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A theory of linkage between monetary policy and banking failure in developing countries

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Abstract

Purpose – The purpose of this paper is to present a model that studies the impact of a tightening monetary policy on banking failure in a developing country.

Design/methodology/approach – The interest rate on treasury bills is included in the model to measure monetary policy. Since the model considers developing countries with low-income level, the paper assumes that a secondary market does not exist.

Findings – The model shows that, despite treasury bills constituting an alternative source of profit for banks in developing countries, a tightening monetary policy increases the probability of banking failure. In addition, the model shows that efficiency level explains the asymmetric effect of monetary policy on the profit of the banks.

Practical implications – The policy implication of the results of the paper is that the central bank should take into account the adverse effect of a tightening monetary policy on banking failure, when planning policy decisions.

Originality/value – The paper offers insights into the linkage between monetary policy and banking failure in developing countries.

Keywords Banking, Business failures, Monetary policy, Interest rates, Developing countries

Paper type Research paper

1. Introduction

Some empirical and theoretical papers study the causes of banking crisis. Empirical studies emphasize the role of the banks conditions as principal factors. Wheelock and Wilson (2000) find that bank specific data are significant factors of the US bank failures and acquisitions. Arena (2008), for instance, reveals that bank-level fundamentals significantly affect banking failure in East Asia and in Latin America. About the macroeconomic conditions, one of the factors of banking crises mentions by Mishkin (1999) is high interest rates.

JEL classification – G21, G33, E52

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Kraft and Galac (2007) analyze deposits interest rate and banking failure in Croatia, where interest rates become high because of liberalization and competition. Actually, in addition to liberalization and competition, a tightening monetary policy may induce increasing of interest rates. Some researchers analyze the way monetary policy affects balance sheets and the behavior of banks. For instance, Kashyap and Stein (1995) examine the impact of monetary policy on bank's balance sheets. van den Heuvel (2002) studies the effects of monetary policy in the US states. Golodniuk (2006) studies lending channel of monetary policy in Ukraine. Bolton and Freixas (2006) analyze the effects of monetary policy on securities market and bank lending.

van den Heuvel (2002) finds that the effects of monetary policy are larger on banks with low capital level, and on banks with low liquidity level. About liquidity level, Freedman and Click (2006) reveal that, in developing countries, banks are highly liquid. Thus, in developing countries, where banks are highly liquid, treasury bills is an alternative source of profit for banks. Actually, Brownbridge (1998), who analyzes banking failure in Africa, underlines that treasury bills enable banks to earn large profits. Thus, does a tightening monetary policy reduce the probability of failure of banks, in developing countries? This question is essential, because a positive answer would suggest an opposite view to theory regarding the link between interest rate and asymmetric information. In addition, because of the consequences of bank failures, it does matter to identify any potential cause of these events, in order to know how to prevent them.

Hancock (1985) and Goyeau *et al.* (2002) analyze bank profitability and interest rates. But, they do not analyze banking failure. Even if there is a link between profitability and solvency, they are different. A bank may be solvent in spite of making losses, if equity is still positive. The empirical results of Goyeau *et al.* (2002) reveal that a decrease of interest rate in Europe has a negative effect on some banking systems whereas some other banking systems still profit. However, according to the study of Hancock (1985), bank profit appears to increase with interest rate increasing, which contradicts Goyeau *et al.* (2002). Thus, the questions still remain for research:

RQ1. Does bank profitability increase when interest rate increase?

RQ2. If some banks profit from interest rates increasing whereas some other banks do not, what can explain this difference?

Beyond these questions, this paper is more concerned about the following:

RQ3. Does a tightening monetary policy reduce probability of bank failure in developing countries?

RQ4. Does a tightening monetary policy increase profit of banks in developing countries?

I show that, despite treasury bills constitute an alternative source of profit for banks in developing countries, a tightening monetary policy increases the probability of banking failure. In addition, the model shows that, unlike an inefficient bank, an efficient bank profits from a tightening monetary policy.

Regarding firms, one of the main findings of Bernanke and Gertler (1989) is that a shortage of money, which increases interest rates, reduces firms net worth. However, there is no theoretical framework about the linkage between monetary policy and individual banking failure in developing countries. Those questions are essential, as banking failure has economic and social consequences. The paper is organized as follows: after this introduction, Section 2 presents the model, and Section 3 exposes some concluding remarks.

