Collateralized Lending, Asset Prices and Financial Crises

Nan-Kuang Chen

Department of Economics, National Taiwan University

and

Hsiao-Lei Chu

Department of Economics, National Chi-Nan University*

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Abstract

The interaction of collateralized lending and asset prices reinforces each other to lending and asset price booms, and subsequently makes the economy vulnerable to bad news. Either over-optimism or a larger initial holding of collateralized assets by entrepreneurs not only results in a greater amount of lending and a higher level of asset price, but also makes it more likely that lenders downsize loans (incomplete runs) or pull out all of the funds when bad news hits, which forces early liquidation to take place. Government guarantee results in an over-investment and an asset price "bubble" but can cause a larger crisis and an asset price collapse. Finally, a financial crisis can also result from the "looting" behavior of the entrepreneurs.

Key words: financial crisis, asset prices, collateralized lending

JEL classification: E44, E5, F3, G2

*Nan-Kuang Chen, Department of Economics, National Taiwan University, 21 Shuchow Road, Taipei 10021, TAIWAN. Tel: 886-2-2351-9641 ext. 471, Fax: 886-2-23215704, E-mail: nankuang@ccms.ntu.edu.tw. Hsiao-Lei Chu, Department of Economics, National Chi-Nan University, 1 University Road, Puli, Nantou, TAIWAN. Tel: 886-2-710-960 ext. 4918, E-mail: hlchu@olympus.ncnu.edu.tw

1 Introduction

Economic crises that cause crashes in prices and market activities have stimulated researchers to look for candidates of causes that directly or indirectly lead to these catastrophic events. Since the financial crisis erupted in Southeast Asia in the second half of 1997, explanations of the causes, consequences and even remedies poured out. Radelet and Sachs (1998a,b) and many others emphasized the instability of international capital flow and the contagious effect of a currency crisis. Indeed, the turmoil in foreign exchange markets and stock markets had always been the spotlight of the event. Therefore, proposals devoted to stabilize capital inflows and outflows by way of various capital control measures are urgently called for. However, in spite of the scale and severity of the 1997 Asian financial crisis, this recent episode shares many features with previous financial crises.

In our view, among various explanations, there are two significant features that precede several recent financial crises. First of all, an asset price inflation preceded the financial crisis: stock and land (real estate) prices surge, then plunge. That is, a boom-bust cycle in the asset markets go along with the eruption of a financial crisis. Secondly, a financial crisis follows a rapid growth of domestic credit. In particular, many of the countries involved in the East Asia crisis heavily relied on foreign capital inflow to create domestic liquidity. Financial intermediaries have been central players who borrow short-term debts from abroad, often in dollars, then heavily lend to investors such as real estate-related businesses (for example, Thailand) or speculative investments by highly leveraged corporations (South Korea). Thus, it is the pivotal factor in propelling the surge of asset prices in these countries.

It is therefore the initial booms in the credit market and the asset market that accelerate the eruption of a financial crisis and collapses of asset markets. If bad news hits or if there is simply a change in market sentiment, investors revise the perspective of the future returns and start to pull out funds. Intermediaries are forced to sell off assets to meet the liquidity demand from international investors. Investment projects are inefficiently halted. Thus, asset prices collapse along with a banking crisis. In sum, we consider the Asian crisis as well as a number of previous crises as a boom-bust cycle of the asset market along

with the expansion-contraction of bank credit due to large swings in international capital inflows and outflows.

A recent example is the dramatic increase in stock prices and real estate prices which occurred in Japan in the second half of the 1980s and the later collapse in the early 1990s. Also, nearly all other OECD countries experienced similar pattern of asset price fluctuations, though not quite as dramatic, around 1984-1993. Most emerging countries in South America and East Asia had drastic asset price cycles since the mid-1980s. All these episodes shared the same feature: asset price inflation often follows a rapid increase in credit expansion before its collapse (Higgins and Osler (1997), Ito and Tokuo (1996), Browne and Rosengren (1992), Shigemi (1995)). Kaminsky and Reinhart (1996a,b) studied a variety of crises in a sample that includes 5 industrialized and 15 emerging countries. Many of them shared a similar story. The initial expansion in credit is accompanied by a rise in the prices for assets such as real estate and stocks. At a certain point the asset markets collapse and their prices plunge. The exposure to the equity and real estate markets initiates a banking crisis. In some cases it is accompanied by an exchange rate crisis. Finally, the difficulties caused from these crises have a tremendous impact on the real sector which persisted for several years. Moreover, they found that banking crises and currency crises are often closely related and in general the former precede the latter.

