Public Debt and Inflation: the Role of Inflation-Sensitive Instruments

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Abstract

This paper examines the effect of inflation on the choice of government debt structure. We develop Missale and Blanchard (1994) to produce a model that allows for the joint determination of inflation and the share of inflation-sensitive securities. We introduce the preference of the government for fixed-rate nominal long-term debt denominated in domestic currency into their loss function and consider the non-commitment solution. We show that the model implies a sub-game perfect equilibrium involving a negative relation between inflationary expectations and the share of such debt. We then test this prediction of the model with time series data for fifteen OECD countries using the nominal long-term yield as a proxy for expected inflation. Panel data estimation provides strong support for the theory.

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1 Introduction

In light of an integrating world economy the issue of public debt becomes even more intriguing. For example, the Stability and Growth Pact adopted by the European Union in 1997 carries a number of implications for the choice of fiscal policies (e.g. Beetsma and Uhlig, 1999). There are several issues that can be examined in the context of debt analysis. A starting point could be the study of the short-run and long-run macroeconomic implications of the issuance of government securities. Such a query is relevant as a strand of the literature argues that Ricardian Equivalence holds: the way a policymaker decides to finance government expenditure –through debt or taxes– does not matter. If debt matters, though, a policymaker can maximize a social welfare function by deciding on the fraction of government expenditure that will be financed with new debt, and by actively choosing the combination of the available instruments employed for that purpose. The debt manager can choose from a variety of instruments including short-term and long-term securities, nominal, price-indexed and financially indexed bonds, domestic and foreign currency debt, etc. In the public debt management literature, it has been shown that governments can succeed in implementing welfare maximizing policies (for example policies aiming to reduce variations in prices and taxes), if they choose the right maturity and contingencies structure of debt (e.g. Barro, 1997).

Another important dimension of government debt management is the effect that different strategies might have on the time-inconsistency problem. Indexation and maturity can play a significant role in affecting the incentives of future policymakers (Lucas and Stokey, 1983). Persson et al. (1988) show that the optimal fiscal and monetary policy can be made time-consistent under discretion if each government leaves to its successor a particular maturity structure of debt, and both nominal and real bonds are traded. In other words, debt management can affect the incentives of the government in order to follow an optimal plan in the future.

This paper focuses on the choice between debt instruments with high inflation elasticity and instruments with low (or zero) inflation elasticity. The question we ask is whether changes in the perception of the public about future inflation affect the amount of deflatable debt issued by the government, and to which extent. Building on Missale and Blanchard (1994) we produce a model that allows for the joint determination of inflation and the share of fixed-rate, nominal long-term debt denominated in domestic currency. We introduce the preference of the government for deflatable liabilities into their loss function and consider the non-commitment solution. We show that the model implies a sub-game perfect equilibrium involving a negative relation between in°ationary expectations and the share of in°ation-sensitive debt. In other words, higher expected in°ation induces a change in debt management: the government issues more instruments of lower in°ation elasticity in order to enhance its credibility. The model is presented in section 3 after a brief review of the literature (section 2). In section 4, we use panel data estimation methods to measure quantitatively the e®ect of our ¯nding. Section 5 concludes the paper.

2 The Literature

2.1 Debt and the Economy

We ¯rst examine the channels through which debt a®ects the economy. The Ricardian Equivalence theorem states that for a given path of government expenditure, the timing of taxes should not a®ect the consumption decision made by the individuals paying the taxes: substituting taxes for taxes plus interest tomorrow, via debt ¯nancing, should not affect the wealth of the individuals. This happens because in this setting agents are forward-looking and base their consumption decisions on permanent income. The Ricardian hypothesis then predicts that agents will save an amount of money equal to this period's tax cut in order to pay next period's increased taxes. Thus, current consumption will be unaffected by a debt-¯nanced tax cut and the choice between debt and taxes is irrelevant. The implications of the theorem contradict the Keynesian approach, which assumes myopic agents who only care about present disposable income. Under this line of thinking, the tax-cut increases the households' disposable income and perhaps their lifetime wealth as well. This increase will boost household spending on consumption goods, and thus, the aggregate demand shifts and national income rises. Such a policy may be recommended during a recession in order to stimulate economic activity.

At high levels of debt, though, a ¯scal de¯cit may even prove to be a contractionary measure as a debt stabilization program will then need to be implemented (Sutherland, 1997). In the long-run, conventional analysis suggests that an e®ect of increased debt will be a reduction in the country's capital stock as a result of a declining national saving and investment. Elmendorf and Mankiw (1998) provide several other long-run e®ects of debt. They report e®ects on monetary policy[1], on the

[1] A high debt to GDP ratio would mean high interest rates. The monetary authorities could follow expansionary policies in order to reduce those rates. In°ation would result in the long-run.

deadweight loss of taxes[2], on the political process that determines ¯scal policy[3], on the vulnerability of the economy to a crisis of international con¯dence[4], and even on the country's political independence[5].

We can now introduce the concept of debt management in our analysis. As mentioned in the introduction, the government can employ several debt instruments in order to achieve its goals (increase its credibility, minimize debt servicing costs after taking into account risk, reduce price and taxes variations, etc.). The composition of debt can a®ect future taxes since di®erent `debt portfolios' can yield di®erent returns on debt across future states of nature. In that way, the path of future government liabilities and, hence, the need to tax will vary according to the choice between the available instruments. The debate on the neutrality of debt can be extended to include these debt management considerations. Missale (1999) presents the assumptions under which the management of public debt does not a®ect the real allocation of resources: (1) agents are not myopic and/or care about future generations, (2) future taxes are state-independent, (3) capital markets are perfect, (4) private asset markets are complete, (5) the use of debt cannot create value, and (6) taxes are not distortionary. Conditions (1), (2), and (5) are not necessary if the return on debt is not a®ected and, consequently, taxes need not adjust.

The empirical literature has not been able to deliver robust results in favour of, or against the Ricardian equivalence. Theoretically, though, there are several reasons why it should not hold and the choice between debt and taxes and the corresponding debt issuing strategies should constitute e®ective ¯scal policies. In what follows, we present the arguments used against the neutrality of debt and debt management.

One reason might be the intergenerational distribution of resources. If the burden of the increased tax tomorrow (implied by a tax cut today or a costly debt management strategy) falls on the next generation, the current generation will not save the tax cut, but, instead, will increase its consumption. Barro's critique on this approach is that the current generations care about the future ones as they are connected with them through family relations (the intergenerational altruism argument). In the same context, Stiglitz (1983) argues that in the absence of intergenerational distribution e®ects, public ¯nancial policy is irrelevant. He

[2]As debt is being accumulated deadweight losses from taxation decrease. The opposite happens when the debt is being serviced with higher taxes.

[3]The possibility of government borrowing might reduce the discipline of the budget process, as the agents will assert less pressure for contained spending.

[4]High debtor countries are more prone to currency crises (especially when debt is held abroad).

[5]High debtor nations are less likely to gain international power.

argues that changes in the level, issuance strategy, and maturity structure of debt have neither real nor financial effects. Whether a change in public financial policy has any effect depends on its effect on the intertemporal distribution of income. It has to be noted, though, that a basic assumption in this analysis is that taxes are non-distortionary. When taxes are distortionary, the timing of taxes also affects the total deadweight loss imposed by the system, and debt management becomes an important concept.

Another argument in support of the idea that a tax cut will indeed increase consumption is that of capital market imperfections. In this context, a debt-financed tax cut can be regarded as the loan that the financially restricted households required but could not obtain from private lenders. This will boost the restricted households' consumption causing the Ricardian Equivalence to fail. Additionally, in the presence of such imperfections that create different borrowing environments for the government and the private sector, debt management alters the tax-return opportunity set that investors face.

An interesting question is what would happen in the case that the government was financing debt's repayment with additional debt instead of imposing taxes. If the interest rate on government debt is greater than the growth rate of the economy, then government debt will increase faster than the economy and this scheme (of rolling debt over) will eventually prove to be infeasible. However, if the interest rate is less than the growth rate, the government can keep on rolling debt over forever. This is an intriguing theoretical possibility but it is not usually the case as the economy would be dynamically inefficient. Hence, one cannot reject the Ricardian Equivalence on these grounds. If the public sector can borrow indefinitely to meet its debt obligations then debt management also becomes irrelevant. However, in the 1960's and early 1970's many countries experienced real GDP growth that exceeded the real interest rate. For these countries budget deficits did not necessarily result in growing debt-GDP ratios. Milbourne (1997) argues that if the rate of growth falls below the real interest rate less the marginal propensity to consume out of wealth, then a country will enter a `debt trap'. There will be high accumulation of foreign debt, and difficulties in repaying the debt (or even the interest on debt) will occur.

Another channel through which debt affects the economy is distortionary taxation. This is another example of how debt crowds out capital: higher debt leads to higher debt service, which in turn requires a higher tax rate. A higher tax rate leads to a higher before-tax interest rate, which leads to a smaller steady-state capital stock. Obviously, if taxes distort incentives debt management plays an important role. The debt managers, then, should choose a structure that promotes the least distortionary tax schedule[6].

We can argue that the Ricardian Equivalence does not hold if a full set of state-contingent claims does not exist (markets are incomplete). The introduction of a new asset could then alter the consumption patterns of the agents and financial innovation as a part of debt management would become relevant.

