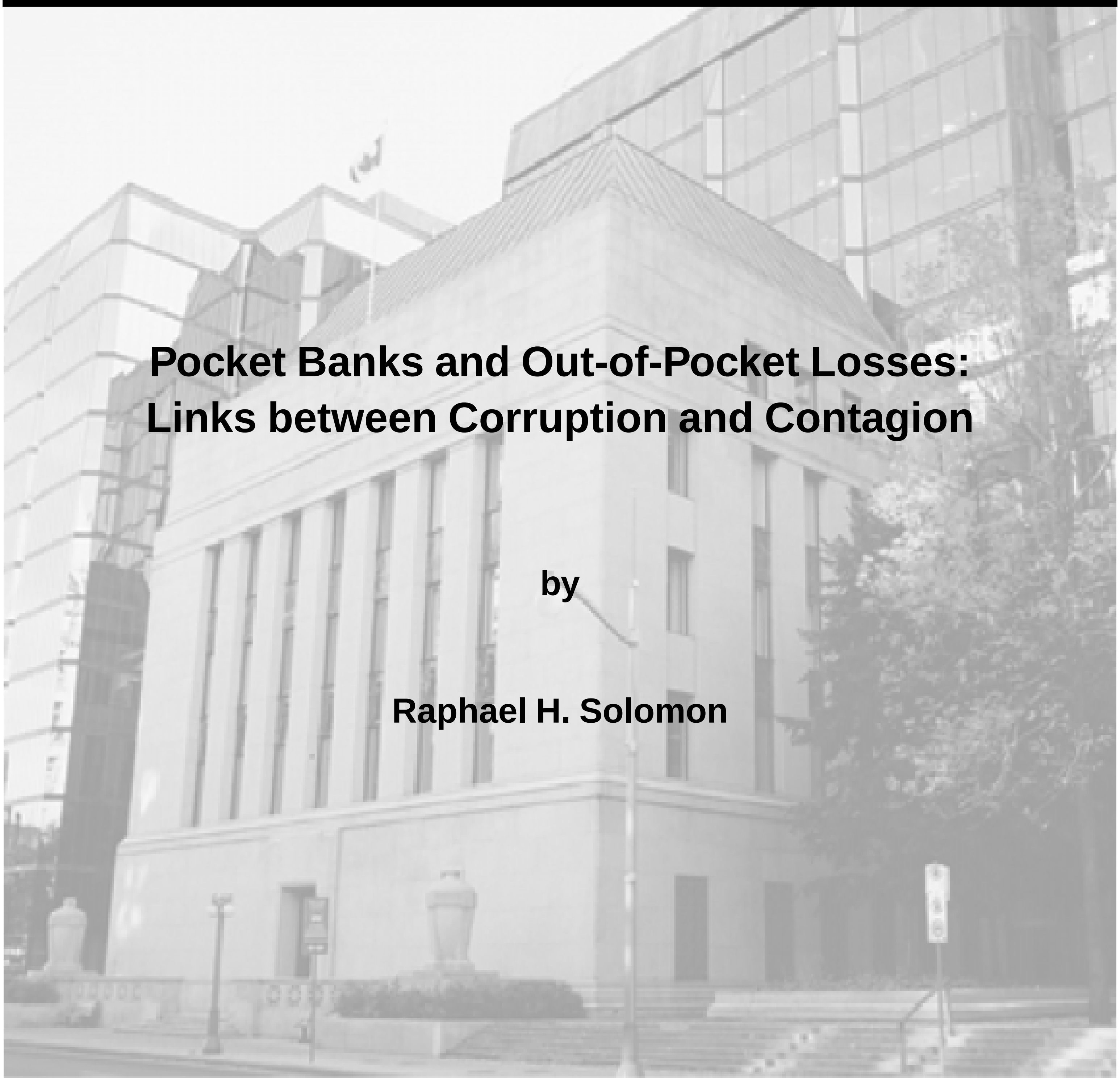
Bank of Canada Banque du Canada

Working Paper 2005-23 / Document de travail 2005-23



Pocket Banks and Out-of-Pocket Losses: Links between Corruption and Contagion

by

Raphael H. Solomon

ISSN 1192-5434

Printed in Canada on recycled paper

Bank of Canada Working Paper 2005-23

September 2005

Pocket Banks and Out-of-Pocket Losses: Links between Corruption and Contagion

by

Raphael H. Solomon

Monetary and Financial Analysis Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
rsolomon@bankofcanada.ca

Contents

Acknowledgements

The author thanks Scott Hendry, Césaire Meh, Miroslav Misina, and Carolyn Wilkins for their helpful comments. The author also appreciates comments made at presentations at the 4th Missouri Economics Conference, the 2004 Canadian Economics Association Annual Meeting, and the 2004 European Economic Association Annual Meetings, as well as comments made by seminar attendees at Queen's University School of Business and the University of Tennessee Department of Economics. All responsibility for errors remains with the author.

Abstract

The author describes a model with a corrupt banking system, in which bankers knowingly lend at market interest rates to back projects riskier than the market rate indicates. Faced with early withdrawals, bankers turn to an interbank market, which may be available in an unfettered way, available but subject to screening, or unavailable. The presence of corruption increases the probability of contagious bank failure significantly. This fact holds in a perfect information environment, as well as in some environments with imperfect information. The model suggests that financial stability can be imperilled by corrupt lending.

JEL classification: D82, G19, G21
Bank classification: Financial institutions; Financial stability

Résumé

L'auteur décrit le modèle d'un système bancaire corrompu où les banquiers prêtent intentionnellement des fonds au taux du marché pour financer des projets plus risqués que ce n'est normalement le cas à un tel taux. Face au retrait précoce de dépôts, les banquiers se tournent vers le marché des prêts interbancaires, lesquels peuvent être accordés sans restrictions, avec restrictions ou ne pas être accordés. La corruption amplifie nettement le risque de propagation des défaillances bancaires. Cela est vrai dans un contexte où on dispose d'information complète et dans certains où l'information est incomplète. Selon le modèle, la stabilité financière peut être compromise par des pratiques frauduleuses en matière de prêts.

Classification JEL : D82, G19, G21
Classification de la Banque : Institutions financières; Stabilité financière

1. Introduction

Interbank contagion[1] is the root of many recent banking crises. Anecdotal evidence from countries that have experienced such crises suggests that some banks engaged in "corrupt" lending practices and that these practices may have exacerbated the contagion problem.[2] Bank managers lent money on favourable terms to corporations "connected" to the bank. Are lending practices of this sort corrupt? A literature started by Rajan and several of his co-authors[3] suggests that banks lend to connected firms on better terms because these loans are easier to monitor and have a higher probability of collection. Laeven (2001) and La Porta, Lopez-de-Silanes, and Zamarripa (2003) document the extent of connected lending practices in Russia and Mexico, respectively.[4] They find that loans to connected parties enter default more frequently and have lower collection rates than loans to non-connected parties. I thus define a loan as corrupt[5] if four conditions hold. First, the loan is to a connected party. Second, the loan is made on favourable terms. Third, the bank does not possess superior information that justifies the favourable terms on which the loan is made.[6] Fourth, prior to granting the loan, the bank's loan office is **aware** that the other three conditions hold.[7]

[1] The first reference to contagion is by Friedman and Schwartz (1963, 308) who refer to a "contagion of fear [that] spread among depositors." I follow the definition of Allen and Gale (2000, 2): "[Contagion occurs w]hen one region suffers a bank crisis, the other regions suffer a loss because their claims on the troubled region fall in value." In their definition, geography is a metaphor for markets segmented by other factors, making the definition applicable to this paper.

[2] The World Bank defines corruption as "the use of public office for private gain" (Huther and Shah 2001, 1). A generous reading of the words "public office" includes the office of a bank manager, even at a privately owned bank.

[3] See, for example, Diamond and Rajan (2001) or Petersen and Rajan (1994).

