence in deciding on the inflation rate reduces the expected inflation. This reduces the familiar time inconsistency of optimal policies. As expected inflation decreases, the government can issue debt with longer effective maturity (e.g. debt denominated in domestic currency instead of foreign currency). This, in turn, may decrease probability of problems related to the refinancing of the debt etc. However, independence of the central bank is never perfect, and the government will always have at least some influence on the inflation rate. This means that also the structure of debt may have some role to play when the government tries to commit itself to a policy of low inflation.

The model predicts, quite intuitively, that a higher degree of central bank independence would be associated with higher effective maturity. Furthermore, the familiar result that higher debt ratio decreases the effective maturity can be found in this model as well.

We test also the predictions of this model empirically. We employ data from 1980 to 1998 for 12 OECD countries. This data covers a period of increasing central bank independence for most of the countries, and therefore it provides a natural testing ground for the model derived earlier. And indeed, empirical results give clear support for the hypotheses that higher central bank independence allows governments to maintain higher effective maturity of their debt. This finding does not depend on the number of conditioning variables used in the regressions, estimation technique, nor on the sample period. However, the effect appears to be non-linear, but this does not change the conclusion that in our sample central bank independence has contributed towards higher effective debt maturity. This means that real values of debt stocks have become more responsive to economic shocks, which in turn should help governments in tax smoothing. Our results also help to shed some light on the recent trends of government debt structure. In most countries in our sample the effective maturity of debt has increased since the late 80s.

However, evidence on the effect of the debt level on effective maturity is more mixed. In most of the estimations debt is not statistically significant, and sometimes it has the wrong sign. However, often a multiplicative interaction term between debt and central bank independence is positive and statistically significant, implying that countries with higher debt levels have more to gain by increasing the independence of their central banks.

The OECD countries in our sample have tended to increase the independence of their central banks from the late 80s onwards. While this trend towards higher central bank independence was mainly inspired by the example of e.g. Germany in fighting inflation with no apparent adverse effect on output or employment, it seems to have had (perhaps unintended) effects elsewhere in the field of economic policies. Reducing the time inconsistency of monetary policy by delegating more power to independent central banks, the countries in our sample also made it possible to extend the maturity profile of their debt stocks and to borrow more in domestic currency. In the late 90s the trend towards greater central bank independence accelerated as many EU countries started to prepare for monetary union. One of the key institutional features of the Maastricht Treaty is a very independent central bank, and in many countries several revisions of the central bank law were needed to bring them into line with the stipulations of the Maastricht Treaty. (Although the Maastricht Treaty also sets limits on public debt, there is no clear downward trend in debt in the late 90s.) Increase in the effective maturity of government debt may have been only a side effect of this larger policy objective, but it is apparent from the data that this did indeed occur. This conclusion can also offer some policy advice to other countries in their debt management strategies. Especially in developing countries institutional reforms such as increasing central bank independence can also help in debt management.

The results of this essay have also clear implications for countries in the euro area. As they have given up monetary policy completely to the hands of a very independent supranational central bank, we should observe over time clear shift towards higher effective maturity of government debt. A one-time jump occurred for most countries when the euro was introduced, as the debt denominated in the currencies of other euro area countries instantly become "domestic" debt.

### 1.2.3 A model of structural reforms and government debt denomination

In the third essay we develop a two-period model linking a government's debt management strategy to structural reforms. Interaction between structural reforms and other aspects of policy-making is of clear importance for many emerging market countries. By undertaking structural reforms (which may be beneficial to the economy's long-term growth potential or to some similar goal) government can affect the risk premium it has to pay on borrowing in domestic currency. Ceteris paribus, this will increase the incentive to borrow in domestic currency. However, higher share of domestic borrowing in the total debt stock would mean a greater danger of surprise inflation in the second period. The higher is the level of domestic borrowing, the higher is the benefit from surprise inflation as the real value of public debt decreases. The private sector understands this temptation, and consequently higher level of structural reform effort is, in fact, associated with lower share of domestic borrowing. An alternative interpretation would be that foreign investors require structural reforms in exchange for extending credits.

Higher debt ratio is also found to be associated with lower level of domestic borrowing. This result is familiar from the other essays of the thesis. The larger is the debt ratio, the larger is the benefit from engineering surprise inflation to reduce the real level of government debt.

In the empirical part of the section we test the predictions of the model with data from the Latin American countries. These countries are used as their economic have undergone deep structural reforms during the past two decades. Moreover, many of the Latin American countries have had quite high debt levels, although during the 90s the level of indebtedness did decrease in most countries. These factors make them very suitable for testing the model.

We find that the Latin American data seem to fulfil the predictions of the model. Regardless of the exact specification, extent of structural reforms is positively correlated with the share of foreign currency debt. Also, higher debt level is associated with higher share of foreign borrowing.

The results of this section offer some policy conclusions for countries contemplating structural reforms. Embarking on a course of structural reforms may very well mean that a country must (or is allowed) to borrow relatively more from abroad. This will increase the exchange rate risk associated with financing of the debt. The higher is the debt level, the larger is this effect. This must be taken into account in planning the reform package and associated economic policies.

## 1.3 Literature on the government debt structure

Over the years a substantial literature concerning the determinants of government debt structure has evolved. However, several different strains can be discerned in this literature, and sometimes both positive and normative statements concerning the debt structure can be very different depending on the model used.

Early on, it was argued (for example, Tobin 1963) that the structure, and more specifically the maturity of government debt could be used even to influence real economic activity. Regardless the validity of this claim, the design of government debt structure can also be influenced by other factors. Governments may want to minimise the expected costs of borrowing over some relevant time period. Alternatively, borrower may want to achieve some combination of expected costs and risks related to re-financing of the debt. Finally, structure of government debt may be used as a commitment device, when a government can not otherwise credibly commit to a set of policies or reforms. In this case time inconsistency problem can be alleviated by choosing the debt structure in appropriate manner.

Before one can start discussing the desirable (from one point or another) characteristics of government debt, it is useful to reflect on the reason why governments do issue debt with different attributes, and, especially, nominal debt? And why do private, presumably rational economic agents willingly hold these different types as government debt?

In a world where the Ricardian equivalence (see Barro, 1974) holds exactly, the composition of government debt is also irrelevant to the economy. This result holds even when taxes are distortionary, provided there is no uncertainty in the economy (Missale, 1999). Obviously, this strong result also presupposes that the relevant authorities have no difficulty in committing to future policies. However, uncertainty over future does provide a role for debt management in reducing risks associated with e.g. distortionary taxation.

Perhaps the first contribution to explicitly consider the way the composition of government (or public sector in general) debt might affect the economy and economic policy was Tobin (1963). In his analysis changes in the government debt maturity can have expansionary or contractionary effects on the economy.[2] Tobin assumes that long-term bonds are not perfect substitutes for capital assets. Increase in the supply of long-term government bonds will reduce their price, i.e. yield increases. Tobin assumes that the expected equity yield (price of capital) is not affected, and therefore the differential between price of capital and the long-term interest rate decreases. This makes capital investment more attractive. Therefore, government debt maturity can have an effect on the level of economic activity. When the optimal maturity of government debt has been chosen, government should pay attention to minimising costs of borrowing. However, this consideration is subordinate to the correct choice of maturity.

Tobin's analysis hinges crucially on the assumption that private agents regard government bonds as net wealth. As such, this can be disputed on theoretical grounds. Also, the hypothesis has not been properly tested. Moreover, Tobin's early contribution did not give rise to significant subsequent literature. Instead, and as we already discussed, literature has concentrated more on other roles of government debt structure: Cost- and risk-minimisation, and debt as a commitment device.

In this section we will review literature relating to these different strands of the literature. However, the main emphasis is placed on contributions where structure of debt is used as a commitment device, as these models will be developed further in models of the next sections. We will first discuss the way government debt structure can be used to reduce costs of borrowing. Discussion continues with risk-reduction, and, finally, we look how debt structure can be used as a commitment instrument.

Different strands of the literature arrive at different predictions concerning e.g. the correlation between the debt ratio and the maturity of the debt. Papers emphasing the risk reduction usually arrive at the conclusion that high debt ratio makes longer government debt maturity more desirable, as this reduces risks associated with refinancing of the debt. On the other hand, studies which emphasise the

[2] Quite interestingly, Tobin also suggests issuing CPI-indexed debt. He argues that this would improve the effectiviness of monetary policy.

problems governments have in committing to any set of policies ex ante give the policy conclusion that high debt levels are associated with short maturity of the debt (or then a large share of the debt is issued in foreign currencies). In the literature both hypotheses seem to find some empirical support. However, this may have to do with the choice of conditioning variables and the sample periods.

### 1.3.1 Maturity of government debt as a way to reduce the costs associated with borrowing

One approach to the structure of government debt would be to try to minimise the debt servicing costs. In addition, one could also place some weight on the variability of borrowing costs. Indeed, these considerations apparently do play a large role in the practical management of government's debt portfolio in many countries.

Currie and Dethier (2003) present evidence on the institutional arrangements for public debt management. In their survey it is found that especially many OECD countries mimic private sector practices in managing their debt portfolios. At the same time, day-to-day debt management has been shifted to specialised debt management units. In many countries the emergence of debt management offices[3] coincided with a clear increase in the public debt. This obviously increased the need for cost reduction.

In several countries this shift involved issuing debt in many different currencies as to minimise the currency risk of the debt portfolio. Also, many OECD countries regularly issue benchmark bonds (Missale, 1999). By creating a liquid market in selected bond issues, a government can decrease the liquidity premium it pays on its borrowing.

On the other hand, and despite the shift towards more private sector-type practices, it is by no means self-evident that public sector should manage its debt portfolio e.g. by trying to guess the future path of interest rates. Moral hazard problem of such a strategy could become large, as other parts of public sector obviously have information and make decisions which affect e.g. interest rates. For example, survey in Missale (1999) found that only 39% of debt managers in the OECD countries favoured taking views on future interest rates.

[3] Either within Ministries of Finance, or as independent governmental agencies.

Even though many OECD countries have shifted the day-to-day management of government debt to debt management offices, these offices are often given quite strict guidelines regarding the actions they can take. Usually, Ministry of Finance[4] gives the debt management office a set of strategic targets (perhaps after negotiation) regarding the currency composition of debt, whether to issue fixed-rate bonds, and perhaps debt's duration. For example, Currie and Dethier (2003)[5] report that in Australia the share of foreign currency denominated debt can be between 10% and 15% of the total debt stock. For the domestic component of debt, the target duration was 3.25 years, with $\pm 0.25$ years fluctuation bands. For the foreign currency denominated debt stock the target duration was 1.25 years (with the same fluctuation bands). In some countries, like the UK and USA, the debt-issuing agency only sells bonds denominated in the domestic currency.

Given the evidence, cost minimisation appears to be quite widespread target of public debt management, but only within relatively narrow, pre-set boundaries. Other factors presumably affect the guidelines given to debt managements offices. Therefore, cost minimisation as such appears not to be the main deciding factor in the broad trends of public debt management.

### 1.3.2 Maturity of government debt as a way to reduce risks

If financial markets function perfectly and without any friction, and a solvent[6] government can commit credibly to the servicing of its debt, then the government does not need to worry about the refinancing of its outstanding debt. Moreover, it can very easily change the structure of its debt by swapping outstanding debt instruments to instruments with different characteristics. If the financial markets are perfectly efficient, then this change in the structure of the government debt is costless. However, in practice refinancing of outstanding debt stock may be difficult, especially if the country in question is facing economic and/or political problems.

[4] Also other institutions can have this role. For example, in Sweden the parliament sets strategic targets (Currie and Dethier, 2003).

[5] Page 34, table 2.

[6] The distinction of insolvency and illiquidity is naturally important. If a government is insolvent, i.e. it violates its own intertemporal budget constraint, then presumably not even perfectly functioning capital markets would allocate new financing to it.

Also, different components of the debt stock may react differently to economic shocks. Debt manager might want to avoid excessive swings in the market value of the debt or debt servicing costs. This aspect could be especially important if the fiscal authority wants to smooth taxes.

In practical debt management of different countries the desire to avoid refinancing or roll-over risk of the government debt is an important factor. For example, Missale (1999, pp. 3-5) reports that in the majority of the OECD countries the officials involved in the actual government debt management regard the reduction of roll-over risk as one of their main duties. Moreover, reduction in the refinancing risk is seen to be in potential conflict with the other main goal of the debt management, i.e. reduction in the costs related to the servicing of the government debt.

It is fairly clear on the intuitive level that if the average maturity of the government debt is long, the risks associated with its refinancing are reduced. When the average maturity of the debt is long and the maturities of different debt instruments fairly evenly spread, every period only a small portion of the debt is due for payment. Alesina et al. (1991) develop a model where lengthening of the government debt maturity decreases the probability of a confidence crisis on the government debt. In the model the government's optimal policy is to roll over the outstanding debt infinitely.

However, the model has two equilibria. In the first equilibrium, the optimal policy is correctly anticipated by the private sector, which holds the government debt. Then the government also carries out this optimal policy. In the second equilibrium, the private sector investors refuse to buy any public debt, because they expect that investors in the future periods will also refuse to do so. This forces the government to default on its debt obligations. The probability of such crisis depends on the amount of debt falling due on each period.

Therefore the model of Alesina et al. (1991) gives fairly clear policy conclusions for the management of the government debt: governments should minimize the amount of debt falling due on each period. Government debt should have long maturity, and its repayment dates should be as evenly spread between different periods as possible. This should be done even at the cost of higher interest payments on the debt. Alesina et al. argue that in a situation where the debt default is a realistic possibility, issuing long-term debt will, in fact, decrease the interest payments, because investors would require larger risk premium for shorter and more unbalanced debt.

Giavazzi and Pagano (1991) develop a similar model, where the government can influence the likelihood it can withstand a confidence crisis by e.g. choosing an appropriate maturity structure for its liabilities. In contrast to the model of Alesina et al. (1991), Giavazzi and Pagano model the confidence crisis as a devaluation of a fixed exchange rate. Therefore debt default as such is not an issue here. In the model the exchange rate is fixed, and monetary policy is consistent with this regime. The investors may launch a speculative attack against the peg despite the consistent monetary policy, perhaps because of sunspot-type beliefs. If an attack occurs, the conditional probability of devaluation increases, and because of the uncovered interest rate parity the domestic interest rate rises too.

In the model the central bank has sufficient reserves to withstand such an attack, provided the monetary base is not expanded at the same time. The size of the monetary base is controlled by the treasury, which may use money creation to refinance part of the maturing government debt. From this property the model derives its results: if the amount of debt falling due is large, then the treasury will have an incentive to refinance part of this debt through money creation. If a speculative attack happens in the same period, the debt problem can be exacerbated because higher interest rates lead to higher interest payments. The larger is the size of the money creation, the higher is the probability that the central bank fails in defending the currency peg.

Also the model of Giavazzi and Pagano offers clear policy recommendations for the debt management. Like in Alesina et al. (1991), the average maturity of the government debt should lenghtened, which will in turn decrease the average amount of debt falling due each period. Also, the maturity structure should be designed so that the refinancing needs are spread as evenly as possible over time. The need to lengthen the maturity of the government debt is increasing in the level of the government debt. Therefore the model would predict a positive correlation between the size of the government debt and its average maturity.

Probability of a devaluation can also be decreased by issuing debt in foreign currencies. If a large proportion of the government debt is denominated in foreign currencies, the treasury has smaller incentive to finance debt payments by money creation. Therefore the monetary policy is more consistent with the regime of fixed exchange rate.

However, Giavazzi and Pagano fail to mention that prohibiting the central bank to finance the government debt repayment by allowing the monetary base to grow would also achieve the same result, if such a prohibition would be credible. The monetary base is controlled by the central bank, which may or may not want to increase it, depending on *its* preferences. This is of course one part of the argument for stronger central bank independence. Moreover, in all models of government debt structure, where the incentive to inflate a part of the debt away plays a significant role, introducing an independent central bank would at least alleviate some of the problems caused by the time inconsistency issue. This theme will be developed further in the second essay

Governments may also want to avoid large swings in the real value of their debt stock or debt servicing costs. Bohn (1988) argues that when taxes are distortionary and there are stochastic shocks to the budget, the optimal composition of the government debt will always include nominal debt. It is optimal for the government to smooth taxes across states of nature as well as across time. This result holds, even though the issuance of nominal debt will result in an incentive to inflate and higher inflation on the average.

In his model Bohn shows that it is socially optimal for the government to issue nominal debt, because in the event of a negative shock to the economy, the shock will also depress the price level and therefore the real value of government debt. This in turn reduces the resources needed for servicing the debt. The price level effect may reduce the amount of required taxes, which is welfare improving when taxes are distortionary. Therefore the government will always prefer to have a non-zero effective maturity. Bohn (1990) provides empirical evidence on tax smoothing with U.S. data and finds strong support for issuing nominal government debt. However, the evidence concerning optimal maturity structure of the government debt is weak.

Also Fischer (1983) discusses the desirability of government having the option of reducing the real value of the government debt in an unusual circumstances (such as war), but all in all he favors the issuance of index-linked bonds. The same conclusion is reached by Barro (1997). In this contribution a model of tax-smoothing is used to study the optimal structure of government debt, and it is concluded that governments would be best served by issuing indexed debt with infinite maturity, i.e. indexed consols.

Barro argues that moral hazard would prevent governments from exploiting possible correlations between e.g. tax revenue and price level. However, in the model the government can credibly commit to its future policies, i.e. there is no time inconsistency. Therefore the conclusions are not immediately applicable to the present case. In Barro (1995) it is argued that the issuance of nominal (and short-term) debt has become more widespread only after the abandonment of the gold standard. Furthermore, in earlier periods nominal bonds were also very close to real bonds (i.e. bonds linked to the price level), because the average inflation was very low.

Giordano (2001) examines in a three-period model how a suitable maturity structure of debt can reduce the risk of running deficits in excess of a predetermined ceiling (i.e. the 3% ceiling of Growth and Stability Pact). However, no straightforward policy conclusions emerge from the study. Depending on the correlation of various shocks hitting the economy, the optimal maturity is either longer or shorter. However, if the correlation structure of the economy is known *ex ante*, maturity can be used to keep the deficit constraint from binding. Giordano also provides some preliminary empirical estimates on the effect of debt ratio, and standard deviations of real interest rate and government expenditure on average maturity in European countries.

He finds that before 1990, higher debt ratio is associated with lower average maturity, but in the 90s the relation is reversed. However, debt ratio is not statistically significant in explaining the average maturity, if high debt countries[7] are excluded from the study. In the whole sample, volatility of interest rate also increases the average maturity, as does the volatility of government expenditure Also the effect of these variables is different in the post-1990 sample. Giordano attributes the different effects to the impending monetary union. The prospect of monetary union may have boosted credibility of economic policies in many European countries.

Gennari and Giordano (2002) explore a situation where governments can commit to optimal policies ex ante, but they can not issue state-contingent debt. This gives the structure of debt a role to play in tax smoothing in the presence of economic shocks. The policy results are similar to those obtained e.g. by Alesina et al. (1991) and Giavazzi and Pagano (1991): Governments with the largest debt stocks should issue their with long maturities. According to the results of Gennari and Giordano the result is even stronger if there are limits imposed on the government deficit (as is the case with the Stability and Growth Pact in the EU).

Gennari and Giordano test their model on a sample of eight EU countries[8] between 1980-1995 in a vector autoregressive framework.

[7] Belgium and Italy.

[8] Belgium, Finland, France, Germany, Italy, Netherlands, Spain and the UK.

They find that maturity of debt is positively correlated with the level of debt, as their model suggests. Also, correlation between innovations in output and interest rate is negatively correlated with the debt maturity. These results do not seem to depend on including two high-debt countries (Belgium and Italy) or on the exact sample period (before or after 1990). It should be noted that the results depend on a considerably smaller sample than the estimations performed in our first essay. Moreover, the economic impact of debt level on maturity seems to be very small. According to the estimations by Gennari and Giordano (Table 2, first column, full sample), ten percentage point increase in debt level would increase maturity by 0.15 years (i.e. 1.8 months).

Nevertheless, even if governments (or their debt management offices) do pay attention to the risks of refinancing and debt service costs, cursory glance of available empirical evidence suggests that governments (even in OECD countries) do not always act in a way which is consistent with e.g. conclusions of Giavazzi and Pagano. Therefore governments may not be able to simply minimise some desired combination of costs and risks of their debt portfolio. In the next subsection we review literature on government debt as a commitment device, when government can not credibly commit itself to a set of optimal policies.

### 1.3.3 Structure of government debt as a commitment device

In this subsection we review contributions where the structure of government debt is used as a commitment device. Following Kydland and Prescott (1979), governments can not always commit themselves ex ante to a set of optimal policies. In the well-known example of Barro and Gordon (1983), a government can not commit ex ante to a policy of low inflation. After inflation expectations have been formed, government finds it optimal to "surprise" to the private sector with higher inflation. This should result in higher level of economic activity. As the private sector agents have rational expectations, they adjust their inflation expectations accordingly. In equilibrium, government can not surprise the private sector with inflation, but inflation is higher than if the government had been able to commit itself, which reduces welfare in comparison with the commitment case. Obviously, the relevant policy variable can be something else than inflation rate as well.

The situation is further complicated in a political setting where governments change. Incumbent government has even less power to commit the actions of its successor. Some features of economic policies can even be written into legislation, but most laws can be changed readily as well.

Therefore, an instrument, which would help the government to commit itself e.g. to a policy of low inflation, could increase welfare. There are obviously several ways in which the government can try to increase its perceived commitment to a set of policies. For example, several OECD countries have in recent years embarked on reforms where the independence of central banks has been increased and they have been given an explicit mandate to pursue a policy of low inflation. This has been one way to reduce the inflationary bias stemming from time inconsistency.

Also government debt (both its size and structure) can be used as an instrument to influence private agents' expectations and, possibly, future governments actions (even if the political party in power changes). Two contributions where the structure of debt is used to affect incentives of the government e.g. to inflate are due to Calvo and Guidotti (1989 and 1990).

In their 1989 paper, Calvo and Guidotti develop a three-period model, where the government can not completely commit to any specific set of policies (in fact, every period is reported to have a different government, but their loss functions are identical). There are stochastic shocks to public spending (excluding interest payments on debt), and government tries to smooth taxes between the periods, as tax variability is costly. Also, the government can issue part of its liabilities as indexed to the price level.

It turns out that when there is no uncertainty, optimal policy is to index all of the debt to the price level. If that is not possible, it is optimal to issue only short-term debt. Reason is that this will decrease the temptation for "excessive" inflation. When there is some uncertainty over future government expenditure, it may no longer be optimal to fully index to the price level. Furthermore, if indexing is not possible at all, the optimal average debt maturity is very short. If some indexation would have been optimal, then the inflation tax base is large relative to its optimal level. This gives an added incentive for the government to engineer higher inflation in later periods. To counteract this effect, shorter maturity is needed. Therefore the structure of government debt has a clear role as a commitment device.

Calvo and Guidotti (1990) extends the analysis to a case where indexation is not possible, but where the level of debt has a role to play. As before, lack of capability to commit to a set of ex ante optimal policies makes the debt structure influential. Otherwise the analysis proceeds as in Calvo and Guidotti (1989), but level of debt is found to increase the optimal maturity of government debt. Also, lack of commitment calls for a relatively balanced maturity structure of debt, as in Giavazzi and Pagano (1991). Therefore the results are, in fact, similar to the ones obtained in the literature concerning debt structure as a way to minimise risks. On the other hand, higher government spending is associated with lower debt maturity.

Missale and Blanchard (1994)[9] model a situation where the government faces a temptation to inflate the economy. There are two reasons for this temptation. First, there is the by-now familiar time inconsistency of optimal economic policies. In the two-period set-up the government always faces a temptation to engineer higher inflation in the second period, as this would lift output (employment) over its long-run natural level. The private sector understands this and correspondingly expected inflation is higher. In the equilibrium inflation is higher, but this has no effect on output or employment. Second, surprise inflation can be used to reduce the real value of outstanding government debt. This temptation is naturally higher, when the level of debt (as percentage of GDP) is high.

In the model government receives disutility from inflation and taxation. Engineering surprise inflation in the first period reduces the costs of debt service in all future periods, and this effect is larger the higher is the ratio of debt to GDP. The private sector (which holds government bonds) understands this temptation. Initially private sector expects inflation to be zero, but if the government decides to inflate in the first period, the private sector will revise its inflation expectations upwards for all the future periods. Correspondingly, also the realised inflation will be higher. Interestingly, the government can use the structure of its debt to enhance its commitment to the policy of low (or non-existent) inflation. The lower is the maturity of the debt, the smaller is the benefit from surprise inflation. One of the results is that countries with highest debt ratios should also have the lowest debt maturities to reduce the temptation to inflate. Missale and Blanchard speculate that this effect may be the strongest at high debt levels. However, de Haan et al. (1995) find evidence on the negative relationship between the government debt maturity and its

[9]This model is explored more fully in Appendix C of this essay.

level also in countries with lower debt level, although only in periods when the debt was increasing. This would further validate the model of Missale and Blanchard.

Benigno and Missale (2004) offer a possible way to combine the roles of commitment and risk reduction for the structure of government debt. In their three-period model government can gain credibility by defending fixed exchange rate. However, if debt level is high, defending the fixed exchange rate regime may actually decrease government's credibility, as it increases the debt burden (as share of GDP). In such a model multiple equilibria are possible. Short-term debt can be used as a commitment device, if the initial credibility is high enough. However, if this is not the case, having a large share of short-term debt may increase the probability of having to abandon the regime of fixed exchange rate, as it is e.g. in Giavazzi and Pagano (1990).

In the model developed by Milesi-Ferretti (1995)[10] a government can manipulate its re-election (in the elections the media voter decides who is in the power after the elections) probability by changing the structure of public debt. The model has two parties, one more inflation-averse than the other. If the more inflation-averse party is in power, it can issue nominal debt before the election. This increases the benefits of surprise inflation after the elections. The median voter understands this, and since she dislikes inflation, is more likely to choose the inflation-averse party into power. Symmetrically, if the less inflation-averse party is the incumbent, it can issue indexed debt before the elections in order to reduce the post-election temptation to inflate. This will increase the less inflation-averse party's re-election probabilities.

Miller (1997) presents a model where investors demand higher return on government bonds when inflation uncertainty is higher. Inflation in turn is decided by preferences of the political party in power, and therefore increase in political polarization leads to higher inflation uncertainty. She finds that government debt maturity is lower in countries with more unstable political life (proxied by the frequency of government changes). Miller also finds that granting more independence to central banks seems to increase the government debt maturity.

Goldfajn (1998) develops a two-period model where a government decides on the optimal allocation of debt between domestic and for-

[10] Also this model is explored more fully in Appendix C of this essay.

eign denomination. As in many other similar models, government minimises a loss function with inflation and tax rate (or, more specifically, distortions arising from taxation) as its arguments. Government can finance its deficit with bonds denominated in foreign currency, indexed bonds or ordinary nominal bonds in domestic currency. If the government can commit itself to a set of policies, the optimal structure of debt depends only on the variances and covariances of variables, as government uses structure of debt for hedging purposes. For example, if variance of inflation is high, government will issue a lot of indexed debt, which will leave the real value of debt unchanged. If covariance between inflation rate and real exchange rate is negative, larger debt stock (as share of GDP) is associated with larger share of foreign denominated debt.

The situation changes somewhat if the government can not commit to a set of optimal policies. Then the government faces a temptation to inflate away some part of the real value of the outstanding debt in the second period. Presence of this temptation reduces the share of nominal debt issued. This effect is stronger when the level of debt higher, *ceteris paribus*, i.e. the same result as in Blanchard and Missale (1994). As indexed debt can be used for commitment, share of foreign currency denominated debt is decreasing in the level of debt. Goldfajn also tests his model with Brazilian data. He finds that higher level of debt does reduce the share of nominal debt in the total debt stock. Also, higher variance of inflation reduces the share of nominal debt. These observations support the hypotheses that structure of debt can be used both for commitment and hedging purposes.

Falcetti and Missale (2002) develop a model where delegation of monetary policy to an independent central bank reduces government's temptation to inflate away the real value of outstanding public debt. As is usual in such models, government can use higher inflation to smooth output fluctuations, but this results in time-inconsistency problem. In addition, there is temptation to inflate in order to reduce the real value of outstanding government debt. However, in the model monetary policy and setting of inflation can also be delegated to a central bank, which may have different loss function than the government itself. Of course, this set-up is familiar from a number of contributions concerned with central bank independence and delegation of monetary policy.

Appointing an extremely inflation-averse central banker (Falcetti and Missale equate this with independence of the central bank) and issuing an infinitely large share of nominal debt would be the optimal policy in such a model. Higher share of nominal debt increases the inflation tax base, and decreases the distortions associated with other forms of taxation for any given (unanticipated) inflation rate. Nominal debt makes output more responsive to inflation, which in turn allows better stabilising of shocks. Usually this would lead to higher inflation bias, but extremely inflation-averse central banker will alleviate this problem. However, in reality governments can not issue arbitrarily large amounts of debt. If there is an upper limit for the amount of debt the government can issue, the optimal policy is to issue debt right up to that limit, and appointing a correspondingly inflation-averse central banker.

Falcetti and Missale also examine how the results change if there is a linear inflation contract between the government and the central bank, as proposed by Walsh (1995). They find that if there is a limit to the amount of debt the government can issue (as is usually the case), inflation contract delivers higher welfare than conservative central banker. However, this requires that the inflation contract can be written in such a way that penalty for inflation is increasing in the level of debt. Practical implementation of such a contract can be quite difficult. However, inflation targeting has the same properties as inflation contract.

Finally, Falcetti and Missale look at empirical evidence concerning composition of government debt and central bank independence. They note that the share of nominal debt has increased or stayed the same in a sample of 20 OECD countries from the 1970s to 1990s. As central banks have generally become more independent during this time period, the authors conclude that predictions of the model are confirmed. Delegating responsibility for monetary policy to a more independent central bank has allowed government to issue more nominal debt, which improved welfare. Also, the share of long-term debt in total debt stock has increased in almost all countries since the 1980s. For further evidence, Falcetti and Missale regress share of nominal debt and share of long-term nominal debt on indices of central bank independence and a set of control variables (debt ratio, government consumption and exchange rate regime). They find support for the theory, and higher central bank independence clearly increases the shares of both nominal and long-term nominal debt in the total debt stock. On the other hand, political instability appears to reduce the share of nominal debt. However, Falcetti and Missale only use cross-section regression with less than 20 observations, which reduces the reliability of results. In section 3 we are able to use time series of e.g. central bank independence[11] in panel regressions, which will make the results perhaps more convincing. Also, it is of interest in itself to track the changes in central bank independence and government debt structure.

[11] Due to Kilponen (2000) and extended by the author.

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# 2 Political economy model of government debt maturity

In this section I present a political economy model of government debt maturity, which is based on the work of Missale and Blanchard (1994), explored in more detaild in Appendix C. In the present model, it is assumed that there are *two* possible governments instead of one. Here I label these governments simply A and B.[12] The parties have infinite lives.

The private sector is not modelled in detail, but also it is assumed to be infinitely-lived. Furthermore, the private sector acts as a single entity, i.e. there is no heterogeneity (or, alternatively, private agents are able to coordinate their actions regarding government debt). All agents in the model have rational expectations. The preferences of the political parties are defined below in subsection 2.1. The private sector holds the government debt.

The purpose of the model is to find the maximum effective maturity consistent with a zero inflation equilibrium in an environment where the policymaker may change. The factors affecting this maximum effective maturity are then assessed. Finally, we take the model to data. Its main predictions are found to conform with the data.

## 2.1 Preferences of the parties

In the model we have two political parties, A and B. They have preferences over inflation and taxation, and in their loss functions the only difference is in their relative aversion to taxation. Also, loss functions are decreasing in surprise inflation. If there would be no political dimension to the model, the one-period loss functions could be written as:

$$L^A = \frac{1}{2}\pi^2 - \alpha(\pi - E\{\pi\}) + \beta T \tag{1}$$

$$L^B = \frac{1}{2}\pi^2 - \alpha(\pi - E\{\pi\}) + \gamma T \tag{2}$$

[12] The convention to label governments or parties with different preferences Left and Right could also be used, but I do not want to cause confusion with the model of Milesi-Ferretti (1995) in the Appendix C, as the preferences used here are slightly different, as we will see.