It is also possible that government debt changes the agents' perception of risk. It can be the case that consumers discount risky uncertain income and uncertain future taxes at a higher rate than the interest rate on debt. This means, that in the event of a tax cut they prefer to increase their current consumption.

Another argument that the literature offers against the Ricardian Equivalence is myopia. Myopia questions the assumption of rational, forward-looking individuals, which is one of the assumptions that the Ricardian hypothesis is based on. In this case, agents correspond to a tax cut with an increase in consumption since they cannot realize the implied future tax increase. With myopic agents debt management does not matter.

All these theoretical approaches have been used to question the relevance of the Ricardian Equivalence[7]. The effects of higher government debt on interest rates, exchange rates and other macroeconomic variables have been studied in the empirical literature but do not provide clear evidence on the validity of the Ricardian hypothesis. Becker (1997) tests for Ricardian and non-Ricardian behavior in the US economy. He finds some support for the theorem, but he also concludes that there are some deviations from its predictions as well. Additionally, he finds little support for a simple Keynesian model.

In Woodford (1998), limits upon the permissible growth of public debt, like those stipulated in the Maastricht Treaty, will eliminate the effects of fiscal shocks on real or nominal variables. A certain type of fiscal instability, namely variations in the present value of current and future primary government budgets, necessarily results in price level instability, in the sense that there exists no possible monetary policy that results in equilibrium with stable prices. In the presence of sluggish price adjustment, the fiscal shocks disturb real output and real interest rates as well. Shocks of this kind can be eliminated by a limit on the value of public debt. In the presence of the debt limit Ricardian Equivalence holds. Aiyagari and McGrattan (1997) develop a model for deriving an

[6]See next section and Barro (1997).

[7]Our analysis of the Ricardian hypothesis has largely been based on Elmendorf and Mankiw (1998) and Missale (1999).

optimum quantity of debt. This quantity will be high if debt is e®ective in smoothing out consumption over the lifetime of an individual and it will be low if debt crowds out capital and, therefore, lowers consumption. It will also be low if the incentive e®ects of higher distortionary taxes are important.

Despite the ambiguity of the literature, most policymakers follow a `pragmatic' approach when making decisions on the level of debt: the issuance of government debt stimulates aggregate demand and increases national income in the short-run, but crowds out capital and reduces national income in the long-run. In addition, debt managers are actively engaged in the task of optimally selecting the composition of their governments' debts in order to implement desired economic policies.

2.2 Managing Public Debt

We have thus far established that public debt management is a relevant function of a government's economic policy. The debt managers are facing a trade-o® between the minimization of debt servicing costs and the minimization of budgetary risk. Ideally, if the government is risk-averse, an instrument indexed to output or public spending would be issued. It would pay low in states of the world that output is low and public spending is high. In that way the budget would be insulated from the e®ects of a down-turn of the economy on debt returns and risk would be minimized as this instrument would imply smoother tax rates. However, due to recording delays and moral hazard problems respectively, such debt is not being issued. As a result, the managers have to rely on other more conventional instruments.

In macroeconomic policymaking, credibility problems typically arise. This is a situation where the policymaker ¯nds that the ex ante policy is not optimal ex post as a result of the di®erent constraints that he/she faces at the start and at the end of the period. Thus, a di®erent policy must be implemented at the end of the period, and this makes the original plan time-inconsistent. However, a necessary condition is that the policymaker faces a second-best situation: if the policymaker had already achieved a ¯rst-best allocation at the start of the period, there would be no point in deviating from the ex ante optimal plan (Persson and Tabellini, 1995). Time-inconsistency would not matter if the policymaker could abide by a rule. It is most common, though, that policymaking takes place in discretionary regimes where policies are often revised. Credibility problems, then, do matter and the ambition of the policymaker to move the economy from a second-best regime to a ¯rst-best regime can lead to a third-best equilibrium (Barro and Gordon, 1983). What is important for our analysis is that as Lucas and Stokey

(1983) and Persson et al. (1988) show, a careful management of the maturity and contingency structure can be so e®ective that it can make the time inconsistent second-best policy optimal. In other words, the full precommitment optimum can be achieved in a rational discretion world (Calvo and Guidotti, 1990).

In the same context, the work of Missale and Blanchard (1994) is relevant. They derive an inverse relationship between the level of debt and its maturity for high levels of indebtedness. In other words, an increase in the debt/GDP ratio is accompanied by a decrease in maturity (this result is robust for high debtor countries, but it disappears for countries with low levels of debt). The explanation is that as a government with nominal debt outstanding bene¯ts from surprise in°ation (and the bene¯ts increase with the level and the maturity of debt), it will try to keep its non-in°ationary policy credible by switching to shorter-term debt, as debt increases. Their result is promising because in a reputational equilibria regime, if the government has had resort to surprise in°ation in the past, it can still achieve zero equilibrium in°ation if it drastically shortens the maturity structure of debt. We extend this model in the next section.

High indebtedness does not only lead to issuance of short-term debt, but also increases the default risk on government debt. Alesina et al. (1992) ¯nd a positive correlation between default risk and the level and growth of debt for the highly indebted OECD countries. This risk premium is incorporated in the long-term nominal interest rates possibly leading governments to issue more short-term debt. Alesina et al. (1992), though, were not able to con¯rm empirically a positive relation between default risk and the share of short-term debt.

However, the maturity of debt does not only depend on the level of debt. As Missale et al. (1997) show, during ¯scal stabilizations the maturity of government bonds tends to lengthen the more credible[8] is the stabilization program, the lower is the long-term interest rate and the higher is the volatility of the short-term interest rates. In the presence of asymmetric information, high long interest rates may re°ect credibility problems and the government will issue short-term debt to reduce debt-servicing costs.

Barro (1997) derives a certain structure of the maturity and contingencies of public debt so as to achieve tax smoothing (assuming that variations in taxes over time cause distortions that the government would like to avoid). In this model, the optimal decision for the policymaker is to issue indexed consols (bonds of in¯nite maturity indexed to the price

[8] They identify as credible an attempt which leads to a fall in the long interest rate relative to the German rate.

level). In contrast with Barro's argument that nominal debt should not be issued, Bohn (1988) displays the properties of nominal debt as a hedging device against productivity shocks that demand changes in the path of taxes. Indeed, a worsening of the budget will be followed by unexpected in°ation that reduces the government's liabilities. In an empirical work of Missale (1997), it is con¯rmed that, in the case of Italy, nominal debt has been a valuable hedging instrument since the late 1980s. Such a result, though, is not con¯rmed for UK data where it seems to be the case that debt should be wholly indexed to the price level.

Cochrane (1998) ¯nds cases in which long-term debt helps to stabilize in°ation. This is achieved when the present value of surpluses (nominal debt over the price level) varies by more than the surpluses themselves. Alesina et al. (1990) argue that a long and smooth maturity structure of government debt reduces the risk of con¯dence crises.

The interactions between monetary regimes and di®erent debt management strategies are examined in Falcetti and Missale (2000). They conclude that an independent central bank bene¯ts from domestically denominated debt, possibly of a long maturity, since such debt dampens the impact of productivity shocks on taxes and output. If the central bank is not independent or has not enough of a reputation for being tough with in°ation, a debt denominated in foreign currencies or with a short maturity may enhance the credibility of the anti-in°ationary policy.

Summarizing, public debt management can be useful in implementing several macroeconomic goals (e.g. price stability, tax smoothing, avoidance of con¯dence crises, reduction in public sector's borrowing costs, etc.). In the next section, we develop a debt management model in which in°ation and the share of de°atable debt are jointly determined. We capture the idea that the government has a preference for debt instruments of high in°ation elasticity, and show that the share of such debt as a fraction of total debt is a negative function of in°ationary expectations.

3 The Model

This section extends the Missale and Blanchard model (henceforth MB) to allow for the joint determination of in°ation and the proportion of in°ation-sensitive debt issued by the government. Unlike MB, in this paper we do not rely on trigger strategies to enforce an outcome better than the non-commitment equilibrium. Trigger strategy equilibria, although sub-game perfect are not \renegotiation-proof" and this raises questions about the credibility of such equilibria (al-Nowaihi and Levine, 1994). We therefore con¯ne ourselves to non-commitment solutions to the government's problem without trigger strategies. The model is based on MB but with one change. We capture the idea that de°atable debt is preferred to low (or zero) in°ation-elasticity debt and we use this observation to form the government's loss function.

The literature in public debt management is not yet conclusive regarding the kinds of debt that should be preferred by debt managers. The selected instruments may re°ect several underlying economic conditions: credibility problems, supply or demand shocks hitting the economy, or simply the need to buy insurance from the private sector. In this paper we take the view that the government has a preference for nominal long-term debt denominated in domestic currency. The role of such debt in cases where output shocks are negatively correlated with unexpected in°ation is quite obvious: the government will have to pay lower returns to bond holders when output and consequently the tax base are surprisingly low. This shock-absorbing role of nominal debt is even more apparent during wars or crises (e.g. oil shocks). Generally, as in Missale (1999) \nominal debt is a better hedging instrument than price-indexed debt if productivity and public spending shocks prevail". The optimal share of nominal bonds is increasing in the covariance of in°ation with public spending and decreasing in the covariance of in°ation and output.