2. The model

This section presents a model of the banking sector that maximizes profit, and an individual bank which is a price taker. In this model, prices are interest rates on treasury bills, loans, and deposits. All interest rates are determined by the banking market, except interest rate on treasury bills. This model assume that interest rate on treasury bills, which is an exogenous price to the banking sector, is affected by stochastic shocks. The reaction function of the interest rate on treasury bills to stochastic shocks is not discussed in this paper. The paper only assumes that any change in interest rate is due to the response of monetary policy authority to stochastic shocks that affect the economy.

Since the model considers developing countries with low-income level, I assume that secondary market does not exist. In these countries, the secondary market is not well developed or does not exist at all. I show that, in developing countries with low-income level, a tightening monetary policy increases the profit of efficient banks whereas inefficient banks do not profit from it. The model shows that although treasury bills constitute an alternative source of profit for banks in developing countries, an increase of interest rate on treasury bills increases the probability of banking failure.

2.1 The banking sector

I assume that the banking sector is a competitive market. The banking sector has three assets: loans (L), treasury bills (B), and reserve (R). In the liability side of the sector's balance sheet, there are the shareholders equity (K) and deposits (D). The reserve of the banking sector is a proportion of deposits. The reserve rate is denoted by α. Central bank requires from the banking sector a capital adequacy which should be superior or equal to a proportion of risk-weighted assets (denoted by ϕ).

Reserve:

$$R = \alpha D \tag{1}$$

Capital requirement:

$$\phi(\sigma_l L + \sigma_b B) \leq K$$

where σ_l and σ_b are the risk-weight of loans and treasury bills, respectively. It is assumed that the risk-weight of loans is identical for all banks. Since treasury bills are risk-free, $\sigma_b = 0$. Thus, the capital requirement inequality becomes:

$$\phi\sigma_l \sum L \leq K \tag{2}$$

The balance sheet identity:

$$L + B + R = K + D \tag{3}$$

In the balance sheet identity (equation (3)), I replace reserve (R) by its value from equation (1). It is assumed that all banks maintain the shareholders equity equal to the minimum of capital requirement, $\phi\sigma_l L$. One of the propositions proved by Rochet (2004) is that under deposit insurance, commercial bank's optimal behavior is to maintain capital just sufficient for meeting capital requirement. However, in developing countries, there is implicit deposit insurance. Thus, K is replaced by its value:

$$L + B + \alpha D = \phi\sigma_l L + D \quad L(1 - \phi\sigma_l) + B = D(1 - \alpha)$$

$$L = \frac{1 - \alpha}{1 - \phi\sigma_l} D - \frac{1}{1 - \phi\sigma_l} B \tag{4}$$

$$B = D(1 - \alpha) - L(1 - \phi\sigma_l) \tag{5}$$

Since their reserve rate, α, is superior to the reserve rate imposed by the authority of supervision, banks can reduce their liquidity to increase treasury bills. In addition, the banks may still increase loans, despite they increase treasury bills, because banks are highly liquid in developing countries. Thus, in developing countries, banks do not necessarily substitute loans to treasury bills, vice versa. In this case, the effect of open market operations of the central bank, which increases interest rate to sell treasury bills, is weak on loans, in developing countries. That is the reason why, the efficacy of monetary policy may be weak in these countries.

Each bank of the banking sector has the same cost function of intermediation, $C(D, L)$. This cost function, is equal to the sum of the cost of the management of deposits, $C_d(D)$, and the cost of management of loans, $C_l(L)$. The cost function satisfies the assumptions of convexity, such as the decreasing returns to scale. The profit function of the sector is the following (see Appendix 1):

$$E(\pi) = r_l(1 - \bar{p})L + r_b B - r_d D - C_d(D) - C_l(L) - \bar{p}L \tag{6}$$

Because of the assumptions on $C(D, L)$, the profit function is concave in D and L. The interest rates on loans, deposits, and treasury bills are, respectively, r_l, r_d, and r_b. The expected default rate of the banking sector is denoted $\bar{p}$. The variable p is a random variable. All banks face the same marginal costs whereas the expected default rate, $\bar{p}_i$, differs from bank to bank[1]. The expected default rate affects the profit margin of the banks, by reducing the interest the banks should received on loans. Second, the expected default rate causes loss in loans portfolio. These effects of the default rate on the expected profit is take into account in equation (6) by the terms $r_l(1 - \bar{p})L$ and $-\bar{p}L$. The marginal costs of the banking sector and the marginal cost of any individual bank are identical[2]. Since interest rate on treasury bills is used as instrument of monetary policy in most developing countries, it is used in this model as the indicator of monetary policy.

