Government, taxes and banking crises

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A B S T R A C T

This paper analyzes the effectiveness of different government policies to prevent the emergence of banking crises. In particular, we study the impact on welfare of using taxpayers money to recapitalize banks, government injection of money into the banking system through credit lines, the creation of a buffer and taxes on financial transactions (the Tobin tax). We illustrate the trade off between these policies and derive policy implications.

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1. Introduction

The recent financial turmoil has revived the debate concerning government responsibility in crises management. It also shows that investors, governments and depositors share their ignorance about the real quality of banks' investments, and this ignorance has been made worse by the actions of the main risk rating agencies like Moody's, Standard and Poor's and Fitch Ratings. As the crises of the 1929, Black Friday, LTCM and the subprime crises have shown, governments cannot predict the proximity of a crisis and consequently can only address it once it has already occurred.

Whenever there is a systemic banking crisis there is a need to inject liquidity into the banking system in order to avoid an excessive credit contraction.[1] Different mechanisms can be used, but all of them are costly. A recent study by Laeven and Valencia (2008) analyses 42 systemic banking crises[2] and shows that there was some kind of government intervention to rescue banks in 32 of them. In seven cases, the government bought bad assets/loans, in twelve cases, the government injected cash in banks; whereas in two cases governments provided credit lines to banks.

In the Mexican and Japanese crises, in particular, the government purchased toxic assets, but the fiscal cost of such policy was very high. In contrast, in the banking crises of Sweden, Norway and Finland, the recapitalization was done mainly by injections of public capital into the banking system. The US government, however, has hesitated on the possibility of buying toxic mortgage assets.

Therefore, governments have taken an active role in most crises. However, this has been ignored in the banking literature, which is mostly concerned with the role of the Central Bank. The aim of this paper is to analyze theoretically the role of the government in crisis management.[3] In particular, it is a well known fact that deposit insurance is not sufficient to impede systemic banking crises. While it can be effective to prevent some panic behaviour (like in Diamond and Dybvig (1983)), it is not effective when bank runs are informa

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[1] For example, Ramírez (2009), presents evidence that a 1% increase in bank instability reduced output growth by 2 5%.

[2] Bank runs are a common feature of banking crises, with 62% of crises experiencing sharp reductions in total deposits. For example, Argentina experienced system wide runs in the crisis of 2001. Banking panics were a common occurrence in the United States in the late 19th and early 20th century, as well as in the Great Depression and have occurred in several developing countries including Brazil 1990, Russia 1995, Malaysia 1999, Ecuador 1999 and Uruguay 2002, among others (see Laeven and Valencia, 2008).

[3] In particular, recent examples in Argentina and Uruguay (2001 2002) have shown that government policies might in some cases intensify while in others attenuate the effect of banking crises. While Uruguay kept property rights, the currency denomination of bank deposits and public debt, and promoted a mutual agreement with international debt holders, Argentina did exactly the opposite; more specifically, it "pesofied" deposits (changed the denomination of deposits from American dollars to Argentinean pesos), unilaterally declared default and devaluated the currency.

tion induced or when many banks are affected. In these cases, other safety nets, like injection of funds, are usually needed.[4]

We model an economy where agents can deposit their money in banks[5] or privately invest it in a long term technology. In addition, agents may face a liquidity shock and become impatient depositors. Impatient depositors face a utility loss of not having enough liquid assets, and therefore the possibility of risk sharing provided by banks is generally welfare improving. In our model, the government may raise taxes so as to provide public services, as for instance education, health, social security, national security, recreation activities, etc. Taxing has an implicit cost because at the same time it lowers the availability of funds for private investments. In this paper, we show that this may exacerbate a banking crisis. Although funds might be reoriented once a crisis is expected to occur, this practice normally has an additional cost that decreases its effectiveness. In the absence of taxes, agents may not face the risk of a bank run but they do not consume public services either.

We analyze the effectiveness of the different policy options available to the government for preventing systemic banking crises, such as using taxpayers money to recapitalize banks[6] or to inject liquidity into the banking system through credit lines. We show that recapitalization dominates public lending in terms of welfare and it is less costly. In other cases, the government should create a buffer, in particular, when the cost of liquidating the public asset is low.

We also study taxes on financial transactions that exist in some developing countries like Argentina, Brazil, Colombia and Serbia. These taxes have been used extensively in emerging markets not to prevent bank runs, as we analyze in this paper, but as a way to obtain government funding. Taxes on financial transactions represent an important source of funding for those governments (22,471.9 millions of dollars for Brazil and around 2700 millions of dollars for Argentina in 2007), and can be considered as a special case of the Tobin tax. Usually those taxes are implemented over a certain period (a year, for example, in Venezuela). The existence of a tax on short term transactions creates incentives to use the assets that are not taxed, and as a result might decrease the incentives to run on banks.[7] Nevertheless, banking crises might sometimes be efficient. This is the case when using taxpayers money is too costly or too risky and/or the government is not able to reorient resources efficiently.

This article is related to several papers in the banking literature. In the seminal model by Diamond and Dybvig (1983), banks are considered to be liquidity providers, but are subject to bank runs in the form of sunspots. In our setting agents also face liquidity shocks, but bank runs are the result of a bad signal about the success of the long term project. Consequently, our paper is close in spirit to Goldstein and Pauzner (2005), where bank runs are a phenomenon closely related to the state of the business cycle.[8] Similarly, Gorton (1988) suggests that bank runs are not due to sunspots but to the existence of rational agents that modify their expectations due to a change in economic conditions (i.e., a change in the business cycle).

In the present paper, a smaller banking activity is compensated by a greater government size. Governments and banks both improve welfare but have to compete for private funds. Besides the fact that a government can provide public services, it makes banking crises more likely to occur. Also, crises occur with positive probability as in Cooper and Ross (1998) and Chang and Velasco (2000a,b).

We build on the model of Chen and Hasan (2006), although we modify their framework by introducing a government that may raise taxes so as to provide public services. Additionally, in our model, depositors receive a more informative signal about the evolution of the investment. Moreover, we investigate how governments can affect the occurrence as well as the resolution of banking crises instead of focusing only on the bank side as it is the case in most of the previous academic banking literature.[9] For open economies, Chang (2007) presents a very good approach for the coexistence of financial and political crises but without focusing neither on the financial activity of banks nor on the role of the government as a provider of public services, which are our main concerns.

The rest of the paper is organized as follows. Section 2 presents the basic features of the model. Section 3 studies bank runs and the optimal deposit contract. Sections 4 and 5 analyze different government policies to handle banking crises. Section 6 provides some comparative statics among the different policies and finally, Section 7 summarizes the concluding remarks.

