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Abstract

This paper develops an analytical framework to explore how financial sector characteristics shape domestic debt dynamics in emerging market economies. Our analysis suggests that the more competitive the banking sector and the more liquid and deeper the deposit market, the better would be the conditions in the public securities market. Our results also reveal that the lower the financial depth, the greater the scale of private sector credits that are crowded-out by public borrowing. To the extent that credit availability is associated with improved productivity and better output performance, the lack of financial depth in emerging market countries implies that extensive domestic borrowing in these countries may have consequences far beyond the concern with fiscal sustainability. As such, our results higlight the importance of developing domestic debt markets for financial and macroeconomic stability.

Key words: Financial sector; public debt; cost of borrowing.

JEL classification: E52, E63, H63

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1 Introduction

The past decade has been a challenging time for policy-makers in a large number of emerging market countries. Starting with the Tequila crisis in 1994, authorities in a group of Asian countries, Russia, Argentina, Turkey and Brazil were faced with collapsing currencies which were followed by financial crises with serious economy-wide consequences. Interestingly, currency collapses were also experienced by some industrial countries during the 1990s -most notably in Western Europe with the ERM (European exchange rate mechanism) crises in 1992 and 1993- where the recovery was fast and relatively painless. A closer look at these experiences highlights important differences in the institutional framework of financial systems in emerging market countries from those of the developed countries (see, for example, Bleaney, 2005). Indeed, there is now a broad consensus that the fragilities in the functioning of the banking and financial systems in emerging market countries have played a crucial role in turning these currency collapses into full-blown financial crises.

One common feature of the functioning of the financial system in emerging market countries is that, due to the underdeveloped nature of the bond and equity markets, financial intermediation is mostly carried out through the banking system. Although the significance of the banking sector has been declining over the last decade globally, it continues to form a significant part of the financial structure in many emerging market countries (see, for example, Abbas and Christensen, 2007 and Das, 2004). A a crucial aspect of banks' financial intermediation is related to their role as the major lenders to the government due to the lack of well developed domestic debt markets in these countries. For example, the ratio of domestic debt securities held by commercial banks was as high as 85.3 per cent in Turkey, 42.73 per cent in Thailand, 25.7 per cent in Hungary and 24.2 per cent in Israel in 2000.[1] It has been argued that these high exposures for national banking systems result from legal and institutional imperfections in these countries, which lead to substantial risks being associated with lending to the private sector (Kumhof and Tanner, 2005). Holding government securities in such environments is therefore a much safer investment option for banks, which results in banks being highly exposed to government debt and thus to macroeconomic shocks.

[1] These figures are compiled from respective country central bank and treasury web sources. When expressed as a ratio of the banks' total assets, net credit to government ratios around and above 50 per cent are commonly observed in a number of emerging market countries (Kumhof and Tanner, 2005).

Another empirical regularity faced by emerging market countries has been the volatility of international capital flows into and out of these countries, as was repeatedly experienced by countries that were hit by crises. External borrowing which is usually on a short-term basis, puts the authorities at the mercy of the markets as a change in sentiments can lead to either capital flowing out of the country or renewed borrowing at unfavorable terms. Given these uncertainties and costs in obtaining external funds it is clear that a properly functioning internal debt market is crucial for emerging market countries.[2] This is especially the case as the public finances in these countries are generally characterized by inefficient tax systems, difficulties with tax collection and insufficient tax bases. The resulting short-fall of tax revenues requires authorities to resort to domestic borrowing on a regular basis. Moreover, changes in macroeconomic policy-making structures during the 1990s -with increased emphasis on price stability and the resulting shift from monetizing deficits- has increased the importance and thus the size of the debt markets substantially in emerging market countries. The need to develop domestic securities markets has now been widely recognized by both the international financial institutions and national policy-makers. Such importance of the domestic debt markets for these countries, when combined with the banking sector's role in financial intermediation implies that the banking sector plays a major role in shaping the debt structure in emerging market countries.

Although the issues of foreign borrowing and the debt problems of developing countries have been analyzed extensively in the literature, the dynamics of domestic public debt have been a subject of investigation only very recently (see, for example, Jeanne and Guscina, 2006 and Hanson, 2007).[3] Moreover, we are not aware of any existing work, theoretical or empirical, analyzing the role of the financial sector in domestic debt dynamics.[4] Motivated by the importance and the relevance of the above mentioned issues and

[2] Hausler *et al* (2003) report that domestic bond issues by governments are thirteen times greater than foreign currency issues in emerging market countries. See, also Mihaljek *et al,* 2002.

[3] Two important exceptions are Edwards and Tabellini (1991) and Guidotti and Kumar (1991). The former studies the empirical determinants of inflation and fiscal deficits in developing countries while the latter analyzes the evolution of domestic debt and links between internal and external borrowing. In addition, in a recent paper, Claessen *et al* (2003) provide an empirical examination of the determinants of the size and the currency composition of government bonds for a sample of emerging market and industrialized countries.

[4] Similarly, the financial implications of fiscal policy have been only recently attracting attention in formal analyses (see, for example, Christensen, 2005 and Hauner, 2006).

the lack of work in this area, this paper attempts to provide an examination of the linkages between the financial sector and domestic borrowing.

In order to analyze this issue, we develop an analytical framework which integrates the profit maximizing motives of the financial sector in lending to government with the welfare maximizing policy-makers. This is done using a simple dynamic game theoretic model with three players; monetary and fiscal authorities and the financial sector. Interactions between the two macroeconomic policy-making authorities determine the stance of policy and thus the public sector borrowing requirement (PSBR) and the interactions between the fiscal authority and the financial sector determine the cost of that borrowing. Modelling the motives of the lender as well as the preferences of the borrower that issues the debt enables us to explore the determination of both the supply of and the demand for funds available for borrowing. Our framework allows us to derive a number of policy implications for countries that heavily rely on domestic debt where the terms of debt are greatly influenced by the characteristics of the financial sector. We argue that recent changes in macroeconomic policy-making institutions in the emerging market countries, which often involved the adoption of explicit or implicit inflation targets, have made it even more important to understand the dynamics of domestic debt markets. This is because a well-functioning domestic securities market reduces the need for monetary financing that is instrumental for successful implementation of any inflation targeting regime.

The remainder of the paper is structured as follows. Section 2 introduces the basic model. Section 3 presents the characterization of equilibrium and analyzes both the financial and institutional determinants of the cost of borrowing. The basic model is extended to incorporate the possibility of banks' lending to the non-public sector in Section 4. Section 5 concludes the paper.

2 The Basic Model

Policy makers' preferences

In order to analyze the interactions between the policy-making authorities and the financial sector we utilize a simple model of discretionary monetary and fiscal policy-making.[5] The model specifies a two-period game

[5] Similar variants of this model are used by Beetsma and Bovenberg (1999), Ozkan (2000) and Ismihan and Ozkan (2004). Unlike in our paper, however, the framework utilized by these studies excludes the financial sector.

with monetary and fiscal authorities and the banking sector. Now consider a policy-maker whose preferences can be summarized by the following loss function:

$$L_t^G = \frac{1}{2}\sum_{t=1}^{T=2} \beta_G^{t-1}[\delta_1 {\pi_t}^2 + (x_t - \overline{x}_t)^2 + \delta_2(g_t - \overline{g}_t)^2] \tag{1}$$

where L_t^G denotes the welfare losses incurred by the government, δ_1 and δ_2 represent, respectively, the government's relative dislikes for the deviations of inflation (π_t) and public spending as a share of output (g_t) from their target levels (0 and $\overline{g}_t$ respectively) relative to the deviations of output (x_t) from its target level ($\overline{x}_t$) and β_G is the government's discount factor.

