# Seemingly Adequate Capital in Banks in an Emerging Economy

Gurbachan Singh[1]

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**Abstract**

Our model is motivated by conditions in India (and to some extent in Greece). In our model, the government borrows from banks, and invests some of it in capital of these very banks. We show that the government's share capital is effectively *contingent capital*, which is credible if government is in a good fiscal state in future. If this condition is satisfied, there is no crisis. If this condition is not satisfied, a crisis is theoretically possible. However, this may not happen in practice. We try to explain this in the end with the help of behavioral economics. We analyse government-backed banks and banks-backed government.

**Key words:** Banking crisis, fiscal deficit, contingent capital, behavioral economics.

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[1]Visiting faculty, Planning Unit (Department of Economics), Room No. 301, Indian Statistical Institute (ISI), Delhi Centre, 7 SJS Sansanwal Marg, New Delhi, India, Pin: 110016 (E-mail: gurbachan.arti@gmail.com Ph: +91-9910058954). I appreciate the role of my family, and ISI in making this possible. I thank Shubhashis Gangopadhyay, Chetan Ghate, Bappa Mukhopadhyay, Tridip Ray, Tridib Sharma, Arti Singh and an anonymous referee for their comments. Any errors are my responsibility.

# 1 Introduction

Governments in several emerging economies (like India) have invested in the capital of several domestic banks. It is interesting that they have done so even though they have faced a resource crunch. So it is important to ask how these governments have managed to find resources for investment in banks' capital. Now it turns out that many governments have borrowed from domestic banks to finance their fiscal deficits. One important expenditure is investment in the capital of banks (recapitalization of public sector banks in many cases). In the absence of borrowing from (domestic) banks, it may have been very difficult, if not impossible, to invest in the capital of many banks. So we may say that these governments have borrowed from domestic banks[2] and used some of these very funds for investment in the capital of several banks. Is all this significant?

Note that when the government invests in the bank capital by borrowing from the same (set of) banks, then there is no net inflow of resources into the banks. This is unlike the case in which shareholders of a bank use their endowment (or even borrowing from outside the banks) to invest in bank capital. In the latter case, there is a net inflow of resources into the bank under consideration. It is true that the net inflow of resources at the initial stage per se is not important. Instead it is the commitment of shareholders to take risks that matters. If this commitment is credible, then banks do meet capital requirements[3] even if there is no net inflow of funds into banks

[2]Source for India: Table 125, p. 191, Handbook of Statistics on Indian Economy.

[3]There is a substantive literature now that studies optimal capital rather than adequate capital. See, for example, Diamond and Rajan (2000). This is a welcome change. However, for convenience, we will throughout use adequate capital rather than optimal capital in the formal model. Our point is, however, more general. It is not just that banks are

to begin with. A credible commitment on the part of the government may require resources with the government in future, even if these are absent at present. So we have then *contingent capital* provided by the government in banks. This immediately ties up the credibility of contingent bank capital with the ability of the government to provide funds in future if the need arises.

We have just seen a link between bank capital and government finances. There can be one other link between the two. Government bonds have almost always been risky (Reinhart and Rogoff, 2009). There is, however, a somewhat new dimension lately. In early stages, the governments could use debasement of (gold and silver) coins. This is how the effective seignorage increased and governments could use this to repay some of the debt. Later, the governments could opt for excess issue of fiat money. This led to inflation (which was very often unanticipated), and so there was default on government (and other) bonds in real terms even if there was none in nominal terms. Of late, this policy option has become limited - at least for some countries. Countries like Greece are part of the European Union and use the common European currency over which they have little control. So there is no longer the option of complete, or near-complete, redemption of bonds in nominal terms and some default in real terms. This is significant for banks.

Banks typically both borrow and lend in nominal terms. So banks are concerned about redemption of government bonds in nominal terms only. If a borrower defaults in real terms, it does not matter to the banks so long as there is redemption in nominal terms. The risk that the government may not

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seemingly holding adequate capital. The point is that banks may be seemingly holding sub-optimal amount of capital.

redeem fully in real terms was not important for banks in the past. It has, however, become important now. The reason is simple. If the government has a resource crunch and is unable to redeem or roll over its debt, and it cannot find its way out through inflation, then there can be an open default i.e. in nominal terms. This is a new risk that banks face as investors in government bonds, and so banks need more capital now than they did in the past. This is an important lesson from the recent events in Europe in general and in Greece in particular.

A somewhat similar story holds even in countries outside the European Union though the urgency and severity may be less elsewhere. Many countries have formally adopted the monetary regime of *inflation targeting*. This implies that there is limited scope to use inflation to take care of fiscal difficulties. Even in countries that have not formally adopted inflation targeting, there is less tolerance for high inflation now than there was in the past. Accordingly governments that face serious fiscal difficulties may have to default in nominal terms. This can be problematic for banks. If the latter kept bank capital to take care of usual banking risks but not for meeting possible default by the government, then banks effectively have inadequate capital.

We have just seen two reasons why banks may effectively have inadequate capital. First, bank capital by the government may not be entirely credible. Second, banks may be taking risks by investing in government bonds but not preparing for the risk in such an investment. In both cases, the issue is critically the fiscal conditions in future. There can be a debate on the future fiscal conditions. Let us say that there are the optimists and the pessimists. The former believe that future fiscal conditions will be good. The pessimists believe otherwise[4]. If the optimists are right, then it is obvious that there is no crisis. But what if the pessimists are right? Is zero probability of a crisis in the short and the medium term still possible?

One reason why the pessimists may be right and yet there is no crisis is that a common person (unlike a rational economic agent) does not quite understand all the economics outlined above (and modelled later in this paper). This lack of understanding may give a (false) sense of comfort and avoid a run on banks. So the reason for bank stability may well be that people do not quite realize that there is possibly a serious problem[5]. This is different from the reason that banks are resilient and so there is no crisis (See Acharya et al. (2010) for empirical support for this). It is true that banks have deposit insurance by the government, which can make the banks immune to a bank run. But is deposit insurance always credible? Note that the insurance premiums collected are usually small compared to the required funds, if there is a systemic bank run. The only remaining source

[4] In India, the public debt to GDP ratio is 0.60, which is very low compared to the figure of 1.08 for Greece (the problem country in news recently). However, the tax-GDP ratio in India is .177, which is well below the figure of .335 for Greece. It is easy to check that the debt to tax ratios in India and Greece are about 3.40 and 3.23 respectively. So the figure for India is not very different from that for Greece (it is actually higher).

Though there has been some upward revision recently, the ratings of Government of India are still low. Fitch Rating of Greece local currency debt was BBB- (negative) whereas that for India local currency debt was BBB (stable) on 14 June, 2010.

Reinhart and Rogoff (2009) report the figure for total public debt to revenue ratio for thirteen countries at the time of default. The figure for six countries was *lower* than that for India or Greece (Table 8.1, p. 120).

[5] As Hausmann and Purfield (2004) observed in the Indian context, 'In India, the job of convincing the politicians and society that adjustment is necessary is made more difficult by the apparent absence of any symptoms of fiscal illness.' (p. 3)

for funds in future is then the public exchequer, which may or may not be credible if the public debt is large relative to national income or relative to the government's revenues.

Let us return to contingent bank capital. In recent years, contingent capital in banks has received considerable attention. See, for example, Flannery (2009). In these models, contingent capital can supplement usual capital to reduce the cost of total capital. In our model, the issue is not that usual capital is costly. Moreover, contingent capital in our model is primarily in the context of an emerging economy, unlike much of the recent literature on contingent capital which really deals with banks in developed countries. In our model, private capital in banks is the usual capital, whereas government capital in banks is effectively contingent capital, which may or may not be entirely credible. The government in an emerging economy may want to invest in bank capital for various reasons, and allow a somewhat residual role for private capital. While this by itself may or may not be significant[6], it is important in the context of macro-financial stability if government capital in banks is contingent (and possibly not credible) capital, and private capital is usual (and entirely credible) capital.