[4] Some other papers discuss Thailand (Charumilind, Kali, and Wiwattanakantang 2003), the Baltic States (Bakker, Chu, and Fleming 1996), Russia (Gnezditskaia 2003), Bulgaria (Nenovsky, Peev, and Yalamov 2003), and Turkey (Hebb, İşcan, and Soral 2004).

[5] "Related lending" and "connected lending" are terms that have a slightly negative nuance in the literature. The term "relationship lending" has a strong, positive nuance. I use the term "corrupt lending" to convey a nuance as strong as that conveyed by the term relationship lending, but in the opposite direction.

[6] These justifications are typically grouped under the rubric of "relationship lending." Drucker and Puri (2004) suggest that superior information may come from having issued previous loans or from having underwritten securities.

[7] Without awareness, the "corrupt" loan is just mispriced risk, misperceived risk (Borio 2003), or moral hazard (Park 1994).

There are several reasons why a bank manager might extend a corrupt loan. First, the manager might receive a bribe from the borrower. Laeven (2001) shows that, even if shareholders can fire the manager when the corruption is discovered, managers choose to make corrupt loans if the payoffs to doing so are high or the probability of detection is low. Second, the manager might be obliged to lend to companies owned by the bank's majority shareholder. In this case, the manager's private benefit is job retention, together with other benefits. Business traditions require that these loans be made. Third, a bank manager might lend to someone with political power: either an elected official or a high-ranking bureaucrat. Even if the manager receives no explicit benefit at the time of the loan, the manager might hope for future benefits.[8]

The question this paper asks is the following: given that corrupt loans exist, are they a quantitatively significant determinant of interbank contagion? In asking this question, this paper breaks new ground; the literature has addressed interbank contagion[9] and corrupt lending practices[10] separately, but not the interplay between the two. Because this paper's focus differs from that of the previous literature, it does not model the rationale for corrupt lending explicitly.

The essence of the model is as follows. The banking system consists of many small banks and a large bank. Small banks lend to small firms and take demand deposits from individuals. The large bank sells time deposits to large firms. It invests the proceeds in the government bond market and the interbank loan market.[11] Demand deposit interest rates are high (because small bank deposits are risky), but time deposit rates are low.

Small banks invest in lucrative but risky projects.[12] Each small bank

[8] Charumilind, Kali, and Wiwattanakantang (2003, 3) argue that political connections are an essential part of connected lending in Thailand. Nenovsky et al. (2003, 2) make a similar point for Bulgaria.

[9] For a good survey of the corruption literature, see Furfine (2003).

[10] Boone et al.'s (2000) paper on tunnelling provides a fascinating look at legal ways that a company can be stripped of its value to benefit the majority shareholder at the expense of the minority shareholders.

[11] I assume this scheme of interactions between market participants. That is, small banks do not deal with large firms; the large bank does not deal with small firms. While these assumptions are extreme, they reflect the fact that small banks more readily collect "soft" information. In reality, small banks deal primarily with small firms, but assuming that they do so exclusively simplifies the analysis.

[12] The roles of the small banks and the large bank in this model mirror those observed

makes one corrupt loan.[13] The interest rate charged on this loan is the same as on all other loans. Since the project underlying this loan is riskier than the others, the risk of the loan is underpriced.

When depositors of the small banks withdraw, the small banks turn to the interbank market. The large bank may screen some interbank loans; whether it does so depends (in part) on the cost of screening. Legislation in the economy under study specifies that if a small bank cannot pay back its interbank loan in full, it must do so partially, even at the cost of not paying depositors. That is, its liabilities in the interbank market are senior to its deposit liabilities.[14] Even so, small banks may be forced to default on their liabilities in the interbank market. The presence of corruption may increase the probability of the small banks defaulting on loans from the large bank. This, in turn, may cause the large bank to default on its obligations to its depositors and fail. In this model, I define contagion as several small bank defaults that collectively lead to the failure of the large bank.[15] Thus, corruption cannot create contagion, but may exacerbate it. This echoes the comment in La Porta, Lopez-de-Silanes, and Zamarripa (2003, 262) that "The best way to reduce the fragility of financial systems may be to reduce the importance of related lending."

---

by Berger et al. (2002, 3). The fact that small, risky projects are financed by bank loans (instead of resorting to capital markets) accords with evidence presented by Cantillo and Wright (2000, 1).

[13]Implicit in this assumption is the fact that the corrupt contract is (self-)enforceable. That is, given the bribe or threat made to induce the corrupt loan, the bank manager does not renege on the promise to extend it. Lambsdorff and Schinke (2002) suggest that the enforcement of contracts to engage in corrupt behaviour may be difficult. They suggest that, in the absence of side-payments, repetitive deals with the same firms and other reputational devices are probably required for the corruption to occur.

[14]Freixas, Parigi, and Rochet (2003, 10) suggest that this seniority scheme is possible. As a practical matter, in common law countries, unsecured interbank loans have the same seniority as deposits. In order for the seniority assumption I make to be feasible, two conditions must hold. First, there must be a government securities market. Second, there must be a transfer mechanism so that loans can be secured. Fully incorporating these conditions into the model would require complicating the model significantly. In the background, one may picture the loans from the large bank to the small bank as being buy/sell arrangements (repo's) and thus constituting secured loans senior to bank deposits.

[15]This is a stylized definition of contagion. Because all small banks are presumed to be identical in size and preferences (and, consequently, actions), no interbank market would exist unless a lender with different characteristics (such as those of the large bank) were active in the interbank market.

There are several possible interpretations of the model described above. The classical interpretation points to a banking system like that of the United States, in which there are small, regional banks and large "money-centre" banks. But there is nothing in the model that requires the large bank (and its depositors) to be based in the same country as the small banks. If the large bank were based in a developed country and the small banks were based in a developing country, one could reinterpret the model within the paradigm of international financial contagion. This second interpretation makes the model potentially relevant to a larger set of policy-makers.

The rest of this paper is organized as follows. Section 2 explains the model environment. Section 3 specifies the games and its subgames. Section 4 defines an equilibrium. In section 5, I solve the model numerically. Sections 6 through 8 explore the consequences for the equilibrium of differing assumptions about the information shared by the actors in the model. Section 9 offers some conclusions.

2. The Model Environment

This is a three-period, partial-equilibrium model of a solvent banking system. The banking system consists of many small (retail) banks and a large (commercial) bank. The choices of the banks and other actors in the model are detailed in the following subsections.[16]

2.1 Depositors

In the tradition of bank-run models that follow Diamond and Dybvig (1983), individuals deposit at a bank because its contract offers higher utility than autarkic self-finance. I depart from this literature in three ways. First, the number of depositors at each small bank, J, is small.[17] Second, no depositor has an urgent need for liquidity. Withdrawals in period 1 are purely strategic, motivated by the possibility of bank runs and the fear of

[16] Tables 5 through 7 list the variables used in the paper.

[17] This assumption simplifies equilibrium calculations and affects the types of possible equilibria. See section 5 for more discussion.

corruption.[18] Third, depositors are risk neutral.[19]

Depositors' choices resemble those of the Diamond-Dybvig literature—whether to deposit and when to withdraw. Consider the deposit decision. By depositing, each depositor eschews the zero net interest rate payable on (mattress) storage. Thus, if an individual expects to receive a positive net return, that individual will deposit at a small bank.

Depositors may withdraw in period 1 or in period 2. Let x_{im} be the decision of the i^{th} depositor of the m^{th} bank, where $x_{im} = t \pmod 2$ indicates a withdrawal in period t. The payoff function for depositors is $V_D(x_{im}, \cdot)$. Depositors choose x_{im} to maximize the expectation of this payoff function, details of which are given in the appendix. Let x^*_{im} represent the optimal choice. Then, $w_{-i,m} = \sum_{x_{jm}=1}^{j \neq i} x_{jm}$ and $w_m = \sum_{x^*_{jm}=1} x_{jm}$. In equilibrium, since all banks are identical, it will be possible to drop the "m" subscript. Thus, w^*_{-i} and w^* denote the equilibrium equivalents of $w_{-i,m}$ and w_m, respectively.