Similarly, the preferences of the central bank (CB) can be described as:

$$L_t^{CB} = \frac{1}{2}\sum_{t=1}^{T=2} \beta_{CB}^{t-1}[\mu_1 {\pi_t}^2 + (x_t - \overline{x}_t)^2] \tag{2}$$

where L_t^{CB} denotes the welfare losses incurred by the *CB*, μ_1 is the *CB*'s inflation stability weight, β_{CB} is the *CB*'s discount factor. In addition, the *CB* is more conservative than the elected government; $\mu_1 > \delta_1$ and it does not discount the future at as a high rate as the elected government; $\beta_{CB} > \beta_G$. Since the *CB* does not have any target for public spending, no terms relating to g_t enter the *CB*'s loss function.

As is seen from equations (1) and (2) policy-makers' welfare losses increase in the deviations of inflation, output and public spending from their target levels (or 'bliss' points). As is standard, the target level of inflation is taken to be zero to indicate the desirability of price stability. A non-zero output target represents the bliss point for output in the absence of non-tax distortions, for example, due to labour or commodity market imperfections. The bliss point for public spending can be interpreted as the optimal share of non-distortionary output to be spent on public spending. Both weights μ_1, δ_1, δ_2 and the bliss points for output and public spending; $\overline{x}_t$ and $\overline{g}_t$ reflect the political and the institutional structure of the economy.

Output is given by the following production function: $Y_t = N_t^\gamma$, where Y_t and N_t represent output and labor respectively, in period t and $0 < \gamma < 1$. Distortionary taxes, which are the only form of taxes available to the government, are levied on output at the rate τ_t. A representative competitive firm's problem is to maximize profits $P_t(1 - \tau_t)N_t^\gamma - W_t N_t$, where P_t and W_t represent the price level and the wage rate respectively, in period t. A representative competitive firm chooses labor to maximize profits by taking P_t,W_t and τ_t as given. The resulting output supply function is $y_t = \alpha(p_t - w_t - \tau_t) + z$, where lower case letters represent logs, e.g. $y_t = ln(Y_t)$, $\alpha = \gamma/(1-\gamma)$, and $z = \alpha ln(\gamma)$.[6] Normalizing output by subtracting z from y_t, for simplicity and utilizing $w_t = p_t^e$ yields the following normalized output supply function:

$$x_t = \alpha(\pi_t - \pi_t^e - \tau_t) \tag{3}$$

where π_t^e is expected inflation and all other variables are as defined above.

Demand for funds

Government is in charge of fiscal policy-making while monetary policy decisions are taken by an independent *CB*. The budget constraint creates the link between the policies chosen by the *CB* and the fiscal authority. Public expenditures are financed by tax revenues, money creation and the debt issued by the government. The government, thus, faces the following budget constraint at time t:

$$g_t + (1 + r_{t-1})\, d_{t-1} = \tau_t + k\pi_t + d_t \tag{4}$$

where d_{t-1} denotes the amount of single-period debt issued (as a ratio of output) in period $t-1$ and to be re-paid in period t, r_{t-1} represents the rate at which it is borrowed, d_t is the new debt issue in period t and k is the real money holdings as share of output.[7] All other variables are as defined earlier.

[6] Note that $\ln(1-\tau) \simeq -\tau$.

[7] Equation (4) suggests that all debt is indexed. In the presence of non-indexed debt, surprise inflation would erode the real value of the government's obligations providing a further incentive for surprise inflation. We are excluding this possibility by focusing on indexed debt. One motivation for this is the increasing reliance on indexed debt instruments in emerging market countries where this incentive has been traditionally more important. For example, in 2001 the ratio of indexed bonds -including foreign currency denominated ones- in the total domestically issued government bonds was 90 per cent in Chile, 86 per cent in Turkey, 81 per cent in Brazil and 79 per cent in Mexico (see, for example, Borensztein *et al*, 2004).

It should be noted that, however, all our results under non-cooperative monetary and fiscal policymaking -as is maintained in our benchmark model- hold also in the presence of non-indexed debt.

It follows that the borrowing requirement, d_t would be determined by the preferences of the monetary and fiscal policy-makers as described above and the interactions between the two. In order to focus on the interactions between the financial sector and the government in determining the terms of domestic borrowing, we abstract from issues of capital inflows and foreign debt dynamics that are beyond the scope of this paper.

In what follows, we first treat d_t as the total demand for funds in this economy. This simplification is based on the experiences of a number of emerging market countries. For example, public sector bonds accounted for well over 80 per cent of the total domestic debt issued in Brazil, Mexico and Hungary and as much as 100 per cent in Turkey, Poland and Russia as of September 2000 (see, IBRD and IMF, 2001, p.3).[8]

Section 4 relaxes this assumption by extending the basic model to incorporate banks' lending to the private sector.

Supply of loanable funds

Now we turn to the determination of the supply of loanable funds available to the government. The importance of banks as dominant buyers of government paper in emerging market countries was discussed above. As explained, this is mainly due to the relatively underdeveloped nature of the financial markets in these countries, resulting in banks playing a major role in mobilizing savings for the use of governments. Stable interest income on government securities makes them attractive for banks that can use these securities to balance more volatile investments (see, IBRD and IMF, 2001). Given the dominance of banks as investors in government securities, in what follows the banking sector is taken to be the main lender.

Consider a financial sector that is composed of n banks. Banks compete with each other both in collecting deposits and in lending the collected funds. In the deposit market, the relationship between the deposit rate offered by bank i and the supply of deposits facing the bank is summarized by the following:

$$z_t^i = \frac{1}{n}(A + \eta r_t^{z_i}) + \omega \sum_{j=1, j\neq i}^{n} (r_t^{zi} - r_t^{zj}) \tag{5}$$

where z_t^i is the deposit supply facing bank i, r_t^{zi} is the deposit rate offered by bank i and A and η are constants characterizing the structure of the deposit market.

[8] Moreover, Hauner (2006) reports that the share of bank credit absorbed by the public sector in emerging market countries has been rising rapidly over the last decade.

The profit function of bank i can now be written as:

$$V_t^{Bi} = r_t b_t^i - r_t^{z_i} z_t^i - \frac{c}{2}\left(b_t^i - \phi z_t^i\right)^2 \tag{6}$$

where V_t^{Bi} is bank i's profit function at time t, b_t^i is the bank i's bond holdings of government securities, r_t is the rate of interest on these securities and c is the cost associated with illiquidity.[9] These costs are assumed to increase at an increasing rate as illiquidity increases. One explanation for this is that, as a result of illiquidity, banks may have to borrow from the central bank's discount window which may prove increasingly costly. Given the dominance of government debt in total securities traded in emerging markets, lending to the government through the purchase of bonds is treated as the only form of lending for the banks (this assumption is relaxed in Section 4). The maximum that a bank can lend is then the difference between the amount of deposits that it collects and the amount that it needs to hold as required reserves. This ratio is captured by ϕ in equation (6).[10]

In addition to deciding on the deposit rate, r_t^i, the representative bank also chooses how much to lend to the government, b_t^i, which determines the demand for bonds. This will clearly depend upon the return on government bonds as well as on the reserves requirement ratio and the cost of illiquidity.