The presence of nominal liabilities allows the government to use a combination of taxes (including the in°ation tax) during output or public spending shocks. This idea is pictured in Bohn (1988): given a shock that a®ects the government's budget, the changes in the path of prices will reduce the real value of debt, thus requiring less distortionary taxes to be raised. We do not explicitly model these responses to shocks. To keep the modelling tractable we capture these stabilization reasons for preferring long-term nominal debt in a single term. In Calvo and Guidotti (1990) we also ¯nd a role for nominal debt even if price-indexed debt is available. In their own words \full price indexation is shown not to be necessarily optimal, because the government would be completely prevented from applying the in°ation tax on bonds to smooth out conventional taxes". In Fischer (1983) \The best of all possible worlds, if governments acted optimally, might be one in which governments had the option of imposing a capital levy in this way in emergencies like wars". But that is, if governments acted optimally. In other words, the issuance of long-term nominal securities creates an incentive for the government to resort to surprise in°ation and raises the credibility issue. Note, though, Dornbusch (1998) who argues that today, in°ating away debts no longer works because the costs (higher real interest rates) are too high.

But how does the private sector perceive the issuance of long-term nominal securities (deflatable debt)? Does it require a premium in order to hold such debt? The answer to these questions is that, in the absence of informational asymmetries and credibility problems, a debt manager should not look to minimize costs but rather minimize risks; and since nominal long-term debt can serve as an effective hedging device during productivity and spending shocks, paying a premium should not be a consideration, at least for credible governments[9].

The credibility considerations involving the issuance of nominal public debt have triggered a boost in the relevant literature. In our analysis we take up this issue; our model shows that given the government's preferences, if the government can fully precommit itself to future inflation and a certain structure of public debt, then all debt should be in the form of deflatable securities. In the absence of government precommitment, our specification calls for a negative relationship between the share of deflatable debt and inflationary expectations. In an environment where expectations about future levels of inflation are increasing, the government in our model switches to other instruments that enhance its credibility (short-term bonds, real or foreign currency debt, etc.). However, the degree of issuance of incentive-compatible securities should be carried out with prudence (e.g. Giovannini 1997). The Mexican crisis is an example of a situation where the effort to acquire credibility through the debt markets resulted in a disaster.

Indexing debt to a (strong) foreign currency for credibility purposes entails the risk of an appreciation of the foreign currency and exposes the budget to exchange rate risk in the same way short-term debt exposes the budget to interest rate risk. Ignoring incentive considerations, rolling over short-term debt exposes the budget to interest rate risk. Shocks that raise interest rates are more costly if the government has to refinance its debt often. Additionally, the transaction costs incurred if short-term debt has to be rolled over regularly impose an additional burden on the taxpayers' money. For these and other reasons the governments (especially the more credible) have historically relied on long-term securities.

Taking the above into consideration we construct the government's single period loss function:

$$L_t = \frac{1}{2}\pi_t^2 - b(\pi_t - \pi_t^e) + cT_t + \frac{a}{2}(1 - m_t)^2; \qquad (1)$$

where π_t and π_t^e are the inflation rate and the rational expectations of inflation respectively, T_t is total taxation and m_t is the proportion of

[9]Participation in Monetary Unions where the monetary policy is conducted centrally enhances the national governments' credibility.

in°ation-sensitive debt, i.e. nominal long-term debt in domestic currency.

The ¯rst term re°ects the costs of in°ation, the second the bene¯ts of surprise in°ation arising from the labour market. If wage contracts are nominal then an in°ation surprise reduces the real wage and unemployment. The third term represents the (linear) costs of taxation and the last term the government's preference for domestic, nominal, long-term debt for the reasons mentioned above. The accumulation of real debt is given by

$$D_{t+1} = (1 + r_t)\,[1 - m_t(\pi_t - \pi_t^e)]\,D_t + G_t - T_t; \qquad (2)$$

where D_t is the stock of debt at the beginning of period t, r_t is the real interest rate and G_t is government spending.

The timing of events is as follows:

1. Government sets G_t (government spending in fact plays no role). The government commits itself to a tax rule:

   $$T_t = r_t\,[1 - m_t(\pi_t - \pi_t^e)]\,D_t + G_t; \qquad (3)$$

   which implies

   $$D_{t+1} = [1 - m_t(\pi_t - \pi_t^e)]\,D_t; \qquad (4)$$

   i.e., debt is constant in the absence of an in°ation surprise. Given D_t and m_t, it follows that $D^e_{t+1;t} = D_t$:

2. Government announces tax rule (3).

3. Government sets m_t for the period t:

4. The private sector sets π_t^e:

5. Government chooses in°ation rate in period t:

In each period the government chooses its instruments m_t and π_t to minimize an intertemporal loss function

$$V_t = \sum_{i=0}^{\infty} \frac{1}{(1+\delta)^i} L_{t+i}: \qquad (5)$$

To ¯nd the time-consistent (sub-game perfect) equilibrium to this game we proceed by backward induction at event 5.

Event 5. Choice of π_t:

Using (1); equation (5) can be written as:

$$V_t = L_t + \frac{1}{1+\delta}V_{t+1} = \frac{1}{2}\pi_t^2 - b(\pi_t - \pi_t^e) + cr[1 - m_t(\pi_t - \pi_t^e)]D_t$$
$$+\frac{1}{2}a(1 - m_t)^2 + \frac{1}{1+\delta}[cr(D_{t+1} + \frac{1}{1+\delta}D_{t+2} + \ldots)]$$
$$+\text{terms in } \pi_{t+1}; \pi_{t+2}; \pi_{t+1}^e; \pi_{t+2}^e; m_{t+1}; m_{t+2} \ldots \tag{6}$$

Equation (6) expresses V_t in terms of the inflation rate in period t and all future inflation rates. The effect of an inflation surprise in period t is to reduce debt to $D_{t+1} = [1 - m_t(\pi_t - \pi_t^e)]\, D_t$ permanently. Thus, the debt terms in (6) may be written as

$$cr[1 + \frac{1}{1+\delta} + \frac{1}{(1+\delta)^2} + \ldots]\,[1 - m_t\,(\pi_t - \pi_t^e)]\,D_t$$
$$= \frac{cr(1+\delta)}{\delta}\,[1 - m_t\,(\pi_t - \pi_t^e)]\,D_t.$$

Here (6) may be written as

$$V_t = \frac{1}{2}\pi_t^2 - b(\pi_t - \pi_t^e) + \frac{cr(1+\delta)}{\delta}\,[1 - m_t\,(\pi_t - \pi_t^e)]\,D_t +$$
$$\frac{1}{2}a\,(1 - m_t)^2 + \text{terms in } \pi_{t+1}; \pi_{t+2}; \pi_{t+1}^e; \pi_{t+2}^e; m_{t+1}; m_{t+2} \ldots \tag{7}$$

To obtain a time consistent solution the government minimizes V_t with respect to π_t given π_t^e; m_t and future policies (which are decided by future decisions). The first order condition is

$$\pi_t - b = \frac{1+\delta}{\delta}crm_tD_t = 0 \tag{8}$$

and the second order condition is

$$\frac{d^2V_t}{d\pi^2} = 1 > 0.$$

Thus, the loss minimizing choice of inflation given π_t^e; m_t and future policies is

$$\pi_t = b + cr(1 + \delta^{-1})m_tD_t = \pi_t\,(m_t)\,. \tag{9}$$

Event 4.

$$\pi_t^e = \pi_t(m_t);$$

given by (9).
Event 3. Choice of m_t:

The government chooses m_t given the reaction function (9) and $\pi_t^e = \pi_t$, i.e., m_t is chosen to minimize

$$V_t = \frac{1}{2}\left(\pi_t\left(m_t\right)\right)^2 + crD_t + \frac{1}{2}a\left(1 - m_t\right)^2; \tag{10}$$

given D_t.

The first order condition is:

$$\frac{dV_t}{dm_t} = \pi_t \frac{d\pi_t}{dm_t} - a\left(1 - m_t\right) = 0.$$

Here using (9)

$$m_t = 1 - \frac{\pi_t cr\left[1 + \delta\right]^{-1}}{a} D_t. \tag{11}$$

The second order condition is

$$\frac{d^2V_t}{dm_t^2} = \left(\frac{d\pi_t}{dm_t}\right)^2 + \pi_t \frac{d^2\pi_t}{dm_t^2} + a > 0.$$

Thus, the loss function is minimized at values of m_t and $\pi_t\left(m_t\right)$ which satisfy $\pi_t = \pi_t^e$. For the non-commitment (time consistent) equilibrium, inflation and the share of inflation sensitive instruments are jointly determined simultaneously by equations (9) and (11). We estimate (11) in the next section and we interpret the inflation rate π_t as the expected rate π_t^e. Equation (9) indicates that inflation should be instrumented.

The model shows that increased inflationary expectations lead to issuance of less deflatable debt; this could mean a shortening of the maturity or issuance of instruments with low (or zero) inflation elasticity: variable-rate debt, price-indexed debt or foreign currency debt.