2.2 Firms

There is a countable infinity of small firms, indexed on the unit continuum. Every small firm has a single project requiring one dollar in period 0. The firm observes the success or failure of the project in period 1, but full returns to successful projects are unavailable until period 2, the last period of the model economy. Each project has a success probability, θ; project successes are mutually independent events. Firms may thus be distinguished by their particular value of θ. The return to the firm on the project (net of returns to entrepreneurial services), $R(\theta)$, is inversely related to the probability of the project's success.[20] If a successful project can be liquidated in period 1, the returns are limited to $\gamma R(\theta)$. I do not model the distribution of

[18] That withdrawals are purely strategic eliminates the need for financing the deposit contract both by loans and by a risk-free asset.

[19] The assumption of risk neutrality also simplifies calculations. In addition, if there are states of the world in which some depositors receive zero dollars, implementing a risk-averse utility function becomes tricky, since most of these functions "behave badly" in the neighbourhood of zero. For an example of a function that overcomes this problem, see Solomon (2003).

[20] Several regularity conditions add structure to the small banks' maximization problem: $R'(\theta) < 0$, $R''(\theta) < 0$, $R(0) > 0$, and $R(1) < |R'(1)|$. These conditions suffice to ensure that the expected return function, $\theta R(\theta)$, has a unique interior maximum.

θ explicitly, but assume that it has sufficient mass at such projects to which banks willingly lend that credit rationing is not required. I also do not model the activities of large firms, because these activities are not central to the model. Large firms purchase two-period time deposits from the large banks and are "satisfied" with the return.

2.3 Small banks

There are M identical small banks in the economy. Each of J depositors brings $1-K$ dollars to a bank. Each bank also has capital of JK.[21] I do not model the small banks' choice of deposit contract. To simplify, I impose an exogenous (simple interest) contract common to all banks, denoted r_D.[22] Competitive considerations also require all banks to finance their deposit obligations identically.

Banks have two choices: to which firms to lend and how much to lend. Since all loans are one dollar each (a simplifying assumption) and each bank has J dollars to lend, each bank must choose λ, the number of loans to make, where $\lambda \in \mathbb{Z}_J = \{0 \leq z \leq J | z \in \mathbb{Z}\}$. I assume that unlent funds are storable at no cost. For each of the loans, the bank must choose θ, the riskiness of the loan. The interest rate on the loan is $R(\theta)$.

Until this point, I have considered banks to be monolithic, as if the interests of managers and owners were aligned. This cannot be the case, since corrupt loans are suboptimal for the owners of the bank. To justify the existence of corrupt loans, I assume an agency problem between the owners of the banks and their management. Owners choose both λ and $R(\theta)$. That is, the owners set the interest rate policy and the loans policy. Managers, however, must find the firms to which to lend. I denote the objective function of the owners as V_S; details are given in the appendix. So long as the

[21] The capital requirement is critical. Below a given level of bank capital, there is disintermediation in the interbank market. In requiring that loans be financed both by deposits and by bank capital, I respond to the critique that Dowd (2000) levels against most models of the Diamond-Dybvig type.

[22] In Diamond and Dybvig (1983), the bank chooses the deposit contract but the returns on its investment are exogenous. In this paper, I reverse the situation. Banks offer a fixed deposit contract but choose how to fund it by lending. By keeping the deposit contract fixed, I focus on the financing of that contract. Note that the contract has a simple form (r_D), in which depositors arriving in period 1 receive either r_D or 0 and depositors arriving in period 2 receive either $2(r_D-1)+1$ or 0. For a discussion of the properties of this contract in a risk-averse environment, see Solomon (2003).

managers charge the interest rate $R(\theta)$, the owners cannot easily determine that the managers are extending optimal loans or corrupt loans.[23] Since I do not model the benefits to the manager of extending the corrupt loan (say, the bribe), or the potential costs of making the corrupt loan, I cannot determine the "optimal" level of corruption. I assume that each small bank manager extends exactly one corrupt loan, with success probability $\tilde{\theta} < \theta^*$, where θ^* is the Nash equilibrium value of θ (chosen by the bank owner), charging interest rate $R(\theta^*)$.

2.4 The large bank

The risk-neutral[24] large bank has two choices: the interbank interest rate, r_I,[25] and its lending policy. Since each small bank has J depositors, small banks demand loanable funds in J discrete amounts, each one corresponding to a different number of individuals withdrawing during period 1. Consider a loan that is used to satisfy liquidity demands of i depositors as a loan of size i. A lending policy is a function $\phi \in \Phi : \mathbb{Z}_J \longrightarrow \{E, N, S\}$, where E designates a loan extended without screening,[26] N designates the case where no loan is extended, and S designates a loan extended but with screening.[27] Screening carries a fixed cost, c; the large bank may choose to screen loans of some sizes and not to screen loans of other sizes. The large bank chooses ϕ and r_I to maximize its objective function, V_L; details of this function are

[23] In this model, corrupt loans are loans whose risk is mispriced. While only deliberate mispricing of risk would constitute corruption, I ignore this distinction, since managers' choices are exogenous in this framework.

[24] Allowing the large bank to be somewhat risk-averse does not change the qualitative results of the model.

[25] In theory, it is possible for the large bank to set a different interbank interest rate for loans of different sizes. For screened loans, third-degree price discrimination is possible. But if loans are not screened, the interest rate function collapses to a single point—the cheapest cost of interbank funds—with small banks either combining or dividing their loans to fit their actual needs.

[26] If the large bank screens loans of a given size, it invites all small banks interested in loans of that size to pay a screening fee. The large bank then examines the balance sheet of the small bank and determines whether the potential loan is profitable. If the large bank extends the loan, it refunds the fee. In equilibrium, a small bank whose balance sheet is sufficiently poor so as not to merit the loan does not pay the fee to have its balance sheet examined. The screening fee thus plays no role in equilibrium.

[27] A lending policy thus specifies what the large bank would do in many states of the world that may not occur in equilibrium.

given in the appendix.

Government bonds pay r_g if held for one period.[28] Large bank deposits must be repaid in period 2 at rate $r_t < (r_g)^2$. The deposit liabilities of the large bank are $(1-K)A$. The large bank also has capital of KA, so it can invest up to A in the interbank market and the government bond market, combined. In period 0, the large bank purchases one-period government bonds. In period 1, it lends MLA^* to small banks and reinvests the unlent portion, $A - MLA^*$, in more one-period bonds.[29] The large bank chooses its interest rate and lending policy in such a way as to equate the return to investing in the interbank market with that of investing in government bonds.

The large bank does not lend directly to the small firms. Since I impose this condition directly, this model has a segmented-markets flavour. But, given the riskiness of lending to small firms, this is not a choice the large bank would likely make.

3. The Game

The model contains a game of complete and perfect information according to the definitions of Harsanyi (1967, 163). In this section, I discuss the informational requirements of the game, explain the order of play, and define several subgames. The definition of equilibrium is reserved for the following section.

3.1 Common information

Before any choices can be made, all players—the large bank, the small banks, and their depositors—must learn the values of a set of constants $C = \left\{A, \gamma, J, K, M, R(\theta), r_D, r_g, \theta, \tilde{\theta}\right\}$. If all players have "common knowledge" of C and the rules of the game, the game satisfies Harsanyi's conditions. To explore the realism of this assumption, partition C into C_P, C_S, and C_N, where $C_P = \{A, K, M, r_D, r_g\}$, $C_S = \{\gamma, J, R(\theta)\}$, and $C_N = \left\{\theta, \tilde{\theta}\right\}$.

[28] Minimum investment restrictions on government bonds guarantee that only the large bank can purchase them.

[29] LA^* is the value of LA, the amount lent per bank, when all decision makers play equilibrium choices. Details of LA are given in the appendix.