The formal model in this paper is based on Diamond and Dybvig (1983), and on a simplified version of Gangopadhyay and Singh (2000). However, it goes well beyond these models to include institutional features that are peculiar to emerging economies like India[7], and fiscally constrained economies like Greece. Diamond and Dybvig (1983) showed how there can be multiple equilibria[8] including a panic run, and how this can be prevented by a

[6]See La Porta, et al. (2002) for an empirical study on government ownership of banks.

[7]See Buiter and Patel (2010) for the fiscal conditions in India. See Acharya et al. (2010) for a recent study on Indian banking.

[8]Goldstein and Pauzner (2005) have shown how we can get unique equilibrium if there

tax-subsidy scheme. Implicit in their model is a balanced budget in each period. Gangopadhyay and Singh (2000) showed how a bank can be made run-proof with capital adequacy (instead of using a tax-subsidy scheme)[9]. The model here is novel in that it incorporates fiscal difficulties in a model of banking crisis[10].

There are several risks in banking. We will make the analysis simple here by considering only one kind of risk. Banks can be vulnerable to a run, given the maturity mismatch between the two sides of the balance sheet of a bank. We will see the capital requirement for this purpose. The point is not that the balance sheet mismatch is the only risk or that this is the most important risk[11]. Instead, the point is to use a familiar approach and simplify the analysis.

Plan of the paper is as follows. We will begin with a simple model of capital adequacy in banks (section 2). Thereafter, we will incorporate financial transactions between the government and the banks (section 3). Finally, we will use behavioral finance to see how the probability of a crisis can be zero, even though a bank is vulnerable (section 4). The paper ends with some concluding remarks (section 5).

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is some noise in the model. Though this is a very good advance in the literature, we find the original Diamond and Dybvig (1983) tractable for the purpose on hand.

[9]Yet another policy that can be used is the lender of last resort policy. However, following Diamond and Dybvig (1983), we will throughout abstract from this.

[10]Chang and Velasco (2001) extend Diamond and Dybvig (1983) to incorporate an open emerging economy. We extend the model to include fiscal conditions in an emerging economy.

[11]See Caprio and Honohan (2010) for the crucial role played by 'bad banking and bad policies' in practice.

## 2 A benchmark model

The model in this section serves as the benchmark model. We will come to the main model in the next section.

This is a three period model, 0, 1, 2. There is a continuum of risk averse agents in the interval $[0, 1]$. They are either of type 1, or type 2. Type 1 agents derive utility from consumption in period 1 only, and type 2 agents from consumption in period 2 only. In period 0, each agent faces a probability $t$ of being type 1. $t$ lies between 0 and 1. The distribution of $t$ is common knowledge in period 0. However, in period 1, the type of an agent is known privately to the agent only. Each risk averse agent has an endowment of 1 unit in period 0 and nothing in other periods.

Besides the risk averse agents, there are risk neutral agents. For simplicity, all these are type 2 agents (as in Allen and Gale, 2007). Each risk neutral agent has an endowment $K^P$ in period 0 and nothing in any other period.

There is a large number of competitive identical banks. We will consider a representative bank. Henceforth, we will refer to it as the bank.

The technology is as follows. For each unit of resource invested in period 0, the return is $R$ in period 2, where $R > 1$. Alternatively, the investment may be liquidated in period 1 in which case only 1 unit can be recovered. Thus, the technology is constant returns to scale, and the long term return rate is greater than the short term return rate. This technology is available to everyone. Also observe that there is no uncertainty in the technology. Observe that if the investment is made for one period only, then it is simply the storage technology with zero net return.

Let $c^a_{ij}$ denote the consumption of a type $i$ risk averse agent in period

$j$, where $i = 1, 2$ and $j = 1, 2$. Given our assumption on the consumption requirements of these agents, $c_{12}^a$ or $c_{21}^a$ are irrelevant. We need to consider only $c_{11}^a$ and $c_{22}^a$. For simplicity, let us use the notation $c_i^a$, where $i = 1, 2$. $c_1^a$ is consumption of a type 1 risk averse agent in period 1. Similarly, $c_2^a$ is consumption of a type 2 risk averse agent in period 2. The expected utility of a risk averse agent in period 0 is

$$EU^a = \int_0^1 [tu(c_1^a) + (1-t)u(c_2^a)]f(t)dt \tag{1}$$

Observe that the discount rate is zero. For risk averse agents, the issue is similar to the problem of insurance. Being type 2 is a "win" situation, while being type 1 is a "loss". However, since the information regarding types is private, an insurance market with risk averse agents only, will fail (Diamond and Dybvig, 1983). We will investigate how far this insurance market can be mimicked by the presence of shareholders of the banks.

If each risk averse agent invests her endowment of 1 unit on her own, then

$$EU^a = t^e u(1) + (1-t^e)u(R) \equiv \underline{U}^a \tag{2}$$

where $t^e$ is the expectation of $t$. Similarly if each (type 2) risk neutral agent invests her endowment of $K^P$ on her own, then

$$EU^n = K^P R \equiv \underline{U}^n \tag{3}$$

A bank in our model is an institution that can sell shares and (demand) deposits. These are issued in period 0. Deposit claims in any period are senior to claims by the shareholders in that period. For each unit invested in deposits, an agent receives either $r_1$ in period 1 and zero in period 2, or zero in period 1 and $r_2$ in period 2. Shares are long term assets (irredeemable in period 1), while deposits can be liquidated in period 1 if the depositor so wishes.

Assume that risk averse agents invest in deposits and that risk neutral agents invest in equity (this is formally shown in Gangopadhyay and Singh (2000)). Type 1 agents withdraw in period 1 regardless of whether or not the bank is in good condition. If the bank is not vulnerable to a run, then type 2 agents withdraw in period 2 only. Consider a run-proof bank. After redeeming deposits of type 1 agents, the bank has $1 + K^P - r_1 t$ units that can stay invested in long term project of the bank. In period 2, given the technology, the bank will have $[1 + K^P - r_1 t]R$. For type 2 depositors to wait till period 2, it must be the case that this amount is greater than or equal to the amount that the bank needs to repay type 2 depositors, which is $r_2(1-t)$. So the no-run condition is given by

$$r_2(1-t) \leq [1 + K^P - r_1 t]R$$
$$\Rightarrow \quad t \leq \frac{(1+K^P)R - r_2}{Rr_1 - r_2} \equiv \bar{t}, \quad r_1 R - r_2 > 0.$$

The maximum value that $t$ can take is 1. So there will no bank run if $\bar{t} \geq 1$. It is easy to check that this implies that the no-run condition is

$$K^P \geq (r_1 - 1). \tag{4}$$

This is the capital adequacy condition. Henceforth, in this section, we will assume that this condition is satisfied.

It follows from the above discussion that $c_i = r_i$ where $i = 1, 2$.

In equilibrium, due to competition, the total expected return to shareholders in period 0 is equal to the reservation utility of the risk neutral shareholders (see (3)). Hence,

$$\int_0^1 \Big[(1 + K^P - r_1 t)R - r_2(1-t)\Big] f(t)dt = K^P R$$

$$\Rightarrow \quad (1 - r_1 t^e)R - r_2(1 - t^e) = 0. \tag{5}$$

The optimization problem for the bank is to maximise (1) subject to (5). Let $r_i^*$ $(i = 1, 2)$ denote the solution. We have the following result due to Gangopadhyay and Singh (2000):

**Prior result 1.** *Assume that relative risk aversion is greater than* 1*, and capital adequacy condition $K^P \geq (r_1^* - 1)$ is met. Then the representative bank is run-proof, and the solution to the inter-temporal consumption smoothing problem is given implicitly by the following two equations:*

$$u'(c_1^*) = Ru'(c_2^*)$$

$$(1 - c_1^* t^e)R - c_2^*(1 - t^e) = 0.$$

*where $r_i = c_i$, for $i = 1, 2$.*

Note that $c_i$ denotes consumption in period $i$. The first of the two equations is the standard optimality condition for inter-temporal consumption smoothing[12]. So we have optimal allocation, given adequate capital[13]. The second equation states that the participation constraint of the shareholders is met. They act as shock absorbers. The condition under which the above result holds is that the bank has adequate capital i.e. $K^P \geq (r_1^* - 1)$. Without capital, the bank can be vulnerable if it promises to pay $r_1$ in period 1, and this is greater than 1, which is the amount of resources with the bank

[12]The more general condition is $u'(r_1^*) = \rho Ru'(r_2^*)$, where $\rho$ is the discount factor. See Diamond and Dybvig (1983).