2. The model

We consider a three date (0, 1, and 2) and one good economy. There is a continuum of agents, of measure one, in the economy. Each agent receives an endowment of one unit of the good at date 0 and can deposit it in a bank or alternatively invest it in a long term project. This long term project transforms each unit of the good at date 0 into R units with probability p and 0 with probability $(1-p)$, at date 2. Let $p \equiv p_0$ be the prior probability of success of this project. We assume that $p_0R > 1$ and that the long term technology can be liquidated at no cost. At date 1, depositors receive a public signal $s \in \{H,L\}$ on the true return of the long term project, where H reveals that the probability of success is higher than 1/2 and L reveals the contrary. Depositors update their beliefs in accord with Bayes' rule. Let p^H and p^L be the posterior probabilities of success when $s = H$ and $s = L$.[10] We assume that $p^H > p_0 > p^L$ and that $p^LR > 1$. Finally, there exists a short term technology that is not profitable at any date. In particular, this technology transforms each unit of the good at date t into $R' > 1$ units with probability p' and 0 with probability $(1-p')$ at date $t+1$, with $p'R' < 1$. Therefore, at date 0 neither banks nor agents will find it optimal to invest in such technology. However, as we show in Section 4, a government policy may induce banks to do so.

At date 0, the government may raise T taxes, with $0 < T < 1$, so as to invest in a public asset.[11] The taxpayers are both depositors and agents who privately invest in the long term project. The public asset transforms the T units of the good into public services that are con

4 For example the size of the Japanese equivalent to the FDIC (Federal Deposit Insurance Corporation) was so small that it exhausted its resources almost immediately after the first bank failures in 1995 (Mishkin, 2007).

5 In our model banks are any type of financial intermediaries that finance long term loans with short term deposits or maturity bonds.

6 In this paper, recapitalization can be interpreted as the government buying banks' assets for less than their market value.

7 A recent paper by Schuh and Stavins (2010) shows how small changes in relative costs of payment instruments can have important effects on their substitutability.

8 Recent studies, see e.g., Hasman and Samartín (2008) and Hasman et al. (2008),

9 For an excellent review of the academic literature on banking see Gorton and Winton (2002).

10 Therefore, $p^H \equiv \Pr[R|H] = \Pr[H|R]p_0/(\Pr[H|R]p_0 + \Pr[H|0](1-p_0))$ and $p^L \equiv \Pr[R|L] = \Pr[L|R]p_0/(\Pr[L|R]p_0 + \Pr[L|0](1-p_0))$.

11 We assume that the size of the public expenditure, T, is exogenous. For instance, T could be the result of a political program or the rate of taxation at which maximal revenue is generated (the point at which the Laffer curve achieves its maximum). Nevertheless, the level of taxes has to be kept under certain limits. If T was unconstrained then it could result in an excessive collection of taxes that may impede participation in the banking system. The maximum T is thus related to the magnitude

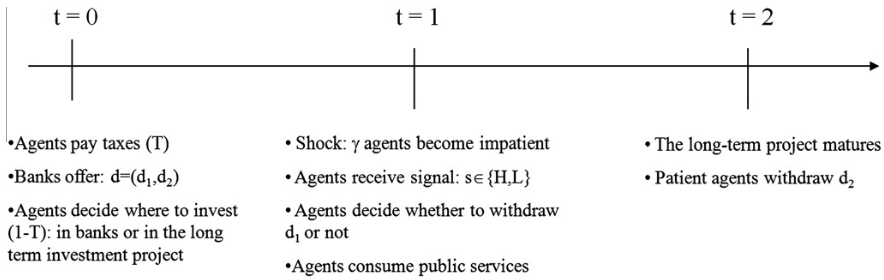

Fig. 1. Sequence of events.

sumed by everybody at date 1. We assume that the utility of consuming public services is as follows: $U(T) = \theta\frac{T^{1-\rho}}{1-\rho}$, where $0 < \theta < 1$ and $0 \leqslant \rho < 1$. The government's objective is to maximize the agents' expected utility. Agents are ex ante identical. At date 1 agents may face a liquidity shock: a proportion γ of them becomes impatient and must consume by date 1. Agents do not know at date 0 whether they will be impatient (type 1) or patient (type 2), but they know the value of γ. We assume that if impatient agents consume less than $r > 1$ of the private good at date 1, then they will suffer a utility loss $X > 0$. Agents normally face fixed payments but sometimes they need extra funds to deal with special contingencies. In such cases they need liquid assets in order to afford the payments plus the contingencies (so as to cover r). If they do not have enough cash, then they will have to face different costs (i.e., lawyers or search costs to obtain cash). The idea is therefore to consider an economy in which a group of agents in the population faces liquidity needs (as in Diamond and Dybvig (1983)).[12] Let c_t denote the agent's consumption at date t. The utility function of a type 1 agent, U_1, is

$$U_1(c_1, X) = \begin{cases} c_1 - X + \theta\frac{T^{1-\rho}}{1-\rho} & \text{if } c_1 < r \\ c_1 + \theta\frac{T^{1-\rho}}{1-\rho} & \text{if } c_1 \geqslant r \end{cases} \quad (1)$$

whereas the utility function of a type 2 agent is $U_2(c_1, c_2) = c_1 + c_2 + \theta\frac{T^{1-\rho}}{1-\rho}$.[13]

We assume a perfectly competitive banking industry, where banks maximize the expected utility of depositors subject to a zero profit constraint. At date 0 each bank offers a deposit contract d_t ($t = 1, 2$) to agents, where d_t denotes the maximum amount of money that depositors can withdraw at date t. Depositors are sequentially served, so if all of them run to withdraw their money at date 1, only a fraction of them will receive the promised amount. The depositor's type is her private information.

Any impatient agent who has not invested her money in a bank succeeds to obtain one unit of the good from liquidation, as a result she will always suffer the utility loss X. The existence of a banking industry that promises $d_1 \geqslant r$ should then improve her welfare. In the next section we derive conditions under which this is the case.

The sequence of events is as follows: at $t = 0$, agents pay taxes and invest the rest of their resources in banks or in the long term investment project. We show that if X is large enough, agents always invest the whole amount $(1 - T)$ in the bank.[14] The bank then invests this amount in the long term project. At $t = 1$, agents suffer the liquidity shock, receive the public signal s, decide whether to withdraw their money from banks and consume public services. At $t = 2$, the long term project matures and patient depositors are paid. Fig. 1 illustrates the timing of the model.

3. Bank runs and the optimal deposit contract

In this section we study the effect of taxes on bank runs and derive the optimal deposit contract $d = \{d_1, d_2\}$.