If the government could precommit at event 1 to inflation and maturity rates, then with $\pi_t^e = \pi_t$ it minimizes

$$\sum_{i=0} \left(\frac{1}{1+\delta}\right)^i L_{t+i}$$

where

$$L_t = \frac{1}{2}\pi_t^2 + cr_tD_t + \frac{a}{2}\left(1 - m_t\right)^2$$

and $D_{t+1} = D_t = D$. Clearly, the solution to this optimization problem is

$$\pi_t = 0,\ m_t = 1. \tag{12}$$

Then, a trigger strategy should sustain an equilibrium π_t^*, m_t^* where $0 \leq \pi_t^* \leq \pi_t$; $m_t \leq m_t^* \leq 1$ where π_t; m_t is the non-commitment solution above. However, for reasons we have discussed we do not allow for trigger strategy equilibria and we focus on the time consistent equilibrium given by (9) and (11).

4 Panel Data Estimation

4.1 Descriptive Statistics

The empirical analysis of this section aims to validate our theoretical result that the share of in°ation-sensitive public debt is a negative function of expected in°ation and of government debt. Put it simply, increased in°ationary expectations and the level of government debt are associated with less de°atable debt issued.

Since our data set follows a sample of 15 OECD countries over time, we shall use panel data techniques to estimate the coe±cients of the selected model. The share of in°ation-sensitive instruments is denoted by m (see the Appendix for de¯nitions). Nominal long-term yields are denoted by i and will be used to approximate expected in°ation $¼^e$. Actual in°ation {as measured by the percent change in de°ator values over the previous year{ is denoted by ¼. We use d for the ratio of total debt to GDP. Table 1 reports the average values of the four variables for each country in our data set. The sample period for which data were available for each country is also reported. Apparently, ¯xed-rate, nominal, long-term debt in domestic currency has been the main instrument for government borrowing for the majority of countries. Nine countries have a share of such debt that amounts to over 50 percent of their total debt. On average, de°atable securities account for 54 percent of total debt[10]. In°ation in our data set averaged 6.4 percent, and indebtedness as a fraction of GDP 40.7 percent[11]. The long-term yield averaged 9.1 percent and, as expected, it exhibits high correlation with in°ation (60.6 percent). Low in°ation countries like Germany and the Netherlands exhibit a particularly long maturity structure. The opposite happens with countries that have experienced higher levels of in°ation, like Italy and Spain: the maturity structure of their liabilities leans toward the short end. Figures 1 and 2 show the evolution of the share of nominal long-term debt and in°ation for Italy and Spain from 1962 to 1995. It can be seen that the two variables move in the opposite direction for many periods. The general trend can be inferred from ¯gure 3 where we have used the averages of ¼ and m for the ¯fteen countries of our data set: high in°ation countries issue less long-term debt than low in°ation countries. The panel data estimation enables us to capture some interesting dynamics that cross sectional analysis on its own cannot provide. For example, countries that experienced high indebtedness for some periods in the past had to drastically shorten the maturity of their securities and

[10] This stylized fact provides support to our argument that governments have a preference for domestic, nominal, long-term debt.

[11] See Table 1 for country statistics.

loans (see Figures 4 and 5 for Italy and Belgium).

The scatter plot in Figure 6 is indicative of the negative pattern between π and m, as the (small) negative trend can be easily identified. Figure 7 graphically illustrates the relation between the share of nominal long-term debt and the debt to GDP ratio. The pattern here is not very clear.

Table 1: Average Values Reported by Country

Country	m	π	i	d	Period
Australia	0.640	0.077	0.011	0.213	1974 − 95
Austria	0.467	0.048	0.081	0.315	1969 − 95
Belgium	0.649	0.048	0.085	0.736	1962 − 94
Canada	0.336	0.052	0.089	0.451	1962 − 94
Finland	0.097[12]	0.075	0.095	0.191	1970 − 96
France	0.432	0.069	0.099	0.225	1971 − 95
Germany	0.826	0.039	0.075	0.311	1962 − 95
Ireland	0.513	0.081	0.107	0.758	1962 − 95
Italy	0.312	0.096	0.111	0.570	1962 − 95
Japan	0.644	0.040	0.063	0.330	1966 − 97
Netherlands	0.920	0.047	0.076	0.400	1962 − 95
Spain	0.353	0.103	0.134	0.220	1962 − 95
Sweden	0.562	0.067	0.093	0.430	1962 − 96
UK	0.676	0.076	0.099	0.430	1962 − 96
USA	0.583	0.048	0.077	0.354	1962 − 96

4.2 Heterogeneity Tests

Standard least squares methods cannot be applied on longitudinal data sets unless we assume that the regression coefficients do not change across countries and time. If this assumption does not hold and the intercepts and/or the slope coefficients vary across individuals and/or time, we must employ other estimation techniques. For example, if we assume variable intercepts, we can use the least squares dummy variable method (LSDV) to estimate a fixed effects model and the feasible GLS method to estimate a random effects model. However, if the coefficients prove to be homogeneous across the two dimensions of the data set, we pool the data and use OLS. In the presence of structural changes in economic behavior one might also allow for variable slope coefficients. However, such models are more complex and are not widely used. In our

[12] The share of long term debt for Finland might look particularly low. The explanation is that for several years the government had been using foreign currency debt as its main instrument.

analysis, we examine models with constant slopes and variable intercepts since such models provide reasonable alternatives to models with invariant intercepts and slope coefficients. We can identify whether the data are compatible with a pooled regression model or with some kind of intercept variation by employing heterogeneity tests. Heterogeneity tests can be carried out using the analysis of covariance procedure as outlined in Hsiao (1986). We begin the presentation of the basic model considering a one way and two way fixed effects approach. The one way models incorporate country (or time) specific constants. The two way model has an overall constant as well as a 'country' effect for each country and a 'time' effect for each period.

By basic model we mean the one directly implied by the theory: the share of nominal and domestic long-term debt m is on the left-hand side and expected inflation π^e is on the right-hand side together with the total amount of total debt as a percentage of GDP, d. In other words, we estimate a linearized form of equation (11). We expect a negative sign for the coefficient of π^e as higher inflationary expectations should trigger a shortening of the maturity structure of debt or issuance of low inflation elasticity securities, and a negative sign for the coefficient of d as high debt governments are expected to do the same in order to reduce the incentives to inflate in the future and signal their non-inflationary commitment.

Our first model describes the homogeneous case:

$$m_{it} = a + \beta_1 \pi^e_{it} + \beta_2 d_{it} + \varepsilon_{it} \qquad \text{(i)}$$

The stochastic term is assumed to have mean zero, $E[\varepsilon_{it}] = 0$; and constant variance $Var[\varepsilon_{it}] = \sigma^2_\varepsilon$.

The second specification allows the intercept to vary across countries i with homogeneous slope coefficients.

$$m_{it} = a_i + \beta_1 \pi^e_{it} + \beta_2 d_{it} + \varepsilon_{it} \qquad \text{(ii)}$$

Our next model has time-specific intercepts and homogeneous slope coefficients over both dimensions of the data set.

$$m_{it} = a_t + \beta_1 \pi^e_{it} + \beta_2 d_{it} + \varepsilon_{it} \qquad \text{(iii)}$$

The two factor model displays varying intercepts over time and countries.

$$m_{it} = a_0 + a_i + \gamma_t + \beta_1 \pi^e_{it} + \beta_2 d_{it} + \varepsilon_{it} \qquad \text{(iv)}$$

To avoid the problem of multicollinearity we impose the restriction that $\sum_{i=1}^{N} a(i) = \sum_{t=1}^{T} \gamma(t) = 0$.

Table 2 presents results from OLS regressions[13] of the previous models. Speci¯cations (ii), (iii), and (iv) incorporate group and/or time dummy variables (¯xed-e®ects).

Table 2: Fixed E®ects Results				
Model	Type of Variation	R^2	RSS	DoF
(i)	Homogeneous case	0:128	20:2	444
(ii)	Intercept variation across i	0:840	3:7	430
(iii)	Intercept variation across t	0:184	18:9	409
(iv)	Intercept variation across t and i	0:863	3:2	394

Our next step is to test (ii), (iii), and (iv) on (i) to reach a conclusion about the kind of the possible variation of the intercept. We use F-tests to examine whether the intercept varies over time, countries, or both over time and countries, or if it does not vary at all (the homogeneous case). The results of the tests are presented in Table 3.

Table 3: Testing for Heterogeneity of the Intercept					
Test	F-value	DoF_N	DoF_D	p-value	Decision
(ii) vs (i)	137:100	14	430	0:000	Reject (i)
(iii) vs (i)	0:810	35	409	0:774	Reject (iii)
(iv) vs (i)	42:331	50	395	0:000	Reject (i)
(iv) vs (ii)	1:848	35	395	0:003	Reject (ii)

The results in Table 3 indicate that we should employ a model that allows the intercept to vary across both countries and time. The test between model (ii) with the country variant intercept and model (i) with the country invariant intercept delivers the statistically strong result that the homogeneous case should be rejected. Thus, we accept that the intercept varies across countries. On the other hand, the data do not seem to support the idea of time-speci¯c e®ects. An F-test of model (iii) with intercept variations over time versus (i) {the pooled regression model{ is clearly rejecting the idea of heterogeneous intercepts over time. Our next test {(iv) on (i){ suggests that the two way model cannot be rejected in favor of a pooled regression model. As indicated by the two previous tests, the main source of variation that enables us to accept the two factor model is country-speci¯c. Finally, we further test the two way model (iv) against the group e®ects model (ii) in order to reach a conclusion about the model that better ¯ts our data. The relevant F-test favors the two factor model and our intercept is assumed to vary both across countries and over time.