If equation (5) is replaced in the profit function, it becomes:

$$E(\pi) = r_l(1 - \bar{p})L + r_b(1 - \alpha)D - r_b(1 - \phi\sigma_l)L - r_d D - C_d(D) - C_l(L) - \bar{p}L \tag{7}$$

Proposition 1. The interest rates on loans and deposits are both positive functions of the interest rate on treasury bills; and the costs of intermediation increase the interest rate on loans, and decreases the interest rate on deposits.

Proof. The problem of the banking sector is to maximize profit. To resolve it, banking sector chooses the optimal amounts of loans and deposits. Because of the assumptions of convexity on the cost function, the maximization of the profit is characterized by the first order conditions:

$$\frac{\partial E(\pi)}{\partial L} = r_l(1-\bar{p}) - r_b(1-\phi\sigma_l) - C_l'(L) - \bar{p} = 0$$
$$r_l = \frac{1}{1-\bar{p}}\left[r_b(1-\phi\sigma_l) + C_l'(L) + \bar{p}\right] \tag{8}$$

$$\frac{\partial E(\pi)}{\partial D} = r_b(1-\alpha) - r_d - C_d'(D) = 0 \quad r_d = r_b(1-\alpha) - C_d'(D) \tag{9}$$

Equation (8) shows that the risk-weighted capital requirement, $\phi\sigma_l$, reduces interest rates on loans, whereas equation (9) indicates that the reserve rate, α, reduces interest rate on deposits. Capital requirement constitutes a cost supported by banks, as it prevents the bank to provide loans to a certain extent. Zarruk and Madura (1992) find a similar result. The model developed in their paper shows that capital regulation results in a reduced interest margin. □

The rate of reserve, α, which is equal or superior to the rate of reserve requirement, is also a cost, as banks do not get return from it. This cost is supported by the depositors. Indeed, the interest rate paid to depositors is inferior to what it should be if there was not any reserve in the assets of the banks. Regarding the costs of financial intermediation, only the customers support them. These costs reduce interest rate they should receive on deposits, and increase what they should pay on loans.In addition, the expected default rate is added to the interest rate that banks'customers pay on loans. Thus, in this model, banks receive a risk prime which is equal to the expected default rate. This result is coherent with financial economic theory. Higher expected default rate induce higher interest rate on loans.

2.2 An individual bank

In this subsection, a bank profit and its probability of failure are modeled. All variables are used with the subscript i to indicate that only one bank is considered instead of the banking sector. The bank is a price taker. Thus, interest rates received on loans and paid on deposits are those determined by the market (equations (8) and (9)), whereas the value of the interest rate on treasury bills is decided by central bank, as a reaction to stochastic shocks that affect the economy. The expected default rate of the bank is $\bar{p}_i$. The value of $\bar{p}_i$ may be different from $\bar{p}$. This subsection models the individual bank as follows:

Reserve:

$$R_i = \alpha D_i \tag{10}$$

Capital requirement:

$$\phi\sigma_l L_i \leq K_i \tag{11}$$

The balance sheet identity:

$$L_i + B_i + R_i = K_i + D_i$$

In the balance sheet identity, reserve (R_i) is replaced by its value from equation (10), and K_i by its value from equation (11)[3]:

$$L_i + B_i + \alpha D_i = \phi\sigma_l L_i + D_i \quad L_i(1-\phi\sigma_l) + B_i = D_i(1-\alpha)$$
$$B_i = D_i(1-\alpha) - L_i(1-\phi\sigma_l) \tag{12}$$