3.1. Bank runs

Suppose that all the agents deposit their endowment (net of taxes) in banks, the return of the total amount of money left in banks at date 2 is $(1 - T - \gamma d_1)R$, provided that the long term project succeeds.[15] Due to perfect competition, this amount of money is totally transferred to type 2 depositors,[16] therefore it must hold that $(1 - \gamma)d_2 = (1 - T - \gamma d_1)R$. Then, for a given d_1 the optimal d_2 is

$$d_2 = \max\left\{0, \left(\frac{1 - T - \gamma d_1}{1 - \gamma}\right)R\right\}. \quad (2)$$

At date 1, depositors update their beliefs according to Bayes' rule, so the expected return of a patient depositor is pd_2, where $p \in \{p^L, p^H\}$. For a given d_1, a type 2 depositor will not withdraw if $pd_2(T) \geqslant d_1$, or equivalently, if

$$p \geqslant \widehat{p}(T) = \frac{(1 - \gamma)d_1}{(1 - T - \gamma d_1)R}. \quad (3)$$

We focus on the case $\widehat{p}(T) < p^H$ for a given d_1. This means that if the realization of s is H, the patient consumer will not withdraw at date 1. Consequently, the observation of H rules out the possibility of bank runs; the economy faces three possible states of nature when $s = L$: (i) if $p^L < \widehat{p}(0) < \widehat{p}(T)$, a bank run will occur in the presence and absence of taxes; (ii) if $\widehat{p}(0) < p^L < \widehat{p}(T)$, a bank run will only occur in the presence of taxes; (iii) if $\widehat{p}(0) < \widehat{p}(T) < p^L$, a bank run will never occur. We are primarily interested in the second case, which reflects a situation in which the economy is more sensitive to the observation of a low profitability signal due to taxes. The reason is that in the presence of taxes there is less money invested in the long term project, and this in turn lowers its expected return $pd_2(T)$. From now on, we assume that this case holds.[17]

[12] X can also be interpreted as a discount factor.

[13] We use the same utility function for private goods as in Chen and Hasan (2006, 2008).

[14] Aggarwal and Goodell (2009) present a detailed description of how national

[15] After paying taxes, $(1 - T)$ is invested in banks and γ impatient depositors withdraw d_1 at date 1.

[16] This is the standard debt contract whereby at maturity, banks offer the total return of the long term project when it succeeds and the return from liquidating the bank's assets when it does not succeed (the latter return is zero in our model).

[17] For any given $d_1 > 0$ and $d_2 > 0$, there exists a low enough p^L so that $p^L d_2 < d_1$. Notice that if agents do not invest their endowment in the banking industry and observe $s = L$, then they will not liquidate the technology when they are patient as $p^L R > 1$. Conversely, if they invest their endowment in the banking industry and observe $s = L$, they will run on banks. Moreover, banks will have to liquidate the

3.2. Optimal deposit contract

As agents can privately invest their endowment in the long term project (or capital market), banks can only obtain deposits by offering a sufficiently attractive contract. In order to ensure participation, the agent's expected utility of depositing their endowment in banks, $W^B(d_1,T)$, must be equal or higher than the agent's expected utility of privately investing it in the long term project, $W^{NB}(T)$. The agent's expected utility of privately investing in the long term project is:

$$W^{NB}(T) = \gamma(1 - T - X) + (1 - \gamma)p_0(1 - T)R + \theta\frac{T^{1-\rho}}{1-\rho}, \tag{4}$$

i.e., agents pay taxes, the impatient agent suffers the utility loss X, the patient agent obtains the expected return on the long term project and both the patient and impatient agent obtain utility from consumption of public services.

On the other hand, the expected utility of depositing the endowment in banks, $W^B(d_1,T)$, is a step function: if $d_1 \geqslant r$ and $s = H$, the impatient depositor will not suffer the utility loss X, whereas if $d_1 < r$ and $s = H$, she will suffer this utility loss. In the presence of a bank run the expected utility of an impatient depositor also depends on d_1: if $d_1 \geqslant r$, only a fraction of impatient depositors who are not served by banks suffer the utility loss X, whereas if $d_1 < r$, any impatient depositor gets $-X$. Formally, we have

$$W^B(d_1,T)|_{d_1\geqslant r} = (1-\pi)V_{BR}|_{d_1\geqslant r} + \pi\left[\gamma d_1 + (1-\gamma)p^H\frac{(1-T-\gamma d_1)}{(1-\gamma)}R + \theta\frac{T^{1-\rho}}{1-\rho}\right], \tag{5}$$

where π is the prior probability of the event H[18] and

$$V_{BR}|_{d_1\geqslant r} = \gamma\left[\frac{(1-T)}{d_1}(d_1) - \left(1-\frac{(1-T)}{d_1}\right)X\right] + (1-\gamma)\left[\frac{1-T}{d_1}(d_1)\right] + \theta\frac{T^{1-\rho}}{1-\rho} = (1-T)\left(1+\frac{\gamma X}{d_1}\right) - \gamma X + \theta\frac{T^{1-\rho}}{1-\rho}. \tag{6}$$

Here, $(1-T)/d_1$ is the probability of being paid d_1 when a bank run occurs. Notice that T has a threefold impact on the expected utility. An increase in T (i) lowers the probability of being paid d_1: $\partial[(1-T)/d_1]/\partial T = -1/d_1$, (ii) lowers the expected utility of a type 1 depositor through the utility loss of not having liquidity: $-\frac{\gamma X}{d_1}$ and (iii) raises the depositor's expected utility through a higher consumption of public services. Similarly,

$$W^B(d_1,T)|_{d_1<r} = (1-\pi)V_{BR}|_{d_1<r} + \pi\left[\gamma(d_1 - X) + p^H(1-\gamma)\frac{(1-T-\gamma d_1)}{(1-\gamma)}R + \theta\frac{T^{1-\rho}}{1-\rho}\right], \tag{7}$$

where

$$V_{BR}|_{d_1<r} = 1 - T - \gamma X + \theta\frac{T^{1-\rho}}{1-\rho}. \tag{8}$$

The next proposition establishes the optimal deposit contract and provides the conditions for banks to dominate private investing. In other words, the conditions for which the expected utility of depositing in banks is at least as high as the expected utility of direct investing: $W^B(d_1,T) \geqslant W^{NB}(T)$.

Proposition 1. *In equilibrium, agents deposit their endowment in banks as long as T is kept under certain limits and X is large enough. Additionally, banks offer the deposit contract*

$$d(T) = \left[r, \left(\frac{1-T-\gamma r}{1-\gamma}\right)R\right].$$

Proof. See the Appendix. □

Assuming that $\gamma < ((1-T)R - r)/(rR - r)$ ensures that $d_1 < d_2$, otherwise a bank run would always occur because all depositors would find it optimal to withdraw at date 1. Note that this condition also implies that $d_2 > 0$. A large enough X ensures full participation. Intuitively, if agents deposit their endowment in banks, then they will suffer the utility loss X with probability $\gamma(1-\pi)$ (i.e., agents must be impatient and also receive the bad signal), whereas if they invest their endowment in the long term project, then they will suffer this loss with a higher probability: γ. From now on, we assume that the conditions provided in Proposition 1 hold.