Loss functions of the two different governments are indicated with subscripts. In what follows we assume that party A is more tax averse than B, i.e. $\beta > \gamma$. It is assumed that the government in power derives also utility from any possible surprise inflation, i.e. $\alpha > 0$. Perhaps the economy will experience a boom because of a loosening of the monetary policy. This assumption is, of course, a standard one in the literature on the time (in)consistency of monetary policy, see Barro and Gordon (1983).[13]

The government in power minimizes the discounted value of one-period loss functions from the initial period to infinity. Losses in the future periods are discounted with the rate of time preference, $\delta$.

The political economy side of the model is explained in more detail below, but it can be noted that in our set-up with two parties, the voters punish the party in power if it "cheats" and engineers surprise inflation. If the party in power does not engineer inflation, it remains in power forever, but if it inflates, there is a possibility of government change in every subsequent period (except in the period immediately following the cheating, when the opposition party is in power for sure). In this case, the probability of government A being in the office at the end of a period is $p$ (when inflation is decided), while the probability of B being in the power is naturally $1 - p$. In addition to the loss function described above, a party receives disutility $C_i$ $(i = A, B)$ when it is not in the power.

## 2.2 The economy

In the model the government finances government primary expenditure $G$ and the interest payments on its debt $D$ with taxes $T$. Correspondingly, the government debt evolves over time according to an accumulation function:

$$D_{t+1} = (1 + r)[1 - m(\pi - E\{\pi\})]D + G - T \qquad (3)$$

The subscript $t+1$ always refers to the period after the first, initial period. Variables without any subscripts refer to the values of the

[13]It is interesting to note that already Barro and Gordon mentioned the incentive to reduce the real value of the government debt as one additional incentive to engineer inflation. They suggest that indexing the debt to the price level would reduce this incentive. In the terminology of the present model, this means lowering the effective maturity of the government debt.

variables in the first period. The nominal interest rate is $r$ and this is also the real interest rate, when there is no surprise inflation, i.e. when $\pi = E\{\pi\} = 0$. In the model, and following Missale and Blanchard (1994), it is assumed that $G = 0$. Nothing significant hinges on this assumption. Taxes are collected only to service the government debt, and when $\pi = 0$, the real value of the government debt stays constant, i.e. $D_{t+1} = D$. From this identity we can calculate the level of taxes:

$$T = r[1 - m(\pi - E\{\pi\})]D \tag{4}$$

In absence of surprise inflation this reduces to:

$$T = rD \tag{5}$$

The effective maturity of the government debt, $m$, tells how much the real value of the debt is affected by surprise inflation. For example, if the whole debt is indexed to the price level, its effective maturity is zero. Debt dominated in foreign currencies will also have an effective maturity of zero, if purchasing power parity holds. If government inflates, the nominal exchange rate will change by an amount corresponding to the inflation differential, and the real value of foreign debt remains constant.

It is assumed that the government will always honour its nominal debt commitments, i.e. it will not default on the debt. Alesina et al. (1991) consider a model where the debt default is a possibility, although a costly one. In their model the maturity structure of the government debt is used to decrease the probability of default. In the present model default is ruled out. In principle the government can always engineer inflation to reduce the real value of nominal domestic debt. However, the structure of government debt is not explicitly defined (except with regard to the effective maturity) in the model, and it can contain also e.g. debt denominated in foreign currencies. Government can not affect the real value of foreign currency debt.

### 2.3 The game

The model can be interpreted as a game between the two parties and private sector. Private sector holds the government debt. At the beginning of the period one the government inherits a stock of debt $D$. The government can choose the effective maturity of the debt. By choosing a low value of $m$, the government makes the debt stock $D$

less responsive to surprise inflation. Correspondingly, a high effective maturity of the government debt makes it easier to reduce the real value of the debt.

It is assumed that the government can achieve any maturity structure it wants for the government debt without costs, i.e. the capital markets are perfect in this sense. This is clearly somewhat unrealistic assumption, especially for smaller countries, but it can also be interpreted as the desired optimal effective maturity. Transaction costs and low liquidity in the relevant capital markets may prevent the government from achieving the desired maturity in practise at any precise moment in time, but even then we should observe movement in the desired direction.

Assume that the private sector follows the trigger strategy: if the party in power has not deviated, private sector does not expect it to inflate. Let's assume that party A is in power at the beginning of period one. If party A does not deviate, and inflation remains at zero, it will also remain in power forever, i.e. it is not punished for its defection. If A inflates, it is punished. In the period following A's defection, party B will be in power for sure, and thereafter party A is in power with probability $p$ and party B with probability $1-p$. In the second period, inflation expectation is still zero, $E\{\pi\}=0$, as B has not deviated, at least not yet. From third period onwards the rational inflation expectation at the beginning of the period is $p\alpha$, IF party B has not deviated and A deviated in the first period.

In the first period the party in power inherits the stock of debt, $D$. It then decides on the effective maturity of the debt, $m$. Following this, private sector forms its inflation expectations (which are zero in the first period). Then the party in power decides on the inflation rate $\pi$. If it inflates, the other party is in power for sure in the second period. Thereafter, party A is in power with probability $p$ and party B with probability $1-p$ as explained before.

In this model the probability $p$ is exogenous. This can be rationalised in a variety of ways. In many countries governments change frequently also between election dates. Also, governments can change in some other, undemocratic fashion. Furthermore, the probability of government change can also be interpreted as reflecting general political uncertainty in the country. This idea has been explored by Miller (1997), who reports that political instability tends to decrease the average maturity of the government debt in OECD countries.[14] There-

[14]She uses two proxies for political instability: the frequency of government changes and the indicator developed by Alesina (1989), which tries to take into

fore the exogenous probability of a government change is perhaps not as unrealistic an assumption as a first reading might suggest.[15]

Moreover, when one of the parties deviates and cheats, effective maturity is $m = 0$ thereafter. One can for example posit that government has only one chance to fool the private sector, independent of which party happens to be in the power. Also, if one party has cheated, the expected inflation is larger than zero, i.e. $E\{\pi\} > 0$ from period three onwards, which means that if maturity is larger than zero, inflation expectations will explode. Given this and as $m = 0$, it is immediately obvious from the functions 1, 2 and 4 that optimal inflation is $\alpha$, for the same reasons as in Missale and Blanchard (1994).

Chart 1 depicts the timing of the game in a more concise manner, assuming that the incumbent government cheats in the first period (otherwise it would just remain in power forever). To reiterate, the expectation mechanism of the model is the following:

1. If a government inflates in the first period, it is expected to inflate forever after that

2. The first time a government cheats, meaning it inflates when the expected inflation is zero, it is punished and it is out of power in the next period for sure

3. If government inflates when the expected inflation is non-zero, it has a chance of being in power in the next period

**Chart 1. Timing of the game between the government and private sector, if the incumbent government cheats in the first sector**

| Action | Govt inherits $D_t$ | Govt decides m | Priv. sector forms $E\{\pi_t\}=0$ | Govt. chooses $\pi_t$ | If $\pi_t > 0$, govt. changes |
|---|---|---|---|---|---|
| Step | 1 | 2 | 3 | 4 | 5 |
| Period | 1 | | | | |

account also the polarisation of political life.

[15] This also means that probability of government change, $1 - p$, is not affected e.g. by inflationary expectations.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Govt. | Priv. sector | Govt. | Govt. | Priv. sector | Govt. | Govt. | Govt |
| inherits | forms | chooses | inherits | forms | changes | chooses | inherits |
| $D_{t+1}$ | E{$\pi_{t+1}$}=0 | $\pi_{t+1}$ | $D_{t+2}$ | E{$\pi_{t+2}$}=0 | Ainpowerprp, | $\pi_{t+2}$ | $D_{t+3}$ |
| | | | | | B in power pr 1-p | | |
| 1 | 2 | 3 | 1 | 2 | 3 | 4 | 1 |
| 2 | | | 3 | | | | 4 |

In the following we calculate the highest effective maturity which is consistent with the reputational equilibrium, whether the party A or B is in power initially. In the standard fashion, we solve the model backwards, starting from period 2. (Everything of interest happens in the first two periods, as the game just repeats itself thereafter.)

We examine the model with the two possible scenarios, one where the more tax-averse party is initially in power and one where the less tax-averse party is initially in power.

### 2.3.1 More tax-averse party initially in power

We start from a situation where the party A is in power in the first period. We try to find the maximum effective maturity consistent with the non-inflation equilibrium $m^*$, and then study the properties of $m^*$.

First, we study the situation where party A cheats in the first period. We will first see what happens when party B then comes into power in the second period. Even though party A has inflated, the private sector's expected inflation in the second period is 0, but in our set-up $m = 0$, for the reasons outlined above. As $m = 0$, government B has no *added* incentive to inflate in order to reduce the debt burden, and inflation is $\alpha$. Therefore, the discounted (to period 2) loss function of government B if it inflates, $L_2^{devB}$, is[16]

$$L_2^{devB} = \frac{1}{2}\alpha^2 - \alpha(\alpha - 0) + \frac{1}{\delta}(\frac{1}{2}\alpha^2 + pC_B) = \alpha^2(\frac{1}{2\delta} - \frac{1}{2}) + \frac{1}{\delta}pC_B \quad (6)$$

If B inflates, inflation is always $\alpha$, and, in addition, party B will suffer penalty $C_B$ in every period it is not in power (which happens

[16]In addition, government B receives disutility from taxes levied to service government debt. However, this term $\gamma T$ is the same in both equations 6 and 7, and therefore it cancels out.

with probability $p$). We let parties' punishment for not being in power vary. This can be thought to reflect the relative importance of particular economic policies being followed to the party's constituency, for example.

If party B does not inflate in period 2, its loss function in period 2 is

$$L_2^{repB} = \frac{1}{2\delta}p\alpha^2 + \frac{1}{\delta}pC_B \tag{7}$$

Party B will not deviate and inflate, if $L_2^{repB} < L_2^{devB}$. This is the same as requiring $0 < L_2^{devB} - L_2^{repB}$ i.e. $0 < \alpha^2(\frac{1}{2\delta} - \frac{1}{2} - \frac{1}{2\delta}p)$. This is true if $0 < (\frac{1}{2\delta} - \frac{1}{2} - \frac{1}{2\delta}p)$, which can be written $p < 1 - \delta$. If discount factor is, say, 0.05, this is the same as requiring that the probability of one party being in government in any given period does not exceed 0.95. In the context of this model, this is a realistic assumption. Therefore, we conclude that party B does not inflate even if party A has cheated and engineered inflation. If party B inflates, expected inflation increases in all future periods (third term in 6 in contrast with the first term in 7), without a corresponding reduction in the real value of the debt (and taxes).

Taking into account the aforementioned results, we can write the loss function of party A (when it is in power) in period 1, if it cheats and engineers inflation as follows (taking into account the fact that in the first period $E\{\pi\} = 0$):

$$\begin{aligned} L_1^{devA} &= \frac{1}{2}\pi^2 - \alpha\pi + \beta r\left[1 - m\pi\right]D \qquad (8) \\ &+ \frac{1}{1+\delta}(\beta r\left[1 - m\pi\right]D + C_A) \\ &+ \frac{1}{\delta}(\frac{1}{1+\delta})\left\{\begin{array}{l} \beta r\left[1 - m\pi\right]D + p\left(\frac{\alpha^2}{2} - \alpha\left(\alpha - p\alpha\right)\right) \\ +\left(1-p\right)\left(0 - \alpha\left(0 - p\alpha\right)\right) + (1-p)C_A \end{array}\right\} \end{aligned}$$

Here the party A derives utility from inflation as the real value of the outstanding debt stock decreases. At the same time, expected inflation in all future periods (evaluated in period one) increases to $p\alpha$, although party B will not inflate. From this we can calculate the optimal inflation for party A, if it decides to inflate. The associated FOC is $\frac{\partial}{\partial\pi}L_1^{devA} = \pi - \alpha - \beta rmD - \frac{1}{1+\delta}\beta rmD - \frac{1}{\delta}(\frac{1}{1+\delta})\beta rmD = 0$, from which we can solve the optimal inflation for party A, $\pi = \alpha +$

$(1+\frac{1}{\delta})\beta rmD$. Therefore, the value of the expected loss function for party A in period 1 if it decides to inflate, $L_1^{devA}$ is:

$$
\begin{aligned}
L_1^{devA} &= \frac{1}{2}\left(\alpha + (1+\frac{1}{\delta})\beta rmD\right)^2 - \alpha\left(\alpha + (1+\frac{1}{\delta})\beta rmD\right) \qquad (9)\\
&+ \beta r\left[1 - m\left(\alpha + (1+\frac{1}{\delta})\beta rmD\right)\right] D \\
&+ \frac{1}{1+\delta}(\beta r\left[1 - m\left(\alpha + (1+\frac{1}{\delta})\beta rmD\right)\right] D + C_A) \\
&+ \frac{1}{\delta}(\frac{1}{1+\delta})\left\{ \begin{array}{c} \beta r\left[1 - m\left(\alpha + (1+\frac{1}{\delta})\beta rmD\right)\right] D + \\ p\left(\frac{\alpha^2}{2} - \alpha\left(\alpha - p\alpha\right)\right) + (1-p)\left(-\alpha\left(0 - p\alpha\right)\right) + (1-p)C_A \end{array} \right\}
\end{aligned}
$$

Now party A is able to decrease the real value of the outstanding debt stock, which decreases taxation in the first and all subsequent periods. In addition, it receives the "traditional" benefit of surprise inflation. If party A does not deviate (and remains in power forever), value of its discounted loss function $L_1^{repA}$ is:

$$L_1^{repA} = (1+\frac{1}{\delta})\beta rD$$

For the reputation equilibrium to exist, loss from cheating must be larger than the loss from not cheating and inflating. In other words, $L_1^{repA} \leq L_1^{devA}$, which is the same as $L_1^{repA} - L_1^{devA} \leq 0$. If we take this as an equality, we can find the maximum effective maturity consistent with the reputational equilibrium. (We must also note that in the second period the party A receives disutility $C_A$ from the fact that it is not in power, as well as from taxies levied.)

Combining the above equations, we set

$$
\begin{aligned}
& L_1^{repA} - L_1^{devA} = \\
& (1+\frac{1}{\delta})\beta r D - \frac{1}{2}\left(\alpha^2 + 2\alpha(1+\frac{1}{\delta})\beta r m D + (1+\frac{1}{\delta})^2\beta^2 r^2 m^2 D^2\right) \\
& \quad + \alpha^2 + \alpha(1+\frac{1}{\delta})\beta r m D - \beta r\left[1 - m\left(\alpha + (1+\frac{1}{\delta})\beta r m D\right)\right] D \\
& \quad\quad - \frac{1}{1+\delta}(\beta r\left[1 - m\left(\alpha + (1+\frac{1}{\delta})\beta r m D\right)\right] D + C_A) \\
& \quad\quad - \frac{1}{\delta}(\frac{1}{1+\delta})\left\{\begin{array}{c} \beta r\left[1 - m\left(\alpha + (1+\frac{1}{\delta})\beta r m D\right)\right] D \\ +p\left(\frac{\alpha^2}{2} - \alpha\left(\alpha - p\alpha\right)\right) + \\ (1-p)\left(-\alpha\left(0 - p\alpha\right) + C_A\right) \end{array}\right\} \leq 0
\end{aligned}
$$

and solve for $m^*$ which satisfies this as an equality. This $m^*$ is then the maximum effective maturity consistent with reputational equilibrium. After some algebra, we get

$$
\begin{aligned}
L_1^{repA} - L_1^{devA} &= \frac{1}{2}\alpha^2 + (\frac{-1-\delta}{\delta(1+\delta)})C_A + \frac{1}{\delta}(\frac{1}{1+\delta})p(C_A - \frac{\alpha^2}{2}) \\
&\quad +\alpha\beta r D(\frac{1+\delta}{\delta})m + (\frac{(1+\delta)}{2\delta})(1+\frac{1}{\delta})\beta^2 r^2 D^2 m^2 = 0.
\end{aligned} \tag{10}
$$

This is a quadratic equation in $m$, and we should note that coefficients of both $m$ and $m^2$ are positive. Therefore, the function is convex, and reaches its minimum for a negative value of $m$. (As such this is not terribly important, as we are interested in the derivative of the optimal $m^*$ with respect to $p$ and later with respect to $D$.) Sufficient and necessary condition for m to exist is that $\frac{1}{2}\alpha^2 + (\frac{-1-\delta}{\delta(1+\delta)})C_A + \frac{1}{\delta}(\frac{1}{1+\delta})p(C_A - \frac{\alpha^2}{2}) < 0$. This is equivalent to $\frac{1}{2}\alpha^2(\frac{\delta(1+\delta)-p}{\delta(1+\delta)}) + (\frac{-1-\delta+p}{\delta(1+\delta)})C_A < 0$, where the coeffient of $C_A$ is always negative, and condition for the coeffient of $\frac{1}{2}\alpha^2$ to be negative is $p > \delta(1+\delta)$. As the discount factor should not be higher than 0.05, this does not restrict the possible values of $p$ too much.

Solving for $m$ we get

$$m^* = \left\{ \begin{array}{c} -\frac{1}{r\beta D(\delta+1)^2} \times \\ \left( \begin{array}{c} \alpha\delta + \alpha\delta^2 \\ \delta^4 \sqrt{\frac{2C_A+4C_A\delta+2C_A\delta^2+p\alpha^2-2C_Ap-2C_Ap\delta+p\alpha^2\delta}{\delta^7}} \end{array} \right), \\ -\frac{1}{r\beta D(\delta+1)^2} \times \\ \left( \begin{array}{c} \alpha\delta + \alpha\delta^2 \\ -\delta^4 \sqrt{\frac{2C_A+4C_A\delta+2C_A\delta^2+p\alpha^2-2C_Ap-2C_Ap\delta+p\alpha^2\delta}{\delta^7}} \end{array} \right) \end{array} \right\}. \quad (11)$$

In the Appendix we show that the term under the square root is always defined. Of these roots, the first one is always negative (because the first term is negative and the second term is positive when the term inside square root is positive). Second root is larger, if

$$\begin{array}{c} \left(\alpha\delta + \alpha\delta^2 + \delta^4 \sqrt{\frac{2C_A+4C_A\delta+2C_A\delta^2+p\alpha^2-2C_Ap-2C_Ap\delta+p\alpha^2\delta}{\delta^7}}\right) > \\ \left(\alpha\delta + \alpha\delta^2 - \delta^4 \sqrt{\frac{2C_A+4C_A\delta+2C_A\delta^2+p\alpha^2-2C_Ap-2C_Ap\delta+p\alpha^2\delta}{\delta^7}}\right) \end{array}. \quad (12)$$

This is trivially true, if $\delta^4 > -\delta^4$, and as long as the square root is defined[17].

Next, we assess how the maximum effective maturity changes as the probability of the more tax-averse government being in power increases. To do this, we differentiate the larger root with respect to $p$.

$$\frac{\partial}{\partial p}\{-\frac{1}{r\beta D\left(\delta+1\right)^2} \times \quad (13)$$

$$\left(\alpha\delta + \alpha\delta^2 - \delta^4 \sqrt{\frac{2C_A+4C_A\delta+2C_A\delta^2+p\alpha^2-2C_Ap-2C_Ap\delta+p\alpha^2\delta}{\delta^7}}\right)\} \quad (14)$$

$$= \frac{\left(\alpha^2-2C_A\delta-2C_A+\alpha^2\delta\right)}{2r\beta\delta^3 D(\delta+1)^2 \sqrt{\frac{2C_A+4C_A\delta+2C_A\delta^2+p\alpha^2-2C_Ap-2C_Ap\delta+p\alpha^2\delta}{\delta^7}}}$$

In principle, the derivative can be either positive or negative, depending on the sign of the numerator (because denominator is always positive). If $\alpha^2 - 2C_A\delta - 2C_A + \alpha^2\delta < 0$, or $C_A > \frac{1}{2}\alpha^2$, derivative is

[17] In the Appendix we show that this is the case with the parameter values we are interested in.

negative and higher probability of the tax-averse government being in power decreases the maximum effective maturity consistent with the reputational equilibrium. This means that if the more tax-averse political party cares more about staying in power (i.e. the penalty for being out of power is high) than about the positive effects of surprise inflation on, say, employment, then the probability of that party being in power decreases the maximum effective maturity consistent with the reputational equilibrium. Ultimately it is of course an empirical question whether the correlation between the probability of more tax-averse party being in power and the effective maturity is positive or negative, but this such correlation may also reveal something about the relative preferences of the parties as well as the effectiviness of debt structure as commitment device.

### 2.3.2 Less tax-averse party initially in power

Now we study a situation where the party B is in power in the beginning of the first period. We try to find the maximum effective maturity consistent with the non-inflation equilibrium $m^*$, and then study the properties of $m^*$.

First, we study the situation where party B cheats in the first period. We will first see what happens if party A then comes into power in the second period. Even though party B has inflated, the private sector's expected inflation in the second period is 0, but in our set-up $m = 0$, for the reasons outlined above. Analoguos to the previous case[18], the discounted (to period 2) loss function of government A if it inflates, $L_2^{devA}$, is

$$\begin{aligned} L_2^{devA} &= \frac{1}{2}\alpha^2 - \alpha(\alpha - 0) + \frac{1}{\delta}(\frac{1}{2}\alpha^2 + (1-p)C_A) = \\ &\alpha^2(\frac{1}{2\delta} - \frac{1}{2}) + \frac{1}{\delta}(1-p)C_A \end{aligned} \tag{15}$$

And, naturally enough, the value of the loss function if party A does not inflate in the second period is

$$L_2^{repA} = \frac{1}{2\delta}(1-p)\alpha^2 + \frac{1}{\delta}(1-p)C_A \tag{16}$$

[18] And also in the same fashion as in the previous case, government A receives disutility from taxes levied to service government debt. As term $\beta T$ is the same in both equations 15 and 16, and therefore it cancels out.

Party $A$ will not deviate and inflate in the second period, if $L_2^{repA} < L_2^{devA}$. The condition for A not defecting is therefore the same as requiring that $\alpha^2(\frac{1}{2\delta} - \frac{1}{2} - \frac{1}{2\delta}(1-p)) > 0 => p > \delta$. This is true as long as long the probability of more tax-averse party being in power $p$ is larger than the discount factor $\delta$, which we assume to be the case. Again, the increase in expected inflation in all future periods deters A from inflating, as there is no corresponding decrease in the real value of the outstanding government debt stock.

Therefore we proceed to analyse the situation in the first period when the less tax-averse party is in power. The party knows that if inflates, party A will not inflate in the next period (or in any of the future periods, which are of course all alike). In the first period the expected inflation is still zero, and therefore the loss function of incumbent party B - if it inflates - can be written as:

$$\begin{aligned} L_1^{devB} &= \frac{1}{2}\pi^2 - \alpha\pi + \gamma r\left[1-m\pi\right]D + \frac{1}{1+\delta}(\gamma r\left[1-m\pi\right]D + C_B) \\ &+ \frac{1}{\delta}(\frac{1}{1+\delta})\left\{\begin{array}{c} \gamma r\left[1-m\pi\right]D \\ +p\left(0-\alpha\left(0-(1-p)\alpha\right)+C_B\right)+ \\ (1-p)\left(\frac{\alpha^2}{2}-\alpha\left(\alpha-(1-p)\alpha\right)\right) \end{array}\right\} \end{aligned} \tag{17}$$

One should note that in this case the excepted inflation at the beginning of every period is $(1-p)\alpha$, as B will set inflation at $\alpha$ in every period when it is power, while A will set $\pi = 0$. Again, initial inflation decreases the real value of the outstanding debt - and therefore taxes - in the first and all future periods. We can then calculate the optimal inflation for B in the first period, if it decides to inflate. It is not hard to see that for party B the associated FOC is $\frac{\partial}{\partial\pi}L_1^{devB} = \pi - \alpha - \gamma rmD - (1+\frac{1}{\delta})\gamma rmD = 0$, from which we can solve the optimal first-period inflation for party B, $\pi = \alpha + (1+\frac{1}{\delta})\gamma rmD$. With this result, we can calculate explicitly the value of the loss function for party B in the first period:

$$
\begin{aligned}
L_1^{devB} &= \frac{1}{2}\left(\alpha+(1+\frac{1}{\delta})\gamma rmD\right)^2-\alpha\left(\alpha+(1+\frac{1}{\delta})\gamma rmD\right) \quad (18)\\
&+\gamma r\left[1-m\left(\alpha+(1+\frac{1}{\delta})\gamma rmD\right)\right]D\\
&+\frac{1}{1+\delta}(\gamma r\left[1-m\left(\alpha+(1+\frac{1}{\delta})\gamma rmD\right)\right]D+C_B)\\
&+\frac{1}{\delta}(\frac{1}{1+\delta})\left\{\begin{array}{c}\gamma r\left[1-m\left(\alpha+(1+\frac{1}{\delta})\gamma rmD\right)\right]D+\\ p\left(0-\alpha\left(0-(1-p)\alpha\right)+C_B\right)+\\ (1-p)\left(\frac{\alpha^2}{2}-\alpha\left(\alpha-(1-p)\alpha\right)\right)\end{array}\right\}
\end{aligned}
$$

It should be noted that since the tax-aversion parameter is lower for B than A, $\beta > \gamma$, inflation B would choose is lower than A's inflation, which is intuitively easy to grasp. In the same manner as in the case of A being in power, the loss function for B, if it does not inflate is

$$
L_1^{repB} = (1+\frac{1}{\delta})\gamma rD \qquad (19)
$$

For the reputational equilibrium to hold when B is in power, we need to have $L_1^{repB} - L_1^{devB} \leq 0$. Setting this as a strict equilibrium we can derive the maximum effective maturity consistent with the reputational equilibrium.

$$
L_1^{repB} - L_1^{devB} = (1+\frac{1}{\delta})\gamma rD - \frac{1}{2}\left(\alpha^2+2\alpha(1+\frac{1}{\delta})\gamma rmD+(1+\frac{1}{\delta})^2\gamma^2r^2m^2D^2\right)
$$

(20)

$$
\begin{aligned}
&+\alpha^2+\alpha(1+\frac{1}{\delta})\gamma rmD-\gamma r\left[1-m\left(\alpha+(1+\frac{1}{\delta})\gamma rmD\right)\right]D\\
&-\frac{1}{1+\delta}(\gamma r\left[1-m\left(\alpha+(1+\frac{1+2\delta}{\delta(1+\delta)})\gamma rmD\right)\right]D+C_B)\\
&-\frac{1}{\delta}(\frac{1}{1+\delta})\left\{\begin{array}{c}\gamma r\left[1-m\left(\alpha+(1+\frac{1}{\delta})\gamma rmD\right)\right]D\\ +p\left(0-\alpha\left(0-(1-p)\alpha\right)+C_B\right)\\ +(1-p)\left(\frac{\alpha^2}{2}-\alpha\left(\alpha-(1-p)\alpha\right)\right)\end{array}\right\}\leq 0
\end{aligned}
$$

Again, some algebra yields the following equation:

$$L_1^{repB} - L_1^{devB} = \frac{1}{2}\alpha^2 + (\frac{(1+\delta)^2}{2\delta^2})\gamma^2 r^2 m^2 D^2 \tag{21}$$
$$+m\gamma r D\alpha(\frac{1+\delta}{\delta}) - \frac{1}{1+\delta}C_B - \frac{1}{\delta}(\frac{1}{1+\delta})\frac{1}{2}\alpha^2(1-p) - \frac{1}{\delta}(\frac{1}{1+\delta})pC_B = 0,$$

We can the solve for the largest effective maturity consistent with the reputational equilibrium, $m^*$. The two roots of the equation are

$$m^* = \left\{ \begin{array}{c} -\frac{1}{r\gamma D(\delta+1)^2}\times \\ \left( \begin{array}{c} \alpha\delta + \alpha\delta^2 \\ +\delta^4\sqrt{\frac{2C_B\delta+\alpha^2+2C_B\delta^2-p\alpha^2+\alpha^2\delta+2C_Bp+2C_Bp\delta-p\alpha^2\delta}{\delta^7}} \end{array} \right), \\ -\frac{1}{r\gamma D(\delta+1)^2}\times \\ \left( \begin{array}{c} \alpha\delta + \alpha\delta^2 \\ -\delta^4\sqrt{\frac{2C_B\delta+\alpha^2+2C_B\delta^2-p\alpha^2+\alpha^2\delta+2C_Bp+2C_Bp\delta-p\alpha^2\delta}{\delta^7}} \end{array} \right) \end{array} \right\} \tag{22}$$

Again, the first root is clearly negative. The second root is larger, as in the case with the more tax-averse government in power, because $\delta^4 > -\delta^4$, as long as the square root is defined.[19]

Next, we want to investigate how the probability $p$ of the more tax-averse party, A, being in power affects the maximum effective maturity $m^*$. We differentiate the larger root with respect to $p$.

$$\frac{\partial}{\partial p}\{-\frac{1}{r\gamma D(\delta+1)^2}\times \tag{23}$$
$$\left(\alpha\delta + \alpha\delta^2 - \delta^4\sqrt{\frac{\left(2C_B\delta+\alpha^2+2C_B\delta^2-p\alpha^2+\alpha^2\delta+2C_Bp+2C_Bp\delta-p\alpha^2\delta\right)}{\delta^7}}\right)\} \tag{24}$$
$$= \left\{ -\frac{\left(\alpha^2-2C_B\delta-2C_B+\alpha^2\delta\right)}{\begin{array}{c}\{2r\gamma\delta^3 D(\delta+1)^2\times \\ \sqrt{\frac{\left(2C_B\delta+\alpha^2+2C_B\delta^2-p\alpha^2+\alpha^2\delta+2C_Bp+2C_Bp\delta-p\alpha^2\delta\right)}{\delta^7}}\}\end{array}} \right\}.$$

In principle, the derivative can be either positive or negative, depending on the sign of the numerator (because denominator is always

[19] In the Appendix we show that this is the case with realistic combinations of parameter values.

positive). If $(\alpha^2 - 2C_B\delta - 2C_B + \alpha^2\delta) > 0$, or $C_B < \frac{1}{2}\alpha^2$, derivative is negative and higher probability of the tax-averse government being in power decreases the maximum effective maturity consistent with the reputational equilibrium. We can note that the higher probability of more tax-averse government being in power is associated with lower effective maturity in both political scenarios only if the costs for being out of the government are so that $C_B < \frac{1}{2}\alpha^2 < C_A$. This may or may not be true at all points in time. Of course, $\frac{\partial m^*}{\partial p} < 0$ may be true in one of the two cases even when $C_B < \frac{1}{2}\alpha^2 < C_A$ does not hold.

Unfortunately, there is no immediately clear metric for the size of the punishments $C_A$ and $C_B$.[20] Therefore, the effect of probability of the more tax-averse government being in the power on debt maturity is ultimately an empirical question, but if the data even tentatively support this result, we have learned something about the political determinants of government debt maturity.

### 2.3.3 Debt level and maturity

Finally, we check whether the level of debt affects the maximum effective maturity also in this model. In the previous literature on the government debt maturity, higher debt level has been linked with both higher and lower maturity. Of course, our present model is partially based on Missale and Blanchard (1994) where higher debt level decreases the effective maturity of the government debt.

As explained before, when the more tax-averse government is in power, we can calculate the maximum effective maturity consistent with the reputational equilibrium. Differentiating this maximum maturity with respect to the debt level D gives us the effect of debt on maturity. First we do this in the case when the more tax-averse government is in power.

[20] One should note that if the costs of being out of power, $C_A$ and $C_B$ , are equal, $\frac{\partial m^*}{\partial p}$ can not be negative for both parties.

$$\frac{\partial}{\partial D}\{-\frac{1}{r\beta D\left(\delta+1\right)^{2}}\times \tag{25}$$

$$\left(\begin{array}{c}\alpha\delta+\alpha\delta^{2}\\ -\delta^{4}\sqrt{\frac{\left(2C+4C\delta+2C\delta^{2}+p\alpha^{2}-2Cp-2Cp\delta+p\alpha^{2}\delta\right)}{\delta^{7}}}\end{array}\right)\} \tag{26}$$

$$=\left\{\begin{array}{c}\frac{1}{r\beta D^{2}\left(\delta+1\right)^{2}}\times\\ \left(\alpha\delta+\alpha\delta^{2}-\delta^{4}\sqrt{\frac{2C+4C\delta+2C\delta^{2}+p\alpha^{2}-2Cp-2Cp\delta+p\alpha^{2}\delta}{\delta^{7}}}\right)\end{array}\right\}.$$

In the Appendix we show that 25 is negative with all realistic parameter values. Therefore, $\frac{\partial m^*}{\partial D} < 0$ when the more tax-averse party is in power.