The elements of C_P are publicly available. The large bank publishes its assets, A, in its annual report. Statutory requirements fix bank capital, K. The number of banks in the economy, M, can be obtained by counting. The interest rate, r_D, is a published deposit contract. Finally, r_g is a matter of public record, typically reported in the media.

The elements of C_S are semi-public. The number of borrowing firms per bank, J, can be observed indirectly, since there are MJ small firms operating in the economy and M banks. The parameter γ is technological and common to all small firms. It could be observed over time by depositors, small banks, and the large bank. Over time, players could observe $R(\theta^*)$, the returns to lending to firms in an optimal way; this parameter is also technological. The function $R(\theta)$ is unobservable, since small banks choose no points other than θ^* in equilibrium.

The elements of C_N are private. The riskiness of the loans θ and $\tilde{\theta}$ is private information for small banks.

To create a game of complete and perfect information, I assume[30] the following:

Assumption 1 *A business-oriented newspaper publishes information about productivity, γ and $R(\theta^*)$, as part of its periodic "survey of the local economy." It also counts the number of banks and the number of small firms, so that everyone knows J and M.*

Assumption 2 *Small banks reveal θ^*, $\tilde{\theta}$, and the fact that there is exactly one corrupt loan.*

3.2 Order of play

The following events occur in period 0 (in order):

(i) All players learn C.

(ii) The large bank chooses[31] ϕ and r_I.

(iii) The small banks select λ and θ.

(iv) Depositors decide whether to deposit and they choose x_{im}. Large firms purchase time deposits at large banks.

[30] I relax some of these assumptions below.

[31] All choices are publicly visible, so this is a sequential-equilibrium game.

(v) Small banks combine deposits and capital, lending part or all of it to small firms. Large banks purchase one-period government bonds.

The following events occur in period 1 (in order):

(i) Small banks learn whether the projects they financed have succeeded.

(ii) Some depositors may withdraw from their small banks.

(iii) Small banks meet the demands of their depositors by a combination of retained funds, early liquidation of loans to small firms (if possible), and borrowing from the large bank (if possible). If they cannot meet their depositors' demands by paying them $r_D(1-K)w$, they pay the depositors proportionately and close their doors.

The following events occur in period 2 (in order):

(i) Unliquidated loans to small firms mature; small firms pay interest to the small banks.

(ii) Small banks repay any loans they have taken from the large bank (if possible).

(iii) Small banks pay their depositors (if possible). If any small bank cannot pay its depositors $[2(r_D-1)+1](1-K)(J-w)$, it fails.

(iv) The large bank pays its depositors, if possible. If it cannot pay its depositors $r_t(1-K)A$, it fails.

4. Equilibrium

I solve for the subgame perfect Nash equilibrium of the game, if it exists.[32]

[32] A profile of strategies is subgame perfect if it induces a Nash equilibrium in every subgame (Mas-Colell, Whinston, and Green 1995, 275).

Definition 3 *A strategy vector* $(\phi^*, r_I^*, \lambda^*, \theta^*, x^*)$ *is a subgame perfect Nash equilibrium if the following conditions hold:*

(i) The vector x^* *is a Nash equilibrium of the depositors' subgame. There is no depositor* i *and withdrawal plan* $\hat{x}_i$*, such that* $E\left[V_D\left(\hat{x}_i, x_{-i}^*, \cdot\right)\right] > E\left[V_D\left(x_i^*, \cdot\right)\right]$. *Then,* w_i^* *is the aggregator of* x_i^*.

(ii) The small bank has no profitable deviation, either in terms of interest rates or in terms of quantity of funds lent. There is no $\hat{\theta}$ *or* $\hat{\lambda}$*, such that* $E\left[V_S\left(\hat{\theta}, \hat{\lambda}, w^*, \cdot\right)\right] > E\left[V_S\left(\theta^*, \lambda^*, w^*, \cdot\right)\right]$.

(iii) The large bank has no profitable deviation, either in terms of interest rates or in terms of screening policy. There is no $\hat{r}_I$ *or* $\hat{\phi}$*, such that* $E\left[V_L\left(\hat{\phi}, \hat{r}_I, \theta^*, \lambda^*, w^*\right)\right] > E\left[V_L\left(\phi^*, r_I^*, \theta^*, \lambda^*, w^*\right)\right]$.

Definition 4 *A strategy vector is individually rational if* $E\left[V_D\left(x_i^*, \cdot\right)\right] > 1 - K$ *and if* $E\left[V_L\left(\phi^*, r_I^*, \theta^*, \lambda^*, w^*\right)\right] LA^{-1} > r_g$.

I consider only subgame perfect Nash equilibria that are individually rational.

Lemma. *In all subgame perfect Nash equilibria,* $\lambda^* = J$.

Proof. See the appendix. ■

Because small banks have potential access to the interbank market, there is no need for them to hold excess reserves; all loanable funds are lent in equilibrium.

5. Numerical Solution

Closed-form solutions for this model cannot be obtained, in part because the model has many discrete variables.[33] I calibrate the model and solve it numerically. Table 1 summarizes the parameterization.

Data drive most of the parameterization. First, since $\tilde{\theta} = 0.5$ and $\theta^* = 0.82$, corrupt loans are 35 per cent riskier than non-corrupt loans to unrelated

[33]If one allowed the number of depositors and borrowers from a given small bank to become infinite, the results reported in this and subsequent sections would unravel, because the banks can rely on the "law of large numbers" to anticipate the number of early withdrawals and loan failures. The results therefore depend on the discreteness of the parameter space for (s, w). I interpret this as corresponding to imperfect diversification of loan portfolios by banks in the real world.

parties. Second, since $J = 3$, one in three loans is corrupt. These two figures match approximately the empirical observations made by La Porta, Lopez-de-Silanes, and Zamarripa (2003, 248) about Mexico. Third, the capital ratio, $K = 0.08$, mimics the average capital ratio in Basel I. Fourth, $c = 0.03$, which is inferred from data related to screening costs.[34] I do not choose the size of the banking system (one large bank with assets of \$54 and 50 small banks with assets of \$3) to match any particular country.

The optimal policies are reported in Table 2.[35] The probability of the large bank failing if there are corrupt loans is denoted $\Pr fc$. The variable $\Pr fnc$ denotes the probability of the large bank failing if the corrupt loans cannot be liquidated early, but these loans are as likely to succeed as the non-corrupt loans.

The probability of the large bank failing absent corruption is very low: less than one in a million. The monthly probability of bank failures in the United States[36] was about the same during the 1990s. One may interpret the no-corruption regime as representing a banking system with strong surveillance and "prompt corrective action," such as the United States. By contrast, the probability of the large bank failing with corruption is more than 250 times as large! This is the model's key result: a relatively small amount of corruption has a large impact on contagion risk.

Several other results are noteworthy. In equilibrium, small banks make three loans; of their three depositors, only one withdraws in equilibrium.[37] As a result of the optimal choices by depositors and the large bank's optimal screening policy, no screening occurs in equilibrium. When the large bank does not screen its loans to the small banks, it prices the risk of default into

[34] I examine 135 countries who reported lending and deposit rates in 2001, drawing data from the International Monetary Fund's *International Financial Statistics*. The average spread in developed countries is 3.83 per cent, but the global average is 8.42 per cent. If screening costs are a large fraction of the spread, then setting the screening cost to \$0.03 is conservative for most countries.

[35] The equilibrium is robust to varying the parameters somewhat. In particular, the numbers in square brackets in Table 1 denote ranges for which the equilibrium is substantially similar to that reported in Table 2.

[36] I computed this using Federal Deposit Insurance Corporation data, 1994–2003.

[37] The Nash equilibrium is not unique. Suppose that the three depositors at a particular small bank are named A, B, and C. There are three equilibria, one in which A is the sole withdrawer, one in which B is the sole withdrawer, and one in which C is the sole withdrawer. But from the perspective of a small bank, there is a unique equilibrium aggregator, $w^* = 1$.

the terms of the loan. Since there is only one large bank, it has monopoly power and sets terms in the interbank market accordingly. In equilibrium, the individual rationality constraint for depositors at small banks binds; the seniority of interbank loans to deposits effectively passes on the costs associated with this risk premium directly to depositors.