4. Analysis of government policies

Collecting T taxes, raises the expected utility of agents as long as $\Delta = W^B(r,T) - W^B(r,0) > 0$. In particular, $\partial\Delta/\partial\theta = \frac{T^{1-\rho}}{1-\rho} > 0$ and

$$\frac{\partial\Delta}{\partial X} = \gamma(1-\pi)\left[\frac{1-T}{r} - 1\right] < 0. \tag{9}$$

Therefore, for a given X there exists a high enough θ so that raising taxes is socially optimal. Conversely, for a given θ there exists a large enough X so that raising taxes is not socially optimal. The probability of being an impatient depositor and receiving the bad signal has a clear impact on $\partial\Delta/\partial X$: decreasing γ or increasing π, lowers the impact of X on Δ.

In our economy there is a bank run when the government raises taxes and agents receive the bad signal, $s = L$. However, the government may resolve a banking crisis by means of different policies. Next, we analyze some of them.

4.1. Spending taxpayers money

In this section we study a bailout plan that is paid by taxpayers: the government spends taxpayers money in order to increase the liquidity of the banking sector (as in recent events). We assume that using taxpayers money to rescue banks has a direct negative impact on the utility of taxpayers. In this paper, the taxpayers money comes from liquidation of the public asset, i.e., the government liquidates part of the public asset for cash and injects it into the banking industry. By liquidating the public asset we mean modifying the direction of public funds before they are spent but once they have been accepted in the public budget.[19]

Liquidating the public asset implies consuming less public services. However, this policy has an opportunity cost, as this money could be passed directly to agents (i.e., by collecting less taxes). Moreover, it implies that taxpayers take a risk: if banks fail they will lose their money. On the other side, a bailout plan may generate some externalities in the economy that could lead to an increase in the return of the banks' assets. For example, when banks succeed in paying loans back, resulting in increased economic activity. We show that in this case, the government can transfer those returns to agents although probably at some cost. Let $\lambda < 1$ denote this additional cost for each unit of the public good.

[19] Alternatively, the government could borrow money and use it to bail out banks.

To rescue the financial system, the taxpayers money should cover up the losses on the balance sheet of banks. We consider two alternatives for the government to inject liquidity into the banking industry: recapitalization or lending money to banks.

4.1.1. Recapitalization

Let δ denote the amount of money that should be injected into the banking system so as to recapitalize banks and stop the bank run, then $r = p^L d_2(T) + \delta/(1-\gamma)$ (patient depositors are thus indifferent between withdrawing and not).[20] Hence we have

$$\delta = (r - p^L d_2)(1-\gamma) \tag{10}$$

The depositors' utility is given by

$$U_R = r + \theta \frac{(T-\delta)^{1-\rho}}{1-\rho} \tag{11}$$

Therefore, it is welfare improving to stop the bank run only if $V_{BR}|_{d_1=r}$, which is given by (6), is lower than U_R, which holds if

$$\theta \leqslant \theta^R \equiv \frac{[r-(1-T)]\left(1+\frac{\gamma X}{r}\right)}{\frac{1}{1-\rho}\left[T^{1-\rho} - (T-\delta)^{1-\rho}\right]} \tag{12}$$

The utility loss of using taxpayers money is offset by the depositors' utility gain of having liquidity only when θ is lower than θ^R. Notice that this policy is limited by the total amount of money that is required to bailout banks: θ^R decreases with δ, i.e., the higher is δ, the higher will be the utility loss of agents from using the taxpayers money in a bailout plan, which in turn lowers θ^R. This is not to say that such a policy is never socially optimal. Indeed, from (12) we have that for a given (small) θ recapitalization improves social welfare when X is large enough. Next, we compare this policy with public lending based on taxpayers money.

4.1.2. Public lending

In this case, the government lends money to banks. At date 1, banks receive an amount of money δ, which they must pay back at the end of date 2. Let the interest rate on this loan be i. To pay the loan back, banks will invest in the short term project that yields R' at date 2, with probability p'.[21] The expected return of this technology is: $p'R' < 1$. However in the presence of limited liability, banks have incentives to invest in this technology as they will only pay the debt back when they can do so. This is true whenever $p'[R' - (1+i)] > 0$, which is satisfied for a small (large) enough i (R'). Therefore, to prevent a bank run the loan δ must satisfy the following condition:

$$\widetilde{d_2} = p^L d_2 + \frac{p'[R' - (1+i)]}{(1-\gamma)}\delta = r, \tag{13}$$

where $\widetilde{d_2}$ is the expected payoff to a patient depositor. This condition imposes that the patient depositor is indifferent between withdrawing and not at $t = 1$. The value of δ is then

$$\tilde{\delta} = \frac{\delta}{p'[R' - (1+i)]}, \tag{14}$$

where we have used the fact that $\delta = (r - p^L d_2)(1-\gamma)$, given in Eq. (10).

As we show above, when banks succeed to pay loans back, the government can transfer the returns, $\delta(1+i)$, to the economy at a cost λ. Therefore, the depositors' utility with public lending is given by

$$U_L = r + \theta \frac{[T - \tilde{\delta} + \lambda p' \tilde{\delta}(1+i)]^{1-\rho}}{1-\rho} \tag{15}$$

or replacing the value of δ from Eq. (14) we obtain that

$$U_L = \frac{\left(T - \frac{\delta\alpha}{\beta}\right)^{1-\rho}}{1-\rho} \tag{16}$$

where $\alpha = 1 - \lambda p'(1+i)$ and $\beta = p'[R' - (1+i)]$. In particular, it is welfare improving to stop the bank run through lending only if $V_{BR}|_{d_1=r} < U_L$, or equivalently, if

$$\theta \leqslant \theta^L \equiv \frac{[r-(1-T)]\left(1+\frac{\gamma X}{r}\right)}{\frac{1}{1-\rho}\left[T^{1-\rho} - \left(T - \delta\frac{\alpha}{\beta}\right)^{1-\rho}\right]} \tag{17}$$

If Eq. (17) is satisfied, then even though the government knows that banks will invest in the negative NPV technology, it is welfare improving to extend credit to banks, instead of allowing bank runs.

As $\frac{\alpha}{\beta} > 1$ it is straightforward to show that U_R, given by Eq. (11) is higher than U_L, given by Eq. (16). In addition, notice that recapitalization is less costly than lending ($\delta < \widetilde{\delta}$). We thus have the following.

Proposition 2. *Recapitalization yields higher expected utility than lending and moreover it is less costly. Nevertheless, when $T < \delta$, the government cannot stop the bank run through recapitalization or lending due to its budget constraint.*

5. Additional policies for small economies

In this section we analyze two additional policies that may be of special interest when either recapitalization or lending money to banks is too expensive, or there are commitment problems from the government side. This may be the case of small economies, where the public budget is so small that there is not scope for liquidating public assets (the Iceland recent subprime mortgage crisis may be an example)[22] or when the country has great difficulty obtaining external funding, as for instance emerging economies during a crisis (or Greece during the recent one).