[13]If $t > 0$ for risk neutral agents, we need a trading restriction. See Gangopadhyay and Singh (2000). However, we have here $t = 0$ for risk neutral agents.

in period 1, given the technology. With adequate capital, the vulnerability is no longer there.

Summing up, in this section, we have considered a benchmark model. There are two groups of investors. One group invests in deposits and another group invests in bank capital. If this capital is adequate, banks are run-proof and (ex-ante) efficient. We will not go into the other case in which the endowment of risk neutral agents is inadequate, in which case there is inadequate capital with banks[14].

The government is not directly involved so far[15]. In the next section, we will incorporate direct government involvement in banks.

# 3 Effectively contingent bank capital, and lending to the government

We will make a few changes to the model in the previous section. Assume that the government invests $K^G$ units in bank capital and spends another $s$ units in period 0 on an outside 'project'. Government spending includes expenditure on physical infrastructure, setting up enabling institutions, and putting in place regulatory framework. These activities do not give any return to the government. However, these help increase the return on projects

[14]The interested reader can see Gangopadhyay and Singh (2000) for one approach to this case. Another approach is as follows. The issue is not the availability of capital but the price at which it is available. This brings us to optimal capital vis-a-vis adequate capital. This is outside the scope of this paper.

[15]The only exception is that the government is present in the background to perform its very basic functions in a market economy - maintain law and order, enforce contracts, and so on. For simplicity, assume that there are zero costs of these operations.

in the private sector. We will assume that the return rate is

$$R' \geq R,$$

where $R$ is the return on private projects if the government does not actively intervene in the economy as in the previous section. The strict inequality holds if and only if $s > 0$. Governments in many emerging economies (now and in the past) have actively intervened in the economy to help increase the growth rate (though the results have not always been clear-cut).

We assume that the government has a fiscal deficit in period 0. Assume, for simplicity, that taxes are zero in period 0. To keep the model simple and retain the focus on banking here, we will assume that the future taxes are exogenous. It borrows $(s + K^G)$ units from the bank in period 0 for two periods and the interest factor is $R'$. So it promises to repay $(s + K^G)R'$ in period 2. Though the interest factor on government bonds is the same as the return on projects, it is, as we will see, effectively less due to possibility of default.

The government does not incur any expenditure in period 1. In period 2, it receives a tax amount $T$. If $T$ is large, there is no default by the government. If it is small, the government defaults in period 2. We will come to what large or small means later.

Typically, in practice, a variable like $T$ is uncertain. However, we will consider a simple case in which $T$ is known in period 0. The only uncertainty in our model is that $t$ is not known. We will see how even the assumption of a certain $T$ can be useful. It is obvious that if $T$ is small, then banks would not choose to invest in government bonds. However, banks are often not free to choose to invest in government bonds. They are often required to do so[16].

$T$ is exogenous in our model. This is to keep the model simple. If it is endogenous, there can be distortions due to taxes. Though more realistic, these distortions are well known and these take our focus away from the main theme of the paper. Besides, when the fiscal crisis hits, the government typically looks for innovative and fresh ideas to improve the fiscal conditions (as in UK now). So these may be treated as exogenous. Finally consider revenues $T$ in the context of the government borrowing $s$. Observe that the government uses $s$ in our model to increase the return on projects in the economy from $R$ to $R'$. So $s$ does not contribute to a change in $T$ in our model. Also, $K^G$ is borrowed by the government and invested in bank capital. So this cannot contribute to a change in $T$ though it does contribute to changing $G$ (see (7) a little later).

As before, there are risk averse agents who invest 1 unit in bank deposits,

[16] For example, in India, there is, what is called, the *statutory liquidity ratio* (SLR). Banks are required to invest about 25% of their deposits in government bonds.

In recent times banks have chosen to invest more than they are required to invest in government bonds. So the SLR requirement is not, it may be argued, a binding constraint on banks. However, this may be an exception due to special circumstances. If banks are always willing to invest considerable amount in government bonds, then there would have been no need for an SLR *requirement* in the first place.

Government documents often convey the impression that the SLR requirement is a prudential requirement to ensure that banks are safe. This actually may or may not be the case. SLR requirement has been there for very long though government bonds have not always been liquid assets in India. That is a contradiction since the stated purpose of SLR requirement is to ensure that banks have liquidity.

It is interesting that banks are required to observe the SLR requirement all the time. This implies that banks cannot use their holdings of government bonds for liquidity purposes. This again is contradictory if the stated objective is to ensure liquidity for banks.

| Assets | Liabilities |
|---|---|
| Government bonds $= s + K^G$ | Deposits $= 1$ |
| Loans $= 1 + K^P - s$ | Private capital $= K^P$ |
| | Government capital $= K^G$ |
| Total assets $= 1 + K^P + K^G$ | Total liabilities $= 1 + K^P + K^G$ |

Table 1: Balance sheet of representative commercial bank

and risk neutral agents who invest $K^P$ units in bank capital. Observe that now on the liabilities side of the balance sheet of the bank, we have $1+K^P+K^G$, where, as mentioned already, the last term is the investment in bank capital by the government. On the asset side, the bank lends $s+K^G$ units to the government. It invests the remaining amount i.e. $(1+K^P+K^G)-(s+K^G)$ in a project, as in the previous section. Observe that this amount is simply $1+K^P-s$. This amount does not involve $K^G$ for the simple reason that the government does not bring in any funds to the bank as a shareholder in period 0, unlike the private shareholders who bring in $K^P$ units to the bank. See Table 1. This shows the balance sheet of the bank. The total capital in the representative bank is $K^P+K^G$. We will assume that $K^G$ is exogenously given. We will work out the capital adequacy condition, and see how much $K^P$ is required.

Given the technology, the bank has the same amount of units in period 1 as it did in period 0. Type 1 agents withdraw in period 1. If the bank is run-proof, type 2 agents withdraw in period 2 only. Consider a run-proof bank. After redeeming deposits of type 1 agents, the bank has

$$1+K^P-s-r_1t$$

units that can stay invested in long term project of the bank. In period 2, the bank will have

$$(1 + K^P - s - r_1 t)R' + \min\Big[(s + K^G)R', G\Big].$$

There are two terms in this expression. The first term is the return on bank's project and the second term is the return on government bonds in period 2. This depends on whether or not resources of the government are adequate to meet its payment obligation i.e. $(s + K^G)R'$. In contrast, $G$ is the actual resources with the government which can be less than, equal to, or more than its payment obligation. $G$ is endogenous and uncertain since it includes the return from government capital in the bank (more on this a little later).

For type 2 depositors to wait till period 2, it must be the case that the above amount is greater than or equal to the amount that the bank needs to repay type 2 depositors, which is $r_2(1 - t)$. So the no-run condition is

$$(1 + K^P - s - r_1 t)R' + \min\Big[(s + K^G)R', G\Big] - r_2(1 - t) \geq 0, \tag{6}$$

where the left hand side is the residual with the bank in period 2.

Government's resources in period 2 are given by

$$\begin{aligned} G &= T + \frac{K^G}{K^P + K^G}\max\Big\{(1 + K^P - s - r_1 t)R' + \min\Big[(s + K^G)R', G\Big] \\ &\quad -r_2(1 - t), 0\Big\}, \end{aligned}$$

where the first term ($T$) is exogenous resources with the government in period 2, and the second term is the government's share of the endogenous residual with the bank (see inequality (6)) above. The government gets this amount as a shareholder in the bank. This cannot be less than zero, given limited liability of the shareholders. We assume that $T \geq 0$.

