Public Debt Indexation and Denomination with an Independent Central Bank

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July 24, 2000

Abstract

This paper examines the interaction between public debt management and the design of monetary institutions. The analysis shows that delegation of monetary policy to an independent central bank is more effective in containing inflationary expectations than the use of foreign currency or inflation-indexed debt. If delegation of monetary policy is viable, the optimal policy is to issue conventional debt. This increases the sensitivity of taxes and output to unexpected inflation, thus minimizing the inflation needed to offset supply shocks. Evidence on central bank independence, debt composition and output variability suggests that the normative argument has some positive content.

JEL Classification: E52, E58, H63.

Keywords: central bank independence, public debt management, foreign currency debt, inflation-indexed debt.

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1. Introduction

In the 1990s the share of long-term conventional debt has increased in almost all OECD countries. In the same period the governments of these countries have made their central banks more independent in order to strengthen the commitment to price stability. This paper examines the relative role of institutional design and public debt management for monetary policy.

The literature on public debt management suggests that inflation-indexed debt enhances the credibility of anti-inflationary policy. The argument has been made by Back and Musgrave (1941) and later formalized by Lucas and Stokey (1983), Bohn (1988), Calvo (1988), Calvo and Guidotti (1990). The same role for foreign currency debt has been suggested by Bohn (1990a, 1991) and Watanabe (1992). This literature, however, implicitly assumes that the government cannot delegate monetary policy to an independent institution.

On the other hand, the literature on central bank independence points to policy delegation as the best way to reduce the inflationary bias. Some attention is given to the implications of public debt, but not to its composition. Cukierman (1994) argues that the larger the debt the more likely it is that politicians will delegate authority to the central bank and the more independent the bank will be. Beetsma and Bovemberg (1997) show that delegation of monetary policy to a properly conservative central banker achieves the second-best inflation tax on money balances without distorting debt accumulation, but they confine attention to indexed debt.

As a matter of fact the interaction between the choice of debt instruments and the design of monetary institutions remains largely unexplored. This paper compares institutional design and debt management as alternative solutions to credibility problems, showing that the best solution is to delegate monetary policy to an independent central bank. The point is made within a standard rules-versus-discretion framework where output is affected by tax distortions and, thus, by the type of debt that the government issues.

The role of currency denomination and indexation of public debt depends on the monetary regime. If monetary policy can be delegated to an independent inflation-averse institution or an inflation contract is viable, then indexed or foreign currency debt are not needed for anti-inflationary policy. The government should instead provide the monetary authority with the largest possible share of conventional debt to support output stabilization. Intuitively, a greater share of conventional debt implies lower taxes and tax distortions for any given unexpected inflation. By increasing the sensitivity of output to inflation, conventional debt makes monetary policy more effective: less unexpected inflation is needed to counter supply shocks. Although conventional debt may give rise to inflationary expectations, credibility problems are dealt more effectively by monetary policy delegation.

This result is important for two reasons. First, it supports the conventional wisdom that institutional design and, in particular, central bank independence is the best way to avoid the inflationary bias, while little is gained by increasing the cost of inflation with indexed or foreign currency debt. Secondly, it provides an explanation for the lengthening of debt maturity in OECD countries since the late 1980s reported in Missale (1999).

The paper is organized as follows. Section 2 presents evidence on debt composition. The government problem is set up in Section 3. Section 4 shows the role of debt instruments in committing to low inflation when the government retains full discretion over the choice of the inflation rate. Results are discussed in light of alternative specifications of the social loss. The following section examines the role of debt management when monetary policy is delegated to an independent institution. Section 5.1 studies delegation to a weight-conservative central banker. Section 5.2 considers an inflation contract while Section 5.3 focuses on inflation targeting. Section 6 presents evidence on debt structure, central bank independence and inflation which suggests that the normative argument has some positive content. Section 7 concludes.

2. Debt composition: evidence from OECD countries

Economists have long been puzzled by the absence of inflation-indexed debt. Indeed, until the 1990s indexed bonds had been issued only in Australia and the UK, among OECD countries. Although a number of countries have then started an indexation program, the share of inflation-indexed debt is still quite low. At the end of 1998 real bonds accounted for 16.4% of total gross debt in the UK, 6.5% in Sweden and 6.0% in Australia, but their share was as low as 2.5% in the US, 2.4% in New Zealand, 1.9% in Canada and 0.8% in France.

The reliance on fixed rate debt denominated in domestic currency is surprising in that conventional debt should give rise to inflationary temptations and lead to expectations of higher inflation. The point was first made by Back and Musgrave (1941) and later formalized within the time-consistency literature by Lucas and Stokey (1983), Calvo (1988) and Bohn (1988). Explanations of the use of conventional debt vary from the tax-smoothing argument that conventional debt offers budgetary insurance against supply shocks (Bohn 1988, 1990b) and public spending shocks (Lucas and Stokey 1983, Calvo and Guidotti 1990) to arguments based on transaction costs, frictions and portfolio hedging (Fischer 1983). As a matter of fact, foreign currency denominated debt offers an alternative, perhaps cheaper, commitment to (fixed exchange parity and) low inflation (Bohn 1990a, 1991, Watanabe 1992).[1] Short maturity debt and floating-rate debt are also effective as commitment devices. Missale and Blanchard (1994) show that in the period 1960-1989 in three highly indebted countries, Belgium, Ireland and Italy, the share of fixed rate long-term debt displayed a negative relation with the debt-to-GDP ratio.

Table 1 reports the percentage of foreign currency debt out of total central government debt for 20 OECD countries in the period 1970-1997. All the liabilities denominated in foreign currency have been grouped together, be they marketable securities or loans. Table 2 reports for the same period the percentage of fixed rate debt denominated in domestic currency with an initial maturity longer than one year.

The share of foreign currency debt varies widely across countries: from zero in Germany, Japan, the Netherland, Switzerland and the US to almost 30% in Ireland and Sweden and up to 40% in Finland. These differences can partly be explained by institutional aspects[2] and also reflect past difficulties and costs encountered by small economies in raising funds on domestic markets.[3]

The absence of foreign currency debt in countries whose currencies are used as foreign reserves is also noteworthy. This can be explained by lower cost of borrowing in reserve currencies but, in the case of Germany, Japan and Switzerland, also by a strong anti-inflationary stance. The Netherlands clearly fits this explanation. Indeed, institutional aspects and the lack of liquid bond markets cannot fully account for the evidence in Table 1. In particular, foreign currency debt was issued in large amounts by "high yielders", that is, countries where interest rates on conventional bonds reflected expectations of a substantial depreciation of the domestic currency and inflation fears. Debt managers may have issued foreign currency debt in an attempt to reduce the cost of debt servicing, to the extent that their expectations about currency depreciation were more optimistic than the market. As private investors' expectations reflect the lack of confidence in the government's anti-inflationary policy, this explanation clearly points to the problem of credibility as an important motivation for the government issuing policy. While the main insight from the time-consistency literature —that debt management allows to establish the "credibility" of a particular policy— may not guide everyday policy-making, debt managers' reaction to high interest rates may in fact be based on the same motivations and lead to the same choice of debt instruments as those predicted by the theory.

The decline in the share of debt denominated in foreign currency, which takes place in many OECD countries since the late 1980s, is also remarkable. When we consider

[1] For a discussion of funding in foreign currency see Pecchi and Ripa-di-Meana (1998).

[2] In a number of countries foreign currency debt is not used for deficit financing but only for the purpose of managing foreign exchange reserves. This is now the case in Canada, Denmark and the UK. Sweden followed this rule until 1993.

