

Macroeconomic Risk and Banking Crises in Emerging Market Countries: Business Fluctuations with Financial Crashes

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Abstract

This paper investigates the interaction between aggregate risk, financial fragility, and the macroeconomic performance of emerging market countries when asymmetric information at the level of firms and banks gives rise to agency costs. Two-sided debt contracts are the funding mechanism through which banks borrow from international investors and lend to domestic firms. Banks are risky because their portfolio returns hinge on the strength of the economy and an adverse macroeconomic shock can therefore cause bank failures. Banking crises are sporadic and driven by fundamentals. *Macroeconomic risk* affects business cycles because all agents incorporate the endogenously determined probability of a crisis into their economic decisions. Model results are consistent with the empirical evidence on banking crises because a slowdown of the economy or an unforeseen interest-rate rise tends to breed banking sector problems. Furthermore, the country-specific-interest-rate spread is counter-cyclical because financial crises are less likely during booms.

Keywords: Banking crises, macroeconomic risk, financial frictions, business cycles.

JEL classification codes: E44, F32, F33, F34, F41.

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1 Introduction

Banking crises are not a strange episode in market economies. Indeed, they have been recurrent and costly in emerging market countries during the last 25 years (see Lindgren et al., 1996; Caprio and Klingebiel, 1997, 1999; and Bordo et al., 2001). As long as banks are major players in modern economies, a banking crisis sparks off multiple adverse consequences including output losses, monetary instability, and other nonmonetary effects associated to information losses.¹ The sequels of widespread banking failures are worse in developing countries because their banks own a larger share of total financial assets than the share owned by banks in industrial countries.² Furthermore, the costs of restructuring a bankrupt banking system are inversely related to the degree of poverty of the nations and can be as large as one fourth of the GDP (Goldstein and Turner, 1996; Hoggart et al., 2001).

Notwithstanding being costly, to some extent crises are inevitable because every financial system is risky. An examination of the way banks do business reveals that under a reasonably high level of leverage, banks cannot guarantee the claims of investors if large adverse macroeconomic shocks occur (Dewatripont and Tirole, 1994, chap. 2). The value of the banks' portfolios may fall because of a weak economic performance of banks' borrowers, specially when some credit risk cannot be diversified. A slowdown of the economy bankrupts a higher proportion of borrowers compared to "normal times", and it is conceivable that the downturn be severe enough that the banks themselves are in distress and cannot fully repay their creditors. This reasoning along with the greater volatility of emerging market economies can account for the higher vulnerability of these economies to waves of banking failures.³

The causality between macroeconomic conditions and financial instability also goes the other way around because an expected decline in the value of banks' portfolios can weaken the economy. In a world of forward looking economic agents, everybody incorporates the

¹See Hoggart et al. (2001) for an estimate of the costs arising from generalized banking failures. Bernanke (1983) discusses the nonmonetary effects of banking crises with reference to the US depression; for an international comparison of these effects see Bernanke and James (1991).

²On the importance of banks in the financial system of developing countries, see Beck et al. (1999).

³International business cycles studies indicate that whereas business cycles are qualitatively uniform across countries, macroeconomic volatility is observed to be higher in developing than in industrial countries (see Mendoza, 1995; Agénor et al., 2000.)

eventual negative effects of a crash into his economic decisions. Therefore, not only financial crises but also their likelihood of occurrence affect the economy. Consider the case of international investors which are a large fraction of the banks' creditors in developing countries. As forward-looking agents, these investors demand risk premiums and take portfolio decisions that respond to the financial fragility of the economy. At least, it is clear that these investors will play any but the passive role suggested by the standard business-cycles model of a small open economy (SOE).⁴

The country-risk premium brings about the interest rate on bank loans to firms. Therefore, a riskier financial system depresses the net rate of return of the productive activities that depend on bank loans. This pushes the demand for inputs down and then lowers the household employment and income. In sum, on one hand macroeconomic conditions are an important determinant of the soundness of the financial system and on the other hand the degree of financial fragility pervades all sectors of the economy.

This study builds a model of business cycles in a SOE where aggregate risk produces sporadic banking failures in a world where banks intermediate inflows of capital. Banks issue debt among international investors, fund a large number of firms, and are subject to a capital-adequacy regulation. Firms borrow from banks because they have to pay factors of production before realizing their sales proceeds. As project risk is not completely diversifiable, economic downturns trigger a large ratio of poor project returns depreciating the value of the banks' portfolios. Under some circumstances, recessions are severe enough that they produce the insolvency of the banking system.

The paper abstracts from monetary and liquidity aspects of financial intermediation and stresses the aggregate risk involved in the credit creation process in a small open economy (SOE). Panics, understood as circumstances where depositors attempt to withdraw their funds simultaneously, play no role in the model as deposits are represented by single-period contracts. A banking crisis is defined here as the inability of the banks to honor their debts. Crises are therefore driven by fundamentals and not by a change of expectations.

The probability of widespread banking failures is known in every period and it is part of the information set of all agents in the economy. Consequently, all economic decisions

⁴In that model, the international-interest rate is given and capital flows are (mainly) demand determined.

depend on the likelihood of a financial crash due to the eventual crisis sequels. Exogenous capital requirements on banking impose a risk on bankers who can lose part of their wealth during a crisis. International investors face a similar risk insofar as a financial crash affects the repayment capacity of the banks. As long as household income depends on the state of financial markets and is affected by bank failures, the household sector is not immune from financial turmoils either.

The financial frictions in the economy that justify the existence of banks arise from a combination of two related elements. One is the presence of information asymmetries about both firms' output and banks' portfolio returns; the other is the existence of agency costs coming from the employment of a costly-state-verification technology. In this context, financial intermediation resembles delegated-monitoring banking because from time to time international investors have to 'monitor a monitor'. Following Krasa and Villamil (1992a,b), a two-sided simple-debt contract is the optimal investment mechanism employed to solve the asymmetric information problem.

The contribution of the paper consists in addressing the following points using a computable general equilibrium framework. First, macroeconomic conditions and not self-fulfilling expectations trigger banking crises. Second, the likelihood of a crisis being incorporated into the decisions of every economic agent, both macroeconomic risk and financial fragility affect business cycles. Third, the country-specific interest rate is endogenous because international investors evaluate the fundamentals behind their borrowers' future ability to repay.

Following Diamond and Dybvig (1983), most macroeconomic models dealing with banking crises in developing countries emphasize the role of sudden expectation changes in setting off bank runs.⁵ However, the empirical evidence on the determinants of banking crises seems to indicate that pure self-fulfilling expectations are one but not the most important determinant of the crashes. For instance, Kaminsky and Reinhart (1999) point out that "in both [currency and banking] crises we find a multitude of weak and deteriorating economic fundamentals that it would be difficult to characterize them as a self-fulfilling crises."⁶ The

⁵See for example Chang and Velasco (2000) and Cook and Devereux (2000).

⁶Among other empirical studies that support the view that fundamentals are among the most important

two prominent fundamentals that explain the crises seem to be a weak macroeconomic performance and rising interest rates.

The literature on the effects of credit frictions on macroeconomic fluctuations that emphasizes agency costs follows Bernanke and Gertler (1989). Within the real business cycle paradigm, Fuerst (1995) and Carlstrom and Fuerst (1997) incorporate agency costs into the standard model by assuming informational asymmetries in the production of capital goods. Bernanke et al. (1999) synthesize this literature and offer a detailed analysis of the so called “financial accelerator”. Both Carlstrom and Fuerst (1998) and Cooley and Nam (1998) compare the consequences of assuming that financial frictions arise in the production of capital goods, vis-à-vis the case where the frictions arise in the production of final output. Despite dealing with credit and financial issues, this literature has not addressed the role of either bank credit risk or aggregate risk. In Bernanke et al. (1999) banks never default because borrowers offer a state-contingent non-default payment that guarantees the lender a return equal in expected value to the riskless rate. Cooley and Nam (1998) and Carlstrom and Fuerst (1998) take an alternative way out of aggregate risk by assuming that debt contracts are signed after the realization of the stochastic component that explains the macroeconomic uncertainty.

Out of the business-cycle paradigm, several works have studied the relationship between aggregate risk and banking crises by extending the Diamond and Dybvig (1983)’s framework (see Allen and Gale, 1998 and the papers cited therein). While this literature shows how business-cycle risk can lie at the root of run-driven banking crises, it is silent about the specific mechanism through which economic fluctuations impact on the bank-portfolio return. Similarly, the way through which the financial fragility can exert influence on business cycles is not at the aim of these works either.

Consistent with the empirical evidence, both declining aggregate productivity and rising interest rates are capable of bringing about a banking crisis in the model. Particularly, a calibration of the model to emerging market countries shows that the probability of a banking crisis goes from 0.5% during a boom to 1% during a deep recession. However, not

factors that tend to breed banking sector problems, the reader can see Gorton (1988), Lindgren et al. (1996), Demirgüç-Kunt and Detragiache (1997), Caprio and Klingebiel (1997), and Eichengreen and Rose (2002).

every recession, no matter how deep, causes a crisis; it certainly does when the downturn is both deep and unexpected. Other results show that the interest rate on the debt issued by banks in international markets as well as the interest rate on debt issued by firms are counter-cyclical and responsive to the aggregate risk. Once a crisis is in place, its ability to produce long-lasting effects depends on the existence of explicit crisis-related costs.

The paper proceeds as follows. The next section describes the model and explains how the probability of a bank failure depends on fundamentals. It also characterizes the financial contracting technology. Section 3 discusses static general equilibrium results, and Section 4 discusses the dynamic effects of banking crises and aggregate risk. Section 5 contains concluding remarks and avenues to be explored in future research.

2 The Model

This section models a non-monetary open economy where banks intermediate inflows of capital that finance domestic production. Banks borrow from international investors and lend to domestic firms. Firms have no wealth and have to pay for their inputs before getting their sale proceeds. Consequently, firms must borrow working capital from banks to start their production. The outcome of production depends on both, an idiosyncratic and an aggregate productivity shock.

All firms in the economy are owned by a mutual fund and every household holds a share of that fund, so that households are isolated from the realization of idiosyncratic productivity shocks. Households do not face financial frictions and have access to international markets where they may borrow and lend at the risk-free rate r_t^* . There is only one good which is freely tradable, and both domestic and international agents own the capital employed domestically.

Bankers and investors are regarded as international agents whose only relationship with the economy is the provision of financial services, i.e. they neither consume nor invest domestically. This assumption avoids modelling bankers' and investors' economic history. Also, to refrain dealing with firms credit history, it is assumed that the only contracting technology available precludes subsequent contracting. Financial markets are competitive

so that investors and banks accept any contract giving them profits equal to the opportunity cost of capital.

The economy is subject to hidden information because, at the firm-bank relationship, the bank cannot freely observe the firm's output; and at the bank-investor relationship, international investors cannot assess the return on banks' portfolios without incurring auditing costs. The information asymmetry about the bank-portfolio return arises because the realization of the aggregate productivity shock is non-verifiable straightaway. Therefore, it is impossible to infer both the fraction of firms that has declared bankruptcy and the output that has been produced by these firms. Under these assumptions along with bounded costs of monitoring banks, Krasa and Villamil (1992a,b) show that two-sided debt contracts dominate any other investment scheme.

The impossibility of observing the value of aggregate productivity shocks provides a rationality for a standard assumption made in the SOE version of RBC models, namely that debt contracts with international investors cannot be made contingent on output (Mendoza, 1991). This can be justified noting that aggregate productivity is a catchall for factors other than labor and capital that affect output. Terms of trade shocks, weather conditions, government intervention in the economy, and political turmoils are a few examples of possible components of aggregate productivity. Furthermore, these components may have uneven consequences across sectors of the economy. Therefore, it is difficult to pick a set of variables whose realizations can be readily observable and reflect the *overall* productivity.