3 Characterization of Equilibrium

3.1 Solution in t=2

Once the second period of this game is reached, the equilibrium values of inflation, taxes, government expenditures and public debt issued in t=1 are known to all agents. In t=2 the fiscal authority pays back the amount borrowed in t=1, and therefore, the banking sector does not have an explicit role to play in t=2. As a result, the strategic decision making in this period involves only two players.

In t=2 the *CB* chooses inflation to minimize the losses in:

$$L_2^{CB} = \frac{1}{2}\left[\mu_1 \pi_2^2 + (x_2 - \overline{x}_2)^2\right] \tag{7}$$

[9] See, Cukierman (1991).

[10] This suggests that the reserve requirement ratio can be expressed as $(1-\phi)$.

Similarly, the government chooses the tax rate and public spending to minimize:

$$L_2^G = \frac{1}{2}\left[\delta_1\pi_2^2 + (x_2 - \overline{x}_2)^2 + \delta_2(g_2 - \overline{g}_2)^2\right] \tag{8}$$

The government budget constraint in $t = 2$ is given by:

$$g_2 + (1 + r_1)\, d_1 = \tau_2 + k\pi_2 \tag{9}$$

where d_1 is the debt issued in period $t = 1$ that should be paid back in period $t = 2$, r_1 is the *ex ante* real interest rate.[11] Equation (9) suggests that resources required to pay for public outlays -current spending and the debt service- come from taxes and seigniorage in $t = 2$.

The government and the *CB* choose their choice variables simultaneously, leading to a Nash equilibrium. The resulting inflation in t=2 is given by

$$\pi_2 = (\delta_2\widetilde{\lambda}/\mu_1)(\overline{x}_2/\alpha + \overline{g}_2 + (1 + r_1)d_1) \tag{10}$$

where $\widetilde{\lambda} = 1/(1 + \widetilde{\varphi})$, and $\widetilde{\varphi} = \frac{\delta_2}{\alpha^2} + \frac{k\delta_2}{\mu_1}$.

Clearly, non-zero levels of both output and public spending targets form part of the inflationary bias. The higher are these targets the higher is current inflation. In addition, a rise in public borrowing in the previous period leads to higher inflation.

Similarly, equilibrium levels of taxes and public expenditure in $t = 2$ are given by:

$$\tau_2 = (\delta_2\widetilde{\lambda}/\alpha^2)[\overline{g}_2 + (1 + r_1)d_1] + ((\delta_2\widetilde{\lambda}/\alpha^2) - 1)\overline{x}_2/\alpha \tag{11}$$

and

$$g_2 = \widetilde{\lambda}(\widetilde{\varphi}\overline{g}_2 - (1 + r_1)d_1 - \overline{x}_2/\alpha) \tag{12}$$

As is clear from (11) and (12), a rise in debt re-payments requires higher taxation whilst restricting the policy-makers' ability to expand other spending, thus requiring a fall in public spending in equilibrium.

[11] While seigniorage revenues, $k\pi_t$ tend to be negligible in industrial economies, emerging market countries with less developed financial systems routinely resort to seigniorage as a source of revenue (see, for example, IMF, 2001).

3.2 Solution in t=1

In period $t = 1$ the banking sector chooses the amount of government bonds to hold and, therefore, directly influences the strategic choices facing the government. The fiscal authority now makes three decisions; how much to spend, how much to tax and how much to borrow. Since taxes are distortionary higher current borrowing enables the policy-maker to lower current taxes, which leads to lower distortions now but at the expense of higher distortions in the next period and *vice versa*.

Demand for borrowing

As in $t = 2$, government and the independent *CB* play a Nash game in $t = 1$. *CB* chooses π_1 to minimize $\frac{1}{2}[\mu_1\pi_1^2 + (x_1 - \overline{x}_1)^2]$. The government chooses τ_1, g_1 and d_1 to minimize its intertemporal loss function as given in (1). Formally, by substituting the equilibrium values from $t = 2$ and output supply function into the intertemporal loss function in $t = 1$, the government's loss minimization in $t = 1$ can be written as follows:

$$\begin{aligned} L_1^G &= \frac{1}{2}[\delta_1\pi_1^2 + (\alpha(\pi_1 - \pi_1^e - \tau_1) - \overline{x}_1)^2 + \delta_2(g_1 - \overline{g}_1)^2] + \beta_G(\delta_2/2)\widetilde{D} \\ & (\overline{x}_2/\alpha + \overline{g}_2 + (1 + r_1)d_1)^2 + \lambda_1(g_1 - \tau_1 - k\pi_1 - d_1) \end{aligned} \tag{13}$$

where λ_1 is the Lagrange multiplier and $\widetilde{D} = (\frac{\delta_2}{\alpha^2} + \frac{\delta_2\delta_1}{\mu_1^2} + 1)\widetilde{\lambda}^2$.

Differentiating (13) w.r. to the choice variables, imposing the rational expectations condition and then combining the first order conditions from the *CB*'s and the government's loss minimization problems and re-arranging yields the borrowing requirement in $t = 1$:

$$d_1 = \Phi[\overline{g}_1 - \digamma\overline{g}_2 + \frac{1}{\alpha}\overline{x}_1 - \frac{\digamma}{\alpha}\overline{x}_2 + (1 + r_0)d_0] \tag{14}$$

where $\Phi = \frac{1}{1+(1+r_1)\digamma}$, $\digamma = (1+\widetilde{\varphi})\widetilde{D}^*$ and $\widetilde{D}^* = (1+r_1)\beta_{FA}\widetilde{D}$. Appendix *A* provides the details of this derivation and lists the equilibrium values of other variables in $t = 1$.

As is seen from (14), the demand for borrowing (the supply of bonds) is defined in terms of the borrowing rate, r_1, as well as the spending and output targets and the scale of initial borrowing.

Supply of lending

The supply of lending to the government (demand for bonds), on the other hand, is determined as an outcome of each bank's own profit maximizing actions. In $t = 1$ bank i's profit function takes the following form:

$$V_1^{Bi} = r_1 b_1^i - r_1^{zi} z_1^i - \frac{c}{2}\left(b_1^i - \phi z_1^i\right)^2 \tag{15}$$

where b_1^i is the amount that bank i is willing to hold as bonds, i.e. the amount that it is willing to lend to the government in t=1. Taking the bond rate and the deposit rate offered by all other banks as given, bank i chooses its own deposit rate and the amount of bond holdings to maximize profits.