Given that (6) is satisfied, we may write the previous equation as follows:

$$G = T + \frac{K^G}{K^P + K^G}\left\{(1+K^P-s-r_1t)R' + \min\left[(s+K^G)R', G\right] - r_2(1-t)\right\} \tag{7}$$

In the equation above, we need to compare $G$ and $(s+K^G)R'$. If $G > (s+K^G)R'$, the government has a surplus in period 2. If $G = (s+K^G)R'$, the government has a balanced budget. In these two cases, there is no default by the government. In the third case, $G < (s+K^G)R'$, the government repays only $G$ to the bank. So it defaults to the extent of $(s+K^G)R' - G$ on its borrowing from the bank. $t$ plays a crucial role in determining $G$. We will accordingly write $G(t)$ instead of $G$.

For completion and to keep the model simple, assume that the government uses the surplus, if any, to build 'monuments'. Some countries have a 'rich' heritage in this context. A possible investment in unproductive monuments may be interpreted more broadly. It is well known that there is some wastage in government spending in many economies. One way to capture this is to include spending on monuments in the model. The idea here also is to simply close the model.

In Proposition 1 below, we have the capital adequacy condition for a given $r_1$ and $r_2$. Later, in Proposition 2, we have the solution for $r_1$ and $r_2$.

As mentioned already, the government invests $K^G$ units in bank capital without bringing in resources into the bank. This, as we will see, can be treated as contingent capital which may or may not be credible. In Proposition 1, we will work out the effective capital adequacy requirement.

**Proposition 1.** *Assume that $r_1R' - r_2 > 0$. The minimum amount of private bank capital required to avoid systemic bank runs is $r_1 - 1$ (the* *benchmark amount) minus the effective amount of capital invested by the government in the bank i.e. min*$\left[K^G, \frac{T}{R'} - s\right]$. *Formally, the condition is*

$$K^P \geq \begin{cases} (r_1 - 1) - K^G, & \textit{if } T \geq (s + K^G)R' \\ (r_1 - 1) - \left(\frac{T}{R'} - s\right), & \textit{if } T < (s + K^G)R'. \end{cases} \tag{8}$$

**Proof:** There are two cases: (a) $G(t) \geq (s + K^G)R'$, and (b) $G(t) < (s + K^G)R'$ (see (6) and (7)). We will first consider case (a) and then case (b). Thereafter, we will check the conditions on parameters of the model under which case (a) and case (b) hold.

In case (a), $\min[G(t), (s + K^G)R'] = (s + K^G)R'$. So we can write (6) as

$$(1 + K^P - s - r_1 t)R' + (s + K^G)R' - r_2(1 - t) \geq 0 \tag{9}$$

$$\Rightarrow \quad t \leq \frac{(1 + K^P + K^G)R' - r_2}{r_1 R' - r_2} \equiv \bar{t}, \quad r_1 R' - r_2 > 0,$$

where the last condition holds by assumption. The maximum value that $t$ can take is 1. So there will no bank run if $\bar{t} \geq 1$. It is easy to check that this implies

$$K^P \geq (r_1 - 1) - K^G, \text{ given case (a).}$$

Next consider case (b). In this case, $\min[G(t), (s + K^G)R'] = G(t)$, which is endogenous. So we will first compute $G(t)$. In case (b), we can write (7) as

$$G(t) = T + \frac{K^G}{K^P + K^G}\left\{(1 + K^P - s - r_1 t)R' + G(t) - r_2(1 - t)\right\}.$$

$G(t)$ appears on both sides of the equation. Rearranging the terms, we get

$$G(t) = \frac{K^P + K^G}{K^P} T + \frac{K^G}{K^P}\left\{(1 + K^P - s - r_1 t)R' - r_2(1 - t)\right\} \tag{10}$$

Given case (b), substituting for $G(t)$ by using (10) in (6), we get

$$\frac{K^P + K^G}{K^P} T + \left(\frac{K^G}{K^P} + 1\right)\left\{(1 + K^P - s - r_1 t)R' - r_2(1 - t)\right\} \geq 0$$

Given that $\frac{K^P + K^G}{K^P} > 0$, we have

$$T + \left\{(1 + K^P - s - r_1 t)R' - r_2(1 - t)\right\} \geq 0$$

$$\Rightarrow \quad t \leq \frac{(1 + K^P - s)R' + T - r_2}{r_1 R' - r_2} \equiv \bar{t}, \quad r_1 R' - r_2 > 0,$$

where the last condition holds by assumption. The maximum value that $t$ can take is 1. So there will no bank run if $\bar{t} \geq 1$. It is easy to check that this implies

$$K^P \geq (r_1 - 1) + s - \frac{T}{R'}, \text{ given case (b).}$$

Next we will check the conditions on parameters of the model under which case (a) and case (b) hold. Case (a) holds for a given $t$ when $G(t) \geq (s + K^G)R'$. Using (7), and taking $T$ on the left hand side, we get

$$T \geq (s + K^G)R' - \frac{K^G}{K^P + K^G}\left\{(1 + K^P - s - r_1 t)R' + (s + K^G)R' - r_2(1 - t)\right\}.$$

The least value of the term in curly brackets is zero (see (9)). So case (a) holds $\forall\, t$ when $T \geq (s + K^G)R'$. If $T < (s + K^G)R'$, then, in general, we have case (a) for some values of $t$, and we have case (b) for other values of $t$. However, we do not know the value of $t$ in period 0. So the capital adequacy requirement has to be determined as if case (b) holds $\forall\, t$. Hence, the result in (8). ||

We would like to make a few observations. *First*, there is a continuity in the amount of adequate capital at the point $T = (s + K^G)R'$. *Second*, the total capital requirement $(K^P + K^G)$ is $r_1 - 1$, if $T \geq (s + K^G)R'$. This requirement is similar to that in the previous section (see Prior Result 1). The intuition is that in both cases, the total bank capital is credible. *Third*, the capital requirement is $(r_1-1)+s-\frac{T}{R'}$, if $T < (s+K^G)R'$. It is interesting that the amount of capital requirement is independent of $K^G$ in this case. So $K^G$ is just, what we may call, the notional amount of capital with the bank in this case. *Fourth*, capital adequacy depends on the links between the banks and the government, and the nature of the government. These can vary from one country to another. Accordingly, the capital adequacy norms need to be country-specific. This is unlike what we have seen so far in Basle capital adequacy norms. They tend to be applied more uniformly across countries than may be desirable. *Fifth*, we have assumed that $r_1R' - r_2 > 0$ in Proposition 1. Later in Proposition 2, we will see that this condition holds under some reasonable restrictions on parameters.

Proposition 1 is about the general case, $s \geq 0$, and $K^G \geq 0$. Let us consider some special cases to get a better understanding of Proposition 1.

<u>Special Case I: $s = 0, K^G = 0$.</u> This special case is the benchmark model in the previous section. The capital adequacy condition in this case is simply

$$K^P \geq (r_1 - 1).$$

This is the same condition as in (4). Since $s = 0$, the government does not spend on 'infrastructure' and hence, in this case $R' = R$.

<u>Special Case II: $s = 0, K^G > 0$.</u> In this case, the government borrows from the bank and invests the entire amount in bank capital. As in the previous case, $R' = R$ since $s = 0$. Given this case, it follows from (8) that

$$K^P \geq (r_1 - 1) - \min\left[K^G, \frac{T}{R}\right].$$

First consider the case $T \geq K^G R$. In this case, the total minimum capital requirement ($K^P + K^G$) is $r_1 - 1$, which is the same as that in the benchmark model. The intuition is simple. Bank capital provided by the government is effectively contingent capital but it is entirely credible because the government has adequate resources in period 2. Next consider the case $T < K^G R$. In this case, the amount invested by the government in bank capital in period 0 is $K^G$ but all of this not credible. Only $\frac{T}{R}$ units are credible since the government will have $T$ units in period 2 and $R$ is the discount factor. Accordingly, the private capital requirement in this case is $K^P \geq (r_1 - 1) - \frac{T}{R}$.