[3] Note that countries which relied more on foreign currency debt can be described as small (open) economies. These countries could obtain better conditions when borrowing abroad in reserve currencies than on domestic under-developed markets.

the share of fixed rate long-term debt denominated in domestic currency shown in Table 2, the lower use of instruments which provide protection against inflation is evident. In the 1990s the share of long-term conventional debt has increased in all countries except those where such a share was already high. In the same period many countries have increased the independence of their central banks in order to strengthen their committment to price stability (see e.g. Eijffinger and De Haan 1996). The argument of this paper is that central bank independence offers a better, more efficient technology to commit to low inflation and thus reduces the need for instruments which minimize inflationary temptations.

In the following sections we focus on time-consistency motivations for the choice of debt instruments and highlight the role of the monetary regime in this decision.

3. The government problem

We examine the interaction between the monetary regime and debt management using a version of Barro and Gordon's (1983a) model of monetary policy where distortionary taxation creates a wedge between the first-best level of output and its natural rate. We explicitly model this output loss which is the source of time inconsistency in the rules-versus-discretion literature (along with labor market distortions). Following Barro and Gordon we assume that the output loss depends on the tax rate but extend the analysis to consider that the tax rates varies with the real value of public debt (and the tax base; i.e. the level of output). The idea is that the level of output decreases with tax distortions and thus with the real value of public debt. In turn, the value of debt is determined by its composition and the unexpected inflation and exchange rate depreciation which arise from the policy response to the shocks hitting the economy.

A welfare maximizing government weighs the costs of expected inflation (and exchange rate depreciation) against the cost of output deviations from its optimal level in the absence of distortions. The expected social loss is equal to[4]

$$E_0 L = \theta E_0 \pi^2 + E_0[y - \bar{y} - k(\tau)]^2 \tag{1}$$

where θ reflects social preferences, i.e. the cost of inflation relative to output deviations, π denotes the inflation rate, y is the logarithm of actual output and $\bar{y}$ is its natural rate. Finally, $k(\tau)$, is the output loss from tax distortions, modeled as an increasing convex function of the tax rate, τ. The social loss function is further discussed in Section 4.1.

A time consistency problem arises in that the government aims at the level of output, $y^T = \bar{y} + k(\tau)$, that would emerge in the absence of distortions. In the

[4] For the same specification, or specifications where output is replaced by the unemployment rate or the level of employment see Barro and Gordon (1983a), Rogoff (1985), Svensson (1997) and Walsh (1997), among others. For a microfoundation see Herrendorf and Neumann (1998).

literature, an output target greater than the natural rate is justified by the existence of either tax or labor market distortions or simply by political pressure (see Eijffinger and De Haan 1996 and Walsh 1998). In what follows we shall focus on tax distortions.

Output is given by a traditional Phillips curve:

$$y = \bar{y} + b(\pi - E_0\pi) - u \tag{2}$$

where b is the output sensitivity to unexpected inflation and u is an adverse output shock distributed on the compact support $[u^l, u^h]$, with mean $E_0 u = 0$ and variance $E_0 u^2 = \sigma^2$.

Following the literature, we assume that the output loss $k(\tau)$ depends on the tax rate, but extend the analysis to allow the tax rate to vary with the real value of public debt. The latter is affected by unexpected inflation depending on its currency composition, indexation and maturity structure.[5]

To maintain analytical tractability, we take a linear approximation of $k(\tau)$ around the expected tax rate $E_0\tau$. Denoting with k' the first derivative of $k(\tau)$, the latter is approximated by[6]

$$k(\tau) \simeq k(E_0\tau) + k'(\tau - E_0\tau) \tag{3}$$

Then, assuming that the entire debt and public spending are repaid at the end of the next period and using a linear approximation for the impact of inflation, the tax rate is equal to[7]

$$\tau = G + (1 + i - E_0\pi)xB + (1 + i - \pi)mB + (1 + i^* + e - \pi)(1 - x - m)B \tag{4}$$

where G and B are the ratios of government spending and public debt to the natural rate of output, i and i^* are the nominal domestic and foreign interest rates, e is the rate of depreciation of the exchange rate, x is the share of inflation-indexed debt, m denotes the share of fixed rate debt in domestic currency, while $(1 - x - m)$ is the share of foreign currency debt.

Using the uncovered interest parity condition $i = i^* + E_0 e$, assuming Purchasing Power Parity and normalizing foreign inflation to zero, we can write the tax rate as[8]

[5] It is worth noting that, as the tax rate and thus distortions vary, so does the natural rate of output, $\bar{y}$. This suggests that debt management may have implications for monetary policy even if the authorities target the natural rate of output.

[6] Notice that under a special case $k(\tau)$ is linear in the tax rate. Abstracting from output shocks and following Beetsma and Bovemberg (1997) assume that output is given by $Y = L^a (0 < a < 1)$ where L is labor, so that maximization of after-tax profit yields the labor demand $L = [Pa(1-t)/W]^{1/(1-a)}$ where W is the nominal wage. It follows that, if workers aim solely at a target real wage, the log of which is normalized to zero, and contracts are signed one period in advance based on inflation expectations, then the log of output is given by $y = (a/(1-a))(\pi - E\pi - \tau + loga)$, and the output loss is $k(\tau) = (a/(1-a))\tau$.

[7] This also holds as an approximation since the tax rate depends on the realization of the output shock, u. We shall come back to this point in Section 4.1.

[8] Note that, due to the linear approximation, unanticipated inflation may turn the real value of

$$\tau = G + [1 + i^* - m(\pi - E_0\pi)]B \tag{5}$$

After replacing the value of τ in equation (3), we substitute equations (2) and (3) in the loss function (1) to obtain:

$$E_0L = \theta E_0\pi^2 + E_0[(\pi - E_0\pi)(b + k^{'}mB) - u - k(E_0\tau)]^2 \tag{6}$$

where $k(E_0\tau) = k(G + B + i^*B)$ denotes the expected output loss due to tax distortions.

The sequence of events is as follows: (i) the government designs monetary institutions and chooses the debt composition; (ii) private agents forms rational inflation expectations; (iii) the output shock realizes; (iv) the monetary authority sets the inflation rate.

In the next section we first derive the basic insights from the standard framework which adopts the loss function (1) and then discuss microfoundations and robustness when alternative specifications are considered.

4. A dependent Central Bank

Consider a government that does not delegate monetary policy and retains full discretion over the choice of the inflation rate. After observing the realization of the shock, u, the government chooses inflation so as to minimize

$$L = \theta\pi^2 + [Z(\pi - E_0\pi) - D - u]^2 \tag{7}$$

where $Z = b + k^{'}mB$ denotes the marginal output gain from unexpected inflation and depreciation and $D = k(G + B + i^*B)$ is the expected output loss due to tax distortions.

Assuming rational expectations, inflation and output are given by

$$\pi = \frac{Z}{\theta}[D + \lambda u] \tag{8}$$

$$y = y^T - D - \lambda u \tag{9}$$

where $\lambda = \theta/[\theta + (b + k^{'}mB)^2]$ is decreasing with the share of conventional debt, m.

Therefore, inflation and exchange depreciation allow the government to dampen the impact of output shocks —the more so the the lower is λ and thus the larger

the debt negative, clearly a nonsense since the most inflation can do is to cancel the debt. In order to rule out negative real payments, an upper bound on the distribution of u must be imposed such that

$$u \leq u^h \equiv (1 + i^*)(k^{'}B + \frac{b}{m} + \frac{\theta}{mb + m^2k^{'}B})$$

If we assume that the government can raise funds in domestic currency to lend in foreign currency, then m tends to infinity, but a positive upper bound would still exist and be equal to $u^h = (1+i^*)k^{'}B$.

is the share of conventional debt, m. However, as the private sector anticipates the incentive to inflate, a larger share of conventional debt leads to higher expected and equilibrium inflation, thus increasing the government loss.