The profit function of the bank is written as follows:

$$E(\pi_i) = r_l(1-\bar{p}_i)L_i + r_b B_i - r_d D_i - C_d(D_i) - C_l(L_i) - \bar{p}_i L_i \tag{13}$$

In the profit function (equation (13)), interest rates on loans and deposits are replaced by their respective value which are in equations (8) and (9). Thus, the profit function of the bank becomes[4]:

$$\begin{aligned} E(\pi_i) = {} & \frac{\bar{p}-\bar{p}_i}{1-\bar{p}} L_i[1 + r_b(1-\phi\sigma_l)] + C_d'(D_i)D_i - C_d(D_i) \\ & - C_l(L_i) + C_l'(L_i)\frac{1-\bar{p}_i}{1-\bar{p}} L \end{aligned} \tag{14}$$

The gap between the expected default rate of the banking sector and the default rate of an individual bank, $\bar{p}-\bar{p}_i$, is the relative efficiency of this bank. Thus, the profit of a bank is a function of the relative efficiency of this bank.

Proposition 2. When central bank tightens monetary policy, by increasing interest rate on treasury bills, depending on bank's relative efficiency, three cases are possible, regarding profit.

Proof. The partial derivative of the profit function of the bank, with respect to interest rate on treasury bills, is the following:

$$\frac{\partial E(\pi_i)}{\partial r_b} = \frac{\bar{p}-\bar{p}_i}{1-\bar{p}} L_i(1-\phi\sigma_l) \tag{15}$$

- If the relative efficiency of the bank is negative, i.e. $\bar{p}-\bar{p}_i < 0$, a tightening of monetary policy will reduce the bank's profits:

$$\frac{\partial E(\pi_i)}{\partial r_b} < 0$$

- If the relative efficiency of the bank is null, i.e. $\bar{p}-\bar{p}_i = 0$, a shock of monetary policy will have no impact on the profits of the bank:

$$\frac{\partial E(\pi_i)}{\partial r_b} = 0$$

- If the relative efficiency of the bank is positive, i.e. $\bar{p}-\bar{p}_i > 0$, its profits will increase when central bank tightens monetary policy:

$$\frac{\partial E(\pi_i)}{\partial r_b} > 0$$

The efficiency level is a factor that explain the asymmetric effect of monetary policy on the profit of the banks. An inefficient bank does not profit from a tightening monetary policy, whereas an efficient bank. When central bank tightens monetary policy, even if an efficient bank does not buy treasury bills, it should modify the structure of its balance sheet to maintain its profits at the same level or to increase it. Since the interest rates increase when the central bank tightens monetary policy, if a bank maintain the growth of its loans at the same level, the amount of non performing loan may increase.

For, the increasing of the interest rate on loans induces an increase of asymmetric information.

Thus, when central bank tightens monetary policy, an efficient bank should reduce the growth of its loans to reduce the effect of asymmetric information. That is the reason why a tightening monetary policy may induce an increase of the profit of an efficient bank. Actually, a tightening monetary policy may also have a neutral impact on the profit of an efficient bank. Since an inefficient bank does not deal well with asymmetric information, a tightening monetary policy induces a decrease of the profit of such a bank.

Proposition 3. Since it decreases the efficiency level of the bank, an increase of interest rate on treasury bills, which is a tightening monetary policy, increases the probability of failure of the bank.

Proof. I consider that a bank fails when it is insolvent. Thus, the bank is insolvent if the sum of shareholders equity and profit is negative. The probability of failure of the bank, which is denoted ρ, is calculated as follows (see Appendix 2):

$$\rho_i = P(K_i + E(\pi_i) < 0) = P(E(\pi_i) < -K_i)$$

$$\rho_i = \text{Prob}\Bigg(\frac{\bar{p} - \bar{p}_i}{1 - \bar{p}} L_i[1 + r_b(1 - \phi\sigma_l)] + C'_d(D_i)D_i - C_d(D_i) - C_l(L_i) - C'_l(L_i)L_i \frac{1 - \bar{p}_i}{1 - \bar{p}} < -K_i\Bigg)$$

$$\rho_i = \text{Prob}\Bigg[\bar{p}_i > \frac{K_i + C'_d(D_i)D_i - C_d(D_i) - C_l(L_i)}{L_i} \frac{1 - \bar{p}}{1 + r_b(1 - \phi\sigma_l) + C'_l(L_i)} - \frac{C'_l(L_i)}{1 + r_b(1 - \phi\sigma_l) + C'_l(L_i)} + \frac{\bar{p}(1 + r_b(1 - \phi\sigma_l))}{1 + r_b(1 - \phi\sigma_l) + C'_l(L_i)}\Bigg] \tag{16}$$