[13] We have used Limdep for all estimations except where indicated.

4.3 Fixed vs Random Effects

Whether one treats the effects of the model as fixed or random is an important question in panel data estimations. If the sample of individual observations (countries in our case) are drawn from a large population (all the countries in the world) then it might be appropriate to view individual specific constant terms as randomly distributed across cross-sectional units (Greene, 2000). Moreover, "when inferences are going to be confined to the effects in the model, the effects are more appropriately considered fixed. When inferences will be made about a population of effects from which those in the data are considered to be a random sample, then the effects should be considered random". From a first glance, it seems that in our case the proper strategy would be to consider the effects to be random, as our data set does not cover the entire population of countries. On the other hand, it would not be wise to generalize our conclusions from this empirical study and assert that they describe the whole population, as the OECD countries bear similar characteristics and economic structures which are not common to all the countries in the world. This viewpoint would argue for the case of fixed effects. Hence, the decision is not a straightforward one. Another point that needs to be made is that the estimation methods employed vary in effectiveness according to the formulation of the effects. The LSDV estimator (the covariance estimator CV) is unbiased and consistent in both cases of fixed and random effects. However, while it is also BLUE when effects are fixed, it is not BLUE when the effects are random. The BLUE in the latter case is the generalized least squares estimator.

For the country-specific intercept case, the random effects approach specifies that the constant term is a group-specific disturbance, similar to ε_{it} except that for each group, there is but a single draw that enters the regression identically in each period (Greene, 2000). We can now re-specify our model under a random effects approach. In the case of country effects we have:

$$m_{it} = a + u_i + \beta_1 \pi^e_{it} + \beta_2 d_{it} + \varepsilon_{it} \qquad (ii')$$

where u_i is a country-specific disturbance, and $E[u_i] = 0$, $Var[u_i] = \sigma^2_u$, and $Cov[\varepsilon_{it}; u_i] = 0$. Respectively, the model with time-specific effects becomes

$$m_{it} = a + w_t + \beta_1 \pi^e_{it} + \beta_2 d_{it} + \varepsilon_{it} \qquad (iii')$$

Finally, the model that allows for variation of the intercept over countries and time under the random effects assumption is

$$m_{it} = a + u_i + w_t + \beta_1 \pi^e_{it} + \beta_2 d_{it} + \varepsilon_{it} \qquad (iv')$$

A Lagrange Multiplier test con¯rms our previous results that the appropriate model should allow for some kind of intercept variation (specifically, for countries e®ects). The Â^2 value of the LM statistic with one degree of freedom for country-speci¯c e®ects (=3214.93) exceeds the 3.84 critical value. The null hypothesis of a classical regression model with a single constant term is rejected in favor of a random or ¯xed model. The same holds true for models (iii) and (iv). However, the Â^2 value for time e®ects is only 4.29, which indicates the weakness of the time e®ects. The respective value for the two way model is 3219.22. As mentioned earlier, the choice between random or ¯xed modelling of the e®ects is a crucial one. Several theoretical dimensions must be taken into account when selecting the appropriate model. Additionally, the Hausman test is the relevant statistical test that enables us to make a decision based on sound statistical criteria. The results from the Hausman tests are presented in Table 4.

Table 4: Hausman Tests

Test	Â^2 value	DoF	p-value	Decision
(ii^0) vs (ii)	4:04	2	0:133	Reject (ii)
(iii^0) vs (iii)	11:33	2	0:003	Reject (iii^0)
(iv^0) vs (iv)	44:01	2	0:000	Reject (iv^0)

Since our previous tests indicate that the intercept should be modelled as country and time variant we are interested in the last test of table 4: we clearly reject the case for random e®ects even at the 99.5 percent level of signi¯cance; the data seem to be consistent with a ¯xed e®ects model. The Hausman tests together with the discussion made earlier on the theoretical dimensions of the decision provide support to a ¯xed formulation of the e®ects.

4.4 Estimated Coe±cients

In the previous section we discussed the choice between ¯xed and random e®ects. In this section, the relevance of this discussion is con¯rmed as our results show that the estimated coe±cients di®er in explaining power and signi¯cance between the two models. The regression outcomes of the two way ¯xed and random e®ects models are reported in Table 5 for reasons of comparison. We can see that there is strong evidence for a signi¯cant negative relationship between the share of nominal, domestic long-term debt and expected in°ation in our data set. This relation is twice as strong for the ¯xed e®ects model. A 1 percentage point increase in in°ationary expectations as captured by an increase in the nominal long-term yield, will lead to almost 2.5 percentage points decrease in the amount of deflatable long-term debt issued. For the random effects the same increase will result in 1.24 percentage points decrease. The t-ratio of the coefficient of the long-term yield is also higher in the fixed effects model. The coefficient of debt to GDP ratio is negative and significant in the fixed effects model, but, although with the expected sign, it loses its significance under a random effects approach. The R-squared statistic for the fixed effects is almost 86.3 percent[14].

These results provide support to Missale and Blanchard (1994) and Missale (1999) at least with regard to the relevance of the debt ratio. In Missale and Blanchard (1994) the authors use time series data for Italy, Belgium, and Ireland to establish the negative effects of the debt burden and inflation on the maturity structure of government debt. In Missale (1999) there are also regressions with the long-term interest rate on the RHS. For these country regressions (the countries of our data set plus Portugal and Denmark), the long-rate (which we use as a measure of inflation expectations) does not perform well, or it is generally outperformed by the debt ratio. Our study, which also incorporates the cross-sectional dimension of the data, delivers different results. The panel estimation argues for a significant negative effect of the long-term interest rates on the share of deflatable securities[15].

Table 5: Estimated Fixed and Random Effects

Model	Variable	Coefficient	StErr	t-ratios	p-value
Fixed	π^e	-2.44416	0.313	-7.800	0.000
	d	-0.12576	0.038	-3.350	0.009
	constant	0.82603	0.033	24.295	0.000
Random	π^e	-1.24150	0.244	-5.089	0.000
	d	-0.05498	0.031	-1.789	0.073
	constant	0.66606	0.059	11.238	0.000

Missale (1999) identifies six countries for which the time series regressions have shown a negative relation between the debt to GDP ratio and the share of fixed-rate nominal long-term debt[16] (Italy, Belgium, Ireland, and Sweden, Finland, Spain). For these countries this variable outperforms the long-term interest rate. Also note that these countries have experienced either high debt ratios or fiscal imbalances. In order to identify any particular causes for the magnitude of our results in relation

[14] The random effects model is estimated with GLS. As a result, the R-squared is not meaningful.

[15] We have also estimated the model without Finland, which could be a potential outlier in our data set. The results were essentially the same.

[16] Note that for Spain, Italy, and Ireland effective maturity is used instead of the share of long-term debt.

to particular patterns in our data set, we have divided our sample into two sub-groups: group one which includes the six countries mentioned above, and group two which includes the rest of the countries (Australia, Austria, Canada, France, Germany, Japan, Netherlands, UK, and USA).

We have estimated the basic equation using both country, and country and time e®ects. The ¯xed e®ects coe±cients are presented in tables 6 and 7. It is quite apparent that the relationship is stronger for group 1, leading us to conclude that these countries have responded to higher nominal interest rates by issuing non-de°atable securities, thus signalling their non-in°ationary intentions. For the country-only e®ects it is con¯rmed that the debt to GDP ratio is more signi¯cant than ¼e but when we also take into account the time e®ects, d becomes insigni¯cant. For the low-debt countries the signi¯cant negative result for ¼e is also reported for the group and time ¯xed e®ects. The debt-ratio, though, enters with the wrong sign (probably a®ected from US co-movements of the debt-ratio and the share of long-term debt). For the country only e®ects, both the coe±cients come up with positive signs indicating the absence of a negative cross-sectional pattern between de°atable debt and our explaining variables for the countries in group 2.

Table 6: Regression Results for Group 1				
Variable	Coe±cient	StErr	t-ratio	p-value
Fixed Group E®ects				
¼e	¡1:16334	0:214	¡5:248	0:000
d	¡0:21452	0:028	¡7:719	0:000
Fixed Group and Time E®ects				
¼e	¡0:91264	0:417	¡2:186	0:030
d	¡0:58208	0:057	¡1:028	0:305
constant	0:55623	0:048	11:595	0:000

Table 7: Regression Results for Group 2				
Variable	Coe±cient	StErr	t-ratio	p-value
Fixed Group E®ects				
¼e	0:53925	0:245	2:201	0:029
d	0:36046	0:039	9:288	0:000
Fixed Group and Time E®ects				
¼e	¡1:21428	0:437	¡2:776	0:006
d	0:28062	0:058	4:829	0:000
constant	0:62880	0:049	12:715	0:000

Finally, we estimate the model using the group means. Since our groups are unequal (they do not have the same number of time series observations) the regression is heteroscedastic, and is estimated with weighted least squares (WLS). The estimation outcome is given in Table 8. The results are strongly in preference of a significant negative effect of the long-term interest rate on m, but they reject the significance of debt to GDP ratio which turns up with the wrong sign anyway. In other words, the cross-country results discard d as a significant explaining variable for the share of inflation-sensitive securities. This shows that Missale's observation on the relevance of the debt to GDP ratio in explaining movements in the shares of long-term debt holds for time series of highly indebted countries, but loses its strength across countries. Additionally, the panel estimation assigns a rather small in effect role to this variable. On the contrary, inflationary expectations, as depicted in long-term rates, exhibit a remarkable power even when we take into account several forms of heteroscedastic and autocorrelated disturbances, as we shall see in the next section.