When the less tax-averse party is in power, we differentiate

$$\frac{\partial}{\partial D}\{-\frac{1}{r\gamma D\left(\delta+1\right)^{2}}\times \tag{27}$$

$$\left(\alpha\delta+\alpha\delta^{2}-\delta^{4}\sqrt{\frac{2C\delta+\alpha^{2}+2C\delta^{2}-p\alpha^{2}+\alpha^{2}\delta+2Cp+2Cp\delta-p\alpha^{2}\delta}{\delta^{7}}}\right)\}$$

$$=\left\{\begin{array}{c}\frac{1}{r\gamma D^{2}\left(\delta+1\right)^{2}}\times\\ \left(\alpha\delta+\alpha\delta^{2}-\delta^{4}\sqrt{\frac{2C\delta+\alpha^{2}+2C\delta^{2}-p\alpha^{2}+\alpha^{2}\delta+2Cp+2Cp\delta-p\alpha^{2}\delta}{\delta^{7}}}\right)\end{array}\right\}$$

Again, we show in the Appendix that this partial derivative is negative with realistic parameter values. Therefore, the result of e.g. Missale and Blanchard (1994) is replicated also in this political economy model of government debt maturity. Higher debt maturity makes the gains from deviating larger, ceteris paribus, which must be counterbalanced by lower effective maturity.

## 2.4 Discussion of the results

Many of the features found in the model of Missale and Blanchard (1994) carry over to the present contribution as well. For example, regardless of the type of party in power and the probability of government change, larger government debt is always associated with lower effective maturity, *ceteris paribus.*

The sequencing of the game is quite similar to the one in Milesi-Ferretti (1995), but there are also important differences. In this model there is no room for announcements of future policies; the private sector knows the preferences of the parties and the probability they will be in the power when the inflation is decided. Also, taxes are not explicitly a decision variable in the model, as the level of primary government expenditure (i.e. expenditure net of interest payments) is assumed to be zero, and taxes are only used to service the government debt. Furthermore, and unlike in the model of Milesi-Ferretti (1995), the real interest rate and the nominal one coincide, unless the government cheats and inflates. And finally, in this model the probability of government changing is exogenous.

Although the model is highly artificial as such, it would also suggest that when a government which dislikes taxes[21] is in power, it will have a large incentive to inflate away some of the outstanding government debt. Because the private sector understands this, the debt maturity must be lower than under a government which is less tax averse (unless the tax-averse government can achieve credibility in opposing inflation through some other mechanism). When the more tax-averse government is in power, increased probability of government change increases the maximum effective maturity This is because the expected inflation rate decreases.

Milesi-Ferretti (1995) uses a model where the governments differ in their aversion to inflation, but in appendix he also present a model where the preferences of the parties differ with regards to public spending. Since public spending must be financed from taxation, the model is closer in spirit to the present contribution than other models discussed in previous subsections. However, since in that model parties also derive utility from being in power, they use the structure of the government debt to increase their chances of being elected. This is contrast to the present contribution, where the probability of being in power is exogenous.

As far as we know, no previous model of government debt structure has assessed the effect of political polarisation on debt. Our results, where political polarisation decreases the effective maturity, is intuitively quite appealing. When preferences of the two parties move away from each other, uncertainty concerning the future policies increases. Therefore private investors are less willing to hold bonds with longer effective maturity.

[21] Relative to other potential governments.

However, it is clear that the results obtained above must be treated with caution. First, in the model inflation is mainly used to engineer a reduction of the real value of government debt (although the government's loss function results in the familiar inflationary bias, as well). Second, to be able to solve the model, parameter values had to be restricted. However, we have tried to argue that these restrictions are not overtly artificial, given the economic nature of the problem. Nevertheless, these limitations have to be taken into account when we interpret the empirical results below.

## 2.5 Empirical evidence

There are few studies which link the government debt maturity and the level of government debt. The contribution of Missale and Blanchard (1994) finds that the level of debt and its effective maturity are inversely related in countries with high debt ratios (i.e. over 100% of GDP). de Haan et al. (1995) find that the level of government debt affects maturity also in countries with lower debt levels, although the evidence is more mixed in those cases. *Also the present contribution would indicate negative correlation between the level of government debt and its (effective) maturity.*

In subsection 2.3 we derived hypothesis relating political parties' preferences to the effective maturity of the government debt. To reiterate, when the incumbent party is more tax averse than the opposition party, higher probability of a government staying in the power dencreases the maximum effective maturity $m^*$.

The hypothesis relate to the preferences of the incumbent government and opposition over tax rate, and the probability of a change in government. Of course, when the incumbent party is less tax averse than the opposition, higher probability of a government change will decrease the maximum effective maturity.

In reality, it would be extremely hard – if not impossible – to observe directly parties' preferences over tax rates. Therefore we shall model the discrepancy between the government's and opposition's preferences over tax rate simply by looking at their general political preferences, i.e. whether they lean towards left or right. It is assumed that left-wing parties have preference for higher tax rate than right-wing parties, ceteris paribus. This simple coding system works well in two-party systems, but things are slightly more complicated in multi-party setting. We shall return to this question later. However, we must admit that mapping from the model to the messy political reality may be less than perfect in many countries. For example, in this model the preference for lower taxes implies that government prefers higher inflation, ceteris paribus. This may have an effect on empirical results, as shall be discussed below.

Related to the discussion above, polarisation of political preferences may also affect effective debt maturity. However, polarisation is also difficult to measure, if we can not properly quantify the preferences e.g. over taxation. Nevertheless, we can use several proxies relating e.g. to the fragmentation of political field or party system. The simple idea here is that a more fragmented political system (be it legislature or government) is also more likely to be polarised.

In the following subsections we will take a closer look at the data used in the analysis and run several panel regressions to test these hypotheses. To our knowledge, this is the first time such political economy model has been tested in a panel setting. Generally, the model derived earlier is found to conform quite well with the data. However, many open questions do remain.

### 2.5.1 Data

We look at the effective maturity of government debt in 13 OECD countries.[22] The selection of countries is partly dictated by availability of data, but there are also other considerations. For the political economy model of government debt maturity (or structure, more generally) to be viable, the countries studied should most probably have democratic systems. Although the theory could in principle work also in countries where the government changes by undemocratic means, it is unclear how the incumbent party (or similar organisation) would actually take into account the probability of a government change. Also, mature market economies are more likely to be able to change the structure of their debt stock, if they wish to do that. Therefore the analysis is in this instance restricted to stable democracies. Most

[22] The countries are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden, and United Kingdom. For USA the data on effective maturity of government debt ($EFMAT$) is not available. For USA (as for most other countries in our sample) we have the average maturity of fixed-rate bonds and notes ($FIMAT$). This variable will be used to check robustness of our results.

of the variables are available from 1975 to 1997, although there are some missing observations for individual countries.

Next, we look at the variables used in the analysis. We shall first look at the economic variables and then turn to the political indicators.

**Macroeconomic variables Effective maturity ($EFMAT$).** Data on effective government debt maturity is taken from Missale (1999).[23] In short, effective maturity indicates how much the real value of government debt reacts to unexpected inflation. For example, if it is assumed that purchasing power holds and therefore the government can not affect the real value of debt denominated in foreign currencies, the effective maturity of foreign currency denominated debt is zero.[24]

**Table 1 Descriptive statistics**

| | $EFMAT$ | $DEBT$ |
|---|---|---|
| mean | 4.28 | 0.48 |
| median | 4.14 | 0.46 |
| standard dev. | 2.19 | 0.27 |
| maximum | 11.70 | 1.23 |
| minimum | 0.63 | -0.02 |
| observations | 252 | 305 |

Source: Missale (1999) and own calculations

Table 1 lists descriptive statistics on the variables discussed here.[25] The average effective maturity of debt in the 13 OECD countries in the sample is 4.28 years. However, over to the time and across the countries the effective maturity differs quite substantially, as the

[23] I am thankful to Alessandro Missale for kindly distributing his data on government debt maturity and debt levels in electronic format.

[24] Calculation of effective maturity is explained on page 72 of Missale (1999). Maturities of five different debt types are weighted according to their share in the total government debt. For i) the fixed-rate securities the average term to maturity is used, for ii) variable-rate securities the time to the next coupon rate adjustment is used, for iii) putable and convertible securities the earliest redemption date is used, and iv) for callable securities the latest redemption date is used. As noted before, for v) foreign currency denominated and indexed debt maturity of zero is used.

[25] Descriptive statistics are calculated for all the available observations from the 13 OECD countries, i.e. we leave out the US data. In the panel regressions we are unable to use all the observations, however.

standard deviation is 2.19. Figure 1[26] shows the effective maturity of government debt in 13 OECD countries. In addition, effective maturity can vary within a single country over time. For example, in Italy the effective maturity decreased from over four years in mid-1970s to less than one year by the early 1980s. On the other hand, in Denmark the effective maturity increased from approximately one year in the late 1970s to more than four years in the mid-1990s.

**Average maturity of fixed-rate bonds and notes** ($FIMAT$). Data on the average maturity of domestic currency fixed-rate government bonds and notes is also taken from Missale (1999). Figure 2 plots FIMAT for 14 countries between 1975 and 1997 (or for the period when the data is available). Although the average maturity of fixed-rate bonds appears to have trend in some countries, trends are less visible than in the case of effective maturity (Figure 1).

**Government debt ratio** ($DEBT$). This variable is the gross government debt as a share of GDP. Again, the source of the data is Missale (1999). In theory, one should employ data on government's net debt, as the effects of surprise inflation on government's gross debt and gross assets may cancel each other out, at least partially. However, data on public sector assets can be quite unreliable. For example, if market value of public sector assets is not readily available (unlike the market value of public debt), attaching a value on the assets becomes quite arbitrary. Therefore gross government debt is used in this study.

For the overwhelming majority of countries the variable $DEBT$ refers to the central government debt. Maturity and currency composition for this definition of debt is usually the most readily available. Moreover, development of central government and local governments' debt was usually quite similar during the period in question (Missale, 1999). However, for some countries (Germany, Italy and Portugal) we use the total public sector debt (and, naturally, its effective maturity). Finally, the variable $DEBT$ refers to the amount of debt held by the private sector.

[26] Throughout this contribution, abbreviations are used in the figures. Usually they consist of two parts, the first one referring to the variable in question, and the second part referring to a particular country. Abbreviations for the variables are given in the text. Country abbreviations are as follows: AUS - Australia, BEL-Belgium, CAN - Canada, DEN - Denmark, FIN - Finland, FRA - France, GER - Germany, IRE - Ireland, ITA - Italy, NET - the Netherlands, SPA - Spain, SWE - Sweden, UK - United Kingom and USA - United States.

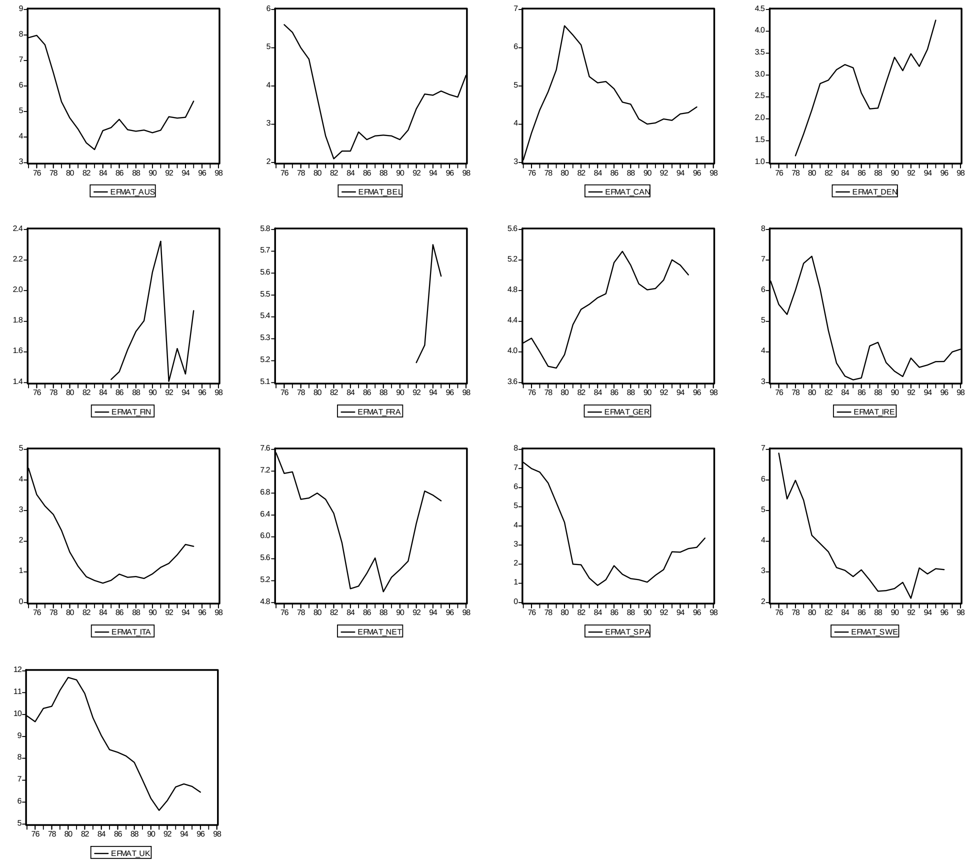


Figure 1: Effective maturity of government debt in 13 OECD countries, 1975-1997

Again, the level of government debt varies widely from one country to another. Belgium had a debt ratio of more than 100% for most of the period under review here. Debt ratio of Denmark stabilised around 60% in mid-1980s. On the other hand, Australia's debt ratio has been on downward, although volatile, trend for most of the period studied here. The mean ratio of government debt to GDP in the 13 countries under review here was 48.1% between 1975 and 1997. Debt ratio ranged from -2.0% to 122.5% with a standard deviation of 24.2%. Also, as can be seen from Figure 3, in most countries studied here there was a definite upward trend in the debt ratio during late 1970s and 1980s. During the 1990s the debt ratio either levelled off, or turned down.

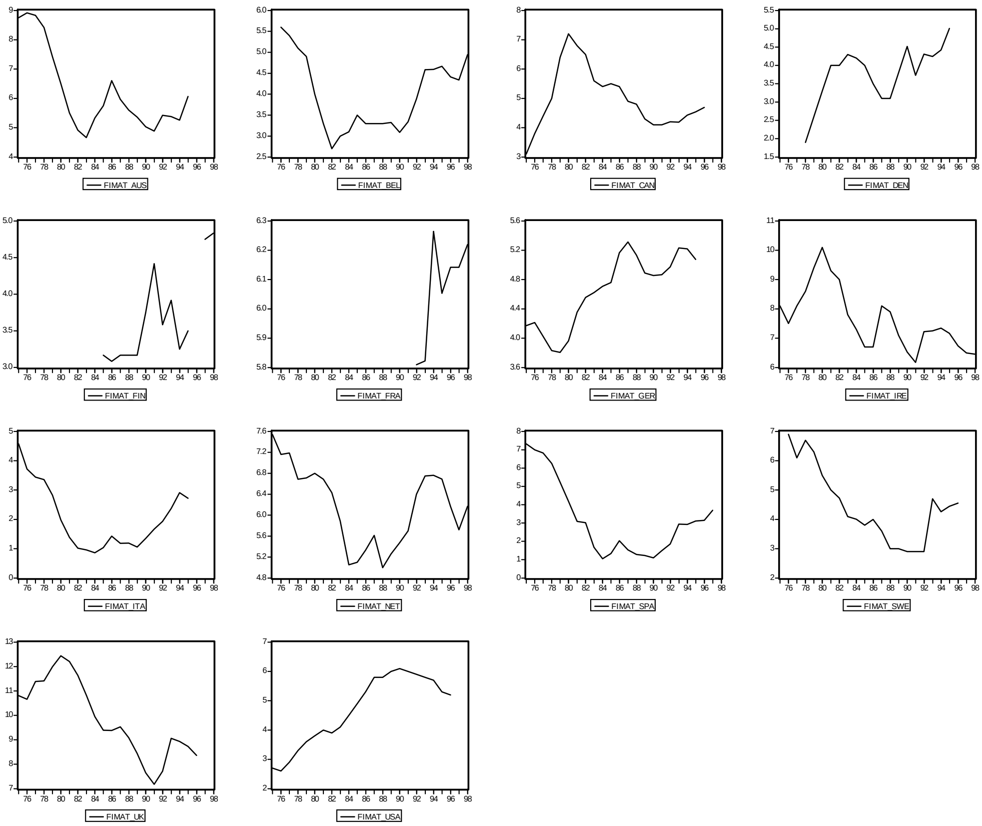


Figure 2: Average maturity of fixed-rate government bonds and notes in 14 OECD countries, 1975-1997

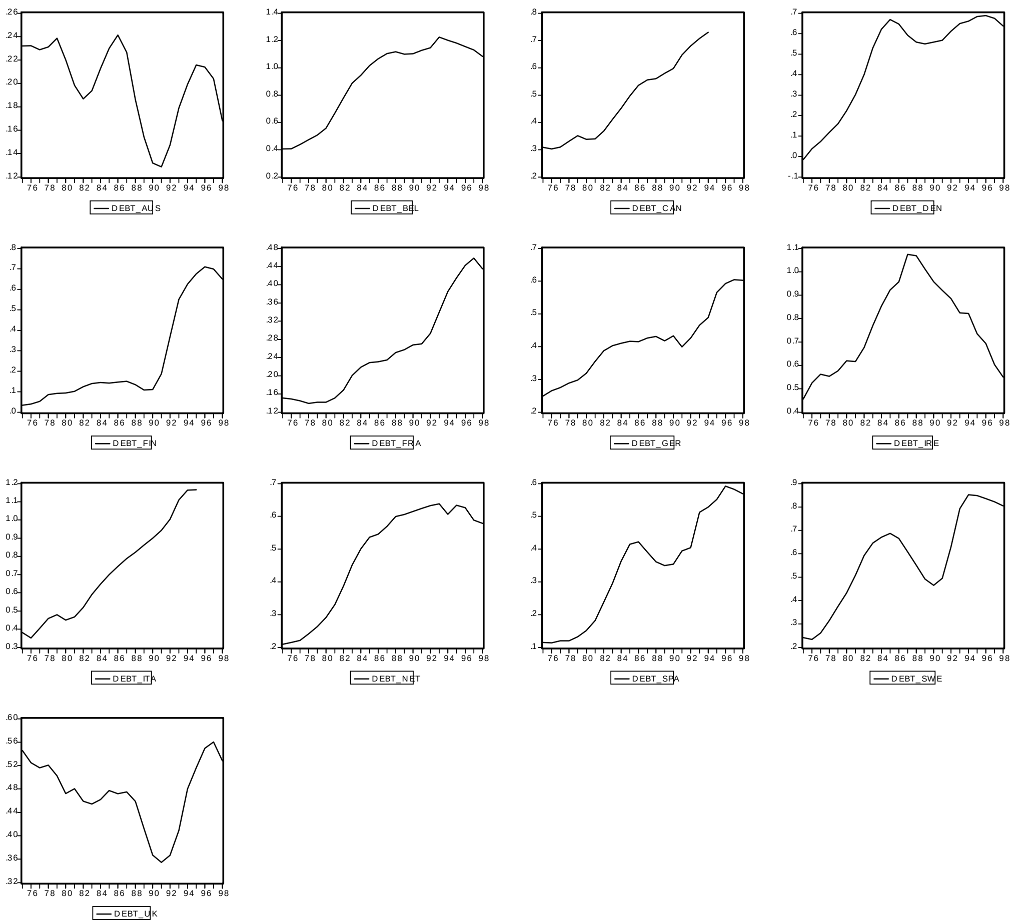


Figure 3: Ratio of public debt to GDP in 13 OECD countries, 1975-1998

**Political variables** The political indicators we use are mainly due to Beck et al. (2001). Beck et al. have collected a very large comparative database on political institutions, covering 177 countries from 1975 to 1997.[27] Obviously, not all the variables are available for the whole period for all of the countries, but for the OECD countries we are interested in, the necessary data is available. All in all, the Database of Political Institutions (DPI) contains 108 variables. The variables describe different aspects of elections, electoral rules, type of political system, party composition of the government and opposition

[27] The DPI and more detailed information about it can be downloaded from the World Bank's home page: http://www.worldbank.org/research/bios/pkeefer.htm.

coalitions, and the extent of military influence on government. There are also a number of measures of various checks and balances, and political stability. Unlike many other datasets of political indicators, the DPI's variables are not subjective.

Following the model derived earlier, we would need variables which describe the political orientation of the incumbent government, probability that the government will change, and a measure of the polarisation of the political field (or preferences). There are no unique indicators for any of these variables of interest, but in the following we will motivate why the particular empirical variables were chosen.

**Political orientation of the incumbent government** ($INCR$) One of the key elements in our model is the relative preference for taxation. In the model of political determinants of government debt structure, it was established that the incumbent government's preference for taxes together with the probability of change in government have an effect on the maximum effective maturity of government maturity. As it is difficult to observe directly different parties' preferences for the level of taxation, we follow the usual convention, and assume that right-wing parties are generally more averse towards taxation.

The DPI database contains information about the political orientation of the largest party in the government coalition, i.e. whether its orientation is LEFT, CENTRE or RIGHT. If the largest government party has been deemed RIGHT in the DPI database, the dummy variable $INCR$ (as in incumbent right-wing party) gets value 1, otherwise it is zero.

**Probability of government change** ($ELECDUM$) One obvious way of modelling the probability of government change is to look at election dates. The DPI database contains information on the dates of parliamentary elections (by month). The idea is that the longer time it is from the last parliamentary elections, the larger is the probability of government changing. This assumption can be motivated with two observations:

1) Generally most OECD countries have regularly scheduled parliamentary elections every three or four years. However, in most political systems there is a possibility of premature elections as well, if, for example, a government coalition falls apart. Generally, the probability of premature elections increases as the distance to the last held regular elections increases. Also, there are only few cases where elections are held on consecutive years. In our sample of 13 OECD

countries between 1975 and 1997, there are exactly four cases of parliamentary elections held on two consecutive years in the same country (Australia in 1983 and 1984, Canada in 1979 and 1980, Denmark in 1987 and 1988, and the Netherlands in 1981 and 1982).

2) The probability of government change increases as regularly scheduled elections approach, *ceteris paribus*.

We denote the variable measuring time from last elections as $ELECDUM$. Obviously, this is a somewhat crude measure of probability of a government change. On the other hand, it treats all countries and cases in the same way. In the empirical work we shall also experiment with different transformations of $ELECDUM$, as it is by no means certain that the effect of time since last elections is linear.

**Polarisation of political opinions** ($FRAC$, $HERFTOT$, $IPCOH$, $HERFGOV$, $POLARIZ$, $GOVFRAC$) As noted earlier, polarisation of political opinions may also decrease the effective maturity of government debt. Obviously, polarisation of political opinions can be interpreted in many ways. In a two-party system it is relatively easy to grasp the idea that preferences concerning e.g. the level of taxation can move further apart. However, in a multi-party system the concept of polarised opinions (or preferences) is not so straightforward. It may be hard to know ex ante which party has the most power in the next government coalition, for example. (Of course, also in two-party systems there can be substantially different preferences e.g. over taxation within a single party.). As most of the countries we study here have multi-party systems, we try to proxy the polarisation of political preferences by fragmentation of the political field.

An alternative, or complementary, interpretation of polarisation variables is that they reflect the stability of the political system. Very fragmented political systems can also be more unstable, i.e. governments and policies change often.

The DPI database has several variables relating to the fragmentation of political field. As it is not *a priori* clear from the theory which variable would best describe polarisation of political opinions or political field, we include several such variables in our initial estimations. $FRAC$ is the probability that two deputies picked at random from the legislature will be of different parties. At one extreme $FRAC = 0$, and there is no polarisation of political opinions (except within the one party represented in the legislature). At the other extreme $FRAC = 1$, and all the deputies come from different parties.

Presumably such a legislature would be very divided, and uncertainty concerning future policies would be high. A similar index can be constructed for the government coalition. This is called $GOVFRAC$.

$HERFTOT$ is calculated in the same manner as the ordinary Herfindahl index for the total legislature. $HERFTOT$ is the sum of squared shares of all parties in the legislature. With $HERFTOT$, a smaller value is associated with more fragmented legislature. The DPI database contains also Herfindahl indices for the government coalition (and opposition). We include the corresponding Herfindahl index for government coalition as $HERFGOV$, as this may reflect polarisation within the government already before the next elections.

$IPCOH$ is a somewhat crude measure of political cohesion. In parliamentary systems[28], the indicator runs from 0 to 3, where 0 denotes majority one-party government, 1 coalition government with two parties, 2 coalition government with more than two parties, and 3 minority government. Therefore larger value of the indicator is associated with more unstable government coalition.

Another variable looking at the fragmentation of the political life is $POLARIZ$. In calculating this variable, numerical values are assigned to the political orientation of parties (LEFT = -1, CENTRE = 0 and RIGHT = 1). $POLARIZ$ is the absolute value of the greatest difference between two veto players, minimum value of being zero and maximum two. In parliamentary systems the three largest government coalition parties are all veto players.[29]

*Time series properties of the data*

Before proceeding to the testing of the derived model, we must investigate the time series properties of the variables used. More precisely, we are interested whether the variables are stationary or not. If some variables are not stationary (i.e. integrated of order zero, or I(0)), then statistical inference might be erroneous. As we will conduct the testing of the derived model in a panel setting, we also perform the unit root testing as a panel. However, we have a strong theoretical prior to think that the variables are, indeed, stationary, because of the way the variables are defined.

First, it is not sensible to think that government debt ratio would

[28] In our sample there is only one country which is not classified as a parliamentary system, the USA. In a presidential system the value of $IPCOH$ depends on whether the same party controls the executive and legislature.

[29] In presidential system the president and the largest party in the government are veto players.

be a non-stationary process in the long-run. Government's solvency constraint restricts the level of debt. For example, in our sample the maximum debt ratio is 122%. Moreover, debt ratios of over 100% are rare in any country. A similar argument applies to $EFMAT$ and $FIMAT$. Maturity is by construction bounded at zero from below. Also, we do not observe very long average maturities in any country, therefore it seems natural to assume that there is some upper limit of maturity as well. Moreover, the theory developed earlier explicitly deals with levels of variables, and therefore their use in the empirical testing would be preferred as well.

Nevertheless, we do conduct the panel unit root tests to ensure that our variables are not obviously in conflict with the statistical assumptions employed in our empirical testing.

In recent years a number of procedures for panel unit root tests have been developed. We will utilise the tests developed by Hadri (2000), Im et al. (2003), and Levin et al. (2002).[30] It is of interest to compare results across the tests, as their null hypotheses differ. Moreover, all three aforementioned tests allow constants and trend parameters to vary across cross-units of the panel. Although our sample countries are all OECD members, and have e.g. reasonably high per capita GDP, it is quite likely that they are also different in many aspects. Therefore allowing for heterogeneity in the panel allows us to be more certain about the time series properties of the data.

All test procedures require balanced panel, i.e. all cross-units (N) must have the same number of observations. This means that the number of time periods (T) in testing for unit roots in the panel data is slightly smaller than in the actual estimation of the model (which can be done also with unbalanced panel).

We discuss panel unit root test and the test results in more detail in the Appendix B, but some general observations do emerge. Different panel unit root tests yield contradictionary results. For example, results seem to change depending on what kind of deterministic terms (a constant or a constant and a trend) are included in the test regressions. Also, whether coefficients are allowed to vary from country to

[30] The tests were done in Stata 7.0 software package. The program file for Hadri's LM test (hadrilm.ado) was developed by Christopher Baum (http://ideas.repec.org/c/boc/bocode/s419701.html). Program files for the other tests (levinlin.ado and ipshin.ado) were developed by Fabian Bornhorst and Christopher Baum (http://econpapers.hhs.se/software/bocbocode/s419702.htm and http://ideas.repec.org/c/boc/bocode/s419704.html).

country can change results. Most likely our reasonably small sample (especially in the time dimension) is responsible for the non-robust results.

Given the mixed empirical evidence and our strong theoretical priors, we shall primarily treat all the variables as stationary. Robustness checks with differenced variables indicate that specifications with variables in levels have much better fit. Also, differenced variables rarely have statistically significant coefficients in estimations. These estimations are not reported here.

Most political variables are merely dummy variables or indicators bounded between some predetermined limits (e.g. $HERFTOT$ and $HERFGOV$). Therefore they can be treated as stationary.

At the end of next subsection also inflation is included as an explanatory variable. Assuming that inflation is non-stationary is quite unattractive from theoretical point of view, but merely eyeballing the data would suggest that there is a clear downward trend in inflation in most countries. This is also confirmed by unit root tests on individual time series. Therefore we will also experiment with the first difference of inflation in our robustness tests.

### 2.5.2 Testing the political model of government debt structure

In this subsection we test in a panel setting the politico-economic model of government debt structure developed earlier. We shall treat the relevant variables ($DEBT$, $EFMAT$, $FIMAT$) as being stationary in the panel, and therefore the estimations are done in levels. On theoretical grounds it would be extremely hard to argue that these variables are random walks, and the empirical evidence is conflicting. Therefore the variables are treated as I(0).

In the panel specifications we will estimate both fixed and random effects models, where the dependent variable is $EFMAT$. However, fixed effects estimator should always be consistent, but this is not always true for the random effects estimator (if random effects are not orthogonal to the regressors, the random effects estimator is inconsistent). More formally, we will always start testing a particular hypothesis by estimating the following fixed effects panel regression[31]

[31] Obviously, the random effects version of the equation to be estimated is $EFMAT_{it} = \theta + \mu_i + \beta DEBT_{it} + \sum_{j=1}^{n} \gamma_j x_{j,it} + \epsilon_{it}$, where $\mu_i$ is time-invariant cross-section specific random variable, and therefore constant term for each coun-

(when EFMAT is the dependent variable):

$$EFMAT_{it} = \alpha_i + \beta DEBT_{it} + \sum_{j=1}^{n} \gamma_j x_{j,it} + \sum_{j=1}^{l} \eta_j d_{j,it} + \varepsilon_{it} \qquad (28)$$

In equation 28 variables $x_j$ represent n political variables. The exact variables to be included in each estimation depend on what aspect of the derived political economy model we want to investigate, but in the final subsection we will also test whether all our political variables are statistically significant in explaining the effective maturity of government debt. Variables $d_j$ denote various other dummies we may use.

*Effect of debt on effective maturity*

We start by regressing $EFMAT$ only on $DEBT$. Results are reported in Table 3.[32] This is basically a test of original model of Missale and Blanchard (1994). We can see that higher debt levels decrease the effective maturity, as predicted. The result is the same whether we use fixed (columns marked FE) or random effects (RE) model. It is obviously possible that the relationship between $EFMAT$ and $DEBT$ is not linear. Including a squared $DEBT$ in the panel regression increases the absolute value of the coefficient on $DEBT$. Coefficient on $DEBT^2$ is positive, although usually not statistically significant (but quite close to it). Also, we experimented with adding to dummy variables to the panel regression.

In these regressions we are implicitly assuming that the debt level affects the chosen effective maturity, not the other way around. This is in line with the model developed earlier. Moreover, it seems to be a fairly realistic assumption. Changing the composition of debt stock (its maturity and currency composition) is fairly easy achieve in modern financial markets. Even if capital markets are not perfect, such shifts in the debt composition can be achieved within a reasonably short time-frame. However, it would be much harder to argue that a government would, or *could*, change debt stock (as share of GDP) within a year, or even during a longer time period, in response

try is $\theta + \mu_i$.

[32] Panel estimations are done mainly in econometric software EViews 4.1. For fixed effects estimator, we report the estimations using cross-section weights. This will alleviate the problem of cross-section heteroskedasticity. Also, in the fixed effects estimation we use White heteroskedasticity consistent covariance.

to changes in the effective maturity. Therefore, the issue of reverse causality does not seem to be a particularly important one here.

First, including a dummy for observations where $DEBT$ was increasing did not change results, and the dummy came in insignificant. However, including a dummy ($HDEBT$) for observations where the debt to GDP ratio is over 80%, changes the results somewhat. More specifically, $HDEBT$ is statistically significant in all possible configurations. Results imply that, at high levels of debt, the relationship between $DEBT$ and $EFMAT$ is not linear.

Judging from the last two columns of table 3, it appears that at very high debt levels the marginal effect of debt ratio on effective maturity decreases, because of the squared $DEBT$ term. However, when debt ratio is high, the level of maturity is negatively affected, as evidenced by the $HDEBT$ dummy.

Taking the results of this subsection together, the original model of Missale and Blanchard receives support, but we must recognise the non-linear relationship between the debt ratio and effective maturity.