Equation (16) shows that the probability of failure is the probability that the default rate of the bank is superior to a threshold which is denoted T, with:

$$T = \frac{K_i + C'_d(D_i)D_i - C_d(D_i) - C_l(L_i)}{L_i} \frac{1 - \bar{p}}{1 + r_b(1 - \phi\sigma_l) + C'_l(L_i)} - \frac{C'_l(L_i)}{1 + r_b(1 - \phi\sigma_l) + C'_l(L_i)} + \frac{\bar{p}(1 + r_b(1 - \phi\sigma_l))}{1 + r_b(1 - \phi\sigma_l) + C'_l(L_i)}\Bigg]$$

Thus, the probability of the failure of the bank, ρ_i, is:

$$\rho_i = \text{Prob}\,(\bar{p}_i > T) = 1 - \text{Prob}\,(\bar{p}_i \leq T) \quad \rho_i = 1 - \text{Prob}\,(\bar{p}_i \leq T) \tag{17}$$

The default rate may be interpreted as an indicator of the efficiency level of the bank. Because the probability of failure is the probability that the expected default rate is superior to a threshold, efficiency level and the probability of failure are linked.

The partial derivative of the probability of failure, with respect to the interest rate on treasury bills, can now be calculated to verify the impact of a tightening monetary policy:

$$\frac{\partial \rho_i}{\partial r_b} = -\frac{\partial \mathrm{Prob}\,(\bar{p}_i) \leq T}{\partial r_b} \tag{18}$$

$$\frac{\partial \mathrm{Prob}\,(\bar{p}_i \leq T)}{\partial r_b} = \frac{\partial \mathrm{Prob}\,(\bar{p}_i \leq T)}{\partial T}\,\frac{\partial T}{\partial r_b} \tag{19}$$

$$\begin{aligned}\frac{\partial T}{\partial r_b} = &-\frac{L_i(1-\phi\sigma_l)(1-\bar{p})(K_i + C'_d(D_i)D_i - C_d(D_i) - C_l(L_i))}{[1 + r_b(1-\phi\sigma_l) + C'_l(L_i)]^2} \\ &+ \frac{C'_l(L_i)(1-\phi\sigma_l)}{[1 + r_b(1-\phi\sigma_l) + C'_l(L_i)]^2} \\ &+ \frac{\bar{p}(1-\phi\sigma)[1 + r_b(1-\phi\sigma_l) + C'_l(L_i)] - \bar{p}(1-\phi\sigma_l)[1 + r_b(1-\phi\sigma_l)]}{[1 + r_b(1-\phi\sigma_l) + C'_l(L_i)]^2}\end{aligned} \tag{20}$$

Because of equations (18) and (19), the sign of the impact of the monetary policy interest rate on the probability of failure, $\partial\rho_i/\partial r_b$, is the opposite sign of the derivative of the threshold T, with respect to the interest rate of the monetary policy, $\partial T/\partial r_b$.

According to the last result (equation (20)), the sign of $\partial T/\partial r_b$ depends between the equity and the total cost of intermediation. Since the paper assumes that all banks respect the minimum capital requirement, shareholders equity is enough to be higher than the intermediation costs. Thus, the derivative of the threshold, with respect to r_b, is inferior to zero. Thus, the derivative of the probability of failure, with respect to r_b, is superior to zero:

$$\frac{\partial T}{\partial r_b} < 0 \tag{21}$$

$$\frac{\partial \rho_i}{\partial r_b} > 0 \tag{22}$$

□

The sign of $\partial\rho_i/\partial r_b$ shows that, because it decreases the efficiency level of the bank, a tightening monetary policy increases the probability of failure of this bank. As underlined previously, the expected default rate is an indicator of the efficiency level of the bank. Indeed, the increasing of interest rates causes the increasing of asymmetric information. That is the reason why the probability of failure of all banks increase when the central bank tightens monetary policy. To deal with asymmetric information an efficient bank should reduce the growth of its loan portfolio.