The sequence of events in a given period t can be described in terms of four subperiods, t_1 to t_4 , and it is summarized in Table 1. At t_1 , knowing the value of the international risk-free interest rate but ignoring the actual value of firms productivity, firms, banks, and investors sign financial contracts. The contracts establish loan sizes, a bank deposit rate, and a bank loan rate. At t_2 , still ignoring the value of their productivity, firms spend the loan proceeds in hiring labor and capital services and input markets clear. At t_3 , firms start to produce, realize their productivity value and obtain output. Some firms cannot repay their loans and have to declare their bankruptcy. These firms are audited by the bank. Other firms obtain nonnegative profits which accrue to the household. Under some circumstances the fraction of firms declaring bankruptcy is so high that the value of the bank portfolio falls short of

the value of bank liabilities; faced with an insolvent bank, depositors confiscate its portfolio. Before the next subperiod starts, the value of the risk-free international interest rate for $t+1$ is known. At t_4 , household take consumption and saving decisions; household savings are allocated between physical capital and international risk-free bonds. The amount of capital to be employed in the next period depends on the household allocation of savings and on the international supply of capital. Finally, output market clears in this last subperiod.

Under one of the setups of the model, reorganizing production becomes costly in the aftermath of a banking crisis; specifically, the cost of employing the pre-crisis stock of capital is higher after a crisis has hit the economy than otherwise. This feature recognizes the informational losses derived from a bank failure and shows an additional channel through which a crisis affects macroeconomic aggregates.

2.1 Firms

Output is produced by a unit mass of *competitive* firms, which each having access to a decreasing returns technology. Firm i 's output at time t , Υ_{it} , depends on the capital and labor services employed by the firm, k_{it} and n_{it} , respectively and on the productivity shock, z_{it} ; i.e. $\Upsilon_{it} = \Upsilon(z_{it}, k_{it}, n_{it})$. Particularly,

$$\Upsilon(z_{it}, k_{it}, n_{it}) = z_{it}A \left(k_{it}^\alpha n_{it}^{1-\alpha} \right)^\beta \quad \alpha \in [0, 1]; \quad \beta < 1 \quad (1)$$

where the parameter A scales total factor productivity and $\alpha\beta$ is the share of output paid to capital. z_{it} represents the realization of the random variable Z_{it} , which is the sum of other two random variables: a) an idiosyncratic i.i.d. productivity shock, X_{it} ; and b) an economy-wide productivity shock, Y_t , whose dynamics is governed by a Markov process. That is to say, $Z_{it} = X_{it} + Y_t$.⁷ The realizations of these three random variables are indicated with lowercase letters: z_{it} , x_{it} , and y_t , respectively.

Let $h_X(x_t)$ denote the probability density function of the X_{it} 's; and let $h_Y(y_t|y_{t-1})$ and $h_Z(z_t|y_{t-1})$ denote the conditional probability density function of Y_t , and the Z_{it} 's,

⁷Notice that the random variables Z_{it} are not independent because macroeconomic conditions affect all projects in the same way. This is the source of the non-diversifiable aggregate risk.

respectively, conditional on the realization of the previous period aggregate productivity shock, y_{t-1} . The conditional density function of the firm's productivity shock, $h_Z(z_t|y_{t-1})$, is the convolution between the density functions $h_X(x_t)$ and $h_Y(y_t|y_{t-1})$.⁸ All probability density functions above have a nonnegative support and are positive and differentiable on their respective supports. $H_j(\cdot)$, $j = X, Y, Z$ is the correspondent conditional probability distribution function.

When a firm borrows working capital from a bank to hire inputs, it does not know the realization of its productivity shock, z_{it} . Although firms and banks are fully informed about the conditional distribution of the Z_{it} 's, there exists asymmetric information about the ex-post realizations: while firm i costlessly observes the realization of its own productivity shock, other agents have to employ a costly technology to verify it. Furthermore, the outcome of the verification is only revealed to whom monitors the firm.

It is known that under the informational conditions described above, simple-debt contracts (SDCs) dominate any other possible one-sided funding arrangement (Gale and Hellwig, 1985; Williamson, 1986). Thus, regardless of how the bank funds its loans, a working-capital loan is a SDC. This type of contract is completely characterized by a loan size, m_{it} , and a promised repayment, i.e. a gross interest rate, r_{it}^L . Thereupon, firm i will declare its bankruptcy when it is unable honor that promised repayment. The working-capital loan described here will be part of a two-sided simple debt contract in the recursive competitive equilibrium of the economy to be defined later.

Once firm i has secured a loan of size m_{it} , it seeks to maximize its *expected* profits. Provided these profits are nonnegative, the firm's problem reduces to producing the maximum amount of output subject to the constraint that requires the expenditure on inputs not exceeding m_{it} . Indeed, when the production possibility set posses a convex input structure,

⁸Let s and t be two continuous random variables with density functions $\phi_s(s)$ and $\phi_t(t)$ defined for all real numbers, then the *convolution* $\phi_s * \phi_t$ of ϕ_s and ϕ_t is the function given by:

$$\phi_u(u) = (\phi_s * \phi_t)(u) = \int_{-\infty}^{+\infty} \phi_s(u-t)\phi_t(t)dt = \int_{-\infty}^{+\infty} \phi_t(u-s)\phi_s(s)ds$$

it guarantees the existence of the following indirect production function⁹:

$$\Gamma(z_{it}, w_t, r_t^K, m_{it}) \equiv \max_{\{k_{it}, n_{it}\}} \{\Upsilon(z_{it}, k_{it}, n_{it}) : w_t n_{it} + (r_t^K - 1) k_{it} \leq m_{it}\} \quad (2)$$

where w_t and r_t^K are the wage rate and the gross rental rate of capital, respectively; Γ expresses output as a function of the productivity shock, parametric input prices, and the loan size. Particularly, for the functional form of Υ_{it} stated in eq. (1),

$$\Gamma(z_{it}, w_t, r_t^K, m_{it}) = z_{it} \Lambda_t m_{it}^\beta \quad (3)$$

where $\Lambda_t \equiv A \left(\frac{\alpha}{r_t^K - 1} \right)^{\alpha\beta} \left(\frac{1-\alpha}{w_t} \right)^{(1-\alpha)\beta}$ is constant across firms. Furthermore, notice that the duality between $\Upsilon(z_{it}, k_{it}, n_{it})$ and $\Gamma(z_{it}, w_t, r_t^K, m_{it})$ also holds in expectation when z_{it} is replaced by $E[Z_{it}|y_{t-1}]$.

For a given combination of input prices and loan size, i.e. a pair (Λ_t, m_{it}) , it is easy to see from eq. (3) that there exists a one-to-one relation between output and the value of z_{it} . Therefore, a value of z_{it} , say $\bar{z}_{it} \in [0, \infty)$, can be found that gives firm i just enough output to repay the loan:

$$r_{it}^L m_{it} = \Gamma(\bar{z}_{it}, w_t, r_t^K, m_{it}) \quad (4)$$

Under these conditions the firm is bankrupt when $z_{it} < \bar{z}_{it}$ but it is not when $z_{it} \geq \bar{z}_{it}$. In the latter case, the firm repays the loan at the agreed interest rate ($r_{it}^L = \bar{z}_{it} \Lambda_t m_{it}^{\beta-1}$). In the former case, the firm declares its bankruptcy and it is audited and seized by the bank. The nonnegative profits of firm i , i.e. π_{it} , can then be written as

$$\pi_{it} = \begin{cases} \Gamma(z_{it}, w_t, r_t^K, m_{it}) - m_{it} r_{it}^L, & \text{if } z_{it} \geq \bar{z}_{it} \\ 0, & \text{if } z_{it} < \bar{z}_{it} \end{cases} \quad (5)$$

The aggregation of profits across firms can be simplified recognizing that all firms are ex-ante identical. Hence, the terms of the SDC as well as the optimal input combination, are

⁹The convex-input-structure condition is production theory's analogue of convex preferences. It implies that the set of input combinations capable of obtaining or exceeding any given target output level is convex. See Cornes (1992) and Shephard (1970).

exactly the same for every firm.¹⁰ Consequently, aggregate profits, Π_t , are:

$$\Pi_t = \int_{\bar{z}_t}^{\infty} \Gamma(z_{it}, w_t, r_t^K, m_{it}) h_Z(z_t | y_{t-1}) dz_t - m_t r_t^L [1 - H_Z(\bar{z}_t | y_{t-1})] \quad (6)$$

where $H_Z(\bar{z}_t | y_{t-1})$ is the measure of firms with a productivity lower than \bar{z}_t and hence bankrupt. The remaining $[1 - H_Z(\bar{z}_t | y_{t-1})]$ firms are solvent and repay their loans at the agreed rate r_t^L .

2.2 Banks and the Probability of a Bank Failure

There is a large number of banks (the length of the set is equal to one), each of who finances a large number of firms through SDCs. The bank's gross income from firm i is given by $\Lambda m_t^\beta g(\bar{z}_t, x_{it}, y_t)$, where:

$$g(\bar{z}_t, x_{it}, y_t) = \begin{cases} \bar{z}_t, & \text{if } z_{it} \geq \bar{z}_t \\ z_{it} - \mu^f, & \text{if } z_{it} < \bar{z}_t \end{cases}$$

By exploiting the relation between \bar{z}_t and r_t^L stated in eq. (4), this expression recognizes the two possible firm outcomes from the bank standpoint: the firm either repays its loan at the interest rate r_t^L , or surrenders its output to the bank. The latter is costly because monitoring a bankrupt firm costs $\Lambda_t m_t^\beta \mu^f$, a cost that depends on input prices, the loan size, and the parameter μ^f .¹¹

When the bank contracts with N ex-ante identical firms, its average gross income per borrower is equal to $\Lambda_t m_t^\beta G_N(\bar{z}_t, x_{1t}, \dots, x_{Nt}, y_t)$ where G_N involves a simple average:

$$G_N(\bar{z}_t, x_{1t}, \dots, x_{Nt}, y_t) = \frac{1}{N} \sum_{i=1}^N g(\bar{z}_t, x_{it}, y_t)$$

As N becomes infinitely large, the bank diversifies away the idiosyncratic risk and only the realization of Y_t matters for the determination of the average income per borrower.

¹⁰By dropping the subscript i in all variables but the random variables X_{it} and Z_{it} and their realizations, this allows to simplify the notation hereupon.

¹¹The constancy of monitoring costs across insolvent firms facilitates aggregation.

Therefore, the macroeconomic risk remains as a non-diversifiable risk which could cause a bank failure. Absent the macroeconomic risk, the expected and actual income of a bank financing an infinitely large number of firms would be equal.¹²

Once aggregate risk is considered, the average income per borrower, $\Lambda_t m_t^\beta G_N$, is stochastic and converges in probability to another random variable, $\Lambda_t m_t^\beta G(\bar{z}_t, Y_t)$, whose value depends on the realization of the macroeconomic shock. Conditional on the value taken by Y_t , by the strong law of large numbers,

$$\Lambda_t m_t^\beta G_N(\bar{z}_t, X_{1t}, \dots, X_{Nt}, Y_t) \xrightarrow{p} \Lambda_t m_t^\beta G(\bar{z}_t, Y_t)$$

where, for a realization of Y_t such that $0 \leq y_t \leq \bar{z}_t$, the limiting value of the bank gross portfolio return is given by:

$$\Lambda_t m_t^\beta G(\bar{z}_t, y_t) = \Lambda_t m_t^\beta \left\{ \int_0^{\bar{z}_t - y_t} (x_t + y_t) h_X(x_t) dx_t - \mu^f H_X(\bar{z}_t - y_t) + \bar{z}_t [1 - H_X(\bar{z}_t - y_t)] \right\} \quad (7)$$

Here, the first two terms on the right hand side are the bank income coming from bankrupt firms and the third term on that side is the bank income coming from solvent firms. The former is made of surrendered output minus the monitoring costs whereas the latter represents (gross) interest income. Notice that for $y_t > \bar{z}_t$, $G(\bar{z}_t, y_t) = \bar{z}_t$ because the aggregate productivity shock is large enough so that no single firm is bankrupt.

