Too Many to Fail – An Analysis of Time-inconsistency in Bank Closure Policies[1]

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Abstract

While the too-big-to-fail guarantee is explicitly a part of bank regulation in many countries, this paper shows that bank closure policies also suffer from an implicit "too-many-to-fail" problem: when the number of bank failures is large, the regulator finds it ex-post optimal to bail out some or all failed banks, whereas when the number of bank failures is small, failed banks can be acquired by the surviving banks. This gives banks incentives to herd and increases the risk that many banks may fail together. The ex-post optimal regulation may thus be time-inconsistent or sub-optimal from an ex-ante standpoint. In contrast to the too-big-to-fail problem which mainly affects large banks, we show that the too-many-to-fail problem affects small banks more by giving them stronger incentives to herd.

1 Introduction

Historically, central banks evolved as a response to wide-spread banking crises (Gorton, 1985). The central banks were seen as crisis managers who may rescue troubled banks in times when closures could exacerbate welfare losses. Over time, central banks have also taken on the role of crisis prevention and often justified prudential regulation norms as a way of mitigating systemic risk, the risk that many banks may fail together. In this paper, we argue that the crisis-prevention role of a central bank (more generally, the bank regulator) conflicts with its crisis-management role due to a lack of commitment in optimal policies. This lack of commitment induces bank behavior that increases the likelihood of systemic banking crises.

Specifically, time-consistent regulation of banks suffers from a “too-many-to-fail” problem: In order to avoid continuation losses, a regulator finds it ex-post optimal to bail out banks when the number of failures is large; in contrast, if only some banks fail, then these banks can be acquired by the surviving banks. In particular, as the number of failed banks increases and the number of surviving banks decreases, the investment opportunity set for surviving banks becomes larger but the total investment capacity of surviving banks decreases. Thus, it becomes more likely that some banks would have to be liquidated to investors outside the banking sector resulting in a loss of continuation values. In turn, it becomes optimal for the regulator to bail out some of these failed banks instead of liquidating them.

This too-many-to-fail guarantee induces banks to herd ex ante in order to increase the likelihood of being bailed out. For example, they may lend to similar industries or bet on common risks such as interest and mortgage rates. This, in turn, leads to too many systemic banking crises. The regulator's problem is thus one of time-inconsistency. Its ex-post optimal bailout policy is not ex-ante optimal. Or said differently, the ex-ante optimal policy would involve not rescuing banks in crises, but this is not time-consistent.

While the too-big-to-fail problem has been extensively studied in the literature,[1] the too-many-to-fail guarantees have received less attention from policy makers and academics even though such guarantees have been provided regularly to banks during systemic crises. Recognizing and modeling the too-many-to-fail guarantees focuses attention on choices of banks as a group rather than on individual choices, which are the focus of the too-big-to-fail literature. Furthermore, while the too-big-to-fail problem affects primarily the large banks, the too-many-to-fail problem is potentially different in that it may also affect smaller banks.

We formalize these ideas in a framework wherein the ex-ante and the ex-post optimal policies are endogenously derived based on a well-specified objective function for the regulator.

[1] See Freixas (1999) and Goodhart and Huang (1999) for theoretical analysis, and O'Hara and Shaw (1990), Barth, Hudson and Jahera (1995) and Penas and Unal (2005) for empirical work. In Section 5, we discuss this literature in more detail.

To start with, we consider the simplest possible setting. In particular, we first consider a two-period, two-industry model with two identical size banks, a regulator, and outside investors who can purchase banking assets were they to be liquidated. We then extend the basic setup to allow for asymmetric sizes of banks.

Two central assumptions drive our results: (i) banks are more efficient users of banking assets than outsiders as long as they take good projects, and (ii) there is a possibility of moral hazard in that bank owners derive private benefits from bad projects; hence, banks take good projects only if bank owners are given a large enough share in bank profits. We require that each bank invests in one of the two industries. Banks choose whether to invest in the same industry or in different ones. This decision affects the correlation of bank returns and in turn the likelihood that banks fail together. For simplicity, we assume that deposits are insured in the first period. The immediacy of funds employed for deposit insurance, net of any proceeds from bank sales or liquidations, entails fiscal costs for the regulator (assumed to be exogenous to the model). Specifically, we analyze the case where fiscal costs are linear in the amounts of funds needed. The regulator designs closure and bailout policies in order to maximize the total output generated by the banking sector net of any costs associated with deposit insurance, closures and bailouts. These policies are assumed to be rationally anticipated by banks and depositors.

If the bank return from the first-period investment is high, then the bank operates one more period and makes the second-period investment. If the bank return from the first-period investment is low, then the bank is in default and the regulator pays off the insured depositors. If there is a surviving bank, then it can use its resources from first-period profits to purchase the failed bank. The regulator decides whether to let the surviving bank (if any) purchase the failed bank, or keep the bank open through a bailout, or to liquidate its assets to outside investors. When a bank is bailed out, the regulator may dilute the equity share of bank owners.

Relative to the sale of a bank to a surviving bank, liquidation to outsiders and bailout entail welfare losses. In particular, assumption (i) generates an allocation inefficiency from liquidating assets to outsiders. Bailouts are also costly in the model since the regulator suffers an opportunity cost from not receiving any proceeds from bank sales or liquidations. Thus, when only one bank fails, the failed bank's assets are sold to the surviving bank, the efficient user of these assets. The surviving bank captures a surplus from its superior skills in running banking assets, but there are no additional welfare losses. However, when two banks fail, both may be bailed out if the costs of injecting funds are smaller than the misallocation cost of liquidating assets to outsiders. This gives rise to a "too-many-to-fail" problem. Crucially, the joint-failure state always entails disproportionately high welfare losses compared to the single-failure state.

Ex ante, the regulator wishes to implement a low correlation between banks' investments in order to minimize the likelihood of the joint-failure state, and simultaneously implement closure policies that are ex-post optimal. The regulator can implement such a welfare-maximizing outcome if it can commit to sufficiently diluting the share of bank owners in bailed-out banks when banks have failed together. With sufficient dilution, the bailout subsidies are small, and ex ante banks invest in different industries to capture the gains from purchasing the failed bank when they survive. However, assumption (ii) implies that such a dilution may not always be feasible. If the moral hazard due to private benefits is sufficiently high, then excessive dilution leads bank owners to choose bad projects and this generates continuation values that are worse than liquidation values.[2] In this case, the only credible mechanism through which the regulator can implement low correlation is committing to liquidate banks in the joint-failure state. In general, this is ex-post inefficient and thus lacks commitment. In turn, this lack of commitment gives rise to an incentive among banks to invest in the same industry in order to capture bailout subsidies in joint-failure states.

From the standpoint of positive analysis, our model suggests that the time-inconsistency of bailouts or the too-many-to-fail problem is likely to be more prevalent in banking systems (a) where the governance of banks is poor: in other words, where agency problems (for example, fraud by bank owners) are more severe, and, in turn, banks are required to hold greater equity stakes for incentive reasons; (b) in times when the fiscal costs of bailing out banks are high.

Next, we examine the case where we have two banks with asymmetric sizes, one big and one small. This helps us contrast the effects of too-many-to-fail with the much-studied too-big-to-fail problem and constitutes a significant contribution of the positive analysis of the paper. Our main result is that the big bank has incentives to differentiate itself whereas the small bank has incentives to herd with the big bank. The rationale for this is that a big bank can acquire the small bank when it fails, whereas the small bank has no such (or, in general, limited) opportunity. Furthermore, the bailout subsidy for the large bank does not increase when the small bank has also failed, whereas it does for the small bank when the big bank has also failed.

To summarize, too-many-to-fail problem is different from too-big-to-fail along an important dimension in that it affects small banks more, and induces herding incentives in them. Jain and Gupta (1987) empirically investigate herding behavior among US banks in their lending decisions to less developed countries prior to the debt crisis of 1982-84 and provide evidence consistent with different incentives that too-big-to-fail and too-many-to-fail guarantees can create for banks. In support of our hypothesis that too-many-to-fail would mostly

[2] For example, a sufficient dilution of the bailed-out bank's equity by the state could lead to the bank being "state-owned," and in turn, may generate inefficiencies in lending. Sapienza (2004) documents the inefficient lending and pricing decisions by the state-owned banks in the Italian banking sector.

affect small banks, they show that the regional banks herded and followed the decisions of 24 large banks. Barron and Valev (2000) focus on the same episode and show that an increase (decrease) in the level of investment in a country by large banks led to an increase (decrease) in the level of investment by small banks.

The remainder of the paper is structured as follows. Section 2 discusses related literature. Section 3 and Section 4 present the model and the analysis. Section 5 considers the case with asymmetric bank sizes. Section 6 presents robustness discussion and empirical evidence in support of our assumptions and results. Section 7 concludes and the proofs that are not in the text are contained in the Appendix.

2 Related literature

The idea that bank regulation may be time-inconsistent and may induce moral hazard is not new, but our specific application of these ideas is novel. For example, Mailath and Mester (1994) and Freixas (1999) discuss the time-inconsistency of closure policy in a single-bank model, and Bagehot (1873) in his famous piece discusses the moral hazard from rescuing failed banks. The focus in this literature is however on an individual bank and its choice of risk rather than on multiple banks and their choice of joint-failure risk.

We view the too-many-to-fail channel of bank herding proposed in this paper as being complementary to the channels discussed in the literature. These other channels include bank herding based on reputational considerations (discussed below) and herding by banks to exploit their limited-liability options (Acharya and Yorulmazer, 2005a).[3]

Rajan (1994) builds a theoretical model where bank managers have short horizons and reputational concerns. This creates incentives for managers to manipulate current earnings by concealing the extent of bad loans (for example, by extending the term of loans, lending new loans to insolvent borrowers to keep them afloat, etc.). When the entire borrowing sector is hit by an adverse systematic shock, the market is more forgiving of a bank's poor performance. This informational externality generates an interdependence between banks' credit policies: Banks coordinate on an adverse shock to announce poor earnings and to tighten their credit policies. Mitchell (1997) considers an argument along the lines of this "signal-jamming" model of Rajan to show that if the regulator bails out banks when they fail together, then banks coordinate on disclosing their losses and delay classifying bad loans. Thakor (2005) considers a variant of the reputational based argument to show that loan

[3]In Acharya and Yorulmazer (2005a), the failure of one bank conveys adverse information about the systematic factor in bank loan returns and increases the cost of borrowing for the surviving bank relative to the case with no bank failures. Hence, banks herd ex ante to increase the likelihood of joint survival: given limited liability, bank owners are not concerned about the associated increase in the likelihood of joint failure.

commitments can also result in excessive lending. After screening their customers, banks provide loan commitments, which contain the Material Adverse Change (MAC) clause that permits the bank to decline to lend ex post if the borrower's financial condition declines significantly. In this model, some banks are better at screening borrowers and invoking the MAC clause reveals adverse information about a bank's screening ability. In turn, banks are reluctant to invoke the MAC clause, resulting in overlending.

Since our channel of herding is based on regulatory subsidies, we view it as being more specific to the banking sector than these channels. In a paper more directly related to ours, Penati and Protopapadakis (1988) assume that the regulator provides insurance to uninsured depositors when the number of banking failures is large, and illustrate that this leads banks to invest inefficiently in common markets to attract deposits at a cheaper cost. In contrast, we endogenize the ex-post bailout policies of the regulator. Furthermore, banks herd in our model not because it affects deposit rates but in order to capture the (endogenously derived) bailout subsidies. Perotti and Suarez (2002) consider a dynamic model where selling failed banks to surviving banks (reducing competition) increases the charter-value of surviving banks and gives banks ex-ante incentives to stay solvent. This strategic benefit is present in our model in a different guise as the discount at which surviving banks purchase failed banks. However, in contrast to our model, their paper does not examine the effect of closure policies on inter-bank correlation. Similarly, Cordella and Yeyati (2003) show that the regulator, by bailing out banks during systemic crises, can increase the charter value of banks and this induces banks to manage their risk in a prudent manner. In their model, systemic crises occur because of adverse macroeconomic shocks that are exogenous, whereas in our paper, systemic crises arise endogenously as a result of banks' overinvestment in particular industries. Hence, bailing out banks during systemic crises increases the likelihood of such crises in our model.