5.1. A preventive policy: Creating a buffer

The government may freeze some funds to prevent the emergence of crises. Since the government can only anticipate the realization of the event after raising taxes, it may prefer to invest only part of the funds in the public services and store the rest of them as a buffer for a potential banking crisis.[23]

Let B denote the necessary buffer size to stop the financial crisis, then $B = (r - p^L d_2)(1-\gamma)$,[24] as a result the government invests only $T' = T - B$ in public services. We may also assume that when the government observes the realization of the event H, it may reinvest B in the public service but at expense of some cost $\lambda < 1$. Here, the government faces the following trade off: whether to spend money in public services but to make the system more prone to shocks or to spend less money in public services and to make the

[20] See footnote 5.

[21] Notice that banks are going to invest the public funds in the short term project. The reason is that the signal about the evolution of the investment is received at date 1, once the long term investment is no longer available since it requires two periods

[22] Iceland could not afford itself the banking crisis. Also, it found difficulties obtaining external funding: western countries refused to help Iceland, after which it asked Russia to extend euro 4 bn (pounds 3.1 bn) credit.

[23] This is the case of Chile, which has a buffer that accounts for 11% of its GDP so as to deal with potential problems. This policy is also in the agenda of the Euro governments.

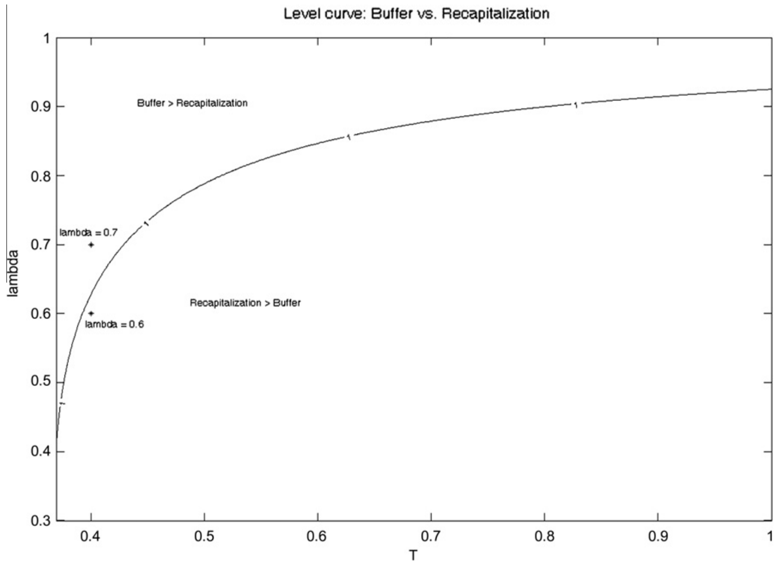

Fig. 2. Recapitalization vs. buffer.

system more resilient to shocks. More specifically, it is socially optimal to create the buffer as long as the agents' expected utility of doing so is higher than the agents' expected utility of investing all the taxes in public services:

$$(1-\pi)r+\pi[\gamma r+(1-\gamma)p^H d_2]+\theta\frac{(T'+\pi\lambda B)^{1-\rho}}{1-\rho}$$
$$\geqslant (1-\pi)V_{BR}|_{d_1=r}+\pi[\gamma r+(1-\gamma)p^H d_2]+\theta\frac{T^{1-\rho}}{1-\rho}. \quad (18)$$

This last expression can be rewritten as follows:

$$\theta\leqslant\theta^{BF}\equiv\frac{(1-\pi)\left(r-\overline{V}_{BR}|_{d_1=r}\right)}{\left(\frac{1}{1-\rho}\right)\{T^{1-\rho}-[T-B(1-\pi\lambda)]^{1-\rho}\}}, \quad (19)$$

where $\overline{V}_{BR}|_{d_1=r}\equiv V_{BR}|_{d1=r}-\theta\frac{T^{1-\rho}}{1-\rho}$. This condition says that creating the buffer B is socially optimal when the expected gain of stopping the bank run is higher than the expected utility loss of using taxpayers money. Therefore, the size of θ and λ are key in determining whether the government will prefer to invest all the funds in the public services or not. In particular, for given π and λ there may exist a high enough θ so that the government may prefer that banking crises occur with positive probability.

We can also compare recapitalization with the creation of a buffer. Notice that the expected utility with recapitalization at date 0 is:

$$W^R=(1-\pi)\left[r+\theta\frac{(T-\delta)^{1-\rho}}{1-\rho}\right]+\pi\left[\gamma r+(1-\gamma)p^H d_2+\theta\frac{T^{1-\rho}}{1-\rho}\right]. \quad (20)$$

Hence, recapitalization dominates the creation of a buffer whenever:

$$W^R\geqslant(1-\pi)r+\pi[\gamma r+(1-\gamma)p^H d_2]+\theta\frac{(T'+\pi\lambda\delta)^{1-\rho}}{1-\rho}, \quad (21)$$

which simplifies to:

$$(T-\delta)^{1-\rho}(1-\pi)+\pi T^{1-\rho}$$

Table 1
Calibration.

r	T	γ	p^L	R	p'	R'	i	λ	ρ	π
1.1	0.4	0.08	0.3	4.2	0.5	1.5	0.2	0.6	0.7	0.53

Proposition 3. *Recapitalization is preferred to creating a buffer when condition (22) holds.*

Fig. 2 presents the comparison between recapitalization and the creation of a buffer, using Eq. (22). The level curve $f(T,\lambda)$ represents the combinations of (λ,T) for which recapitalization and the creation of the buffer yield the same utility. In the northern region the buffer is preferred whereas in the southern region recapitalization is the dominant policy. We observe for a given T, Eq. (22) is satisfied if λ is low enough. In particular, for each T, there exists a $\overline{\lambda}<1$ such that if $\lambda<\overline{\lambda}$ then recapitalization dominates the creation of a buffer and vice versa.

Moreover, if there are commitment problems or the government cannot redirect resources efficiently, recapitalization might not be credible, and so the creation of a buffer is a feasible alternative.

5.2. Taxes on financial transactions (the Tobin tax)

This policy is more prone to be used in emerging markets, where governments are more constrained in their funding capacity or when using taxpayers money is too costly.