The relevant first order conditions are:

$$-\tfrac{1}{n}\left(A + 2\eta r_1^{zi}\right) - \omega\left(n-1\right) r_1^{zi} - \omega \sum_{j=1, j\neq i}^{n} (r_1^{zi} - r_1^{zj}) +$$

$$c\left[\phi\left(\frac{\eta}{n} + \omega\left(n-1\right)\right)\left[b_1^i - \phi\left(\frac{\left(A + \eta r_1^{zi}\right)}{n} + \omega \sum_{j=1, j\neq i}^{n} (r_1^{zi} - r_1^{zj})\right)\right]\right] = 0 \tag{16}$$

and

$$r_1 - c\left[b_1^i - \phi\left[\frac{\left(A + \eta r_1^{zi}\right)}{n} + \omega \sum_{j=1, j\neq i}^{n} (r_1^{zi} - r_1^{zj})\right]\right] = 0 \tag{17}$$

Equations (16) and (17) suggest that bank i's choice of the deposit rate, r_1^{zi} and the scale of its lending to the government, b_1^i, depend upon the actions of other banks. It follows that in equilibrium:

$$r_1^{zi} = r_1^{zj} \text{ and } b_1^i = b_1^j \text{ for all } j. \tag{18}$$

Substituting (18) into the FOCs and re-arranging yields the following demand for bonds on the part of bank i

$$b_1^i = \frac{[(c\eta^2 + c\eta n_1)\phi^2 + nn_1 + 2n\eta]r_1 + (\eta + n_1)cA\phi}{cn(n_1 + 2\eta)} \tag{19}$$

where $n_1 = \omega(n-1)n$.

The expression for b_1^i in (19) is bank i's demand for bond holdings in terms of the bond rate, r_1. As expected, this is an increasing function of the bond rate, $\partial b_1^i / \partial r_1 > 0$ for $n > 1$. Clearly, this relationship is shaped by the number of banks operating in the financial system, n, the scale of the costs of illiquidity, c and the determinants of the deposit supply, A and η as well as the reserve requirements, $(1-\phi)$.

3.3 Determination of the Cost of Borrowing

Let us now turn to the determination of the bond rate, r_1 by combining the banks' total demand for bonds, $b_1 = nb_1^i$, with the government's demand for borrowing (supply of bonds), d_1. The bond rate adjusts till the demand for bonds, b_1 is exactly matched by its supply d_1, thereby eliminating any excess demand for borrowing and thus any excess supply of bonds. More formally, in equilibrium

$$E_1^d(r_1) = d_1(r_1) - b_1(r_1) = 0 \tag{20}$$

where $E_1^d(r_1)$ denotes excess demand for borrowing expressed in terms of the bond rate and $d_1(r_1)$ and $b_1(r_1)$, are, respectively the demand for borrowing (supply of bonds) and the demand for bonds. As presented above, $d_1(r_1)$ is also a function of a number of political and institutional factors while $b_1(r_1)$ is a function of financial characteristics of the banking sector.

Utilizing (14) and (19) from above, representing $d_1(r_1)$ and $b_1(r_1)$ respectively, (20) can now be expressed as

$$E_1^d(r_1) = \Phi[\overline{g}_1 - F\overline{g}_2 + \tfrac{1}{\alpha}\overline{x}_1 - \tfrac{F}{\alpha}\overline{x}_2 + (1+r_0)d_0] - \\ \frac{[(c\eta^2 + c\eta n_1)\phi^2 + nn_1 + 2n\eta]r_1 + (\eta + n_1)cA\phi}{c(n_1 + 2\eta)} = 0 \tag{21}$$

Solving (21) for r_1 yields the equilibrium bond rate (the details of solving (21) for r_1 is presented in Appendix B).

The following section analyzes the determinants of the equilibrium bond rate which we interpret as the cost of public borrowing.

3.3.1 The Role of the Financial Characteristics of the Banking Sector

Competition in the banking sector

As discussed above, the banking sector's predominant role in the government securities market is a main source of financial fragility in emerging market countries. It is, therefore, not surprising that a commonly proposed policy measure to develop domestic capital markets in these countries has been the enhancement of the investor base to deepen the demand for (all) securities. The same reasoning also applies to the structure of competition in the banking sector when it is the only or the dominant source of demand for government securities. More specifically, having a greater number of banks would reduce the pressure in the securities market by extending the supply of credits. This argument can be formalized as follows.

Result 1. The greater the competition in the banking sector, that is the greater is n, the lower the cost of public borrowing.

Proof 1. Differentiating b_1 w.r.to n yields, $\frac{\partial b_1}{\partial n} = [(2n-1)(c\phi A\omega\eta + c\phi^2\eta^2\omega r_1) + (n-2)\, n^3\omega^2 r_1 + r_1 n^2\omega^2 + 4r_1\eta^2 + 4r_1\eta n_1]/[c(n_1+2\eta)^2]$. Given that $n \geqq 2$ and b_1^i, c, ϕ , A and r_1 are all non-negative, it follows that $\frac{\partial b_1}{\partial n} > 0$. Since $\frac{\partial r_1}{\partial E_1^d} > 0$ and $\frac{\partial E_1^d}{\partial b_1} < 0$, it is straightforward to establish that $\frac{\partial r_1}{\partial n} < 0$.

Recent research suggests that one way to increase competition in the banking sector is through foreign bank participation. There has been a substantial increase in the level of foreign bank control in most emerging market countries and a resulting rise in competitive pressures in their banking sectors during the 1990s (Gelos and Roldos, 2004).

Features of the deposit market

The previous section discussed the effect of extending the investor base on the functioning of the domestic securities market. One important source of this demand for securities is obviously the depth of liquidity banks face in the deposit market. It therefore follows that the deeper a country's deposit base, the better able are its banks in channelling resources towards meeting the public sector's borrowing requirements. It might usefully be noted here that in emerging markets during the 1990s, there were sharp rises in government bond issues the same time as significant increases in bank deposits.[12,13]

Utilizing our framework, this link between deposit market and the terms of borrowing can be established as follows.

Result 2. The deeper the deposit market, that is the higher is A and/or η, the lower the cost of public borrowing.

Proof 2. The derivative of b_1 w.r.to A is $\frac{\partial b_1}{\partial A} = \frac{\phi(\eta+n_1)}{(n_1+2\eta)}$. Given that $(n-1) > 0$ and all other parameters are non-negative, $\frac{\partial b_1}{\partial A} > 0$. Thus, similar to under *Proof* 1, it can be established that $\frac{\partial r_1}{\partial A} < 0$ since $\frac{\partial b_1}{\partial A} > 0$ and $\frac{\partial r_1}{\partial b_1} < 0$. Likewise, the derivative of b_1 w.r.to η is $\frac{\partial b_1}{\partial \eta} = \phi[(n-2)\, r_1\phi\omega^2 n^3 + 2r_1\phi\eta n_1 + r_1\phi\omega^2 n^2 + 2r_1\phi\eta^2 + (n-n^2)A\omega]/(n_1+2\eta)^2$. It can then be established that $\frac{\partial b_1}{\partial \eta} > 0$ for $n \geqq 2$ and $(n-2)\, r_1\phi\omega^2 n^3 + 2r_1\phi\eta n_1 + r_1\phi\omega^2 n^2 + 2r_1\phi\eta^2 > An_1$.

Costs of illiquidity

Another factor that is likely to impact upon the availability of funds in the banking sector is the cost of illiquidity. Clearly, the higher the cost of obtaining funds, the lower would be the bank's demand for holding government securities. This relationship between the cost of illiquidity and demand for government bonds may be especially strong during financial crises when obtaining liquidity is particularly difficult and/or costly.[14]

By utilizing the above proposed model, this relationship can be stated more formally as follows.

Result 3. The greater the cost of illiquidity, the lower the demand for government bonds and, therefore, the higher the terms of borrowing for the government.

Proof 3. The derivative of b_1 w.r.to c is $\frac{\partial b_1}{\partial c} = \frac{-r_1 n}{c^2}$. Clearly, $\frac{\partial b_1}{\partial c}$ is unambiguously negative given that both n and c are non-negative parameters. Thus $\frac{\partial r_1}{\partial b_1} < 0$ establishes that $\frac{\partial r_1}{\partial c} > 0$.