A limitation of my model is that it does not account for time, which limits the possibility to show the dynamic impact of monetary policy on banking failure. Although static, the model meets the questions to which it intended to answer; the model shows that, despite treasury bills constitute an alternative source of profit for banks in developing countries, a tightening monetary policy increases the probability of banking failure. In addition, the model shows that an efficient bank profits from a tightening monetary policy, whereas an inefficient bank does not.

3. Concluding remarks

In this paper, I show that efficiency level explains the asymmetry of the effect of monetary policy on banking profit. The level of relative efficiency explains why some banks profit from a tightening monetary policy, whereas some other banks do not. In addition, the model shows that, despite treasury bills constitute an alternative source of profit for banks in developing countries, a tightening monetary policy increases the probability of banking failure. Actually, an increase of the interest rates induces an increase of asymmetric information. An efficient bank should decrease its loan portfolio to deal with asymmetric information.

If the interest rate is so high so that loan portfolio should be null, there will be a banking crisis. There is a threshold of interest rate, which I call a threshold of crisis, that interest rate on treasury bills should not exceed.

The policy implication of the results of this paper is that, the central bank should take into account the adverse effect of tightening monetary policy on banking failure, when planning policy decisions. Actually, although monetary policy intend to stabilize the price level, it may destabilize the banking sector if the growth of the interest rate is not moderate.

Notes

1. The default rate is the ratio of loans not reimburse to total loans.
2. Since all banks face the same marginal cost, $C'_d(D) = C'_d(D_i)$ and $C'_l(L) = C'_l(L_i)$.
3. Remember that it is assumed that all banks maintain the exact minimum of capital requirement.
4. See Appendices for details about calculus.

References

Arena, M. (2008), "Bank failures and bank fundamentals: a comparative analysis of Latin America and East Asia during the 1990s using bank-level data", *Journal of Banking & Finance*, Vol. 32 No. 2, pp. 299-310.

Bernanke, B. and Gertler, M. (1989), "Agency costs, net worth, and business fluctuations", *The American Economic Review*, Vol. 79, pp. 14-31.

Bolton, P. and Freixas, X. (2006), "Corporate finance and the monetary transmission mechanism", *Review of Financial Studies*, Vol. 19, pp. 829-70.

Brownbridge, M. (1998), "Financial distress in local banks in Kenya, Nigeria, Uganda and Zambia: causes and implications for regulatory policy", *Development Policy Review*, Vol. 16, pp. 173-88.

Freedman, P.L. and Click, R.W. (2006), "Banks that don't lend? Unlocking credit to spur growth in developing countries", *Development Policy Review*, Vol. 24 No. 3, pp. 279-302.

Golodniuk, I. (2006), "Evidence on the bank-lendind channel in Ukraine", *Research in International Business and Finance*, Vol. 20, pp. 180-99.

Goyeau, D., Sauviat, A. and Tarazi, A. (2002), "Rentabilité bancaire et taux d'intérêt de marché: une application aux principaux systèmes bancaires européens sur la période 1988-1995", *Revue d'Economie Politique*, Vol. 112 No. 2, pp. 275-91.

Hancock, D. (1985), "Bank profitability, interest rates, and monetary policy", *Journal of Money, Credit, and Banking*, Vol. 17 No. 2, pp. 189-202.

Kashyap, A.K. and Stein, J.C. (1995), "The impact of monetary policy on bank balance sheet", *Carnegie-Rochester Conference Series on Public Policy*, Vol. 42, pp. 151-95.

Kraft, E. and Galac, T. (2007), "Deposit interest rates, asset risk and bank failure in Croatia", *Journal of Financial Stability*, Vol. 2, pp. 312-36.

Mishkin, F.S. (1999), "Global financial instability: framework, events, issues", *The Journal of Economic Perspectives*, Vol. 13 No. 4, pp. 3-20.

Rochet, J.C. (2004), "Capital requirements and the behavior of commercial banks", *Credit, Intermediation and the Macroeconomy: Models and Perspectives*, Oxford University Press, Oxford.

van den Heuvel, S.J. (2002), "Banking conditions and the effects of monetary policy: evidence from US states", mimeo, University of Pennsylvania, Philadelphia, PA.