Crucially, in contrast to the entire literature cited above, we analyze asymmetric sizes of banks and show that the strategic choices of banks in response to regulatory actions differ between large and small banks.

3 Benchmark model

The model is outlined in Figure 1. We consider an economy with three dates – $t = 0, 1, 2$, two banks – Bank A and Bank B, bank owners, depositors, outside investors, and a regulator. Each bank can borrow from a continuum of depositors of measure 1. Bank owners as well as depositors are risk-neutral, and obtain a time-additive utility w_t where w_t is the expected wealth at time t. Depositors receive a unit of endowment at $t = 0$ and $t = 1$. Depositors also have access to a reservation investment opportunity that gives them a utility of 1 per unit of investment. In each period, that is at date $t = 0$ and $t = 1$, depositors choose to invest their good in this reservation opportunity or in their bank.

Deposits take the form of a simple debt contract with maturity of one period. In particular, the promised deposit rate is not contingent on investment decisions of the bank or on realized returns. In order to keep the model simple and yet capture the fact that there are limits to equity financing due to associated costs (for example, due to asymmetric information as in Myers and Majluf, 1984), we do not consider any bank financing other than deposits.

Banks require one unit of wealth to invest in a risky technology. The risky technology is to be thought of as a portfolio of loans to firms in the corporate sector. The performance of the corporate sector determines its random output at date $t+1$. We assume that all firms in the sector can either repay fully the borrowed bank loans or they default on these loans. In case of a default, we assume for simplicity that there is no repayment.

Suppose R is the promised return on a bank loan. We denote the random repayment on this loan as $\widetilde{R}$, $\widetilde{R} \in \{0, R\}$. The probability that the return from these loans is high in period t is α_t:

$$\widetilde{R} = \begin{cases} R & \text{with probability} \quad \alpha_t, \\ 0 & \text{with probability} \quad 1-\alpha_t. \end{cases} \tag{1}$$

We assume that the returns in the two periods are independent but allow the probability of high return to be different in the two periods. This helps isolate the effect of each probability on our results.

There is a potential for moral hazard at the individual bank level. If the bank chooses a bad project, then when the return is high, it cannot generate R but only $(R-\overline{\Delta})$ and its owners enjoy a non-pecuniary benefit of $B < \overline{\Delta}$. Therefore, for the bank owners to choose the good project, appropriate incentives have to be provided by giving them a minimum share of the bank's profits. We denote the share of bank owners as θ. If r is the cost of borrowing deposits, then the incentive-compatibility constraint is:

$$\alpha_t \theta (R-r) \geqslant \alpha_t \left[\theta((R-\overline{\Delta}) - r) + B \right]. \qquad (IC) \tag{2}$$

We have assumed that the bank is able to pay the promised return of r when the investment had the high return irrespective of whether the project is good or bad. The left hand side of the (IC) constraint is the expected profit for the bank from the good project when it has a share of θ of the profit. On the right hand side, we have the expected profit from the bad project when bank owners have a share of θ, plus the non-pecuniary benefit of choosing the bad project. Using this constraint, we can show that bank owners need a minimum share of $\overline{\theta} = \frac{B}{\overline{\Delta}}$ to choose the good project.[4] We assume that at $t=0$, the entire share of the bank profits belongs to the bank owners, and therefore, there is no moral hazard to start with.

[4] See Hart and Moore (1994) and Holmstrom and Tirole (1998) for models with similar incentive-compatibility constraints.

In addition to banks and depositors, there are outside investors who have funds to purchase banking assets were these assets to be liquidated. However, outsiders do not have the skills to generate the full value from banking assets. In particular, outsiders are inefficient users of banking assets relative to the bank owners provided bank owners operate good projects. To capture this, we assume that outsiders cannot generate R in the high state but only $(R-\Delta)$. Thus, when the banking assets are liquidated to outsiders, there is a social welfare loss due to misallocation of these assets.[5] We also assume that $\overline{\Delta} > \Delta$ so that outside users of the banking assets can generate more than what the banks can generate from the bad project.

The notion that outsiders may not be able to use the banking assets as efficiently as the existing bank owners is akin to the notion of *asset-specificity*, first introduced in the corporate-finance literature by Williamson (1988) and Shleifer and Vishny (1992). This literature suggests that firms whose assets tend to be *specific*, that is, whose assets cannot be readily redeployed by firms outside of the industry, are likely to experience lower liquidation values because they may suffer from "fire-sale" discounts in cash auctions for asset sales, especially when firms within an industry get simultaneously into financial or economic distress.[6] In the evidence of such specificity for banks and financial institutions, James (1991) studies the losses from bank failures in the United States during the period 1985 through mid-year 1988, and documents that "there is significant going concern value that is preserved if the failed bank is sold to another bank (a "live bank" transaction) but is lost if the failed bank is liquidated by the Federal Deposit Insurance Corporation (FDIC)."

Finally, there is a regulator in our model whose objective is to resolve bank failures in order to maximize the total output generated by the banking sector net of any costs associated with the resolution policies. These policies are assumed to be rationally anticipated by banks and depositors. Below we describe these policies informally. The formal description follows in the model analysis.

If the bank return from the first-period investment is high, then the bank operates one more period and makes the second-period investment. If the bank return from the first-period investment is low, then the bank is in default. The regulator decides whether to let the failed bank be acquired by a surviving bank (if any), or to liquidate its assets to outside investors,

[5] Our assumptions are similar in spirit to those of Diamond and Rajan (2001) who also assume inalienable, relationship-specific skills with each bank manager, but different in that we assume a distinction in skills between bank managers and outside investors (rather than between bank managers themselves). Note also that in our setup the return from banks' investments in the down state is 0 and the misallocation cost arises only when the return is high. However, it is likely that during times of distress, banks can recover higher returns from their assets compared to outsiders. Alternatively, we can have a low but positive return, instead of 0, to introduce a misallocation cost in the down state.

[6] There is strong empirical support for this idea, as shown, for example, by Pulvino (1998) for the airline industry, and by Acharya, Bharath, and Srinivasan (2004) for the entire universe of defaulted firms in the US over the period 1981 to 1999 (see also Berger, Ofek, and Swary, 1996, and Stromberg, 2000).

or to keep the bank open through a bailout.

We assume that deposits are fully insured in the first period. The provision of immediate funds to pay off failed deposits, net of any proceeds from the sale of failed bank's assets, entails fiscal costs for the regulator (assumed to be exogenous to the model). In particular, the regulator incurs a cost of $f(x)$ when it has to provide x units of funds to meet the insurance cover promised to depositors. For simplicity, we consider a linear cost function: $f(x) = ax, a > 0$.

The fiscal costs of providing funds with immediacy can be linked to a variety of sources, most notably, (i) distortionary effects of tax increases required to fund deposit insurance and bailouts; and, (ii) the likely effect of huge government deficits on the country's exchange rate, manifested in the fact that banking crises and currency crises have often occurred as twins in many countries (especially, in emerging market countries). Ultimately, the fiscal cost we have in mind is one of immediacy: Government expenditures and inflows during the regular course of events are smooth, relative to the potentially rapid growth of off-balance-sheet contingent liabilities such as deposit-insurance funds, costs of bank bailouts, etc.[7]

Note that when a bank is bailed out, the regulator must bear the entire cost of deposit insurance cover (there are no proceeds from bank sale or liquidation). The regulator may dilute the equity share of bank owners in a bailed-out bank. However, since bank equity is not pledgeable in capital markets, the equity stake taken by the regulator in bailed-out banks does not reduce the immediacy costs for providing deposit insurance. Hence, bailouts are associated with an opportunity cost for the regulator relative to bank sales. These opportunity costs are also a part of the regulator's objective function.

Finally, since the second period is the last period in our model, there is no further investment opportunity. As a result, our analysis is not affected by whether deposits are insured for the second investment or not.

The possible states at date 1 are given as follows, where S indicates survival and F indicates failure:

SS : Both banks had the high return, and they operate in the second period.

SF : Bank A had the high return, while Bank B had the low return. Bank B is bailed out, or acquired by bank A, or liquidated.

[7] See, for example, the discussion on fiscal costs associated with banking collapses and bailouts in Calomiris (1998). Hoggarth, Reis and Saporta (2002) find that the cumulative output losses have amounted to a whopping 15-20% annual GDP in the banking crises of the past 25 years. Caprio and Klingebiel (1996) argue that the bailout of the thrift industry cost $180 billion (3.2% of GDP) in the US in the late 1980s. They also document that the estimated cost of bailouts were 16.8% for Spain, 6.4% for Sweden and 8% for Finland. Honohan and Klingebiel (2000) find that countries spent 12.8% of their GDP to clean up their banking systems whereas Claessens, Djankov and Klingebiel (1999) set the cost at 15-50% of GDP.

FS : This is the symmetric version of state SF.

FF : Both banks failed. Banks are either bailed out or liquidated.

3.1 Correlation of bank returns

A crucial aspect of our model is the choice of correlation of bank returns. At date 0, banks borrow deposits and then they choose the composition of loans that compose their respective portfolios. This choice determines the level of correlation between the returns from their respective investments. We refer to this correlation as "inter-bank correlation".

We suppose that there are two possible industries in which banks can invest, denoted as 1 and 2. Bank A (B) can lend to firms A_1 and A_2 (B_1 and B_2) in industries 1 and 2, respectively. If in equilibrium banks choose to lend to firms in the same industry, specifically they either lend to A_1 and B_1, or A_2 and B_2, then they are assumed to be perfectly correlated, that is, $\rho = 1$. However, if they choose different industries, then their returns are less than perfectly correlated, say independent ($\rho = 0$). This gives us the joint distribution of bank returns as given in Table 1. Note that the individual probability of each bank succeeding or failing is constant (α_0 and $1 - \alpha_0$, respectively).

Let $E(\pi(\rho))$ be the expected profit for a bank from the two investments when the inter-bank correlation is equal to ρ. In a Nash equilibrium, if banks invest in the same industry, that is, in (A_1, B_1) or (A_2, B_2), then they receive $E(\pi(1))$, whereas if they invest in different industries, that is, in (A_1, B_2) or (A_2, B_1), then they receive $E(\pi(0))$. Thus, for the same level of inter-bank correlation, the identity of the industries banks invest in does not matter in terms of bank returns. In other words, while there may be multiple Nash equilibria resulting in the same level of inter-bank correlation, they are payoff equivalent. Thus, for the remainder of the paper, we concentrate on the inter-bank correlation ρ, rather than on individual industries for banks' choice. Specifically, given the symmetry in our basic model, banks invest in the same industry if $E(\pi(1)) > E(\pi(0))$, and invest in different industries otherwise.

4 Analysis

We analyze the model proceeding backwards from the second period to the first period. We examine separately the outcomes under each of the four states at $t = 1$: SS, SF, FS, and FF. The promised deposit rate in state i at $t = 1$ is denoted as r_1^i, and in the first period as r_0. Given full deposit insurance in the first period, r_0 equals 1. However, we exploit this fact only in some parts of the analysis. Hence, we generally refer to the first-period deposit rate by r_0. We assume throughout that $R > r_0$ and $R > r_1^i$.

4.1 Both banks survived (SS):

In this case, both banks operate for another period. Since returns from each period's investments are assumed to be independent, the probability of having the high return for each bank is equal to α_1. This is the last period and there is no further investment opportunity. Since there is no deposit insurance in the second period, depositors get the promised rate r_1^{ss} when the bank has the high return and they get 0 when the return is low. The expected payoff to the bank from its second-period investment when both banks survived, $E(\pi_2^{ss})$, is thus

$$E(\pi_2^{ss}) = \alpha_1[R - r_1^{ss}] = \alpha_1 R - 1, \tag{3}$$

where we have assumed the individual rationality of depositors: $\alpha_1 r_1^{ss} = 1$. Note that the expected payoff, $E(\pi_2^{ss})$, is independent of inter-bank correlation.

4.2 Only one bank survived (SF or FS):

This is the case where one bank had the high return while the other had the low return. Note that this state has a positive probability only when banks invest in different industries. Without loss of generality, we concentrate on the case SF where Bank A had the high return and Bank B had the low return.