[12] Hanson (2003) reports that bank deposits as a percentage of GDP rose from an average of 35 per cent in 1990 to above 50 per cent in 2000 in emerging market countries.

[13] Indeed, Claessen *et al* (2003) use the ratio of the total deposit base over nominal GDP as a proxy for the demand for government bonds in investigating the size and currency composition of government bonds in a sample of both developed and developing countries.

[14] For example, during the financial crisis in Turkey in 2000, the severe liquidity squeeze in the banking sector resulted in interest rates on a 12-month government bond jumping to nearly 82 per cent in December 2000 from just over 32 per cent in July 2000.

Reserve requirements

In some countries banks are regularly subjected to reserve requirements that are used as a monetary policy tool. Given the importance of banking system's characteristics for the functioning of the domestic securities market in emerging market economies, changes in the reserve ratio would clearly impact upon the borrowing conditions. More specifically, the greater the reserve requirements, the smaller the pool of funds available for government borrowing, thus the less favourable would be the terms of borrowing. *Result* 4 below formalizes this relationship.[15]

Result 4. The higher the reserve requirement, the greater is $(1-\phi)$, *the higher the cost of public borrowing.*

Proof 4. Differentiating b_1 w.r.to ϕ yields $\frac{\partial b_1}{\partial \phi} = (\eta + n_1)(A + 2\phi\eta r_1)/(n_1 + 2\eta)$, which is non-negative. Thus, this result when combined with $\frac{\partial r_1}{\partial \phi} < 0$ suggests that $\frac{\partial r_1}{\partial (1-\phi)} > 0$.

3.3.2 The Role of Macroeconomic and Institutional Factors

We now turn to the demand for borrowing and analyze the role of macroeconomic and institutional factors on the bond rate working through the demand side.

The initial level of indebtedness

It is widely recognized that fiscal discipline is a pre-condition for financial stability. In countries where there is a long history of lax fiscal stance resulting in high levels of existing government liabilities, further borrowing is highly likely to be at unfavourable terms. Indeed, the existence of high domestic debt levels is commonly viewed as an important early warning signal for financial crises (see, for example, Kaminsky *et al,* 1998).

The framework we developed above clearly highlights the link between the extent of existing public indebtedness and the terms of newly issued securities.

[15] Note that this is based on the assumption that government securities cannot be used to meet reserve requirements. However, there are provisions in some countries that allow the use of these securities as part of the regulatory reserve requirements. Clearly, when that is the case, a rise in these requirements would encourage greater holdings of government securities thereby improving the terms of borrowing for governments.

Result 5. The higher the initial scale of public debt, d_0, the higher the cost of current public borrowing, r_1.

Proof 5. The derivative of d_1 with respect to d_0 is $(1+r_0)\Phi$. Given that both r_0 and Φ (see above) are positive it can easily be verified that $\frac{\partial r_1}{\partial d_0} > 0$ given $\frac{\partial r_1}{\partial d_1} > 0$.

Policy-maker's time preference and political instability

An important aspect of policy-making structure is related to the government's time preference. Policy-makers who discount future heavily would be less concerned about the distortionary effects of servicing the debt in future and would thus resort to borrowing more often. This would, in turn, have an unfavourable impact on the terms of borrowing, leading to higher interest rates. Conversely, a high discount factor implies greater importance being attached future, characterizing a government more concerned about the implications of current borrowing on future distortions. The resulting lower borrowing would lower the rates at which such borrowing is secured. These arguments are formalized in the following.

Result 6. The lower the incumbent government's subjective discount factor, β_{FA}, the higher the equilibrium cost of public borrowing.

Proof 6. The derivative of d_1 with respect to β_{FA} is $-\frac{F}{\beta_{FA}}\Phi^2[(\overline{g}_2 + \frac{1}{\alpha}\overline{x}_2) + (1+r_1)(\overline{g}_1 + \frac{1}{\alpha}\overline{x}_1 + (1+r_0)d_0)]$. Given that all parameters in this expression are positive this derivative is unambiguously negative. It, therefore, straightforwardly follows that $\frac{\partial r_1}{\partial \beta_{FA}} < 0$.

Such a link between the time preference of the policy-maker and the terms of its borrowing suggests that political instability, which is prevalent in many of the less developed and emerging market economies, may have important implications for the dynamics of public borrowing in these countries. Greater political instability prepares the ground for more 'impatient' policy-makers who would be reluctant to raise taxes that would increase the current distortions, making them more likely to resort to additional borrowing with unfavourable consequences for the terms of borrowing.[16]

[16] See, Edwards and Tabellini (1991) for formal empirical evidence on the link between political instability and public finances in developing countries.

The independence and the conservativeness of the central bank

In the model analyzed above the *CB* operates independently of the political authority. While this may be a good representation of policy-making in, for example, Eurozone countries or the US, where *CB*s have a considerable degree of independence from the political authorities, this is not the case in many emerging market countries notwithstanding the recent moves towards more independent monetary policy-making in these countries. Rogoff (2003) shows that although *CB* institutions and independence universally improved during the last decade, industrial countries still dominate emerging market ones on both fronts. This suggests that other policy-making arrangements where the government has a more dominant role in the determination of both monetary and fiscal instruments may still be relevant for some developing countries.

In order to assess the role of *CB* independence on the cost of domestic borrowing, equilibrium debt levels under an independent central banking arrangement- as was analyzed above- and under the centralized framework where a government chooses both monetary and fiscal instruments should be compared. These are provided, respectively, by (22) and (23)

$$d_1^{CCB} = \Phi[\overline{g}_1 - \digamma \overline{g}_2 + \frac{1}{\alpha}\overline{x}_1 - \frac{\digamma}{\alpha}\overline{x}_2 + (1+r_0)d_0] \tag{22}$$

$$d_1^{G} = \Phi^*[\overline{g}_1 - \digamma^* \overline{g}_2 + \frac{1}{\alpha}\overline{x}_1 - \frac{\digamma^*}{\alpha}\overline{x}_2 + (1+r_0)d_0] \tag{23}$$

where d_1^{CCB} and d_1^G denote, respectively, the equilibrium borrowing under an independent and conservative *CB* and under the centralized outcome where G is used to denote the government. Also, $\Phi^* = \frac{1}{1+(1+r_1)\digamma^*}, \digamma^* =$

$(1+\widetilde{\varphi}^*)\widehat{D}^*, \widehat{D}^* = (1+r_1)\beta_{FA}\widehat{D}, \widehat{D} = \widetilde{\lambda}^* + \frac{(k+1)\delta_2}{\delta_1}\widetilde{\lambda}^{*2}, \widetilde{\lambda}^* = \frac{1}{(1+\widetilde{\varphi}^*)}$ and $\widetilde{\varphi}^* = \frac{\delta_2}{\alpha^2} + \frac{(k^2+k)\delta_2}{\delta_1}$.

Result 7. Delegating monetary policy-making powers to an independent and conservative CB leads to a higher public debt in equilibrium, $d_1^{CCB} > d_1^G$*, and therefore raises the cost of borrowing,* $r_1^{CCB} > r_1^G$.