Are any particular assumptions in the model environment driving the results? The assumption that each small bank makes exactly one corrupt loan is made without loss of generality. If some fraction of the small banks made exactly one corrupt loan and the remainder made no corrupt loans, only the equilibrium interbank interest rate would be affected, assuming that banks remained indistinguishable. If corrupt banks became identifiable, corrupt banks would have to offer a better contract to depositors to satisfy their individual rationality constraint. This would be a separating equilibrium, in which the large bank charges different interest rates to corrupt and non-corrupt banks. Neither of these possibilities overturns the result that corruption exacerbates contagion.

A somewhat more troubling assumption in the model is that the large bank has no alternative investment opportunities with which to diversify its risky portfolio of interbank loans. Clearly, the large bank lends because it is profit-maximizing to do so. Nevertheless, a “real-world” large bank might try to hedge its risk by creating a financial instrument whose best payoffs coincide with small bank defaults. The incompleteness of markets makes contagion more potent.

The assumptions about information are also somewhat troubling. Sections 6, 7, and 8 examine versions of the model where these assumptions are weakened.

6. Alternative Informational Assumption (I)

The results in the numerical example above depend on Assumptions 1 and 2. In this section, I replace Assumption 2, which is unrealistic, with something weaker, and examine the consequences for the banking system. In particular, I explore what happens if depositors and the large bank are uncertain about the number of corrupt loans, even though the number of corrupt loans per bank remains one, the same number as in the base case.[38]

[38] Agents' ignorance about the true state of corruption at each bank can also be interpreted in a heterogeneous corruption context.

Let κ denote the number of corrupt loans at each bank.

6.1 Beliefs of depositors and the large bank

Definition 5 *A belief,*[39] $B = (b_0, b_1, b_2, b_3) \in [0,1]^4$, *is a set of* ***subjective*** *probabilities regarding how many corrupt loans each bank has extended. In particular:*

$\Pr(\kappa = 0) = b_0,$
$\Pr(\kappa = 1) = b_1,$
$\Pr(\kappa = 2) = b_2,$
$\Pr(\kappa = 3) = b_3,$
such than

$$b_0 + b_1 + b_2 + b_3 = 1. \quad (1)$$

I restrict the analysis to "reasonable beliefs," that is, probability distributions whose greatest mass is centred at the true level of corruption, $\kappa = 1$:

$$\begin{aligned} b_3 &= 0, & (2) \\ b_0 &\leq b_1, & (3) \\ b_2 &\leq b_1. & (4) \end{aligned}$$

Assumption 3 *All agents know θ^* and $\tilde{\theta}$. While the true number of corrupt loans at each bank remains one, this is private information for the bankers, which they cannot credibly reveal. Beliefs about corruption at small banks can be summarized by B and conditions (2) through (4); these beliefs are commonly held by depositors and the large bank. Furthermore, the small banks are unaware that depositors and the large bank have belief B.*

Assumption 3 replaces Assumption 2 for the rest of this section. The definition of Nash equilibrium above is modified to take into account the (erroneous beliefs) of the large bank and the depositors of the small banks. In particular, depositors maximize $\sum_{\kappa} B(\kappa, \lambda) V_D(\kappa, \lambda, \cdot)$ and the large bank maximizes $\sum_{\kappa} B(\kappa, \lambda) V_L(\kappa, \lambda, \cdot)$, choosing f, r_I, and ϕ, respectively. The small banks continue to choose λ, thinking that $\kappa = 1$ is common knowledge.

[39] Note that beliefs are not updated in this game, since it is played only once. In a repeated game context, depositors might learn that $\kappa = 1$, but such learning might be slowed by the failures of small banks. The large bank might learn that $\kappa = 1$ by conducting surveys of small-bank depositors immediately prior to each play of the game.

6.2 Numerical results

I consider three beliefs of the type B: $(0, 0.895, 0.105, 0)$, $(0.2, 0.615, 0.185, 0)$, and $(0.4, 0.5, 0.1, 0)$. If $b_1 = 0$, depositors and the large bank believe that small banks have extended **at least** one corrupt loan. This view is more pessimistic than the full-information view. If $b_1 = 0.4$, depositors and the large bank essentially believe that small banks have extended **at most** one corrupt loan. This view is more optimistic than the full-information view. One may interpret the neutral belief ($b_1 = 0.2$) as approximating the full-information view with uncertainty.[40]

For each of the three beliefs, I examine the optimal policy conditional on choosing $\phi = (E, N, S)$[41] and the optimal policy conditional on choosing $\phi = (S, S, S)$. In the full-information case, $\phi^* = (E, N, S)$. The "next-most-successful" policy (before imposing screening costs) is $\phi = (S, S, S)$. I also include the disintermediation case, $\phi = (N, N, N)$ for comparison purposes. Since the solution is more difficult to obtain in a game of imperfect information, I restrict my calculations to these three policies. Table 3 reports the results.

To compute the optimal policy, it is necessary to define a "score" function that allows comparisons across policies. The score is the large bank's expected return less screening costs incurred, if any. The policy $\phi = (E, N, S)$ is "optimal" for all three beliefs. Table 4 reports the scores for different policies and beliefs.

Under all three beliefs, the values of w^* and λ^* are unchanged from their full-information optimal values, 1 and 3, respectively. By construction, the probabilities of the small banks causing a contagious bank failure of the large bank are the same as they were in the full-information case, since the true distributions of project failures are unchanged. That is, the presence of corruption still makes the large bank's failure 250 times more likely. In this uncertain case, the interbank interest rate rises as agents' beliefs become more optimistic. The change to the interbank interest rate is the only difference between the full-information equilibrium and this imperfect-information equilibrium.

[40] The expected number of corrupt loans for the pessimistic, neutral, and optimistic beliefs are 1.105, 0.985, and 0.7, respectively.

[41] The notation $\phi = (z_1, z_2, z_3)$ for any values of z is equivalent to $\phi(1) = z_1$, $\phi(2) = z_2$, and $\phi(3) = z_3$.

7. Alternative Informational Assumption (II)

It is also possible that the depositors and the large bank are uncertain about θ^*, the probability of a project succeeding, if it underlies a non-corrupt loan. The variable θ^* could potentially take any value between 0 and 1. Consider the case where $\tilde{\theta}$ is known to be 0.5 and κ is known to be 1, but depositors and the large bank are uncertain about $\hat{\theta}$. Since H and R are continuous in θ^*, define $\theta_{\min}$ implicitly by $V_D\left(\phi^*, r_I^*, \lambda^*, f^*, \theta, \tilde{\theta}\right) \geq (1-K)$ iff $\theta \geq \theta_{\min}$.[42] Let g be the belief of depositors and the large bank about θ^*, with support $[\theta_{\min}, 1]$.[43]

Assumption 4 *All agents know that exactly one loan is corrupt and they know the extent of that corruption. Agents are uncertain as to how likely uncorrupt projects are to succeed. In particular, the depositors and the large bank believe that θ^* is distributed g_{θ^*}, but this fact is unknown to the small banks.*

In this section, Assumption 4 takes the place of Assumption 2. The depositors maximize $\displaystyle\int_{\theta_{\min}}^{1} V_D(\theta^*)\, g_{\theta^*}(\theta^*)\, d\theta^*$ and the large bank maximizes $\displaystyle\int_{\theta_{\min}}^{1} V_L(\theta^*)\, g_{\theta^*}(\theta^*)\, d\theta^*$. Let g_{θ^*} be the uniform distribution on $[\theta_{\min}, 1]$.[44] Employing the parameter values used elsewhere in the paper, there does not exist an interbank interest rate such that the large bank will lend in equilibrium. That is, given the beliefs of agents, the optimal lending policy is $\phi = (N, N, N)$, the disintermediation policy.[45] Therefore, depositors will choose autarky and no production will take place.[46] Some intuition for this result is as follows. Small-bank depositors are uncertain about θ^*. If θ^* were low, depositors would require a low interbank interest rate to make them

[42] If $\theta^* < \tilde{\theta}$, the definition of a corrupt loan ceases to make sense. Thus, $\theta_{\min} \geq \tilde{\theta}$ is an implicit constraint.