**Table 3 Baseline regressions for effective maturity and debt level**

| | EFMAT | | EFMAT | | EFMAT | |
|---|---|---|---|---|---|---|
| Variable | FE | RE | FE | RE | FE | RE |
| DEBT | -1.65***(-4.75) | -2.15***(-4.99) | -3.19***(-2.72) | -4.23***(-3.06) | -4.31***(-3.82) | -5.74***(-3.78) |
| $DEBT^2$ | | | 1.01 (1.17) | 1.69 (1.59) | 2.67***(2.96) | 3.83***(2.73) |
| HDEBT | | | | | -0.96***(-3.10) | -1.11**(-2.28) |
| $R^2$ | 0.89 | 0.71 | 0.88 | 0.71 | 0.89 | 0.72 |
| F (p-v.) | 147.20 (0.00) | | 127.72 (0.00) | | 122.93(0.00) | |
| N | 250 | 250 | 250 | 250 | 250 | 250 |

t-values in parentheses, *** means the coefficient is significantly different from zero at 1% confidence level, ** at 5% level and * at 10% level

*Effect of political variables relating to polarisation on effective maturity*

We continue testing of our model with political variables. First, we introduce separately variables depicting polarisation of political field and the political orientation of the incumbent party. We test to see which variables are most powerful in explaining the effective maturity of government debt. Second, we bring together all the remaining variables. In testing, we will always include $DEBT$ in the panel regressions as a control variable.

Initially, when we introduce the variables depicting polarisation of political field one at a time into panel regressions, where $DEBT$ is used as a control variable, only $IPCOH$ is statistically significant. However, it may be that by including only one variable at a time we are missing important interactions between variables. Therefore, an alternative strategy is preferred.

Next, we include all relevant political variables at the same time to see which of them are statistically significant and then drop statistically insignificant variables one at a time, i.e. we proceed from general to specific.

However, looking at the political variables and recalling how they are constructed, it is clear that multicollinearity is a potential danger. Table 4 displays a correlation matrix of the political variables. Correlation between $GOVFRAC$ and $HERFGOV$ is -1, which is clear given the way they are calculated for the government coalition. The same applies obviously to $FRAC$ and $HERFTOT$, which replicate the same calculations for the entire legislature. Therefore including $GOVFRAC$ and $HERFGOV$, on the one hand, and $FRAC$ and $HERFTOT$, on the other, in the same estimation is not possible. Also, correlation of $GOVFRAC$ and $FRAC$ is fairly high, 0.79. (Given the above observations about correlations, it is obvious that correlation between $FRAC$ and $HERFGOV$ is -0.79.) Therefore, including these variables into the same estimation would increase the risk of multicollinearity.

**Table 4 Correlation matrix for political variables**

| | FRAC | GOVFRAC | HERFTOT | HERFGOV | IPCOH | POLARIZ |
|---|---|---|---|---|---|---|
| FRAC | 1 | | | | | |
| GOVFRAC | 0.79 | 1 | | | | |
| HERFTOT | -1 | -0.79 | 1 | | | |
| HERFGOV | -0.79 | -1 | 0.79 | 1 | | |
| IPCOH | 0.68 | 0.47 | -0.68 | -0.47 | 1 | |
| POLARIZ | 0.43 | 0.51 | -0.43 | -0.51 | 0.28 | 1 |

As explained earlier, we begin our testing by including all the political variables in the right-hand side of the panel estimation. We continue by dropping statistically insignificant variables one at the time. ($DEBT$ is used as a conditioning variable in all estimations.) Table 5 lists the estimation results. In the end, the preferred specification is one where $DEBT$, $FRAC$ and $IPCOH$ affect the effective maturity of government debt. $DEBT$ remains highly significant in all possible specifications. The size of coefficients on $FRAC$ and $IPCOH$

changes somewhat depending on the estimation method used. The absolute size of $FRAC$ coefficient is the largest with random effects specification, although in most fixed effects estimations the size of coefficient is fairly close.

As a check on the robustness of results, squared explanatory variables were also added to the estimation to account for potential non-linearity. It turns out that $IPCOH^2$ is statistically significant, while $FRAC^2$ and $DEBT^2$ are not. This result is also reported in the table 5. The behaviour of political variables in this set-up is fairly interesting. In the first glance, it would appear that $FRAC$ has the predicted effect on $EFMAT$, i.e. more polarised polity (in this case, fragmented legislature) results in shorter effective maturity of government debt.

However, positive coefficient on $IPCOH$ is more difficult to explain in this framework. At first glance, it seems that more unstable government coalition is associated with longer effective maturity of government debt. Recall that $IPCOH$ runs from 0 to 3, 0 indicating majority one-party government and 3 a minority government. However, it is possible that a move from one-party government into two-party government ($IPCOH = 1$) or into a government with more than two parties ($IPCOH = 2$) actually improves the stability of political system. Responsibility for economic policies is shared among different parties. This also reduces the risk for significant policy reversals when the government changes, as parties from the old coalition are more likely to be in the new government as well.

According to this interpretation, $IPCOH$ does not measure polarisation of political preferences. This interpretation is perhaps supported also by the results from the estimation with squared explanatory variables. Coefficient of $IPCOH^2$ is negative, and statistically highly significant. Furthermore, when one looks at the effect of $IPCOH$ on effective maturity between 0 and 3 (taking into account the quadratic term), it is found that the overall effect starts to decrease before the variable reaches 3. This would suggest that some political fragmentation within the government coalition is good. Responsibility for policies is shared, and this makes policy reversals less likely. However, a minority government may have less credibility. A minority government will find it more difficult to implement its economic policies, and minority governments may be more unstable. This could also increase the probability of policy reversals.

**Table 5 Panel regressions for effective maturity and political polarisation**

| | DEFMAT | | DEFMAT | |
|---|---|---|---|---|
| Variable | FE | RE | FE | RE |
| DEBT | -1.01*** (-2.91) | -1.44*** (-3.53) | -1.11*** (-3.08) | -1.48*** (-3.66) |
| FRAC | -1.28 (-0.87) | -4.15** (-2.37) | -1.96 (-1.36) | -5.22*** (-2.88) |
| IPCOH | 0.39*** (4.32) | 0.39*** (4.17) | 1.09** (2.57) | 1.20*** (3.26) |
| $IPCOH^2$ | | | -0.21* (1.71) | -0.24** (-2.25) |
| $R^2$ | 0.85 | 0.77 | 0.85 | 0.78 |
| F (p-value) | 83.03 (0.00) | | 76.22 (0.00) | |
| N | 240 | 240 | 240 | 240 |

t-values in parentheses, *** means the coefficient is significantly different from zero at 1% confidence level, ** at 5% level and * at 10% level

Last, and to obtain an idea about the economic significance of estimated coefficient values, we can calculate how the effective maturity would change if right-hand side variables would increase from their mean values by one standard deviation. Mean of $DEBT$ is 0.527, and its standard deviation 0.264. Corresponding values for $FRAC$ are 0.683 and 0.104, and for $IPCOH$ 1.467 and 1.116. If debt to GDP ratio in a given country would rise by 0.264, this would correspond to a decrease of 0.29 years in the effective maturity of this country's debt.[33] A rise of $FRAC$ by 0.104 would, in turn, decrease the effective maturity by 0.20 year. The largest influence seems to come from $IPCOH$, though. One standard deviation change in the variable would increase the effective maturity of government debt by 0.96 years. As $IPCOH$'s standard deviation is almost exactly unity, this corresponds also to a move from e.g. from two-party government to a government with more parties. Therefore the composition of government seems to have a very significant effect on the effective maturity of government debt. As the effective maturity can be changed e.g. by shifting the currency composition of borrowing, a one-year change in effective maturity can mean a sizeable change in the debt stock's currency distribution.

To summarise, in this subsection we have seen that political variables relating to the polarisation and fragmentation of legislature and political apparatus in general could have a clear effect on the effective maturity of government debt. Also, level of government debt has the predicted effect on effective maturity.

[33] With coefficients obtained from fixed effects estimation. Coefficient from the random effect estimator would produce larger results.

*Effect of political variables relating to preferences of incumbent on effective maturity*

In this subsection we estimate how the political preferences of the incumbent government together with the probability of government change affect the effective maturity of government debt. In our model, one of the results was that when the incumbent government dislikes taxes more (than the opposition party), increasing probability of government change increases the effective maturity of government debt In our empirical application, we identify right-wing governments (see subsection 2.5.1) as being more tax-averse. Also, probability of a government change increases with the number of years that have passed from the last elections.

We start our testing with panel estimations where the effective maturity of government debt ($EFMAT$) is explained by the level of debt ($DEBT$) and the political orientation of the largest party in the government coalition ($INCR$) and the variable depicting the number of years since the last election ($ELECDUM$). Variable $ELECDUM$ is meant to reflect the probability of a government change. The longer it has been since the last elections, the more likely a change of government is. However, since the model predicts that the probability of government change raises the effective maturity, when the more tax-averse government is in power, we will include $INCR$ and $ELECDUM$ as a multiplicative interaction term, as well as the interaction term squared, to account for possible non-linearities in data.

Again, $DEBT$ is negative and statistically significant in all possible specifications of the model. Moreover, the behaviour of interaction term is quite interesting, and in accordance with the model derived earlier. When the incumbent party (or the largest party in a coalition government) is right-wing (and presumably more tax-averse), increasing probability of government change increases the effective maturity of government debt. Results are reported in table 6.

Coefficient on the interaction term is statistically significant in the fixed effects estimation, and borderline significant in the random effects estimation. However, this effect is not linear. Squared interaction term appears to be significant and negative. The absolute size of this coefficient is clearly smaller than the one on $ELECDUM \times INCR$. The estimated coefficients imply that influence of interaction term reaches its maximum effect slightly more than two years after the last elections.

How should we interpret these results? First, the expected results of our model receive modest support, as the interaction term between $INCR$ and $ELECDUM$ has the expected sign, and it is statistically significant. When the incumbent party is right-wing, increasing probability of government change increases the effective maturity of government debt, as investors perceive that the next government may not be so tax-averse. Second, when the interaction term is included also in its squared form, we can see that there is some evidence of non-linearity, but the statistical significance of the result is not the highest possible. Nevertheless, the negative effect of $DEBT$ on effective maturity is present and statistically significant.

**Table 6 Panel regressions for effective maturity and probability of government change**

| | EFMAT | |
|---|---|---|
| Variable | FE | RE |
| DEBT | -1.33*** (-3.64) | -1.45*** (-3.36) |
| ELECDUM $\times$INCR | 0.31** (2.30) | 0.32 (1.53) |
| (ELECDUM $\times$INCR)$^2$ | -0.07* (-1.62) | -0.12* (-1.81) |
| $R^2$ | 0.91 | 0.77 |
| F-stat.(p-value) | 156.59 (0.00) | |
| N | 221 | 221 |

t-values in parentheses, *** means the coefficient is significantly different from zero at 1% confidence level, ** at 5% level and * at 10% level

*Combined effects of political variables on government debt maturity*

In this section we pull together the analysis from the three preceding subsections, where subsets of explanatory variables have been used to test the model derived earlier.

Previously, one class of variables was tested at the time. Here we start by estimating a panel model with all the political variables deemed statistically significant in the previous subsections as well as the level of debt. If squared terms were found to be significant in the previous subsections, they are included in the initial specification as well. Then, insignificant variables are dropped one at a time. In table 7 we first report the somewhat reduced specification (without the squares of $DEBT$ and $ELECDUM \times INCR$, as they were not statistically significant), then some subsequent specifications, and, finally, the preferred equation.

Regarding the initial specification, it appears quite clear that the variables relating the political orientation of the incumbent party and probability of government change are not statistically significant (although they are qualitatively similar to the coefficients obtained in previous subsection). Also, there are clear differences between fixed effects and random effects regarding the significance and size of $FRAC$.

Difference between estimates of $FRAC$ in fixed and random effects models persists in all specifications. Because $FRAC$ is highly significant in the random effects specification, we first drop the interaction term. Dropping the interaction term changes the coefficients of other variables only marginally.

**Table 7 Panel regressions for effective maturity and political variables**

| | EFMAT | | EFMAT | |
|---|---|---|---|---|
| Variable | FE | RE | FE | RE |
| DEBT | -1.21*** (-3.09) | -1.44*** (-3.52) | -1.12*** (-3.08) | -1.48*** (-3.66) |
| FRAC | -2.06 (-1.40) | -5.21*** (-2.87) | -1.96 (-1.36) | -5.22*** (-2.88) |
| IPCOH | 1.06** (2.49) | 1.21*** (3.31) | 1.09** (2.57) | 1.19*** (3.26) |
| $IPCOH^2$ | -0.20* (-1.63) | -0.24** (-2.29) | -0.21* (-1.71) | -0.24** (-2.25) |
| ELECDUM × INCR | 0.03 (0.59) | -0.06 (-0.95) | | |
| $R^2$ | 0.85 | 0.78 | 0.85 | 0.78 |
| F-stat.(p-value) | 71.28 (0.00) | | 76.22 (0.00) | |
| N | 240 | 240 | 240 | 240 |

t-values in parentheses, *** means the coefficient is significantly different from zero at 1% confidence level, ** at 5% level and * at 10% level

Obviously, results in the last two columns of table 7 are the same as obtained in the subsection 2.5.2. Although the model's predictions regarding the probability of government change when the incumbent party is right-wing seem to be confirmed when the hypothesis is tested alone, we can see that influence of political polarisation is much more pronounced when all variables are considered together. Also, $DEBT$ retains its statistical significance.

*Robustness tests*

In this subsection we perform some robustness tests for the results derived in previous subsections. First, we will make $FIMAT$ the dependent variable to see whether $DEBT$ and our political variables affect it in the same way as they appear to influence the average effective maturity of government debt.

Second, we will add inflation as a control variable to various estimations of the previous subsections.[34] The model derived earlier assumes that in the equilibrium the government does not inflate in order to reduce the real value of outstanding public debt. However, inflation rates in different countries have been clearly positive during the past years. Obviously, there are several reasons for non-zero inflation, and we do not propose that inflation was engineered solely in order to decrease the real value of outstanding government debt stock. Nevertheless, and since this observation is in contrast with one of our assumptions, we want to see whether including inflation has any bearing on our results.

**Table 8a Panel regressions for FIMAT**

| | FIMAT | | FIMAT | |
|---|---|---|---|---|
| Variable | FE | RE | FE | RE |
| DEBT | -0.38 (-1.05) | -0.83** (-2.07) | -0.58 (-0.49) | -2.33* (-1.80) |
| $DEBT^2$ | | | -0.04 (-0.05) | 1.23 (1.22) |
| $R^2$ | 0.95 | 0.74 | 0.94 | 0.75 |
| F-stat.(p-value) | 369.43 (0.00) | | 275.89 (0.00) | |
| Total number of obs | 280 | 280 | 280 | 280 |

t-values in parentheses, *** means the coefficient is significantly different from zero at 1% confidence level, ** at 5% level and * at 10% level

First, we perform again our main panel regressions, but with $FIMAT$ as the dependent variable instead of $EFMAT$. This allows us to include the US data in the sample. Also, for some countries we are able to include more observations. Tables 8a and 8b reports some of our results. First, we regress $FIMAT$ on $DEBT$ and $DEBT^2$. Influence of the debt ratio on $FIMAT$ is not very strong. Higher debt ratio does decrease the average maturity of government's fixed-term debt instruments, but statistical significance of this result is not very high. Also, there is really no evidence of non-linearity.

Significance of $DEBT$ (and $DEBT^2$, although this result is not displayed here) disappears completely if political variables are included in the estimation. Also, the results concerning interaction term of $ELECDUM$ and $INCR$ are not statistically significant at 10% level. This result is similar to the one we obtained when $EFMAT$ was the dependent variable. Therefore, by dropping insignificant variables one at a time, we end up with a specification where only the variables

[34] We assume that inflation is a stationary process, i.e. that price level contains an unit root. Late 70s and early 80s was marked by a clear deceleration of inflation in almost all the countries studied here, but during late 80s and 90s inflation rates were reasonably stable.

relating to polarisation or fragmentation of the political arena seem to affect the average maturity of fixed-rate government bonds. This is somewhat in contrast with the results we obtained when $EFMAT$ was the dependent variable, as in that specification $DEBT$ was clearly significant. The difference may be due to the fact that there is somewhat less variability in $FIMAT$ than $EFMAT$, as $FIMAT$ omits some important debt classes.

**Table 8b Panel regressions for FIMAT**

| | FIMAT | | FIMAT | | FIMAT | |
|---|---|---|---|---|---|---|
| Variable | FE | RE | FE | RE | FE | RE |
| DEBT | -0.14 (-0.35) | -0.31 (-0.84) | | | | |
| FRAC | -2.61 (-1.60) | -5.51*** | -2.93* (-1.96) | -5.76*** | -2.84* (-1.87) | -5.93*** |
| | | (-3.29) | | (-3.53) | | (-3.63) |
| IPCOH | 1.29*** | 1.29*** | 1.27*** | 1.30*** | 1.30*** | 1.33*** |
| | (3.57) | (4.10) | (3.54) | (4.16) | (3.61) | (4.28) |
| $IPCOH^2$ | -0.25** | -0.26*** | -0.25** | -0.25*** | -0.25** | -0.26*** |
| | (-2.45) | (-2.78) | (-2.40) | (-2.78) | (-2.46) | (-2.87) |
| $ED \times INCR$ | 0.21 (1.54) | 0.19 (1.14) | 0.20 (1.49) | 0.18 (1.08) | | |
| $(ED \times INR)^2$ | -0.07 (-1.49) | -0.09 (-1.56) | -0.06 (-1.47) | -0.08 (-1.55) | | |
| $R^2$ | 0.83 | 0.82 | 0.82 | 0.82 | 0.83 | 0.82 |
| F-stat.(p-v.) | 62.99 (0.00) | | 64.39 (0.00) | | 78.47 (0.00) | |
| N | 265 | 265 | 267 | 267 | 267 | 267 |

t-values in parentheses, *** means the coefficient is significantly different from zero at 1% confidence level, ** at 5% level and * at 10% level

Variables relating to political polarisation or fragmentation have a similar effect on $FIMAT$ as they had on $EFMAT$ earlier. Therefore these results from the political economy model of government debt structure are confirmed also with an alternative dependent variable. Nevertheless, $EFMAT$ represents more closely the theoretical concept used in the derived model, and therefore results from $FIMAT$ regressions must be considered only auxiliary.

Next, we include inflation in the panel regressions explaining government debt maturity[35]. Inflation can, *a priori*, affect the effective maturity in many ways. First, it reduces the real value of outstanding debt stock, and therefore decreases the temptation to inflate *in future periods.* This would increase the effective maturity of government debt. However, there can also be an opposite effect. If inflating

[35] But we revert to using $EFMAT$ as the dependent variable to ensure better compatibility with our earlier results. As for explanatory variables, we start with all relevant political variables used in the previous subsections.

now decreases the credibility of government's economic policies, it can lead to worse time-inconsistency problem. This would lead to lower effective maturity. Presumably, this effect would be stronger when the level of debt is high. Therefore, we shall include also an interaction term between inflation and debt level in the following panel regressions.

**Table 9 Panel regressions for effective maturity, political variables and inflation**

| | EFMAT | | EFMAT | |
|---|---|---|---|---|
| Variable | FE | RE | FE | RE |
| DEBT | 1.57* (1.73) | 1.29 (0.72) | | |
| $DEBT^2$ | -0.78 (-1.00) | -0.39 (-0.34) | | |
| FRAC | -2.93** (-1.99) | -5.68*** (-3.18) | -2.48* (-1.85) | -5.17*** (-3.05) |
| IPCOH | 0.82* (1.95) | 1.01*** (2.85) | 0.91** (2.17) | 1.08*** (3.10) |
| $IPCOH^2$ | -0.14 (-1.21) | -0.18* (-1.79) | -0.17 (-1.40) | -0.21** (-2.04) |
| INF | 0.14*** (4.55) | 0.16*** (3.32) | 0.10*** (4.83) | 0.12*** (4.63) |
| INF × DEBT | -0.36*** (-3.03) | -0.30** (-2.04) | -0.28** (-2.49) | -0.21* (-1.76) |
| $(INF \times DEBT)^2$ | 0.02** (2.06) | 0.01* (1.65) | 0.02** (2.02) | 0.01 (.54) |
| $R^2$ | 0.86 | 0.81 | 0.85 | 0.89 |
| F-stat.(p-value) | 69.17 (0.00) | | 78.18 (0.00) | |
| Total number of obs | 240 | 240 | 240 | 240 |

t-values in parentheses, *** means the coefficient is significantly different from zero at 1% confidence level, ** at 5% level and * at 10% level.

Table 9 reports results from panel estimations where inflation is included among regressors. Again, we proceed from general to specific, and in the initial specification we included $DEBT$, $FRAC$, $IPCOH$, interaction term between $ELECDUM$ and $INCR$, inflation, and interaction term between inflation and the debt level. In addition, we included squared transformations of the aforementioned variables. By dropping the variables which are obviously not statistically significant, we arrive at the specification in the first two columns of table 9. Somewhat curiously, larger debt ratio seems to be associated with higher effective maturity of government debt when contemporaneous inflation is included in the estimation. However, statistical significance of $DEBT$ and $DEBT^2$ is dubious at best. Leaving out $DEBT^2$ does not change the situation, as $DEBT$ remains statistically insignificant.

This leaves us with a specification where the effective maturity of government debt is mainly explained by political variables. However, also inflation seems to influence $EFMAT$, both directly and through the interaction term with the debt level. It appears that both of our conjectures concerning the effect of inflation are reflected in the data. Inflation in itself increases the effective maturity. This could seem somewhat counter-intuitive, but we must remember that inflation, by reducing the real value of government debt, reduces the need for public expenditure in the future periods. However, higher inflation may also be interpreted as a signal of looser future policies. In this case holders of government debt would respond by demanding shorter effective maturity of debt. The interaction term with $DEBT$ may be picking up this effect, because the loss of credibility may be more severe when the level of debt is high.

Which one of the effects dominates? We can calculate different effects of higher inflation on effective maturity for different debt levels. Mean value of debt-to-GDP ratio in our whole sample is 0.48, which forms a natural benchmark. It turns out that when debt ratio is 0.48, inflation has negative effect on effective maturity when inflation is less than 7.5%, but the effect turns positive after that. If debt ratio is higher, negative effect on the effective maturity is also higher as credibility of future policies is weakened. However, if inflation is high enough, effective maturity increases. When debt is sufficiently large, high inflation reduces the future value of debt servicing.

To illustrate this scenario, in the figure 4 dotted line shows the effect of inflation on $EFMAT$ when $DEBT$=1.02 (two standard deviations above the mean). On the other hand, low debt level seems to alleviate the problem of credibility, and higher inflation is associated with higher effective maturity. Obviously, there must a limit as to how many times a government can cheat bond-holders, i.e. high inflation as a permanent strategy for reducing the real value of outstanding government debt is not realistic.

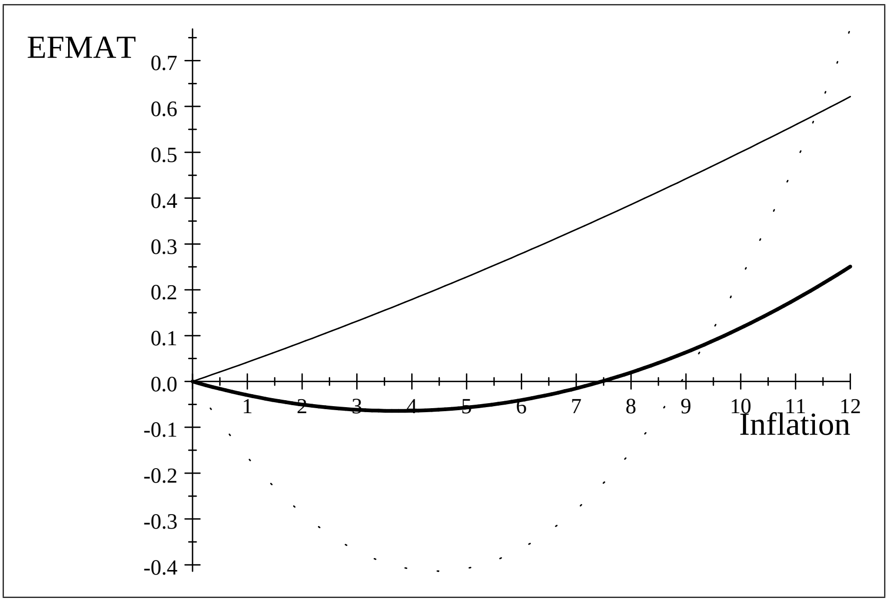

Figure 4: Influence of inflation on effective maturity of government debt with different debt levels: DEBT=0.48 (thick solid line), DEBT=0.21 (thin solid line), DEBT=1.02 (thick dotted line)

Regarding the political variables, the variables regarding fragmentation or polarisation of the political arena have the same signs and practically the same magnitudes also when inflation is included in the panel regression. Therefore the effect of FRAC and the non-linear effect of IPCOH on the effective maturity of government debt can be considered very robust to different specifications.

Therefore our robustness tests do give additional support to the results concerning the effects of debt ratio and political variables on the effective maturity of government debt. However, we have also discovered that inflation has an influence on effective maturity, but its effect depends on the level of debt outstanding.

## 2.6 Concluding remarks

In this section we have presented a model, where political variables and debt level have an influence on the effective maturity of government debt. The model predicts that higher debt ratio decreases the effective maturity, a result which is not unique to this contribution. When a more tax-averse party is in power, higher probability of government change seems to increase the effective maturity, although strictly speaking this result depends on restricting the parameter values in a certain way. (As there seems to be some empirical support for the prediction, these restrictions are probably not too much in conflict with reality.) The result is due to the fact that more tax-averse government would like to avoid spending resources on servicing the government debt.

Even though the model is by necessity highly stylised, its predictions are borne out by the data, perhaps surprisingly well. Debt ratio does have negative and statistically significant influence on the effective maturity of government debt. This result is robust across many different empirical specifications. Previous empirical evidence on the effect of debt ratio on maturity has been somewhat contradictionary, but our results offer clear support for the view that high debt ratio is associated with lower debt maturity.

When the incumbent party is right-wing[36], increasing probability of government change does increase effective maturity. However, this result is not perfectly robust to inclusion of other political variables.

As a robustness check, we also included variables related to the polarisation of the political field in the regressions explaining effective maturity. It seems clear that political fragmentation (or polarisation) is associated with lower effective maturity. However, the effect is not entirely straightforward. Having more parties than one in the government actually increases the maturity, but having a minority government decreases it. We speculated that having a broad-based government, *ceteris paribus*, increases the general credibility of economic policies and reduces the risk of policy reversals in the case of government change.

We also experimented with a different dependent variable (the average maturity of government's fixed-term bonds). Results were mostly qualitatively unaffected, although the statistical significance of many estimations was decreased. Furthermore, we added inflation as a control variable to the regressions. Inflation does seem to affect the effective maturity, and its inclusion also changes other results somewhat. When debt level is high, moderate inflation reduces the effective maturity. However, when inflation is high enough, it increases the effective maturity, presumably because it reduces the future cost of debt servicing. Also, including inflation in the regressions makes the debt ratio statistically insignificant, except when it is interacted with inflation rate.

[36] Which we take to be the same as tax-averse.

Taken together, our empirical results give clear support to the idea that political variables do affect structure of government debt, although their influence may depend e.g. on the debt level.

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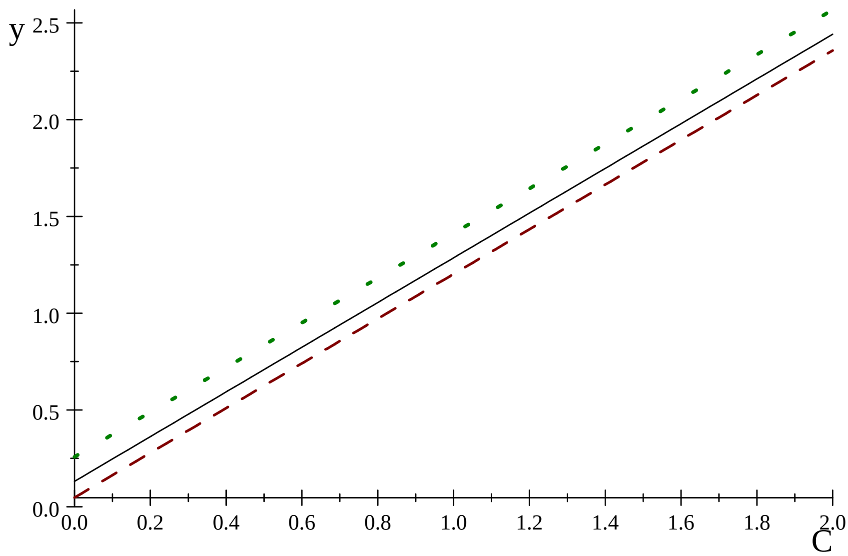
# Appendix A

**Ensuring that $m^*$ is defined, when the more tax-averse party is initially in power**

Remember that $-\frac{\left(-\delta^4\sqrt{\frac{1}{\delta^7}\left(2C+4C\delta+2C\delta^2+p\alpha^2-2Cp-2Cp\delta+p\alpha^2\delta\right)}+\alpha\delta+\alpha\delta^2\right)}{r\beta D(\delta+1)^2}$ is the larger root of $m^*$, and therefore the maximum effective maturity consistent with the reputational equilibrium. Here we show that, with realistic parameter values, the term inside the square root is always positive and hence the square root is defined. We plot expression $2C + 4C\delta + 2C\delta^2 + p\alpha^2 - 2Cp - 2Cp\delta + p\alpha^2\delta$ with the punishment of not being in power, $C$, on the horizontal axis (between 0 and 2). In the figure we fix $p = 0.5$ and $\delta = 0.05$ and let parameter $\alpha$ to vary from 0.3 (dashed red line) to 0.5 (solid thin line) and to 0.7 (green dots). We can see that the value of expression is always positive. This result does not depend e.g. on the value of $p$.



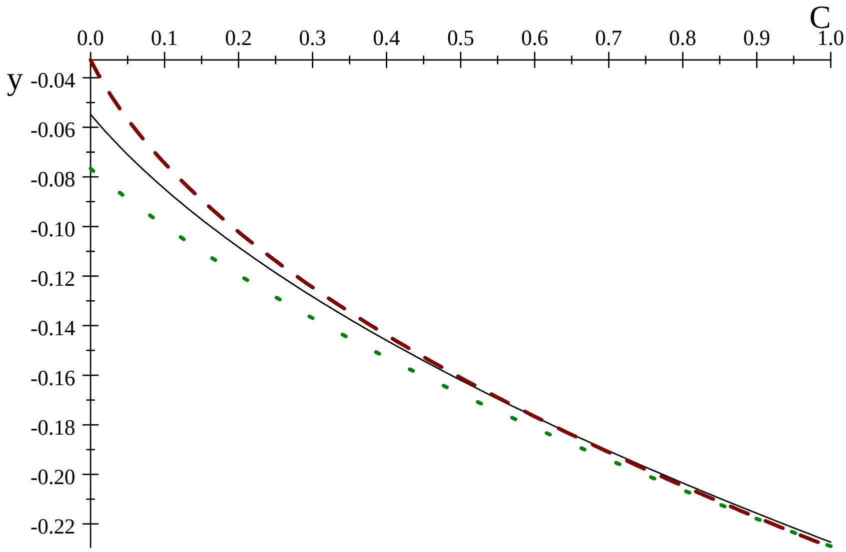

Sign of $2C + 4C\delta + 2C\delta^2 + p\alpha^2 - 2Cp - 2Cp\delta + p\alpha^2\delta$

**Ensuring that $m^*$ is defined, when the less tax-averse party is initially in power**

Remember that $-\frac{\left(\alpha\delta+\alpha\delta^2-\delta^4\sqrt{\frac{1}{\delta^7}\left(2C_B\delta+\alpha^2+2C_B\delta^2-p\alpha^2+\alpha^2\delta+2C_Bp+2C_Bp\delta-p\alpha^2\delta\right)}\right)}{r\gamma D(\delta+1)^2}$ is the larger root of $m^*$, and therefore the maximum effective maturity consistent with the reputational equilibrium. Here we show that the term inside the square root is always positive and hence the square root is defined. For this, we need $2C\delta + \alpha^2 + 2C\delta^2 - p\alpha^2 + \alpha^2\delta + 2Cp + 2Cp\delta - p\alpha^2\delta > 0$. This is equivalent to $2C(\delta + \delta^2 + p + p\delta) > \alpha^2(\delta p + p - \delta - 1)$, which is trivially true since $(\delta p + p - \delta - 1) < 0$ and $C > 0$.