For a bank to continue operating for another period, it needs to pay its old depositors r_0 and it needs an additional one unit of wealth for the second investment. The failed bank B cannot generate the needed funds, $(1 + r_0)$, from its depositors at $t = 1$: Its depositors are endowed with only one unit of wealth at $t = 1$. The bank is thus in default. An important possibility is that the surviving bank A may be able to purchase the assets of the failed bank B. Next, we argue that it is optimal for the regulator to let Bank A purchase Bank B's assets. Indeed, we also show that it is optimal for Bank A to do so.

Profitability of asset purchases: To show that it is indeed profitable for the surviving bank to acquire failed bank's assets, we make the following set of assumptions:

(i) Bank A makes a take-it-or-leave-it offer to purchase Bank B: Note that outsiders can generate a maximum return of $(R - \Delta)$ in the high-return state from assets of Bank B. However, there is a refinancing cost of one unit for these assets to be reinvested. Therefore, outsiders are willing to pay a maximum of $\underline{p} = [\alpha_1(R - \Delta) - 1]$ for these assets. If Bank A has all the bargaining power, then because of its special skills it can purchase the assets of Bank B at a "discount": Bank A can make a take-it-or-leave-it offer to the regulator for purchasing Bank B at a price $\underline{p}$, in other words, equal to the amount the outsiders are willing to pay. The main thrust of our results would not change if the surviving bank is assumed to have a partial bargaining power, as long as it can capture some of the surplus arising from its efficient management of assets relative to the outsiders.

(ii) Bank A has access to depositors of Bank B only after the purchase: The acquiring bank needs one unit of wealth for its own investments, one unit for the purchased bank's investments, and $\underline{p}$ units to purchase failed bank's assets, therefore $[1 + \alpha_1(R - \Delta)]$ in total. We assume that acquiring the assets of Bank B also enables Bank A to access Bank B's depositors (operate Bank B's "branches"). Thus, Bank A can borrow one unit from its own depositors and one unit from Bank B's depositors for second period investments.

(iii) Deposit insurance is costly to the regulator when there is a bank failure: We assume that the proceeds from the sale of Bank B's assets, $[\alpha_1(R - \Delta) - 1]$, are smaller than r_0. That is, $[\alpha_1(R - \Delta) - 1] < 1$ to ensure that deposit insurance is always costly to the regulator when a bank fails. This condition implies that the expected profits from the second-period investment are not very high or that banks are sufficiently "special", that is, $\Delta > \left(R - \frac{2}{\alpha_1}\right)$. Absent this condition, deposit insurance is never required to pay off depositors their initial investment of one unit.

Under these assumptions, Bank A always has enough funds to purchase assets of Bank B. To see this, observe that $(R - r_0) = (R - 1) \geqslant \underline{p} = [\alpha_1(R - \Delta) - 1]$. The question is: Will Bank A be willing to buy Bank B's assets? The answer is yes: The expected borrowing cost for a bank will always be 1 due to the risk-neutrality of depositors, and Bank A buys Bank B's assets at a discount equal to $\alpha_1\Delta$, the surplus from its efficient management of assets relative to the outsiders.

The sale of Bank B's assets to Bank A results in a transfer of wealth between banks, but it is not associated with a misallocation cost as long as assets stay within the banking system and banks choose good projects. In contrast, the sale of Bank B's assets to outsiders results in a misallocation cost since Bank A is a more efficient user of these assets compared to outsiders. Under assumption (i) stated above, the proceeds from a sale to Bank A are always at least as high as those from liquidation to outsiders. In turn, the cost of deposit insurance cover is smaller from sale to Bank A. Finally, a bailout of Bank B is also dominated by sale to Bank A since both avoid any misallocation cost, but the sale results in lower cost of deposit insurance. Therefore, it is optimal for the regulator to let Bank A acquire Bank B's assets.

Lemma 1 *It is profitable for Bank A to purchase assets of Bank B in state SF. The value of Bank A increases by $(\alpha_1\Delta)$ from the asset purchase. Furthermore, it is optimal for the regulator to resolve failure of Bank B through its sale to Bank A.*

Proof: *See Appendix.*

4.3 Both banks failed (FF)

In state FF, assets of failed banks can be purchased only by outside investors. Hence, the regulator compares the welfare loss resulting from asset sales to outsiders with the cost of bailing out one or both of the failed banks. The regulator's ex-post decision is thus more involved in state FF and we examine it fully.

The regulator can take an equity stake in the bailed-out bank(s). Let β be the share the regulator takes in a bailed-out bank. If the bailed-out bank has a high return from the second investment (which is likely with a probability α_1), then the regulator gets back $\beta(R - r_1^{ff})$ at $t = 2$. Since bank equity is not pledgeable in capital markets, the equity stake taken by the regulator in bailed-out banks does not reduce the immediacy costs for providing deposit insurance. Ex post, such dilution of bailed-out bank's equity is thus merely a transfer from bank owners to the regulator. As argued before, if the regulator takes a share greater than $(1 - \overline{\theta})$, then the bank owners are left with a share of less than $\overline{\theta}$, the critical share below which the bank chooses the bad project. Since liquidating the bank generates a higher payoff compared to that from a bailed-out bank that chooses a bad project ($\overline{\Delta} > \Delta$), bailing out a bank and taking a share greater than $(1 - \overline{\theta})$ is a dominated strategy and the regulator never takes a share greater than $(1 - \overline{\theta})$ in a bailed out bank.

The regulator's optimal policy can now be characterized as follows. The regulator's objective in state FF is to maximize the total expected output of the banking sector net of any bailout or liquidation costs. We denote this as $E(\Pi_2^{ff})$. Thus, if both banks are liquidated to outsiders, the regulator's objective function takes the value

$$E(\Pi_2^{ff}) = 2\left[\alpha_1(R - \Delta) - 1\right] - a(2r_0 - 2\underline{p}), \tag{4}$$

since funds required to provide deposit insurance cover are $2r_0$ minus the liquidation proceeds of $2\underline{p}$, and $[\alpha_1(R - \Delta) - 1]$ is the value of each bank when run by outsiders.

If one bank is bailed out and the other is sold to outsiders, then the regulator's objective function takes the value

$$E(\Pi_2^{ff}) = (\alpha_1 R - 1) + [\alpha_1(R - \Delta) - 1] - a(2r_0 - \underline{p}). \tag{5}$$

This can be expressed as $[2(\alpha_1 R - 1) - \alpha_1 \Delta - a(2r_0 - \underline{p})]$.

Finally, if both banks are bailed out, then the regulator's objective function takes the value

$$E(\Pi_2^{ff}) = 2(\alpha_1 R - 1) - a(2r_0), \tag{6}$$

as the bailout costs are now based on the total amount of funds, $2r_0$, required for deposit insurance.

Comparing these objective-function evaluations, we obtain the following closure/bailout policy for the regulator in state FF. It has the intuitive property that if liquidation costs ($\alpha_1\Delta$) are sufficiently high, and/or the costs of bailouts ($f(x)$) are not too steep, then there are "too many (banks) to fail". With a linear fiscal cost function, the regulator either bails out both banks or liquidates both as formally stated in the following Lemma. The relevant condition is whether the liquidation cost ($\alpha_1\Delta$) is smaller or greater than the opportunity cost of a bailout ($a\underline{p}$).[8] In terms of specificity of banking skills, the regulator sells banks to outsiders when banks are not "too special" and bails them out otherwise.

Lemma 2 *Let* $\Delta^* = \left[\frac{a(\alpha_1 R-1)}{\alpha_1(1+a)}\right]$. *In any sub-game perfect equilibrium, in state FF, the regulator takes the following actions:*

(i) *If* $\Delta \leqslant \Delta^*$, *then both banks' assets are sold to outsiders.*

(ii) *If* $\Delta > \Delta^*$, *then the regulator bails out both banks.*

Furthermore, when a bank is bailed out, the regulator takes a share in the bank's equity of $\beta \leq (1-\overline{\theta})$, *but is indifferent between shares over the range* $[0,(1-\overline{\theta}))$.

Thus, the expected second-period profits of the bank depend on the regulator's decision as:

$$E(\pi_2^{ff}) = \begin{cases} 0 & if \quad \Delta \leqslant \Delta^* \\ (1-\beta)(\alpha_1 R - 1) & if \quad \Delta > \Delta^* \end{cases} . \tag{7}$$

4.4 First investment problem (date 0) and inter-bank correlation

In the first period, both banks are identical. Hence, we consider a representative bank. Formally, the objective of each bank is to choose the level of inter-bank correlation ρ at date 0 that maximizes

$$E(\pi_1(\rho)) + E(\pi_2(\rho)), \tag{8}$$

where discounting has been ignored since it does not affect any of the results. Recall that if banks invest in different industries, then inter-bank correlation ρ equals 0, else it equals 1.

[8] This condition can be written as $\alpha_1\Delta \leqslant a\underline{p} = a\left[\alpha_1(R-\Delta)-1\right]$. Note that this translates into $\Delta \leqslant \Delta^* = \left[\frac{a(\alpha_1 R-1)}{\alpha_1(1+a)}\right]$.

Since banks pay depositors the promised return r_0 only if the return on loans is high, the expected payoff of each bank from its first-period investment is

$$E(\pi_1) = \alpha_0(R - r_0). \tag{9}$$

Note that banks choose the correlation after deposits are borrowed. Hence, $E(\pi_1)$ does not depend on the level of inter-bank correlation, and banks only take into account the second-period profits when choosing ρ.

We can calculate the expected second-period return of Bank A (and by symmetry, of Bank B) as

$$E(\pi_2(\rho)) = \sum_i \Pr(i)\ E(\pi_2^i(\rho)) \tag{10}$$

where i represents the possible states, that is, $i \in \{SS, SF, FF\}$.

Note that when banks invest in the same industry, $\Pr(SF) = 0$, so that

$$E(\pi_2(1)) = \alpha_0\ E(\pi_2^{ss}) + (1 - \alpha_0)\ E(\pi_2^{ff}). \tag{11}$$

When banks invest in different industries, from Table 1, we obtain that

$$E(\pi_2(0)) = \alpha_0^2\ E(\pi_2^{ss}) + \alpha_0(1 - \alpha_0)\ E(\pi_2^{sf}(0)) + (1 - \alpha_0)^2\ E(\pi_2^{ff}). \tag{12}$$

From Lemma 1, we obtain that $E(\pi_2^{sf}(0)) = E(\pi_2^{ss}) + \alpha_1\Delta$. Thus, we can write

$$E(\pi_2(0)) = \alpha_0\ E(\pi_2^{ss}) + \alpha_0(1 - \alpha_0)\ (\alpha_1\Delta) + (1 - \alpha_0)^2\ E(\pi_2^{ff}) \tag{13}$$

which gives us

$$E(\pi_2(1)) - E(\pi_2(0)) = \alpha_0(1 - \alpha_0)\ [E(\pi_2^{ff}) - \alpha_1\Delta]. \tag{14}$$

Thus, the only terms that affect the choice of inter-bank correlation are the discount $(\alpha_1\Delta)$ the surviving bank gets in state SF from buying the failed bank's assets and the subsidy it receives $(E(\pi_2^{ff}))$ from a bailout in state FF. Using equation (7) for $E(\pi_2^{ff})$ as a function of dilution β employed by the regulator, we obtain the following characterization of the best response of banks in choosing inter-bank correlation.

Given Lemma 2, it is sufficient to characterize the best response when the regulator's equity stake in bailed-out banks in state FF, β, is less than or equal to $(1 - \overline{\theta})$. As explained before, a bailout with a regulator's equity stake greater than or equal to $(1 - \overline{\theta})$ is dominated by a strategy of liquidating the bank to outsiders, and is therefore never used in any equilibrium.

Lemma 3 *Let* $\beta^* = \left(1 - \frac{\alpha_1\Delta}{(\alpha_1 R - 1)}\right)$.

(1) If the regulator liquidates both banks in state FF, that is $\Delta \leqslant \Delta^*$, then banks choose the lowest level of correlation, $\rho = 0$.