In order to study bank failures, the bank funding mechanism has to be specified: banks issue debt among international investors to finance its portfolio of loans. These investors are risk neutral and of small capacity as compared to the size of the loan, so that each firm would need funds from several investors if it would want to obtain direct financing.¹³ A bank becomes insolvent when its net cash flow turns negative and exceeds its capital. Therefore, the probability of a bank bankruptcy is equal to the probability that the bank

¹²The statement is also true when the financial contract is signed after observing the aggregate shock. This is the Carlstrom and Fuerst (1998) and Cooley and Nam (1998)'s way out of aggregate risk. In Bernanke et al. (1999) the bank-portfolio return is always equal to zero and banks are never insolvent because the borrowers absorb all the risk, either individual or aggregate. They agree to pay a variable interest rate which guarantees that depositors obtain a rate of return equal to the riskless rate.

¹³When an investor is able to fund a firm by its own, duplicative monitoring costs never arise and delegated monitoring is no longer an efficient investment mechanism.

cannot repay its depositors.

For κ denoting the regulated bank capital-asset ratio, the bank balance-sheet constraint indicates that the bank must borrow $m_t(1 - \kappa)$. Letting r_t^D be the gross interest rate on bank liabilities, and recalling that the stochastic gross bank-portfolio return is equal to $\Lambda_t m_t^\beta G(\bar{z}_t, Y_t)$, the following are equivalent expressions for the probability of a bank failure:¹⁴

$$\mathbf{P} \left[\Lambda_t m_t^\beta G(\bar{z}_t, Y_t) < r_t^D (1 - \kappa) m_t | y_{t-1} \right] = \mathbf{P} \left[Y_t < G^{-1}(\bar{z}_t, m_t, r_t^D) | y_{t-1} \right]$$

As $H_Y(y_t | y_{t-1})$ is the conditional probability distribution function of Y_t , the probabilities above can be written as:¹⁵

$$H_Y \left[\hat{y}_t(\bar{z}_t, m_t, r_t^D) | y_{t-1} \right] \quad \text{where} \quad \hat{y}_t \equiv G^{-1}(\bar{z}_t, m_t, r_t^D) \quad (8)$$

The likelihood of a bank collapse converges to the probability that the aggregate productivity shock y_t be lower than a threshold value \hat{y}_t , which is implicitly defined by the inverse function G^{-1} . All elements in these two subsections are next joined to characterize the structure of two-sided debt contracts.

2.3 The Two-Sided Debt Contract

A two-sided debt contract is the investment mechanism through which banks borrow from international investors and lend to domestic firms. This contract establishes a gross deposit rate r_t^D , a gross loan rate r_t^L (i.e. a value of \bar{z}_t), as well as the loan size, m_t . It also specifies two bankruptcy states. One indicates that when the productivity shock is so low that the firm cannot repay the bank, the bank audits and seizes the firm. The other indicates that when the bank portfolio return is so low that the bank cannot repay its depositors, the latter also audit and take possession of the bank portfolio.

Following Krasa and Villamil (1992a,b), a two-sided debt contract can be characterized

¹⁴The invertibility of the function $G(\cdot)$ is shown in the Appendix.

¹⁵Notice that the functional form of the threshold \hat{y}_t depends on the distribution function of the idiosyncratic shocks as is clear from eq. (7).

as the problem of choosing triples (\bar{z}_t, m_t, r_t^D) so as to maximize firm expected profits subject to two participation constraints, one for the international investor and another for the banker,

$$\max_{\{\bar{z}_t, m_t, r_t^D\}} \int_{\bar{z}_t}^{\infty} \Gamma(z_t, w_t, r_t^K, m_t) h_Z(z_t|y_{t-1}) dz_t - \Lambda_t m_t^\beta \bar{z}_t [1 - H_Z(\bar{z}_t|y_{t-1})] \quad (9a)$$

subject to:¹⁶

$$H_Y(\hat{y}_t|y_{t-1}) E \left\{ \Lambda_t m_t^\beta [G(\bar{z}_t, Y_t) - \mu^b] | y_{t-1} \right\} + [1 - H_Y(\hat{y}_t|y_{t-1})] r_t^D m_t (1 - \kappa) \geq r_t^* m_t (1 - \kappa) \quad (9b)$$

and:

$$[1 - H_Y(\hat{y}_t|y_{t-1})] E \left[\Lambda m_t^\beta G(\bar{z}, Y) - r_t^D m_t (1 - \kappa) | y_{t-1} \right] \geq r_t^* \kappa m \quad (9c)$$

where the dependency of \hat{y} on the choosing triple has been omitted for notational convenience. The risk-free international interest rate r_t^* represents the opportunity cost of capital for bankers and investors, and its dynamics is governed by a Markov process.

The objective function (9a) is the expected value of profits in eq. (5) after using the relation between \bar{z}_t and r_t^L implicit in eqs. (3) and (4). Constraint (9b) refers to the bank-investor side of the contract. It states that investors fund risky intermediaries only if the gross expected return from lending to the bank is the same as the return promised by the risk-free asset. Recall that $H_Y(\hat{y}_t|y_{t-1})$ is the conditional probability of a bank failure –which is equivalent to the probability that the aggregate productivity shock be lower than \hat{y}_t – and that banks must fund $m_t(1-\kappa)$ from its creditors. Investors audit and confiscate the portfolio of an insolvent bank. The confiscation proceeds are equal to $\Lambda_t m_t^\beta [G(\bar{z}_t, y_t) - \mu^b]$ where μ^b stands for the costs of auditing the bank. On the other hand, investors earn $r_t^D m_t(1 - \kappa)$ when the bank does not fail, something that happens with probability $[1 - H_Y(\hat{y}_t|y_{t-1})]$.

Constraint (9c) claims that a competitive bank participates in the contract only if its net expected profits compensate the opportunity cost of the capital. In bankrupt states, the bank loses its capital, κm_t , which is the same as saying that the bank obtains a gross return

¹⁶An additional constraint guarantees the participation of the firms, i.e. the maximal objective function (9a) must be positive.

equal to zero. In solvency states, the bank gets the difference between its gross portfolio return, $\Lambda_t m_t^\beta G(\bar{z}_t, y_t)$, and its dues, $r_t^D m_t(1 - \kappa)$, which accrue to investors.

From eq. (8) and the characterization of the contract made above, it is clear that the intermediation problem involves choosing a particular probability of bank failure. Consequently, bank failures do not represent a ‘misjudgement’ of the banking risk by any agent or the selection of an inappropriate contract, but the natural consequence of hidden information related to the the bank portfolio return.

A failing bank produces other costs in addition to investors’ auditing costs in actual economies. Reorganizing production in the aftermath of a financial collapse is costly compared to normal times. Transferring the ownership of banks involves significant losses of information that bank-bankruptcy costs do not account for. This happens because a credit history is built over time and its value depends on the relationship between the bank and the firm. This information is much more valuable in the hands of the originating bank than in the hands of a taking-over bank. However, these information losses do not enter into the contract because they do not affect the return of any of the three agents signing the financial contract.

Whereas several investors have to monitor a single firm under a SDC, under a two-sided simple debt contract investors delegate the verification task to a single bank. This delegation saves on monitoring costs because a failed firm is monitored by just one agent, i.e. the bank. This is true even though sometimes investors have to monitor the bank. The saving of monitoring costs explains why two-sided debt contracts dominate one-sided debt contracts.¹⁷

¹⁷For a detailed proof of the argument see Krasa and Villamil (1992a,b). They also prove that the two-sided contract dominates any other investment mechanism under the hidden information problem discussed in the text.

2.4 The Representative Household

The economy is inhabited by a large number of identical and infinitely lived households whose objective is to maximize the utility function

$$U = E_0 \sum_{t=0}^{\infty} \theta^t u(c_t, n_t) \quad (10a)$$

$$u(c_t, n_t) = \frac{(c_t - \frac{n_t^\nu}{\nu})^{1-\gamma} - 1}{1-\gamma} \quad (10b)$$

subject to the time t ($t = 0, 1, 2, \dots, \infty$) flow-resource constraint

$$c_t + a_{t+1} \leq w_t n_t + \Pi_t + a_t r_t^* \quad (11)$$

and the borrowing constraint $a_t > \Delta$, where Δ is an exogenously imposed limit on the household wealth, a_t . c_t is consumption and n_t is the time allocated to work, which is constrained to be lower than the time endowment, \bar{n} . The rate of time preference implicit in θ is such that $\theta r^* < 1$, which guarantees a stationary and well defined equilibrium (see Lungqvist and Sargent (2000), ch. 14). The parameter γ sets the value of the intertemporal elasticity of substitution.

Wealth is composed of the household holdings of physical capital, k_t^H , and international bonds, b_t . As explained below, these two assets are perfect substitutes from the standpoint of the household as well as from the standpoint of international agents, and therefore their rate of return are equal in equilibrium. Notice that inasmuch as foreign residents also supply physical capital, k_t^H constitute only a fraction of the total supply of capital. Household income is composed of labor income, the mutual fund dividends, Π_t , and the gross return on wealth. The household uses its resources for consumption and saving.¹⁸

Equating the marginal rate of substitution of labor for consumption to the wage rate leads to the following labor supply:

$$n_t = w_t^{\frac{1}{\nu-1}} \quad (12)$$

¹⁸The assumption that households lend at the rate r_t^* could be justified assuming the existence of a deposit-insurance scheme.

The employment of capital in the economy is subject to the following adjustment costs:

$$\Phi(k_t - K_{t-1}) = \frac{\phi}{2}(k_t - K_{t-1})^2$$

where K_t is the per-capita stock of capital employed in the economy at time t . Function Φ indicates that it is costly to employ an amount of capital different from the per-capita amount employed in the previous period.

The supply of capital is derived taking into consideration four elements that specialize the optimal accumulation of wealth. First, the world-capital-market interest rate r_{t+1}^* is known when capital supply decisions are taken at time t ; second, the return on capital at time $t + 1$ depends on the productivity observed at time t because factors of production are paid in advance; third, a financial crisis may enlarge the capital adjustment costs shown above because of the nonmonetary sequels that follow a financial crash; fourth, the adjustment costs above. Thus, the supply of capital is described by:

$$r_t^K = r_t^* + \delta + \phi(k_t - (1 - \iota(y_{t-1} < \hat{y}_{t-1})\zeta)K_{t-1}) \quad (13)$$

which accounts for the reorganization costs arising from a banking crisis and which do not accrue to bankers and investors. Here δ is the depreciation rate of capital; the function ι is an indicator function returning 1 when the statement in parenthesis is true and zero otherwise; and $0 \leq \zeta \leq 1$ is a parameter that captures the cost of reorganizing production in the aftermath of a banking crisis. During non-crisis time, as well as when ζ is set equal to zero, the arbitrage condition in eq. (13) becomes:

$$r_t^K = r_t^* + \delta + \phi(k_t - K_{t-1})$$

When $\zeta \neq 0$ the adjustment costs are larger in a quarter following a crisis. In other words, in a post-crisis period, keeping constant the level of capital is not enough to bring adjustment costs down to zero: it requires reducing the employment of capital in $\zeta \times 100$ percent.

2.5 The Recursive Competitive Equilibrium

Equilibrium is defined recursively. The following four variables characterize the state of the economy: $s_t^1=(r_t^*, y_{t-1}, a_t, K_t, A_t)$; $s_t^2=(r_{t+1}^*, y_t, a_t, K_t, A_t)$; $S_t^1=(r_t^*, y_{t-1}, K_t, A_t)$; $S_t^2=(r_{t+1}^*, y_t, K_t, A_t)$; where A_t denotes the aggregate per-capita level of wealth. Distinguishing between s_t^1 and s_t^2 is relevant because household input-supply and consumption/saving decisions are taken with different information sets (See Table 1). S_t^1 and S_t^2 are the corresponding aggregate state variables.