**Sign of $\frac{\partial m^*}{\partial D}$, when the more tax-averse party is initially in power**

Here we will simply show that under plausible parameter values, the derivative of the maximum effective maturity with respect to $D$ is negative. Higher debt level decreases the maximum effective maturity consistent with reputational equilibrium. For $\frac{\partial m^*}{\partial D} < 0$, we need $\alpha\delta - \delta^4\sqrt{\frac{1}{\delta^7}\left(2C + 4C\delta + 2C\delta^2 + p\alpha^2 - 2Cp - 2Cp\delta + p\alpha^2\delta\right)} + \alpha\delta^2 < 0$. As before, we plot this expression with the punishment of not being in power, $C$, on the horizontal axis (between 0 and 1). We plot this expression with the punishment of not being in power, $C$, on the horizontal axis (between 0 and 1). In the figure we fix $\alpha = 0.5, \delta = 0.05, D = 0.5$ and let probability $p$ to vary from 0.3 (dashed red line) to 0.5 (solid thin line) and to 0.7 (green dots) We can see that the expression is negative for the whole interval we are interested in here. Moreover, changing other parameters of the model do not affect the result, and the derivative of $m^*$ is with respect to the debt level $D$ is always negative.

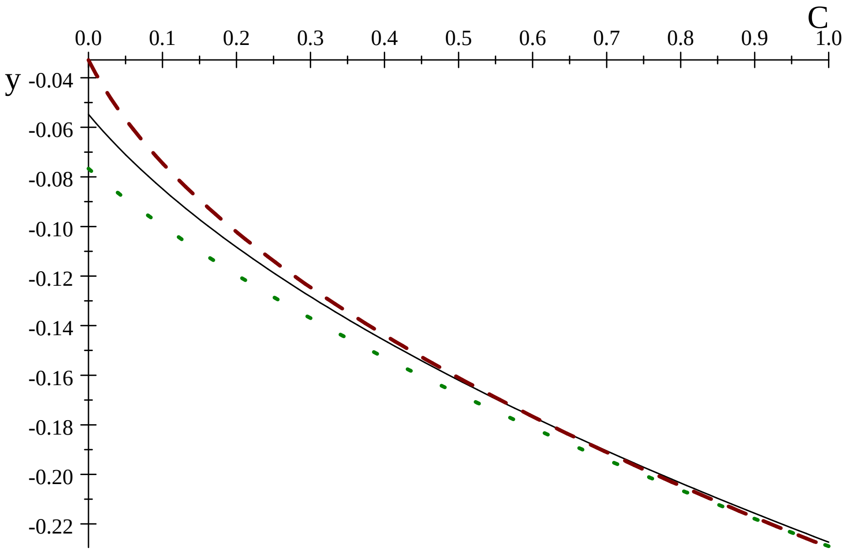



Derivative of $m*$ with respect to $D$ when the more tax-averse government is in power

**Sign of $\frac{\partial m^*}{\partial D}$, when the less tax-averse party is initially in power**

Here we assess $\frac{\partial m^*}{\partial D}$ the same way as above. For $\frac{\partial m^*}{\partial D} < 0$ we require $\alpha\delta + \alpha\delta^2 - \delta^4\sqrt{\frac{1}{\delta^7}\left(2C\delta + \alpha^2 + 2C\delta^2 - p\alpha^2 + \alpha^2\delta + 2Cp + 2Cp\delta - p\alpha^2\delta\right)} < 0$.

We plot $\alpha\delta+\alpha\delta^2-\delta^4\sqrt{\frac{1}{\delta^7}\left(2C\delta + \alpha^2 + 2C\delta^2 - p\alpha^2 + \alpha^2\delta + 2Cp + 2Cp\delta - p\alpha^2\delta\right)}$ with the punishment of not being in power, $C$, on the horizontal axis (between 0 and 1). In the figure we fix $\alpha = 0.5, \delta = 0.05, D = 0.5$,and let probability $p$ to vary. from 0.3 (dashed red line) to 0.5 (solid thin line) and to 0.7 (green dots). We can see that the expression is negative for the whole interval we are interested in here.




Derivative of $m*$ with respect to $D$ when the less tax-averse government is in power

# Appendix B

In this Appendix we will briefly discuss the panel unit root tests used to investigate whether the time series we use are stationary. Also, we report the test statistics obtained from the tests in Table A.1.

Hadri's test is residual-based Lagrange multiplier test. One advantage of Hadri's test is that its size is fairly close to true size even in small samples. In Hadri's statistic the time series are decomposed into a deterministic trend, a random walk and a stochastic disturbance term. Under the null, variance of the random walk component is zero. Hadri's test is an extension of the by-now standard KPSS unit root test for individual time series (Kwiatkowski et al., 1992). More formally (and abstracting from the deterministic trend), time series $y_{it}$ is decomposed into random walk $r_{it}$ and stochastic disturbance $\epsilon_{it}$:

$$y_{it} = r_{it} + \epsilon_{it} \tag{29a}$$

$$r_{it} = r_{it-1} + u_{it} \tag{29b}$$

The null of stationary implies that variance of stochastic disturbance $u_{it}$ is zero, $\sigma_u = 0$. Hadri defines the Lagrange multiplier statistic (which can be normalised to N(0,1)) as

$$LM = \frac{\frac{1}{N}\sum_{i=1}^{N}\frac{i}{T^2}\sum_{i=1}^{T}S_{it}^2}{\widehat{\sigma}_{\epsilon}} \tag{30}$$

Here $S_{it}$ is defined as the partial sum of residuals in a regression of $y$ on fixed effects, i.e. $S_{it} = \sum_{j=1}^{t} e_{ij}$, where t will take values from 1 to T. Denominator of LM statistic is the long-run variance of $\epsilon_{it}$. In the case of serial correlation, the long-run variance is not the same as the variance of residuals from regression 29a, but has to be estimated separately. Hadri's test statistic may be sensitive to this procedure.

Test of Levin et al. (2002) is based on augmented Dickey-Fuller test. The test statistic is calculated from residuals of two regressions:

$$\Delta y_{it} = \sum_{l=1}^{P_i} \pi_{1,il}\Delta y_{it-l} + \alpha_{1,mi}d_{mt} + e_{it} \tag{31a}$$

$$y_{it} = \sum_{l=1}^{P_i} \pi_{2,il}\Delta y_{it-l} + \alpha_{2,mi}d_{mt} + v_{it} \tag{31b}$$

Here $d$ denotes the relevant set of deterministic variables (in our empirical application constant, and constant and trend). The lag order $P_i$ can differ between cross-sections, and it is determined from individual ADF tests:

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=1}^{P} \delta_i \Delta y_{t-i} + \alpha_m d_m + \epsilon_t \tag{32}$$

Residuals $e$ and $v$ have to normalised by residuals $\epsilon$ to control for the heterogeneity between cross-section units in the panel. The normalised residuals, $\tilde{e}$ and $\tilde{v}$, are used to estimate the following regression:

$$\widetilde{e}_{it} = \beta \widetilde{v}_{it-1} + u_{it} \tag{33}$$

If the underlying model has fixed effects or individual trends, the t-statistic of $\beta$ must be corrected using the first and second moments calculated by Levin et al. and the ratio of long-run to short-run variance. The resulting test statistic has then normal distribution as $N \to \infty$ and $T \to \infty$. According to simulations in Levin et al. (2002), the test performs reasonably well, when the size of the panel is "moderate", i.e. N=10 and T=50 or N=25 and T=25. Our panel is somewhat smaller than this, however.

The test of Im et al. (2003) is based on individual augmented Dickey-Fuller tests[37] (ADF). The test statistic, t-bar, is average over individual ADF statistics:

$$t - bar = \frac{1}{N} \sum \widetilde{t}_{iT} \tag{34}$$

The resulting t-bar statistic can be normalised by the first two moments of the distribution of $\widetilde{t}$. The normalised statistic has a N(0,1) distribution as $N \to \infty$ and $T \to \infty$.

Table 2 reports the results of panel unit root tests.

[37] Dickey-Fuller test statistic is due to Dickey and Fuller (1981). More formally, unit root in time series $y_t$ is tested with a regression $\Delta y_t = \alpha + \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i}$. The coefficient of interest is $\gamma$. If $\gamma = 0$, the variable has a unit root and is non-stationary. This is also the null hypothesis of Dickey-Fuller test. If $\gamma < 0$, $y_t$ is stationary. Critical values of the test statistic depend on the deterministic components included in the regression.

**Table A.1 Value of unit root tests**

| Test | Hadri (2000), $Z_{\mu}$ | | Im et al.(2003), t-bar | | Levin et al.(2002), | |
|---|---|---|---|---|---|---|
| Null hypothesis | All time series are stat. | | All time series are non-stat. | | All time series are non-stat. | |
| Alternative hyp.s | | | Some time series are non-stat. | | All time series are stat. | |
| Det. components | | | Constant | Constant and tr. | Constant | Constant and tr. |
| Other spec. | Heterogeneous | Serial depend. | | | | |
| | panel | in errors | | | | |
| DEBT | 35.749*** | 13.195*** | -1.825* | -1.588 | -0.0784*** | -0.17811 |
| EFMAT | 16.749*** | 6.581*** | -2.416*** | -4.329*** | -0.1822*** | -0.5535*** |
| FIMAT | 18.405*** | 6.620*** | -2.201*** | -2.933*** | -0.1990*** | -0.4655*** |

*** signifies rejection of the null hypothesis at 1% confidence level, ** at 5% level and * at 10% level. In all tests the lag length was set at 2.

Both from looking at the charts depicting the time series and from the panel unit root tests, it appears that we can at least reject the hypothesis that all series are stationary within our sample period. Hadri's LM test rejects this very clearly. Rejection does not depend on whether we include as deterministic components a constant, a constant and a trend, whether we assume homogeneous or heterogeneous intercepts and short-run responses, or serial dependence in errors. On the other hand, it appears that not all time series are non-stationary either, especially if only a constant is included $DEBT$ appears to stationary around a trend, according to Im et al. and Levin et al. tests. For $EFMAT$ and $FIMAT$ the evidence is even more mixed. Hadri's test rejects the hypothesis that all time series are stationary, but at the same it appears to be clear that all the series are not non-stationary either. One possible reason for these contradictory results is that the time series contain structural breaks.

Given the mixed empirical evidence and our strong theoretical priors, we shall primarily treat all the variables as stationary. Robustness checks with differenced variables indicate that specifications with variables in levels have much better fit. Also, differenced variables rarely have statistically significant coefficients in estimations. These estimations are not reported here.

Most political variables are merely dummy variables or indicators bounded between some predetermined limits (e.g. $HERFTOT$ and $HERFGOV$). Therefore they can be treated as stationary.

# Appendix C

In this Appendix we review in more detail two models of government debt structure, Missale and Blanchard (1994) and Milesi-Ferretti (1995). These two models are closely related to the model developed in this essay.

**C.1 Missale and Blanchard (1994)**

In their model Missale and Blanchard (1994) study the relationship between the government debt burden and maturity. First they observe that in three countries with high government debt burden (close to or in excess of 100% of the nominal GDP), i.e. Belgium, Ireland and Italy, the level of government debt and its effective maturity tend to move in opposite directions. They try to explain this stylized fact with a model where the government's incentive to engineer an inflation in the economy increases with the maturity of the government debt. The model is presented here in fairly detailed manner, because the political economy model of government debt maturity introduced in the essay is based on this one.

In the model government faces a temptation to inflate the economy for two reasons. First, there is the usual temptation arising from the temporary expansionary effects of unanticipated inflation, as in Barro and Gordon (1983). Second, the novel feature of the model is that the incentive to inflate is also related to the stock of outstanding government debt. Servicing of the outstanding debt requires resources, which have to be acquired by taxation. It is assumed that the government dislikes taxation, perhaps because of the welfare losses it creates. If the real value of the debt outstanding is reduced in the initial period, then taxation can be reduced in all future periods. More formally, government's one-period loss function is

$$L = \frac{1}{2}\pi^2 - \alpha(\pi - E\{\pi\}) + \beta T \tag{35}$$

Here $\pi$ is the actual inflation rate, $E\{\pi\}$ the expected inflation and $T$ taxes. The coefficient of inflation is chosen to be $\frac{1}{2}$ for the sake of simplicity, $\alpha$ and $\beta$ are positive constants. (All through the presentation the terms without time subscripts refer to the first period, and the subscript $t+1$ is used to denote the next period.) Therefore the government gets disutility from inflation and also taxes, perhaps because they add distortions to the economy. The government gains in any period if the actual inflation is higher than expected inflation. One can postulate that surprise inflation creates an economic boom, which benefits also the government The government minimizes the present discounted value of one-period loss functions from the present time period to infinity. In the model the government inherits a an initial stock of debt $D$, which evolves over time according to the following accumulation equation:

$$D_{t+1} = (1+r)[1 - m(\pi - E\{\pi\})]D + G - T \tag{36}$$

Here $r$ is the interest rate on the government debt (in absence of surprise inflation the nominal and real interest rates are the same), $G$ is the primary government expenditure (i.e. expenditure apart from the interest paid on the government debt) and $T$ taxes. The level of government debt in the next period is given by $D_{t+1}$. The government debt is held by the private sector of the economy. In the present model $m$, the *effective maturity* of the government debt, is a key variable.

Missale and Blanchard define effective maturity as the effect of an unexpected inflation on the real value of the government debt. Therefore it is not the same thing as the average maturity of government debt. It is assumed that foreign currency denominated debt has an effective maturity of zero, because the government can not change its real value by engineering an inflation. If there is inflation, the nominal exchange rate will depreciate (restoring the purchasing power parity between the home country and the rest of the world) and the real value of the foreign currency denominated bond remains unchanged. Without any loss of generality, the primary government expenditure $G$ is assumed to be zero.

When the government uses taxes only to pay for the interest on its debt, $T$ is

$$T = r[1 - m(\pi - E\{\pi\})]D \tag{37}$$

Here one can already observe the reason why government might want to inflate: it reduces the taxes needed to collect for servicing the debt already in the first period. Moreover, there is a second incentive. Equation 36 can be rewritten with the help of equation 37:

$$D_{t+1} = [1 - m(\pi - E\{\pi\})]D \tag{38}$$

The level of government debt can be reduced by unexpected inflation, which is understood by the private sector.

In the model government inherits a stock of debt, $D$, and then decides on the effective maturity of that debt, $m$.[38] After observing the

[38] In the model it is implicitly assumed that the capital markets function perfectly and the government can attain the desired maturity without any costs. In practice this may not always be the case.

effective maturity, the private sector forms its inflation expectations. After this the government chooses the inflation rate.

Ex ante, the optimal policy for the government would be to choose a zero inflation. However, as is typical in such models, the optimal ex ante policy is not time-consistent. In this model, the private sector follows a trigger strategy: as long as the government refrains from inflating, the private sector sets $E\{\pi\} = 0$. If the government cheats in the initial period, i.e. inflates, the private sector assumes that the government will act in a similar manner also in all future periods. In the model government must decide in the initial period whether to inflate or not. To do this, it compares the discounted value of loss functions from the initial period to the infinity under the two alternatives.

First, if the government does not inflate, it maintains the reputational equilibrium, and inflation is always zero. In this case, the discounted value of the loss functions is

$$V^R = (1 + \frac{1}{\delta})L^R = (1 + \frac{1}{\delta})\beta r D \tag{39}$$

Here the superscript R refers to the reputational equilibrium. Inflation and inflation expectations are zero from the initial period onwards, and therefore the government receives disutility only from taxes, which are levied to pay for the interest on the government debt. Values of the future loss functions are discounted with the discount rate $\delta$. It is worth noting here that the value of discounted loss functions, $V^R$, is increasing in the level of government debt.

The government has also an option to cheat, i.e. inflate in the initial period. Because the private sector is assumed to follow a trigger strategy, if the government inflates, it loses credibility for all future periods, and the inflation is expected to be larger than zero in all future periods. Because of this, the government will set the effective maturity $m$ to zero. If the maturity were higher than zero, the government would have an added incentive to inflate. The private sector would perceive this, and would expect higher inflation, which in turn would result in higher actual inflation and higher value of the loss function. Therefore, in the period $t + 1$ the government's loss function can be written as

$$L^C_{t+1} = \frac{1}{2}\pi^2_{t+1} - \alpha(\pi_{t+1} - E\{\pi_{t+1}\}) + \beta r D_{t+1} \tag{40}$$

As it is assumed that $E\{\pi_{t+1}\} > 0$, the optimal rate of inflation is $\alpha$ and then the $E\{\pi_{t+1}\} = \alpha$ as well. The present value of loss functions discounted to the period $t+1$ is

$$V_{t+1}^C = (1+\frac{1}{\delta})(\frac{1}{2}\alpha^2 + \beta r D_{t+1}) \tag{41}$$

Here the superscript $C$ refers to cheating. The last term of equation 41 reveals how the government can decrease its discounted losses from taxation by reducing the value of $D_{t+1}$ through surprise inflation in the first period. If the only incentive to inflate came from taxation (i.e. $\alpha = 0$), the government would set the inflation to be zero also in all future periods after cheating in the first period.

In the first period the government decides whether to inflate or not by comparing the values of discounted loss functions under reputational equilibrium and cheating. The discounted value of loss function in the first period in the case of cheating can be obtained by combining equations 35 and 41:

$$V^C = \frac{1}{2}\pi^2 - \alpha\pi + \beta r(1-m\pi)D + \frac{1}{1+\delta}[(1+\frac{1}{\delta})(\frac{1}{2}\alpha^2 + \beta r D_{t+1})] \tag{42}$$

Using 38 and simplifying gives the following expression for the discounted government loss under cheating:

$$V^C = \frac{1}{2}\pi^2 - \alpha\pi + \frac{\alpha^2}{2\delta} + (1+\frac{1}{\delta})(1-m\pi)\beta r D \tag{43}$$

We can solve the optimal inflation under cheating by minimizing equation 43 with respect to the inflation. Setting the derivative to zero ($\frac{\partial V^C}{\partial \pi} = 0$) allows us to solve for the optimal inflation:

$$\pi = \alpha + (1+\frac{1}{\delta})\beta r m D \tag{44}$$

The optimal inflation under cheating is increasing in the benefit of the surprise inflation not associated with the value of government debt, $\alpha$, and the effective maturity of the debt $m$ as well as its level, $D$. Substituting the optimal inflation from equation 44 into equation 43 gives us the value of loss function under cheating $V^C$

$$V^C = -\frac{1}{2}[\alpha + (1+\frac{1}{\delta})\beta r m D]^2 + (1+\frac{1}{\delta})\beta r D + \frac{\alpha^2}{2\delta} \tag{45}$$

Now one can solve for the maximum effective maturity which is consistent with the reputational equilibrium. This maximum maturity $m^*$ is solved by requiring that value of the loss function in the reputational equilibrium, $V^R$, is not larger than the value of the loss function when the government cheats, i.e. $V^C$. By using equations 39 and 45 we can express the condition for reputational equilibrium ($V^R - V^C \leq 0$) in the following form:

$$-\frac{1}{2}[\alpha + (1+\frac{1}{\delta})\beta rmD]^2 + (1+\frac{1}{\delta})\beta rD + \frac{\alpha^2}{2\delta} \geq (1+\frac{1}{\delta})\beta rD \quad (46)$$

From this expression one can solve the $m^*$ by treating the inequality as a strict equality. As can observed, the resulting polynomial is quadratic in $m$, and therefore it has two solutions, one positive and one negative. Because we are looking for the maximum effective maturity consistent with the reputational equilibrium, it is natural to concentrate on the positive solution.[39] The maximum effective maturity consistent with the reputational equilibrium and hence zero inflation is:

$$m^* = \left(\sqrt{\delta} - \delta\right) \frac{\alpha}{D\beta r\,(1+\delta)} \quad (47)$$

This solution is positive because it is assumed that the discount rate $\delta < 1$, and therefore $\sqrt{\delta} > \delta$.[40] The maximum maturity is decreasing in the level of debt, which is consistent with the evidence of at least some of the highly indebted countries. The maximum maturity is also decreasing in the disutility the government gets from taxes, $\beta$. Intuition behind the result is clear: if government receives disutility from taxes, it wants to reduce them.

In the model the only way to reduce taxes (because other government expenditure is zero) is to lower the value of the outstanding government debt in the first period, which in turn reduces debt servicing costs in all future periods. It is interesting to note that the maximum effective maturity is increasing in $\alpha$, i.e. the temptation to inflate for other reasons than reducing taxes.

The model is naturally fairly sparse, and the authors also discuss some of its shortcomings and possible extensions. First, the way taxes are assumed to behave makes the level of government debt constant over time in absence of inflation. However, in Missale & Blanchard (1991) the model is extended to allow for changes in the government spending. In this extension the loss function 35 is modified to be quadratic in taxes, which in turn gives rise to tax smoothing and non-trivial debt dynamics. It turns out that the inverse relationship

[39] This same property of the solution is encountered again in the political economy model of the problem.

[40] The negative solution is $m = \left(-\sqrt{\delta} - \delta\right) \frac{\alpha}{D\beta r(1+\delta)}$

between the level of government debt and its effective maturity survives also in this alternative set-up.

The second potential problem associated with the model concerns the maximum effective maturity consistent with the reputational equilibrium, $m^*$. It should be remembered that this is indeed the *maximum* possible maturity, and in principle the government could choose any maturity between zero and $m^*$ while maintaining the reputational equilibrium. However, we rarely see governments actually choosing zero effective maturity, i.e. borrowing just in foreign currencies or with very short-term domestic debt certificates. Therefore, there almost certainly are some reasons why governments do prefer to have non-zero maturity on their debt.

The first of these possible reasons has already been discussed earlier. The risk of refinancing the outstanding debt could induce governments to issue bonds with longer maturities. If the amount of debt maturing in each period is fairly stable and not too large a fraction of the whole debt, then there is smaller probability that the government experiences difficulties in refinancing the maturing debt.

However, this explanation may not be the most relevant in the present context. Missale and Blanchard (1994) argue that the relevant maturity concept in the model is *effective* maturity: The government could issue just 10-year foreign currency bonds and the debt would still have an effective maturity of zero. Nevertheless, they do not consider the possibility that governments might want to diversify their debt portfolio across different currencies because obviously purchasing power parity (PPP) does not hold in the short- or even in the medium-run.[41] Therefore governments would presumably always want to issue some debt in the domestic currency.

In principle governments could then issue e.g. domestic debt indexed to the price level, which would also have an effective maturity of zero. The fact that so few governments actually do so may suggest that such indexation schemes are still unattractive for investors, perhaps because the details of indexation are not transparent enough, and in any event the data on price level becomes available only with delay. This would give some room for issuing nominal debt papers denominated in the domestic currency, which again brings in the question of refinancing risk.

The second, perhaps more plausible explanation for the govern-

[41] However, the PPP probably holds in the long-run, i.e. several decades. For recent studies concerning (and confirming) the empirical validity of long-run PPP, see e.g. Koedijk et al. (1998), and Higgins and Zakrajsek (1999).

ments propensity to choose a non-zero effective maturity, is offered by Bohn (1988). He argues that when taxes are distortionary and there are stochastic shocks to the budget, the optimal composition of the government debt will always include nominal debt. It is optimal for the government to smooth taxes across states of nature as well as across time. This result holds, even though the issuance of nominal debt will result in an incentive to inflate and higher inflation on the average.

In his model Bohn shows that it is socially optimal for the government to issue nominal debt, because in the event of a negative shock to the economy, the shock will also depress the price level and therefore the real value of government debt. This in turn reduces the resources needed for servicing the debt. The price level effect may reduce the amount of required taxes, which is welfare improving when taxes are distortionary. Therefore the government will always prefer to have a non-zero effective maturity. Bohn (1990) provides empirical evidence on tax smoothing with U.S. data and finds strong support for issuing nominal government debt. However, the evidence concerning optimal maturity structure of the government debt is weak.

**C.2 A two-party model of government debt structure**

Milesi-Ferretti (1995) develops a political economy model where a government facing election may manipulate policy instruments in order to increase its re-election probability. In the model two parties have different preferences concerning inflation, and they also derive utility from being in power. The incumbent party can issue either nominal or indexed debt before the election, which in turn affects the potential benefits of inflating after the election; the real value of nominal debt can be decreased by inflation.

In the model the more inflation-averse party can issue nominal debt, which increases the likelihood of inflation, if the less inflation-averse party is voted in the power. The median-voter realises this threat, and is more likely to vote for the inflation-averse party. Symmetrically, the more inflation-prone party, if in power, may issue indexed debt in effort to reduce the incentive to inflate after the election.

More formally, there are two parties, Left and Right, and their loss functions are increasing in inflation, level of taxation, and in being out of power (i.e. the parties like being in power):

$$L_L = \frac{1}{2}(\lambda_L \pi^2 + T^2) + \zeta C \tag{48}$$

$$L_R = \frac{1}{2}(\lambda_R \pi^2 + T^2) + (1-\zeta)C \qquad (49)$$

The subscripts $L$ and $R$ refer to the left- and right-wing party, $\lambda_L$ ($\lambda_R$) is the weight given by the Left (Right) to the inflation in its loss function, $C$ is the cost of being out of power, and $\zeta$ takes the value of one (zero) when Right (Left) is in power. Other notation is as in the previous subsection.[42] It is assumed that Right is more inflation averse than Left, i.e. $\lambda_R > \lambda_L$. There is a continuum of voters indexed by j, and they differ in the weight they give to inflation in their own loss functions:

$$L_j = \frac{1}{2}(\lambda_j \pi^2 + T^2) \qquad (50)$$

Furthermore, it is assumed that the median voter has preferences which are between the two parties: $\lambda_R \geq \lambda_j \geq \lambda_L$. In the model the government raises taxes $T$ in order to finance real government expenditure $G$, and service nominal and real debt. The debt is held by private agents of the economy. The ratio of inflation-indexed debt to the total debt is given by $\theta$. As before, $r$ is the real interest rate and $i$ is the nominal interest rate. Then the government's budget constraint is given by:

$$T + k\pi = G + \theta D(1+r) + (1-\theta)D(1+i-\pi) \qquad (51)$$

In this model government also raises revenue from seigniorage, and the revenue from this source is given by $k\pi$. Otherwise the notation is as before. Private agents are risk neutral and have perfect foresight, so in equilibrium the expected real return on nominal debt must equal the (world) real interest rate. The sequence of the game between the parties and the private sector is almost identical to the model developed in this essay, but there are also some significant differences.[43] In the model of Milesi-Ferretti (1995) the game proceeds as follows:

1. The government inherits a stock of debt, $D$.
2. The government decides on the structure of the debt, i.e. on the parameter $\theta$.
3. The government and the opposition party announce their future policy in $\pi$ and $T$.

[42] Again, the notation is somewhat different from the original contribution in order to preserve compatibility with the other models studied and developed in more detail.

[43] These are discussed in detail in section 3.

4. Elections take place and the median voter chooses the party to be in power.

5. The nominal interest rate $i$ is determined.

6. The government chooses $\pi$ and $T$.

The investors know the preferences of the parties and thus they are able to forecast the realized inflation. Therefore also the nominal interest rate, which is determined after the elections, can be forecast. As is often the property of such models, in the case of credible and effective commitment, the structure of the government debt becomes irrelevant. Both governments will announce - and execute - the policy preferred by the median voter. Therefore the inflation and tax rate would be:

$$\pi = \frac{k}{k^2 + \lambda_j}[G + D(1 + r)] \tag{52}$$

$$T = \frac{\lambda_j}{k^2 + \lambda_j}[G + D(1 + r)] \tag{53}$$

The parties will want to pursue the policies preferred by the median voter because they dislike being out of power (the term $C$ in equations 48 and 49). And because the median voter decides on the party being in the party, deviating from her preferences would imply losing the election with a probability of one.

However, when credible commitment is not possible, there is scope for using the structure of the government debt to affect the result of the election. As a benchmark case Milesi-Ferretti first considers the case where there are no elections, but the government cannot commit itself credibly. The model is solved recursively starting from the last stage where the government chooses inflation and taxes. At the last stage the structure of the government debt (i.e. the parameter $\theta$) is taken as given. Therefore the government (Left or Right) minimizes its loss function subject to the budget constraint 51. It is observed that if only a portion of the government debt is indexed, then the relevant tax base for inflation tax is also larger.

The government has two instruments to collect the needed revenue, the ordinary tax intake $T$ and inflation tax, which depends on parameter $k$ and inflation rate $\pi$. These both entail distortionary costs in the economy, and the government will equalize the marginal costs associated with both of these instruments. The inflation rate and taxes under discretion are then given by[44]:

$$\pi_i = \frac{(1-\theta)D + k}{\lambda_i + k[(1-\theta)D + k]}[G + D(1+r)] \quad i = L, R \tag{54}$$

$$T_i = \frac{\lambda_i}{\lambda_i + k[(1-\theta)D + k]}[G + D(1+r)] \quad i = L, R \tag{55}$$

If only a part of the government debt is indexed, in the discretionary equilibrium the inflation will be higher than in the case of credible commitment, and fully anticipated by the private sector, exactly as in the benchmark model of Barro and Gordon (1983). However, if there are no elections, the government can remove the ex post incentive to use part (or all) of the government debt as a tax base for the inflation tax by *indexing all of the debt.* Intuition for this result is simple enough: if there is no tax base for the inflation tax, the government will have no incentive to inflate as inflation itself is costly. However, the result would not hold if the inflation tax on money held by the private sector (term $k\pi$ in the budget constraint 51) would depend on expected inflation.

More interestingly, when elections are held, there is a genuine role for the structure of the government debt to influence the ex post incentive faced by the elected government and, consequently, the decision of the median voter. In the model the median voter decides whether the Left or Right party is in power after the elections, and the median voter will prefer the party who will deviate the least from her desired inflation rate and taxes as given by equations 52 and 53. An examination of these equations reveals that the inflation rate or taxes preferred by the median voter do not depend on the structure of the government debt (i.e. the parameter $\theta$). However, from the equations 54 and 55 it is obvious that the inflation and tax rates chosen by the party when in power do depend on the parameter $\theta$. Therefore the structure of the government debt also influences which party the median voter will choose in the elections.

The value of indexation parameter $\theta$ at which the median voter is indifferent between the two parties is determined by replacing inflation and tax rates in the median voter's loss function with their values from equations 54 and 55, and setting the loss functions under

[44] The subscripts L and R refer to the Left and Right parties, respectively.

the two potential governments equal.[45] Then the maximum value of $\theta$ that ensures the re-election of a Right incumbent and the minimum value of $\theta$ that ensures the re-election of a Left incumbent can be solved from the following equality[46]:

$$\pi_L(\theta_E) - \lambda_j = \lambda_j - \pi_R(\theta_E) \tag{56}$$

If the indexation parameter $\theta$ is high, the Left would implement inflation rate closer to the preferences of the median voter than the right. Conversely, if the indexation parameter is low, the Right would choose an inflation rate closer to her preferences. The intuition is again fairly clear: because the Left is more prone to engineer higher inflation, it should tie its hands ex ante by indexing a large portion - or all - of the outstanding government debt.

Because the value of the indexation parameter $\theta$ affects the choice of the median voter, the incumbent party can use it strategically to affect the outcome of the elections. For example, issuance of more nominal debt by an incumbent Right government would favour the Right party in the elections, because the median voter would perceive lower indexation parameter as an indication of higher inflation, if the Left party would be in power after the elections. The effect is naturally the opposite, if the Left party is incumbent: It can increase its chances of re-election by issuing more indexed debt in order to reduce the ex post incentive to inflate more than the median voter would like.

In fact, if the costs of being out of power are sufficiently high, both parties will choose exactly $\theta = \theta_E$. This will happen even when the parties have partisan preferences, if the cost of being out of government is sufficiently high.

However, if it is assumed that the parties are purely partisan, i.e. they care only about the policy outcomes and do not receive extra utility from being in power, the indexation parameter $\theta$ can be used strategically to ensure that the government in power after the election will follow policies preferred by the incumbent. Then the exact values of $\theta$ depend on the preferences of the median voter. However, as Milesi-Ferretti points out, the assumption of pure partisanship is probably not the most realistic one.

[45] This is an important difference from the model to be introduced in Section 3, where the probability of a government change is exogenous.

[46] After expressing taxes as a function of inflation and substituting them into the loss function of the median voter.