(2) If the regulator bails out both banks in state FF, that is $\Delta > \Delta^*$, then we have:

(i) *If $\beta^* \leqslant (1 - \overline{\theta})$, then for a bailout strategy of $\beta \in [\beta^*, (1 - \overline{\theta})]$, banks choose the lowest level of correlation, $\rho = 0$, and, for a bailout strategy of $\beta \in [0, \beta^*)$, banks choose the highest level of correlation, $\rho = 1$.*

(ii) *If $\beta^* > (1 - \overline{\theta})$, then for a bailout strategy of $\beta \in [0, (1 - \overline{\theta})]$, banks choose the highest level of correlation.*

Proof: *See Appendix.*

We combine the results in Lemma 2 and Lemma 3 to characterize the unique subgame perfect equilibrium. The formal statement is contained in the proposition below and it is captured graphically in Figure 2.

Proposition 1 *In the unique subgame perfect equilibrium:*

(1) The regulator does not intervene in state SS.

(2) The surviving bank always buys the assets of the failed bank in states SF and FS.

(3) In state FF, we obtain the following:

(i) If $\Delta \leqslant \Delta^*$, then the regulator liquidates both banks to outsiders. Under this case, banks invest in different industries at date 0.

(ii) If $\Delta > \Delta^*$, then the regulator bails out both banks. The regulator never takes a share β greater than $(1 - \overline{\theta})$ if it bails out a bank. If the regulator takes a share of β in the bailed out banks that is less than $\beta^* = \left(1 - \frac{\alpha_1 \Delta}{(\alpha_1 R - 1)}\right)$, then banks invest in the same industry at date 0; otherwise, they invest in different industries.

Note that there is an indeterminacy in our model in the ex-post choice of β, the share that the regulator takes in a bailed-out bank. We analyze below the expectation at date 0 of the output of the banking sector and illustrate that this indeterminacy is resolved when viewed from an ex-ante standpoint for the regulator.

4.5 Time-inconsistency of ex-ante optimal regulation

We show below that the total expected output at date 0 depends on whether banks invest in the same industry or in different industries. We assume that the regulator cannot write contracts that "force" banks to adopt specific investment choices, that is, the regulator cannot impose regulation that is explicitly contingent on inter-bank correlation.

Let $E(\Pi_t(\rho))$ be the expected output generated by the banking sector in period starting at date t, net of liquidation and/or bailout costs. If banks invest in the same industry at date 0, then with probability α_0 both banks have the high return so that $E(\Pi_1(1)) = 2(\alpha_0 R - 1)$. However, if they invest in different industries, then with probability α_0^2 both banks have the high return whereas with probability $2\alpha_0(1-\alpha_0)$, one bank has the high return while the other has the low return. This gives us $E(\Pi_1(0)) = 2\alpha_0^2 R + 2\alpha_0(1-\alpha_0)R - 2 = 2(\alpha_0 R - 1)$. Thus, total expected output in the first period is independent of the choice of inter-bank correlation.

In the second period, the number of banks that operate depends on the outcome of the first-period investments and the regulator's action. In state SS, both banks operate one more period and the total expected output can be written as $E(\Pi_2^{ss}) = 2(\alpha_1 R - 1)$. In state SF or FS, failed bank's assets are purchased by the surviving bank and the total expected output is given as $E(\Pi_2^{sf}) = E(\Pi_2^{fs}) = E(\Pi_2^{ss}) - a(r_0 - \underline{p}) = 2(\alpha_1 R - 1) - a(r_0 - \underline{p})$.

However, the expected output in state FF depends on the policy adopted by the regulator. In this state, either banks are sold to outsiders and liquidation costs are incurred, or, some banks are bailed out by the regulator resulting in a greater fiscal cost. Thus, in state FF, we have

$$E(\Pi_2^{ff}) = \begin{cases} 2(\alpha_1 R - 1) - 2\alpha_1\Delta - a(2r_0 - 2\underline{p}) & if \quad \Delta \leqslant \Delta^* \\ 2(\alpha_1 R - 1) - a(2r_0) & if \quad \Delta > \Delta^* \end{cases}.$$

Thus, we have $E(\Pi_2^{ff}) < E(\Pi_2^{sf}) < E(\Pi_2^{ss})$. Using the corresponding joint probabilities, we get:

$$E(\Pi_2(1)) = \alpha_0 E(\Pi_2^{ss}) + (1-\alpha_0)E(\Pi_2^{ff}), \tag{15}$$

$$E(\Pi_2(0)) = \alpha_0^2 E(\Pi_2^{ss}) + 2\alpha_0(1-\alpha_0)E(\Pi_2^{sf}) + (1-\alpha_0)^2 E(\Pi_2^{ff}). \tag{16}$$

Hence, we have

$$E(\Pi_2(0)) - E(\Pi_2(1)) = \alpha_0(1-\alpha_0)\left[2E(\Pi_2^{sf}) - E(\Pi_2^{ss}) - E(\Pi_2^{ff})\right]. \tag{17}$$

Note that

$$\left[2E(\Pi_2^{sf}) - E(\Pi_2^{ss}) - E(\Pi_2^{ff})\right] = \begin{cases} 2\alpha_1\Delta & if \quad \Delta \leqslant \Delta^* \\ 2a\underline{p} & if \quad \Delta > \Delta^* \end{cases}. \tag{18}$$

In either case, this difference is positive, that is, $E(\Pi_2(0)) > E(\Pi_2(1))$. This gives us the following result:

Lemma 4 *Expected total output of the banking sector at date* 0 *(net of any anticipated costs of liquidations and bailouts) is maximized when banks operate in different industries, that is, when* $\rho = 0$.

Since in state FF the social welfare losses are disproportionately high compared to states SF and FS, the regulator may wish to implement closure policies that minimize the probability of state FF, that is, policies that give incentives for banks to choose low correlation. These policies may however not be ex-post optimal. For example, committing to liquidate both banks in state FF has the ex-ante advantage that it gives banks incentives to invest in different industries. However, conditional upon reaching state FF, liquidation of banks may not be credible if costs of bailout are smaller than liquidation costs. Another way the regulator can induce low correlation among banks is by diluting the equity share of bailed-out banks in state FF (see Lemma 3). However, this may also lack commitment ex post: if the minimum dilution required to induce low correlation is sufficiently large, then such dilution may have adverse consequences for continuation moral hazard and banks may choose bad projects.

We formalize this trade-off below. In particular, we characterize the ex-ante optimal regulatory policy assuming that the regulator can commit to ex-post implementation of this policy. We also examine the case where the ex-ante optimal policy is not subgame perfect and thus time-inconsistent.

Consider the two cases for state FF as in Lemma 3 and Proposition 1.

In the first case, we have $\Delta \leqslant \Delta^*$, and it is ex-post optimal to liquidate both banks. In turn, this induces banks to invest in different industries. Hence, it is also ex-ante optimal to commit to liquidating both banks in state FF.

In the more interesting second case, we have $\Delta > \Delta^*$ and it is ex-post optimal to bail out both banks. Ex ante, the regulator wishes to implement this ex-post optimal outcome and yet induce a low correlation among banks at date 0. The regulator can achieve this if it can take a share $\beta > \beta^*$ in the bailed-out bank without inducing continuation moral hazard. That is, β should be greater than β^* (as defined in Lemma 3) to induce low correlation, but be smaller than $(1-\overline{\theta})$ in order to provide continuation incentives. If $\beta^* < (1-\overline{\theta})$, then such a dilution scheme can be implemented by choosing $\beta = \beta^*$ and it is ex-post credible.

However, if $\beta^* > (1-\overline{\theta})$, then a dilution scheme that sets $\beta = \beta^*$ is dominated ex ante by a strategy that liquidates banks. This is because under our maintained assumption ($\overline{\Delta} > \Delta$), liquidation costs of a bank are smaller than agency costs arising from an excessive dilution of bank owners' stake in profits. Is it ex-ante optimal for the regulator to commit to liquidating *both* banks in this case even though it is ex-post optimal to bail out *both* banks? The answer is yes for at least a part of the parameter range. To see this, note that if the regulator can commit ex ante to liquidating both banks, this induces banks to choose the low correlation. Therefore, in this case $E(\Pi_2^{ff}) = E(\Pi_2^{ss}) - 2\alpha_1\Delta - a(2r_0 - 2\underline{p})$. In turn, this gives (see equation (16)):

$$E(\Pi_2(0)) = E(\Pi_2^{ss}) - 2\alpha_0(1-\alpha_0)\left(a(r_0 - \underline{p})\right) - (1-\alpha_0)^2\left(2\alpha_1\Delta + a(2r_0 - 2\underline{p})\right). \quad (19)$$

If the regulator follows the ex-post optimal strategy of bailing out both banks, then it cannot implement a low correlation. Hence, $E(\Pi_2^{ff}) = E(\Pi_2^{ss}) - a(2r_0)$, and from equation (15), we have

$$E(\Pi_2(1)) = E(\Pi_2^{ss}) - (1-\alpha_0)\left[a(2r_0)\right]. \quad (20)$$

Thus, it is optimal for the regulator to commit to liquidating both banks if and only if $E(\Pi_2(0)) > E(\Pi_2(1))$, which can be written as

$$2\alpha_0\left(a(r_0 - \underline{p})\right) + (1-\alpha_0)\left(2\alpha_1\Delta + a(2r_0 - 2\underline{p})\right) < a(2r_0). \quad (21)$$

This translates into $(1-\alpha_0)(\alpha_1\Delta) < a\underline{p}$. Let $\alpha_0^* = \left(1 - \frac{a\underline{p}}{\alpha_1\Delta}\right)$. Note that $\alpha_0^* < 1$. Thus, the regulator would like to commit ex ante to liquidating both banks for $\alpha_0 > \alpha_0^*$, whereas it is ex-post optimal to bail out both banks for the entire range of $\alpha_0 \in [0,1]$. The trade-off is simple: ex post, the regulator cares only about expected profits in state FF, whereas ex ante, the regulator is willing to give up some of these profits in order to induce better incentives for banks to be less correlated and reduce the likelihood of ending up in state FF.

More generally, we obtain the following proposition on the time-inconsistency of ex-ante optimal regulation. The range of the primitive parameter α_0 over which time-inconsistency arises is illustrated graphically in Figure 3.

Proposition 2 *Let* $\alpha_0^* = \left(1 - \frac{a\underline{p}}{\alpha_1\Delta}\right)$ *and* $\alpha_0^{**} = \left(1 - \frac{2a\underline{p}}{(\alpha_1\Delta + a\underline{p})}\right)$. *Also, let* $\beta^{**} = \left(1 - \frac{2\alpha_1\Delta}{(\alpha_1 R - 1)}\right)$. *In state FF, for $\Delta > \Delta^*$, the ex-ante optimal policy that maximizes the expected output of the banking sector at date 0 differs from the ex-post optimal policy characterized in Proposition (1) in the following cases:*

(1) $(1-\overline{\theta}) < \beta^{**}$: *For $\alpha_0 > \alpha_0^*$, the regulator commits ex ante to liquidating both banks to outsiders and banks invest in different industries at date 0. Ex post, it is optimal to bail out both banks and this induces banks to invest in the same industry at date 0.*

(2) $\beta^{**} < (1-\overline{\theta}) < \beta^*$: For $\alpha_0 > \alpha_0^{**}$, the regulator commits ex ante to liquidating one bank to outsiders and banks invest in different industries at date 0. For $\alpha_0^* < \alpha_0 \leqslant \alpha_0^{**}$, the regulator commits ex ante to liquidating both banks to outsiders and banks invest in different industries at date 0. Ex post, it is optimal to bail out both banks and this induces banks to invest in the same industry at date 0.

In all other states (SS, SF and FS) and all other cases in state FF, ex-ante policy is the same as the ex-post optimal policy characterized in Proposition (1).

Note that, in cases where $\beta^* < (1-\overline{\theta})$, it is possible for the regulator to implement a low correlation among banks without affecting the ex-post optimal policy. This is because when the bank-level moral hazard is small, the regulator is able to dilute bailed-out bank(s)' equity sufficiently to make the bailout subsidy in joint-failure state smaller than the surplus gained by banks in individual survival state. This induces banks to invest in different industries, and crucially, without exacerbating incentives in the continuation game.