The *recursive competitive equilibrium* of this economy consists of a value function $v(s_t^2)$; a set of financial contract rules, $\bar{z}_t = \bar{z}(S_t^1)$, $m_t = m(S_t^1)$, and $r_t^D = r^D(S_t^1)$; a labor decision rule $n_t = n(s_t^1)$, and its corresponding aggregate per capita decision, $N_t = N(S_t^1)$; a set of consumption/saving decision rules for the household, $c_t = c(s_t^2)$, $k_{t+1}^H = k^H(s_t^2)$, $b_{t+1} = b(s_t^2)$; a corresponding set of aggregate per capita decision rules $C_t = C(s_t^2)$, $K_{t+1}^H = K^H(S_t^2)$, $B_{t+1} = B(S_t^2)$, plus the international supply of capital $K^W(S_t^2)$, where $K = K^H + K^W$; a set of factor-price functions $w_t = w(S_t^1)$, and $r_t^K = r^K(S_t^1)$; a set of profit functions, $\pi_t = \pi(S_t^2)$, one for each firm; and its corresponding aggregate profit function $\Pi_t = \Pi(S_t^2)$ such that they satisfy:

1. The following household optimality equation:

$$v(s^2) = \max_{\{n, c, k^H, b'\}} \left\{ u(c, n(s^1)) + \beta E \left[v(s^2) \right] \right\} \quad (14a)$$

$$\text{s.t. } c + a' \leq w n + r^* a + \Pi \quad (14b)$$

$$a = k^H + b \quad (14c)$$

$$c \geq 0, \quad n \leq \bar{n}, \quad a \geq \Delta \quad (14d)$$

where the symbol ' is used to denote the next-period value of a variable.

2. The condition that the financial contract stated in eqs. (9) is solved when

$$\Lambda = A \left(\frac{\alpha}{rK-1} \right)^{\alpha\beta} \left(\frac{1-\alpha}{w} \right)^{(1-\alpha)\beta}, \text{ so that firms maximize expected profits}$$

3. The consistency of individual and aggregate decisions, that is $c = C$, $a' = A'$, $n=N$, $k^H = K^H$, $b = B$.

4. The aggregate resource constraint:

$$C + A' + \int_{\bar{z}-y}^{\infty} m r^L h_X(x_t) dx_t = \int_{\bar{z}-y}^{\infty} \Gamma(x + y, w, r^K, m) h_X(x) dx + r^* A$$

3 Static Equilibrium Results

The equilibrium allocation and prices of the economy of the precedent section are studied first in a static framework to better show the financial structure of the economy. Further specifications are made with respect to the probability distribution functions of aggregate and idiosyncratic shocks and parameters values in the model. Particularly, while the idiosyncratic shocks are assumed to be draws from a normal distribution, i.e. $X_{it} \sim N(\mu_x, \sigma_x^2)$, the law of motion of the aggregate productivity is:

$$y_t = (1 - \rho^y)\bar{y} + \rho^y y_{t-1} + \varepsilon_t^y$$

where $\varepsilon_t^y \sim N(0, \sigma_y^2)$; $E[\varepsilon_t^y, \varepsilon_{t-s}^y] = 0$ for $s = 1, 2, \dots$; \bar{y} is the unconditional mean of the process; and ρ^y is the autocorrelation parameter. As a consequence of this specification, the conditional distribution function of aggregate shocks $h(y_t|y_{t-1})$ is characterized by its first two moments, the first one being equal to:

$$E[Y_t|y_{t-1}] = (1 - \rho^y)\bar{y} + \rho^y y_{t-1}$$

and the second one is σ_y^2 . The dynamics of the world-market interest rate, r_t^* , is also characterized by an autoregressive structure:

$$r_t^* = (1 - \rho^r)\bar{r} + \rho^r r_{t-1}^* + \varepsilon_t^r$$

where ε_{rt} is a zero mean i.i.d. Gaussian process with $\text{Var}[\varepsilon_t^r] = \sigma_r^2$, and \bar{r} and ρ^r parallel \bar{y} and ρ^y , respectively.

Table 2 displays the assumed parameter values for the distributions of the productivity shocks. The unconditional mean value of the (net) international interest rate was fixed equal

to 6.5% on annual basis. The autocorrelation parameters in the aggregate productivity and interest-rate processes are 0.5 and 0.9 respectively.

As for the remaining parameter values, in the production side of the economy, α is equal to 0.4 and $\beta=0.95$. The preference parameter ν is set equal to 1.5, so that the elasticity of labor supply is equal to 2. Following Carlstrom and Fuerst (1997), the firm-monitoring cost parameter μ^f is set equal to 0.25. The same value is assumed for μ^b under the (conservative) presumption that restructuring a bank is as costly as restructuring a firm. The capital asset ratio κ is set equal to 0.08 and this value corresponds to the capital adequacy ratio adopted in the 1988 Basle accords, where international negotiations established uniform capital requirements for banks. The parameter ϕ in the adjustment cost function is set equal to 0.008 and on annual basis, $\delta=0.075$.

3.1 Macroeconomic Risk, International Liquidity, and Capital Inflows

By fixing the international risk-free interest rate to its mean value, Figure 1 maps combinations of aggregate productivity and capital stocks into financial variables and equilibrium input allocations. Notice that the interest-rate spreads (in panels a and b) are invariant to the previous period per-capita stock of capital K_{t-1} . This is consistent with the fact that the cost of borrowing in international capital markets does not change with the size of debtor economies. The internal spread $r^L - r^D$ is also independent of the stock of capital. On the contrary, the loan size is positively related to both aggregate productivity shocks and the previous stock of capital. Thus, larger economies receive more external financing, and capital inflows are procyclical. On the other hand, the interest rate on the debt issued by banks is negatively related to the overall productivity shock. If the country is observing a high productivity, the premium asked by international investors falls because the likelihood of a banking failure is relatively low (see panel d). Conversely, lower values of the aggregate productivity shock hint that a failure is more conceivable and the economy is financed only at an increasing premium.

The relation between aggregate productivity shock and the probability of a banking crash

is explored in more detail in Figure 2. The first panel of the figure plots the aggregate productivity shock on which contracts are written, y_{t-1} , against the endogenously-determined crisis value of that variable, \hat{y}_t . The dotted line is a 45-degree line. The second panel of Figure 2 shows that the difference between the two lines in the first panel is increasing in y_{t-1} , which renders crises as a less likely event at higher levels of the productivity shock.¹⁹ This assertion is verified in the third panel of the figure where the probability of bank bankruptcy is plotted against the value of previous aggregate productivity shock.

Figure 3 plots a mapping similar to that of Figure 1, but now the stock of capital K_{t-1} is fixed to its unconditional-mean value and the international interest rate is allowed to vary. Given the economy-wide productivity shock, a higher international interest rate raises the difficulties of the firms, and then of the banks, to repay their credits. Therefore, both interest-rate spreads are increasing in the opportunity cost of international capital (see panels a and b). Also, the graph shows that it becomes easier to issue more international debt when world capital markets are relatively more liquid. These results are agreeable with the evidence found by Reinhart and Reinhart (2001) and Calvo et al. (1992) among others, which indicates that contractions in the industrialized world are more prone to make capitals flow into emerging countries than expansions.

3.2 Agency Costs, Capital Requirements, and Banking Risk

Completing the study of the financial arrangement, Tables 3 to 8 show how the value of monitoring-cost parameters, the exogenously fixed bank capital-asset ratio, and the statistical properties of the shocks impact on the financial arrangement. An increment in any of the monitoring costs (Tables 3 and 4) reduces the inflows of capital (see the loan size m) but takes the probability of bank bankruptcy down. Raising the cost of monitoring the firms (i.e. μ^f) diminishes the external spread $r^D - r^*$, but raises the internal spread $r^L - r^D$. Raising the cost of monitoring the banks (i.e. μ^b) reverses the effect on the spreads: the former rises and the latter falls.

As expected, raising the required bank capital-asset ratio (Table 5) reduces the likelihood

¹⁹Recall that the conditional variance of Y_t is constant. Thereupon, as the two lines are approaching it is more likely that the actual productivity shock be lower than its crisis value.

of a financial crash and induces larger inflows of capital. The interest rate on bank liabilities falls because the risk premium of a safer bank is lower. However, other things constant, the interest rate on firms debt rises with the capitalization of the banking system. Notice that, other things constant, the bankers losses arising from a bank failure increase with κ . These losses are not compensated by the incremental expected profits arising from the reduced financial costs (i.e. the lower value of r_t^D). Therefore, only by raising the interest rate on their loans, banks find the appropriate incentives to keep intermediating the inflows of capital when the requirements of capital are more strict.

Picking the mean of any of the shocks up produces intuitive results (see Table 6)²⁰: capital inflows are larger, and interest rates and the probability of bank bankruptcy are both lower. This is because a higher productivity reduces the likelihood of a negative bank cash flow. This became clear in eq. (7) where, in the limit, for some high values of the overall productivity shock, no single firm is bankrupt.

On the other hand, the variance of aggregate productivity shocks is positively related to the probability of a bank failure, while the variance of idiosyncratic shocks is negatively related to it (see Tables 7 and 8). The former result is in line with the overwhelming empirical evidence that points out that macroeconomic volatility is the main cause of banking sector problems. Furthermore, the result also explains why a change in the perception of the country's macroeconomic risk can alter the amount of capital flowing into a SOE.

The result that indicates that a higher variance of idiosyncratic shocks lowers the probability of a banking failure, which may become counterintuitive at first sight, is sympathetic with recent remarks made by the Federal Reserve Chairman, Alan Greenspan: "The result of the 1990s of this seeming-heightened instability for individual businesses, somewhat surprisingly, was an apparent *reduction* in the volatility of output and in the frequency and amplitude of business cycles for the macroeconomy".²¹ And he adds "On the same period [second half of the 1990s and into 2000] risk spreads on corporate bonds rose markedly on net, implying a rising probability of default". In the model and from the creditors standpoint, a

²⁰The effect of changes in the mean of the overall productivity shock was studied in Figure 2.

²¹Remarks at a symposium sponsored by the Federal Reserve Bank of Kansas City on August 30, 2002, at Hole, Wyoming.

higher variance of idiosyncratic shocks reduces the importance of the macroeconomic shock on the banks' portfolio return, and then the probability of a bank failure.

4 General Equilibrium Dynamic Results

This section studies the dynamic properties of the model described above. The focus is on the production side of the economy because the model adds nothing to what is already known about the saving decisions of a household that receives a stochastic income flow. In other words, the goal is to understand the macroeconomic consequences of inflows of capital that are driven not by consumption smoothing, but by portfolio and production decisions in the economy. For the sake of completeness, notice that the stochastic household income is given by $w_t n_t + r_t^* a_t + \Pi_t$, and the household knows the return on its savings, i.e. r_{t+1}^* , in advance.

4.1 Business Cycles with Banking Crises

The economy described above has two primary sources of fluctuations, namely, the overall productivity shock and the interest rate in world capital markets. The dynamics induced by these two variables are shown in Figures 4 and 5, under random sequences of shocks for 50 observations. The parameter ζ in eq. (13) is set equal to zero so that only the aggregate risk but not crises affect the allocations of domestic agents.

In Figure 4, the international interest rate, r_t^* , is fixed to its mean (1.065 in annual terms) and the economy is then subject to productivity shocks. The incidence of the overall productivity shock and macroeconomic risk on output fluctuations can be seen in the first row of Figure 4. Output swings (in panel 4.c) are the result of two forces: fluctuations in productivity, as in any RBC model; and the amount of capital flowing into the economy to finance working capital. Capital inflows affect output because larger inflows raise output at the rate β (see eq. (3)). This effect is dampened by the lower value of Λ_t arising from the upward pressure on input prices that follows a larger inflow of capital.

For a given value of input prices and a value of β close to one, eq. (2) shows that the loan

size is almost as important as the productivity shock to explain output dynamics. However, as the loan size (panel f) depends on the expected value of that shock, which depends on its lagged value, the financial structure of the model reinforces the effect of the previous period productivity on the current level of output. The dependency of the size of capital flows on the state of the overall productivity shock can be seen observing the dynamics of the loan size in Figure 4.f and the behavior of the overall productivity shock in Figure 4.b.