The expected loss, as of time 0 when the government chooses the indexation and currency denomination of the debt, is given by

$$E_0 L^D = \frac{D^2}{\lambda} + \lambda\sigma^2 \tag{10}$$

The discretionary solution can be contrasted with the expected loss when the government credibly commits to zero inflation and depreciation by following the "fixed rule" $\pi = e = 0$:

$$E_0 L^R = D^2 + \sigma^2 \tag{11}$$

Noting that $0 \leq \lambda \leq 1$, equations (11) and (10) show that under the fixed rule the government loses flexibility in reacting to output shocks but avoids the costs of expected inflation. Indeed, the expected loss (10) depicts the trade off between credibility and flexibility that is at the heart of the rules-versus-discretion literature. This trade off is spanned by $\lambda = \theta/[\theta + (b + k'mB)^2]$ varying between zero and one, and thus by the share of conventional debt, m.

The government can generally do better than the rule solution by choosing a proper, possibly negative, m, so as to select the optimal point on the credibility-flexibility spectrum.[9] The optimal share of conventional debt increases with output variability, σ^2, while it decreases with the temptation to inflate which depends on tax distortions, D, and thus on the level of government expenditure and debt as in Bohn (1988) and Calvo and Guidotti (1990). Hence —with a dependent central bank— inflation-indexed debt and/or foreign currency debt (in amounts possibly exceeding the level of debt) are optimal if the impact of tax distortions on inflationary expectations is large relative to the variance of output shocks.

4.1 The social loss function: an assessment

In this section we discuss the motivation behind the choice of the loss function (1) and examine whether the trade off between credibility and flexibility, which emerges in our basic set-up, can be generalized to other specifications.

The choice of the loss function is important because it defines a particular regime, for example, it characterizes the preferences, the nature and extent of independence of the institution in charge of monetary policy. We adopt the loss function (1) which is

[9] In fact, if the government can choose any debt combination, including the possibility to raise funds with one type of debt to lend in the other type, the expected loss under discretion can be made no greater than the loss under a fixed rule. This conclusion follows immediately from the fact that the zero inflation rule is equivalent to setting a negative m such that $b + k'mB = 0$ and hence $\lambda = 1$. However, the government can do no better than opt for a fixed rule when $D^2 > \sigma^2$.

standard in the literature on central bank independence (see Walsh 1998) and model the output loss as a function of the tax rate.

A possible objection to this approach is that the marginal cost in welfare terms of tax distortions is relatively higher in bad states of nature, i.e. when adverse output shocks occur so that $y - \bar{y} < 0$ (as shown by equation (1)). This partly reflects the assumption that society has a preference for stabilizing output fluctuations arising from nominal rigidities (see e.g. Walsh 1998 and Herrendorf and Neumann 1998). However, the implication that the marginal cost of tax distortions is counter-cyclical is quite strong from the viewpoint of real business-cycle theory of output fluctuations where distortionary taxation is the only source of inefficiency. In fact, in utility-based models where the output loss reflects disincentives to work induced by proportional taxation of labor income (as opposed to losses from tax collection), the relation between the marginal cost of taxation and the level of output is uncertain (see Chari, Christiano and Kehoe 1994). Intuitively, taxation could be less distortionary in bad output states as labor could be supplied more inelastically.

In the absence of nominal rigidities, a possible motivation for equation (1) is that a greater marginal cost in bad output states captures the higher tax rates that are required to ensure fiscal solvency.[10] In fact, the same implications can be derived from a specification of the loss function where the marginal cost of tax distortions is independent from the state of nature. The formal argument is as follows. Suppose that society cares about output expansions rather than output stabilization, as in Barro and Gordon (1983b) and Cukierman and Meltzer (1986).[11] Then, the social loss is linear in output and tax distortions:

$$E_0 L = \theta E_0 \pi^2 + E_0(\bar{y} - y) + c E_0 \tau^2 \tag{12}$$

where the output loss from distortions is assumed to be quadratic in the tax rate.

Although the marginal cost of taxation is independent from the output shock, u, the dependence of the tax rate from the level of output implied by the budget constraint may lead to the same specification as in equation (6). While this is easily verified in a one-period framework where tax revenues, τY, must cover spending commitments and debt repayments, a negative relation between output shocks and the tax rate also emerges over longer horizons if the government smooths taxes. For instance, using the linear approximation around a zero output growth of the intertemporal budget constraint suggested by Bohn (1990b), it can be shown that tax-smoothing implies the following tax rule:

$$\tau_t = G_t^{P*} + i(1+i)^{-1}[1 + i - m(\pi_t - E_{t-1}\pi_t)]B_{t-1}^* - \bar{\tau}\Sigma_{i=0}^{\infty}(1+i)^{-i}E_t\hat{y}_{t+i} \tag{13}$$

[10] Chari, Christiano and Kehoe show that, for reasonable parameter values, in bad states of nature it is optimal to cover most of the financing needs in contingent markets for debt even when raising tax rates is efficient.

[11] The argument goes through independently of the presence of output in the loss function.

where $\hat{y}_{t+i} = y_{t+i} - y_{t+i-1}$ is the rate of output growth, $G_t^{P*} = G_t^P \bar{Y}/Y_{t-1}$ is permanent (or normal) public expenditure relative to time $t-1$ output and $B_{t-1}^* = B_{t-1}\bar{Y}/Y_{t-1}$ is the debt-to-output ratio. Finally, $\bar{\tau} = iB_{t-1}^* + G_t^{P*}$ is the point of linearization for the tax rate. Then, assuming that initial output is at its natural level; i.e. $y_{t-1} = \bar{y}$ and that output shocks are not persistent, so that $E_t y_{t+i} = \bar{y}$ for $i = 1, 2, 3...\infty$, the tax rate is equal to

$$\tau_t = \bar{\tau} - \frac{i}{1+i}\left[(\pi_t - E_{t-1}\pi_t)mB_{t-1} + \bar{\tau}(y_t - \bar{y})\right] \tag{14}$$

which can be substituted for τ_t in equation (12) to yield a similar specification as equation (6).

This motivation for equation (1) hinges however on tax-smoothing as the rule for fiscal policy. In fact, a series of negative output shocks will eventually force the government to raise taxes independently of the fiscal rule but such adjustments can be considerably delayed in the real world. If the government does not smooth taxes, then the persistence of shocks, the level of debt and the length of time intervals between monetary policy decisions are all relevant aspects to consider. If tax rates are invariant to economic activity, i.e. if $\tau = G + [1 + i^* - m(\pi - E_0\pi)]B$, both output stabilization and tax variability are irrelevant for welfare. In this case raising funds in foreign currency to lend in conventional debt —i.e. a 'negative' m— can completely remove the inflationary bias at no cost. Hence, an argument for institutional design would have to be based on the existence of practical constraints to this funding policy.

Therefore, our analysis requires either that the government cares about output stabilization (i.e. because of nominal rigidities) and taxes affect output, or that it wants to stabilize tax rates which vary in response to output changes. Acknowledging that our analysis is not fully general, in what follows we maintain the motivating hypothesis that a trade-off between credibility and flexibility exists, which depends on tax distortions, and can be improved upon by designing institutions besides choosing the debt composition. In Section 6 we shall provide evidence of a negative relation between central bank independence and the share of foreign currency and indexed debt which is consistent with the existence of such a trade-off.

In the next section we consider the choice of debt instruments and highlight the role of the monetary regime in this decision. In particular, we study the case of a weight-conservative central banker and compare this solution to an inflation contract and to inflation targeting.

5. An independent Central Bank

5.1 A weight-conservative central banker

The role of foreign currency and inflation-indexed debt as commitment devices which can possibly enhance the credibility of anti-inflationary policy is a well known result in the literature on debt management. The new interesting issue is how debt policy interacts with and compares to institutional design as a solution to credibility problems. In fact, the natural solution to inflationary temptations is delegation of monetary policy to an independent central banker where independence refers either to goal independence or instrument independence (operational independence).