Table 8: Groups Means Estimation Results

Variable	Coefficient	StErr	t-ratios	p-value
π^e	-6.71992	3.044	-2.207	0.027
d	0.23178	0.295	0.785	0.432
constant	1.06799	0.291	3.676	0.000

4.5 Correcting for Autocorrelation and Heteroscedasticity

Do our results change in the presence of autocorrelation and why should we care about it? The answer to the second part of the question is given by Baltagi (1995): ignoring serial correlation when it is present results in consistent but inefficient estimates of the regression coefficients and biased standard errors. The answer to the first part is that even though the estimated coefficients lose some of their explaining power, they remain significant and come with the expected signs when autocorrelated errors are taken into account.

First, we estimate a one way model with country specific effects. The fixed effects case is $m_{it} = a_i + \beta_1 \pi^e_{it} + \beta_2 d_{it} + \varepsilon_{it}$ and the random effects case is $m_{it} = a + u_i + \beta_1 \pi^e_{it} + \beta_2 d_{it} + \varepsilon_{it}$. Now, suppose that the errors in period t are correlated with the errors in period $t - 1$ in the following fashion: $\varepsilon_{it} = \rho \varepsilon_{i,t-1} + \eta_{it}$ (ε_{it} is a first-order autoregressive disturbance). The Cochrane-Orcutt transformation and the feasible GLS estimation method are being used to derive efficient estimates for both the fixed and the random effects models.

We also examine the case in which ρ is specific to each group (AR1 processes di®er within group {group speci¯c ½)[17]. Unfortunately, we cannot allow for cross-sectional correlation since our data set is unbalanced. The following table summarizes the results from the regressions with autocorrelated error components. It can be easily seen that even though the e®ect of an increase in in°ationary expectations is now lower than before, the result is still robust. The coe±cient of long-term yield lies in the vicinity of around ¡40 percent in all three models. The debt to GDP ratio remains signi¯cant in the case of non-panel-speci¯c AR(1), but becomes insigni¯cant when ½ is group-speci¯c.

Table 9: Corrected for Autocorrelation				
Variable	Coe±cient	StErr	ratios	p-value
Fixed Model with AR1, ½ = 0:841				
¼e	¡0:39334	0:148	¡2:666	0:008
d	¡0:09594	0:038	¡2:532	0:012
Random Model with AR1, ½ = 0:841				
¼e	¡0:40211	0:147	¡2:730	0:006
d	¡0:09317	0:038	¡2:479	0:013
constant	0:62726	0:063	10:000	0:000
AR1 within group, group-speci¯c ½				
¼e	¡0:40999	0:151	¡2:719	0:007
d	¡0:00939	0:040	¡0:233	0:816
constant	0:56455	0:029	19:775	0:000

Heteroscedasticity has the same e®ects on the estimates and the standard errors as autocorrelation, if it is present and we ignore it. Table 10 presents the results for the ¯xed e®ects model assuming groupwise heteroscedasticity. In°ation remains a signi¯cant variable although the t-ratio experiences a small decline from ¡7:800 in the heteroscedastic model, to ¡6:217 in the homoscedastic one. However, the same does not apply to the debt/GDP ratio: a decrease from ¡3:350 to ¡1:465 in the t-ratio makes the variable insigni¯cant at the 5 percent level of signi¯cance.

Table 10: Corrected for Heteroscedasticity				
Variable	Coe±cient	StErr	ratios	p-value
Robust -, Fixed Model, Groupwise Heteroscedasticity				
¼e	¡0:98633	0:159	¡6:217	0:000
d	¡0:03862	0:026	¡1:465	0:143

[17] We have used Stata for this estimation.

In order to be able to estimate a heteroscedastic model with contemporaneous cross-sectional correlation we have created a balanced version of our data set. In other words, each country now has the same number of time series observations. Our new data set consists of 24 observations (from 1971 to 1994) for twelve countries (Austria, Belgium, Canada, France, Germany, Ireland, Italy, Japan, Netherlands, Sweden, United Kingdom, and USA). This leaves us with 288 observations. Assuming that the variance for each country will differ and that the disturbances of countries are correlated, we can estimate a heteroscedastic model with cross-sectional correlation using FGLS[18]. The results are in Table 12 and are similar to the LSDV results of Table 5. The estimated coefficients are roughly of the same magnitude. Their significance, though, has now increased by more than three times.

Table 11: Het. Panels with Cross-Sectional Corr.				
Variable	Coefficient	StErr	ratios	p-value
π^e	-2.65594	0.103	-25.847	0.000
d	-0.10491	0.008	-12.343	0.000
constant	0.88522	0.010	88.407	0.000

Overall, we would argue that possible heteroscedasticity and autocorrelation will have a rather small impact on the results of the model. The coefficient of long-term yield is robust to the alternative methods used to correct for these potential problems. It enters the estimated equation with the expected sign and retains its significance in all cases, even though the magnitude of its effect varies according to the assumed patterns of heteroscedasticity and autocorrelation. The effects of the debt to GDP ratio coefficient are rather ambiguous. It loses its significance when we estimate models with group-specific autocorrelation or groupwise heteroscedasticity but is still significant when autocorrelation is not assumed group-specific or when we estimate a heteroscedastic model with cross-sectional correlation. However, in all cases we get the expected sign.

5 Concluding Remarks

The aim of this study has been to present some basic issues concerning the management of public debt in the presence of higher expected inflation. In the 'real world' government debt is actively managed and there is a wide spectrum of decisions to be made regarding the maturity, currency denomination, indexation features and overall structure of

[18]We have used Stata for this estimation.

the public sector's liabilities. As mentioned, we have focused our attention on the amount of inflation-sensitive instruments (nominal long-term debt which is denominated in the domestic currency). Our model is an extension of the Missale and Blanchard (1994) model and allows for the joint determination of inflation and the proportion of inflation-sensitive government debt. We have shown that increases in the perception of the public about future inflation are related to decreases in the amount of deflatable, long-term securities issued as a fraction of total debt. Our theoretical result has also been tested empirically. We have measured the effect of expected inflation and debt using an unbalanced longitudinal data set consisting of time series observations for fifteen OECD countries. Our specification has also included the ratio of debt to GDP as a measure of indebtedness. We have used the long-term yield as a proxy for expected inflation.

The panel data estimation has produced results that are compatible with the theory. Of course, our examination has not been exhaustive or free of complications. The trend, though, has been clearly identified, that higher expected inflation and higher total debt lead to the use of fewer inflation-sensitive instruments.

In further research, it would be interesting to investigate the relation between m and π^e and d for developing, highly indebted countries. It has been observed that these countries usually display a very short maturity structure of liabilities and significant amounts of foreign currency debt. Foreign investors do not want to find themselves `trapped' in long-horizon investments in countries with high default risk and unstable political regimes. Additionally, the economic environment of such countries usually promotes uncertainty about inflation triggering the process we described earlier. Unfortunately, data on debt structure for developing countries are difficult to obtain. Nevertheless, one would expect an even stronger relation than the one observed for OECD countries.

It would also be interesting to investigate the role of Central Bank independence on the structure of public debt. A more independent –and inflation averse– Central Bank will generally enjoy more credibility in its fight against inflation. An institution shielded from political powers that often assert pressure for excess monetary expansion is expected to perform better in the inflation front. A longer maturity structure of nominal debt is expected to be the result of an independent monetary institution. A theoretical model that accounts for the degree of Central Bank independence would be of considerable importance. Several authors have examined the effects of the independence of the monetary authorities on the level and the structure of public debt and some early findings can be found in Grilli et al. (1991), Beetsma and Bovenberg

(1997), and Falcetti and Missale (2000).

A Description of Data

Data on the composition of debt were taken from Public Debt Management (Missale, 1999). Data on GDP, GDP de°ators, and government bond yields were obtained from the International Financial Statistics of the IMF.

We have collected 474 observations for Australia, Austria, Belgium, Canada, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Spain, Sweden, UK, and the USA. The data set is unbalanced in that the sample period is not the same for each country (this should not cause problems with the estimation, though). In our analysis we focus our attention on privately held debt (or market holdings of debt, using British terminology). Holdings by the Central Bank or the Government are not considered relevant, as they do not increase the debt burden. Market holdings of debt were estimated for most countries since only a few countries distinguish between privately held and o±cial debt in their accounts. Where such estimation was not possible, we have used the total amount of debt.