The third row of Figure 4 shows how downturns are associated with both a higher probability of a bank failure, and a higher rate of bankruptcy among firms. The annual total spread ($r^L - r^*$) in Figure 4.e incorporates these two risks and is counter-cyclical. In linking the state of the macroeconomy to capital inflows and interest rates, a change in the overall productivity shock induces a large adjustment of capital inflows and a small adjustment in the interest rate on bank liabilities. Furthermore, the interest rate on firms' debt is more volatile than the interest rate on banks' debt.

The simulations in Figure 4 include a banking crisis on quarter 13 which has been marked in the i-panel of the figure. Section 2 showed that a bank failure happens when the actual overall productivity shock y_t is lower than the threshold value of productivity \hat{y}_t . At quarter 13, $y_t=0.3802$ and $\hat{y}_t=0.3821$. Interesting is that not every recession, not matter how deep, is able to produce a crisis; observe for example that output in quarter 45 is lower than in quarter 13. What really triggers a crisis is a *sudden* change in the value of the overall productivity shock. On the other hand, when the economy goes through a period of low productivity shocks, even though a crisis is more likely to happen vis-á-vis a boom (see the static result in Figure 2), this is part of the information that agents internalize and incorporate into the contracts. The size of capital inflows along with the interest rates are adjusted accordingly so that a banking crisis does not necessarily materialize.

The dynamics induced by interest-rate shocks when the overall productivity remains constant are shown in Figure 5. There are two interesting results. First, international interest-rate fluctuations are able to drive business cycles. As it was pointed out by Calvo et al. (1992), and more recently by Reinhart and Reinhart (2001), international developments can determine business cycles in emerging countries. However, interest-rate swings induce output changes of second order of magnitude in RBC models of SOE's (see Mendoza

(1991)), and this neutrality to interest-rate shocks is not modified substantially by adding a demand for working capital (see Oviedo (2002)). These results, however, were derived under a constant returns to scale production function and assuming a world of symmetric information which rules out firms and bank bankruptcies. The results in Figure 5 show that, under asymmetric information and decreasing returns, the economy is not neutral to disturbances to the interest-rate on world capital markets.

The second result arising from Figure 5 is that the likelihood of a banking crisis is invariant to the *level* of the international interest rate, as it has been shown in Figure 3. The setup of the model describes a world of fixed-interest-rate debt, which, by definition, prevents that an interest-rate change triggers a bank failure. This is because, debt contracts are one-period contracts, and the interest rates are known at the time contracts are signed. In a world of variable interest rates, however, it is easy to see how an interest-rate rise can trigger a banking crisis. The setup of two-sided debt contracts could be changed so that, although r_t^* remains to be the opportunity cost of capital for bankers and investors, this interest rate is unknown at the time contracts are signed. Therefore, if investors *have* to be compensated at the rate r_t^* , but contracts are written on the expected value of r_t^* , an interest-rate hike raises the value of \hat{y}_t . This essentially renders crises more likely under all values of the overall productivity shock.

4.2 Reorganization Costs in the Aftermath of a Banking Crisis

Under the model setup discussed above, a banking crisis does not have an effect on equilibrium allocations. While the risk of a crisis is present in the decisions taken by banks, firms, and international investors, and therefore in the model dynamics, the crisis itself is not costly for the economy. This does not imply that a bank failure does not produce wealth losses for bankers and investors. Bankers lose what they have invested in banking, i.e. bank capitals. Also, although investors seize banks' portfolios, the value of these portfolios is lower than the beginning-of-period expected return. However, bankers and investors are not domestic but international agents and the model allocations do not depend on their wealth.

Notice that economy described in Figure 4 recovers completely after the crisis in the 13th quarter. Every bank has rebuilt its bank capital, capital resumes flowing into the economy, and the economy operates exactly the same way it did before the crisis. However, this is not what happens when banking crises hit actual economies. Bank failures destroy the information created through years of bank-client relationships. The informational losses that follow a banking crash make difficult to produce under the same pre-crisis conditions. To account for the reorganization costs arising from a banking crisis and which do not accrue to bankers and investors, the parameter ζ in eq. (13) should be different from zero.

Figure 6 compares the effect of assuming two different values for ζ . The sequence of productivity shocks is the same that produced a crisis in the 13th quarter in Figure 4. The solid lines in Figure 6 are used for the case where $\zeta = 0$ and so the dynamics are the same as those in Figure 4. The lines marked with asterisks show the model dynamics when ζ is arbitrarily fixed to 0.25. When it is costly to reorganize production in the aftermath of bank failures, a banking crisis produces long lasting effects. Only by the end of the simulated period, that is approximately after 35 quarters, the economy recovers completely from the crisis. While the probability of another crisis, as well as domestic interest rates, remain constant, now the sequels of a crisis extend to the labor income of the household (see panels k and l), firms profits, and domestic output.

4.3 Agency Costs and Business Cycles

Two-sided agency costs are one of the new features the paper proposes to investigate the connection between the state of liquidity of international capital markets, macroeconomic risk, and the business cycles in SOEs. This section shows that changing the value of either the firms' or the banks' bankruptcy cost, does not produce sensible changes in output fluctuations. In Figure 7 bank monitoring costs remain constant and the value μ^f is decreased from 0.25 to 0.15. In Figure 8 μ^f is equal to 0.25, and μ^b takes three values: 0.25, 0.15, and 0.05. Since debt contracts are single-period loans and credit is extended without any collateral, the persistence of business cycles is independent of the values taken by monitoring costs.

5 Concluding Remarks

Banking crises are costly not only because of the costs associated with restructuring a collapsed banking system, but also because they give rise to negative monetary and non-monetary consequences for other sectors. While banking crises are not exclusive to emerging market economies, they are recurrent among these economies. The recurrence of the crises in developing countries is linked to their higher macroeconomic volatility. Furthermore, banking failures have produced devastating consequences in developing countries because their banks play an important role in the credit creation process.

In a world of forward looking economic agents, both macroeconomic risk and the risk of a financial crisis affect the equilibrium prices and allocations of an economy, even during ‘normal times’. Therefore, the characterization of business cycles in emerging market economies needs to take into account the likelihood of occurrence of a financial crash. The paper intends to provide a dynamic general equilibrium framework capable of accounting for two related phenomena. First, banking crises are driven by fundamentals and not by self-fulfilling expectations. Second, financial stability and macroeconomic risk have an important incidence on business cycles.

The probability of widespread banking failures is shown to be endogenously determined by the value of the state variables in the economy. Consistent with the empirical literature on banking crises, the numerical results show that crises are more likely to happen during economic downturns and also as a result of interest-rate hikes. The model explains why banking crises are sporadic phenomena and also why not every recession, not matter how deep, is capable of triggering a financial crash. The model also explains how country risk depends on macroeconomic conditions and the strength of the financial system and why country-specific interest rates are counter-cyclical.

It has been shown that the combination of the contracting technology developed by Krasa and Villamil (1992a,b) along with the assumption of non-verifiable aggregate productivity shocks can provide a rationality to one standard assumption in SOE versions of RBC models, namely that debt contracts contingent on productivity shocks are not available. Being aggregate productivity a non-observable variable, the best investment mechanism involves

standard simple-debt-type contracts where, in the absence of bankruptcy, repayments are constant for all levels of productivity.

On the other hand, the combination of a decreasing returns technology in the production of final output and agency costs at the level of firms and banks can successfully explain the mechanism through which domestic fluctuations can be driven by international financial variables. After recognizing that reorganizing the production process in the aftermath of a banking crisis is costly, the simulations also showed that crises have long lasting effects on production and household income.

There are several avenues which could be investigated using the framework developed in this paper. The agenda for future research includes two policy issues. First, the extent to which tighter capital requirements for banks can help reduce the incidence of macroeconomic risk on domestic fluctuations. Second, given the adverse effects of volatile capital flows on the stability of financial systems, the extent to which restrictions on these flows can reduce their destabilizing effects. An interesting extension of the model would be to endogeneize the portfolio decisions taken by bankers. By explicitly modelling decisions on how much wealth is allocated to banking, the model would produce a richer interaction between the financial and real sectors of the economy. It would also help to better understand the effect of financial fragility on macroeconomic fluctuations and provide better foundations for the long-lasting effects of financial crises.

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Appendix

5.1 Invertibility of the Limiting Distribution of the Bank Average Income per Borrower

The function G is invertible with respect to y if it is monotonic in y . Taking the derivative of G w.r.t. y gives,

$$-((\bar{z} - y) + y) h_X(\bar{z} - y) + \int_0^{\bar{z}-y} h_X(x) dx + (\mu^f + \bar{z}) h_X(\bar{z} - y)$$

which simplifies to:

$$\int_0^{\bar{z}-y} h_X(x) dx + \mu^f h_X(\bar{z} - y)$$

This expression is positive for all $y \leq \bar{z}$ and equal to zero when $y > \bar{z}$; the latter is because no single firm is bankrupt when the aggregate productivity is high enough that, even a firm with idiosyncratic productivity shock equal to zero, is able to repay its loans.

Tables and Graphs

Table 1. Sequence of Events in a Given Period

| | | | |
|-------|---|---|---|
| t_1 | Information: Allocations/ Decisions: Prices: | y_{t-1} r_t^* K_t a_t m_{it} r_t^D r_t^L | Last period aggregate productivity shock International interest rate Supply of capital Household wealth Loan sizes (from financial contracts) Gross bank-deposit rate (from fin. cont.) Gross bank-loan rate (from fin. cont.) |
| t_2 | Allocations: Prices | n_t k_t w_t r_t^K | Labor employment Capital employment Wage rate Gross rate of return on capital |
| t_3 | New Information: Allocations/ Decisions: | y_t x_{1t}, \dots, x_{Nt} r_{t+1}^* Υ_{it} π_{it}, Π_t | Aggregate productivity shock Idiosyncratic productivity shocks Next period international interest rate Output Individual and aggregate profits Firm and bank bankruptcy |
| t_4 | Allocations/ Decisions: | c_t b_{t+1} k_{t+1}^H k_{t+1} | Consumption International risk-free asset Household supply of capital Next period total supply of capital |

Notes: every period t is divided into four subperiods, t_1 to t_4 . When a variable has two subindexes the first one is used to individualize a firm.

Table 2. Mean and variance of productivity shocks

| Idiosyncratic shock | | Aggregate shock | | Total Productivity shock | |
|---------------------|------------|-----------------|------------|--------------------------|------------|
| μ_X | σ_X | μ_Y | σ_Y | μ_Z | σ_Z |
| 0.470 | 0.040 | 0.420 | 0.025 | 0.890 | 0.047 |

Notes: X and Y are the random idiosyncratic and aggregate productivity shocks respectively. μ (σ) represents the mean (standard deviation) of the random variable indicated in the subindex.

Table 3. Firm-Monitoring-Cost Parameter (μ^f) and the The Financial Contract

| μ^f | $r^L - 1$ (% annual) | $r^D - 1$ (% annual) | m | \hat{y} | PBB (%) |
|---------|-------------------------|-------------------------|-------|-----------|------------|
| 0.150 | 11.710 | 7.693 | 1.658 | 0.364 | 1.208 |
| 0.200 | 11.683 | 7.365 | 1.509 | 0.360 | 0.796 |
| 0.250 | 11.947 | 7.177 | 1.420 | 0.357 | 0.620 |
| 0.300 | 12.147 | 7.033 | 1.340 | 0.355 | 0.487 |
| 0.350 | 12.300 | 6.923 | 1.270 | 0.353 | 0.385 |

Notes: r^L (r^D) is the gross annual rate on firms (banks) liabilities; m is the loan size; \hat{y} is the threshold value of the aggregate productivity that defines a banking crisis; and PBB is the probability of bank failure.