From the standpoint of positive analysis, our model suggests that the time-inconsistency of bailouts (or the too-many-to-fail problem) and the induced herding behavior of banks are affected by the following features of banking systems in different countries:

(1) Effect of $(1-\overline{\theta})$: In countries where the governance of banks is poor, in other words, where agency problems (for example, fraud by bank owners) are more severe (high $\overline{\theta}$), banks are required to hold greater equity stakes for incentive reasons. Thus, in these countries, subsidies associated with bailouts are higher. This, in turn, exacerbates bank's incentives to herd ex ante, and the too-many-to-fail problem is more severe.

(2) Effect of a : For small values of a, the fiscal costs associated with bailing out banks are small. Hence, ex post it is optimal to bail out banks over a larger range of parameter values. Furthermore, low values of a increase the cost of committing to liquidate banks ex ante since liquidation is now more costly relative to a bailout. In particular, as can be seen from Proposition 2, when a decreases, both thresholds, α_0^* and α_0^{**}, increase. Thus, from Figure 3, the range of α_0 over which we observe time-inconsistency in regulatory actions shrinks (in terms of α_0). Thus, even if we observe fewer bailouts in economies where the fiscal costs of bailing out banks are high, time-inconsistency in regulatory actions, hence the too-many-to-fail problem, is more severe.

(3) Effect of Δ : Consider countries where the banking system is special or not well-integrated with the rest of the financial system and global banking sector. In these cases, natural or regulatory barriers to entry imply that bank closures may result in significant misallocation costs (high Δ). Note that a sufficiently high level of bank specialness is needed to observe bailouts, since for $\Delta < \Delta^*$, it would be less costly to liquidate banks. On the one hand, high bank specialness (high Δ) increases the possibility of bailouts, and therefore, the

incentives for banks to herd. On the other hand, for high values of Δ, banks can benefit more from the purchase of failed banks' assets, which, in turn, creates incentives for low correlation. Formally, threshold levels of dilution β^* and β^{**} in Proposition 2, below which banks herd, decrease. Hence, the overall effect of bank specialness on the herding incentives of banks and on the time-inconsistency problem is ambiguous.

5 Too big to fail vs. too many to fail

In order to derive important positive implications of our analysis, we examine the case where banks have asymmetric sizes. This helps us contrast the results on bank behavior, in particular, banks' incentives to herd, in the presence of too-big-to-fail and too-many-to-fail problems.

The too-big-to-fail problem has been extensively studied in the literature. Freixas (1999) builds a theoretical model that gives a rationale for the existence of the too-big-to-fail policy. In particular, he models the regulator's bailout strategy in a set-up where the cost of liquidating a bank increases with its assets. Thus, if the bank is sufficiently large then it is optimal for the regulator to bail out the bank rather than liquidating it. Goodhart and Huang (1999) build a model where bank failures exacerbate uncertainty, which makes it difficult for policy makers to take the right decisions. In this model, if a bank is sufficiently big, the cost of letting the bank fail becomes so large in terms of uncertainty and loss of confidence that the regulator optimally chooses to rescue the bank.

Empirically, O'Hara and Shaw (1990) study the effect of the public announcement of too-big-to-fail guarantees by the Office of the Comptroller of the Currency in the United States, and find a positive value effect for largest banks in the US. Studying the effect of too-big-to-fail guarantees on strategic choices of banks, Barth, Hudson and Jahera (1995) provide evidence for the S&L industry that larger institutions with a higher probability of being bailed out can choose riskier investments. In particular, they show that larger S&L institutions invested more heavily in non-traditional activities.[9] Penas and Unal (2005) show that one primary determinant of bondholder gains when banks merge is the attainment of too-big-to-fail status and the associated reduction in the cost of funds on post-merger debt issues.

While the too-big-to-fail guarantee has been examined in detail, the too-many-to-fail guarantees have not been explicitly recognized by the literature even though they have been provided regularly to banks during systemic banking crises (see the empirical evidence in Section 6). In this section, we contrast these two forms of regulatory policies and the incentives

[9] Goodhart (2004) in his discussion argues that what matters for incentives is not the threat of closure but the threat of sacking for managers. However, due to expertise, management may be indispensable. See a discussion of insider ownership of banks in Section 6.4.

they create for banks.

Suppose instead of two equal-sized banks, we let Bank A be the large bank with depositors of measure $B > 1$, while we keep the size of Bank B at 1.

In the individual survival state SF, the large bank has enough funds to purchase the small bank. Hence, the regulator sells the small bank to the large bank in state SF. We assume that the size of Bank A is large enough so that, in state FS, the funds available to the small bank are not sufficient to acquire the big bank, that is, $B > \left[\frac{R-r_0}{\underline{p}}\right]$. Thus, in state FS, assets of the big bank can be purchased only by outside investors. Hence, if the cost of bailout, $(a\underline{p})$, is smaller than the misallocation cost $(\alpha_1\Delta)$, then the regulator bails out the big bank, otherwise it is liquidated to outsiders.

Thus, in this case, we obtain the following closure/bailout policy for the regulator.

Lemma 5 *In any sub-game perfect equilibrium, the regulator takes the following actions:*

(1) In state SF, the small bank is acquired by the big bank.

(2) In state FS, if $\Delta > \Delta^*$, then the big bank is bailed out, otherwise it is liquidated to outsiders.

(3) In state FF:

(i) If $\Delta \leqslant \Delta^*$, then both banks' assets are sold to outsiders.

(ii) If $\Delta > \Delta^*$, then the regulator bails out both banks.

Furthermore, when a bank is bailed out, the regulator takes a share in the bank's equity of $\beta \leq (1-\overline{\theta})$, but is indifferent between shares over the range $[0,(1-\overline{\theta}))$.

Next, we investigate banks' choice of correlation. Note that in the individual survival state FS, the small bank cannot acquire the big bank. Thus, there is no additional gain for the small bank to be the only survivor, whereas in the joint failure state FF, depending on the parameter values, the small bank may benefit from a bailout. Thus, the small bank does not have any incentive to differentiate itself from the big bank: it is either indifferent between the low and the high correlation or prefers to be correlated with the big bank.

In contrast, the big bank, when it is the only survivor, can acquire the small bank's assets at a discount, which creates incentives to differentiate. Regardless of what happens to the small bank, that is, in both states FS and FF, the big bank will be bailed out if $\Delta > \Delta^*$. Thus, the big bank does not have any incentive to herd and wishes to differentiate. Since the big and the small bank have conflicting incentives, a situation similar to the "matching pennies" emerges where there is no pure-strategy equilibrium and in the unique mixed-strategy equilibrium both banks choose between the high and the low correlation with probability $1/2$.

We combine the results in Lemma 5 and the above discussion to characterize the subgame perfect equilibrium in the following proposition.

Proposition 3 *In the unique subgame perfect equilibrium:*

(1) The regulator does not intervene in state SS.

(2) In state SF, the surviving big bank acquires the assets of the failed small bank.

(3) In state FS, if $\Delta > \Delta^*$, then the regulator bails out the failed big bank. Otherwise, the failed big bank is liquidated to outsiders.

(4) In state FF, we obtain the following:

(i) *If $\Delta \leqslant \Delta^*$, then the regulator liquidates both banks to outsiders. Under this case, in the only pure strategy equilibria, banks invest in different industries at date 0.*[10]

(ii) *If $\Delta > \Delta^*$, then the regulator bails out both banks. In this case, there is no Nash equilibrium in pure strategies. In the unique mixed strategy equilibrium, banks randomly choose between the two industries with probability $1/2$.*

Proof: *See Appendix.*

To summarize, too-many-to-fail problem is not identical to too-big-to-fail problem since it has different implications for bailouts and induced incentives. First, the bailout subsidy for the large bank does not increase when the small bank has also failed, whereas it does increase for the small bank when the big bank has also failed. Second, the big bank can acquire the small bank when it fails, whereas the small bank has no such opportunity. Thus, the big bank has incentives to differentiate itself whereas the small bank has incentives to herd with the big bank. In other words, too-many-to-fail affects small banks more than large banks.

6 Robustness and empirical predictions

In this section, we discuss the robustness of our analysis to relaxing some of the assumptions, considering alternative theories, and extending the model to n banks. We also present empirical evidence in support of our results.

[10] Note that there may be multiple mixed strategy equilibria. See Appendix for a discussion.

6.1 Relaxing the assumptions

It is important to consider the effect of relaxing our assumptions on the too-many-to-fail problem and/or the induced herding behavior of banks. First, we assumed that in state SF the surviving bank has all the bargaining power and can make a take-it-or-leave-it offer at a price of $\underline{p}$ to the failed bank. If the surplus of $(\alpha_1\Delta)$ was instead split between the two banks, then the strategic benefit from surviving individually would be smaller. In turn, the threshold levels for share taken by the regulator below which banks herd (β^* and β^{**}), would be larger.

Second, we assumed that the cost of providing funds with immediacy for bailing out banks, $f(x)$, is linear in the amount of funds x. If we assumed the cost function was convex, then depending on the magnitude of liquidation costs $(\alpha_1\Delta)$, we would observe an additional ex-post optimal action where the regulator liquidates one bank and bails out the other. While a convex cost function adds this additional layer of complexity to the analysis, we have verified that it does not change any of our results qualitatively.

Third, in an unabridged version of the paper, we check that our herding results are not an artifact of the assumption that banks invest all funds in just one asset. We consider an extension with two banks where each bank chooses what shares of its portfolio to invest in a common asset and a bank-specific asset. Thus, banks' lending choices span a complete spectrum of inter-bank correlations. We show that the intuition from the benchmark model prevails: Banks over-invest in the common industry, compared to the socially optimal level investment.

Fourth, if the regulator sought to maintain a balanced budget instead of maximizing expected output of the banking sector, then our analysis suggests that such an objective may lead to excessive liquidations. Ex post, the regulator would like to take a sufficiently high ownership stake in bailed-out banks so as to keep the budget balanced, but as argued before, excessive dilution of bank equity leads to inefficient continuations. Since liquidation dominates bailout with excessive dilution, the pressure of keeping a balanced budget forces the regulator to exercise excessive liquidations, which is inefficient ex post. However, these forced liquidations may help mitigate herding incentives ex ante. Hence the overall effect of the objective of keeping a balanced budget is ambiguous.

Finally, it is in order to point out that countervailing effects such as competition in loan margins provide "anti-herding" incentives for banks. Effects of competition on loan margins and lack of adequate skills to lend to all sectors, as stressed by Winton (2000), could be particularly strong if one interprets lending in our model as loans to a common set of industrial borrowers banks have access to. We believe however that banks could correlate their portfolios by making syndicated loans to common set of borrowers (as in the debt crises of 1980s for less developed countries and the extension of telecom loans in late 1990s).

Furthermore, banks could bet on systematic risk factors such as interest-rate risk through choosing from a range of products such as mortgages and interest-rate derivatives. That is, banks could specialize within a class of risk exposures to achieve a trade off between incentives to correlate and to differentiate. Ultimately, this question is an empirical one and we provide some evidence in Section 6.4 consistent with the analysis of our paper.

6.2 Considerations outside the model

There are also considerations outside the model that lend an element of robustness to the too-many-to-fail problem and the welfare costs arising from the induced herding behavior. For instance, bank closure policy is often marred by considerations of regulatory reputation (as formally analyzed for the S&L crisis in the United States by Kane, 1989, and Kroszner and Strahan, 1996, and as modeled by Boot and Thakor, 1993) and political economy (as shown empirically by Brown and Dinc, 2005, from a study linking delay in bank failure announcements to elections in 21 major emerging markets). In the presence of such effects, the short horizon of regulatory decision-makers may lead them to exercise forbearance and bail out banks when it is not even ex-post optimal. This is clearly more likely if many banks have failed. Considerations of bank competition may also make it difficult for the regulator to allow failed banks to be acquired by surviving banks when there are only a few banks left. This would render it difficult for the regulator to counteract the perverse effect of bailout subsidies on ex-ante herding incentives.

Similarly, the welfare losses from bank liquidations in joint-failure states may arise not just from an allocation inefficiency as in our model, but possibly also from the loss of consumer confidence, contagious runs on other banks (see Allen and Gale, 2000, and references therein), disruptions in credit creation and investments, problems relating to the payment systems (see Kahn and Santos, 2005, and references therein), and accentuation of liquidity problems in the banking system (see Diamond and Rajan, 2005, and the references therein). Some of these costs arise due to banking crises per se, and not because of specific regulatory actions undertaken in these times.