We de¯ne as long-term debt the sum of ¯xed-rate notes, bonds and loans with initial maturity over a year. The series on m (share of in°ation-sensitive debt) include nominal long-term debt, denominated in domestic currency. The reason for the exclusion of real and foreign currency debt is that unexpected in°ation cannot reduce their real value (due to the indexation feature and the resulting currency depreciation, respectively). We also exclude variable-rate debt as this instrument is usually indexed to short-term interest rates. In other words, in our analysis we shall be using debt with high in°ation elasticity. The long-term series do not include debt that could not be identi¯ed with respect to its maturity characteristics. We make an exception for data on loans from banks. The data set does not contain su±cient information on the maturity structure of such loans, but, in general, the trend leans towards the long-end, and, thus, we include them in the long-term series.

GDP values are nominal. We use de°ator changes (percent change over previous year) as a proxy for in°ation throughout our econometric analysis. Government Bond Yields refer to one or more series representing yields to maturity of government bonds or other bonds that would indicate longer-term rates (see de¯nition in the IFS of the IMF). Note that the number of observations on long-term yields reduces to 447 as we could not obtain data for Finland (1989-1996), Spain (1962-1978), and Sweden (1995-1996). We shall use these long-term yields as a measure of expected in°ation.

B Information on Debt Data

This Appendix contains information on the de¯nitions of debt and long-term debt that have been used for each country. For a more detailed description of the data see Missale (1999).

1. Australia

   Debt refers to Central Government debt and excludes Internal Treasury Bills. Privately held debt does not include holdings by the Reserve Bank of Australia and the Government. Long-term debt consists of ¯xed-rate bonds (from 3 to 30 years).

2. Austria

   Debt refers to Central Government debt. Privately held debt is gross of O±cial holdings since data on Central Bank and Government holdings could not be found except from Central Bank credit to the Government. Long-term debt consists of ¯xed-rate long-term notes (currently 10 years), ¯xed-rate long-term bonds (from 2 to 30 years), and ¯xed-rate loans from banks. Data on long-term notes were not available for the period 1969-74. In the calculation of long-term debt they were assigned a zero value for this period.

3. Belgium

   Debt broadly refers to Central Government debt; it excludes guaranteed debt and includes bonds issued by public agencies. Privately held debt was derived after deducting Central Bank Holdings and Central Bank advances to the \Fonds des Rentes" (the institution performing open market operations until the reform of the money market in January 1991). Long-term debt includes ¯xed-rate long-term debt with initial maturity longer than one year issued by the Government and public agencies.

4. Canada

   Debt refers to National debt, which broadly corresponds to Central Government debt. It considers all ¯nancial and non-¯nancial liabilities but excludes guaranteed debt. Privately held debt is net of securities held by the Central Bank, but is gross of Government holdings of marketable and non-marketable debt as detailed data were not available for the sample period. Long-term debt consists of ¯xed-rate bonds (2, 3, 5, 10 and 30 years).

5. Finland

   Debt refers to Central Government Debt and excludes a small amount of \Debt to the Pension Fund" for the period 1990-94. Privately held debt was derived after deducting Central Bank holdings. Long-term debt is de¯ned as the sum of yield bonds for personal investors (from 2 to 8 years), new ¯xed-rate bonds, Housing Bonds and Serial Bonds (from 3 to 10 years), long-term promissory notes, and long-term loans. Data on long-term government yields were obtained from OECD's Historical Statistics.

6. France

   Debt refers to Central Government debt. Debt ¯gures are gross of the Treasury credit balance with the Bank of France and of debt held by the Central Bank, since data on Bank holdings could not be found. Fixed-rate bonds with the option to exchange them into variable-rate bonds are considered ¯xed-rate bonds. We have deducted, though, the fraction of such debt that was converted into variable-rate debt. Long-term debt is the sum of Treasury notes (2 and 5 years), ¯xed-rate long-term bonds (10, 15, 20, 30, 55 years), ¯xed-rate bonds with the option of conversion into variable-rate bonds (see above), renewable bonds bearing the option for an exchange into later issues, other long-term bonds (which include, though, bonds indexed to the price of Gold and to the European Unit of Account, and non-marketable debt until 1979).

7. Germany

   Debt refers to General Government Debt. O±cial debt data are consolidated across the various levels of government and are net of government holdings. Privately held debt was derived by deducting Central Bank holdings. Long-term debt consists of the following series: Treasury discount notes (from 1 to 2 years), Treasury notes (2 to 6 years), special federal bonds (5 years), ¯xed-rate long-term bonds (mostly 10 years, but up to 30 years), loans from banks, loans from social security funds, and savings bonds (initial maturity of 6 and 7 years). Practically, according to our de¯nition, all ¯xed-rate debt, which is denominated in domestic currency is long-term.

8. Ireland

   Debt refers to National debt, which corresponds broadly to Central Government debt and excludes guaranteed debt. Privately held debt was derived by deducting Central Bank and Government holdings. It has to be noted that full deduction of the stock of bonds held in government department accounts yields an underestimate of privately held debt as part of these bonds represents investments of the deposits of the Post O±ce Savings Bank and hence a liability towards the private sector. Long-term debt consists of ¯xed-rate bonds (mostly 5, 10 and 20 years).

9. Italy

   Debt refers to Public sector debt. Published data distinguish between privately held debt and total debt. Long-term debt includes ¯xed-rate bonds (3, 5, 10 and 30 years), ¯xed-rate bonds COT, old ¯xed-rate bonds issued by the Central Government and ¯xed rate Public sector bonds, and loans from banks.

10. Japan

   Debt refers to Central Government debt. Privately held debt was derived by deducting Central Bank holdings. Long-term debt is the sum of notes (2 and 4 years), 5-year discount bonds, and ¯xed-rate long-term bonds (from 6 to 30 years).

11. Netherlands

   Debt refers to Central Government debt. Privately held debt was obtained by deducting Central Bank holdings. Long-term debt is Treasury notes (2 to 5 years), ¯xed-rate bonds (mostly 10 years and up to 30 years), privately placed loans (10 to 20 years) and long-term Treasury certi¯cates.

12. Spain

   Debt refers to Central government debt. Privately held debt was obtained by deducting Central Bank holdings. Long-term debt consists of ¯xed-rate long-term bonds (3, 5, 10 and 15 years).

13. Sweden

   Debt refers to Central Government debt. Privately held debt was obtained by deducting Central Bank holdings. Long-term debt consists of ¯xed-rate long-term bonds (2, 3, 5, 10 and 15 years), other ¯xed-rate long-term Treasury bonds, loans from banks, and loans from State institutions and funds.

14. United Kingdom

   Debt refers to National debt, which corresponds broadly to Central Government debt. It includes guaranteed marketable securities and excludes interest-free notes due to the IMF. Privately held debt excludes holdings by the Bank of England and the Government. Long-term debt consists of ¯xed-rate long-term bonds (5, 10, 15, 20 and 25 years).

15. United States of America

    Debt refers to Federal government debt and excludes guaranteed debt. Published data on debt distinguish between privately held debt, debt held by the Federal Reserve, and debt held in government accounts. Privately held debt excludes non-marketable paper issued to public pensions for the investment of their funds. Long-term debt is the sum of ¯xed-rate long-term notes (2, 3, 5 and 10 years) and ¯xed-rate long-term bonds (30 years).