Wheelock, D.C. and Wilson, P.W. (2000), "Why do banks disappear: the determinants of US bank failures and acquisitions", *Review of Economics and Statistics*, Vol. 82 No. 1, pp. 127-38.

Zarruk, E.R. and Madura, J. (1992), "Optimal bank interest margin under capital regulation and deposit insurance", *Journal of Financial and Quantitative Analysis*, Vol. 27 No. 1, pp. 143-9.

Appendix 1. Profit function of the bank

The profit function of the bank is written as follows:

$$E(\pi_i) = r_l(1 - \overline{p}_i)L_i + r_b B_i - r_d D_i - C_l(L_i) - C_d(D_i) - \overline{p}_i L_i \tag{A1}$$

In the profit function (equation (A1)) I replace interest rates on loans and deposits by their respective value which are in equations (8) and (9). Thus, the profit function of the bank becomes:

$$E(\pi_i) = \frac{1}{1-\bar{p}}\left[(r_b - r_b\phi\sigma_l + C_l'(L_i) + \bar{p})(1 - \overline{p}_i)L_i\right] + r_b(1-\alpha)D_i - r_b(1 - \phi\sigma_l)L_i$$
$$- r_b(1-\alpha)D_i + C_d'(D_i)D_i - C_l(L_i) - C_d(D_i) - \overline{p}_i L_i$$

$$E(\pi_i) = \frac{1}{1-\bar{p}}\left[r_bL_i - r_b\phi\sigma_lL_i + C_l'(L_i)L_i + \bar{p}L_i - r_b\overline{p}_iL + r_b\phi\sigma_l\overline{p}_iL_i - C_l'(L_i)\overline{p}_iL_i - \overline{pp_i}L_i\right.$$
$$\left.-r_b(1-\phi\sigma_l)(1-\bar{p})L_i + C_d'(D_i)(1-\bar{p})D_i - C_l(L_i)(1-\bar{p}) - C_d(D_i)(1-\bar{p}) - \overline{p}_i(1-\bar{p})L_i\right]$$

$$E(\pi_i) = \frac{1}{1-\bar{p}}\left[r_bL_i - r_b\phi\sigma_lL_i + C_l'(L_i)L_i + \bar{p}L_i - r_bpL_i + r_b\phi\sigma_l\overline{p}_iL_i - C_l'\overline{p}_iL_i - \overline{pp_i}L_i\right.$$
$$-r_bL_i + r_b\bar{p}L_i + r_b\phi\sigma_l\bar{p}L_i - r_b\phi\sigma_l\bar{p}L_i + C_d'(D_i)D_i - C_d'(D_i)\bar{p}D_i - C_l(L_i) + C_l(L_i)\bar{p}$$
$$\left.-C_d(D_i) + C_d(D_i)\bar{p} - pL_i + \overline{pp_i}L_i\right]$$

$$E(\pi_i) = \frac{1}{1-\bar{p}}\left[L_i(\bar{p} - \overline{p}_i) + r_bL_i(\bar{p} - \overline{p}_i) - r_b\phi\sigma_lL_i(\bar{p} - \overline{p}_i)\right.$$
$$\left.+C_d'(D_i)D_i(1-\bar{p}) - C_l'(L_i)(1-\overline{p}_i)L_i - C_d(D_i)(1-\bar{p}) - C_l(L_i)(1-\bar{p})\right]$$

$$E(\pi_i) = \frac{\bar{p} - \overline{p}_i}{1-\bar{p}}\,L_i[1 + r_b(1-\phi\sigma_l)] + C_d'(D_i)D_i - C_d(D_i) - C_l(L_i) - C_l'(L_i)L_i\frac{1-\overline{p}_i}{1-\bar{p}} \tag{A2}$$