Let us elaborate on the case $T < K^G R$. Suppose that $K^P + K^G = r_1 - 1$, which is the benchmark measure of adequate capital. The bank seemingly has adequate capital in period 0. But $K^G$ is effectively contingent capital, and all of it not credible in this case. So a crisis is possible. Let $P(B)$ denote the probability of a banking crisis. Formally, we have

**Corollary 1.1.** *In the special case $s = 0$ and $K^G > 0$, if $K^P + K^G = r_1 - 1$ and $T < K^G R$, then $P(B) > 0$.*

The proof this and other corollaries in the paper are very simple. So they are omitted.

Let us compare this special case with the previous special case. The risk is the same in the two cases (there is a possibility of a bank run). However, credibility of the capital differs in the two cases. In the previous case, bank capital is provided from outside the bank in period 0, and is entirely credible. In this case, bank capital provided by the government is provided from inside the bank in period 0. This is credible provided the government has adequate resources in period 2.

Special Case III: $s > 0, K^G = 0$. In this case, banks are completely private banks as there is no investment in bank capital by the government. However, these banks have a link with the government as they finance the government's deficits.

In this case, it follows from (8) that the capital adequacy condition is

$$K^P \geq (r_1 - 1) + \max\left[s - \frac{T}{R'}, 0\right].$$

Observe that in our model a bank that lends to the government can need more capital than another bank that does not (see Special Case I).

There are two sub-cases here. First, we have $s - \frac{T}{R'} \leq 0$. In this case, there is no default by the government, and so there is no need for additional capital with the bank. Accordingly, the capital adequacy condition is $K^P \geq (r_1 - 1)$, which is similar to that in Special Case I. Second, we have $s - \frac{T}{R'} > 0$. In this case, there is default by the government to the extent of $sR' - T$ in period 2. Accordingly, the capital requirement in this case is more than that in Special Case I. The capital requirement in this case is $(r_1 - 1) + \left[s - \frac{T}{R'}\right] > r_1 - 1$, where the latter amount is the benchmark.

If banks do not have the larger amount of capital required when there is borrowing by the government and the latter can default, then a crisis is possible. Formally, we have

**Corollary 1.2.** *In the special case $s > 0$ and $K^G = 0$, if $K^P = r_1 - 1$ and $T < sR'$, then $P(B) > 0$.*

This may be useful in understanding the story of private (Greek or non-Greek) banks that lent to the Greek Government. It is possible that the banks held capital keeping in mind only the usual risks in banking. They did not, it seems, provide for additional capital as a safeguard for possible default by the Greek Government. Banks that lent to the Greek Government were vulnerable. Banks seemingly had adequate capital. But they actually did not have it since the required amount is larger. Eventually a banking crisis did not actually happen - possibly due to intervention of the European Union as a whole.

<u>Special Case IV: $s > 0, K^G > 0$.</u> In this case, both $s$ and $K^G$ are positive. This is unlike the previous two special cases. In special case II, only $K^G$ is positive whereas in special case III, only $s$ is positive. There is a double link between the banks and the government in this case, unlike in the previous two cases where there was a single link only. In this case, the bank lends to the government, *and* the latter invests in bank capital.

The capital adequacy condition is given by (8). We have two sub-cases. *First*, we have $T \geq (s + K^G)R'$. In this sub-case, the capital adequacy condition is $K^P \geq (r_1 - 1) - K^G$. Observe that $s$ is not present in the expression for adequate capital in this case. So in this case, it does not matter how much the government borrows from the bank to use outside the bank. The intuition is that the interest factor on government bonds is the same as that on the bank's project, and there is no default on government bonds just as there is no risk in the bank's project. *Second*, we have $T < (s + K^G)R'$. In this sub-case, the capital adequacy condition is $K^P \geq (r_1 - 1) + s - \frac{T}{R'}$. Observe that $K^G$ does not figure in this condition. Instead of $K^G$, what figures is $\frac{T}{R'}$ which is the relevant and credible figure.

This case can be used to better understand the situation of *public sector banks* in India. In India, the government borrows from the banks, uses the funds partly for investing in bank capital, and uses the remaining funds outside the banks. The latter have capital from the government but that is not the only source. These banks have private shareholders too.

It is debatable whether or not India is vulnerable to a financial crisis. One way to interpret the debate in the light of our model is that there are, what we referred to in the introduction as, optimists and pessimists[17]. The optimists believe that $T \geq (s + K^G)R'$. So the total bank capital $K^P + K^G = (r_1 - 1)$ is credible and adequate. The pessimists believe that $T < (s+K^G)R'$. So the private capital requirement is $(r_1-1)+s-\frac{T}{R'}$ which is more than $(r_1 - 1) - K^G$, given that $T < (s + K^G)R'$. The possibility of a banking crisis depends on the fiscal conditions in future.

It is important to distinguish between the government's *notional* power to tax (and sell public property) and cut expenditure, and *effective* power to do the same. There is hardly any doubt about the government's notional power in this regard. However, many governments may have little effective power. There may be political constraints on the party or on the individuals in power. Fiscal crisis is often a political problem rather than an economic problem[18].

[17] The paradigm here is that the government's inter-temporal budget constraint has to be met. There are some who do not share this view. See, for example, Rakshit (2005).

[18] It is true that in a bad fiscal state, the government may get the central bank to issue excess base money and redeem its debt placed with commercial banks. Since the latter almost always lend and borrow in nominal terms, there will be no banking crisis. However, note that in this case we will very likely have high inflation (due to an increase in money which is a multiple of increase in base money). So only the form changes. Either a banking crisis is possible or high inflation is possible.

Let us elaborate on the sub-case $T < (s + K^G)R'$. A banking crisis is possible in this case. Formally, we have

**Corollary 1.3.** *In the special case $s > 0$ and $K^G > 0$, if $K^P + K^G = r_1 - 1$ and $T < (s + K^G)R'$, then $P(B) > 0$.*

This concludes the discussion of the special cases. In the rest of this section, we will consider the general case i.e. $s \geq 0$, $K^G \geq 0$. We have already discussed cases of vulnerability. Henceforth, in this section, we will assume that the capital adequacy condition is met.

A critical issue in the paper is whether or not the government defaults. Let us elaborate on this. Consider, what we may call, the *balanced budget equation*:

$$G(t, T) = (s + K^G)R',$$

where we have used the expression $G(t, T)$ (instead of $G(t)$) to study the role of $t$ and $T$. Using (7), we can write the balanced budget equation as

$$T + \frac{K^G}{K^P + K^G}\left\{(1 + K^P - s - r_1 t)R' + (s + K^G)R' - r_2(1 - t)\right\} = (s + K^G)R'.$$

It is easy to check that

$$\left.\frac{dT}{dt}\right|_{G(t,T)=(s+K^G)R'} = \frac{K^G}{K^P + K^G}(r_1 R' - r_2)$$

So we have a linear relationship between $t$ and $T$ for a given $(r_1, r_2)$. Assume that $r_1 R' - r_2 > 0$ as in Proposition 1. We have then an upward sloping

In the context of a developed country like USA, Cochrane (2010) shows that there can be inflation due to a large public debt. Furthermore, the paper shows that this can happen soon, given the expectations now of default in future.

*balanced budget line* on the $(t, T)$ plane. It is easy to check that it passes through the point $t = 0$ and

$$T = sR' - \frac{K^G}{K^P + K^G}(R' - r_2) \equiv \underline{T}, \tag{11}$$

and also through the point $t = 1$ and

$$T = sR' + \frac{K^G}{K^P + K^G}(r_1 - 1)R' \equiv \overline{T}. \tag{12}$$

Note that if $K^P + K^G = r_1 - 1$, then $\overline{T} = (s + K^G)R'$. Above the balanced budget line, the government has a surplus. If $(t, T)$ is below the line, the government has a deficit. Since period 2 is the terminal period in the model here, the government defaults on its borrowing from the bank if $(t, T)$ is below the line.