Corsetti, Pesenti and Roubini (1998a,b) discuss in detail the pre-crisis economic fundamentals of those countries involved in the 1997 Asian crisis. They examine the quantity and quality of lending, and the size and composition of capital inflows. They point out the weakness of the financial system (rapid increase in domestic lending and the rise of non-performing loans) and low foreign reserves as the root of the financial collapse. In a similar line of argument, McKinnon and Pill (1998) and Krugman (1998) all proclaim the potential catastrophic consequence of the "overborrowing" syndrome and the boom-bust cycle of asset prices due to moral hazard problem.

To capture these observations, we construct a simple model to investigate an economy in which lending and borrowing are dependent upon the value of collateral. In particular, the financial contract is based on the ability of lenders to enforce the contract in terms of foreclosing collateral and bargaining over debt repayment. For this aspect, Johnson et al. (1998) present evidence on the correlation between weak corporate governance

and contractual environment in an economy, and the incidence of the Asian crisis. This is consistent with the corporate finance literature that weak contractual enforcement is closely associated with credit market constraint. Therefore, we assume that lenders have the ability to take control of collateralized assets but can only partially enforce cash repayment.[1]

The interaction of collateralized lending and asset prices reinforces each other to lending and asset price booms, and subsequently makes the economy vulnerable to bad news. When financial contracts are based on the value of collateral put forth by the borrowers, more collateralized lending leads to a higher demand for collateralizable assets and bids up their prices. In turn, a higher value of collateral enables borrowers to borrow more to feed on their investments. However, as lenders sense that expected returns in the future might be low, which may be due to a public signal suggesting dire prospects of future returns, they may downsize loans or even refuse to roll over entire loans (or pull funds out of the country in case of foreign lenders) and thus force early liquidation to take place. Productions are interrupted and asset prices crash.

We found that either over-optimism or larger initial holding of collateralized assets by entrepreneurs not only results in a greater amount of lending and a higher level of asset price, but also makes it more likely that lenders downsize loans or even pull out all of their money when bad news hits. This means that the initial boom in the credit market and asset market is more likely to lead to its own crash. We also found that government guarantee will result in a greater boom initially in collateralized lending and asset prices, that is, over-investment and asset price "bubble," but the economy can be even more vulnerable to credit contraction and an asset price collapse. This feature may account for the differential scales of crises that occurred in the past. Finally, if the borrowers are allowed to move first, the borrowers may have the incentive to sell off all of the assets

[1]Hart and Moore (1998) used a similar set of assumptions to study the foreclosure right of financial contracts. Our model differs from theirs in that (1) lenders can partially enforce cash repayment while in their model borrowers can hide all of the output; (2) the value of collateral and thus the borrowing constraint are endogenous while in theirs they are fixed values. Our emphasis here is how the amount of investment and the value of collateralized assets are affected by the existence as well as the exercise of a foreclosure right.

themselves and run away with the money. This suggests that this "looting" behavior of borrowers can give rise to a financial crisis..

A notable feature of our model is that equilibria of incomplete runs (liquidation) are possible. This says that banks-foreign creditors may only downsize the amount of loans by liquidating a fraction of the collateral rather than wipe out all long-term investments as we have seen in the line of Diamond and Dibvig models. The key point of this result is that the liquidation value of the collateralized asset is endogenous. Thus, banks-foreign creditors allow a fraction of the debt to roll over so that the returns from liquidating an additional unit of asset equates their debt repayments in the future.

The rest of the paper is organized as follows. In section 2, we outline the environment of the model and consider financial contracting without interim signals as a benchmark. Section 3 discusses financial contracting with an interim signal, using an example to illustrate our main idea. In section 4 we discuss how the decision rules to roll over loans trigger asset liquidation and financial crisis. Section 5 shows how government guarantee affects the behavior of agents, the market equilibrium, and the likelihood of the eruption of financial crisis. We also investigate whether a financial crisis can arise due to the looting behavior of entrepreneurs-borrowers. Section 6 relates our framework and results to other papers. Section 7 is the concluding remarks.