In a similar vein, herding may not only increase the likelihood of joint-failure states, but also lead to a bypassing of valuable projects by banks. To this extent, the moral hazard induced by bailouts in joint-failure states may have quite adverse welfare consequences from an ex-ante standpoint. Furthermore, another welfare cost of herding may arise from the fact that not only banks but also the overall economy is less well-diversified. Since more firms are funded in the chosen sector(s), problems in those sectors are associated with greater simultaneous losses such as unemployment arising from the lack of opportunity for workers to migrate to other sectors.

6.3 Extension to n banks

In a companion paper (Acharya and Yorulmazer, 2005b), we check the robustness of our results in an extension with n banks where each bank invests either in a common asset or in a bank-specific asset. In particular, total resources of surviving banks may not suffice for purchasing all failed banks when the number of bank failures is large, giving rise to "cash-in-the-market" pricing (as in Shleifer and Vishny, 1992, and Allen and Gale, 1994, 1998). While the analysis is substantially more involved, the too-many-to-fail problem arises as a robust phenomenon in the n-bank setting as well.

In contrast to the n-bank extension, the current paper allows for asymmetrically-sized banks which enables the positive analysis distinguishing the too-many-to-fail problem from the too-big-to-fail problem. This distinction represents an important contribution of the current paper. The n-bank paper focuses less on issues of time-inconsistency, and focuses more on a comprehensive normative analysis. Specifically, the n-bank paper analyzes not only the regulator's closure policy, but also (in conjunction) the lender of last resort (LOLR) policy: we show that in the optimal policy - ex ante as well as ex post - the regulator provides liquidity to surviving banks but not to troubled banks, in turn, allowing the surviving banks to acquire troubled banks (at a subsidy), thereby obviating the need for bailouts and mitigating the herding incentives.

6.4 Empirical support and implications

Several assumptions of our model and the results they lead to find support in prior empirical work. We provide a discussion of this work next.

Insider ownership of banks: Our model has the feature that bank-level moral hazard is addressed by greater ownership of the bank by insiders. Caprio, Laeven and Levine (2005) study the ownership patterns of 244 banks across 44 countries, collecting data on the 10 largest publicly listed banks in those countries. They document that banks in general are not widely held (where a widely-held bank is one that has no legal entity owning 10 percent or more of the voting rights), a finding that is similar to that of La Porta, Lopez de Silanes and Shleifer (1999) for corporations in general. In particular, Caprio et al. document that inside ownership of banks (especially by families that are found to have controlling stakes more than half of the time in the average country) and ownership by the state is more commonly observed than a dispersed ownership of banks, which is found in less than 25 percent of the banks. This observation is stronger in those countries which have weaker shareholder protection laws. For example, more than 90 percent of the banks in Canada, Ireland, and the United States are widely held, but not more than 50 percent in Italy, Spain and Venezuela are widely held with a significant proportion of the remaining ones being controlled by families, whereas 21 out of 44 countries (for example, Argentina, Brazil, Chile, Israel, Mexico and Thailand) do not have a single widely held bank among their largest banks. Importantly, they also find that greater inside ownership of banks enhances bank valuation, especially in those countries where the shareholder protection laws are weaker.

Overall, these findings are consistent with the key assumptions of our model since weaker shareholder protection laws should imply a greater risk of cash-flow appropriation by insiders, and, in turn, lead to greater inside ownership of banks in equilibrium. The findings also lend credibility to the result of our model that a high state ownership of banks following bailouts may not be desirable due to moral hazard problems that arise from a low inside ownership of banks. Put another way, too-many-to-fail and the induced bank herding problem should be more severe in economies with weaker shareholder protection laws, and, in turn, greater inside ownership of banks.

High fiscal costs of deposit insurance: In our model, we observe more bailouts in economies when the fiscal costs of bailing out banks are low, but the time-inconsistency in regulatory actions is less severe in this case. Put another way, the too-many-to-fail problem is more severe in economies where fiscal costs of bailouts are greater. It is thus useful to discuss in which economies and in what times this might be the case.

When the banking sector is large relative to the rest of the economy, problems in the banking sector and bank bailouts would be associated with large fiscal costs: To generate the necessary funds, ultimately the governments have to introduce taxes. The cost of raising taxes can vary in different countries. In particular, in countries where the tax base is narrow, large increases in tax rates have to be introduced. This can introduce a huge tax bill on the society and be very costly for governments.

To generate the needed funds, governments can also borrow domestically. However, its effectiveness depends on how well the public debt markets are established. In countries where a well-established government bond market does not exist, governments may not be able to generate the necessary funds domestically at a reasonable cost. Alternatively, countries can borrow internationally. While some countries may have easier access to international capital markets, it may not be so easy for others. For example, countries with weak economic health would have lower credit ratings and the market would attach higher probabilities for these countries to default on their debt. This would ultimately increase these countries' borrowing costs and may force them to borrow at increasing rates with very short maturities, which may justify the increasing fiscal cost assumption in our analysis.

To summarize, we conjecture that the welfare cost from too-many-to-fail problem would be more severe in economies where banking sector is large relative to the rest of the economy, tax base is narrow, domestic debt markets are not well-developed, sovereign credit rating is low, and access to international borrowing is in general limited.

State-contingent resolution of bank failures: Our model derives the result that in individual bank failure states, the regulator should optimally let the surviving bank(s) acquire failed banks, whereas in multiple bank failures, it may sometimes be optimal for the regulator to exhibit forbearance in the form of bailouts.

Empirical evidence on regulatory actions taken in response to banking problems appears to conform to this implication. In many episodes, these regulatory actions seem to depend on whether the problems arise from idiosyncratic reasons specific to particular institutions or from aggregate reasons with potential threats to the whole system. For instance, Goodhart and Schoenmaker (1995) provide a cross-country survey of 104 bank failures in 24 different countries during the 1980s and early 1990s. They show that liquidation of failed banks has not been the rule but the exception. Only 31 out of the 104 failed banks were liquidated.

In another relevant piece, Santomero and Hoffman (1999) document evidence and provide convincing rationale for the existence of state-contingent regulatory actions. They argue that in reality the options open to the regulator depend not only on the state of the institutions involved, but also on the state of the industry and the broader financial market itself. During systemic crises, the cost of closing down a significant portion of the banking system would be enormous in terms of investment disruption and consumer confidence. Furthermore, they observe that immediate liquidation of banking assets would not be an appropriate strategy since fire-sale prices, large bid-ask spreads and the virtual lack of bids are common elements of a mass liquidation during systemic crises.

Kasa and Spiegel (1999) provide similar evidence for the existence of state-contingent bank closure rules. They compare an *absolute* closure rule, which closes banks when their asset/liability ratios fall below a given threshold with a *relative* closure rule, which closes banks when their asset/liability ratios fall sufficiently below the industry average. A direct implication of the relative closure rule is forbearance when the banking industry as a whole performs poorly. Using a panel-logit regression for a sample of U.S. commercial banks for the period 1992 through 1997, they find strong evidence that U.S. bank closures are based on relative performance.

In a recent study, Hoggarth, Reidhill and Sinclair (2004) analyze resolution policies adopted in 33 systemic crises over the world during 1977–2002. They document that when faced with individual bank failures authorities have usually sought a private-sector resolution in which losses have been passed onto existing shareholders, managers, and sometimes onto uninsured creditors, but not to taxpayers. However, government involvement has been an important feature of the resolution process during systemic crises: At early stages, liquidity support from central banks and blanket government guarantees have been granted, usually at a cost to the budget; bank liquidations have been very rare and creditors have rarely made losses; finally, bank mergers have been employed only at the restructuring phases.

Finally, Brown and Dinc (2006) analyze failures among large banks in 21 major emerging markets in the 1990s and provide strong evidence for state-contingent regulatory actions. They show that the government decision to close or take over a failing bank depends on the financial health of other banks in that country. In particular, intervention of this sort is delayed if other banks in that country are also weak. They show that this too-many-to-fail effect is robust to controlling for bank-level characteristics, macroeconomic factors, political factors such as electoral cycle and potential IMF pressure, as well as worldwide time-specific factors.

Time-inconsistency of regulatory actions: The wide-spread belief that rescuing troubled banks can create moral hazard dates back to Bagehot (1873): "Any aid to a present bad bank is the surest mode of preventing the establishment of a good bank." The time-inconsistency examined in our paper relates to collective moral hazard induced by forbearance in joint bank failure states. While direct evidence linking state-contingent regulatory actions to bank herding is not available, some existing studies reflect well the spirit of our analysis.

Hoggarth, Jackson and Nier (2005) provide evidence of the ex-ante versus ex-post trade-off that is at the heart of our paper. Using cross-country panel data, they show that the provision of safety nets to the banking sector reduces the overall ex-post impact of banking crises, but makes it more likely ex ante that the banking system will face a crisis. In particular, they show that countries with an explicit unlimited deposit protection scheme are the most likely ones to experience banking crises. More interestingly, the next most likely group to have a crisis is that without any ex-ante scheme. However, most countries in this group introduce blanket government guarantees during a crisis. This, in turn, is likely to be built into market expectations and to create moral hazard. They also show that the group least likely to experience a crisis is that with an explicit but *limited* deposit protection scheme and within that group those countries that require depositors to co-insure are less likely to experience banking crises. They conclude that pre-committing to providing only limited cover is effective in limiting moral hazard ex ante.[11]

In a non-banking setting, Berglof and Bolton (2002) discuss how Hungary and Czech Republic had to soften their new bankruptcy code during transition when many firms would otherwise have had to be declared bankrupt.

Bank herding: In evidence that studies correlation of different banks' assets through the

[11] On a similar point, Demirguc-Kunt and Detragiache (2002) analyze the effect of deposit insurance on the stability of the banking system using panel data for 61 countries during 1980-97. They conclude that explicit deposit insurance tends to be detrimental to bank stability, more so when institutional environment is weak, when the coverage is extensive and when the insurance is run by the government.

correlation of their equity returns, Luengnaruemitchai and Wilcox (2004) find that during the period 1976 to 2001, banks in the US chose market and asset betas that clustered together more when banking sector was troubled, in terms of banks having low capital ratios. They find a lower standard deviation of bank betas in such times. Their interpretation of this finding is one of herding by banks to seek "safety in similarity": "[Banks] more tightly mimicked each other during troubled times." In troubled times, banks would be concerned more about regulatory bailouts than from an erosion of profit margins from mimicking each other: The likelihood of default on loans is relatively greater in such times compared to the likelihood of being repaid.

A number of studies employ evidence from the over-exposure of banks to emerging market economies before the debt crisis of 1982–84. Guttentag and Herring (1984), for example, discuss three potential explanations. While their first two explanations are related to bounded rationality of banks, the only rational explanation they consider is that too-many-to-fail guarantees created incentives for banks to get over-exposed to risks in these countries. They suggest that deposit insurance, existence of lender-of-last-resort facilities as well as official support for debtor countries from international institutions such as the IMF, BIS and OECD gave banks the impression that they would be protected against risks. They also suggest that, by herding and keeping concentrations in line with each other, banks made sure that any problem that occurred would be a system-wide problem, not just the problem of an individual institution. Banks reasoned that, this, in turn, would make it harder for the regulatory authorities to blame or discriminate against individual institutions and would induce governments to take action to prevent the adverse consequences of a system-wide banking crisis.

Jain and Gupta (1987) provide evidence consistent with different incentives that too-big-to-fail and too-many-to-fail guarantees can create for banks. They empirically investigate herding behavior among US banks in their lending decisions to less developed countries prior to the debt crisis of 1982-84. Using Granger causality tests, they show that the regional banks herded and followed the decisions of 24 large banks. This finding supports our hypothesis that too-many-to-fail would mostly affect small banks. Barron and Valev (2000) provide similar evidence. They also employ data for the US banks' lending behavior prior to the debt crisis of 1982–84 and show that an increase (decrease) in the level of investment in a country by large banks led to an increase (decrease) in the level of investment by small banks.