Proof 7. For d_1^{CCB} to be greater than d_1^G, both $\Phi > \Phi^*$ and $\Phi\digamma < \Phi^*\digamma^*$ should hold. The requirement for both of these conditions is for μ_1 to be greater than $\frac{\delta_1}{k+1}$. Given that the *CB* is more conservative than the elected government, $\mu_1 > \delta_1$, and k, money holdings as a ratio of output is positive, $k > 0$, this condition is guaranteed and thus $d_1^{CCB} > d_1^G$. Since $\partial r_1/\partial d_1 > 0$, it can easily be established that $r_1^{CCB} > r_1^G$.

The above result follows from the fact that delegating monetary policy-making to an independent *CB* lowers inflation in $t = 1$. This, in turn, reduces the seigniorage revenues and therefore induces a rise in public borrowing as an alternative source of finance in $t = 1$, with unfavorable implications for the cost of borrowing, r_1. Such a link between lower inflation and higher public borrowing would obviously be stronger in emerging market countries where seigniorage revenues are still an important source of revenue (see, for example, IMF, 2001).

Result 7 can also be extended to the effect of the *CB*'s conservativeness, μ. Verifying *Result* 7 above suggested that the greater μ, the greater the difference between the scale of borrowing under an independent *CB* and the centralized outcome. This is because a more conservative *CB* -one with greater inflation aversion- achieves a lower inflation in equilibrium, thereby creating a larger gap to be financed. The resulting higher borrowing requirement, in turn, raises the cost of borrowing.

This result is in line with recent findings that granting independence to central banks alone is not sufficient to alleviate the credibility problem facing the policy-makers. In economies where there are on-going structural distortions -whether due to labour markets or tax systems- all central bank independence achieves is shifting the burden of revenue raising from inflation to other sources such as taxation or borrowing.

It must be noted, however, that there are other channels through which *CB* independence may have a favourable impact on domestic debt markets. For instance, a successfully functioning independent *CB* enhances the overall credibility of macroeconomic policies and may thereby induce a greater interest in government securities. The nature of the actual link between *CB* independence and the borrowing conditions is ultimately an empirical question and would depend upon which effect dominates in practice.

4 The Extended Model: Impact on the Private Sector Credit

The framework developed above has so far maintained that the banking sector can only invest in government bonds. Although this simplification helps to highlight the interactions between government policy and the financial sector, it ignores the possibility of a financial crowding-out where government borrowing replaces private borrowing in the banking sector's loan portfolios. Given the lack of financial depth in emerging market and other developing countries crowding-out remains to be relevant for these economies with potentially serious economy-wide consequences (see, for example, Caballero and Krishnamurthy, 2004 and Christensen, 2005).[17]

In order to analyze the role of public borrowing on the availability of credit to private sector and the macroeconomic implications of this relationship, this section extends the above developed model by allowing the possibility of banks' lending to the private sector.

4.1 Financial crowding-out

The banking industry now competes both for the sources of funds and for borrowers. The demand function for loans facing bank i is given by

$$l_t^i = \frac{1}{n}(A_l - \varepsilon r_t^{li}) - \psi \sum_{j=1, j \neq i}^{n} (r_t^{li} - r_t^{lj}) \tag{24}$$

where l_t^i denote the private sector demand for borrowing from bank i, r_t^{li} is the loan rate charged by bank i, r_t^{lj} is the vector of loan rates charged by all other banks and A_l, ε and ψ are all positive parameters that relate to the structure of the credit market.

Bank i's profit function can now be represented by

$$V_t^{Bi} = r_t^{li} l_t^i + r_t b_t^i - r_t^{z_i} z_t^i - \frac{c}{2}\left(l_t^i + b_t^i - \phi z_t^i\right)^2 \tag{25}$$

where all variables are as defined earlier.

Bank i now chooses the deposit rate; $r_t^{z_i}$, the loan rate; r_t^{li} and the demand for public sector bonds; b_t^i to maximize its profits in (24).

Differentiating (24) w.r.to $r_t^{z_i}, r_t^{li}$ and b_t^i (in $t = 1$), re-arranging the relevant first order conditions and imposing $r_1^{zi} = r_1^{zj}$ and $r_1^{li} = r_1^{lj}$ yield the following equilibrium values for b_1^i, r_1^{li} and r_1^{zi} :

[17] The term 'financial depth' refers to the total supply of funds available in an economy (see, for example, Caballero and Krishnamurthy, 2004).

$$b_1^i = \frac{(\eta+n_1)\phi}{n(n_1+2\eta)}A - \frac{(\varepsilon+n_2)}{n(n_2+2\varepsilon)}A_l + [\frac{[(c\eta^2+c\eta n_1)\phi^2+nn_1+2n\eta]}{cn(n_1+2\eta)} + \frac{(\varepsilon+n_2)\varepsilon}{n(n_2+2\varepsilon)}]r_1 \quad (26)$$

$$r_1^{li} = \frac{A_l}{(n_2+2\varepsilon)} + \frac{(\varepsilon+n_2)}{(n_2+2\varepsilon)}r_1 \quad (27)$$

$$r_1^{zi} = -\frac{A}{(n_1+2\eta)} + \frac{(n_1+\eta)\phi}{(n_1+2\eta)}r_1 \quad (28)$$

where $n_1 = \omega(n-1)n$ and $n_2 = \psi(n-1)n$.

By imposing $r_1^{li} = r_1^{lj} = r_1^l$ in (24) and utilizing the relation $l_1^T = n\ l_1^i$ we can establish that the total bank credits to the private sector amounts to $l_1^T = A_l - \varepsilon r_1^l$.

Result 8. A rise in public sector borrowing from the banking sector reduces the scope of bank lending to the private sector. Moreover, the lower the financial depth, the greater the crowding-out.

Proof 8. It is straightforward to establish that a rise in d_1 reduces the total bank credits to the private sector, l_1^T since both $\partial r_1^l/\partial r_1 = \frac{\varepsilon+n_2}{n_2+2\varepsilon}$ and $\partial r_1/\partial d_1$ are unambiguously positive and $\partial l_1^T/\partial r_1^l = -\varepsilon$ is unambiguously negative; thus $\partial l_1^T/\partial d_1 < 0$.

Given that advanced and emerging economies differ in their financial depth which is lower in the latter, the size of the crowding-out tends to be greater in emerging market countries. Clearly, in economies with lower financial depth, a given rise in public borrowing leads to a greater rise in interest rates, that is both $\partial r_1/\partial d_1$ and $\partial r_1^l/\partial d_1$ are greater in size. It, therefore, straightforwardly follows that the fall in private sector lending will be greater in such economies.[18]

[18] Indeed, Caballero and Krishnamurthy (2004) have shown that crowding-out is systematically larger in emerging market countries. Christensen (2005) also provides support for the significant size of crowding out in less developed countries.

4.2 Implications of credit availability

Having established the existence of financial crowding-out, we now turn to its implications. The notion that credit availability impacts upon real economic activity has long been recognized.[19] One channel through which the availability of credit affects the functioning of an economy is through its impact on productivity. Existing evidence suggests that there is a strong relationship between productivity growth and the share of total domestic credit received by the private sector (see, for example, King and Levine, 1993). Our model developed above provides a suitable framework to establish this link between supply of credits, productivity and real activity. In what follows, therefore, we modify our benchmark model to explore the implications of variations in credit availability and thus of crowding-out generated by a rise in public borrowing.