The government can levy an additional tax on early withdrawals in order to decrease the incentives of patient depositors to withdraw at $t=1$ and thus stop the bank run. These taxes are too costly for impatient depositors: they will afford the whole cost of preventing the crisis and moreover suffer the utility loss of not having enough liquid assets.[25] Type 1 depositors are taxed the amount δ^{TT} that prevents the bank run, then $r-\delta^{TT}=p^L d_2$. As the government can transfer these taxes to the whole population by

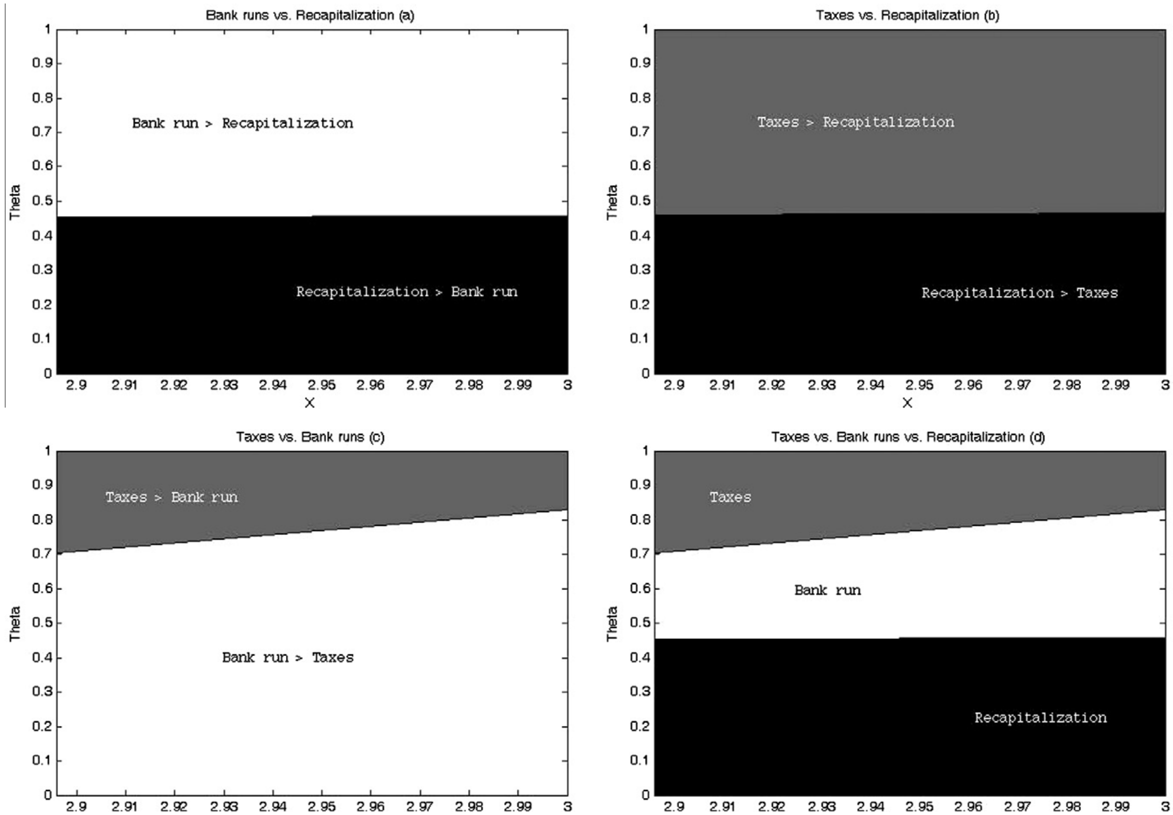

Fig. 3. Recapitalization, taxes and runs.

investing in the public asset (although at some cost λ), we have that the utility of impatient depositors is

$$U_1^{TT}\quad r\quad \delta^{TT}\quad X+\theta\frac{(T+\lambda\gamma\delta^{TT})^{1\quad\rho}}{1\quad\rho}, \tag{23}$$

whereas the utility of patient depositors is

$$U_2^{TT}\quad p^L d_2+\theta\frac{(T+\lambda\gamma\delta^{TT})^{1\quad\rho}}{1\quad\rho}. \tag{24}$$

Thus, the total welfare of this policy is

$$W^{TT}\quad \gamma(r\quad \delta^{TT}\quad X)+(1\quad\gamma)p^L d_2+\theta\frac{(T+\lambda\gamma\delta^{TT})^{1\quad\rho}}{1\quad\rho}, \tag{25}$$

making use of the fact that $\delta^{TT}\quad r\quad p^L d_2$ we have

$$W^{TT}\quad \gamma(\quad X)+p^L d_2+\theta\frac{(T+\lambda\gamma\delta^{TT})^{1\quad\rho}}{1\quad\rho}. \tag{26}$$

This policy must be compared to the expected utility with bank runs ($V_{BR}|_{d_1\quad r}$), in particular $W^{TT}>V_{BR}|_{d_1\quad r}$ as long as

$$\theta\geqslant\theta^{T_1}\equiv\frac{(1\quad T)\left(1+\frac{\gamma X}{r}\right)\quad p^L d_2}{\left(T+\lambda\frac{\gamma}{1\quad\gamma}\delta\right)^{1\quad\rho}\quad T^{1\quad\rho}}(1\quad\rho). \tag{27}$$

Additionally, by comparing taxes on financial transactions with recapitalization, we have that taxes on financial transactions will be preferred to recapitalization whenever

$$\theta\geqslant\theta^{T_2}\equiv\frac{\delta+\gamma X(1\quad\gamma)}{\cdots}\left(\frac{1\quad\rho}{\cdots}\right). \tag{28}$$

Finally, taxes can be compared to the creation of a buffer. Evaluating taxes ex ante yields

$$W_0^{TT}\quad(1\quad\pi)\left\{\left[\gamma(r\quad\delta^{TT}\quad X)+(1\quad\gamma)p^L d_2\right]+\theta\frac{(T+\lambda\gamma\delta^{TT})^{1\quad\rho}}{1\quad\rho}\right\}+\pi\left\{\left[\gamma r+(1\quad\gamma)p^H d_2\right]+\theta\frac{(T)^{1\quad\rho}}{1\quad\rho}\right\} \tag{29}$$

since $r\quad\delta^{TT}\quad p^L d_2$ we have that

$$W_0^{TT}\quad(1\quad\pi)\left\{\left[\gamma(r\quad\delta^{TT}\quad X)+(1\quad\gamma)(r\quad\delta^{TT})\right]+\theta\frac{(T+\lambda\gamma\delta^{TT})^{1\quad\rho}}{1\quad\rho}\right\}+\pi\left\{\left[\gamma r+(1\quad\gamma)p^H d_2\right]+\theta\frac{(T)^{1\quad\rho}}{1\quad\rho}\right\} \tag{30}$$

while the expected utility of creating a buffer is

$$W^{BF}\quad(1\quad\pi)r+\pi(\gamma r+(1\quad\gamma)p^H d_2)+\theta\frac{(T+\pi\lambda B)^{1\quad\rho}}{1\quad\rho} \tag{31}$$

then, taxes will be preferred to the creation of a buffer when $W_0^{TT}>W^{BF}$, or equivalently,

$$\theta\geqslant\theta^{T_3}\equiv\frac{(1\quad\rho)(1\quad\pi)\left(\frac{\delta}{1\quad\gamma}+\gamma X\right)}{\pi T^{1\quad\rho}+(1\quad\pi)\left(T+\lambda\frac{\gamma}{1\quad\gamma}\delta\right)^{1\quad\rho}\quad[T\quad\delta(1\quad\pi\lambda)]^{1\quad\rho}}, \tag{32}$$