[43] If θ were less than $\theta_{\min}$ with positive probability, this would be inconsistent with banks maximizing the utility of their depositors.

[44] Laplace (1951, 18) argues that, in a state of ignorance, uniform beliefs are best.

[45] This matches the findings of Huang and Xu (2000, 14): if project quality is too heterogeneous, the interbank market collapses.

[46] The same result is obtained if the small banks know the distribution $g_\theta(\theta)$ and also know that it represents the beliefs of their depositors and of the large bank.

willing to deposit.[47] With a uniform distribution for g, the interbank interest rate required to make depositors willing to deposit is too low to induce the large bank to lend to the small banks. For there to be an equilibrium, the variance of g_{θ^*} would have to be smaller.

8. Alternative Informational Assumption (III)

Consider the variable $\tilde{\theta}$, which represents the probability that a project underlying a corrupt loan succeeds. Define $\tilde{\theta}_{\min}$ analogously to $\theta_{\min}$ of the previous section.[48] Let the belief for $\tilde{\theta}$ be given by $g_{\tilde{\theta}}$, defined on the support $\left[\tilde{\theta}_{\min}, \theta^*\right]$. I can now state the assumption for this section, which replaces Assumption 2.

Assumption 5 *All agents know that exactly one loan is corrupt and they know the likelihood of uncorrupt loans succeeding. Agents are uncertain as to how likely corrupt loans are to succeed. In particular, the depositors and the large bank believe that $\tilde{\theta}$ is distributed $g_{\tilde{\theta}}$, but this fact is unknown to the small banks.*

Depositors at the small banks maximize $\int_{\tilde{\theta}_{\min}}^{\theta^*} V_D\left(\tilde{\theta}\right) g_{\tilde{\theta}}\left(\tilde{\theta}\right) d\tilde{\theta}$ and the large bank maximizes $\int_{\tilde{\theta}_{\min}}^{\theta^*} V_L\left(\tilde{\theta}\right) g_{\tilde{\theta}}\left(\tilde{\theta}\right) d\tilde{\theta}$. As in the previous section, I use the uniform distribution. There is a no-screening equilibrium of the form $\phi^* = (E, N, S)$, with $r_I^* = 1.06$, $\lambda^* = 3$, and $w^* = 1$. No equilibrium with screening exists. The no-screening equilibrium is barely preferred to the disintermediation equilibrium: the score of the former is 1.0257 and that of the latter is 1.0247, the return on government bonds. As in the case where agents are uncertain about the degree of corruption (in section 6), the probability of corruption causing a contagious bank failure is unchanged from the base case.

[47] This is because the higher the interbank interest rate, the higher the interbank loan repayments. Since the interbank loans are senior to depositors who withdraw in period 2, a higher interbank interest rate lowers returns to depositors withdrawing in period 2, and thus lowers expected returns to depositors generally.

[48] The upper bound on $\tilde{\theta}$ is θ, since, if $\tilde{\theta} > \theta$, the loan is not corrupt.

9. Conclusion

This paper describes a model of corrupt lending practices that exacerbate a contagion problem already present through an interbank lending channel. While the probability of interbank contagion is low (with and without the presence of corruption), corruption increases the probability of the large bank's collapse by more than two orders of magnitude. Moreover, the fact that corruption increases the probability of contagion is robust to various informational environments.

The fact that corruption leads to contagion even in a perfect information environment, where lending risk is properly priced, implies that the contagion in the model is somehow "optimal." This contagion has significant real effects: the assets of the banking system decrease by more than 25 per cent, the asset share of the large bank in the banking system. The possibility of mitigating the consequent real decline creates a role for government policy in economies that resemble the model economy.

Since this model is highly stylized, it cannot answer questions about the decision to be corrupt, or about the optimal amount of corruption to tolerate in a banking system. It may be the case that in a banking system where most banks issue corrupt loans, non-corrupt banks suffer an interest penalty in the interbank loan market because they cannot be distinguished from corrupt ones. To resolve these questions, a model must allow different banks to make different choices about corruption, in effect leaving the symmetric world presented in this paper. This should be a useful avenue for future research.

References

Allen, F. and D. Gale. 2000. "Financial Contagion." *Journal of Political Economy* 108(1): 1–33.

Bakker, M.-R., L. Chu, and A. Fleming. 1996. "The Baltics—Banking Crises Observed." The World Bank Policy Research Working Paper No. 1647.

Berger, A., N. Miller, M. Petersen, R. Rajan, and J. Stein. 2002. "Does Function Follow Organizational Form: Evidence from the Lending Practices of Large and Small Banks." National Bureau of Economic Research Working Paper No. 8752.

Boone, P., A. Breach, E. Friedman, and S. Johnson. 2000. "Corporate Governance in the Asian Financial Crisis." *Journal of Financial Economics* 58: 141–86.

Borio, C. 2003. "Towards a Macroprudential Framework for Financial Supervision and Regulation." *CESifo Economic Studies* 49(2): 181–215.

Cantillo, M. and J. Wright. 2000. "How do Firms Choose Their Lenders? An Empirical Investigation." *Review of Financial Studies* 13(1): 155–89.

Charumilind, C., R. Kali, and Y. Wiwattanakantang. 2003. "Connected Lending: Thailand Before the Financial Crisis." Cornell University. Photocopy.

Diamond, D. and P. Dybvig. 1983. "Bank Runs, Deposit Insurance and Liquidity." *Journal of Political Economy* 91(3): 401–19.

Diamond, D. and R. Rajan. 2001. "Liquidity Risk, Liquidity Creation, and Financial Fragility: A Theory of Banking." *Journal of Political Economy* 109(2): 287–327.

Dowd, K. 2000. "Bank Capital Adequacy Versus Deposit Insurance." *Journal of Financial Services Research* 17(1): 7–15.

Drucker, S. and M. Puri. 2004. "Tying Knots: Lending to Win Equity Underwriting Business." National Bureau of Economic Research Working Paper No. 10491.

Freixas, X., B. Parigi, and J.-C. Rochet. 2003. "The Lender of Last Resort: a 21st Century Approach." Universitat Pompeu Fabra. Photocopy.

Friedman, M. and A. Schwartz. 1963. *A Monetary History of the United States*. Princeton, NJ: Princeton University Press.

Furfine, C. 2003. "Interbank Exposures: Quantifying the Risk of Contagion." *Journal of Money, Credit and Banking* 35(1): 111–28.

Gnezditskaia, A. 2003. "Russian Banks' Profit Strategies: The Evidence From Various Types of Banks." *Communist and Post-Communist Studies* 36: 163–91.

Harsanyi, J. 1967. "Games with Incomplete Information Played by Bayesian Players, I-III. Part I: The Basic Model." *Management Science* 14(3): 159–82. Theory Series.

Hebb, G., T. İşcan, and B. Soral. 2004. "Fraud, Banking Crises and Regulatory Enforcement: Evidence from Micro-Level Transactions Data." Dalhousie University. Photocopy.

Huang, H. and C. Xu. 2000. "Financial Institutions, Financial Contagion and Financial Crises." International Monetary Fund Working Paper No. 00/92.

Huther, J. and A. Shah. 2001. "Anti-Corruption Policies and Programs: A Framework for Evaluation." World Bank. Photocopy.

Laeven, L. 2001. "Insider Lending and Bank Ownership: The Case of Russia." *Journal of Comparative Economics* 29(2): 207–29.