Alternative mechanisms to achieve herding: Banks may increase the correlation of their returns by investing in similar industries. Alternatively, they can achieve high levels of default correlation through inter–bank lending since this leads to the problems of one bank being transmitted to other banks in a contagion-type phenomenon, and indirectly increases the likelihood of bailout of the problem bank. Such alternative mechanisms are interesting to discuss and examine since they do not result in the erosion of profit margins (as in lending), a factor that could countervail the herding incentives in our model.

Creating linkages through inter-bank loans is akin to corporations providing trade credit to each other. On this point, Perotti (1998) provides evidence from the transition experience in Eastern Europe. The first step of the reform programs in the period was a sharp tightening of monetary policy, which was aimed at controlling inflation by inducing firms to substitute internal finance for bank credit. To overcome the liquidity constraint caused by reduction in bank credit, firms accumulated huge trade debt to each other.[12] Fearing that the huge arrears would lead to an economy-wide contagion effect, causing massive failure of "good" firms because of unpaid bills from "bad" firms, governments in some countries, such as Romania, Russia and Ukraine, decided to intervene by expanding credit to firms. In Russia, to clear the rising volume of arrears, the Central Bank expanded its direct credit from 1.4 billion to 2.9 billion roubles within three months in the summer of 1992. Though the creation of trade-credit linkages was a response to the reform program, it is plausible that it was also a way of "gaming" government bailouts: by indirectly increasing the correlation of default, firms increased the likelihood of being bailed out, a version of the too-many-to-fail problem we analyzed.

Another alternative for banks to lend to similar set of customers and to get exposed to similar risks is to participate in syndicated loans. Through syndication, banks can ensure that they are more likely to receive regulatory subsidies when the loans perform poorly, affecting all syndicate members. Adams (1991) argues that before the emerging market debt crisis, banks comforted themselves by herding, thinking that as long as all banks made similar loans, any crisis would be system-wide and would force governments to bail out those countries in trouble.[13] She also argues that syndicated loans acted as an important vehicle for herding and hundreds of billions of dollars in loans were syndicated between 1970 and 1982. On a similar point, Jain and Gupta (1987) also discuss the role of syndicated loans for bank herding during the emerging market debt crisis.

7 Conclusion

The too-big-to-fail problem has been explicitly recognized by bank regulators, and its effect on strategic choices of banks have been extensively studied by researchers. In contrast, the

[12] Trade arrears in Russia increased from 34 million to 3 billion roubles during the period of tight credit between January and June 1992, rising to over two times total bank credit.

[13] According to Pedro-Pablo Kuczynski, a former World Bank official, Peruvian cabinet minister, and later an investment banker with First Boston Corporation, "banks preferred to lend to the public sector, not for ideological reasons but because government guarantees eliminated commercial risk."

too-many-to-fail guarantees have received less attention from policy makers and academics even though such guarantees have been provided regularly to banks during systemic banking crises. Recognizing and modeling the too-many-to-fail guarantee focuses attention on choices of banks as a group, for example, herding by banks in lending to a specific sector or in taking exposures to a systematic risk factor. These choices of the banking sector may be more critical to understanding systemic risk than individual risk-choices of banks. Hence, we believe that our analysis of the (sub-)optimality of these guarantees and their ex-ante costs is novel and important from an academic standpoint as well as from a policy standpoint. The main implication of our analysis is that the genesis of inefficient systemic risk may potentially lie in the very crises-management role of central banks or equivalent bank regulators. Thus, the paper highlights the need for understanding and designing regulatory policies at a systemic level rather than only at an individual bank level.

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Appendix

Proof of Lemma 1: Note that even though there is no deposit insurance in the second period, depositors always receive their reservation value of 1, in expected terms. Thus, in each state i, we have $E(r_1^i) = 1$. Let p be the price the surviving bank acquires the failed bank's assets and $\widetilde{R}_j$ be the random return from Bank j's assets in the surviving banks portfolio for $j = A, B$. We can write the surviving bank's expected profit as:

$$\begin{aligned} E(\pi_2) &= E\left[\widetilde{R}_A + \widetilde{R}_B - 2r_1^{sf} - p\right] = E\left[\widetilde{R}_A + \widetilde{R}_B\right] - 2 - p && (22) \\ &= 2\alpha_1 R - 2 - p = 2\left[\alpha_1 R - 1\right] - p. && (23) \end{aligned}$$

Note that if the bank does not purchase the assets, its expected profit is equal to $(\alpha_1 R - 1)$. Thus, for any price $p < [\alpha_1 R - 1]$, the surviving bank, by acquiring the failed bank, increases its expected profits by $[\alpha_1 R - 1 - p] > 0$. Note that the surviving bank can acquire the failed bank's assets at a price $\underline{p} = [\alpha_1(R - \Delta) - 1]$ and this, in turn, increases its value by $(\alpha_1 \Delta)$.

Finally, we formally show that it is optimal for the regulator to resolve failure of Bank B through its sale to Bank A. When Bank B is sold to Bank A, there is no misallocation cost and the fiscal cost from providing deposit insurance is $a(r_0 - \underline{p})$. If Bank B is sold to outsiders, the fiscal cost is the same, $a(r_0 - \underline{p})$, and there is the additional misallocation cost of $(\alpha_1 \Delta)$. And when Bank B is bailed out, there is no misallocation cost but the fiscal cost is higher, $a(r_0)$. Thus it is optimal for the regulator to sell failed bank's assets to the surviving bank in states SF and FS. $\diamondsuit$

Proof of Lemma 3: From equation (14), we know that banks will choose the highest level of correlation if and only if $E(\pi_2^{ff}) > \alpha_1 \Delta$. Thus, part (1) is trivial, since in this case $E(\pi_2^{ff}) = 0 < \alpha_1 \Delta$.

In part (2), when both banks are bailed out, we have $E(\pi_2^{ff}) = (1 - \beta)(\alpha_1 R - 1)$. Note that, in this case, $E(\pi_2^{ff}) > \alpha_1 \Delta$, if and only if, $\alpha_1 \Delta < (1 - \beta)(\alpha_1 R - 1)$. We can also write this condition as $\beta < \beta^* = \left(1 - \frac{\alpha_1 \Delta}{(\alpha_1 R - 1)}\right)$.

Thus, if $\beta^* \leqslant (1 - \overline{\theta})$, then for a bailout strategy of $\beta \in [\beta^*, (1 - \overline{\theta})]$, we have $E(\pi_2^{ff}) \leqslant \alpha_1 \Delta$, and banks choose the lowest level of correlation, $\rho = 0$, and, for a bailout strategy of $\beta \in [0, \beta^*)$, we have $E(\pi_2^{ff}) > \alpha_1 \Delta$, and banks choose the highest level of correlation, $\rho = 1$ (part ($2i$)).

Furthermore, if $\beta^* > (1 - \overline{\theta})$, then for a bailout strategy of $\beta \in [0, (1 - \overline{\theta})]$, we have $E(\pi_2^{ff}) > \alpha_1 \Delta$, and banks choose the highest level of correlation (part ($2ii$)). $\diamondsuit$

Proof of Proposition 2: We will prove part (*2*) since part (*1*) has already been explained in the text.

If the regulator bails out one of the failed banks and liquidates the other, with each bank having the probability of 1/2 to be bailed out, then $E(\pi_2^{ff}) = \frac{1}{2}(1-\beta)(\alpha_1 R - 1)$. Banks will choose the lowest level of correlation if and only if $E(\pi_2^{ff}) < \alpha_1 \Delta$. This condition holds when $\beta \geqslant \beta^{**} = 1 - \frac{2\alpha_1 \Delta}{(\alpha_1 R - 1)}$.

Suppose that $\beta^{**} \leqslant (1-\overline{\theta}) < \beta^*$. Note that this strategy dominates one of liquidating both banks since liquidating only one bank results in lower ex-post costs but still implements a low correlation. Then, the regulator can implement a low correlation by committing to liquidate only one bank and diluting the share of the bailed-out bank by $\beta = \beta^{**}$. We show that it would be ex-ante optimal for the regulator to commit to do this (at least for some parameter range) even though it is ex-post optimal to bail out both banks. Note that if the low correlation is implemented by committing to liquidate one bank, then $E(\Pi_2^{ff}) = E(\Pi_2^{ss}) - \alpha_1\Delta - a(2r_0 - \underline{p})$, and

$$E(\Pi_2(0)) = E(\Pi_2^{ss}) - 2\alpha_0(1-\alpha_0)\left[a(r_0 - \underline{p})\right] - (1-\alpha_0)^2\left[\alpha_1\Delta + a(2r_0 - \underline{p})\right]. \tag{24}$$

Instead, if the regulator commits to the ex-post optimal strategy of bailing out both banks, then it cannot implement a low correlation. Hence, $E(\Pi_2^{ff}) = E(\Pi_2^{ss}) - a(2r_0)$, and

$$E(\Pi_2(1)) = E(\Pi_2^{ss}) - (1-\alpha_0)\left(a(2r_0)\right). \tag{25}$$

Thus, it is optimal for the regulator to commit to liquidating one of the banks if and only if $E(\Pi_2(0)) > E(\Pi_2(1))$. This is satisfied when:

$$2\alpha_0\left[a(r_0 - \underline{p})\right] + (1-\alpha_0)\left[\alpha_1\Delta + a(2r_0 - \underline{p})\right] < a(2r_0). \tag{26}$$

We can simplify this condition to

$$-\alpha_0(a\underline{p}) + (1-\alpha_0)(\alpha_1\Delta) - (a\underline{p}) < 0. \tag{27}$$

We can write this as a condition on α_0 as:

$$\alpha_0 > \left[1 - \frac{2a\underline{p}}{\alpha_1\Delta + a\underline{p}}\right] = \alpha_0^{**}. \tag{28}$$

Thus, there is a threshold level of α_0, denoted by α_0^{**}, above which, it is optimal for the regulator to commit ex ante to liquidating one of the banks.

As shown in the text, for $\alpha_0^* < \alpha_0 < \alpha_0^{**}$ it is optimal for the regulator to commit ex ante to liquidating both banks, which induces low correlation.

And for $(1-\overline{\theta}) < \beta^{**}$, the strategy of committing ex ante to liquidating only one bank to induce low correlation without given banks the incentive to choose the bad project is no longer possible. Thus, the regulator has to commit ex ante to liquidating both banks to induce banks to choose the low correlation, as explained in part *(1)*. $\diamondsuit$

Proof of Proposition 3: We prove each case separately.

(4i) $\Delta \leqslant \Delta^*$: Note that no failed bank, big or small, will be bailed out in this case. Hence, the continuation payoff of the small bank, when it fails or succeeds, is not affected by the outcome of the big bank's investment. Thus, the small bank is indifferent between the high and low level of correlation. When the big bank fails, regardless of what happens to the small bank, its continuation payoff is 0. However, when it is the only survivor, the big bank can acquire the small bank. Hence, the big bank prefers the low correlation. Thus, both (A_1, B_2) and (A_2, B_1) are pure strategy Nash equilibria, resulting in $\rho = 0$.[14]

(4ii) $\Delta > \Delta^*$: Note that the small bank will be bailed out in this case only in state FF, which creates incentives to herd. However, the big bank will be bailed out in both states FS and FF. And the big bank always gets an additional benefit from being the only survivor, that is, its expected profit is higher in state SF than in state SS. Thus, the big bank wants to differentiate. Hence, there is no equilibrium in pure strategies and we solve for the mixed-strategy equilibrium. Suppose that the big bank (Bank A) chooses industry A_1 with probability b, while the small bank (Bank B) chooses industry B_1 with probability s. For these probabilities to constitute a mixed-strategy equilibrium, when the big (small) bank chooses probability b (s), the small (big) bank should be indifferent between the two industries. Using the payoffs in Table 2, we get the following equality for the big bank:

$$s\left[E_A(\pi(1))\right] + (1-s)\left[E_A(\pi(0))\right] = s\left[E_A(\pi(0))\right] + (1-s)\left[E_A(\pi(1))\right]. \tag{29}$$

Note that the LHS and the RHS in equation (29) are the expected payoffs of Bank A when it chooses industry A_1 and A_2, respectively, when Bank B chooses industry B_1 with probability s. Since $\left[E_A(\pi(0))\right] > \left[E_A(\pi(1))\right]$, for the above equality to hold, we need $s^* = 1/2$. Following the same analysis for the small bank, we get $b^* = 1/2$. Thus, in the unique mixed strategy equilibrium, banks randomly choose between the two industries with probability 1/2. $\diamondsuit$

[14]Note that there may be multiple mixed strategy equilibria in addition to the pure strategy equilibria described above. Suppose that the big bank (Bank A) chooses industry A_1 with probability b, while the small bank (Bank B) chooses industry B_1 with probability s. Since the small bank is indifferent between high and low level of correlation, it can choose any probability $s \in [0, 1]$. However, the big bank wants to differentiate itself from the small bank. So we have $(s^* \in [0, 0.5), b^* = 1)$, $(s^* \in (0.5, 1], b^* = 0)$ and $(s^* = 0.5, b \in [0, 1])$ as mixed strategy equilibria.