Taxes on financial transactions are very unpopular in developed

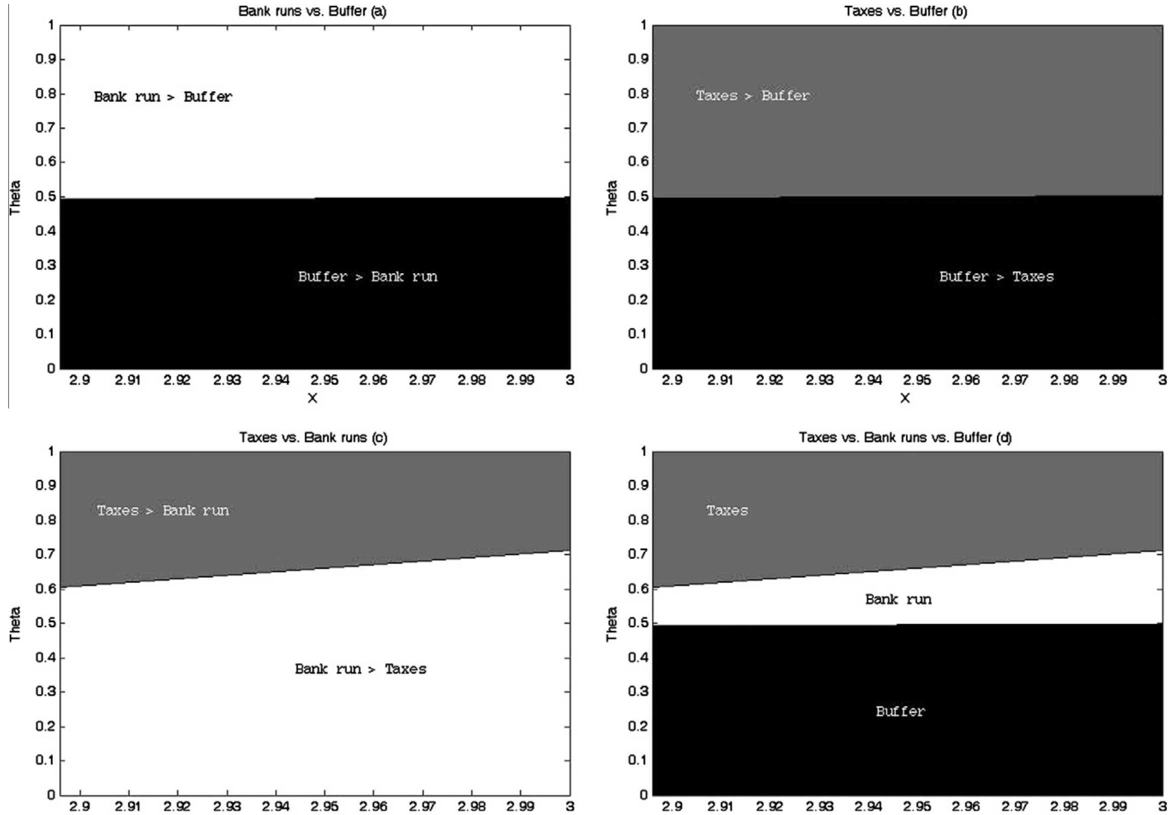

Fig. 4. Buffer, taxes and runs.

whereas they are extensively used in less developed countries where individuals assign a big role to the government or where they value public services highly. In any case, when $T < \delta$, the government might be forced to used the Tobin tax to prevent the bank run due to its budget constraint.

6. Numerical example

This section provides some comparative statics among the different policies, using numerical simulations. Table 1 summarizes the calibration of the model.

These parameter values, satisfy all the conditions of the model.[26] Additionally, these parameters satisfy Proposition 3 and therefore recapitalization dominates the creation of a buffer. Fig. 3a displays the comparison between recapitalization and bank runs, using Eq. (12). The level curve represents the combinations (X,θ) for which recapitalization and bank runs yield the same utility. The northern region represents combinations (X,θ) for which bank runs dominate, whereas in the southern region recapitalization is the dominant policy.

The intuition is that when individuals highly value public services (θ is high), then the best policy in terms of welfare is to allow bank runs as the opportunity cost of impeding them is very high in terms of the consumption of public services. Conversely, when θ is low, recapitalization is the optimal policy.

Fig. 3b carries out a similar analysis to compare recapitalization with taxes on financial transactions (the Tobin Tax), using Eq. (28). The insights are similar to the previous ones. In this case, taxes dominate in the northern region whereas recapitalization in the southern one. Fig. 3c compares taxes on financial transactions with bank runs, using Eq. (27). In this case, taxes are preferred in the northern region, whereas bank runs in the southern one.

Fig. 3d summarizes the previous graphs, showing the comparison between recapitalization, bank runs and taxes on financial transactions. We distinguish three clear regions that represent different policy choices. The northwest region represents a clear dominance of the Tobin tax with respect to the other polices. In the southern region recapitalization dominates the other polices.[27] In the central region the best policy in hands of the government is no intervention, or what is the same, to allow bank runs to occur. That is, taxes dominate bank runs for low values of X and large values of θ, whereas recapitalization is superior to taxes and bank runs for low values of θ.

Fig. 4 presents similar results, when Proposition 3 is not satisfied, and so the creation of a buffer dominates recapitalization (all the parameters remain constant except for λ that now equals 0.7).

Fig. 4a displays the comparison between the creation of a buffer and bank runs, using Eq. (19). The level curve represents the combinations (X,θ) for which the buffer and bank runs yield the same utility. The northern region represents combinations (X,θ) for which bank runs dominate whereas in the southern region the cre

[27] Note that in our paper, a high θ might correspond to a country that has under provision of public services (and hence the marginal utility of consuming public goods is high). This can be the case of developing countries. In Section 5.2 of the paper, we

Table 2
Taxes on financial transaction vs. bank runs vs. recapitalization.

Parameters	Taxes	Bank runs	Recapitalization
r	+	?	–
T	–	+	–
γ	–	+	–
R	+	–	+

Table 3
Taxes on financial transaction vs. bank runs vs. buffer.

Parameters	Taxes	Bank runs	Buffer
r	+	?	–
T	–	?	?
γ	–	?	+
R	+	–	+

ation of a buffer is the dominant policy. Fig. 4b, presents a similar analysis to compare the creation of a buffer with taxes on financial transactions (the Tobin Tax), using Eq. (32). In this case, taxes are preferred in the northern region whereas the buffer in the southern one. Fig. 4d summarizes the previous graphs, showing the compar ison between the creation of a buffer, bank runs and taxes on finan cial transactions. The insights are similar to those of Fig. 3d. We again distinguish three clear regions that represent different policy choices. The northwest region represents a clear dominance of the Tobin tax with respect to the other polices. In the southern region the buffer is the dominant policy. Finally, in the central region the best policy in hands of the government is no intervention, or what is the same, to allow bank runs to occur.