2 The Environment

Consider a small open economy with four groups of risk neutral agents: foreign lenders, banks, entrepreneurs and landlords. There are three periods indexed by t= 0, 1, and 2. In each period there are two types of goods: a consumption good and a durable asset. Assume that all agents consume only at date 2. The durable asset can be considered as real estate, land or buildings. Suppose the total supply of the durable asset is fixed at $\overline{K}$. Initially, the durable asset is held by the entrepreneurs and landlords. Each entrepreneur has access to a risky two-period investment project. The investment project employs the asset as the sole input. When date 2 cash flow is realized, the asset becomes valueless. We assume the cash flow generated by the project follows

$$y_2 = \widetilde{A} k_0,$$

where k_0 is the level of the durable asset invested at date 0 and $\widetilde{A}$ is a productivity parameter. Productivity of the project is stochastic in the sense that $\widetilde{A} = A^h$ with probability π and $\widetilde{A} = A^l$ with probability $1 - \pi$. Let $A(\pi) \equiv \pi A^h + (1 - \pi)A^l$ and $\overline{A} \equiv E[A(\pi)]$. The true value of $\widetilde{A}$ is realized at date 2, which is publicly observable. The probability π is the initial public assessment of the probability that the project yields a high output. It follows the probability density function $g(\bullet)$ and the probability distribution function $G(\bullet)$. The function $g(\bullet)$ is continuously differentiable and positive on $[\underline{\pi}, \overline{\pi}]$. We assume that

$$\underline{\pi} A^h + (1 - \underline{\pi})A^l > (1 + r)^2,$$

where r is the world interest rate. This says investment in the risky project is socially desirable for any initial assessment of probability distribution. The durable asset becomes valueless at the end of date 2. Entrepreneurs borrow funds from banks at world interest rate r to purchase a durable asset to engage in an investment project. The lending arrangement between borrowers and banks is a one-period short-term loan contract which must be renewed at date 1 to keep the project running. Domestic banks are assumed to be competitive so that their expected profits must be zero. The funds of domestic banks come from foreign lenders. For simplicity, we abstract from the contracting problem between domestic banks and foreign lenders. Domestic banks and foreign lenders also share the same assessments over the probability distribution of π. Therefore, domestic banks will behave as foreign lenders in their roll-over decisions.[2]

Each entrepreneur is endowed with an investment project and a quantity of durable asset k_{-1}. At date 0, the flow of funds constraint faced by each entrepreneur is

$$q_0 k_{-1} + b_0 \geq q_0 k_0, \tag{1}$$

[2]The financial intermediaries in our model represent all financial institutions that perform intermediation services for domestic entrepreneurs. These intermediaries may be domestically or foreign owned, and can operate either on-shore or offshore.

where q_0 is the date 0 price of the durable asset. One can think of the asset employed by the entrepreneurs as commercial real estate.

Landlords hold the rest of the asset not employed by the entrepreneurs. We can think of this portion of asset as residential real estate which yields per period rental rate

$$u_t \equiv H'(k'_t), \tag{2}$$

where k' is the quantity of asset that remains to be used for residential purpose. The function $H(\bullet)$ satisfies the usual neoclassical assumptions, $H'(x) > 0$, $H''(x) < 0$ for all x, and $H'(0) = \infty$ and $H'(\infty) = 0$.

We assume that investment technology is specific to each entrepreneur. Without the help of the entrepreneur who made the investment, the project produces nothing and the piece of the asset can only be sold for alternative use.[3] We have two additional assumptions regarding the abilities of banks to enforce the financial contracts. Firstly, banks cannot take full control of project returns. When output is cropped by an entrepreneur, the bank can at most recover a fraction θ of the cash flow, $0 < \theta < 1$. That is, the entrepreneur can hide at least a fraction $1 - \theta$ of cash flow from her creditor. Secondly, banks can take full control of a durable asset in case the borrower does not make repayments.[4] The first assumption can be justified by the ability of the bank to track down the bank accounts of the run-away borrowers, while the second is justified by the convention that a collateralized asset is entitled to the lender. If banks do not have enough capability to enforce debt repayments, a simple and conventional arrangement is to make lending based on the market value of collateral put forth by the borrowers. As it has been widely practiced, especially in Asian countries, lending arrangements are more based on the

[3]Hart and Moore (1994) assume that only the entrepreneur who initiates the investment can reap the return of the project so that they can repudiate their debt to renegotiate for better terms. That is, the human capital of the debtor-producer is inalienable.