If $T < \underline{T}$, the government defaults for all values of $t$. The government defaults for $t > t_1$, where $t_1$ is implicitly given by

$$G(t_1, T) = (s + K^G)R', \quad \underline{T} \leq T < \overline{T}. \tag{13}$$

Finally, if $T \geq \overline{T}$, the government does not default for any value of $t$.

So far, our discussion has been based on a given $(r_1, r_2)$, and on the assumption that $r_1 R' - r_2 > 0$. We will now show how $r_1$ and $r_2$ are determined, and conditions under which $r_1 R' - r_2 > 0$ holds. But before we do this, let us define $\triangle$ as follows:

$$\triangle = \begin{cases} 0, & \text{if } T \geq \overline{T} \\ \int_{t_1}^{1} (s + K^G)R' f(t)dt - \int_{t_1}^{1} G(t) f(t)dt > 0, & \text{if } \underline{T} \leq T < \overline{T} \\ sR' - T > 0, & \text{if } T < \underline{T}, \end{cases} \tag{14}$$

where $\underline{T}$, $\overline{T}$ and $t_1$ are given by (11), (12) and (13) respectively. This $\triangle$ will play an important role in Proposition 2 that follows. We will first formally state and prove this proposition, and then explain it. That will also clarify the economic intuition behind $\triangle$ defined above.

**Proposition 2.** *Assume that relative risk aversion is greater than* 1*, and that effective capital adequacy condition (8) is met. The solution to the problem of inter-temporal consumption smoothing is implicitly given by the following simultaneous equations:*

$$u'(c_1) = R'u'(c_2) \tag{15}$$

$$(1 - c_1 t^e)R' - (1 - t^e)c_2 - \triangle = 0. \tag{16}$$

*where* $c_i = r_i$*,for* $i = 1, 2$*. Finally,* $r_1 R' - r_2 > 0$*.*

**Proof:** Given their utility function, type 1 agents withdraw in period 1. Given that condition (8) is met, type 2 agents withdraw in period 2 only. We will use this throughout in this proof. We have three cases: (1) $T \geq \overline{T}$, (2) $\underline{T} \leq T < \overline{T}$, and (3) $T < \underline{T}$. We will consider each one by one.

In case (1), $G(t) \geq (s + K^G)R' \ \forall\, t$. In this case, expected return of the private shareholders is

$$\frac{K^P}{K^P + K^G} \int_0^1 \Big[(1 + K^P - s - r_1 t)R' + (s + K^G)R' - r_2(1 - t)\Big] f(t)dt,$$

where $\frac{K^P}{K^P + K^G}$ is the share of private shareholders in bank's profits, and the definite integral is the expected profit of the bank (see the discussion before (6)). In equilibrium, due to competition, we have

$$\frac{K^P}{K^P + K^G} \int_0^1 \Big[(1 + K^P - r_1 t)R' + K^G R' - r_2(1 - t)\Big] f(t)dt = K^P R',$$

after simplifying the expression for expected returns, and using (3). It is easy to check that this condition reduces to (5). Optimisation problem is to maximise (1) subject to (5). We get (15) and (16), where $\triangle = 0$ in case (1). This completes proof for case (1).

Now consider case (2) i.e. $\underline{T} \leq T < \overline{T}$. Recall that $\min[G(t), (s + K^G)R'] = (s + K^G)R'$ if $t \leq t_1$, and $\min[G(t), (s + K^G)R'] = G(t)$ if $t > t_1$. Accordingly, the total expected profit of the bank in case (2) is

$$\begin{aligned}
& \int_0^{t_1} \Big[ (1 + K^P - s - r_1 t)R' + (s + K^G)R' - r_2(1-t) \Big] f(t)dt + \\
& \int_{t_1}^{1} \Big[ (1 + K^P - s - r_1 t)R' + G(t) - r_2(1-t) \Big] f(t)dt \\
= \ & \int_0^{1} \Big[ (1 + K^P - s - r_1 t)R' - r_2(1-t) \Big] f(t)dt + \\
& \int_0^{t_1} (s + K^G)R' f(t)dt + \int_{t_1}^{1} G(t)f(t)dt \\
= \ & (1 - r_1 t^e)R' - r_2(1 - t^e) + (K^P - s)R' + [(s + K^G)R' - \triangle]
\end{aligned}$$

where $\triangle$ is given by the second part of (14). In equilibrium, the expected profits of the private shareholders is equal to their reservation utility. Hence,

$$\frac{K^P}{K^P + K^G} \Big\{ (1 - r_1 t^e)R' - r_2(1 - t^e) + (K^P - s)R' + [(s + K^G)R' - \triangle] \Big\} = K^P R'$$

after using (3). After a simple manipulation, we get (16). The optimization problem for the bank is as follows: Maximise (1) subject to (16). This gives (15).

In case (2), it follows from the definition of $t_1$ that $G(t) < (s + K^G)R'$ if $t_1 < t < 1$. Hence, we have $\int_{t_1}^1 (s + K^G)R' f(t)dt - \int_{t_1}^1 G(t)f(t)dt > 0$. This completes proof for part (2) of the proposition.

Finally, consider case (3) i.e. $T < \underline{T}$. In this case, $\min[G(t), (s + K^G)R'] = G(t) \ \forall \ t$. Following the method in the previous two cases, we have in equilibrium

$$\frac{K^P}{K^P + K^G} \int_0^1 \Big[ (1 + K^P - s - r_1 t)R' + G(t) - r_2(1-t) \Big] f(t)dt = K^P R'.$$

Substituting for $G(t)$ from (10) and using some simple algebra, we get

$$(1 - r_1 t^e)R' - r_2(1 - t^e) - (sR' - T) = 0. \tag{17}$$

We have now obtained the expression in the third and final part of (14). The optimization problem for the bank is to maximise (1) subject to (17). This gives (15).

We need to show that $sR' - T > 0$. In case (3), we have $T < \underline{T}$. Using (11), we get

$$T < sR' - \frac{K^G}{K^P + K^G}(R' - r_2) < sR'$$

where the last inequality follows from $r_2 < R'$. We need to show this next.

Observe that (16) is the condition that reservation expected utility of risk neutral agents is just met. So this trades off $r_2$ against $r_1$. Given that relative risk aversion is greater than 1 and $R' > 1$, it now follows from (15) that $1 < r_1 < r_2 < R'$ (Diamond and Dybvig, 1983, p. 407, footnote 3). It now follows that $r_1 R' > R'$ since $r_1 > 1$. Further since $R' > r_2$, we have $r_1 R' > r_2$. $||$

Let us explain the above Proposition[19]. As mentioned earlier, $r_i = c_i$ where $i = 1, 2$, and $c_i$ is consumption in period $i$. Equation (15) is the standard optimality condition in inter-temporal consumption smoothing. This is similar to that in the benchmark model (see Prior Result 1 and its explanation). Equation (16) holds when the participation constraint of the private shareholders is met. This differs from condition (5) in the previous section in that we now have $\triangle$ in the equation. The value of this is given by

[19]Note that $\underline{T}$ and $\overline{T}$ are not exogenously given (see (11) and (12)). But we can get these in terms of the parameters of the model after using a specific utility function and a specific distribution function. We avoided this to keep the analysis general.

equation (14). Observe that $\triangle \geq 0$. It is equal to 0 if the government has adequate resources in period 2, and there is no default by the government. In this case, the solution is similar to that in the benchmark model (see Prior Result 1). It is positive if the government has inadequate resources in period 2, and there is default by the government. See equation (14). This has three cases:

(1) $T \geq \overline{T}$,

(2) $\underline{T} \leq T < \overline{T}$, and

(3) $T < \underline{T}$.