C Figures

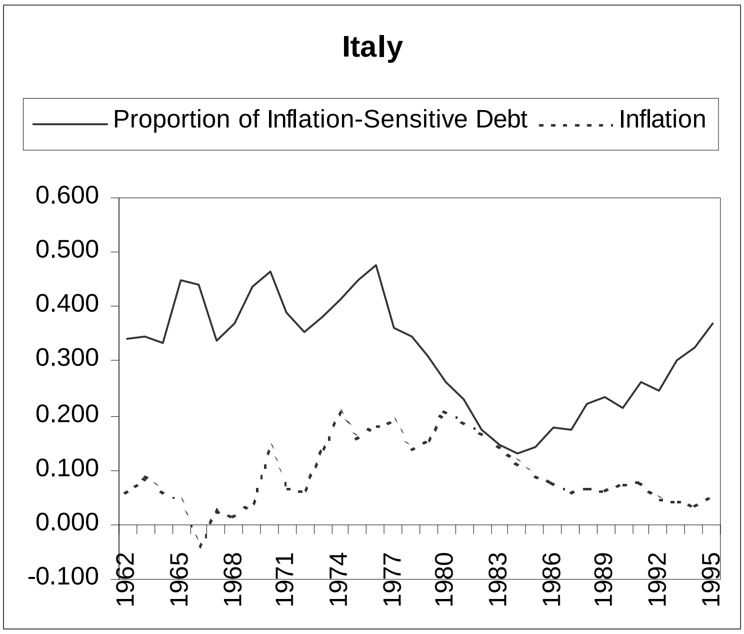

Figure 1: Italy's share of in°ation-sensitive debt and in°ation

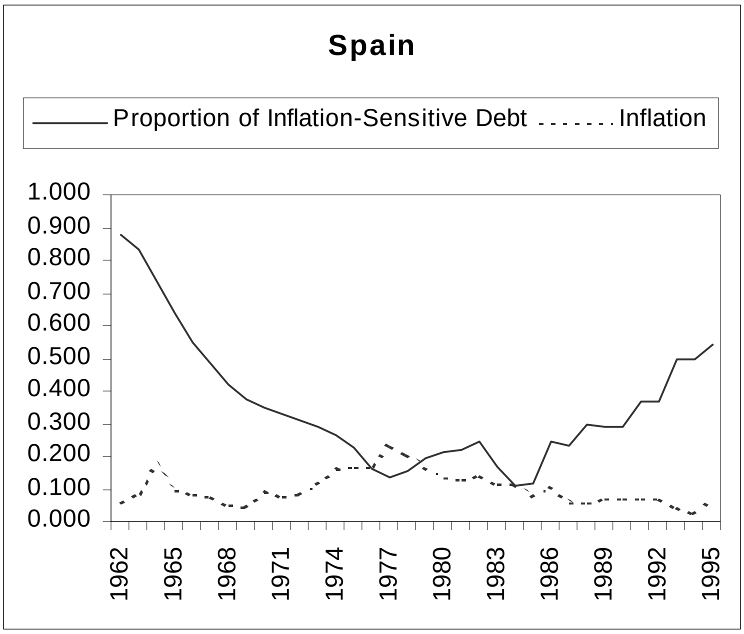

Figure 2: Spain's share of in°ation-sensitive debt and in°ation

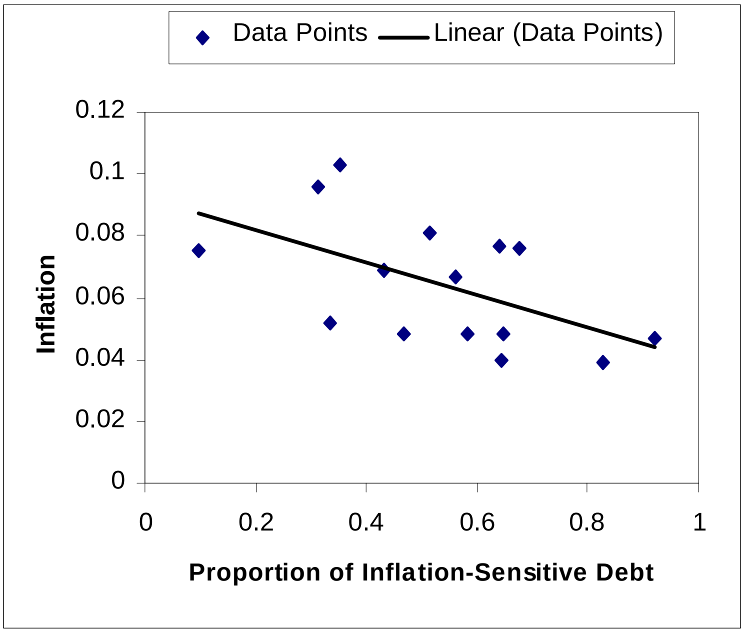

Figure 3: Scatter plot of average values of ¼ and m

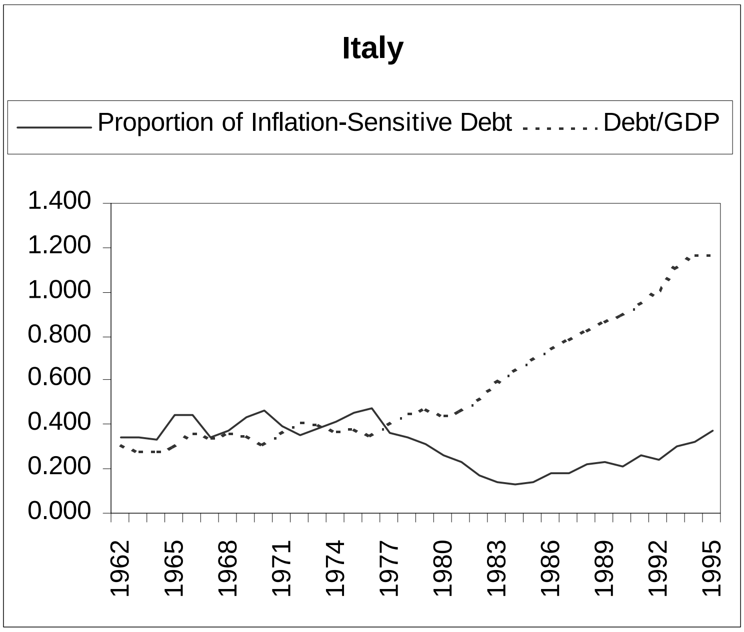

Figure 4: Italy's share of in°ation-sensitive debt and debt/GDP

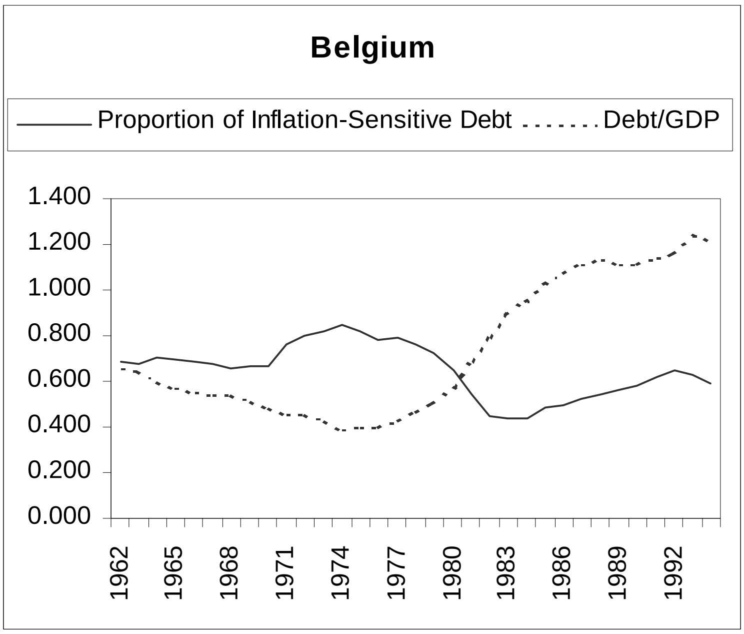

Figure 5: Belgium's share of in°ation-sensitive debt and debt/GDP

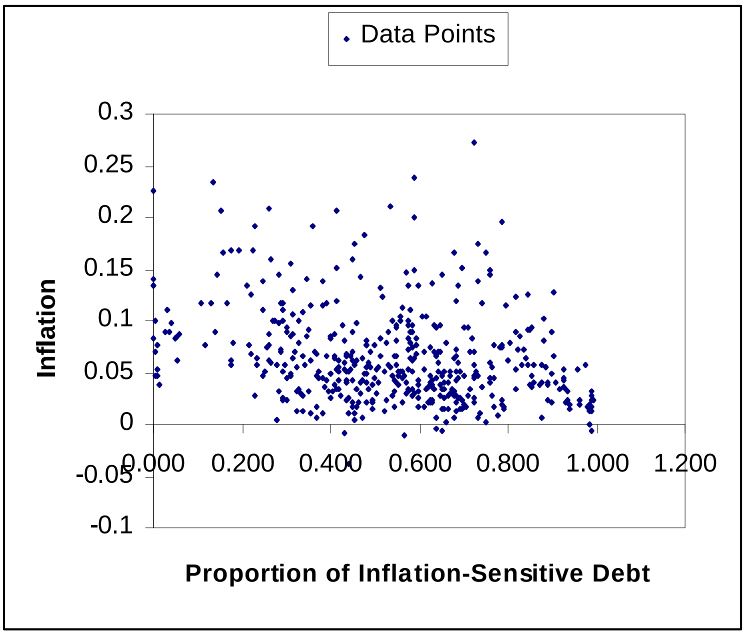

Figure 6: Scatter plot of ¼ and m

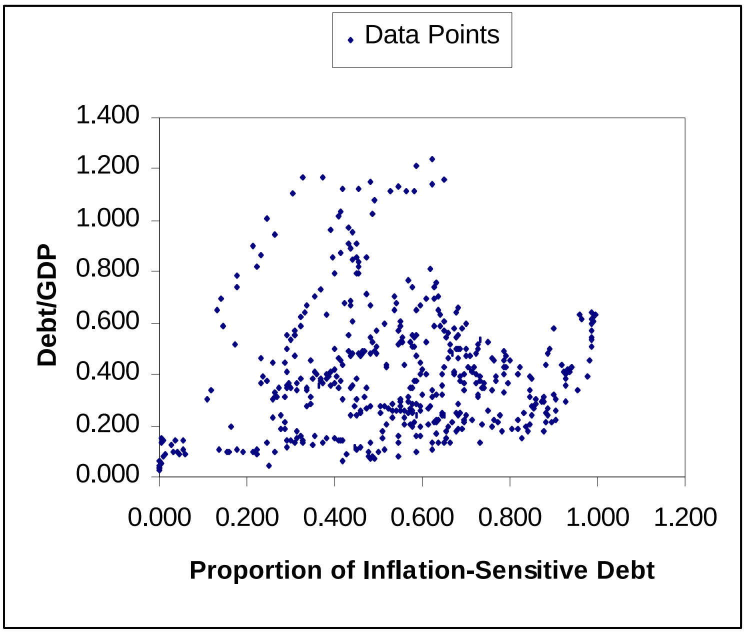

Figure 7: Scatter plot of d and m

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