The model of Milesi-Ferretti has also empirical implications. For reasons related to voting, the Right party would prefer to issue nominal debt ahead of elections to expand the tax base for surprise inflation. This in turn would increase their probability of being re-elected. Conversely, the Left party would like to issue indexed debt to reduce the potential gains from surprise inflation. On the other hand, partisan preferences work in the other direction. Incumbent can choose the indexation parameter so that the new government will follow the incumbent's preferred policy. Which effect dominates depends on the relative size of the cost of being out of government to the benefits of "right" economic policies.

# 3 Central bank independence and government debt maturity

Many models of government debt structure assume that there is a single public entity, government, which controls all the relevant macroeconomic variables, inflation, tax rate and government debt maturity. The government debt maturity can then be used as a commitment device to ensure a low-inflation equilibrium. The importance of government debt structure depended on the inability of the government to commit ex ante to low inflation. In more general terms, difficulty of committing to ex ante optimal policies was explored by Barro and Gordon (1983) in the context of monetary policy. (They also mentioned a possibility of using surprise inflation to reduce the real value of government debt.)

Of course, government debt structure is not the only possible commitment device. In the field of monetary policy greater central bank independence has often been suggested as a possible solution to this problem of time inconsistency. If monetary policy would be conducted by an institution which is not affected by the time inconsistency problem to a same degree, the policy outcome could be different.

For example, introducing a central bank with at least some independence in setting inflation (i.e. monetary policy) can reduce the time inconsistency problem. This essay presents a model where the central bank has some degree of independence in setting inflation rate, although also the government (or the fiscal agent) has a role to play. Preferences of the central bank differ from those of the government. In the model to be presented the government decides whether to inflate or not. If the government wants to inflate, the actual (non-zero) inflation rate is decided jointly with the central bank according to the relative bargaining strength of the central bank and the government. High bargaining power of the central bank is interpreted to signify a high degree of central bank independence. The larger is the independence of the central bank, the higher is the maximum maturity of the government debt consistent with the policy of no inflation. However, because the central bank is never fully independent[47], there is also room for the maturity of government debt in alleviating the time inconsistency problem. Nevertheless, the interaction between central

[47] I.e. there is always a possibility that the government introduces legislation changing the legal status of the central bank.

bank and the government has bearing on the choice of the optimal government debt structure, as well.

There have been a limited number of papers exploring the idea that central bank independence and the government debt structure are related.

Falcetti and Missale (2002) develop a model where delegation of monetary policy to an independent central bank reduces government's temptation to inflate away the real value of outstanding public debt. As is usual in such models, there is the usual temptation for an government to use higher inflation to smooth output fluctuations.And, as is usual in the literature, this results in a time-inconsistency problem. In addition, there is temptation to inflate in order to reduce the real value of outstanding government debt. However, in the model monetary policy and setting of inflation can also be delegated to a central bank, which may have different loss function than the government itself. Of course, this set-up is familiar from a number of contributions concerned with central bank independence and delegation of monetary policy.

Falcetti and Missale look at some of the empirical evidence concerning composition of government debt and central bank independence. They note that the share of nominal debt has increased or stayed the same in a sample of 20 OECD countries from the 1970s to 1990s. As central banks have generally become more independent during this time period, the authors conclude that predictions of the model are confirmed. Delegating responsibility for monetary policy to a more independent central bank has allowed government to issue more nominal debt, which improved welfare. Also, the share of long-term debt in total debt stock has increased in almost all countries since the 1980s. For further evidence, Falcetti and Missale regress share of nominal debt and share of long-term nominal debt on indices of central bank independence and a set of control variables (debt ratio, government consumption and exchange rate regime). They find support for the theory, and higher central bank independence clearly increases the shares of both nominal and long-term nominal debt in the total debt stock. However, their dataset remains quite limited. In this essay we will utilise a larger dataset and employ panel methods, which hopefully allows us to explore to issue even further.

Miller (1997) includes an index of central bank independence in an empirical examination on the determinants of government debt maturity. She finds that a higher degree of central bank independence allows countries to have longer government debt maturity (proxied by a share of government debt that matures in more than one year). However, Miller concentrates more on the effects of political uncertainty, and the way higher central bank independence affects the maturity decision is not formalized in any way. Also, in the empirical estimation only the average maturity in 1980-82 is used.

## 3.1 A model of central bank independence and government debt structure

If one believes that it is the temptation to inflate which gives importance to the government debt structure as a commitment device, then greater central bank independence presumably reduces the need for this commitment device. If management of monetary policy (and consequently inflation) is given to some other institution then government, which is responsible for fiscal policy (and government debt structure), the motive to inflate away some part of the real value of government debt should at least be decreased.

In recent years many OECD (and other) countries have increased the independence of their central banks and given them an explicit mandate to pursue policies conducive for low and stable inflation.[48] These tendencies could have implications for the management of government debt structure as well. In the following we present a model of government debt structure which also incorporates a separate monetary authority with a different objective function from the government.

The model is based on the framework of Missale and Blanchard (1994). First the emphasis is on the actions of the government based on the contribution of Missale and Blanchard, and then interaction between the government and central bank is introduced.

### 3.1.1 Government

We have a government with the following one-period loss function:

$$L = \frac{1}{2}\pi^2 - \alpha(\pi - E\{\pi\}) + \beta T \tag{57}$$

The notation is standard: $\pi$ is the actual inflation rate, $E\{\pi\}$

[48] For a recent overview of theoretical and empirical literature on central bank independence, see Berger et al. (2000).

the expected inflation and $T$ taxes. Parameters $\alpha$ and $\beta$ are positive constants denoting the relative importance of taxes and surprise inflation in the loss function. The government dislikes inflation and taxes, perhaps because they introduce distortions to the economy. The government gains in any period if the actual inflation is higher than expected inflation. One can postulate that surprise inflation creates an economic boom, which benefits also the government. The government inherits a stock of debt, and this evolves over time according to the following accumulation equation:

$$D_{t+1} = (1 + r)[1 - m(\pi - E\{\pi\})]D + G - T \tag{58}$$

The variables without subscripts refer to the first period, and obviously subscript $t + 1$ is used to refer to the value of a particular variable in the next period. It is assumed that the government's primary expenditure $G = 0$, and taxes are used solely to finance interest payments on the outstanding government debt, $D$. Ex ante real interest rate is $r$, and $m$ is the effective maturity of the government debt. Taxes are set so that in absence of surprise inflation the government debt remains constant:

$$T = r[1 - m(\pi - E\{\pi\})]D \tag{59}$$

In the model government inherits a stock of debt, $D$, and then decides on the effective maturity[49] of that debt, $m$.[50] After observing the effective maturity, the private sector forms its inflation expectations. Then the government decides whether to inflate or not.

Ex ante, the optimal policy for the government would be to choose a zero inflation. However, as is typical in such models, the optimal ex ante policy is not necessarily time-consistent. If the government does not inflate, it maintains the reputational equilibrium, and inflation

[49] Effective maturity essentially describes how much the real value of government debt reacts to unexpected inflation. For example, in the model it is assumed that purchasing power parity applies, and therefore the real value of debt denominated in foreign currencies cannot be affected by inflation. If a government decides to engineer an inflation, the exchange rate depreciates in line with the inflation. The effective maturity of foreign currency denominated bonds is zero. Also government bonds indexed to inflation have zero effective maturity. The effective maturity of government bonds with floating interest rate coupons depends on the interest rate the bond is indexed to. For a more comprehensive definition and discussion, see subsection 2.5.1.

[50] In the model it is implicitly assumed that the capital markets function perfectly and the government can attain the desired maturity without any costs. In practice this may not always be the case.

is always zero. In this case, the discounted value of its loss function would be

$$V^R = (1 + \frac{1}{\delta})L^R = (1 + \frac{1}{\delta})\beta r D \qquad (60)$$

Here the superscript R refers to the reputational equilibrium. Inflation and inflation expectations are zero from the initial period onwards, and therefore the government receives disutility only from taxes, which are levied to pay for the interest on the government debt. Values of the future loss functions are discounted with the discount rate $\delta$. It is worth noting that the value of discounted loss functions, $V^R$, is increasing in the level of government debt.

The government has also an option to cheat, i.e. inflate in the initial period. The private sector is assumed to follow a trigger strategy, and if the government inflates, it loses credibility for all future periods. Then inflation is expected to be larger than zero in all future periods. Because of this, the government will set the effective maturity $m$ to zero from the second period onwards. If the maturity were higher than zero, the government would have an added incentive to inflate. The private sector would perceive this, and would expect higher inflation, which in turn would result in higher actual inflation and higher value of the loss function. Therefore, in the period $t + 1$ the government's loss function can be written as

$$L^C_{t+1} = \frac{1}{2}\pi^2_{t+1} - \alpha(\pi_{t+1} - E\{\pi_{t+1}\}) + \beta r D_{t+1} \qquad (61)$$

As it is assumed that $E\{\pi_{t+1}\} > 0$, the optimal rate of inflation is $\alpha$ and then the $E\{\pi_{t+1}\} = \alpha$ as well. The present value of loss functions discounted to the period $t + 1$ is

$$V^C_{t+1} = (1 + \frac{1}{\delta})(\frac{1}{2}\alpha^2 + \beta r D_{t+1}) \qquad (62)$$

Here the superscript $C$ refers to cheating. The last term of equation 62 reveals how the government can decrease its discounted losses from taxation by reducing the value of $D_{t+1}$ through surprise inflation in the first period. If the only incentive to inflate came from taxation (i.e. $\alpha = 0$), the government would set the inflation to be zero also in all future periods after cheating in the first period.

In the first period the government decides whether to inflate or not by comparing the values of discounted loss functions under reputational equilibrium and cheating. The discounted value of loss function in the first period in the case of cheating can be obtained by combining equations 57 and 62:

$$V^C = \frac{1}{2}\pi^2 - \alpha\pi + \beta r(1 - m\pi)D + \frac{1}{1+\delta}[(1+\frac{1}{\delta})(\frac{1}{2}\alpha^2 + \beta r D_{t+1})] \quad (63)$$

Using 58 and simplifying gives the following expression for the discounted government loss under cheating:

$$V^C = \frac{1}{2}\pi^2 - \alpha\pi + \frac{\alpha^2}{2\delta} + (1+\frac{1}{\delta})(1 - m\pi)\beta r D \quad (64)$$

The optimal inflation under cheating can be solved in the first period by minimizing equation 64 with respect to the inflation. Setting the derivative to zero ($\frac{\partial V^C}{\partial \pi} = 0$) allows us to solve for the optimal inflation:

$$\pi = \alpha + (1+\frac{1}{\delta})\beta r m D \quad (65)$$

The optimal inflation under cheating is increasing in the benefit of the surprise inflation not associated with the value of government debt, $\alpha$, and the effective maturity of the debt $m$ as well as its level, $D$. Substituting the optimal inflation from equation 65 into equation 64 gives us the value of loss function $V^C$

$$V^C = -\frac{1}{2}[\alpha + (1+\frac{1}{\delta})\beta r m D]^2 + (1+\frac{1}{\delta})\beta r D + \frac{\alpha^2}{2\delta} \quad (66)$$

In this subsection we have concentrated on the actions of the government as if it could decide the inflation rate. In the next subsection it is assumed that the inflation is decided jointly with at least somewhat independent central bank.

#### 3.1.2 Central bank

We turn now to the behaviour of the central bank and the interaction between the government and central bank. The central bank is introduced into the model by modifying the way inflation rate is decided, if the government decides to cheat. It is assumed that if the government decides to inflate, it must do so with the help of the central bank. In this setting the central bank is not completely independent, and it takes the government's decision whether to inflate or not as given.

The central bank has a following one-period loss function[51]:

$$L_{CB} = \frac{1}{2}\pi^2 - \alpha(\pi - E\{\pi\}) \quad (67)$$

To focus the analysis on the time inconsistency arising from the government debt, central bank's loss function is identical to government's loss function except that central bank does not care about the level of taxation in the economy. This is just another way of saying that the central bank's tax aversion is zero, and hence its inflation aversion is high (relative to the government). If the government does not inflate, the present value of central bank's discounted losses is:

$$V_{CB}^{R} = (1 + \frac{1}{\delta})L_{CB} = 0 \quad (68)$$

Again superscript $R$ refers to the reputational equilibrium. For future reference, we analyse how central bank would set inflation in the initial period, if it were forced to choose a non-zero inflation rate. If $\pi > 0$ in the first period, $E\{\pi\} > 0$ in all future periods. The decision concerning inflation rate is the same in all future periods, and therefore we need to look only at the period $t+1$. In that period the loss function of the central bank is:

$$L_{CB}^{t+1} = \frac{1}{2}\pi_{t+1}^2 - \alpha(\pi_{t+1} - E\{\pi_{t+1}\}) \quad (69)$$

Bearing in mind that $E\{\pi_{t+1}\} > 0$ the optimal inflation rate is found by setting $\frac{\partial L_{CB}^{t+1}}{\partial \pi_{t+1}} = 0$ and solving for $\pi_{t+1}$. It is found that $\pi_{t+1} = \alpha$, i.e. central bank's optimal inflation rate from the second period onwards is the same as the government's. This result depends of course on the way the loss function of the central bank has been posited. One could imagine a more "conservative" central banker with a loss function where the benefit from surprise inflation would be smaller than $\alpha$, and then also her preferred inflation rate in all future periods would be lower. This would decrease the realised inflation also in the first period. However, this is irrelevant to the issues we are analysing here. Determining the inflation rate allows us to calculate the present discounted value of central bank's losses in the period $t+1$:

$$V_{CB}^{t+1} = (1 + \frac{1}{\delta})\frac{1}{2}\alpha^2 \quad (70)$$

[51]Subscript CB refers to central bank.

Closer examination reveals that because the central bank's loss function $L_{CB}$ does not depend on taxes, the central bank faces exactly the same problem when choosing the optimal inflation in the first period as it does in all the periods from $t+1$ onwards. Here it is assumed that the central bank's optimal inflation when cheating is derived taking into account only central bank's own preferences, i.e. the possibility of strategic interaction with the government is ignored. Therefore the central bank would set $\pi = \alpha$ also in the first period, and the present discounted value of its losses in the initial period is:

$$V_{CB} = \frac{1}{2}\alpha^2 - \alpha^2 + \frac{1}{2\delta}\alpha^2 = -\frac{1}{2}\alpha^2\frac{\delta - 1}{\delta} \tag{71}$$

As was explained earlier, the government can not decide on the inflation rate by itself, it needs the cooperation of the central bank. Only the decision whether to inflate or not is solely the government's. If the government wants to "cheat" and engineer inflation, the inflation rate is decided from a linear combination of the preferred inflation rates of government and central bank. Moreover, the weight placed on the preferred inflation of the central bank, $\Omega$, is interpreted in the present context as the degree of central bank independence, and $1 > \Omega > 0$. This set-up is intended to reflect the fact that even the most independent central bank could ultimately be overruled by the government through legislation, i.e. there can not be a completely independent monetary authority. In some countries and circumstances this might be possible also without changes in legislation, which then would be reflected in a low value of $\Omega$. If the government decides to inflate, inflation rate in the first period is therefore given by:

$$\pi^* = \Omega\alpha + (1 - \Omega)(\alpha + (1 + \frac{1}{\delta})\beta r m D) \tag{72}$$

In all the future periods inflation is $\alpha$, since this is preferred both by the government and central bank. To reiterate, in the first period the game proceeds in five steps.

1. The government inherits a stock of debt, $D$.
2. The government decides on the maturity of the debt, i.e. on the parameter $m$.
3. Private sector forms its inflation expectations $E\{\pi\}$.
4. The government decides whether to inflate or not.

5. If the government wants to inflate, it chooses $\pi$ together with the central bank.

The decision whether to inflate or not in the first period depends on the present discounted values of the government's loss functions under the two options. For the price stability to hold, the value of the government's loss function under reputational equilibrium must not be larger than under cheating, i.e. inflating. Inflation rate in the loss function $V^C$ is given by the equation 72. If we write out the condition for reputational equilibrium to hold, we get:

$$V^R - V^C(\pi^*) =$$
$$(1+\frac{1}{\delta})\beta rD - [\frac{1}{2}(\Omega\alpha+(1-\Omega)(\alpha+(1+\frac{1}{\delta})\beta rmD))^2 - \alpha(\Omega\alpha+(1-\Omega)(\alpha+(1+\frac{1}{\delta})\beta rmD))$$
$$+\frac{\alpha^2}{2\delta} + (1+\frac{1}{\delta})(1-m(\Omega\alpha+(1-\Omega)(\alpha+(1+\frac{1}{\delta})\beta rmD)))\beta rD] \leq 0 \tag{73}$$

If we assume that when inequality 73 holds as a strict equality, the government refrains from inflating, we can solve the maximum effective debt maturity consistent with the reputational (i.e. no inflation) equilibrium. Equation 73 is quadratic in $m$, and its two roots are given by:

$$m_1 = \frac{1}{(\Omega^2-1)}\left(\delta+\sqrt{\delta}\right)\frac{\alpha}{(1+\delta)\,Dr\beta} \tag{74}$$

$$m_2 = \frac{1}{(\Omega^2-1)}\left(\delta-\sqrt{\delta}\right)\frac{\alpha}{(1+\delta)\,Dr\beta} \tag{75}$$

Because we have assumed that $1 > \Omega > 0$, the first root $m_1$ is clearly negative. All the other terms in the solution are positive, but $(\Omega^2-1) < 0$ and therefore $m_1 < 0$. Because it is assumed that the rate of time preference $\delta$ is smaller than one, term $\left(\delta-\sqrt{\delta}\right) < 0$, and consequently $m_2 > 0$. Therefore $m_2$ must be the maximum effective maturity, and in what follows we analyse its properties.

#### 3.1.3 Maximum debt maturity

In this subsection we assess the properties of the maximum effective maturity consistent with the reputational equilibrium, which was derived in the preceding subsection. It is especially interesting to see what the effect of higher central bank independence on the maximum effective maturity is, but also the influence of the level of government debt on maturity is assessed. Higher central bank independence increases the maximum effective debt maturity consistent with the reputational equilibrium, while the level of government debt decreases it.

**Proposition 1** *Higher central bank independence increases the maximum effective debt maturity consistent with the reputational equilibrium.*

**Proof.** Differentiating $m_2$ with respect to $\Omega$ yields

$$\frac{\partial m_2}{\partial \Omega} = \frac{2}{\left(\Omega^2 - 1\right)^2} \left(\sqrt{\delta} - \delta\right) \frac{\alpha}{\left(1+\delta\right) D r \beta} \Omega > 0 \tag{76}$$

Term $\left(\Omega^2 - 1\right)^2$ is positive. Because $\delta < 1$, term $\left(\sqrt{\delta} - \delta\right)$ is positive. Therefore $\frac{\partial m_2}{\partial \Omega}$ is positive. ■

This result is quite intuitive. Higher central bank independence means that if the government would inflate in the first period, gains from the surprise inflation would be lower because central bank, which prefers lower inflation, has more influence in setting the inflation rate. This means that the government will have smaller incentive to inflate. Because the private sector understands this, it is willing to hold government debt with longer maturity.

**Proposition 2** *Higher level of government debt decreases the maximum effective debt maturity consistent with the reputational equilibrium.*

**Proof.** Differentiating $m_2$ with respect to $D$ yields

$$\frac{\partial m_2}{\partial D} = -\frac{1}{\Omega^2 - 1} \left(\delta - \sqrt{\delta}\right) \frac{\alpha}{\left(1+\delta\right) D^2 r \beta} < 0 \tag{77}$$

Term $\frac{1}{\Omega^2 - 1}$ is negative because $\Omega < 1$. Because $\delta < 1$, term $\left(\delta - \sqrt{\delta}\right)$ is also negative. Therefore $\frac{\partial m_2}{\partial D}$ is negative. ■

This illustrates that the result found in many contributions concerning the relationship between maturity and debt level survives also when an independent central bank is introduced.

Figure 1 shows graphically how the maximum effective maturity depends on the degree of central bank independence and the level of government debt. High central bank independence and low government debt are associated with high maturity.[52]

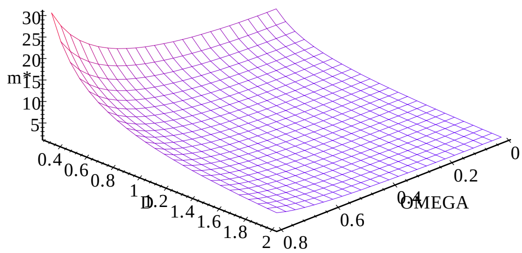



Figure 1: Maximum effective maturity with some parameter values $\alpha = 0.5, \beta = 0.5, \delta = 0.05$

#### 3.1.4 Discussion

Obviously, the model presented in this subsection is highly stylized. In reality, the nature of interaction between the fiscal authority and the central bank is bound to be more complex. Also, in the model the only motive to inflate comes from the one-time desire to decrease the real value of government debt (and consequently future taxation). However, many governments have routinely used inflation also to finance persistent fiscal deficits. Naturally, higher central bank independence would limit the use of seigniorage and lead, ceteris paribus, to lower inflation. This in turn would be in line with the predictions of the relatively sparse model presented here.

The model is also unrealistic in the sense that the degree of central bank independence is taken as given. However, taking the discussion to the design of institutions would only take the game to another level. Different members of society have different preferences over inflation and taxes, and these preferences would need to be mapped

[52] Very high values of central bank independence and very low values of government debt have been omitted from the figure. When $D$ approaches zero and $\Omega$ approaches one, the maximum maturity rises over hundred.

into appropriate institutional design. Here the issue would be choosing an optimal degree of central bank independence for the society, given preferences and the inability to commit. The optimal government debt structure would then follow from this choice. However, the choice of optimal institutional design is out of the reach of this essay. For example, it might be difficult to account for changes in the central bank independence that we observe in our data.

Despite the stylized nature of the model, its predictions are quite intuitive. First, the model retains the negative correlation between the level of debt and its effective maturity discussed in Missale and Blanchard (1994). This feature of the model is a priori attractive, even though previous empirical research supports this result unequivocally only for highly indebted countries. Second, higher central bank independence reduces the government's temptation to inflate and correspondingly allows it to maintain higher debt maturity. Higher central bank independence is generally associated with lower inflation, although there is still some debate on the direction of causality (see Berger et al., 2001).

## 3.2 Empirical evidence

In this subsection we test empirically the derived model of the central bank independence and effective maturity of government debt. Most of the data used is familiar from the previous essay, but we introduce also some new variables. As before, the derived model is tested with panel data.

### 3.2.1 Data

In the empirical testing of the model developed in section 3 I use data for the government debt maturity, debt level, and central bank independence for 12 OECD countries.[53] The data on effective maturity of government debt ($EFMAT$) and the amount of debt held by the private sector ($DEBT$) are based on Missale (1999). The debt data

[53] The countries are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Netherlands, Spain, Sweden, and the UK.

for most countries is available from 1960 to 1998[54], but the availability of maturity data is more restricted and varies from country to country. The same is true of the data on central bank independence. Variables $EFMAT$ and $DEBT$ are described in greater detail in the previous essay, but the main statistical properties of the two variables are presented again in the Table 1.[55]

As a proxy for central bank independence I use the legal independence index ($CBI$) developed by Cukierman et al. (1992).Table 19.1 (pages 373-376) shows in detail how the index is compiled. In principle, the independence index is a weighted average of different subindices, which, in turn, relate to four areas: appointment and term of the central bank's chief executive officer, independence in policy formulation, central bank's final objectives, and limitations on lending to other agencies of the public sector and to private sector. In principle, the index can vary from zero to one, zero signifying no independence at all, while a central bank with an index of one would be extremely independent. In practice, central banks complying with the rules of the Maastricht Treaty are the most independent in the sample, and their index is usually 0.75.[56]

The index is updated for most countries in Cukierman and Lippi (1999) and further in Kilponen (2000). For data points from 1993 onwards we have updated the data with the help of central bank web sites. This updating of data is crucial, because in preparation for monetary union (and in accordance with the stipulations of the Maastricht Treaty) the EU countries revised their central bank laws, many countries more than once. There had been changes in the central bank laws already in the 80s, but in the 90s the changes became more frequent and they took place in all the countries participating in the monetary union.

Index of central bank's legal independence ranges for most countries from the 70s to 1998. The estimations are done with the data spanning years from 1980 to 1998 (or the last year available). Table 10 provides information also on the statistical properties of the central bank independence index. Figure 2 shows the time series of the

[54]In the empirical estimations debt is reported as a share of GDP. Nominal GDP data is taken from the IMF's International Financial Statistics database.

[55]The descriptive statistics in this table refer to the sample used in the regressions of the next sub-section, i.e. to panel observations where we have data on all the variables.

[56]The central bank independence index is available for Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, The Netherlands, Spain, Sweden, the United Kingdom, and United States.

central bank independence index for different countries.

There is a potential problem related to the fact that central bank independence changed so infrequently in the 80s (and, in most countries, it did not change at all). There might not be enough variation in the variable. Therefore we have also estimated the panel regressions with data from 1990 to 1998, a period which had many changes in central bank independence.

The time-series properties of the variables utilised here are somewhat problematic. In the previous essay we discovered that panel unit root tests give very conflicting results for many of series. In this essay the main new variable is the index of central bank independence, which is by design bounded between zero and one. Therefore, we shall continue treating the variables as stationary.

**Table 1 Descriptive statistics**

| | $EFMAT$ | $CBI$ | $DEBT$ |
|---|---|---|---|
| mean | 3.877 | 0.359 | 0.535 |
| median | 3.775 | 0.310 | 0.496 |
| standard dev. | 2.117 | 0.137 | 0.264 |
| maximum | 11.70 | 0.75 | 1.225 |
| minimum | 0.63 | 0.19 | 0.109 |
| observations | 175 | 175 | 175 |

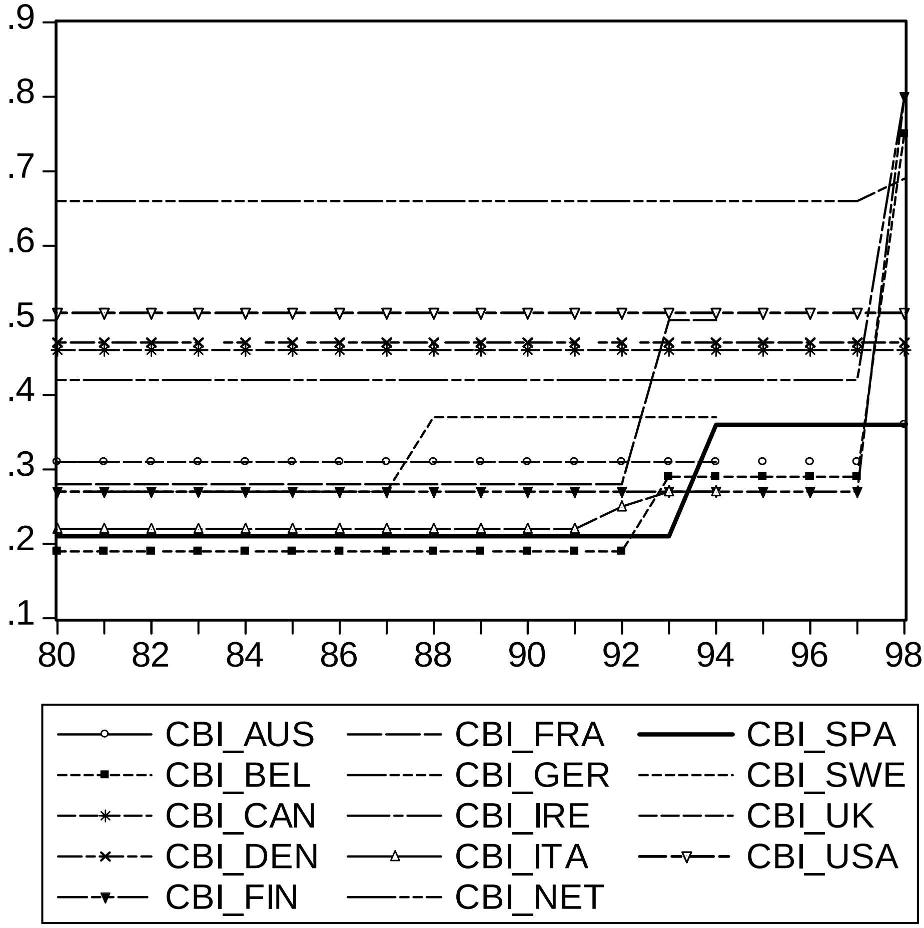



Figure 2: Indices of central bank independence

#### 3.2.2 Results

The effect of central bank independence on the effective maturity of government debt is assessed in a panel data framework.[57] We estimated the regression both with random and fixed effects. Also, robustness of the results is checked by estimating the model with the full sample (1980-1998) and with a sample covering only the 90s.

[57] Estimations were done with EViews 5.0 software package.

*Full sample*

Results from the fixed effects regressions are reported in Table 2a and results from the random effects Table 2b. I started with as general specification of the model as possible, including inflation[58], an interaction terms and squares of all the relevant variables to check for possible non-linearity in the data. Insignificant variables were dropped one at the time from the regression, starting from the variable with the lowest absolute t-value. Column 1 of table 2a reports results from this specification. It is clear this is not a very satisfying specification, as almost none of the variables are statistically significant.[59]

Proceeding with elimination of insignificant variables in the aforementioned fashion, the effective maturity ($EFMAT$) is finally regressed on the level of government debt ($DEBT$), the indicator of central bank independence ($CBI$), its square, and inflation. Column 1 of table 2a reports results from this specification. We can see that the coefficient on central bank independence has the expected sign and is clearly significant. Moreover, the effect of $CBI$ appears to be non-linear, as $CBI^2$ is also statistically significant. When one observes the sizes of the coefficients on $CBI$ and $CBI^2$, it appears that the effect of $CBI$ on the effective maturity peaks around 0.6 (and, in principle, $CBI$ can run from zero to one). It should be remembered that almost all the observations of $CBI$ are, in fact, below 0.6, and therefore in our sample central bank independence clearly increases the effective maturity. However, the effect of debt level seems to positive for the effective maturity, which is in direct contradiction with the prediction of the model (and many previous empirical studies). Also, higher inflation seems to be correlated with higher effective maturity of government debt.

The situation changes somewhat when we introduce country-specific trends into the panel regression. In some countries, clear and distinct trends are present in the time series of the effective maturity, apparently unrelated to the variables we are examining here. When the country-specific trends are included in the fixed effects panel regressions (results are reported in column 3 of Table 2a), effect of $CBI$ remains qualitatively the same as in the previous regression. Effect is non-linear, but the maximum effect of $CBI$ and $CBI^2$ is reached

[58] Inflation has been used in some of the previous empirical studies of the debt maturity, see for example de Haan et al. (1995)

[59] These regressions are performed with least squares estimator, unbalanced sample and no weighting. Qualitatively, the results do not change if cross-section weights are used.

earlier than before. However, one must also take into account the interaction term between the central bank independence and the level of government debt. Coefficient of this variable is positive, indicating that countries with higher debt level can reduce its negative effect on effective maturity by increasing independence of the central bank. Naturally this effect is more pronounced when the debt level is high. For example, if we evaluate the effect of $CBI$ on $EFMAT$ when the debt level is at its median (0.496), central bank independence reaches its maximum effect on effective maturity just at below 0.5. Again, the overwhelming majority of our observations fall into this category.

Interestingly, when individual country trends are taken into account, effect of inflation on maturity turns negative. This result is perhaps more intuitively appealing. In the context of our model, higher inflation means that the government has "cheated" and therefore the effective maturity would tend to decline. There is a general downward trend in inflation in the OECD countries of our sample, and this, coupled with a downward trend of effective maturity in some of the countries may be the reason the observed correlation in column 2. When maturity trends in individual countries are taken into account in the regression of column 3, the spurious positive effect seems to disappear. However, we must remember that in the previous essay (Table 9) the effect of inflation by itself on the debt maturity is positive, while coefficient on interaction term between inflation and debt was negative. Incidentally, multiplicative interaction term between inflation and debt is not statistically significant in any of the present specifications.