In the first case, $\triangle = 0$. In the second case and in the third case, we have $\triangle > 0$. As mentioned earlier, in the second case, the government defaults for some values of $t$, whereas in the third case, the government defaults for all values of $t$. Recall that $t$ is the proportion of risk averse agents who are hit by a liquidity shock in period 1.

In our model, the reservation utility of shareholders is met even though the government can default on its borrowing from the banks. So the cost of default by the government, if any, is borne by the bank depositors. In case (1), there is no default by the government. In case (2) the government may default, and in case (3) the government certainly defaults. Accordingly, the expected utility of depositors is highest in the first case and lowest in the third case, with the expected utility in the second case falling in between. We assume that the expected utility in the third case is greater than the reservation utility of risk averse agents so that participation of these agents is not in question. See equation (2).

The loss of bank depositors due to default by the government may be viewed as a form of *financial repression* (see Agenor and Montiel, 2008). However, observe that this is repression of depositors only. There is no repression for bank shareholders in our model.

In this section, there is possible loss for the depositors due to default by the government. In the previous section, there was no such loss for depositors. This may suggest that the expected utility of depositors in this section is less than that in the previous section. However, this is not necessarily true. The reason is that the return rate in this section is $R'$, which is greater than or equal to $R$, the return rate in the previous section (see the beginning part of this section). A detailed comparison is outside the scope of this paper.

Before we conclude this section, we will make two remarks which will be useful for later reference.

In this paper, we have focused on how inadequate capital in a bank makes it vulnerable to a crisis. We have abstracted from other reasons for a banking crisis. In our model, the probability of a banking crisis ($P(B)$) is zero if and only if the bank capital is adequate. So it follows from Proposition 1 as follows.

**Remark 1.** *Probability of banking crisis is zero if and only if the effective capital adequacy condition (8) is satisfied.*

Recall that condition (8) depends on both the risk in the bank (the mismatch on the two sides of the balance sheet, as reflected in the gap between $r_1$ and 1), and on the fiscal condition of the government.

Next consider the probability of fiscal crisis ($P(F)$). Given the simple treatment of the fiscal side in our model of banking, this simply means that the government's revenues are inadequate to repay the debt.

**Remark 2.** *Probability of fiscal crisis is zero if and only if the government has some minimum taxes and the proportion of depositors hit by a liquidity shock is small. Formally,* $P(F) = 0$ *if and only if* $T \geq \underline{T}$ *and* $t \leq t_1$.

Note that we have $0 \leq t_1 < 1$ if $\underline{T} \leq T < \overline{T}$, and $t_1 = 1$ if $T \geq \overline{T}$ (see the description before Proposition 2).

Probability of a fiscal crisis is zero if and only if two conditions are satisfied. The first condition ($T \geq \underline{T}$) is that the government will have adequate revenues in future. This is intuitively straightforward. The second condition ($t \leq t_1$) is that there is not too much mismatch between the two sides of the balance sheet of the bank (the proportion of type 1 agents who are hit by a liquidity shock is small). If there is a large mismatch, then bank's profits are affected and consequently the government's returns on its share capital in banks is adversely affected.

Note that Remark 1 and Remark 2 highlight how the probability of a banking crisis depends on the fiscal condition, and how the probability of a fiscal crisis depends on the banking condition. This interdependence is not ad-hoc. The formal model brings out the exact nature of the interdependence.

In this section, all the analysis is based on the assumption that agents are rational. However, recent advances in behavioral economics have shown how this assumption is not realistic and how participation of irrational agents can significantly alter well established results in economics. We will consider this next.

## 4 Behavioral economics

The motivation for analysis in this section is as follows. There is a debate on the fiscal condition in a country like India. There are, what we called earlier in the paper, the pessimists and the optimists. The pessimists argue that the credit rating of debt issued by the Government of India is low, which suggests that the fiscal condition is not good. The optimists believe that due to a high economic growth rate, the fiscal condition will improve (and that ratings are not very meaningful or credible). This is really an empirical issue. However, can we use theory to say something beyond what we have learnt in the previous section? More specifically, suppose that the pessimists are right. This implies that there is a possibility of a crisis. Observe that this is under the assumption that agents are rational. But what if they are not rational? Is it possible that the fiscal condition is bad and yet there is no crisis? We will attempt to answer this question in this section. We will show that if beliefs amongst agents are seemingly reasonable but actually wrong, then there can be multiple equilibria. This includes a good equilibrium even if 'fundamentals' are weak.

Following Keynes (1936) and others, it is now well understood that irrationality can lead to panic, loss of confidence and instability. See, for example, Shleifer (2000). We will explore a different possibility. People may have misplaced confidence even where there is reason to be doubtful, and this misplaced confidence may bring about stability. Note that we have used the word 'people' and not the term 'economic agents' in this section.

Public opinion is not always based on scientific economics. People often go by gut feeling, by old ideas, and intuitively appealing ideas. Often each idea, in itself, may have merit but the overall story may not be correct. We will explore such a case here. There is an old idea that banks need to have adequate capital. This point has been hammered repeatedly at least since the late 1980s. This is also an appealing idea. It also has the respectability that it is advocated by Basle Committee (though, of late, credibility of some of these institutions has got somewhat eroded). Indeed, there is nothing wrong with the idea as such but, as we will see, the overall story need not always be correct.

There is another idea which has considerable influence. This idea is that banks are safe so long as government support is there. This idea has become widespread since 1935 when the US government intervened by introducing deposit insurance. But the government support may take other forms like public ownership of banks, or meaningful regulation and supervision of banks. Though of late there is less faith in regulation, the faith in deposit insurance (and public ownership of banks in many places) has persisted. In many cases, it has increased.

One may have thought that the faith in government support in the form of deposit insurance may be questioned now that many governments are facing financial difficulties (some have faced near fiscal crises). But this does not seem to be the case (at least not in all 'difficult' countries). In the context of banking, there is considerable faith in government support for banks in general, and for public sector banks in particular.

People can have wrong beliefs and wrong 'models' in mind. Let us assume that people think that banking crisis is not possible so long as bank has adequate capital, *or* so long as the government support for banks is available. It is believed that government support for banks will always be forthcoming so long as the government itself has funds. In other words, banking crisis is not possible so long as the chances of a fiscal crisis are zero.

The above discussion leads to the following formulation:

$$P(B) \begin{cases} = 0, & \text{if } \mathcal{K} \geq \underline{\mathcal{K}} \text{ or } P(F) = 0 \\ > 0, & \text{elsewhere,} \end{cases} \tag{18}$$

where $P(B)$ is the probability of a banking crisis, $P(F)$ is the probability of a fiscal crisis, $\mathcal{K}$ is the amount of (credible) capital that the bank has, and $\underline{\mathcal{K}}$ is the amount of adequate bank capital. Equation (18) says that the perceived probability of a banking crisis is zero if banks have adequate capital, *or* the perceived probability of a fiscal crisis is zero (which is when bank recapitalization by the government is credible). Furthermore, it says that the perceived probability of a banking crisis is positive elsewhere i.e. if $\mathcal{K} < \underline{\mathcal{K}}$ and $P(F) > 0$ (banks have inadequate capital, *and* the perceived probability of a fiscal crisis is positive).

The probability of banking crisis depends on the probability of fiscal crisis. The latter is endogenous. Let us now consider how a fiscal crisis may be perceived by the public. Suppose that it is believed that no fiscal crisis is possible if the government has adequate taxes in future. It is also believed that there need not be any fiscal crisis even if the government does not have adequate taxes in future, provided the government can continue to borrow from banks. Observe that this is possible provided there is no banking crisis. This discussion motivates the following formulation:

$$P(F) \begin{cases} = 0, & \text{if } \mathcal{T} \geq \underline{\mathcal{T}} \text{ or } P(B) = 0 \\ > 0, & \text{elsewhere,} \end{cases} \tag{19}$$

where $\mathcal{T}$ is the amount of taxes that the government has, and $\underline{\mathcal{T}}$ is the amount of taxes that are adequate. Equation (19) says that the probability of a fiscal crisis is zero if one of the two conditions holds. Either the government has adequate taxes ($\mathcal{T} \geq \underline{\mathcal{T}}$) or the government is able to borrow from commercial banks, which is possible when there is no banking crisis ($P(B) = 0$). Furthermore, formulation (19) says that the probability of a fiscal crisis is positive elsewhere i.e. if $\mathcal{T} < \underline{\mathcal{T}}$ and $P(B) > 0$ (the government does not have adequate taxes *and* the probability of a banking crisis is positive).