Rogoff (1985) shows that the appointment of a central banker with preferences characterized by a stronger aversion to inflation than society —i.e. by a parameter $\theta_B > \theta$ — increases social welfare. In principle, society could choose the degree of conservativeness, θ_B, of the central banker so as to attain the desired combination of credibility and flexibility.[12] By simple inspection of equation (10), noting that $\lambda = \theta/[\theta + (b + k^{'}mB)^2]$, it appears that the choice of debt composition could secure the same outcome as that of central bank independence. In fact, institutional design is a superior solution than indexed debt or foreign currency debt to the problem of reducing the inflationary bias without losing flexibility.

In order to show that delegation of monetary policy improves on debt management solutions, consider the expected social loss, that is, the government loss when the central bank is goal independent:

$$E_0 L = \theta E_0 \pi_B^2 + E_0(y_B - y^T)^2 = -(\theta_B - \theta)E_0\pi_B^2 + E_0 L_B \tag{15}$$

where π_B and y_B are the inflation and output chosen by the central banker whose loss function is denoted by L_B. Note that π_B and y_B follow from the minimization of L_B and thus depend on the preferences of the central banker θ_B. Then, define with m^* the choice of debt composition that minimizes the expected loss under discretion (equation (10)) and the corresponding $\lambda^* = \theta/\left[\theta + (b + k^{'}m^*B)^2\right]$. It can be shown that, the social loss is reduced by choosing a greater share of conventional debt, $m > m^*$, and a central banker with a degree of conservativeness, $\theta_B > \theta$, that implies the same $\lambda = \lambda^*$ as the optimal debt policy. Indeed, choosing $\theta_B = \lambda^*(b+k^{'}mB)^2/(1-\lambda^*)$, the welfare loss for society is equal to

$$E_0 L^{*b} = -(\theta_B - \theta)E_0\pi_B^2 + \frac{D^2}{\lambda^*} + \lambda^*\sigma^2 \tag{16}$$

which is lower than the loss obtained with the optimal debt policy since the central banker is more inflation averse than society.

This result is not surprising because delegation endows the government with an additional control mechanism thus enlarging the space of the possible outcomes. The interesting issue is how the possibility to use both mechanisms affects the banker selection and debt management. The optimal policy involves the choice of an extremely

[12] The central bank has both goal and instrument independence. However, an alternative interpretation is that society delegates monetary policy to an instrument independent central banker that is assigned a particular loss function.

conservative central banker and the use of an infinitely large share of conventional debt. To see this note that the expected welfare loss (15) can be written as

$$E_0 L = \left(D^2 + \lambda_B^2 \sigma^2\right) \left[1 + \theta \left(\frac{Z}{\theta_B}\right)^2\right] \qquad with \quad \lambda_B = \frac{\theta_B}{\theta_B + Z^2} \tag{17}$$

From equation (17) it is clear that any increase in Z and θ_B which increases the ratio Z^2/θ_B (and thus lowers λ_B), while reducing Z/θ_B, reduces the social loss. This is possible if θ_B increases at a faster rate than Z but at a slower rate than Z^2. To make an example, if we set $Z = \theta_B^\alpha$, with $1/2 < \alpha < 1$, then the social loss tends to the global minimum D^2 as θ_B tends to infinity.

The intuition for this result is as follows. A higher share of conventional debt enlarges the inflation tax base and thus allows for lower conventional taxes and tax distortions for any given (unanticipated) inflation.[13] By increasing the sensitivity of output to inflation, conventional debt makes monetary policy more effective in stabilizing output fluctuations: less unanticipated inflation is needed to counter negative supply shocks. It follows that more conventional debt, i.e. a lower λ_B, helps to stabilize both output and inflation as shown by equations (8) and (9). On the other hand, conventional debt gives rise to inflationary temptations which, in the absence of institutional arrangements, would lead to a greater inflation bias. This can be avoided if the government appoints an independent (weight-conservative) central banker. Equations (8) and (9) show that even when inflation aversion, θ_B, goes to infinity and inflation tends to zero, the government need not give up output stabilization. This requires that the share of conventional debt increases so that λ_B goes to zero (i.e. Z^2/θ_B goes to infinity), though at a slower rate than inflation aversion (i.e. Z/θ_B goes to zero).

In practice, the optimal policy is unfeasible. Realistically, the government would not be able to over-fund in conventional debt and invest the proceeds in foreign currency or indexed assets; there is a limit on the amount of nominal debt that can be issued. Then, it is optimal for the government to issue as much conventional debt as possible and choose the central banker accordingly. To see this, define with θ_B^* the preferences of the central banker who minimizes the social loss for any given share, $\bar{m}$, of conventional debt and, correspondingly, $\lambda_B^* = \theta_B^*/[\theta_B^* + (b + k'\bar{m}B)^2]$. Then, the social loss (15) can be written as

$$E_0 L = \left(\frac{D^2}{\lambda_B^*} + \lambda_B^* \sigma^2\right) \left[\lambda_B^* + \frac{\theta}{\theta_B^*}(1 - \lambda_B^*)\right] \tag{18}$$

It is clear that a share of conventional debt, m, lower than $\bar{m}$ cannot reduce the social loss. If it could, θ_B^* would not be optimal since an increase in θ_B, that achieves

[13] Alternatively, as shown by Bohn (1990a, 1990b), conventional debt reduces the need for a higher tax rate when negative supply shocks occur (see equation (14)).

the same effect on λ_B as $m > \bar{m}$, further reduces the second term of (18). On the contrary, the social loss can always be reduced by a higher m: any increase in θ_B and m which leaves $\lambda_B = \lambda_B^*$ unaffected reduces the second term in (18).

Therefore, the expected loss for society can be minimized by issuing the largest possible amount of nominal debt and appointing a correspondingly 'very' conservative central banker. Intuitively, central bank independence is more effective in containing inflationary expectations and should be used to enhance the credibility of anti-inflationary policy, while conventional debt increases the sensitivity of output to surprise inflation and thus reduces the need for flexibility. This is an important result that supports the conventional wisdom that institutional design and, in particular, central bank independence is the effective solution to inflationary expectations while very little is gained by increasing the cost of inflation with index and foreign currency debt.[14] This may also provide a rationale for the conventional belief that foreign currency debt is a sign of weakness of monetary policy rather than an incentive for low inflation.

5.2 An inflation contract

In this section we examine the role of debt denomination and indexation when the delegation mechanism takes the form of an inflation contract between the government and the central bank. The linear contract proposed by Walsh (1995) and extended by Persson and Tabellini (1993) removes the inflationary bias at no cost in terms of output stability, thus providing the best solution to the problem of establishing the credibility of monetary policy without losing flexibility.[15]

The optimal contract delegates monetary policy to a central banker with the same preferences as society (or it assigns to the central banker the social loss function) but imposes a linear cost to inflation upon the monetary authority. Thus, the instrument independent but not goal independent central banker minimizes

$$E_0 L^C = \theta E_0 \pi^2 + E_0[y - \bar{y} - k(\tau)]^2 + C E_0 \pi \tag{19}$$

where C is the linear penalty for inflation outturns greater than zero.

Except for the cost, C, the central banker is faced by the same problem as the government under discretion. After observing the shock u, the monetary authority chooses inflation so as to minimize the loss L^C subject to (2), (3) and (5).

[14] This conclusion is immediate if one accepts McCallum (1995)'s view that a central banker targets the natural rate of output. Indeed, in such event monetary policy delegation completely removes the credibility problem making the choice of debt instruments depend only on risk considerations, as argued by Miller (1997a).

[15] This result is, however, not robust to changes in the assumptions regarding the information set of private agents (Herrendorf and Lockwood 1997) or the persistence of output (Lockwood, Miller and Zhang 1998) if a state contingent contract is not viable.