[4]These two assumptions are similar to those in Hart and Moore (1998), however, in their model, borrowers can hide all of the cash flows. The other difference is that in their model projects yield output in both periods, while in ours projects produce output only at date 2.

value of collateralized assets, such as real estate and stocks, and have less to do with credit worthiness of the potential borrowers.[5]

To determine the debt repayment schedule, let′s consider decision rules of the banks at date 1. Since the durable asset is valueless at the end of date 2, taking control of the durable asset is of no use for the banks to insure themselves from borrowers′ refusal of repayment. Thus, borrowers can negotiate with their banks over their debt repayments. Because the banking sector is assumed to be competitive, the borrower-producers have all the bargaining power. Borrowers are able to reduce their debt repayments to the fraction θ of total cash flow, that is, the fraction of cash flow that can be recovered by banks. This fraction of cash flow can be considered as the collateral value of the investment project.[6] In the meantime, banks observe a public signal which is perfectly correlated with the realization of the probability π. Let $q_1(\pi)$ be the date 1 equilibrium asset price, given the observation of the probability π. If the signal indicates good prospects of project returns, the bank renews loans and receives $\theta A(\pi)k_0$ at date 2, otherwise the bank may recall a certain fraction of loans by liquidating some of the assets, receiving $q_1(\pi)$ for each unit of asset which is liquidated and $\theta A(\pi)$ for each unit of the remaining investment. The choice of banks whether to liquidate the asset given the observation of date 1 signal π is expressed by the following decision rule: liquidate if

$$q_1(\pi) \geq \theta A(\pi)/(1+r), \tag{3}$$

and do not liquidate if

$$q_1(\pi) < \theta A(\pi)/(1+r). \tag{4}$$

Condition (3) must be true because when the date 1 equilibrium asset price $q_1(\pi)$ is greater than or equal to the present value of per unit debt repayment $\theta A(\pi)/(1+r)$ due

[5]By the end of 1997, the property exposure (with collateral valuation) of intermediaries in Hong Kong, Malaysia, Singapore, Thailand, Philippines and Korea was 40-55% (50-70%), 30-40% (80-100%), 30-40% (70-80%), 30-40% (80-100%), 15-20% (70-80%), and 15-25% (80-100%) respectively (Corsetti, Pesenti and Roubini (1998)).

[6]See Hart and Moore (1994, 1998) for more details in the analysis of renegotiation and determination of debt repayment.

to bad news about π, the banks-foreign creditors are better off by starting to liquidate the assets. The liquidation will not stop until the value of the last unit of asset equals the present value of cash flow accrued to the bank from an additional unit of investment. Therefore, the equilibrium with liquidation occurs when (3) holds in equality. On the other hand, (4) says that if the signal indicates good prospects so that the present value of per unit debt repayment is high enough, the banks are better off by rolling over the loans. The decision rules (3) and (4) imply that there exists a threshold value of π below which banks start to liquidate assets.

It remains to determine the amount of date-0 lending. Foreseeing the possibility that entrepreneurs can threaten to walk away from production at date 1 and they also can steal at least a fraction $1-\theta$ of date 2 cash flow, banks would not lend more than the expected value of the collateral. The amount of lending is determined by

$$b_0 \leqq Min\{q_1 k_0/(1+r), \theta\overline{A}k_0/(1+r)^2\},$$

where q_1 is the date 1 expected asset price. That is, the amount of borrowing is the minimum value of the discounted present value of expected date 1 asset price or the present value of the expected cash flow that can be recovered by the lender.

Integrating (3) and (4) respectively over the values of π and then adding them up, we have

$$q_1 < \theta\overline{A}/(1+r),$$

so that the borrowing constraint can be expressed as

$$b_0 \leqq q_1 k_0/(1+r). \tag{5}$$

Thus, an entrepreneur with initial asset k_{-1} at date 0 can borrow up to b_0 and acquire more assets up to k_0 for investment.