Table 4. Bank-Monitoring-Cost Parameters (μ^b) and the financial contract.

| μ^b | $r^L - 1$ (% annual) | $r^D - 1$ (% annual) | m | \hat{y} | PBB (%) |
|---------|-------------------------|-------------------------|-------|-----------|------------|
| 0.150 | 12.163 | 6.871 | 1.479 | 0.359 | 0.739 |
| 0.200 | 12.049 | 7.037 | 1.447 | 0.358 | 0.675 |
| 0.250 | 11.947 | 7.177 | 1.420 | 0.357 | 0.620 |
| 0.300 | 11.855 | 7.296 | 1.395 | 0.357 | 0.575 |
| 0.350 | 11.772 | 7.399 | 1.373 | 0.356 | 0.535 |

Notes: r^L (r^D) is the gross annual rate on firms (banks) liabilities; m is the loan size; \hat{y} is the threshold value of the aggregate productivity that defines a banking crisis; and PBB is the probability of bank failure.

Table 5. The capital-asset ratio (κ) and the financial contract

| κ | $r^L - 1$ (% annual) | $r^D - 1$ (% annual) | m | \hat{y} | PBB (%) |
|----------|-------------------------|-------------------------|-------|-----------|------------|
| 0.060 | 11.749 | 7.681 | 1.307 | 0.362 | 1.013 |
| 0.070 | 11.845 | 7.399 | 1.369 | 0.360 | 0.796 |
| 0.080 | 11.947 | 7.177 | 1.420 | 0.357 | 0.621 |
| 0.090 | 12.048 | 7.004 | 1.461 | 0.355 | 0.479 |
| 0.100 | 12.142 | 6.871 | 1.494 | 0.353 | 0.365 |

Notes: r^L (r^D) is the gross annual rate on firms (banks) liabilities; m is the loan size; \hat{y} is the threshold value of the aggregate productivity that defines a banking crisis; and PBB is the probability of bank failure.

Table 6. The mean of idiosyncratic shocks (μ_X) and the financial contract

| μ_X | $r^L - 1$ (% annual) | $r^D - 1$ (% annual) | m | \hat{y} | PBB (%) |
|---------|-------------------------|-------------------------|-------|-----------|------------|
| 0.450 | 12.186 | 7.262 | 0.849 | 0.358 | 0.675 |
| 0.460 | 12.065 | 7.219 | 1.100 | 0.358 | 0.647 |
| 0.470 | 11.947 | 7.177 | 1.420 | 0.357 | 0.620 |
| 0.480 | 11.832 | 7.138 | 1.826 | 0.357 | 0.594 |
| 0.490 | 11.720 | 7.100 | 2.342 | 0.357 | 0.569 |

Notes: r^L (r^D) is the gross annual rate on firms (banks) liabilities; m is the loan size; \hat{y} is the threshold value of the aggregate productivity that defines a banking crisis; and PBB is the probability of bank failure.

Table 7. The standard deviation of idiosyncratic shocks (σ_X) and the financial contract

| σ_X | $r^L - 1$ (% annual) | $r^D - 1$ (% annual) | m | \hat{y} | PBB (%) |
|------------|-------------------------|-------------------------|-------|-----------|------------|
| 0.030 | 10.190 | 7.250 | 1.834 | 0.359 | 0.699 |
| 0.040 | 11.947 | 7.177 | 1.420 | 0.357 | 0.620 |
| 0.050 | 14.251 | 7.114 | 1.089 | 0.356 | 0.552 |
| 0.060 | 17.075 | 7.067 | 0.836 | 0.356 | 0.502 |
| 0.070 | 20.396 | 7.037 | 0.645 | 0.355 | 0.467 |

Notes: r^L (r^D) is the gross annual rate on firms (banks) liabilities; m is the loan size; \hat{y} is the threshold value of the aggregate productivity that defines a banking crisis; and PBB is the probability of bank failure.

Table 8. The standard deviation of aggregate shocks (σ_Y) and the financial contract

| σ_Y | $r^L - 1$ (% annual) | $r^D - 1$ (% annual) | m | \hat{y} | PBB (%) |
|------------|-------------------------|-------------------------|-------|-----------|------------|
| 0.021 | 11.625 | 6.802 | 1.613 | 0.362 | 0.280 |
| 0.023 | 11.760 | 6.975 | 1.517 | 0.360 | 0.438 |
| 0.025 | 11.947 | 7.177 | 1.420 | 0.357 | 0.621 |
| 0.027 | 12.185 | 7.401 | 1.324 | 0.355 | 0.822 |
| 0.029 | 12.474 | 7.644 | 1.233 | 0.353 | 1.038 |

Notes: r^L (r^D) is the gross annual rate on firms (banks) liabilities; m is the loan size; \hat{y} is the threshold value of the aggregate productivity that defines a banking crisis; and PBB is the probability of bank failure.

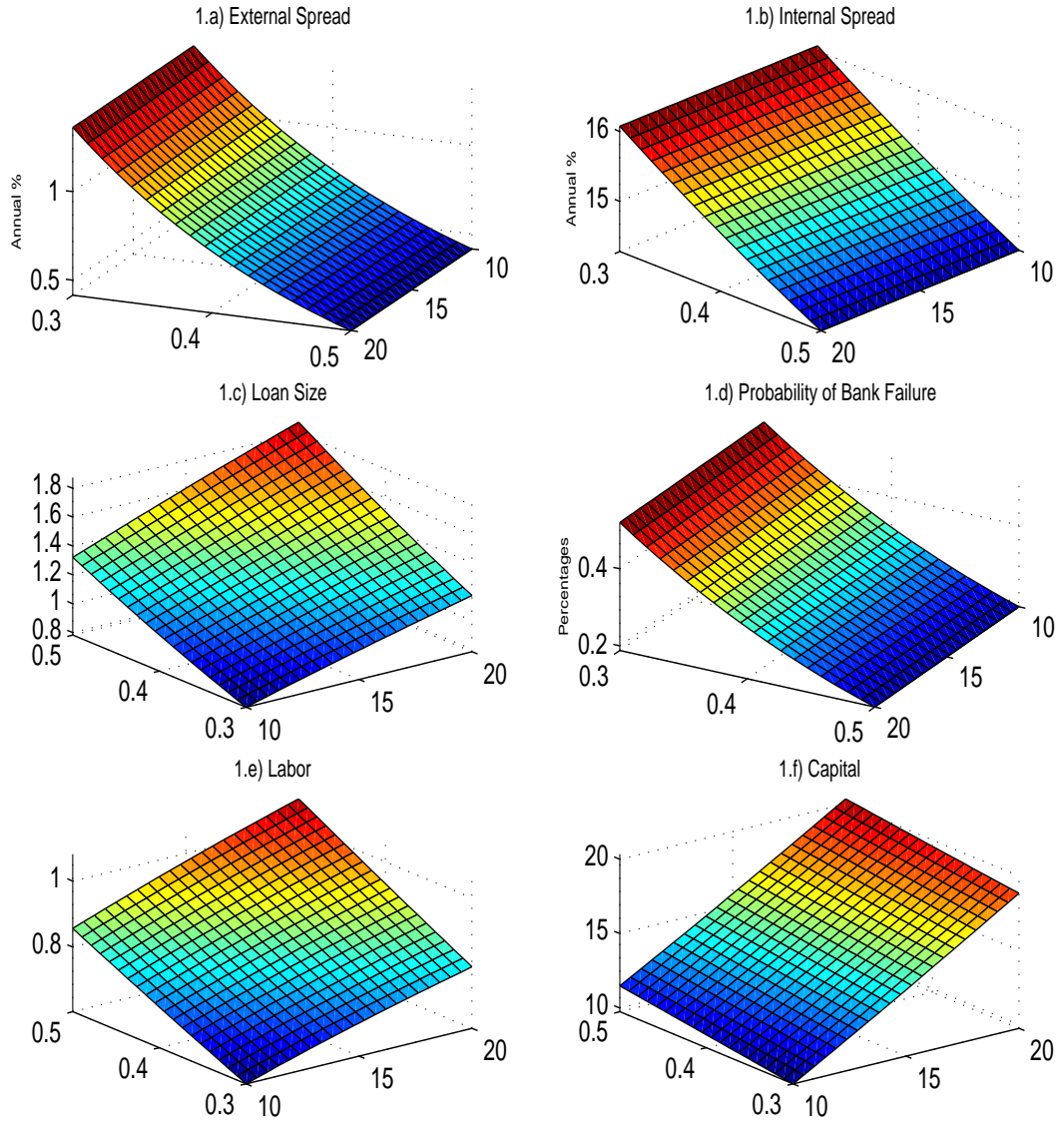


Figure 1: **One Period Financial Contracts with a fixed international interest rate.**

Notes: Aggregate productivity and capital are plotted on the horizontal axes. The productivity range is $[0.3, 0.5]$ and the capital range is $[10, 20]$. The external (internal) spread is equal to $r - r^*$ ($r^L - r$), where r^* is the risk-free international interest rate, r the interest rate on bank liabilities, and r^L the interest rate on the debt issued by firms.

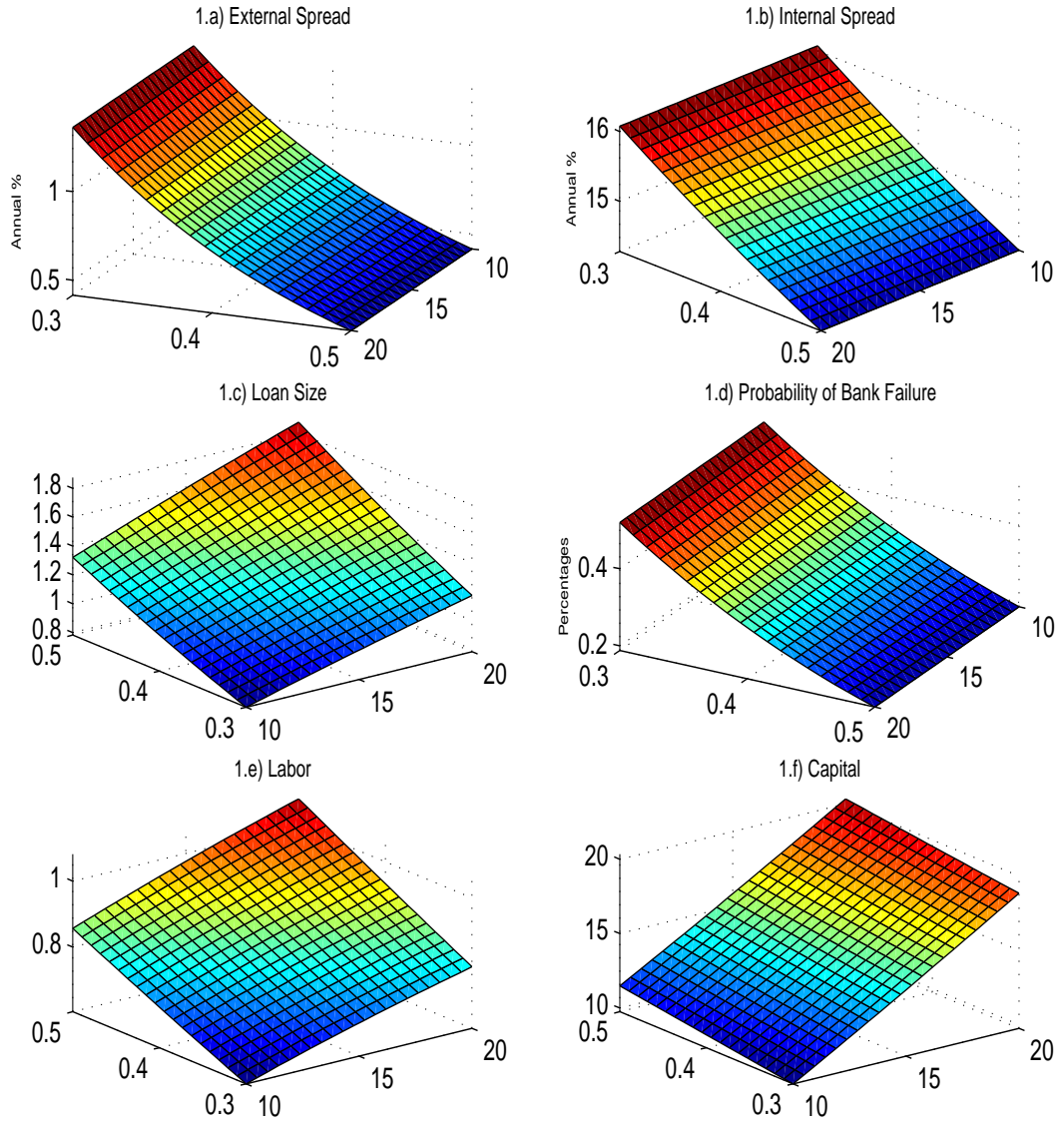


Figure 2: **One Period Financial Contracts with a fixed international interest rate.**

Notes: Aggregate productivity and capital are plotted on the horizontal axes. The productivity range is $[0.3, 0.5]$ and the capital range is $[10, 20]$. The external (internal) spread is equal to $r^D - r^*$ ($r^L - r^D$), where r^* is the risk-free international interest rate, r^D the interest rate on bank liabilities, and r^L the interest rate on the debt issued by firms.