Lambsdorff, J. and M. Schinke. 2002. "Non-Benevolent Central Banks." Center for Globalization and Europeanization of the Economy Discussion Paper No. 16.

Laplace, P. 1951. *A Philosophical Essay on Probabilities*. New York: Dover Publications. Translated by F. Truscott and F. Emory.

LaPorta, R., F. Lopez-de-Silanes, and G. Zamarripa. 2003. "Related Lending." *Quarterly Journal of Economics* 118(1): 231–68.

Mas-Colell, A., M. Whinston, and J. Green. 1995. *Microeconomic Theory.* New York: Oxford University Press.

Nenovsky, N., E. Peev, and T. Yalamov. 2003. "Banks–Firms Nexus under the Currency Board: Empirical Evidence from Bulgaria." University of Michigan Business School: William Davidson Institute Working Paper No. 555.

Park, S. 1994. "Explanations for the Increased Riskiness of Banks in the 1980s." *Federal Reserve Bank of St. Louis Economic Review* 76(4): 3–23.

Petersen, M. and R. Rajan. 1994. "The Benefits of Lending Relationships: Evidence from Small Business Data." *Journal of Finance* 49(1): 3–37.

Solomon, R. 2003. "Anatomy of a Twin Crisis." Bank of Canada Working Paper No. 2003-41.

Table 1: Parameterization of the Model

Variable	Value	Variable	Value
A	\$54 $[38, 89]$	r_t	1.04 $[1, 1.05]$
c	\$0.03 $[0.01, \infty]$	r_D	1.3 $[1.26, 1.35]$
J	3	$R(\theta)$	$2-\theta^2$ $[2-0.96\theta^2, 2-1.24\theta^2]$
k	0.08 $[0.0567, 0.12]$	γ	0.5 $[0, 0.78]$
M	50 $[2, 66]$	$\tilde{\theta}$	0.5 $[0.46, 0.59]$
r_g	$\sqrt{1.05}$ $[1, 1.09]$		

Table 2: Solution of the Model

Variable	Value	Variable	Value
$\phi^*(1)$	E	r_I^*	1.13
$\phi^*(2)$	N	λ^*	3
$\phi^*(3)$	S	w^*	1
$\Pr fc$	1.9E-4	$\Pr fnc$	7.1E-7
LA	\$0.748	θ^*	$\sqrt{2/3}$

Table 3: Policies under Different Beliefs about Corruption

b_1	b_2	$r_I \vert \phi = (N, N, N)$	$r_I \vert \phi = (S, S, S)$	$r_I \vert \phi = (E, N, S)$
0	0.895	1.0247	1.03	1.06
0.2	0.615	1.0247	1.08	1.12
0.4	0.500	1.0247	1.27	1.30

Table 4: Scores for Different Policies and Beliefs

Belief	$\phi = (N, N, N)$	$\phi = (S, S, S)$	$\phi = (E, N, S)$
Pessimistic	1.0247	1.0000	1.0649
Neutral	1.0247	1.0500	1.0975
Optimistic	1.0247	1.2400	1.2799

Table 5: Table of Symbols: Latin A–K

Symbol	Meaning
A	Assets of the large bank
B	Beliefs about the extent of corrupt lending
b_i	The i^{th} component of the beliefs B
C	Set of constants
C_N	Set of private constants
C_P	Set of public constants
C_S	Set of semi-public constants
c	Screening cost
E	Policy: extend a loan without screening
g_{θ^*}	Beliefs about θ^*
$g_{\tilde{\theta}}$	Beliefs about $\tilde{\theta}$
H	Pdf of depositor and loan outcomes
J	Number of depositors
K	The capital ratio

Table 6: Table of Symbols: Latin L–R

Symbol	Meaning
LA	Amount lent from large bank to small banks
LIQ	Number of loans liquidated by a small bank
$LIQD$	Number of loans desired to be liquidated by a small bank
$LIQS$	Number of loans able to be liquidated by a small bank
M	Number of small banks
N	Policy: do not extend loan
$R(\theta)$	Gross return to successful projects
R_D	Gross return to depositors (state by state)
R_{D1}	Gross return to depositors withdrawing in period 1
R_{D2}	Gross return to depositors withdrawing in period 2
R_L	Gross return to the large bank
r_D	Gross return promised to depositors withdrawing in period 1
r_g	Gross return on one-period government bonds
r_I	Gross interest rate on interbank loans
r_t	Gross interest rate on time deposits

Table 7: Table of Symbols: Latin S–Z and Greek

Symbol	Meaning
S	Policy: extend loans only after screening
s	Number of successful projects
V_D	Objective function of depositors
V_L	Objective function of the large bank
w	Number of withdrawals per bank
x	1, if the depositor withdraws, else 0
$\mathbb{Z}_J$	$\{0 \leq z \leq J \vert z \in \mathbb{Z}\}$
γ	Liquidation value of a loan
θ	Probability of project's success
$\theta_{\min}$	Smallest θ^*, such that depositors deposit
$\tilde{\theta}$	Probability of corrupt project's success
$\tilde{\theta}_{\min}$	Smallest $\tilde{\theta}$, such that depositors deposit
λ	Fraction of depositors' funds lent
Φ	Set of all policy functions
ϕ	Policy function from $[J]$ to $\{E, N, S\}$

Appendix A

A.1 Details of Functions in the Main Text

As explained in the main text, each of these functions potentially depends on $\theta^*, \tilde{\theta}, \phi, r_I, \lambda$, and f. The probability function $H(s, w|\cdot)$ can be factored into $H(s|\cdot)$ and $H(w|\cdot)$, since depositor behaviour and the success of investment projects are mutually independent:

$H(w|\cdot) = 1$, if $w = w^*$.

$H(w|\cdot) = 0$, otherwise.

$H(s = 0|\cdot) = (1 - \theta^*)^{\lambda - 1} \left(1 - \tilde{\theta}\right)$.[49]

$H(s = J|\cdot) = (\theta^*)^{J-1} \tilde{\theta}, \lambda = J$, 0 otherwise.

$$H(s|\cdot) = \binom{\lambda - 1}{s} (\theta^*)^s (1 - \theta^*)^{\lambda - 1 - s} \left(1 - \tilde{\theta}\right)$$
$$+ \binom{\lambda - 1}{s - 1} (\theta^*)^{s-1} (1 - \theta^*)^{\lambda - s} \tilde{\theta},\ 1 \leq s \leq \lambda - 1.$$

Let LA be the loan amount function. $LA = 0$ whenever $w = 0$, or whenever $\phi(w) = N$, or when it is the case both that $\phi(w) = S$ and that $sR(\theta^*) > [r_D(1 - K)w - (J - \lambda) - JK] r_I$. If these conditions do not hold, $LA = r_D(1 - K)w - (J - \lambda) - JK$.

$R_L(s, w) = 0$, if $LA = 0$.[50]

$R_L(s, w) = \min(LAr_I, sR(\theta^*))$.[51]

To compute expected returns to depositors, it is necessary to examine the liquidation behaviour of small banks when they cannot get loans

[49] The $H(s|\cdot)$ function differs only from a binomial distribution with J draws in that it must take into account whether for s successes there are $s - 1$ non-corrupt loan successes or s non-corrupt loan successes.

[50] The large bank makes no money in the interbank lending market when it does not lend in the interbank market.