Assuming rational expectations, expected inflation is given by

$$E_0\pi = \frac{Z}{\theta}\left(D - \frac{C}{2Z}\right)$$

and the inflation bias can be eliminated by imposing a linear cost for inflation equal to

$$C = 2ZD = 2(b + k^{'}mB)D \tag{20}$$

Since the temptation for inflationary financing increases with conventional debt the cost, C, imposed on the central banker must increase with the share of such debt. Using this result, the solution to the government problem is equal to

$$\pi = \frac{Z}{\theta}\lambda u \tag{21}$$

$$y = y^T - D - \lambda u \tag{22}$$

which implies an expected loss for society equal to

$$E_0 L^C = D^2 + \lambda\sigma^2 \tag{23}$$

By comparing equation (23) to equation (17) or (18) it can be shown that, if there is no constraint on the choice of the penalty —but there is a limit on the amount of conventional debt that can be issued— the inflation contract provides a better solution than delegating policy to a weight-conservative central banker. More importantly from the point of view of debt management, it is clear that increasing the share of conventional debt (thus making λ small) reduces the impact of output shocks and thus the social loss. Intuitively, conventional debt makes taxes and output sensitive to unexpected inflation thus minimizing the inflation needed to offset output shocks. As for the solution with a weight-conservative central banker a large, possibly infinite, share of nominal debt would be optimal; the social loss would tend to the global minimum D^2 as it does in Rogoff's solution when both the degree of conservativeness of the central banker and the share of conventional debt go to infinity. However, the central bank contract requires a penalty for inflation that increases with the share of conventional debt, as shown by (20). Imposing such a cost can be problematic even if justified by the objective of avoiding income redistribution from debt holders to taxpayers or simply by the objective of defending the real value of wealth.

5.3 Inflation targeting

Finally, it is important to ask how these results relate to inflation targets, as they currently operate in the United Kingdom and elsewhere. In effect, inflation targets can be seen as the practical counterpart of either delegating policy to a weight-conservative central banker (Canzoneri, Nolan and Yates 1997 and Haldane 1995) or choosing the contract solution (Svensson 1997).

Adopting Svensson's (1997) interpretation of an inflation targeting regime, the central bank is given operational independence to minimize the following loss function

$$E_0 L^T = \theta E_0(\pi - \pi^T)^2 + E_0[y - \bar{y} - k(\tau)]^2 \tag{24}$$

where π^T denotes the inflation target. Hence, the central bank is assigned a loss function with a target for inflation different from the one which is socially optimal, say, $\pi^* = 0$. It is easy to show that by fixing a target equal to

$$\pi^T = -\frac{1}{\theta}(b + k' m B) D$$

the targeting regime yields the same solution as the inflation contract. In particular, the expected loss for society, $E_0 L^T = D^2 + \lambda\sigma^2$, is equal to the loss under the contract.

While implications for debt management are the same as in the contract solution, it is worth noting that a high share of conventional debt would imply an inflation target that, if not negative, could lie much below the socially optimal rate of inflation, thus creating problems for the implementation of the optimal policy.[16]

6. Independence and debt structure: the evidence

In the previous section we have shown that delegation of monetary policy to an independent central bank is the best solution to inflationary temptations while conventional debt should be issued to support output stabilization. If this normative argument has a positive content, the share of such debt should increase with the independence of the central bank. Certainly, long-term conventional debt has gained importance since the late 1980s as shown in Table 2 and debt duration has lengthened as reported in Missale (1999) and Favero, Missale and Piga (2000). Economists also agree that in this period central banks have enjoyed an increasing independence in the conduct of monetary policy (see e.g. Eijffinger and De Haan 1996, King 1998). However, a formal analysis of the relation between independence and debt structures is prevented by the lack of data on the time variation of independence. Thus, the prediction of a positive relation between independence and conventional debt is tested in this section using cross-sectional evidence for the 20 industrial OECD countries shown in Tables 1 and 2.[17]

Central bank independence is measured by three main indexes in the literature: the index of political independence developed by Alesina (1989) (AL); the total index of political and economic independence of Grilli, Masciandaro and Tabellini (1991) (GMT) and; the legal index of Cukierman (1992) (CU). Data on debt composition

[16] Haldane (1995) uses the same argument to cast doubts on the relevance of Svensson's interpretation for the UK's monetary regime.

[17] We exclude Norway because of data availability and Luxemburg which has a monetary union with Belgium.

refer to gross central government debt except for Germany where the level is the general government. They are from national sources and are reported in Missale (1999). Two measures of debt composition are considered: (i) the share of foreign currency and inflation-indexed debt (foreign currency debt for short in what follows) and; (ii) the share of fixed rate long-term debt. The former is defined as the percentage of bonds and loans denominated in foreign currency or indexed to the price level. The latter is the percentage of fixed rate bonds and loans denominated in domestic currency with an initial maturity longer than one year and is shown in Table 2.[18] The other macroeconomic variables used in the estimation are from OECD National Accounts and Economic Outlook.

Table 3 reports pairwise correlations and rank correlations between the share of foreign currency and indexed debt in 1985 and the three indexes of central bank independence. We choose 1985 as the reference year since the indexes of independence refer to legal and institutional arrangements of the 1980s, but results are robust to the choice of other dates or the use of period averages. The correlation between the share of foreign-currency debt and the indexes of independence is negative, as expected, and significant at the 10% level for the AL index and at the 5% level for the GMT index. The correlation is not significant in the case of the CU index. The existence of a negative relation is evident from Panels (a) and (b) of Figure 1 which plot the share of foreign debt against the AL index and GMT index, respectively. Stronger evidence in support of the theory comes from rank correlations in Table 3. The Spearman correlation coefficient is significant at the 5% level for both the AL and the GMT indexes.

The third row of Table 3 reports correlation coefficients for the share of fixed rate long-term debt denominated in the domestic currency which may better reflect actual inflation incentives than the share of debt denominated in foreign currency or indexed to the price level. In fact, a short maturity or variable interest rates limit the time for the impact of unexpected inflation on the value of the debt. The correlations with the share of long-term conventional debt are strong and significant at the 5% level for both the AL and GMT indexes, while there is no evidence of correlation for the CU index. The same results hold true for rank correlations. The negative relation between the share of long-term conventional debt and the AL and GMT indexes is displayed in Panels (c) and (d) of Figure 1.

To examine whether the relation between independence and debt structure is robust to the introduction of other variables, we estimate regressions of debt shares on independence indexes and a set of control variables, limiting the attention to the

[18] Foreign currency debt includes ECU-indexed bills and bonds and is shown in Table 2. At the end of 1985 inflation-indexed bonds accounted for a 6.6% of UK debt while they were just introduced in Australia. Fixed rate long-term debt excludes floating-rate debt but includes extendible bonds and bonds with an option for early redemption if the period preceding the earliest possible maturity is longer than 1 year.

AL and GMT indexes for which a significant relation has been detected. We take debt shares as the dependent variable, even though the choice of debt composition and bank independence has been modeled as a joint decision taking place contemporaneously at the institutional stage of the game. This allows for a clearer presentation of the results and reflects less frequent and more costly changes in institutional arrangements and central bankers compared to changes in the debt structure.

Table 4 shows that the relation between debt shares and the AL and GMT indexes remains significant after controlling for the fiscal stance, the openness of the economy and the adoption of an exchange rate peg. Columns 1 to 4 show that the ratios of government consumption and gross debt relative to GDP in 1985 have no impact on debt composition. Incidentally, this result is quite robust; it holds for different periods, for the use of period averages and for regressions with government deficits and interest payments. In the second part of Table 4 we control for an exchange-rate peg and for the openness of the economy, as measured by the sum of imports and exports relative to GDP in 1985.[19] The exchange regime is important since a peg provides further commitment to low inflation due to the costs associated with the realignments of the fixed parity (Giavazzi and Pagano 1988), and the greater transparency of the exchange rate (Herrendorf 1999). Openness is suggested by its possible correlation with foreign currency debt emerged in Section 2. Furthermore, a larger tradable sector facing international competition may imply less distortions and thus inflationary temptations, as shown by Lane (1997). Columns 5 to 8 show that the AL and GMT indexes of independence perform better than the peg and openness and consistently in sign for the two debt shares. Controlling for exchange rate pegging even enhances the significance of the AL index in explaining variation in foreign currency debt. This is because exchange rate pegging provides a substitute for independence. When the GMT index is considered, openness appears to enlarge the share of foreign currency debt. There is instead no evidence that either openness or exchange rate pegging affect the share of long-term conventional debt.