Appendix 2. The probability of banking failure

$$\rho_i = P(K_i + E(\pi_i) < 0) = P(E(\pi_i) < -K_i)$$

$$\rho_i = \text{Prob}\left(\frac{\bar{p} - \bar{p}_i}{1-\bar{p}} L_i[1 + r_b(1-\phi\sigma_l)] + C_d'(D_i)D_i - C_d(D_i) - C_l(L_i) - C_l'(L_i)L_i\frac{1-\bar{p}_i}{1-\bar{p}} < -K_i\right)$$

$$\rho_i = \text{Prob}\left(\frac{\bar{p} - \bar{p}_i}{1-\bar{p}} L_i[1 + (1-\phi\sigma_l)r_b] < -K_i - C_d'(D_i)D_i + C_d(D_i) + C_l(L_i) + C_l'(L_i)L_i\frac{1-\bar{p}_i}{1-\bar{p}}\right) \tag{A3}$$

$$\rho_i = \text{Prob}\left(\bar{p} - \bar{p}_i < -\frac{K_i + C_d'(D_i)D_i - C_d(D_i) - C_l(L_i)}{L_i}\,\frac{1-\bar{p}}{1+r_b(1-\phi\sigma_l)} + C_l'(L_i)\frac{1-\bar{p}_i}{1+r_b(1-\phi\sigma_l)}\right)$$

$$\rho_i = \text{Prob}\left(-\bar{p}_i < -\frac{K_i + C_d'(D_i)D_i - C_d(D_i) - C_l(L_i)}{L_i}\,\frac{1-\bar{p}}{1+r_b(1-\phi\sigma_l)} + C_l'(L_i)\frac{1-\bar{p}_i}{1+r_b(1-\phi\sigma_l)} - \bar{p}\right)$$

$$\rho_i = \text{Prob}\left[\left(-\bar{p}_i + C_l'(L_i)\frac{\bar{p}_i}{1+r_b(1-\phi\sigma_l)}\right) < -\frac{K_i + C_d'(D_i)D_i - C_d(D_i) - C_l(L_i)}{L_i}\,\frac{1-\bar{p}}{1+r_b(1-\phi\sigma_l)} + C_l'(L_i)\frac{1}{1+r_b(1-\phi\sigma_l)} - \bar{p}\right] \tag{A4}$$

$$\rho_i = \text{Prob}\left[-\bar{p}_i\left(1 + C_l'(L_i)\frac{1}{1+r_b(1-\phi\sigma_l)}\right) < -\frac{K_i + C_d'(D_i)D_i - C_d(D_i) - C_l(L_i)}{L_i} \times \frac{1-\bar{p}}{1+r_b(1-\phi\sigma_l)} + C_l'(L_i)\frac{1}{1+r_b(1-\phi\sigma_l)} - \bar{p}\right]$$

$$\rho_i = \text{Prob}\left[-\bar{p}_i\left(\frac{1+r_b(1-\phi\sigma_l) + C_l'(L_i)}{1+r_b(1-\phi\sigma_l)}\right) < -\frac{K_i + C_d'(D_i)D_i - C_d(D_i) - C_l(L_i)}{L_i} \times \frac{1-\bar{p}}{1+r_b(1-\phi\sigma_l)} + C_l'(L_i)\frac{1}{1+r_b(1-\phi\sigma_l)} - \bar{p}\right]$$

$$\rho_i = \text{Prob}\left[-\bar{p}_i < -\frac{K_i + C_d'(D_i)D_i - C_d(D_i) - C_l(L_i)}{L_i}\,\frac{1-\bar{p}}{1+r_b(1-\phi\sigma_l)+C_l'(L_i)} + \frac{C_l'(L_i)}{1+r_b(1-\phi\sigma_l)+C_l'(L_i)} - \frac{\bar{p}(1+r_b(1-\phi\sigma_l))}{1+r_b(1-\phi\sigma_l)+C_l'(L_i)}\right]$$

$$\rho_i = \text{Prob}\left[-\bar{p}_i > \frac{K_i + C_d'(D_i)D_i - C_d(D_i) - C_l(L_i)}{L_i}\,\frac{1-\bar{p}}{1+r_b(1-\phi\sigma_l)+C_l'(L_i)} - \frac{C_l'(L_i)}{1+r_b(1-\phi\sigma_l)+C_l'(L_i)} + \frac{\bar{p}(1+r_b(1-\phi\sigma_l))}{1+r_b(1-\phi\sigma_l)+C_l'(L_i)}\right]$$

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