[51] If the large bank lends money to a small bank, the small bank either repays the loan with interest, or surrenders all revenues from its successful projects, whichever is less. The small bank's capital does not flow to the large bank in this situation, because the small bank's capital is used to pay depositors in period 1, if necessary.

from the large bank.[52] Let $LIQD$[53] $\in [J-1]$ be the integer that solves $(LIQD-1)\,\gamma R(\theta)+J-\lambda+JK < w(1-K) < (LIQD)\,\gamma R(\theta)+J-\lambda+JK$ if the solution exists, and $J-1$ otherwise. Let $LIQS$[54] $= \min(J\lambda-1, s)$ and $LIQ = \min(LIQD, LIQS)$. Since corrupt loans cannot be liquidated, define the function PL[55] as follows: $PL = 1$, if $LIQ \leq s-1$.

$$PL = \frac{\binom{J-1}{s}(\theta^*)^s(1-\theta^*)^{J-1-s}\left(1-\tilde{\theta}\right)}{\binom{J-1}{s}(\theta^*)^s(1-\theta^*)^{J-1-s}\left(1-\tilde{\theta}\right)+\binom{J-1}{s-1}(\theta^*)^{s-1}(1-\theta^*)^{J-s}\tilde{\theta}}, \text{ if } LIQ = s.$$

Finally, $V_L = \sum_{(s,w)} H(s,w)\,R_L(s,w)$.

We can write the returns to the i^{th} depositor as follows.
$E[V_D(x_i=1)] = R_D$,
if $\phi(w_{-i}+1) = E$.
$E[V_D(x_i=1)] = E_s[\max(0, s\gamma R(\theta) - \omega_{-i}R_D)]$,
if $\phi(w_{-i}+1) = N$.
$E[V_D(x_i=1)] = R_D \Pr_s[sR(\theta) - r_I L_1 \geq 0]$
$+ \Pr_s[sR(\theta) - r_I L_1 < 0]\, E_s[\max(0, s\gamma R(\theta) - \omega_{-i}R_D)]$,
if $\phi(w_{-i}+1) = S$.
$L_1 = (w_{-i}+1)\,R_D - (J-\lambda) - (1-K)\,J$
$E[V_D(x_i=2)] = \min[2(R_D-1)+1, \max[0, sR(\theta) - r_I L_2]]$,
if $\phi(w_{-i}+1) = E$.
$L_2 = w_{-i}R_D - (J-\lambda) - (1-K)\,J$
$E[V_D(x_i=2)] = \max[0, \min[2(R_D-1)+1, s\gamma R(\theta) - \omega_{-i}R_D]]$,
if $\phi(w_{-i}+1) = N$.
$E[V_D(x_i=2)] = \min[2(R_D-1)+1, s\gamma R(\theta) - r_I L_1]\Pr_s[sR(\theta) - r_I L_1 \geq 0]$

[52] As a technical matter, a small bank might choose to liquidate loans even if it can borrow in the interbank market. Whether it is profitable to do so depends on the interbank interest rate. Since this will rarely occur in equilibrium and does not occur for the parameter values presented in this paper, I omit this possibility to simplify the algebra without loss of generality.

[53] This is the number of loans that the small bank desires to liquidate: liquidation demanded.

[54] This is the number of loans the small bank can potentially liquidate: liquidation supplied.

[55] This function shows the probability of being able to liquidate a given number of loans.

$+ \Pr_s [sR(\theta) - r_I L_1 < 0] E_s \min [2(R_D - 1) + 1, \max(0, s\gamma R(\theta) - \omega_{-i} R_D)]$, if $\phi(w_{-i} + 1) = S$.

The unconditional expectation of V_D depends on the Nash equilibrium probabilities.

Finally, $V_S = \sum_{(s,w)\in[J]^2} H(s, w|\cdot) \max\left\{0, \max_{\lambda,\theta} \tilde{g}(\mathbf{p})\right\}$,
where $\tilde{g}(\mathbf{p}) = \lambda\theta R(\theta) - wR_D - (J-w)[2(R_D - 1) + 1]$ and $\mathbf{p} = (s, w, \lambda, \theta)$.

A.2 Proof of Lemma in Main Text

Let $P = \mathbb{Z}_J^3 \times [0,1]$. The function $\tilde{g}$ induces a natural partition on P, positive profitability. $\hat{P} = \{\mathbf{p} \in P | \tilde{g}(\mathbf{p}) > 0\}$. The function V_S can be rewritten as follows: $V_S = \begin{cases} \sum_{(s,w)\in\mathbb{Z}_J^2} H(s, w|\lambda, \cdot)\, \tilde{g}(\mathbf{p}), & \mathbf{p} \in \hat{P} \\ 0, & \text{otherwise} \end{cases}$. If $V_S = 0$ in equilibrium, then λ is a free variable; therefore, it can take the value J without loss. But suppose $V_S \neq 0$. It is evident that $g(\mathbf{p})$ is positive and an increasing function of λ. $H(\cdot)$ is a non-negative function, since it is a probability distribution. Thus, V_S is non-decreasing everywhere in λ so long as $H(\cdot)$ is non-decreasing in λ. The relevant portion of H is $H(s|\cdot) = \binom{\lambda - 1}{s} (\theta^*)^s (1-\theta^*)^{\lambda-1-s} \left(1 - \tilde{\theta}\right)$
$+ \binom{\lambda-1}{s-1} (\theta^*)^{s-1} (1-\theta^*)^{\lambda-s} \tilde{\theta}$, $1 \leq s \leq \lambda - 1$. H can be written as the sum of two positive functions, each of which is increasing in λ (to see this, just take the natural logarithm of each term separately). Thus, V_S is non-decreasing in λ and the optimal λ is J. Note that one cannot take the derivative of H with respect to λ, since λ is not a continuous variable.

Bank of Canada Working Papers
Documents de travail de la Banque du Canada

Working papers are generally published in the language of the author, with an abstract in both official languages. ***Les documents de travail sont publiés généralement dans la langue utilisée par les auteurs; ils sont cependant précédés d'un résumé bilingue*.**

2005

2005-22	The Effects of the Exchange Rate on Investment: Evidence from Canadian Manufacturing Industries	T. Harchaoui, F. Tarkhani, and T. Yuen
2005-21	The Effectiveness of Official Foreign Exchange Intervention in a Small Open Economy: The Case of the Canadian Dollar	R. Fatum and M.R. King
2005-20	La fonction de production et les données canadiennes	P. Perrier
2005-19	Bank Failures and Bank Fundamentals: A Comparative Analysis of Latin America and East Asia during the Nineties using Bank-Level Data	M. Arena
2005-18	Lines of Credit and Consumption Smoothing: The Choice between Credit Cards and Home Equity Lines of Credit	S. Dey
2005-17	Risk Perceptions and Attitudes	M. Misina
2005-16	Endogenous Central Bank Credibility in a Small Forward-Looking Model of the U.S. Economy	R. Lalonde
2005-15	Learning-by-Doing or Habit Formation?	H. Bouakez and T. Kano
2005-14	Labour Market Adjustments to Exchange Rate Fluctuations: Evidence from Canadian Manufacturing Industries	D. Leung and T. Yuen
2005-13	Efficiency and Economies of Scale of Large Canadian Banks	J. Allen and Y. Liu
2005-12	Do Exchange Rates Affect the Capital-Labour Ratio? Panel Evidence from Canadian Manufacturing Industries	D. Leung and T. Yuen
2005-11	An Analysis of Closure Policy under Alternative Regulatory Structures	G. Caldwell
2005-10	Educational Spillovers: Does One Size Fit All?	R. Baumann and R. Solomon
2005-9	State Dependence in Fundamentals and Preferences Explains Risk-Aversion Puzzle	F. Chabi-Yo, R. Garcia, and E. Renault
2005-8	Recent Developments in Self-Employment in Canada	N. Kamhi and D. Leung
2005-7	Determinants of Borrowing Limits on Credit Cards	S. Dey and G. Mumy
2005-6	Monetary Policy under Model and Data-Parameter Uncertainty	G. Cateau

Copies and a complete list of working papers are available from:
Pour obtenir des exemplaires et une liste complète des documents de travail, prière de s'adresser à :

Publications Distribution, Bank of Canada
234 Wellington Street, Ottawa, Ontario K1A 0G9
E-mail: publications@bankofcanada.ca
Web site: http://www.bankofcanada.ca

Diffusion des publications, Banque du Canada
234, rue Wellington, Ottawa (Ontario) K1A 0G9
Adresse électronique : publications@banqueducanada.ca
Site Web : http://www.banqueducanada.ca