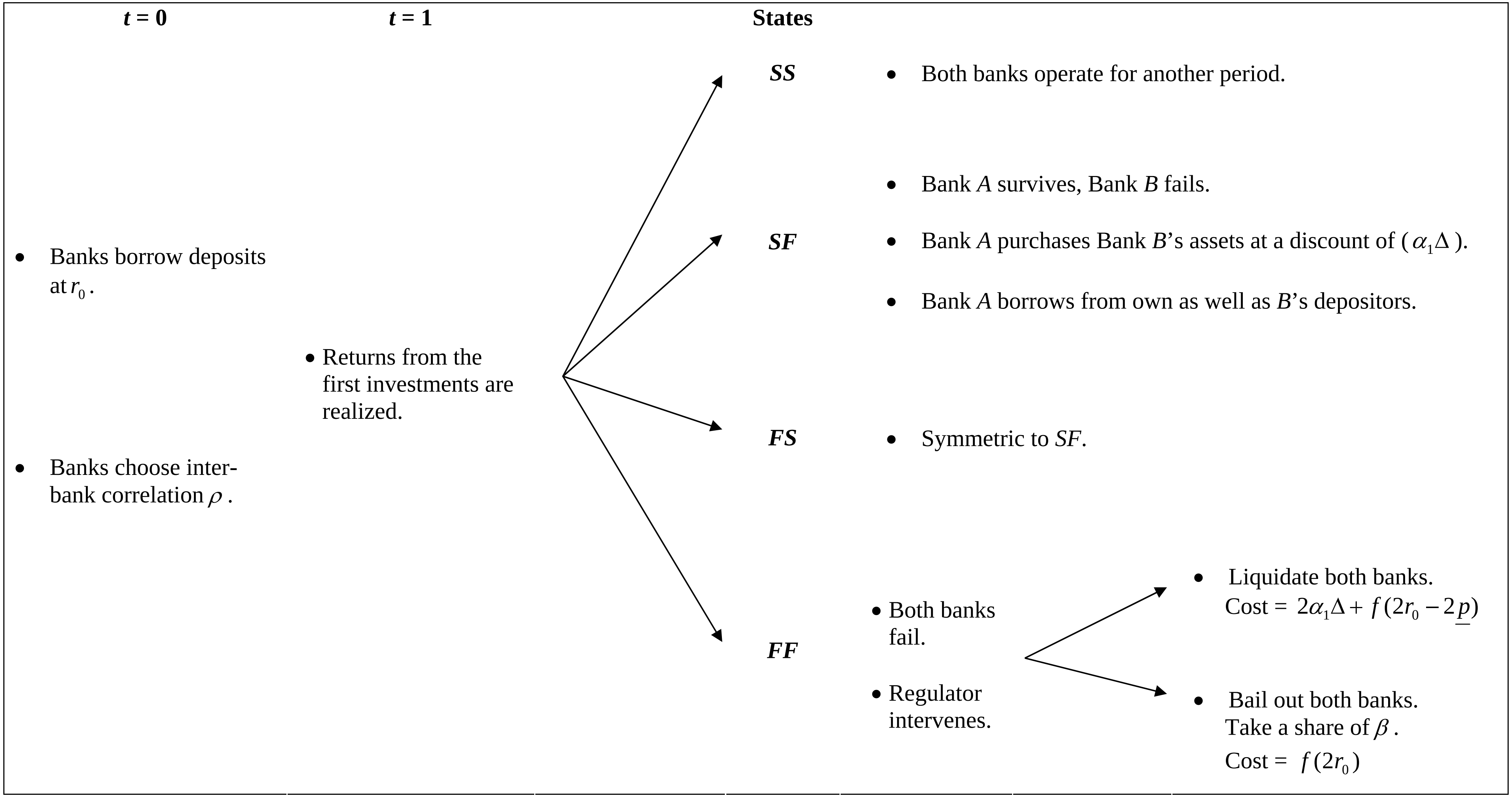

Figure 1: Timeline of the model.

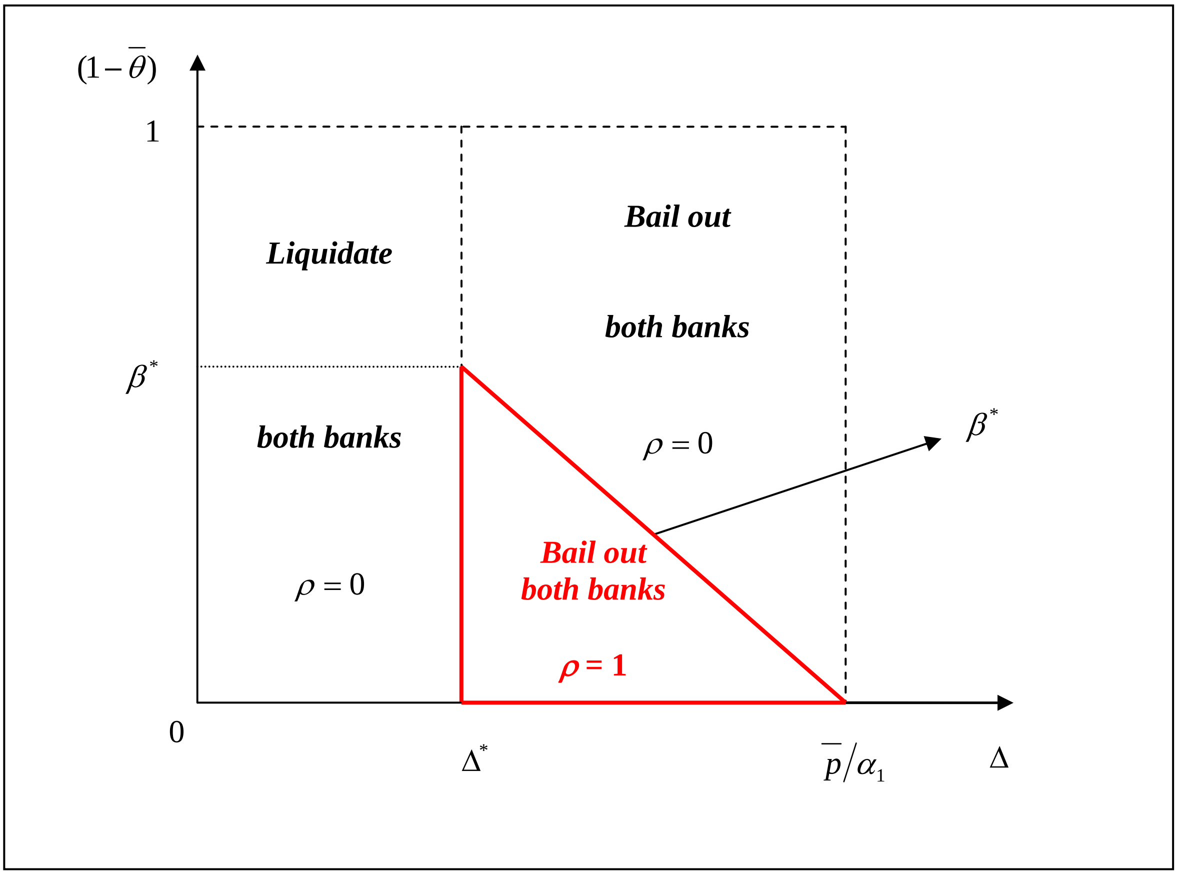

Figure 2: Ex-post optimal closure policy in state *FF*.

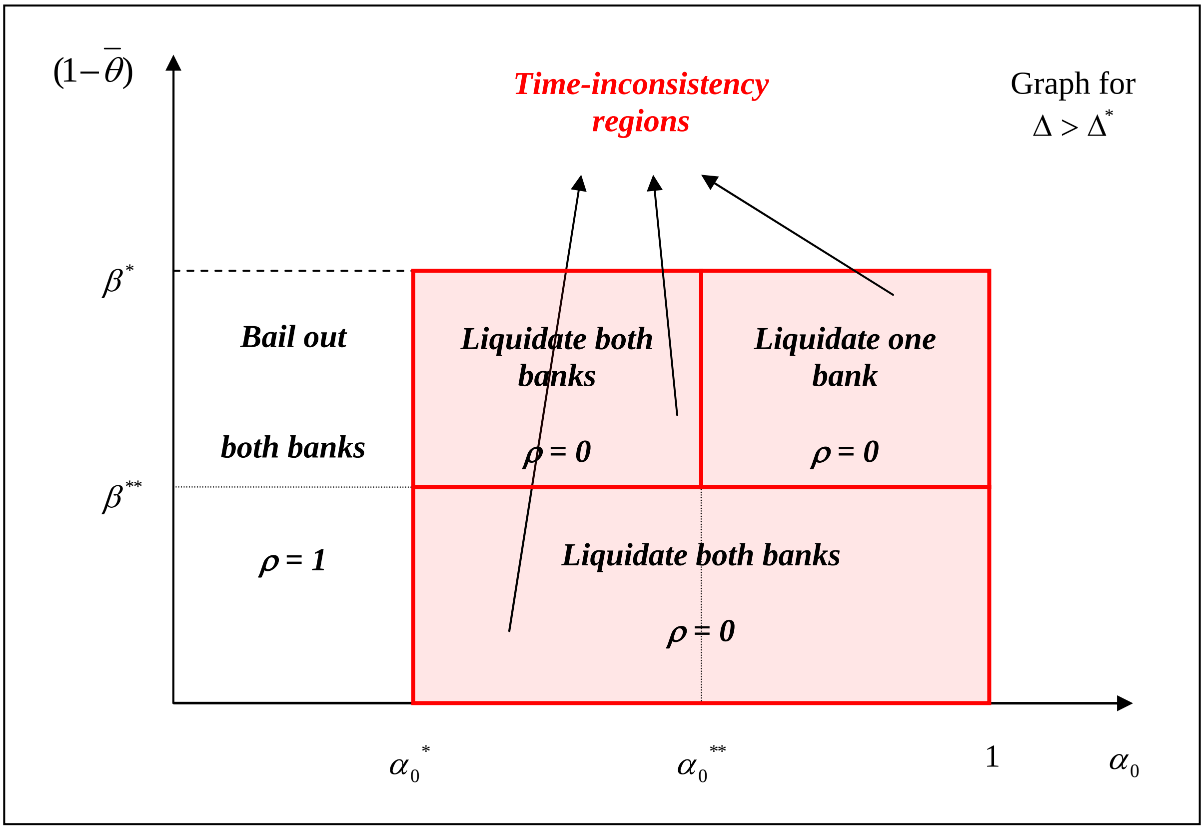

Figure 3: Ex-ante optimal policy and time inconsistency.

		Same Industry		Different Industries	
		Bank *B*'s return		**Bank *B*'s return**	
		***High* (*R*)**	***Low* (0)**	***High* (*R*)**	***Low* (0)**
Bank *A*'s return	***High* (*R*)**	α_t	0	α_t^2	$\alpha_t(1-\alpha_t)$
	***Low* (0)**	0	$1-\alpha_t$	$\alpha_t(1-\alpha_t)$	$(1-\alpha_t)^2$

Table 1: Joint probability of bank returns.

firm	B_1	B_2
A_1	$E_A(\pi(1))$, $E_B(\pi(1))$	$E_A(\pi(0))$, $E_B(\pi(0))$
A_2	$E_A(\pi(0))$, $E_B(\pi(0))$	$E_A(\pi(1))$, $E_B(\pi(1))$

Table 2: Expected payoffs for Bank A (big bank) and Bank B (small bank).