We next examine the effect of political instability on the debt composition, using the index developed by Alesina and Perotti (1996). Political instability is found by Miller (1997b) to significantly reduce the share of long-term conventional debt, possibly because of an inflation-risk premium on long-term debt induced by higher inflation uncertainty. Columns 1 to 4 of Table 5 show, however, that independence performs better than instability in three out of four cases: when foreign currency debt is considered and when independence is measured by the AL index. Political instability has a significant negative impact on the share of long-term conventional debt only with the GMT index. Columns 5 to 8 of Table 5 consider size and openness

[19] Peg is a dummy variable taking the value of one for Belgium, Denmark, France, Ireland, Italy and the Netherlands participating to the exchange rate mechanism (ERM) of the EMS in 1985. Adding Spain joining the ERM in 1989 and/or Austria, Finland and Sweden, *de facto* adopting a peg, does not change the results.

as potential determinants of debt composition, drawing from evidence in Section 2 of a greater use of foreign currency debt by small open economies. Indeed, the log of GDP in 1985 (in US dollars) accounts for most of the variation in foreign currency debt across OECD economies leaving no significant role to central bank independence. The last two columns of Table 5 show, however, that when long-term conventional debt is considered, the AL and GMT indexes remain significant at the 5% and 10% level, respectively, while size does not have a statistically relevant effect. If GDP is viewed as an indicator of the size of the securities market and its liquidity, this evidence suggests that the dimension of the market affects the cost and thus the choice between alternative instruments to commit to low inflation. Although there may be a preference for short-term and variable rate-debt, only in large economies debt managers can rely on deep markets for such instruments while for small economies borrowing on foreign markets is more convenient.

The overall impression is that a relation between debt composition and independence exists which gives a potentially positive content to the theory developed in the previous sections. However, there are other important predictions regarding output variability and inflation to be examined. A stronger testable implication is that a greater share of conventional debt helps to reduce output variability by making the stabilization policy of the monetary authority more effective (see equation (9)). To test this prediction we follow the standard procedure in the empirical literature stemming from Grilli, Masciandaro and Tabellini (1991) and Alesina and Summers (1993). We estimate regressions of the standard deviation of output growth on the AL and GMT indexes, while introducing the two measures of debt composition as additional explanatory variables. We consider the standard deviation of output growth for the period 1986-1997 so as to avoid potential endogeneity problems between output growth and debt structure. The result shown in columns 1 and 2 of Table 6 is striking: a greater initial share of foreign currency debt significantly increases output variability. The effect is significant at the 5% level for both the AL and the GMT indexes and does not disappear when openness and log of GDP are introduced in the regression as control variables (see columns 5 and 6). Evidence on the impact of the debt structure is however mixed: when the share of fixed rate long-term debt is considered no significant effect on output variability is found (see columns 3, 4, 7 and 8).

Finally, we examine the relation between average inflation for the period 1986-1997, central bank independence and debt composition. Since monetary policy delegation does not completely eliminate the inflation bias and the share of conventional debt is limited, inflation is expected to decrease with independence and rise with the share of conventional debt or, in an inflation targeting, bear no relation to it. Evidence in Table 7 contraddicts this prediction: the coefficient of the share of long-term conventional debt is negative and significant with both the AL and the GMT index. This result is robust to the introduction of a dummy variable for exchange rate pegging (see columns 3 and 4) and the consideration of the debt-to-GDP ratio (see columns 7 and 8). As expected, both independence and exchange rate pegging significantly reduce inflation.

The negative relation between inflation and long-term conventional debt may reflect inverse causality running from inflation to the debt composition. A high inflation environment is likely to be associated with high expected inflation and inflation variability making it more costly to issue fixed rate long-term debt. Likewise a lower share of long-term conventional debt may reflect a policy reaction to high inflation in an attempt to reduce inflationary expectations, as suggested by King (1998) and Mandilaras and Levine (2000). In either case the estimated relation suffers from an endogeneity problem that the use of initial period debt shares cannot solve, since average future inflation is tipically correlated with long-term interest rates.

To conclude, the observed debt structures in industrial OECD countries are consistent with the prediction that more independent central banks allow governments to issue a larger share of conventional long-term debt. However, the negative relation between inflation and long-term conventional debt suggests an alternative explanation to the commitment motivation. The positive relation between independence and conventional debt may simply reflect the lower inflation environment that characterizes countries with more independent central banks. So far we have been unable to construct a test that allows to distinguish between these two competing but related explanations. We leave the investigation of this issue to future research agenda.

7. Conclusions

While the role of central bank independence in securing low and stable inflation is undisputed, the idea that indexed and foreign currency and debt may create incentives and expectations for low inflation is not always accepted. This paper argues that the efficacy of debt characteristics as incentives for anti-inflationary policy depends on the choice of the monetary regime. We show that delegation of monetary policy to an independent central bank is a better solution to credibility problems than increasing the costs of inflation by issuing indexed debt, foreign currency debt and short-term conventional debt. Furthermore, an independent central bank may benefit from fixed rate conventional debt, possibly of a long maturity, since such debt increases the sensitivity of taxes and output to unexpected inflation, thus minimizing the inflation needed to counter supply shocks. This explanation is consistent with the decline in the share of debt denominated in foreign currency and the lengthening of debt maturity that has taken place since the late 1980s in OECD countries, with the establishment of increasingly independent central banks.

References

Alesina, A., 1989. Politics and Business Cycles in Industrial Democracies: A European Forum. *Economic Policy* 8, 57-98.

Alesina, A., Perotti, R., 1996. Income Distribution, Political Instability, and Investment. *European Economic Review* 40(6), 1203-1228.

Alesina, A., Summers, L.H., 1993. Central Bank Independence and Macroeconomic Performance: Some Comparative Evidence. *Journal of Money, Credit, and Banking* 25, 151-162.

Back, J.L., Musgrave, R.A., 1941. A Stable Purchasing Power Bond. *American Economic Review* 31, 823-825.

Barro, R.J., Gordon, D.B., 1983a. A Positive Theory of Monetary Policy in a Natural-Rate Model. *Journal of Political Economy* 91(4), 589-610.

Barro, R.J., Gordon, D.B., 1983b. Rules, Discretion, and Reputation in a Model of Monetary Policy. *Journal of Monetary Economics* 12(1), 101-121.

Beetsma, R.M.W.J., Bovemberg, A.L., 1997. Central Bank Independence and Public Debt Policy. *Journal of Economics Dynamics and Control* 21(4-5), 873-894.

Bohn, H., 1988. Why Do We Have Nominal Government Debt?. *Journal of Monetary Economics* 21, 127-140.

Bohn, H., 1990a. A Positive Theory of Foreign Currency Debt. *Journal of International Economics* 29, 273-292.

Bohn, H., 1990b. Tax Smoothing with Financial Instruments. *American Economic Review* 80, 1217-1230.

Bohn, H., 1991. Time Consistency and Monetary Policy in the Open Economy. *Journal of International Economics* 30, 249-266.

Calvo, G.A., 1988. Servicing the Public Debt: the Role of Expectations. *American Economic Review* 78(4), 647-661.

Calvo, G.A., Guidotti, P., 1990. Indexation and Maturity of Government Bonds: An Exploratory Model. In: Dornbusch, R., Draghi M. (Eds.), *Public Debt Management: Theory and History* (52-93). Cambridge University Press, Cambridge.