Now consider the following form of the production function: $Y_t = \widehat{A}_t N_t^{\gamma}$, where $\widehat{A}_t$ represents the level of productivity in period t. The representative competitive firm's problem is to maximize profits $P_t(1-\tau_t)\widehat{A}_t N_t^{\gamma} - W_t N_t$, as above. The representative firm chooses labor to maximize profits by taking P_t,W_t and τ_t as given. The resulting output supply function is $y_t = \alpha(p_t + \frac{1}{\gamma}\widehat{a}_t - w_t - \tau_t) + z$, where, as above, lower case letters represent logs.

Given the productivity enhancing role of credit provision, $\widehat{a}_t$ could be written as follows:

$$\widehat{a}_t = \widehat{a}_0 + \upsilon l_t^T \tag{29}$$

where l_t^T is the level of total bank credits to the private sector as defined earlier, $\widehat{a}_0$ is a constant and positive productivity parameter and $\upsilon > 0$.

Substituting $\widehat{a}_t$ into the modified output supply function, normalizing output by subtracting the constant term $z' = z + \alpha\widehat{a}_0/\gamma$ for simplicity yields the following modified output supply function:

$$x_t^C = \alpha(\pi_t - \pi_t^e - \tau_t + \kappa l_t^T) \tag{30}$$

where x_t^C denote output supply in the presence of the credit availability effect and $\kappa = \frac{\upsilon}{\gamma}$.Superscript C is used for values in the presence of credits to the private sector.

The relationship between credit availability to the private sector and the macroeconomic performance is formalized by Result 9 (Appendix C lists the

[19] See, Calomiris and Hubbard (1989), for example, for evidence from the US.

modified macroeconomic outcome in the presence of credits to the private sector).

Result 9. A fall in credit availability to the private sector is associated with a worse economic outcome in terms of higher inflation and lower output both in current and future periods.

Proof 9. It is straightforward to show $\partial\pi_1/\partial l_1^T = -\kappa(1+r_1)\frac{\delta_2}{\mu_1}\widetilde{D}^*\Phi$ and $\partial\pi_2/\partial l_1^T = -\kappa(1+r_1)\frac{\delta_2}{\mu_1}\widetilde{\lambda}\Phi$ are both unambiguously negative and $\partial x_1^C/\partial l_1^T = \kappa(1+r_1)\frac{\delta_2}{\alpha}\widetilde{D}^*\Phi$ and $\partial x_2^C/\partial l_1^T = \kappa(1+r_1)\frac{\delta_2}{\alpha}\widetilde{\lambda}\Phi$ are both unambiguously positive.

An important question regarding the modified version of the model that needs to be addressed here is whether our earlier results, Results 1-7, remain valid in the presence of bank lending to the private sector and the favourable effects of credit availability on output supply. Characterizing the equilibrium as in Section 2 by utilizing the extended model suggest that Results 2-7 continue to hold as before. Result 1, establishing the relationship between the competition in the banking sector and the terms of borrowing now holds for sufficiently low characterization of credit demand by the private sector. Intuitively, otherwise a rise in the number of banks do not necessarily translate into greater demand for government securities.[20,21]

Regarding the impact of *CB* independence on the scale and the terms of public borrowing, as established by Result 7 above, bank lending to the private sector in fact reinforces the earlier finding of an unfavourable impact of *CB* independence. This is because, a given rise in the borrowing requirement under an independent *CB* reduces the availability of private sector credits and thus equilibrium output in this case. The fall in output, in turn, induces the government to cut back on taxes which would partly be financed through further borrowing. When combined with the direct impact of *CB* independence on the borrowing requirement, this indirect effect would raise the cost of borrowing even further.

5 Conclusions

This paper has developed a theoretical framework to analyze the role of the banking sector on domestic debt dynamics in emerging market countries

[20] Formally, $\frac{\partial b_1}{\partial n} > 0$ for all $A_l < A_l^*$ where $A_l^* = \Omega\phi\omega(A\eta+\phi\eta^2 r_1)+[\frac{\Omega}{c(2n-1)}(((n-2)\,n+1)n^2\omega^2+(\eta+n_1)4\eta)+\varepsilon]r_1$, where $\Omega = \frac{(n_2+2\varepsilon)^2}{\psi\varepsilon(n_1+2\eta)^2}$.

[21] Due to space limitations, the full set of results in the extended version of the model are not provided in the paper. All results are available from the authors upon request.

where banks are dominant intermediaries in the government securities market. This is done by explicitly incorporating the profit maximizing behaviour of the banking sector into a game-theoretic macroeconomic policy-making model. This framework is then utilized to examine the determinants of the terms of public borrowing. Combining the features of the financial sector with the policy–making structure enables us to provide a fuller account of the cost of domestic borrowing especially in emerging market countries.

Our analysis provides a set of interesting results. We show that the cost of domestic borrowing is determined by the financial characteristics of the banking sector as well as by macroeconomic and institutional factors. More specifically, our analysis reveals that the more competitive the banking sector and the more liquid and deeper the deposit market, the better would be the conditions in the public securities market. Our results also suggest that the lower the financial depth, the greater the public borrowing's crowding-out of lending to the private sector. To the extent that credits to the private sector are associated with improved productivity and better output performance, the lack of financial depth in emerging market countries implies that extensive domestic borrowing in these countries may have consequences far beyond the concern with fiscal sustainability.

In addition to the features of the financial sector, macroeconomic and institutional factors play a crucial role in the dynamics of domestic borrowing. Our analysis indicates that countries with high levels of existing debt are more likely to face unfavorable terms in issuing new borrowing. We have also shown that where political instability is an inherent part of the policy-making environment there is likely to be a bias towards debt accumulation with potentially serious consequences for the cost of borrowing. More interestingly, we show that the greater the independence and the conservativeness of the central bank the greater the pressure on the terms of government securities.

A general policy implication of our work is that it is essential to develop domestic debt markets, a proposition often voiced in the aftermath financial and especially currency crises. For example, in the wake of crises in East Asia and Russia one policy measure regularly put forward was the improvement and enhancement of internal debt markets in the crisis-prone countries. Our analysis reinforces this view by suggesting that developing domestic debt markets would not only provide potentially less volatile alternative to external borrowing but would also improve the fiscal environment in which policy-makers operate, with beneficial economy-wide consequences.

One potential extension of our framework would be the consideration of foreign borrowing which is excluded from our analysis. In the presence of external borrowing, policy-makers would switch between different sources of debt depending upon the relative cost of borrowing. However, given the volatility of capital flows to emerging market countries, the structure of financial sector in these economies would continue to play a major role in shaping the debt dynamics.

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Appendix A Deriving the Outcome in t=1

Differentiating (13) w.r.to τ_1, g_1 and d_1 yields the following first order conditions:

$$-\alpha(\alpha(\pi_1 - \pi_1^e - \tau_1) - \overline{x}_1) = \lambda_1 \tag{A1}$$

$$\delta_2(\overline{g}_1 - g_1) = \lambda_1 \tag{A2}$$

$$(1 + r_1)\beta_G \delta_2 \widetilde{D}(\overline{x}_2/\alpha + \overline{g}_2 + (1 + r_1)d_1) = \lambda_1 \tag{A3}$$

Imposing the rational expectations condition (i.e. $\pi_1^e = \pi_1$), and combining the resulting equations with the first order conditions from the *CB*'s loss minimization, the budget constraint and output supply function, yields the equilibrium outcome in $t = 1$. Equilibrium borrowing, d_1 is presented in the text. Equilibrium values of the other variables are listed in the following table.