We carry out additional simulations to see how variations in the parameters of the model affect these three regions. Tables 2 and 3, present the results, where a positive (+) sign means that the region where that policy dominates in terms of welfare increases, a nega tive sign ( ) means that the region where that policy dominates decreases and a question mark (?) means that there is not a clear effect and the result will depend on the magnitude of the change.

7. Concluding remarks

This paper analyzes the role that government policies on public expenditure play in the development as well as in the administra tion of banking crises.

We construct a model that incorporates a government into a banking economy. This government raises taxes so as to provide public services. In this way, we can study the resolution of banking crises from the government's point of view instead of focusing only on the bank side as it is the case of most of the previous academic banking literature.

In particular, we analyze the effect of using taxpayers money either to recapitalize banks or to inject funds into the banking sys tem through credit lines. We show that recapitalization dominates public lending in terms of welfare and moreover it is less costly.

We also study other policies in the hand of governments like the Tobin tax or the creation of a buffer. Whilst the Tobin tax is an emergency policy (applied when a banking crisis is imminent), the creation of a buffer is a preventive one. Nevertheless, we argue that both policies might be more appropriate for small or emerging economies, in which governments have more difficulties to obtain funding or where they have commitment problems. Yet, the crea tion of a buffer may dominate recapitalization when the cost of liq uidating the public asset is low.

The numerical simulations show that there exist three clear re gions. ... services (high θ) and are not very much affected by liquidity prob lems (low X), or when public funds are scarce ($T < \delta$), whereas recapitalization (or the creation of a buffer) should be used when θ is low. Finally, we find that for an intermediate range of param eters bank runs should be allowed.

Future research might be devoted to extending the model to multiple banking systems, successive periods and imperfect com petition for depositors.

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Appendix A

Proof of proposition 1. Notice that perfect competition implies that in equilibrium banks maximize the expected utility of agents. In the presence of taxes ($T > 0$) and using (5), we have

$$\frac{\partial}{\partial d_1}\left(W^B(d_1,T)|_{d_1 \geqslant r}\right) \quad \pi\gamma(1 \quad p^H R) \quad (1 \quad \pi)(1 \quad T)\frac{\gamma X}{(d_1)^2} < 0.$$

Thus, increasing d_1 above r, lowers the expected utility of agents. Additionally, $d_1 > pd_2$ with $p \in \{p^L, p^H\}$, triggers a bank run,[28] in which case the expected utility is lower than $W^B(r,T)$ as some depos itors are not paid and/or suffer the disutility X. Thus, in equilibrium banks cannot offer $d_1 > r$. □

When $d_1 < r$, agents get X with probability γ. Consider the con tract d_1 with $r > d_1 \geqslant p^L d_2$. We have

$$W^B(d_1,T)|_{r>d_1 \geqslant p^L d_2} \quad (1 \quad \pi)V_{BR}|_{d_1<r} + \pi\left[\gamma(d_1 \quad X) + p^H(1 \quad T \quad \gamma d_1)R + \theta\frac{(T)^{1 \quad \rho}}{1 \quad \rho}\right],$$

where $V_{BR}|_{d_1<r}$ is given by (8). Thus, $\partial(W^B(d_1,T)|_{r>d_1 \geqslant p^L d_2})/\partial d_1 < 0$, i.e., $d_1 \quad p^L d_2$ maximizes W^B in the range $r > d_1 \geqslant p^L d_2$. Consider now the contract d_1 with $r > p^L d_2 > d_1$. In this case there is no bank run since $p^L d_2 > d_1$, the expected utility of depositors is then given by

$$W^B(d_1,T)|_{r>p^L d_2>d_1} \quad (1 \quad \pi)[\gamma(d_1 \quad X) + (1 \quad \gamma)p^L d_2] + \pi[\gamma(d_1 \quad X) + (1 \quad \gamma)p^H d_2] + \theta\frac{(T)^{1 \quad \rho}}{1 \quad \rho},$$

where $d_2 \quad (1 \quad T \quad \gamma d_1)R/(1 \quad \gamma)$. Then,

$$\frac{\partial\left(W^B(d_1,T)|_{r>p^L d_2>d_1}\right)}{\partial d_1} \quad (1 \quad \pi)\gamma[1 \quad p^L R] + \pi\gamma[1 \quad p^H R] < 0.$$

That is, $d_1 \quad 0$ maximizes W^B provided that $d_1 < r$. This means that in the presence of perfect competition, the optimal deposit contract is $d_1 \quad r$ whenever $W^B(r,T) > \max\{W^B(p^L d_2,T), W^B(0,T)\}$, where

$$W^B(r,T) \quad (1 \quad \pi)\left[(1 \quad T)\left(1+\frac{\gamma X}{r}\right) \quad \gamma X\right] + \pi[\gamma r + p^H(1 \quad T \quad \gamma r)R] + \theta\frac{(T)^{1 \quad \rho}}{1 \quad \rho},$$

$$W^B(p^L d_2,T) \quad (1 \quad \pi)[1 \quad T \quad \gamma X] + \pi[\gamma(p^L d_2 \quad X) + p^H(1 \quad T \quad \gamma p^L d_2)R] + \theta\frac{(T)^{1 \quad \rho}}{1 \quad \rho}$$

with $d_2 \quad (\frac{1 \quad T}{1 \quad \gamma(1 \quad p^L R)})R$, and

$$W^B(0,T) \quad (1 \quad \pi)[\quad \gamma X + p^L(1 \quad T)R] + \pi[\quad \gamma X + p^H(1 \quad T)R] + \theta\frac{(T)^{1 \quad \rho}}{1 \quad \rho}.$$

In particular, $W^B(r,T) > W^B(0,T)$ holds if

$$T < 1 \quad \frac{\pi\gamma[r(p^H R \quad 1) \quad X]}{(1 \quad \pi)[\frac{\gamma X}{r} + (1 \quad p^L R)]},$$

provided that

$$\frac{\gamma X}{r} > p^L R,$$

which is satisfied for X large enough.

In addition, $W^B(r,T) > W^B(p^L d_2,T)$ provided that

$$T < 1 \quad \frac{r\pi}{[(1 \quad \pi)X]}[(p^H R \quad 1)(r \quad p^L d_2) \quad X].$$

Now we study the conditions that ensure full participation. In the presence of taxes, agents will deposit their endowment in banks whenever $W^B(r,T) > W^{NB}(T)$. Using (4) and (5), this inequality holds if

$$T < 1 \quad \frac{\pi\gamma[r(p^H R \quad 1) \quad X]}{(1 \quad \pi)\left(1+\frac{\gamma X}{r}\right) + \pi p^H R \quad \gamma \quad (1 \quad \gamma)p_0 R}$$

provided that

$$(1 \quad \pi)\left(1+\frac{\gamma X}{r}\right) + \pi p^H R > \gamma + (1 \quad \gamma)p_0 R,$$

which is satisfied for X large enough.

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