Canzoneri, M.B., Nolan, C., Yates, A., 1996. Mechanisms for Achieving Monetary Stability: Inflation Targeting Versus the ERM. *Journal of Money Credit and Banking* 29, 46-60.

Chari, V.V., Christiano, L.J., Kehoe, P.J., 1994. Optimal Fiscal Policy in a Business Cycle Model. *Journal of Political Economy* 102(4), 617-652.

Cukierman, A., 1992. *Central Bank Strategy, Credibility and Independence.* MIT Press, Cambridge, Mass.

Cukierman, A., 1994. Commitment through Delegation, Political Influence and Central Bank Independence. In: De Beaufort Wijnholds, J.O. et al. (Eds.), *A Framework for Monetary Stability* (55-74). Kluwer Academics, Dordrecht, Boston, and London.

Cukierman, A., Meltzer, A., 1986. A Theory of Ambiguity, Credibility and Inflation under Discretion and Asymmetric Information. *Econometrica* 54, 1099-1128.

Eijffinger, S.C.W., De Haan, J., 1996. The Political Economy of Central-Bank Independence. Special Papers in International Economics International Finance Section, Princeton University, No.19, May.

Favero, C., Piga, G., Missale, A. 2000. EMU and Public Debt Management: One Money, One Debt?. *CEPR Policy Paper* No.3, London.

Fischer, S., 1983. Welfare Aspects of Government Issue of Indexed Bonds. In: Dornbusch, R., Simonsen, M.H. (Eds.), *Inflation Debt and Indexation* (223-46). MIT Press, Cambridge, Mass.

Giavazzi, F., Pagano, M., 1988. The Advantage of Tying One's Hand. *European Economic Review* 32, 1055-1082.

Grilli V., Masciandaro, D., Tabellini, G., 1991. Political and Monetary Institutions and Public Financial Policies in the Industrial Countries. *Economic Policy* 342-392.

Haldane, A.G., 1995. Rules, Discretion and the United Kingdom's New Monetary Framework. *Bank of England Working Paper* No.40, November.

Herrendorf, B., 1999. Transparency, Reputation, and Credibility under Floating and Pegged Exchange Rates. *Journal of International Economics* 49, 31-50.

Herrendorf, B., Lockwood, B., 1997. Rogoff's 'Conservative' Central Banker Restored. *Journal of Money Credit and Banking* 29, 476-495.

Herrendorf, B., Neumann, M., 1998. The Political Economy of Inflation, Labor Market Distortions and Central Bank Independence. mimeo, University of Warwick, July.

King, M., 1998. Discussion of Dornbusch's Paper. In: Calvo, G., King, M. (Eds.), *The Debt Burden and its Consequences for Monetary Policy* (23-27). IEA Conference Volume No.118. MacMillan Press, London.

Lane, P.R., 1997. Inflation in Open Economies. *Journal of International Economics* 42, 327-347.

Mandilaras, A., Levine, P. 2000. Public Debt and Inflation: the Role of Inflation-Sensitive Instruments. mimeo, University of Surrey, May.

Lockwood, B., Miller, M., Zhang, L., 1998. Designing Monetary Policy when Unemployment Persist. *Economica* 65(259), 327-345.

Lucas, R.E., Stokey, N., 1983. Optimal Fiscal and Monetary Policy in an Economy without Capital. *Journal of Monetary Economics* 12, 55-93.

McCallum, B.T., 1995. Two Fallacies Concerning Central Bank Independence. *American Economic Review (Papers and Proceedings)* 85, 207-211.

Miller, V., 1997a. Debt Structure as an Indicator of Central Bank Independence. *Southern Economic Journal* 64(1), 85-96.

Miller, V., 1997b. Political Instability and Debt Maturity. *Economic Inquiry* 35(1), 12-27.

Missale, A., 1999. *Public Debt Management.* Oxford University Press, Oxford.

Missale, A., Blanchard, O.J., 1994. The Debt Burden and Debt Maturity. *American Economic Review* 84, 309-319.

Pecchi, L., Ripa-di-Meana, A., 1998. Public Foreign Currency Debt: A Cross-Country Evaluation of Competing Theories. *Giornale degli Economisti* 57(2), 251-288.

Persson T., Tabellini, G., 1993. Designing Institutions for Monetary Stability. Carnegie-Rochester Conference Series on Public Policy 39, 53-84.

Rogoff, K., 1985. The Optimal Degree of Commitment to an Intermediate Monetary Target. *Quarterly Journal of Economics* 100, 1169-1190.

Svensson, L.E.O., 1997. Optimal Inflation Targets, 'Conservative' Central Banks, and Linear Inflation Contracts. *American Economic Review* 87(1), 98-114.

Walsh, C.E., 1995. Optimal Contracts for Central Bankers. *American Economic Review* 85(1), 150-167.

Walsh, C.E., 1997. Accountability, Performance Measures, and Inflation Targeting. mimeo, November.

Walsh, C.E., 1998. *Monetary Theory and Policy.* MIT Press, Cambridge, Mass.

Watanabe, T., 1992. The Optimal Currency Composition of Government Debt. *Bank of Japan Monetary and Economic Studies* 10(2), 31-62.

Table 1: Share of Foreign Currency Debt

	1970	1975	1980	1985	1991	1995	1997
Australia	na	6.7	17.4	17.7	13.8	3.1	1.2
Austria	32.1	33.3	28.1	22.7	15.7	22.0	20.4
Belgium	8.4	0.5	7.8	20.2	15.4	11.4	8.0
Canada	1.3	0.4	5.6	6.9	1.4	3.5	5.8
Denmark	53.9	55.7	33.3	20.5	22.7	15.6	14.2
Finland	37.1	45.4	57.6	54.7	43.5	46.4	40.3
France	1.5	0.4	0.0	4.0	2.1	3.7	5.4
Germany	1.1	0.3	–	–	–	–	–
Greece	na	na	22.8	38.7	31.7	26.0	20.7
Ireland	8.8	22.3	30.5	45.1	33.6	35.1	26.3
Italy	3.1	1.4	1.7	4.3	7.8	8.0	7.8
Japan	0.9	0.1	–	–	–	–	–
Netherland	0.3	–	–	–	–	–	–
New Zealand	na	na	36.5	43.9	47.2	29.8	18.2
Portugal	26.8	18.5	20.3	31.4	11.3	17.3	22.3
Spain	6.6	6.0	9.4	7.9	3.5	8.7	8.9
Sweden	0.0	0.2	18.4	21.6	12.3	27.9	27.0
Switzerland	–	–	–	–	–	–	–
UK	6.5	6.2	2.8	2.3	4.0	4.4	2.8
USA	0.4	0.3	0.7	–	–	–	–

Notes: Percentage of total gross debt. Fiscal years ending in the same year or in March of the next year. Foreign currency debt includes ECU bonds and bills which are payable in domestic currency but are indexed to the ECU.

Table 2: Share of Fixed Rate Long-Term Debt

	1970	1975	1980	1985	1990	1995	1997
Australia	na	67.8	56.1	64.5	64.8	76.3	74.5
Austria	48.2	43.1	59.6	40.9	47.3	54.6	61.0
Belgium	67.7	82.5	67.5	51.1	57.2	68.3	70.5
Canada	51.5	41.0	49.1	40.2	44.1	52.5	61.0
Denmark	46.1	44.3	51.0	66.9	43.8	60.8	71.8
Finland	58.1	46.4	42.2	41.1	56.5	43.4	55.4
France	10.1	16.3	28.1	29.3	56.2	69.6	71.0
Germany	78.3	83.4	89.9	93.3	91.7	89.8	89.5
Greece	na	na	0.0	0.0	4.6	21.3	30.6
Ireland	53.2	57.2	56.6	40.9	40.7	44.9	49.3
Italy	43.0	36.8	24.1	11.2	18.8	35.3	41.9
Japan	67.9	81.8	86.4	88.4	83.9	85.6	82.8
Netherlands	90.3	88.0	92.8	98.8	98.7	94.7	94.2
New Zealand	na	na	na	42.4	33.4	51.7	56.7
Portugal	72.3	80.7	17.8	4.3	2.4	20.6	33.6
Spain	35.0	22.4	21.3	13.4	30.3	54.6	61.9
Sweden	64.8	74.7	59.2	47.9	44.2	51.9	52.0
Switzerland	na	na	72.2	72.3	80.8	66.5	67.0
UK	70.9	69.8	79.5	71.4	55.0	59.7	59.4
USA	42.3	35.1	43.5	53.5	49.3	50.3	49.8

Notes: Fixed rate bonds and loans with initial maturity longer than 1 year. Percentage of total gross debt. Fiscal years ending in the same year or in March of the next year. Data include extendible bonds and bonds with coupons adjustable after a period longer than 1 year.