Table A1- Equilibrium Outcome in $t = 1$.

$g_1 = (1 - \Theta)\overline{g}_1 - \widetilde{D}^*\Phi[\overline{g}_2 + \frac{1}{\alpha}\overline{x}_2 + (1 + r_1)(\frac{1}{\alpha}\overline{x}_1 + (1 + r_0)d_0)]$
$\pi_1 = \frac{\delta_2}{\mu_1}\widetilde{D}^*\Phi[\overline{g}_2 + \frac{1}{\alpha}\overline{x}_2 + (1 + r_1)(\overline{g}_1 + \frac{1}{\alpha}\overline{x}_1 + (1 + r_0)d_0)]$
$x_1 = \frac{-\delta_2}{\alpha}[\widetilde{D}^*\Phi[\overline{g}_2 + \frac{1}{\alpha}\overline{x}_2 + (1 + r_1)(\overline{g}_1 + (1 + r_0)d_0)]] + (1 - \frac{\delta_2}{\alpha^2}\Theta)\overline{x}_1$
$\tau_1 = \frac{\delta_2}{\alpha^2}[\widetilde{D}^*\Phi[\overline{g}_2 + \frac{1}{\alpha}\overline{x}_2 + (1 + r_1)(\overline{g}_1 + (1 + r_0)d_0)]] + (\frac{\delta_2}{\alpha^2}\Theta - 1)\frac{1}{\alpha}\overline{x}_1$

Note: $\Theta = \widetilde{D}^*\Phi(1 + r_1)$ where $(1 - \Theta) > 0$, $(1 - \frac{\delta_2}{\alpha^2}\Theta) > 0$ and all other parameters are as defined in the text.

Appendix B Solving for $\mathbf{r_1}$

Equilibrium in the bond market suggests that $d_1(r_1) = b_1(r_1)$. As derived before, the government's borrowing requirement is given by

$$d_1 = \Phi[\overline{g}_1 - \mathit{\Gamma} \overline{g}_2 + \frac{1}{\alpha}\overline{x}_1 - \frac{\mathit{\Gamma}}{\alpha}\overline{x}_2 + (1 + r_0)d_0] \tag{A4}$$

which can be expressed as

$$d_1 = \frac{[H - (1 + r_1)JB]}{(1 + (1 + r_1)^2 J)} \tag{A5}$$

where $H = \overline{g}_1 + (1/\alpha)\overline{x}_1 + (1 + r_0)d_0$, $J = \beta_{FA}(\widetilde{D}/\widetilde{\lambda})$ and $B = \overline{g}_2 + (1/\alpha)\overline{x}_2$.

Similarly the total demand for bonds is given by

$$b_1 = \frac{[(c\eta^2 + \omega(n-1)c\eta n)\phi^2 + (n-1)\, n^2\omega + 2n\eta]r_1 + (\eta + (n-1)\omega n)cA\phi}{c(\omega(n-1)n + 2\eta)} \tag{A6}$$

which can be more simply expressed as

$$b_1 = C + Mr_1 \tag{A7}$$

where $C = [(\eta + (n-1)\omega n)cA\phi]/[c(\omega(n-1)n + 2\eta)]$ and $M = [(c\eta^2 + \omega(n-1)c\eta n)\phi^2 + (n-1)\, n^2\omega + 2n\eta]/[c(\omega(n-1)n + 2\eta)]$

In equilibrium $E_1^d = d_1 - b_1 = 0$, thus

$$\frac{[H - (1 + r_1)JB]}{(1 + (1 + r_1)^2 J)} - [C + Mr_1] = 0 \tag{A8}$$

Multiplying both sides of this equation by $(1 + (1 + r_1)^2 J)$ yields

$$[H - (1 + r_1)JB] - [C + Mr_1](1 + (1 + r_1)^2 J) = 0 \tag{A9}$$

(A9) can be expressed as

$$-\Psi_1 {r_1}^3 - \Psi_2 {r_1}^2 - \Psi_3 r_1 + \Psi_4 = 0 \tag{A10}$$

where $\Psi_1 = JM, \Psi_2 = J(2M + C), \Psi_3 = M + (M + 2C + B)J$ and $\Psi_4 = H - (B + C)J - C$.

Solving (A10) for r_1 and restricting the solution range to non-negative values yields the equilibrium bond rate.

Appendix C Macroeconomic Outcome in the Extended Model

Equilibrium values of inflation, output and public borrowing in the extended model are listed in Table A2.

Table A2- Equilibrium Outcome in $t = 1$ and $t = 2$

$\pi_2^C = \frac{\delta_2}{\mu_1}\widetilde{\lambda}\Phi[(\frac{1}{\alpha}\overline{x}_2 + \overline{g}_2) + (1 + r_1)(\overline{g}_1 + \frac{1}{\alpha}\overline{x}_1 + (1 + r_0)d_0 - \kappa l_1^T)]$
$x_2^C = -\frac{\delta_2}{\alpha}\widetilde{\lambda}\Phi[\overline{g}_2 + (1 + r_1)(\overline{g}_1 + \frac{1}{\alpha}\overline{x}_1 + (1 + r_0)d_0 - \kappa l_1^T)] + (1 - \frac{\delta_2}{\alpha^2}\widetilde{\lambda}\Phi)\overline{x}_2$
$d_1^C = \Phi[\overline{g}_1 + \frac{1}{\alpha}\overline{x}_1 + (1 + r_0)d_0 - \kappa l_1^T - F(\overline{g}_2 + \frac{1}{\alpha}\overline{x}_2)]$
$\pi_1^C = \frac{\delta_2}{\mu_1}\widetilde{D}^*\Phi[\overline{g}_2 + \frac{1}{\alpha}\overline{x}_2 + (1 + r_1)(\overline{g}_1 + \frac{1}{\alpha}\overline{x}_1 + (1 + r_0)d_0 - \kappa l_1^T)]$
$x_1^C = \frac{-\delta_2}{\alpha}[\widetilde{D}^*\Phi[\overline{g}_2 + \frac{1}{\alpha}\overline{x}_2 + (1 + r_1)(\overline{g}_1 + (1 + r_0)d_0 - \kappa l_1^T)]] + (1 - \frac{\delta_2}{\alpha^2}\Theta)\overline{x}_1$

Note: $\widetilde{\lambda} = \frac{1}{(1+\widetilde{\varphi})}, \widetilde{\varphi} = \frac{\delta_2}{\alpha^2} + \frac{k\delta_2}{\mu_1}, \widetilde{D} = (\frac{\delta_2}{\alpha^2} + \frac{\delta_2\delta_1}{\mu_1^2} + 1)\widetilde{\lambda}^2, \widetilde{D}^* = (1+r_1)\beta_{FA}\widetilde{D}$, $F = (1 + \widetilde{\varphi})\widetilde{D}^*, \Phi = \frac{1}{1+(1+r_1)F}, \Theta = \widetilde{D}^*\Phi(1 + r_1)$. Also, $(1 - \Theta) > 0$, $(1 - \frac{\delta_2}{\alpha^2}\Theta) > 0$ and $(1 - \frac{\delta_2}{\alpha^2}\widetilde{\lambda}\Phi) > 0$.