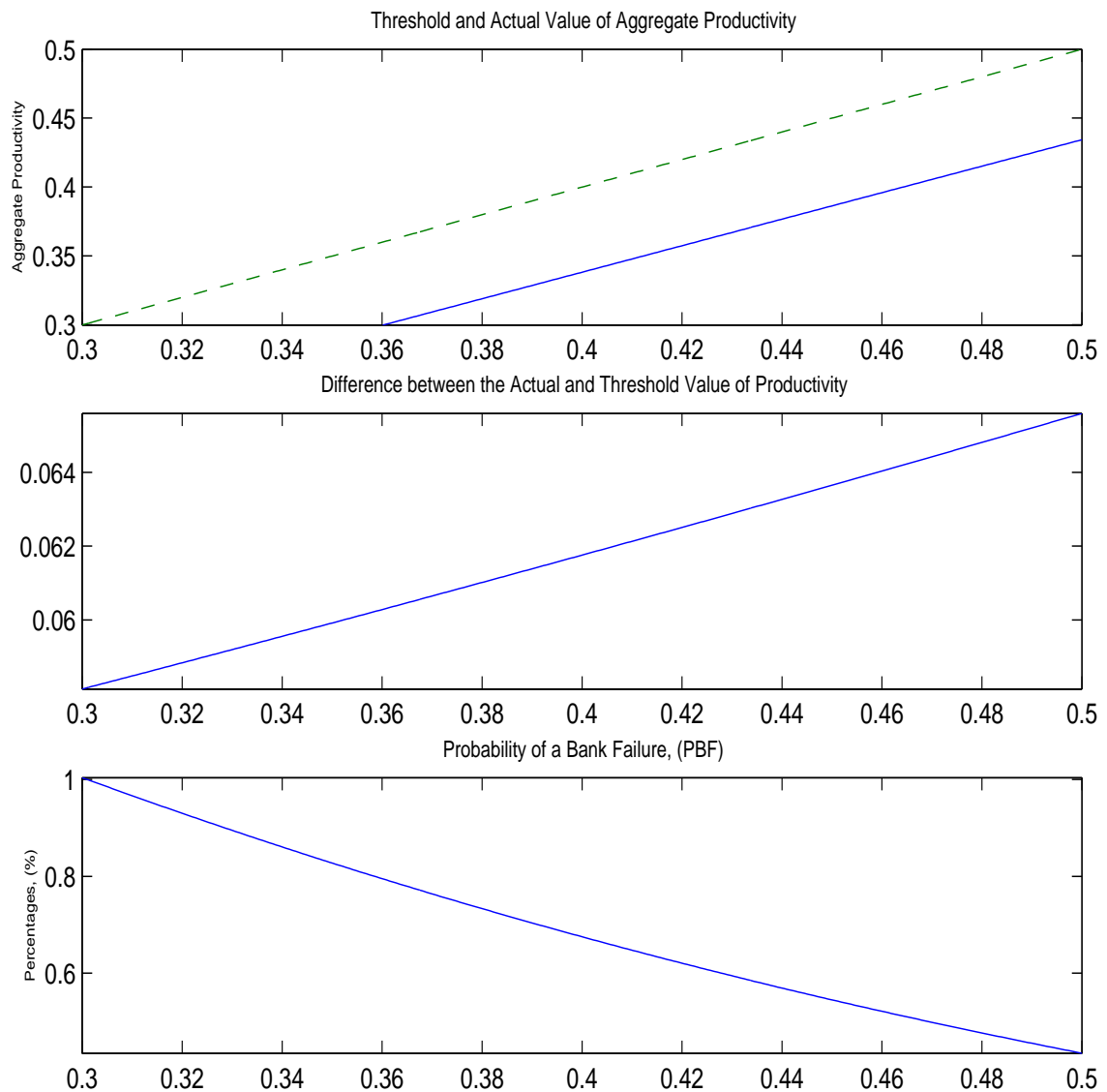


Figure 3: Crisis-Threshold-Value of Aggregate Productivity and Probability of a Bank Failure

The top panel of the figure shows the threshold value of aggregate productivity which triggers a banking crash, \hat{y} , as a function of actual productivity, y ; and a 45% degrees line (dotted line). Each point of the dotted line can be seen as the mean of (vertically plotted) distributions whose tails go beyond \hat{y} . The second panel shows the difference between y and \hat{y} for all levels of y . The third panel of the figure displays the probability of a banking crash at every level of y : the likely of a bank failure falls as productivity rises.

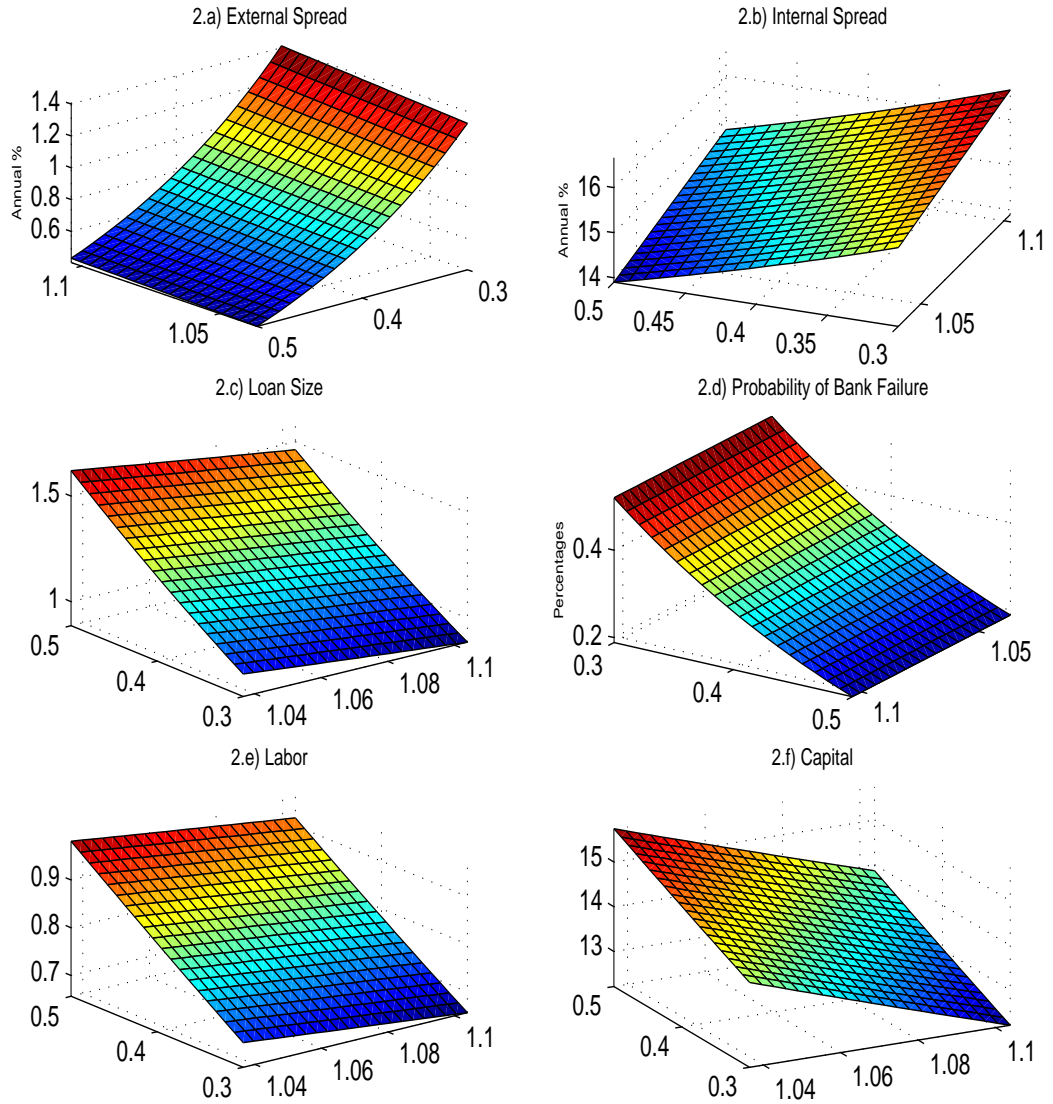


Figure 4: **One Period Financial Contracts with a fixed capital stock**

Notes: Aggregate productivity and the international interest rate are plotted on the horizontal axes. The productivity range is $[0.3, 0.5]$ and the risk-free-rate range is $[4\%, 11\%]$, expressed as net annual rates. The external (internal) spread is equal to $r^D - r^*$ ($r^L - r^D$), where r^* is the risk-free international interest rate, r^D the interest rate on bank liabilities, and r^L the interest rate on the debt issued by firms.

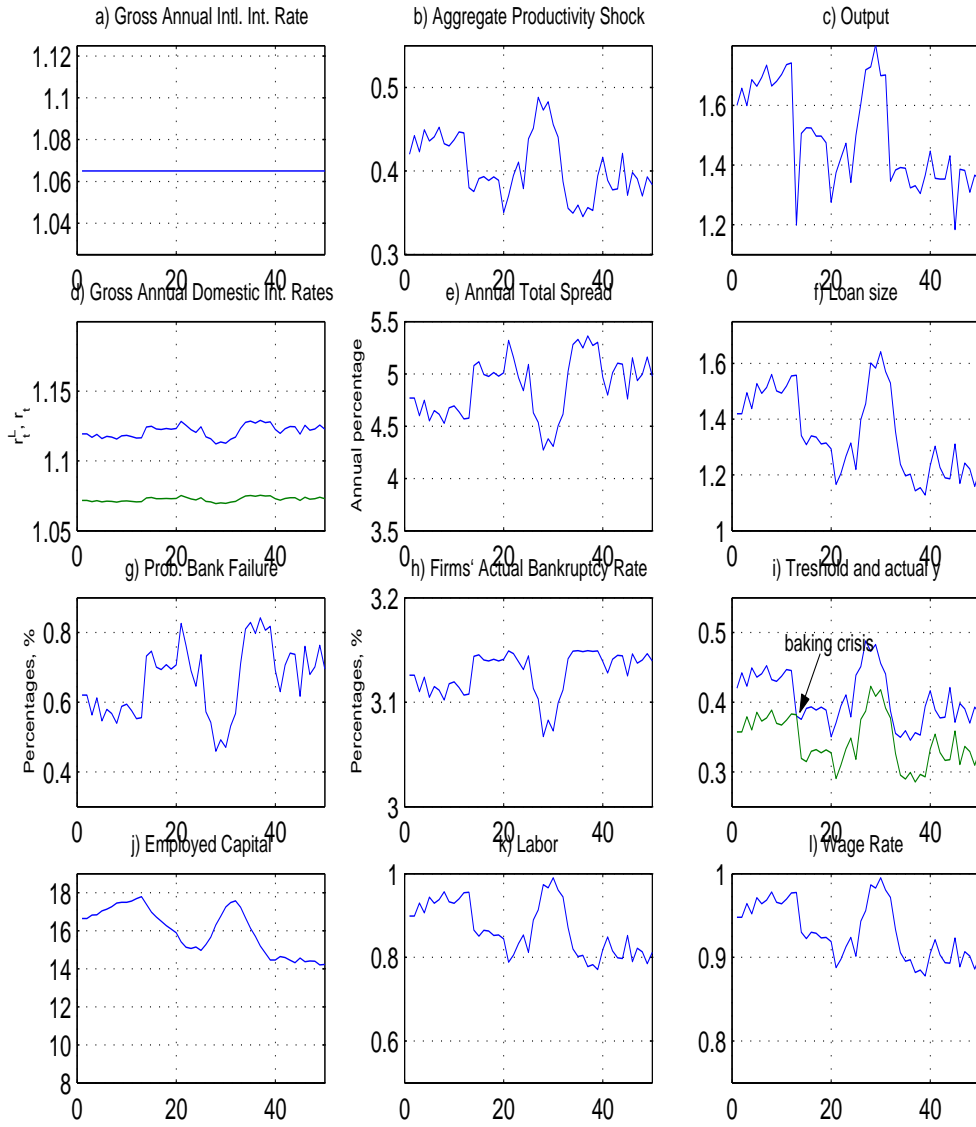


Figure 5: **Productivity Shocks and Model Dynamics**

Notes: The international interest rate r_t^* is fixed at its steady-state value(1.065) and the model is simulated under a random sequence of aggregate productivity shocks that has an autoregressive structure. There is a banking crisis in period 13 that has been marked in panel i.