**Table 2a Panel data results for effective maturity, full sample, fixed effects**

| | 1 | 2 | 3 |
|---|---|---|---|
| $CONSTANT$ | -0.062 (-0.020) | -0.424 (-0.479) | 3.449*** (3.553) |
| $DEBT$ | 1.864 (0.401) | 1.711** (1.980) | -2.245* (-1.95) |
| $CBI$ | 18.059 (1.136) | 12.002*** (3.641) | 11.389** (2.331) |
| $INF$ | -0.045 (-0.716) | 0.010** (2.515) | -0.183*** (-4.513) |
| $DEBT \times CBI$ | -6.183 (–0.412) | | 5.972** (2.005) |
| $DEBT^2$ | 0.365 (0.214) | | |
| $CBI^2$ | -21.041 (-1.215) | -10.187*** (-2.860) | -16.830*** (-3.551) |
| $INF^2$ | 0.008** (2.385) | | 0.013*** (5.155) |
| $(DEBT \times CBI)^2$ | 9.724 (0.654) | | |
| Adjusted $R^2$ | 0.87 | 0.87 | 0.95 |
| S.E. of regression | 0.76 | 0.78 | 0.45 |
| Total panel obs. | 175 | 175 | 175 |

*** denotes significance at one per cent significance level, and ** at five per cent level. t-values in parentheses. Individual country effects are not reported.

**Table 2b Panel data results for effective maturity, full sample, random effects**

| | 1 | 2 |
|---|---|---|
| $CONSTANT$ | 0.979 (0.415) | -0.460 (-0.465) |
| $DEBT$ | 0.083 (0.023) | 1.154* (1.820) |
| $CBI$ | 11.763 (1.02) | 13.30*** (4.189) |
| $INF$ | -0.046 (-0.707) | 0.095** (2.304) |
| $DEBT \times CBI$ | -0.138 (-0.012) | |
| $DEBT^2$ | 0.917 (0.694) | |
| $CBI^2$ | -12.073 (-0.997) | -11.457*** (-3.476) |
| $INF^2$ | 0.008** (2.063) | |
| $(DEBT \times CBI)^2$ | 1.868 (0.183) | |
| Adjusted $R^2$ | 0.16 | 0.13 |
| S.E. of regression | 0.76 | 0.77 |
| Total panel obs. | 175 | 175 |

*** denotes significance at one per cent significance level, and ** at five per cent level. t-values in parentheses. Individual country effects are not reported.

We employ a similar general to specific methodology when using random effects instead of fixed effects. As before, in the first specification with all the variables and their squares, almost nothing comes out statistically significant. And as in the case with the fixed effects estimations, $INF^2$ is the only significant variable. Proceeding as before, and dropping the statistically insignificant variables one at a time, we end up with the specification reported in column 2 of Table 2b. Again, the result concerning effect of central bank independence on maturity of government debt is confirmed, although the effect appears to be non-linear. Looking at the coefficients of $CBI$ and $CBI^2$, it appears that the maximum effect on maturity is reached when the index of central bank independence is 0.58, while almost all of the observations in our sample are below that maximum point.

Effect of inflation on the effective maturity is similar to the one obtained in column 2 of Table 11a, most probably for the same reasons. Contrary to the predictions of the model (and in line with the estimations reported in the column 2 of Table 11a), debt level has a positive effect on the effective maturity However, it is only marginally statistically significant.

*Sample: the 90s*

In this subsection we examine how limiting the data sample to 1990-1998 affects our results. This acts also as a robustness check on our results. However, it should be noted that for the shorter sample we have only 70 observations. Regarding the variables, some differences can be observed in their behaviour as well. $EFMAT$ seems to trend slightly upwards in almost all countries during the 90s.

Results are reported in Table 3a (for the fixed effects estimates) and Table 12b (random effects). As before, we proceed from general to specific. Column 1 of Table 3a reports the results from the first, most general specification. Again, nothing is statistically significant, although $CBI$ and $CBI^2$ are close to being so (at 10% confidence level). Dropping insignificant variables one at a time we arrive at the specification in column 3. $DEBT$ is retained here, although it is only nearly statistically significant. Dropping it would make also $DEBT$ insignificant. Furthermore, when the multiplicative interaction term between government debt and central bank independence is included (column 2), $DEBT$ and $DEBT^2$ are both statistically significant. All in all, results for the shorter data sample are qualitatively similar to the ones observed for the whole sample, when individual country trends are taken into account. (If individual country trends are included in the regressions with short sample, all the economic variables lose their statistical significance, although their signs remain the same. However, including also country-specific trends means that degrees of freedom fall in our smaller sample, which may have an effect on the results.) Central bank independence increases the effective maturity of government debt, which is in line with the model. Again, the non-linear effect of $CBI$ on effective maturity peaks almost exactly at 0.6, and almost all of our observations of $CBI$ fall below this threshold. Debt level has a negative effect on maturity, but also its effect is non-linear in this specification (with maximum reached almost exactly when debt level is 100% of GDP). Finally, inflation has a negative effect on maturity, which seems to be consistent with the assumptions of the model.

When the model is estimated with random effects, results change somewhat, as they did for the whole sample. When all the variables are included, none of them are statistically significant (results reported in column 1 of Table 3b). As before, there probably is too much collinearity between some of the variables. So we proceed towards a more parsimonious representation by eliminating statistically insignificant variables one at a time. The final specification is reported in column 2 of Table 3b. Results from the shorter sample are almost similar to the ones for the whole sample (column 2 of Table 2b). Effect of $CBI$ is almost the same in size with both data samples, and in both cases there is clear evidence of non-linearity (although the coefficient of $CBI^2$ is somewhat larger in absolute value in the random effects specification).

Effect of debt level on the effective maturity of government debt appears to come mainly through the interaction term with the central bank independence, while the variable $DEBT$ itself is not quite statistically significant. (However, it is retained in the regression to preserve compatibility with earlier estimations.) Evaluating the overall effect of $CBI$ on effective maturity when $DEBT$ is 0.62 (the average in the sample during the 90s), we find that the effect reaches its maximum at 0.50. Again, we must remember that almost all of our observations are below this threshold. Inflation seems to decrease effective maturity, as it did in the fixed effects specification. For the whole sample the evidence regarding inflation was not as robust.

**Table 3a Panel data results for effective maturity, sample 1990-1998, fixed effects**

| | 1 | 2 | 3 |
|---|---|---|---|
| $CONSTANT$ | 0.031 (0.01) | 2.075** (2.229) | 1.876** (2.016) |
| $DEBT$ | 0.399 (0.101) | -2.343* (-1.726) | -1.971 (-1.483) |
| $CBI$ | 19.797 (1.43) | 10.204*** (2.928) | 9.903*** (2.907) |
| $INF$ | 0.045 (0.500) | -0.057* (-1.745) | -0.058* (-1.814) |
| $DEBT \times CBI$ | -6.404 (-0.460) | 2.499 (1.126) | |
| $DEBT^2$ | 0.806 (0.693) | 1.642* (1.779) | 2.022** (2.320) |
| $CBI^2$ | -21.490 (-1.549) | -11.202** (-2.602) | -8.207** (-2.372) |
| $INF^2$ | -0.009 (-1.141) | | |
| $(DEBT \times CBI)^2$ | 9.023 (0.717) | | |
| Adjusted $R^2$ | 0.94 | 0.95 | 0.95 |
| S.E. of regression | 0.38 | 0.38 | 0.38 |
| Total panel obs. | 70 | 70 | 70 |

*** denotes significance at one per cent significance level, and ** at five per cent level. t-values in parentheses. Individual country effects are not reported.

**Table 3b Panel data results for effective maturity, sample 1990-1998, random effects**

| | 1 | 2 |
|---|---|---|
| $CONSTANT$ | 2.533 (1.274) | 1.659 (1.509) |
| $DEBT$ | -3.475 (-1.302) | -1.044 (-1.158) |
| $CBI$ | 7.664 (0.87) | 12.338*** (3.927) |
| $INF$ | 0.046 (0.565) | -0.058* (-1.840) |
| $DEBT \times CBI$ | 7.977 (0.889) | 3.224* (1.646) |
| $DEBT^2$ | 1.119 (0.983) | |
| $CBI^2$ | -8.402 (0.997) | -14.398*** (-3.911) |
| $INF^2$ | -0.011 (-1.340) | |
| $(DEBT \times CBI)^2$ | -5.292 (-0.718) | |
| Adjusted $R^2$ | 0.44 | 0.38 |
| S.E. of regression | 0.43 | 0.37 |
| Total panel obs. | 70 | 70 |

*** denotes significance at one per cent significance level, and ** at five per cent level. t-values in parentheses. Individual country effects are not reported.

## 3.3 Discussion and conclusions

In this essay we have introduced a model where central bank independence can be used as an instrument by the public sector in committing to a policy of no inflation. Higher central bank independence also allows the government to increase the effective maturity of the outstanding government debt. A central bank has different loss function from that of the government/fiscal authority, and, therefore, allowing it more independence in deciding on the inflation rate reduces the expected inflation. This reduces the familiar time inconsistency of optimal policies. As expected inflation decreases, the government can issue debt with longer effective maturity (e.g. debt denominated in domestic currency instead of foreign currency). This, in turn, may decrease probability of problems related to the re-financing of the debt etc.

At the same time, as in other models of government debt structure, higher debt level is associated with lower effective maturity of the government debt. Of course, results of the model imply that central bank independence may be even more important in the countries with higher debt levels.

In the empirical part of the section, we employ data from 1980 to 1998 for 12 OECD countries. This data covers a period of increasing central bank independence for most of the countries, and therefore it provides a natural testing ground for the model derived earlier. And indeed, empirical results give clear support for the hypotheses that higher central bank independence allows governments to maintain higher effective maturity of their debt. This finding does not depend on the number of conditioning variables used in the regressions, estimation technique, nor on the sample period. However, the effect appears to be non-linear, as the central bank index squared is also always statistically significant. Magnitudes of the coefficients on $CBI$ and $CBI^2$ suggest that the effect of central bank independence index on effective maturity reaches its maximum at slightly below 0.6. Practically all of our observations are actually below this maximum, reinforcing the conclusion that in our sample central bank independence has contributed towards higher effective debt maturity. This means that real values of debt stocks have become more responsive to economic shocks, which in turn should help governments in tax smoothing. Our results also help to shed some light on the recent trend of government debt structure. In most countries in our sample the effective maturity of debt has increased since the late 80s.

However, evidence on the effect of the debt level on effective maturity is more mixed. In most of the estimations $DEBT$ does not come in as statistically significant, and sometimes it has the wrong sign. However, often a multiplicative interaction term between debt and central bank independence is positive and statistically significant, implying that countries with higher debt levels have more to gain by increasing the independence of their central banks.

As such, our results are in line with those of Falcetti and Missale (2002). Higher central bank independence allows governments to issue debt with longer effective maturity. This can include a mixture of shift away from foreign borrowing to domestic sources as well as lenghtening of the actual maturity of domestic debt issues. However, we also find clear non-linearities in the effect of central bank independence on debt maturity. Effect of central bank independence is much greater at higher debt levels. Policy relevance of this result for countries with high debt ratios is clear.

Our empirical results are based on panel data, while those of Falcetti and Missale are derived from cross-section regressions. While it is not absolutely clear that there is enough variation in the CBI variable in the 80s to justify panel approach, in the 90s such variation clearly exists. Our robustness test with the 90s data confirms the results derived from the full sample.

The OECD countries in our sample have tended to increase the independence of their central banks from the late 80s onwards. While this trend towards higher central bank independence was mainly inspired by the example of e.g. Germany in fighting inflation with no apparent adverse effect on output or employment, it seems to have had (perhaps unintended) effects elsewhere in the field of economic policies. Reducing the time inconsistency of monetary policy by delegating more power to independent central banks, the countries in our sample also made it possible to extend the maturity profile of their debt stocks and to borrow more in domestic currency. In the late 90s the trend towards greater central bank independence accelerated as many EU countries started to prepare for monetary union. One of the key institutional features of the Maastricht Treaty is a very independent central bank, and in many countries several revisions of the central bank law were needed to bring them into line with the stipulations of the Maastricht Treaty. (Although the Maastricht Treaty also sets limits on public debt, there is no clear downward trend in debt in the late 90s.) Increase in the effective maturity of government debt may have been only a side effect of this larger policy objective, but it is apparent from the data that this did indeed occur. This conclusion can also offer some policy advice to other countries in their debt management strategies. Especially in developing countries institutional reforms such as increasing central bank independence can also help in debt management.

The results of this essay have also clear implications for countries in the euro area. As they have given up monetary policy completely to the hands of a very independent supranational central bank, we should observe over time clear shift towards higher effective maturity of government debt. A one-time jump occurred for most countries when the euro was introduced, as the debt denominated in the currencies of other euro area countries instantly become "domestic" debt.

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# 4 Model of structural reforms and government debt denomination

In this essay I present a model of government debt denomination and structural reform effort. In what follows I define structural reform as a reform effort, which produces short-term disutility to the government in power[60], but which also has positive economic effects later on. Here the positive effect manifests itself as a lower interest rate to be paid on government's borrowing in foreign currencies. Structure of the government debt, or, more specifically, its currency denomination can be used as an instrument in committing to a policy of low inflation.

Therefore the model is very much in the same tradition as the previous two essays, where government debt structure provides a way for the government to commit itself to a policy of low inflation.

## 4.1 Brief literature survey on reforms and debt structure

Structure of government debt can be used to influence actions and expectations in various situations. In this section the interaction between different reform efforts and debt structure is examined.

The model presented in subsection 4.2 is loosely based on contribution by Goldfajn (1998). Goldfajn develops a stochastic two-period model where a government decides on the optimal allocation of debt between domestic and foreign denomination. As in many other similar models, government minimises a loss function with inflation and tax rate (or, more specifically, distortions arising from taxation) as its arguments. Government can finance its deficit with bonds denominated in foreign currency, indexed bonds or ordinary nominal bonds in domestic currency. If the government can commit itself to a set of policies, the optimal structure of debt depends only on the variances and covariances of the shocks hitting the variables, as government uses structure of debt for hedging purposes. For example, if variance of inflation is high, government will issue a lot of indexed debt, which will leave the real value of debt unchanged. If covariance between inflation rate and real exchange rate is negative, larger debt stock (as share of GDP) is associated with larger share of foreign denominated debt.

[60] Perhaps because such reforms may mean removal of subsidies or social assistance, which is disliked by the population or some subset of it.

The situation changes somewhat if the government can not commit to a set of optimal policies. Then the government faces a temptation to inflate away some part of the real value of the outstanding debt in the second period. Presence of this temptation reduces the share of nominal debt issued. This effect is stronger when the level of debt higher, *ceteris paribus*, i.e. the same result as in Blanchard and Missale (1994). As indexed debt can be used for commitment, share of foreign currency denominated debt is decreasing in the level of debt. Goldfajn also tests his model with Brazilian data. He finds that higher level of debt does reduce the share of nominal debt in the total debt stock. Also, higher variance of inflation reduces the share of nominal debt. These observations support the hypothesis that structure of debt can be used both for commitment and hedging purposes.

Missale et al. (2002) study a situation where the government uses debt structure as a signal of its preferences in a fiscal stabilisation. In the two-period model there are two possible governments, labelled "tough" and "weak". "Tough" government sets the level of primary spending lower than the "weak" government. However, private investors can not verify the type of the government in advance. At he beginning of first period they know only the short-term (i.e. one period) interest rate.

Uncertainty in the model comes from two shocks. First, there is a fiscal shock, which determines whether fiscal stabilisation succeeds. Also, there is a shock to the second period short-term interest rate. Expected second period short-term interest rate is lower for a "tough" government. A "tough" government can signal its type at the beginning of period with government debt maturity. A "tough" government can separate itself from a "weak" government by issuing debt with short maturity. In fact, Missale et al. show that there is a separating equilibrium for the maturity, if volatility of the interest rate shock is not too large relative to the interest rate discount enjoyed by the "tough" government. When government reveals itself to be "tough", its debt servicing costs decrease. However, signalling is costly because it affects the probability of successful fiscal stabilisation, because government issuing short-term debt is not insulated from budgetary consequences of interest rate shocks.[61] If the initial reputation of the government is high enough, there might also be a pooling equilibrium, where governments of both type issue debt with

[61] Issuing only two-period bonds would remove all uncertainty concerning debt servicing costs.

the same maturity.

Empirical implication of the model is that for governments committed to fiscal stabilisation the share of long-term debt issued depends on whether their announcements are deemed credible by the private sector. Missale et al. proxy credibility as the ex post change of long-term interest rate in the first year of fiscal stabilisation. They test the predictions of the model with 72 episodes of fiscal stabilisation in the OECD countries between 1975 and 1998. Broadly speaking, implications of the model are supported by the data. If long-term interest rates are high and volatility of short-term interest rates low, governments issue more short-term debt. Therefore, there appears to be a clear trade-off between risk and costs of debt service. Although Missale et al. consider only fiscal stabilisation, the issues discussed can also be relevant for other kind of reforms.

## 4.2 Choice of reform effort and government debt denomination

In this section I present a model where the government determines simultaneously the level of reform effort and government debt currency denomination. Reform effort produces disutility to the government. This can be justified on several grounds. Reforms, which may enhance efficiency and ultimately long-term economic growth in the whole economy, may be detrimental to at least some part of the population in the short-run. It may even be that, for some groups in the society, they are detrimental, period. (In the sense that their present discounted utility decreases if the reform is carried out). Therefore, it may be politically difficult to implement such policies.

The model presented here differs from Goldfajn (1998) in several key aspects. He focuses on the way government's inability to commit interacts with the nature of shocks hitting the economy. In this essay the focus is on interaction between reforms and the government's inability to commit. Structural reforms, although costly (or painful) in the first period, provide government with more opportunities in the future periods. On the other hand, the idea that level of debt stock is correlated with the structure of the debt is present in both contributions.[62]

[62] In Goldfajn (1998) the level of debt is negatively correlated with the share of nominal debt in the total debt stock (other components of the debt can be

In the present model the positive effect of reform is that the risk premium on domestic debt decreases. This naturally affects the total cost of credit. If there are different shocks hitting the economy, the government may want to borrow in both currencies, even if the other one has higher interest rate. However, in the present contribution the emphasis is on the problem of commitment, not risk-reduction through portfolio diversification.

The model has two periods. In the first period the government (which consists both of fiscal authority and monetary authority) inherits a stock of debt, $D$. The government decided how much of the outstanding debt is issued in foreign currency and how much in domestic currency. Share of the debt in foreign currency is $\theta$, and consequently $(1-\theta)$ is issued in domestic currency. Note that the government can decide on the currency composition of the debt without costs in the first period. Debt is held by the private sector (which has no other role in the model). Nominal interest rate $i$ on the debt denominated in domestic currency depends on exogenous world real interest rate $r$ and expected inflation $E\{\pi\}$. In addition, investors require risk premium $\mu$ for holding debt denominated in the domestic currency. Risk premium $\mu$ can be rationalised in many ways. For the government it would be easier to default on domestic component of the debt. If investors are risk averse, they will also demand extra compensation for the risk of surprise inflation. On the other hand, if exchange rate is a major source of shocks, risk premium $\mu$ might, in fact, be negative. Government can affect risk premium through structural reforms, but we will return to this issue below.

In addition, it is assumed that relative purchasing power parity holds (i.e. $\pi = e + \pi^f$, where $\pi^f$ is foreign inflation), and expected inflation is the same as expected exchange rate depreciation $E\{e\}$, if foreign inflation $\pi^f$ is zero.

In the second period government decides on the inflation rate, and, because purchasing power parity power holds, this also determines the depreciation of the exchange rate. Government collects taxes $T$, which are used to finance exogenous level of expenses $G$ and to pay interest on the stock of outstanding debt as well as to retire the outstanding debt.

In the first period the private sector forms inflation expectations, which in term determine the nominal interest rate. If there would be

indexed debt and debt denominated in foreign currencies. In the present model the level of debt is negatively correlated with the share of domestic debt in the total debt stock (with the rest of debt stock consisting of foreign currency debt).

no risk premium, nominal interest rate would be simply determined by the familiar Fisher equation $i = r + E\{\pi\}$. The private sector has rational expectations, and correctly perceives the inflation temptation faced by the government. In equilibrium expected inflation coincides with actual inflation. Nominal interest rate is raised by the risk premium, and is given by $i = r + E\{\pi\} + \mu = r + \pi + \mu$.

In the model government can decrease the risk premium $\mu$ by implementing structural reforms. Their intensity and cost to the government is denoted by $R$, and $\mu'(R) < 0$.[63] Obviously, structural reforms can encompass a wide variety of measures, but in the present context they can refer e.g. to the reforms undertaken in the emerging market or transition countries on their way to more market-based economy. Such reforms are usually thought to increase private investors' trust into the economic policies of the relevant countries. Also, such reforms have generally increased economic efficiency, and consequently the long-term growth potential, at least in the medium-term. However, in the short-run such structural reforms can have negative effects on growth.[64] Even if the short-term growth effects are not very negative, on the average, reforms may be associated with politically sensitive distributional effects.

More specifically, government tries to minimise the following loss function in the first period:

$$L = R + \beta(A\frac{T^2}{2} + \frac{\pi^2}{2}) \tag{78}$$

Here $\beta$ is the usual discount factor. Losses in the second period, $A\frac{T^2}{2} + \frac{\pi^2}{2}$, are increasing in the *squared* level of taxes and inflation, which is also a fairly standard assumption. Parameter $A$ describes the relative weight of inflation and taxes in the government's loss function. In the second period the government collects taxes to finance exogenous level of real expenses $G$ and to pay interest on the stock of outstanding debt as well as to retire the outstanding debt. Real value of $T$ in the period $t + 1$ is therefore:

[63] In the following, we will usually drop out $(R)$ from $\mu(R)$. Relationship between these two variables should be obvious.

[64] For example, Fischer and Sahay (2001) survey the literature related to growth performance of transition economies. They find that macroeconomic stabilization and structural reforms are necessary for sustained growth, but reforms can be harmful to growth in the short-run because of unavoidable adjustment costs. Also initial conditions matter for growth.

$$T = G + (1-\theta)D\frac{1+i+\mu}{1+\pi} + \theta D\frac{(1+i^*)(1+E\{e\})}{1+\pi} \quad (79)$$

Recalling that $i = r + E\{\pi\}$ and assuming that uncovered interest rate parity ($(1+i^*)(1+E\{e\}) = (1+i)$) and purchasing power parity ($E\{e\} = E\{\pi\}$, foreign inflation is assumed to be zero) hold allows us to linearise[65] the tax equation:

$$T \approx G+(1+r+E\{\pi\}-\pi+\mu)D-(1+r+E\{\pi\}-\pi+\mu)\theta D+(1+r+E\{\pi\}-\pi)\theta D \quad (80)$$

Substituting equation 80 into equation 78 gives the government's whole loss $L$ as a function of structural reforms, expected and actual inflation, government consumption, initial level of government debt, real interest rate and risk premium.

It is natural to assume that the government cannot ex ante commit itself to any inflation rate in the second period. If the inflation expectations of the private sector were low, also nominal interest rate would be low. This would, in turn, reduce the amount of taxes to be collected in the second period to service the debt. However, in the second period inflation expectations (and consequently nominal interest rates) have already been fixed. This gives rise to the usual time-inconsistency problem of economic policies (Barro and Gordon, 1983). In the second period government could reduce its loss by inflating away part of the real value of its outstanding debt. In the first period the private sector anticipates this and demands higher compensation for holding government debt, i.e. higher nominal interest rate. In this model the government can influence this inflationary bias by implementing costly reforms in the first period, as this reduces the real value of taxes to be collected in the second period. Lower risk premium $\mu$ reduces the cost of debt servicing in the second period.

As is usual in such models, we solve the model backwards. As the government can not commit itself in the period $t$ to any policy regarding inflation in the period $t+1$, it takes inflation expectations formed in that period as given. Recall that in the second period the government's only decision concerns inflation rate which also determines depreciation rate of the exchange rate. In the following we set the level of primary expenditures at zero, i.e. $G = 0$. Therefore government only uses tax revenue to service and retire debt. It is

[65] Recalling that for small values of $\pi$, $\frac{1+i+\mu}{1+\pi} \approx 1 + i + \mu - \pi$.

readily apparent that this simplification does not change the qualitative results. However, it simplifies algebra. If $G$ would be taken into account, it would increase inflationary bias, as government would need to raise more revenue in the second period.

Taking equations 78 and 80 , and rearranging terms in the tax expression, in the period $t+1$ the government minimises the following expression with respect to $\pi$:

$$A\frac{(1+r+E\{\pi\}-\pi+\mu-\theta\mu)^2D^2}{2}+\frac{\pi^2}{2} \tag{81}$$

Differentiating equation 81 with respect to $\pi$ and setting the partial derivative to zero yields the following first-order condition for the optimal inflation:

$$-AD^2-AD^2r-AD^2E\{\pi\}-AD^2\mu+AD^2\theta\mu+AD^2\pi+\pi=0 \tag{82}$$

Since we postulate that the private sector has rational expectations, in the equilibrium the expected inflation and realised inflation are the same. Substituting $\pi=E\{\pi\}$ into the first-order 82 allows us to calculate the government's optimal inflation rate:

$$\pi=AD^2(1+r+\mu(1-\theta)) \tag{83}$$

We can see that the inflation rate $\pi$ is increasing in the level of government debt $D$, the risk premium related to the debt denominated in foreign currency $\mu$, and real interest rate $r$. However, inflation decreases as the share of foreign currency debt in the total debt stock goes up. From the preceding discussion it is quite obvious that higher level of government debt increases temptation to inflate in the second period. Higher inflation reduces the real value of debt and the amount of taxes needed to service the debt. The same argument would apply to the level of exogenous government expenditure $G$, if it was included.

In the first period the government minimises equation 78 with respect to the level of reforms $R$ and the share of foreign currency-denominated debt $\theta$. Substituting inflation rate into the equation allows us to differentiate the equation in order to arrive (after some algebra) to two first-order conditions:

$$A\beta D^2\mu(\mu + AD^2\mu)\theta - A\beta D^2\mu(1 + r + \mu + AD^2 + ArD^2 + AD^2\mu) = 0 \tag{84a}$$

$$1 + A\beta D^2\mu'\mu\left(\theta^2 - 2\theta + AD^2 - 2AD^2\theta + AD^2\theta^2 + 1\right) + \tag{84b}$$
$$A\beta D^2\mu'[1 + r - \theta - r\theta + AD^2 + ArD^2 - AD^2\theta - ArD^2\theta] = 0$$

It should be remembered that the derivative of $\mu$ with respect to $R$ is negative. From the two first-order conditions we can solve the optimal share of foreign currency denominated debt and level of structural reforms. First we solve for the optimal foreign currency debt share $\theta^*$ from equation 84a:[66]

$$\theta^* = \frac{1}{\mu(1 + AD^2)}(1 + r + \mu + AD^2 + ArD^2 + AD\mu) \tag{85}$$

We can immediately see that if $\mu > 0$ and $D > 0$, the optimal share of foreign currency debt is always positive. If $\mu < 0$, optimal share could be negative. In this model we are concerned with the consolidated public sector, consisting of both monetary and fiscal authority. Therefore, it is possible that the foreign currency reserves of the central bank are larger than the government's outstanding foreign debt stock. Also, share of foreign currency denominated debt increases as exogenous real interest rate $r$ goes up.

As we have not made the mapping from the level of reforms $R$ into the risk premium $\mu$ concrete, we can not analytically solve the optimal level of reforms. However, from equation 84b we can make some observations. After some tedious algebra, we can solve the optimal partial derivative of $\mu$ with respect to $R$ as $\mu'^*$. This is, in turn

$$\mu'^* = -\frac{1}{A\beta D^2[(1+AD^2)(1-\theta+r(1-\theta))+\mu(1+\theta^2(1+AD^2)-2\theta(1+AD^2)+AD^2)]} \tag{86}$$

Since the denominator is positive[67], $\mu'$ is indeed negative, as assumed.

Next, we turn to the issue of how the level of reforms affects the optimal structure of government debt. Therefore, we return to the

[66] This solution assumes that $D \neq 0$ and $\mu \neq 0$. If there was no debt, the problem would not exist. And if there was no difference between the domestic and world interest rate, government would be indifferent between borrowing in foreign and domestic currencies, as relative purchasing parity holds.

[67] The first term inside the square brackets, $(1 + AD^2)(1 - \theta + r(1 - \theta))$ is positive because $0 < \theta < 1$.The second term is also positive, because $\left(1 + \theta^2(1 + AD^2) - 2\theta(1 + AD^2) + AD^2\right) = AD^2(1 - \theta)^2 + (1 - \theta)^2 > 0$. Furthermore, $\mu > 0$, and therefore the whole denominator is positive.

definition of optimal share of foreign currency denominated debt, $\theta^*$. We will see how the optimal share of foreign currency denominated debt responds to reform effort.

**Proposition 3** *It can be shown that* $\frac{\partial \theta^*}{\partial R} > 0$. *Proof will be offered in the Appendix, but intuition behind the result will be sketched here. When government increases its reform efforts, risk premium on domestic debt decreases. In itself, this effect would shift borrowing to domestic sources. However, this increases the temptation to inflate away the real value of government debt. To counter this, government need to shift borrowing more to foreign currency denominated bonds. In this model the latter effect dominates the first one. Therefore we should observe a positive correlation between the level of reforms and the share of foreign currency borrowing in government's debt stock.*

The result above may appear to be counter-intuitive, but it can help to understand why many emerging market countries seem increase their foreign borrowing e.g. after macroeconomic stabilisation, when *especially* domestic interest rates have declined. This phenomenon can be observed in several stabilisation/reform efforts. For example, Russia started its economic reforms and stabilisation efforts in 1992. It took several years for the inflation to come down to double-digits; only in 1996 was the average consumer price inflation 48%. Progress was slow also e.g. in structural reforms. Therefore Russia was basically not able to borrow from abroad (apart from loans from the international financial institutions) before 1995, when some 33% of its fiscal data was financed with foreign borrowing (in 1994 less than 9% of financing came from abroad).[68] This example is not meant to imply that the Russian government (or any other government) made its borrowing decisions solely based on inflationary expectations of those holding Russian bonds. However, it does offer an explanation for the course of events.

Another probable factor influencing government's choice of debt structure is the level of debt. Again, we can examine equation 85 to see what is the partial derivative of $\theta^*$ with respect to the level of debt, $D$.

**Proposition 4** *With all feasible values of parameters* $\frac{\partial \theta^*}{\partial D} > 0$. *Proof will be offered in the Appendix, but intuition behind the result is quite clear. The higher is the level of initial debt, the larger is the temptation to inflate away the real value of the debt. From equation 83 we*

[68] Source for fiscal data IMF (2003).

*know that optimal inflation in period* $t+1$ *is increasing in the level of debt.*

Again, it is not uncommon to observe many emerging countries forced to borrow more from foreign sources when the level of indebtedness increases. As such, this result is hardly surprising.

In the following subsection we will discuss empirical evidence relating to the two propositions derived above.

## 4.3 Empirical evidence on relationship between economic reforms and government debt structure: Latin America

In this subsection we provide empirical evidence on the results provided in the previous subsection. We use data on a number of Latin American countries. For these countries, we utilise data on government debt level and debt structure. Also, we are able to proxy level of reform with indices prepared by the Inter-American Development Bank[69]. Latin American countries are good candidates for testing the model, as almost all of them underwent significant structural reforms in the 80s and 90s. Also, many of them have high debt levels.

There are no previous attempts to look at the empirical connection between structural reforms and government debt structure. Obviously, our results should be viewed as preliminary. We are concentrating only on one group of countries, although these countries are arguably among the ones with the most far-reaching economic restructuring behind them. Another alternative would be to look at a group of transition economies, but there the lack of data still hampers econometric analysis.

We try to assess whether the extent of structural reforms in a number of Latin American countries is correlated with the share of foreign debt in total public sector[70] debt stock during the 90s. In addition, we will also test whether the share of foreign debt is associated with the debt ratio itself. The model developed in subsection 4.2 predicts that the share of foreign debt in total debt stock is *positively* correlated with the extent of structural reforms. Reforms are

[69] The original source of the IADB's reform indices is Lora (1997). This paper was updated in Lora (2001). Effect of reforms on growth and welfare are discussed e.g. in Lora et al. (2004).

[70] Usually we must rely only on the data from the central government.

supposed to decrease risk premium on domestic borrowing, which decreases borrowing costs for domestic debt. On the other hand, lower interest rates and potential for higher domestic borrowing increase the benefits from engineering a surprise inflation at some point in time. In the model the latter effect dominates, hence the positive correlation. In addition, we have the familiar result that debt stock (as a share of GDP) is positively correlated with the share of foreign debt. Higher debt stock means, *ceteris paribus*, larger gains from surprise inflation. As the private sector anticipates this, the government will shift borrowing to foreign currency denominated debt in order to avoid increase in inflationary expectations.