The above two formulations may reasonably express the views of many people based on their experience (see Thakore (2010) for a somewhat related model). It is interesting that we now have two 'equations' in two variables $P(B)$ and $P(F)$. We can solve the two equations to determine whether each of the probabilities is zero or positive. The solution can be in terms of the parameters of the model.

We will first mathematically state and prove our next proposition, and then discuss the economic content.

**Proposition 3.** *There is no crisis if the government has adequate taxes or the banks have adequate capital. If this condition is not met, then there are two possible outcomes - (a) zero probability of a crisis, and (b) positive probability of a banking crisis and fiscal crisis. Formally:*

*If $\mathcal{T} \geq \underline{\mathcal{T}}$ or $\mathcal{K} \geq \underline{\mathcal{K}}$, there is a unique solution i.e. $P(F) = P(B) = 0$. If $\mathcal{T} < \underline{\mathcal{T}}$ and $K < \underline{\mathcal{K}}$, then there are two solutions - (a) $P(F) > 0$, $P(B) > 0$, and (b) $P(F) = 0$, $P(B) = 0$.*

**Proof:** The proof is simple. Let $\mathcal{T} \geq \underline{\mathcal{T}}$. From (19), we get $P(F) = 0$. Now it follows from (18) that $P(B) = 0$. Next, let $\mathcal{K} \geq \underline{\mathcal{K}}$. From (18), we get $P(B) = 0$. Now it follows from (19) that $P(F) = 0$.

We are now left with one case in which $\mathcal{T} < \underline{\mathcal{T}}$ *and* $\mathcal{K} < \underline{\mathcal{K}}$. Given

$\mathcal{T} < \underline{\mathcal{T}}$, from (19), we have

$$P(F) \begin{cases} = 0, & \text{if } P(B) = 0, \\ > 0, & \text{if } P(B) > 0. \end{cases} \tag{20}$$

Given $\mathcal{K} < \underline{\mathcal{K}}$, from (18), we have

$$P(B) \begin{cases} = 0, & \text{if } P(F) = 0 \\ > 0, & \text{if } P(F) > 0. \end{cases} \tag{21}$$

Given that $P(F) = 0$, it follows from (21) that $P(B) = 0$. Now given that $P(B) = 0$, it follows from (20) that $P(F) = 0$. So $P(F) = P(B) = 0$ is a solution. By the same logic, there is another solution viz., $P(F) > 0$ and $P(B) > 0$. $||$

When 'fundamentals' are strong i.e. when the government has adequate taxes ($\mathcal{T} \geq \underline{\mathcal{T}}$), or banks have adequate capital ($\mathcal{K} \geq \underline{\mathcal{K}}$), then neither a banking crisis nor a fiscal crisis is possible ($P(F) = P(B) = 0$). This is the first part of the above proposition. Recall that adequate capital here is used in a broad sense to mean that banking is sound. It is obvious that banking crisis can be ruled out if banks have adequate capital. It is also not surprising that a banking crisis can be ruled out if the government has adequate taxes because the government's rescue of weak or difficult banks, if any, is credible. Next consider a fiscal crisis. It is obvious that a fiscal crisis can be ruled out if the government has adequate taxes. It is also not surprising that a fiscal crisis can be ruled out if banks have adequate capital. This is because banks do not face a problem and so their investments in government bonds are credible. Banks are in many countries required to invest in government bonds, provided of course that they are in a position to do so.

Let us now consider the more interesting outcome when 'fundamentals' are weak i.e. $\mathcal{T} < \underline{\mathcal{T}}$ and $\mathcal{K} < \underline{\mathcal{K}}$. This is the second part of the above proposition. When the government has inadequate tax revenues and banks have inadequate capital, then there are two solutions. In one case, we can have a banking crisis and also a fiscal crisis, and in the other case, we have no possibility of a crisis. The former is not surprising, given inadequate tax revenues and inadequate capital with banks. But it is interesting that a good outcome (no crisis) is possible, even though banks have inadequate capital and the government has inadequate revenues. The 'intuition' is as follows. Given that a fiscal crisis is not possible, people have confidence in *government-backed banks*, and are willing to invest in bank deposits. Now given that people invest in bank deposits, the banks can finance the fiscal deficits and so a fiscal crisis is not possible. People have confidence in *banks-backed government*.

The behavioral model in equations (18) and (19) may seem reasonable 'public opinion' but it is no substitute for a really formal model like the one in the previous section. See, in particular, Remark 1 and Remark 2 in the previous section, and compare with equations (18) and (19) respectively. In the previous section, we have outlined a formal model in which agents are rational. We saw how if and only if banks have inadequate capital, they are vulnerable to a run i.e. the probability of a crisis is positive (see the corollaries to Proposition 1). So if agents are rational, the probability of a banking crisis can be zero only if fundamentals are strong (banks have effectively adequate capital). In this section, we have shown how if agents are irrational, the probability of a banking crisis can be zero even when fundamentals are weak.

## 5 Conclusion

We began with a benchmark model of banking with two groups of investors. Each has some endowment. One invests in deposits and the other invests in bank shares. If the bank has adequate capital, then there is no banking crisis. In this benchmark model, the government is neither a borrower from the banks nor an investor in bank shares. Bank capital acts as a cushion for depositors who may otherwise feel the impact of usual risks in banking. In this model, the entire share capital is credible. There is no contingent capital in this model.

After this benchmark model, we considered a more elaborate and new model. In this model, government invests in bank capital. However, the government does not have any resources to begin with. So it borrows from banks, and uses some of these funds to invest in bank capital. The government has some future taxes, which are a source for settling its debt. But these taxes may or may not be adequate. In this context, we have an interesting and important result. Public sector banks in some countries may on the face of it be meeting the capital adequacy requirements. However, the government's share capital in banks in some countries is effectively contingent capital, which may be only partly credible. The credibility of contingent capital provided by the government to banks depends on whether or not the fiscal condition is good in future. Under some conditions, there is no problem. Under other conditions, banks seemingly meet the capital adequacy requirements but effectively this is not the case.

Our analysis leads us to conclude that the probability of a banking crisis is positive if effectively banks do not have adequate capital. However, the probability of a banking crisis can, in practice, be zero. We attempted to explain this with behavioral economics. We have shown that there exist some wrong set of beliefs under which the probability of a crisis is zero even though banks effectively have inadequate capital and are vulnerable.

For a long time, economists have used the assumption that agents are rational. In recent times, there have been advances in behavioral economics. However, the use of behavioral economics has been restricted to financial markets, where it has been useful in understanding excessive volatility in financial markets. This paper has applied behavioral economics to banking (and not to financial markets). Furthermore, behavioral economics in this paper is used not to explain volatility but the opposite. We have shown that banks can be stable if agents have some wrong set of beliefs. It is interesting that wrong public opinion can give us stability. It is, however, not clear if this kind of stability is good for an economy. The problems can become more serious in future. This aspect is, however, beyond the scope of this paper.

The model in this paper has been motivated by some economic and institutional conditions prevailing in the fiscal system in India. We hope that it helps to clarify some issues in the debate between the optimists and the pessimists on the fiscal situation in India. Beyond that, it is an empirical issue whether the optimists or the pessimists are right. The pessimists have noted that on some measures, the Indian fiscal situation is comparable to that in Greece. However, they have been at a loss to explain why there is no crisis in India unlike in the case of Greece. We hope our model helps understand these issues better.

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