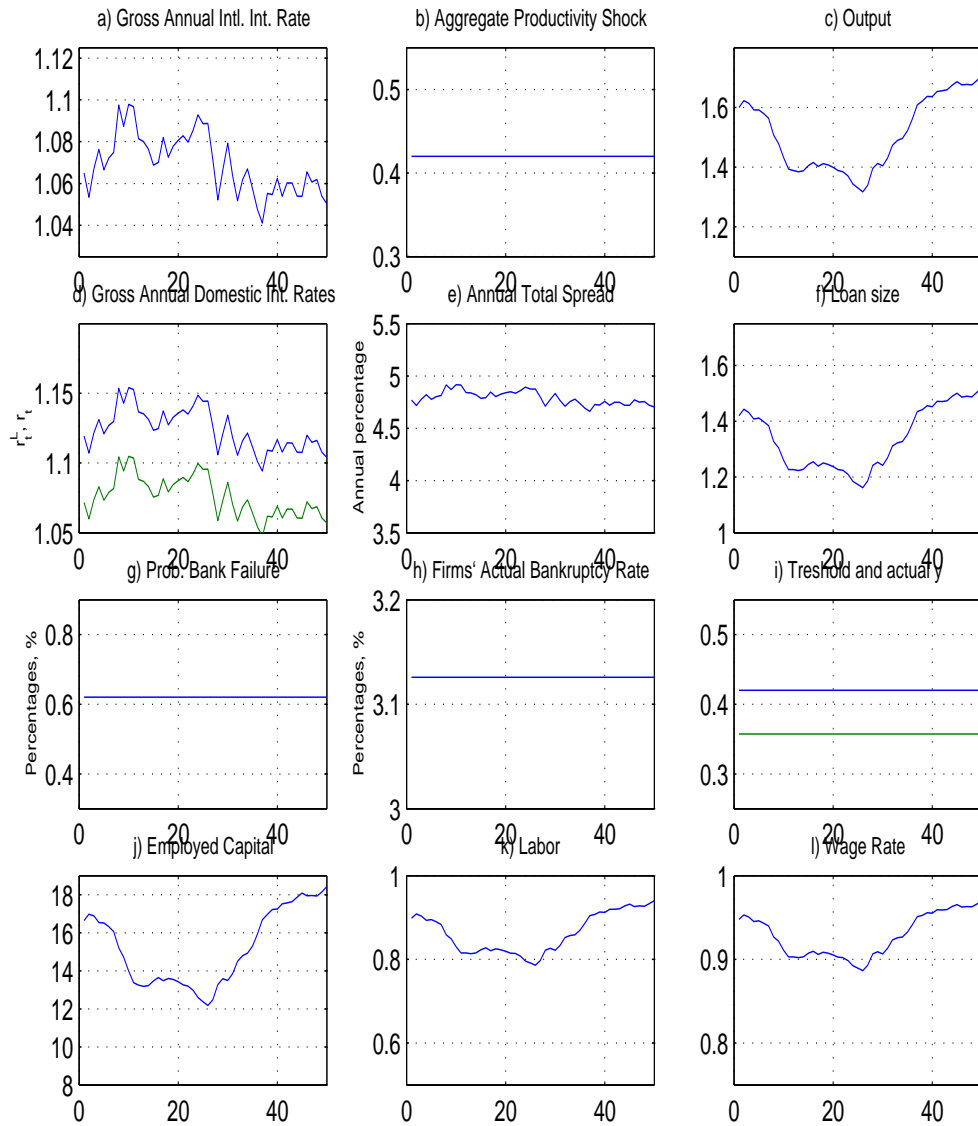


Figure 6: **Interest-Rate Shocks and Model Dynamics**

Notes: The overall productivity shock y_t has been fixed to its mean value (0.42) and the model is simulated under a random sequence of international interest rates r_t^* , which follows an AR(1) process.

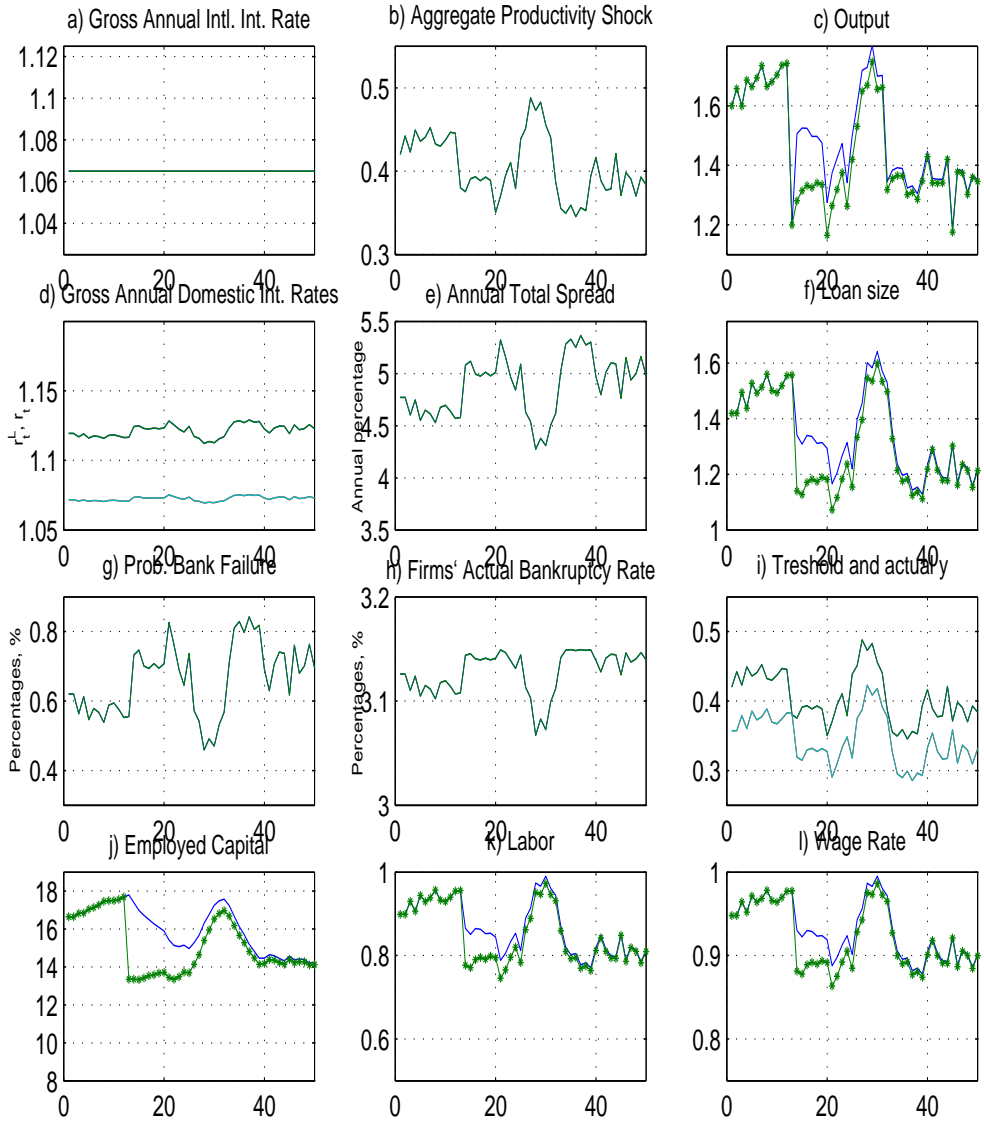


Figure 7: **The Cost of Reorganizing Production in the Aftermath of a Crisis**

Notes: The international interest rate, r_t^* , has been fixed equal to its steady-state value(1.065 in annual terms) and the model is simulated under a random sequence of aggregate productivity shocks that has an AR(1) structure. Asterisks are used for the dynamics generated by the model when it is costly to reorganize the production in the aftermath of a banking crisis. The sequence of overall productivity shocks is the same as in Figure 4, so that a crisis occurs in the 13th quarter.

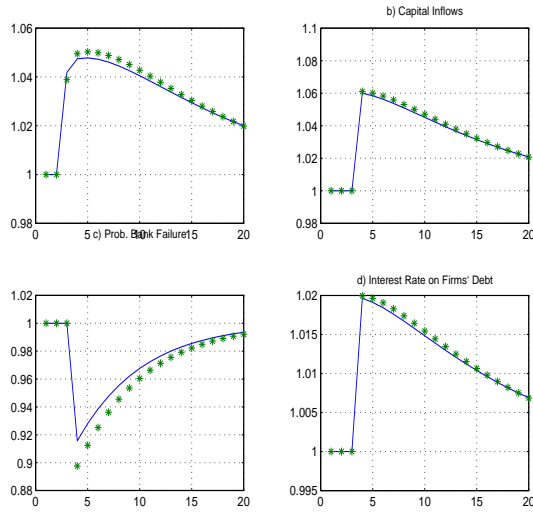


Figure 8: **Firm Monitoring Costs and Model Dynamics**

Notes: Impulse response functions following a 1% deviation in the overall productivity shock in the third quarter, under alternative values of μ^f , i.e. the cost of monitoring the firms. Asterisks are used for the impulse response functions obtained assuming $\mu^f = 0.15$. Solid lines are used for simulations where $\mu^f = 0.25$. All variables have been normalized to be equal to one during the first two quarters.

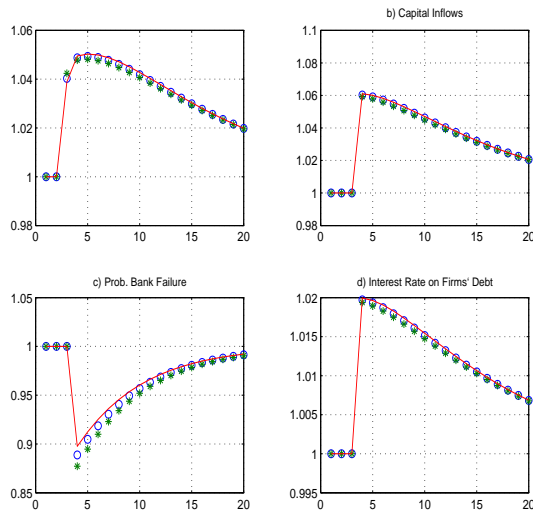


Figure 9: **Bank Monitoring Costs and Model Dynamics**

Notes: Impulse response functions following a 1% deviation in the overall productivity shock in the third quarter, under alternative values of μ^b , i.e. the cost of monitoring the banks. In the economy described by solid lines, $\mu^b = 0.25$; circles are used for the economy where $\mu^b = 0.15$; and asterisks are used for the economy where $\mu^b = 0.05$.