The fiscal data we use comes from International Monetary Fund (2003). Debt stocks and their components relate to the central government gross debt. These have been normalised by the nominal GDP, which is taken from the International Finance Statistics database.

As mentioned earlier, data on structural reforms originally comes from Lora (1997) and the dataset is expanded in Lora (2001). The reform indices measure the degree of neutrality of economic policies in 1) trade policy, 2) tax policy, 3) financial policy, 4) privatisation and 5) labour legislation. The indices are constructed so that they run from 0 to 1, one signifying the least state interference in the economy. In practice, 0 is assigned to the worst observation in the sample, while 1 is reserved for the best. Increase in the average score in then interpreted as progress in structural reform. The underlying assumption is that policy-makers in the Latin American countries have been interested in the efficiency of their economies by reducing the extent of state's interference. While the data on structural reforms starts from 1985, we are interested in the development during the 90s only.

It is not likely that the variables on the right-hand side of our regressions (level of debt and structural reforms) would be influenced by the share of foreign debt in total debt stock. It is much more likely that e.g. structural reforms are decided first, and only then the decisions concerning the debt structure. Also, it would be hard to argue that structure of government debt dictates the debt level. Causality, if any, must run from reforms and debt level to debt structure. However, it is conceivable that in the long-run structural reforms affect debt level. Some structural reforms may mean higher tax revenues and faster GDP growth. Both of these factors would, ceteris paribus, lead to lower debt level. On the other hand, many of the reforms could also work in the opposite direction, i.e. lower tax revenues and state's inference as well as involvement in the economy.

In Lora (1997) the indices run from 1985 to 1995, while Lora (2001) extends the time series to 1999. In our sample of 12 countries[71], the average index of structural reforms[72] ($STRUC$) has a value of 0.44 in 1990[73], but it rose to 0.59 by 1999. We will employ this simple average of different sub-indices in the estimation, as reform indicators of different areas are highly correlated.

First, we illustrate the statistical properties of our variables. Unfortunately, data does not encompass all periods for all countries. The countries chosen to the sample have debt structure data for at least four consecutive years, and most countries have this data for considerably longer period. Table 1 reports some basic statistical properties of debt ratio ($DEBT$), share of foreign currency debt in total debt ($FORSHARE$) and the average of different reform indices ($STRUC$).

**Table 1 Descriptive statistics on Latin American variables**

| | $DEBT$ | $FORSHARE$ | $STRUC$ |
|---|---|---|---|
| mean | 0.37 | 0.62 | 0.53 |
| median | 0.29 | 0.59 | 0.53 |
| standard dev. | 0.22 | 0.21 | 0.07 |
| maximum | 0.90 | 0.20 | 0.71 |
| minimum | 0.11 | 0.98 | 0.45 |
| observations | 78 | 76 | 109 |

Figure 1 shows the evolution of debt ratios ($DEBT$) for the 12 Latin American countries included in the sample. We can see that for many countries there is a slight tendency for the debt ratio to decline during the 90s, but for some countries the debt ratio does not seem to follow any particular trend. Also, one can note that the level of indebtedness varies significantly from one country to another. After the debt crisis of the 80s many Latin American countries found it advantageous to decrease their indebtedness. Financing of such high debt levels required substantial resources.

[71] As before, in figures and tables the latter part of the variable name designates a country according to the following key: BOL - Bolivia, CHI - Chile, COL - Colombia, COS - Costa Rica, ELS - El Salvador, GUA - Guatemala, JAM - Jamaica, MEX - Mexico, PAR - Paraguay, PER - Peru, TRI - Trinidad and Tobago, URU - Uruguay.

[72] The five sub-indices have been simply averaged to form the $STRUC$.

[73] In 1985 the average value was 0.35.

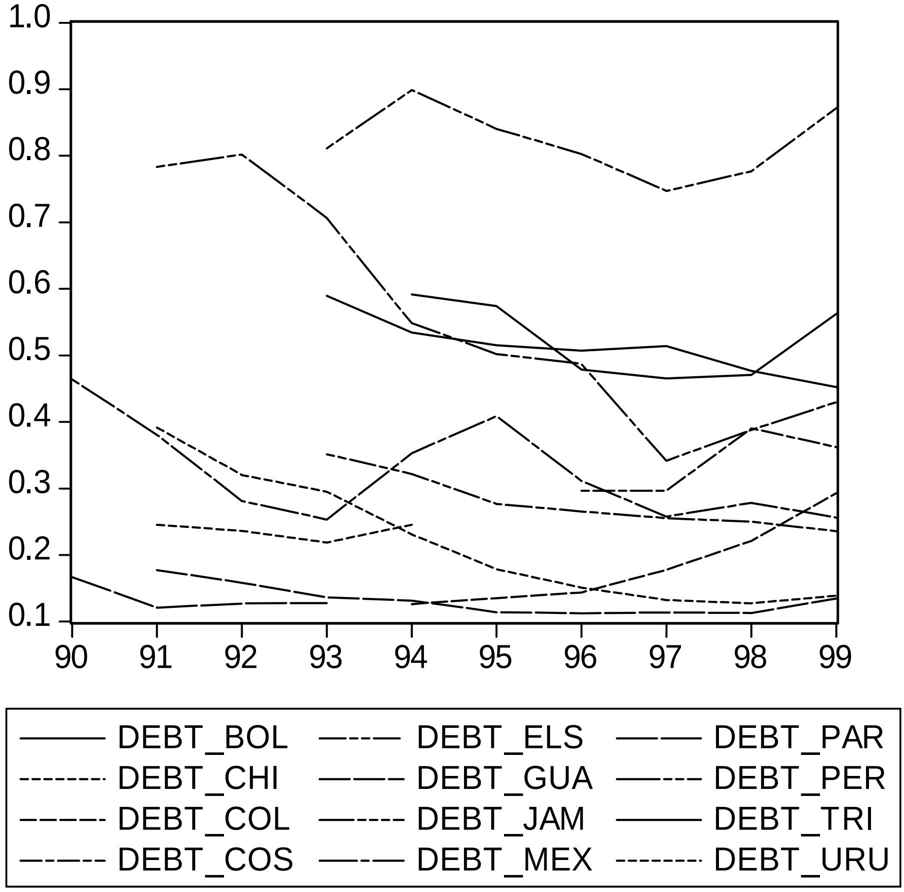


Figure 1: Debt ratios in 12 Latin American countries

Next, figure 2 shows the average share of foreign debt in the total debt stock for our sample countries. Again, for some countries the share seems to follow a downward trend, while for others *FORSHARE* is essentially stable.

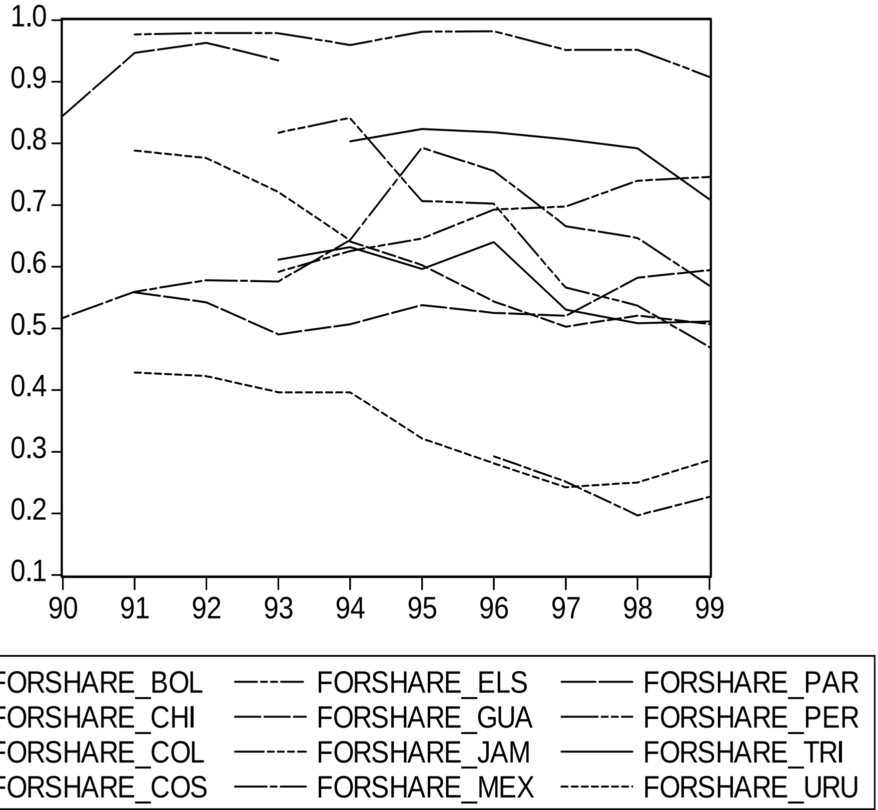


Figure 2: Share of foreign currency debt in the total debt stock

Finally, Figure 3 depicts $STRUC$, the average of structural reform indices. Here all the countries exhibit clear upwards trend, although one can detect occasional backtracking on reforms. As there is such a clear trend in this variable, in the estimations we will also utilise idiosyncratic country trends to check whether they have any effect on the results. Otherwise we will treat variables as being stationary. It is not conceivable that debt ratio could increase without bounds, i.e. it is not non-stationary. Even $STRUC$ itself is bounded between zero and one by construction.

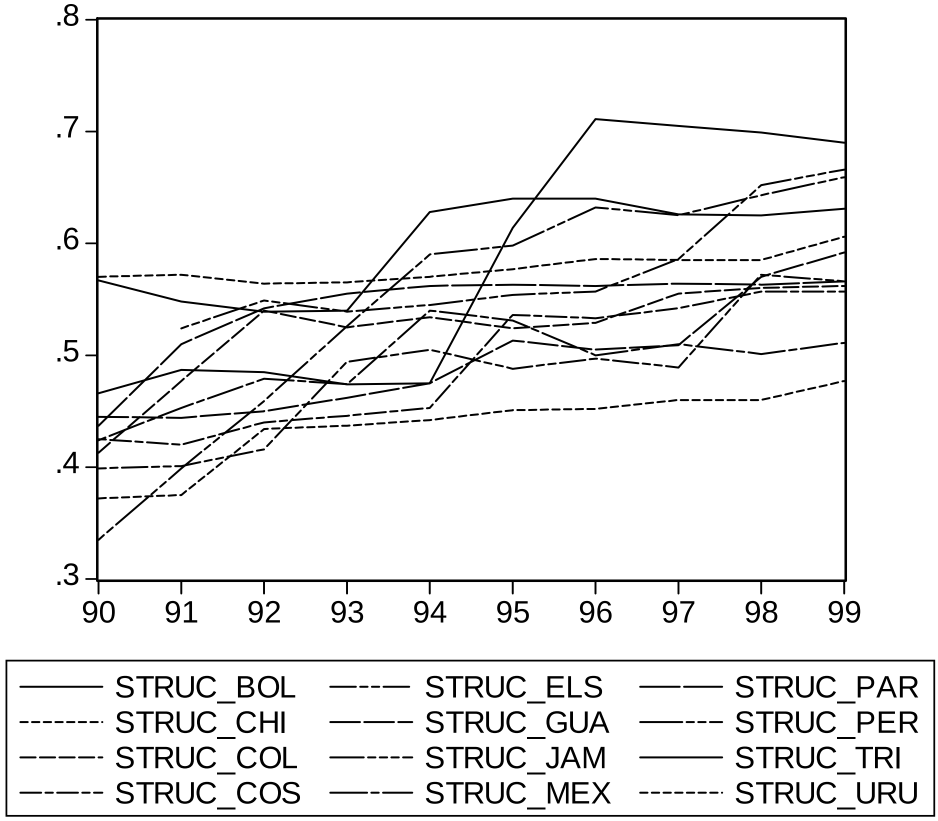


Figure 3: STRUC index

We will estimate the effect of $DEBT$ and $STRUC$ on $FORSHARE$ in a panel setting. We have ten time periods and twelve cross-sections in the panel, but lack of observations reduces the maximum number of available observations to approximately 80 (depending on the exact specification of the model).

In Table 2a we report the first results from our panel estimations, estimated with fixed effects[74]. However, individual country fixed effects are not reported. In column 1 we report just the simplest possible panel regression with $DEBT$ and $STRUC$ on the right-hand side. Signs of the both variables are in line with the predictions of the theory, but coefficient on structural reforms is not statistically

[74]We estimate the regression with cross-section weights, as cross-section heteroskedasticity is likely to be present in the data. Standard deviation of FORSHARE for individual cross-section units varies from 0.024 in Peru to 0.142 in Jamaica. Without this correction the standard errors of estimated coefficients would be too high, although the coefficients themselves are not affected.

significant. However, debt ratio is significant even at 1% significance level.

**Table 2a Panel data results for the share of foreign debt in 12 Latin American countries, fixed effects**

| | 1 | 2 | 3 |
|---|---|---|---|
| $C$ | 0.5225*** (8.1584) | -0.3498 (-0.799) | -0.3682 (-0.7855) |
| $DEBT$ | 0.1358*** (3.7908) | 0.0898 (0.3674) | 0.1934*** (4.4122) |
| $STRUC$ | 0.1121 (1.1032) | 3.2619* (1.941) | 3.2738* (1.8739) |
| $DEBT^2$ | | 0.1012 (0.436) | |
| $STRUC^2$ | | -2.7981* (-1.8248) | -2.8235* (-1.7615) |
| Adjusted $R^2$ | 0.99 | 0.99 | 0.99 |
| S.E | 0.07 | 0.07 | 0.06 |
| Total panel obs. | 82 | 82 | 82 |

*** denotes significance at one per cent significance level, and ** at five per cent level. t-values in parentheses. Individual country effects are not reported.

It is conceivable that the relationship between $FORSHARE$ and the two exogenous variables is non-linear. We test by adding first squared transformations of both $DEBT$ and $STRUC$. Now both $STRUC$ and $STRUC^2$ are (marginally) significant. Dropping out the obviously non-significant $DEBT^2$ results in our preferred specification in column 3 where also $DEBT$ is significant. Effect of structural reforms on share of foreign debt appears to be non-linear. If one examines the net effect of structural reforms on the share of foreign debt in the total debt stock, increase of one standard deviation in $STRUC$ (i.e. 0.07) results in 0.22 boost in the share of foreign debt in total debt. As the mean foreign share in the sample is 0.62, change of 0.22 is actually a very significant shift in country's debt management strategy.

**Table 2b Panel data results for the share of foreign debt in 12 Latin American countries, interaction terms and fixed effects**

| | 1 | 2 |
|---|---|---|
| $C$ | -0.0691 (-0.1919) | -0.4611* (-1.7108) |
| $DEBT$ | -2.9816*** (-3.1164) | 1.0366*** (4.4926) |
| $STRUC$ | 2.6502** (2.2177) | 2.9185*** (3.6007) |
| $DEBT^2$ | 2.2088*** (3.6305) | |
| $STRUC^2$ | -2.7685*** (-2.8275) | -1.3065** (-2.2756) |
| $DEBT * STRUC$ | 6.1363*** (3.9971) | -1.7583*** (-3.9834) |
| $DEBT^2 * STRUC^2$ | -7.9574*** (-5.201) | |
| Adjusted $R^2$ | 0.98 | 0.99 |
| S.E | 0.055 | 0.035 |
| Total panel obs. | 82 | 82 |

*** denotes significance at one per cent significance level, and ** at five per cent level. t-values in parentheses. Individual country effects or trends are not reported.

In Table 2b we conduct otherwise similar estimations, but allow interaction terms between variables. In addition, we entertain the possibility of individual country trends In column 1 of Table 2b we introduce two interaction variables, $DEBT \times STRUC$ and $DEBT^2 \times STRUC^2$. We can see that coefficients of $STRUC$ and $STRUC^2$ are qualitatively unaffected, but direct effect of $DEBT$ is now negative. However, $DEBT^2$ is now significant as well, and debt ratio affects share of foreign debt also through the interaction terms. When one takes into account all these channels of influence[75], $DEBT$ does increase the share of foreign debt in the the total debt stock, when evaluated at the median of $STRUC$ (=0.51). The effect is also positive at the minimum of $STRUC$ in our sample (=0.45), but when $STRUC$ is sufficiently high, the effect is concave in the interval we are interested in (i.e. the variable $DEBT$ lies between 0.11 and 0.90). Figure 4 shows the net effect of $DEBT$, $DEBT^2$, $STRUC$, $STRUC^2$, and both interaction terms on $FORSHARE$ at three different levels of structural reforms. $STRUC$ takes on values of 0.45, 0.53 and 0.71. When structural reforms have progressed far enough, higher debt level tends to decrease the share of foreign debt in total debt. Apparently far-reaching structural reforms give economic policies enough credibility so that borrowing is possible also in the

[75] Between 0.11 and 0.90, as the value of DEBT is always in this interval in our sample.

domestic markets (and currency). And when debt level is sufficiently high, borrowing in domestic currency reduces debt servicing risks, as the exchange rate risk is reduced. However, this option appears to be available only to the countries most advanced in their structural reforms. Nevertheless, this result illustrates the result that effects of $DEBT$ and $STRUC$ are clearly non-linear. In addition, there are clear interactions between the variables.

When country-specific trends are added to the specification, $DEBT^2$ and the squared interaction term lose their statistical significance (column 2 of Table 2b). Effects of $DEBT$ and $STRUC$ are again as predicted by the model developed earlier, and the estimated coefficients are statistically significant. Individual country trends are also highly significant (with the exception of Mexico). And with the exception of Mexico and El Salvador they are negative. However, it should be noted that introducing them does not change the statistical significance of our main variables of interest. Therefore, none of the results seem to hinge on observed trends in individual countries.

Diagnostic tests do not indicate any major problems in the residuals of panel regressions. Therefore the models appear to be well specified. Nevertheless, it is somewhat suspicious that $R^2s$ are so high. However, in random effects specification they drop significantly, while coefficient estimates remain essentially the same.

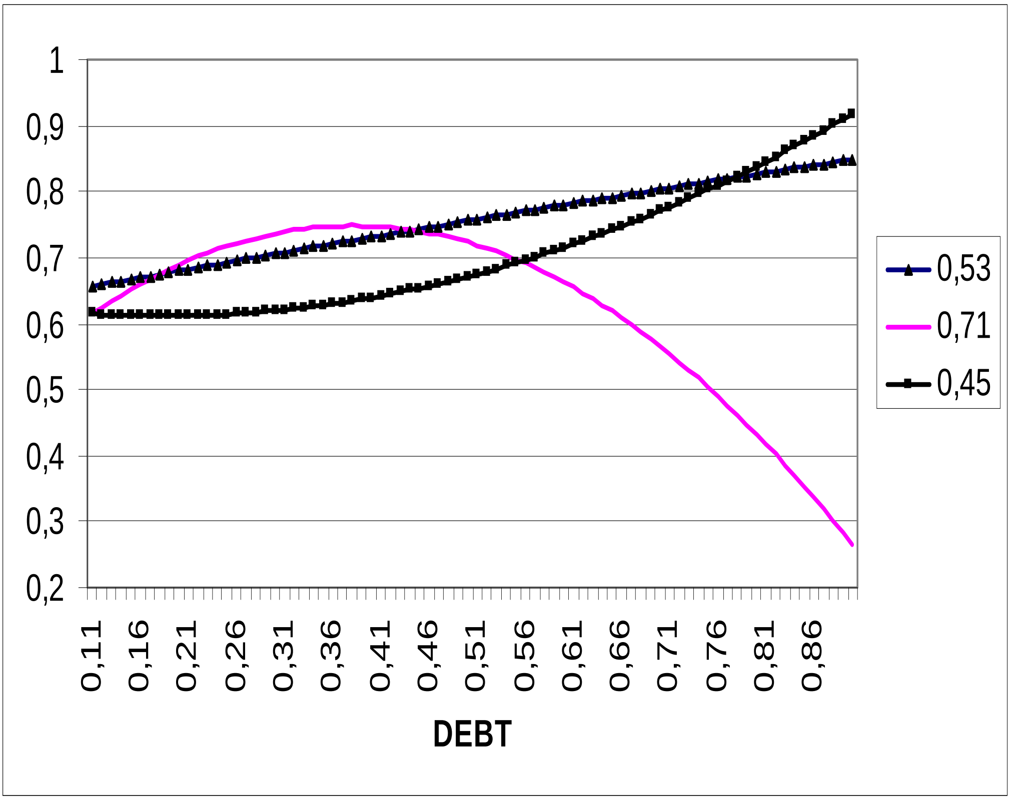


Figure 4: Net effect of DEBT and STRUC on FORSHARE with STRUC=0.53, STRUC=0.45 and STRUC=0.71

Next, we conduct the panel estimations also with random effects specification. We follow the same testing strategy as in the fixed effects case to retain compatibility across different empirical specifications. So, as before, we start with the simplest possible set-up where the share of foreign debt in the total debt stock is explained only by the debt level and the extent of structural reforms. The first column of Table 3a[76] depicts this case. In this simplest scenario, neither variable is statistically significant. However, already in the case of fixed effects estimations we saw that the effects of debt level and structural reforms are likely to be non-linear. Therefore, column 2 reports the case where both $DEBT^2$ and $STRUC^2$ are added. The results are very similar to those from the fixed effect specification. Both $STRUC$ and $STRUC^2$ are statistically significant. As the model developed earlier predicts, the effect of structural reforms on share of foreign currency debt is positive. However, this effect is

[76] Again, individual random effects are left unreported.

clearly non-linear, as $STRUC^2$ is negative. Of course, we must observe that statistical significance of coefficients is not very high, and p-values for both of them are approximately 0.06. Dropping $DEBT^2$ makes $DEBT$ somewhat more significant, but its p-value is still 0.20. The net effect of structural reforms is somewhat larger than in the fixed effect specification. One standard deviation (0.07) change in the index structural reforms results in 0.29 change in the share of foreign debt. As mentioned before, the average share of foreign debt in the sample is 0.62, and therefore 0.29 can be regarded as a very large effect indeed.

Generally, results from the random and fixed effects specifications seem to point very much to the same direction. Signs and magnitudes of coefficients are broadly similar, or in the case of $STRUC$ and $STRUC^2$, the net effects are both quite large.

**Table 3a Panel data results for the share of foreign debt in 12 Latin American countries, random effects**

| | 1 | 2 | 3 |
|---|---|---|---|
| $C$ | 0.6029*** (4.6491) | -0.6465 (-0.9421) | -0.6310 (-0.9193) |
| $DEBT$ | 0.1361 (0.91443) | 0.1239 (0.4187) | 0.1571 (1.2812) |
| $STRUC$ | -0.0288 (-0.1219) | 4.5973* (1.9203) | 4.5265* (1.8812) |
| $DEBT^2$ | | 0.0366 (0.0992) | |
| $STRUC^2$ | | -4.2093* (-1.9304) | -4.1513* (-1.9048) |
| Adjusted $R^2$ | 0.04 | 0.09 | 0.11 |
| S.E | 0.0704 | 0.068 | 0.068 |
| Total panel obs. | 82 | 82 | 82 |

*** denotes significance at one per cent significance level, and ** at five per cent level. t-values in parentheses. Individual country effects are not reported.

Next, we allow for the possibility of inter-action terms between the variables of interest. Results are reported in Table 3b. First, we include $DEBT$ and $STRUC$, both variables squared, a multiplicative interaction term between them as well as the interaction term to the power of two. Results of this estimation are reported in the first column of Table 15b. For the most part, they are very similar to the fixed effect estimations, although here $STRUC$ and $STRUC^2$ are not statistically significant. Therefore, we drop first $STRUC^2$ to see whether its exclusion has any bearing on the results. In this specification the coefficient on $STRUC$ turns negative (as in the fixed effect case) and is statistically significant. Other coefficients are roughly similar to the previous specification.

**Table 3b Panel data results for the share of foreign debt in 12 Latin American countries, interaction terms and random effects**

| | 1 | 2 |
|---|---|---|
| $C$ | 0.7022 (1.0187) | 1.223*** (5.289) |
| $DEBT$ | -4.953*** (-6.1623) | -5.2395*** (-6.637) |
| $STRUC$ | 0.73897 (0.3407) | -1.1621*** (-3.2564) |
| $DEBT^2$ | 3.2719*** (7.2606) | 3.4814*** (7.7786) |
| $STRUC^2$ | -1.7102 (-0.9664) | |
| $DEBT * STRUC$ | 9.1345*** (6.4018) | 9.6470*** (6.8273) |
| $DEBT^2 * STRUC^2$ | -10.095*** (-8.0146) | -10.774*** (-8.7307) |
| Adjusted $R^2$ | 0.31 | 0.31 |
| S.E. | 0.058 | 0.58 |
| Total panel obs. | 82 | 82 |

*** denotes significance at one per cent significance level, and ** at five per cent level. t-values in parentheses. Individual country effects or trends are not reported.

As both of our variables of interest influence the share of foreign debt through a variety of channels, we must again calculate the net effects. We present the net effects in similar fashion as before, in Figure 5 Three lines depict how the share of foreign debt changes with the level of debt for different degrees of structural reforms. The results are almost identical with the fixed effects case: When the level of structural reforms is relatively "normal" (i.e. close to the mean), higher debt level means higher share of foreign debt. Only when the level of structural reform is close to the maximum observed in the sample (well over 0.6), is the relation between debt level and share of foreign debt negative at high debt levels. Again, the intuition is that deep structural reforms give government added credibility, which allows it also to borrow from domestic sources e.g. to reduce the exchange rate risk of borrowing.

Results from both fixed and random effect estimations yield almost identical results. Higher debt level increases the share of foreign debt in the total debt stock, as predicted by the model developed earlier[77]. A more novel result is that higher degree of structural reforms also

[77] And several other models of the same phenomenon.

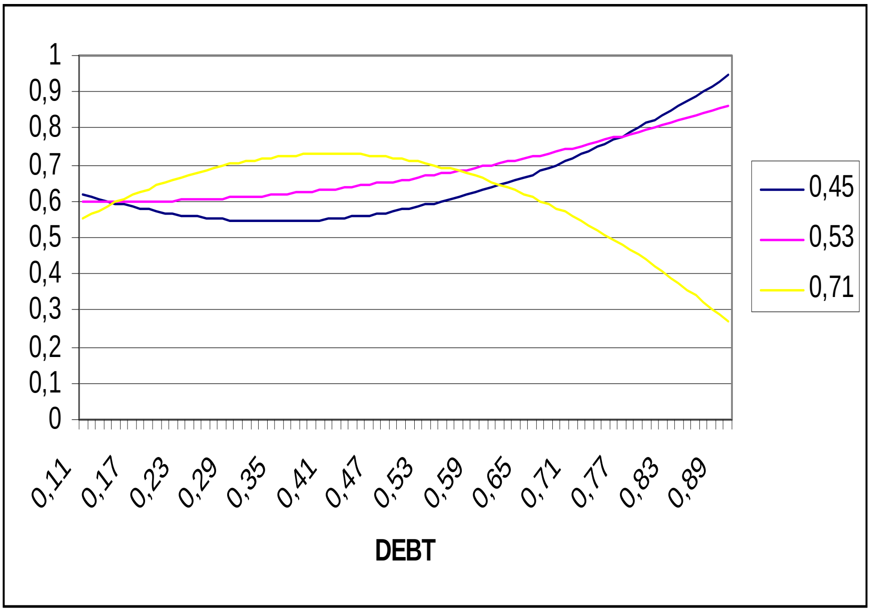


Figure 3: Figure 5: Net effect of DEBT and STRUC on FORSHARE with STRUC=0.53, STRUC=0.45 and STRUC=0.71

seems to be associated with higher share of foreign debt, both in the theoretical model of subsection 4.2 and in the empirical results.

## 4.4 Concluding remarks

In this essay we first developed a model linking a government's debt management strategy to structural reforms. By undertaking structural reforms (which may be beneficial to the economy's long-term growth potential or to some similar goal).government can affect the risk premium it has to pay on borrowing in domestic currency. This will increase the incentive to borrow in domestic currency. However, higher domestic borrowing will mean a greater danger of surprise inflation for the holders of government debt. The higher is the level of domestic borrowing, the higher is the benefit from surprise inflation as the real value of public debt decreases. As government receives disutility from taxation, lowering debt servicing costs increases welfare in all future periods. However, private sector understands this temptation, and consequently higher level of structural reform effort is, in fact, associated with lower share of domestic borrowing. An alternative interpretation would be that foreign investors require structural reforms in exchange for extending credits.

Higher debt ratio is also found to be associated with lower level of domestic borrowing. This result is familiar from many other models of government debt structure. The larger is the debt ratio, the larger is the benefit from engineering surprise inflation to reduce the real level of government debt.

In the empirical part of the section we tested the predictions of the model with data from the Latin American countries. Data from these countries are used as their economic have undergone deep structural reforms during the past two decades. Moreover, many of the Latin American countries have had quite high debt levels, although during the 90s the level of indebtedness did decrease in most countries.

We find that the Latin American data seem to fulfil the predictions of the model. Regardless of the exact specification, extent of structural reforms is positively correlated with the share of foreign currency debt. Also, higher debt levels are associated with more foreign borrowing. However, the effects seem to be non-linear, and therefore some caution must be used when interpreting the individual coefficient estimates.

The results of this section offer some policy conclusions for countries contemplating structural reforms. Embarking on a course of structural reforms may very well mean that a country must (or is allowed) to borrow relatively more from abroad. This will increase the exchange rate risk associated with financing of the debt. The higher is the debt level, the larger is this effect. However, when the level of reforms is very high, government is able to borrow more from domestic markets at reduced interest rates. In our data sample only very few data points would actually fall on this downward sloping part of the relationship. Therefore the main result remains the same, structural reforms result in higher relative level of foreign borrowing. This must be taken into account in planning the reform package and associated economic policies.

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# Appendix A

Proofs

**Proof of proposition 6**

**Proof.** To obtain the result that $\frac{\partial\theta^*}{\partial R} > 0$ we need to differentiate equation 85 with respect to $R$, recalling that $\mu'(R) < 0$ : $\frac{\partial}{\partial R}\{\frac{1}{\mu(1+AD^2)}(1 + r + \mu + AD^2 + ArD^2 + AD\mu)\} = \frac{\mu(1+AD^2)(1+AD)\mu' - \mu'(1+AD^2)(1+r+\mu+AD^2+ArD^2+AD\mu)}{\mu^2(1+AD^2)^2}$. Collecting terms and simplifying yields: $\frac{\mu(1+AD^2)(1+AD)\mu' - \mu'(1+AD^2)(1+r+\mu+AD^2+ArD^2+AD\mu)}{\mu^2(1+AD^2)^2} = \frac{-\mu'(1+r+AD^2+ArD^2)}{\mu^2(1+AD^2)^2}$. Denominator of this expression is necessarily positive, and we assume that $\mu \neq 0$, as before. As $(1 + r + AD^2 + ArD^2) > 0$ and $\mu' < 0$, the numerator is positive as well, and hence $\frac{\partial\theta^*}{\partial R} > 0$. ■

**Proof of proposition 7**

**Proof.** We will only consider cases where the risk premium is not too large, i.e. it is smaller than $\frac{1}{2}$, or 50%. This should cover the real world situations we are interested in. To obtain the result that $\frac{\partial\theta^*}{\partial D} > 0$ we need to differentiate equation 85 with respect to $D$. We obtain $\frac{\partial}{\partial D}(\frac{1}{\mu(1+AD^2)}(1 + r + \mu + AD^2 + ArD^2 + AD\mu)) = \frac{\mu(1+AD^2)(2AD+A\mu+2ArD) - (1+r+\mu+AD^2+ArD^2+AD\mu)(2AD\mu)}{\mu^2(1+AD^2)^2}$. Collecting terms and simplifying yields: $\frac{\mu(1+AD^2)(1+AD)\mu' - \mu'(1+AD^2)(1+r+\mu+AD^2+ArD^2+AD\mu)}{\mu^2(1+AD^2)^2} = \frac{A\mu^2(1-2D)+2A^2D^3(1-\mu)+2A^2D^3r(1-\mu)+A^2D^2\left(\mu-2\mu^2\right)}{\mu^2(1+AD^2)^2}$. Denominator of this expression is obviously positive. Sign of the numerator depends on the values of parameters, but under any realistic (in economic terms) combination of parameter values the numerator is positive as well. When $0 < \mu < \frac{1}{2}$, the last three terms of the numerator are positive, and the whole numerator unambiguously is positive, which means $\frac{\partial\theta^*}{\partial D} > 0$. If both D and $\mu$ are close to unity, numerator will be negative. However, we consider such a large risk premium to be quite unrealistic, and do not pursue this case further. ■

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