Table 3: Correlations of Debt Shares and Central Bank Independence

	Foreign Currency and Indexed Debt		
Indexes of Independence	AL	GMT	CU
Number of observations	16	18	19
Simple correlations	-0.45 (0.07)	-0.58 (0.01)	-0.15 (0.53)
Rank correlations	-0.60 (0.01)	-0.58 (0.01)	-0.16 (0.51)
	Fixed Rate Long-Term Debt		
Indexes of Independence	AL	GMT	CU
Number of observations	16	18	19
Simple correlations	0.57 (0.02)	0.62 (0.01)	0.24 (0.31)
Rank correlations	0.60 (0.01)	0.60 (0.01)	0.21 (0.39)

Notes: Pairwise correlation coefficients and Spearman rank correlation coefficients. P-Values are in parentheses. The index by Alesina is not available for Austria, Greece, Ireland and Portugal. The index by Cukierman is not available for Portugal. The index by Grilli-Masciandaro-Tabellini is not available for Finland and Sweden.

Table 4: Debt Shares, Independence, Fiscal Variables and Openness

Dep. variable	Foreign Currency		Fixed Rate Long		Foreign Currency		Fixed Rate Long	
	AL	GMT	AL	GMT	AL	GMT	AL	GMT
Observations	16	18	16	18	16	18	16	18
Adjusted R^2	0.29	0.39	0.34	0.41	0.39	0.52	0.41	0.41
Constant	22.9	18.6	18.0	5.58	25.8**	25.8**	7.76	-5.56
	(0.98)	(1.01)	(0.50)	(0.16)	(2.15)	(2.66)	(0.41)	(0.27)
Independence	-8.31*	-3.07**	16.6**	6.81**	-9.65**	-3.15**	15.4**	5.95**
	(1.84)	(2.57)	(2.40)	(3.08)	(2.34)	(3.28)	(2.40)	(2.98)
Gov Cons	0.82	0.82	-0.15	-1.06				
	(0.92)	(0.86)	(0.11)	(0.59)				
Debt Ratio	-0.13	0.09	0.08	0.17				
	(0.80)	(0.62)	(0.31)	(0.64)				
Peg					-16.5*	-10.7	-9.51	-2.39
					(1.76)	(1.45)	(0.65)	(0.15)
Openness					0.42	0.51**	0.56	0.31
					(1.50)	(2.29)	(1.28)	(0.67)

Notes: *t*-statistics are in parentheses. * Significant at the 10% level. ** Significant at the 5% level. For the AL and GMT indexes see Notes to Table 5.

Table 5: Debt Shares, Independence, Political Instability and Country Size

Dep. variable	Foreign Currency		Fixed Rate Long		Foreign Currency		Fixed Rate Long	
	AL	GMT	AL	GMT	AL	GMT	AL	GMT
Observations	15	16	15	16	16	18	16	18
Adjusted R^2	0.39	0.30	0.45	0.49	0.60	0.75	0.39	0.46
Constant	7.49	34.3**	-8.60	-3.84	85.1**	73.4**	3.32	-41.4
	(0.50)	(3.08)	(0.38)	(0.22)	(4.24)	(5.51)	(0.08)	(1.13)
Independence	-11.0**	-3.21**	12.2*	2.79	-1.52	-0.93	15.9**	4.34*
	(2.57)	(2.17)	(1.89)	(1.21)	(0.40)	(1.09)	(2.14)	(1.84)
Instability	-2.73*	-0.49	-3.56	-3.44**				
	(1.90)	(0.47)	(1.63)	(2.12)				
Openness					-0.36	-0.17	0.45	0.66
					(1.47)	(0.94)	(0.92)	(1.33)
Log of GDP					-10.7**	-9.02**	0.76	7.06
					(3.38)	(4.08)	(0.12)	(1.16)

Notes: *t*-statistics are in parentheses. * Significant at the 10% level. ** Significant at the 5% level. For the AL and GMT indexes see Notes to Table 5. The Alesina-Perotti index of political instability is not available for Belgium and Portugal.

Table 6: Variability of Output Growth, Debt Shares and Independence

Dep. Variable	Standard Deviation of Output Growth 1986-97							
	AL	GMT	AL	GMT	AL	GMT	AL	GMT
Observations	16	18	16	18	16	18	16	18
Adjusted R^2	0.68	0.33	0.01	0.11	0.77	0.35	0.34	0.20
Constant	0.78**	1.42**	1.96**	2.08**	0.72	0.73	4.27**	2.76**
	(2.34)	(3.56)	(4.04)	(6.70)	(0.72)	(0.62)	(3.96)	(3.56)
Independence	0.25*	0.003	0.003	-0.06	0.25*	0.002	0.21	-0.04
	(2.01)	(0.08)	(0.01)	(1.28)	(2.10)	(0.06)	(0.88)	(0.69)
Foreign Currency	0.04**	0.02**			0.04**	0.03*		
	(5.29)	(2.25)			(4.61)	(1.91)		
Fixed Rate Long			-0.003	0.002			-0.001	0.003
			(0.38)	(0.43)			(0.17)	(0.67)
Openness					-0.01	0.001	-0.02*	-0.01
					(1.22)	(0.10)	(1.81)	(0.54)
Log of GDP					0.06	0.11	-0.39**	-0.15
					(0.42)	(0.65)	(2.28)	(1.16)

Notes: t-statistics are in parentheses. * Significant at the 10% level. ** Significant at the 5% level. For the AL and GMT indexes see Notes to Table 5.

Table 7: Inflation, Debt Shares and Independence

Dep. Variable:	Average Inflation 1986-1997							
	AL	GMT	AL	GMT	AL	GMT	AL	GMT
Observations	16	18	16	18	16	18	16	18
Adjusted R^2	0.60	0.53	0.36	0.50	0.48	0.53	0.57	0.60
Constant	5.96**	6.87**	6.07**	8.68**	6.01**	9.04**	6.23**	10.6**
	(7.17)	(3.18)	(10.7)	(6.68)	(5.06)	(3.72)	(7.03)	(5.28)
Independence	-1.03**	-0.39*	-0.66**	-0.23	-0.94**	-0.42*	-0.64*	-0.30
	(3.62)	(1.82)	(2.56)	(1.17)	(2.91)	(2.06)	(2.05)	(1.46)
Foreign Currency	-0.01	0.05			-0.001	0.07		
	(0.46)	(1.10)			(0.06)	(1.66)		
Fixed Rate Long			-0.02*	-0.05**			-0.02	-0.05**
			(2.02)	(2.43)			(1.61)	(2.27)
Peg	-1.14**	-1.94*	-1.07**	-1.82*				
	(2.30)	(1.76)	(2.59)	(1.87)				
Debt Ratio					-0.01	-0.05**	-0.01	-0.03
					(1.15)	(2.21)	(1.14)	(1.70)

Notes: t-statistics are in parentheses. * Significant at the 10% level. ** Significant at the 5% level. For the AL and GMT indexes see Notes to Table 5.

Figure 1: Debt Shares and Central Bank Independence