2.1 Financial Contracting Without an Interim Signal

If there is no new information regarding the perspective of the investment returns, banks will roll over the loans as expected and nothing happens at date 1. Thus, the maximization problem of a representative borrower is

$$
\begin{aligned}
Max \quad & (1-\theta)\overline{A}k_0 && \text{(P1)}\\
s.t. \quad & (1),(5)\\
& \theta\overline{A}k_0 \geq (1+r)^2 b_0 && (6)\\
& q_0 = H'(k_0') + q_1/(1+r). && (7)
\end{aligned}
$$

Equation (1) and (5) are respectively the flow of funds constraint and the borrowing constraint. Equation (6) is the banker′s participation constraint. Since the banking sector is competitive, zero expected profit requires that this constraint holds with equality.[7] Equation (7) governs the behavior of asset prices over time so that no arbitrage opportunity is allowed. Finally, the land market clears at each period[8]

$$\overline{K} = k_t' + k_t,\ t = 0, 1. \tag{8}$$

The equilibrium can be easily characterized. Using (1), (5), (6), (7) and the land market equilibrium conditions we have

$$
\begin{aligned}
& H'(\overline{K} - k_0)(k_0/k_{-1} - 1) = \theta\overline{A}/(1+r)^2\\
& b_0 = \theta\overline{A}k_0/(1+r)^2\\
& q_0 = H'(\overline{K} - k_0) + \theta\overline{A}/(1+r)^2\\
& q_1 = \theta\overline{A}/(1+r).
\end{aligned}
$$

Comparative statics with respect to model parameters are presented in Table 1. A noteworthy observation is that given a fixed asset supply, lending and investment always

[7]Of course, borrowers must also be better off than autarky. If they invest without borrowing, the expected return is $\overline{A}k_{-1}$. Thus, we require

$$(1-\theta)\overline{A}k_0 \geq \overline{A}k_{-1}.$$

This is equivalent to requiring that θ cannot be too large and we assume this holds for any k_0

$$\theta \leqq 1 - k_{-1}/k_0.$$

[8]Since assets will not be liquidated, we have $k_0 = k_1$ and $k_0' = k_1'$.

go hand in hand with the date 0 asset price, either if there is an increase in initial endowment of borrowers or expected productivity or better cash flow enforcement, or a decrease in the riskless interest rate. A higher asset price enables the borrower to borrow more and acquire more assets for investment.

[Insert Table 1 here]

3 Financial Contracting with an Interim Signal

At date 1, a publicly observable signal that indicates the prospects of project returns (date 2 realization of π) is realized.[9] Based on the signal, banks-foreign lenders revise their expectations about the probability of success of investment projects and decide whether to pull out their lending. They may roll over all of the debts or downsize loans by liquidating a fraction of the assets, or recall all of the loans by liquidating all collateralized assets. When banks-foreign creditors decide to take actions, they seize a part or all of the asset and auction them off to landlords. This leads the price of the durable asset to drop. As a consequence, the country under consideration will experience capital flight, collapse in its domestic asset market and an interruption in investment projects.[10]

For the purpose of illustration, we consider a special case in which the distribution of π has only two states of realizations: $\pi = \pi^h$ with probability p and $\pi = \pi^l$ with probability $1-p$ where $\pi^h > \pi^l$ and $0 < p < 1$. Let $E(\pi) = p\pi^h + (1-p)\pi^l$. Given the two-state distribution, we assume that liquidation occurs when the signal indicates a low value of π. Conditions (3) and (4) become

$$\textit{Liquidation} \qquad \text{if } q_1(\pi^l) \;=\; \frac{\theta A(\pi^l)}{1+r}. \tag{9}$$

[9]This piece of new information comes in a form like $\pi = 0.6$, which may be deduced from a news release of economic indicators or the financial situation of intermediaries such as profitability, bad loan ratio and capital adequacy.

[10]Compared with the role of banks in the line of Diamond and Dibvig (D&D) model, it is obvious that in a D&D type model banks exist to provide liquidity and asset transformation service; in ours the main function of banks is to enforce financial contracts by seizing up collateral when loans are not renewed and collect date 2 debt repayments.

$$\textit{No Liquidation} \quad \text{if } q_1(\pi^h) \;<\; \frac{\theta A(\pi^h)}{1+r}. \tag{10}$$

The optimization problem of a representative entrepreneur is

$$\begin{aligned}
Max \quad & (1-\theta)\{pA(\pi^h)k_0 + (1-p)A(\pi^l)k_1\} && \text{(P2)}\\
s.t. \quad & (1), (5) \\
& p\theta A(\pi^h)k_0 + (1-p)\theta A(\pi^l)k_1 + \\
& \quad (1-p)(1+r)(k_0-k_1)q_1(\pi^l) \geq (1+r)^2 b_0 && (11)\\
& q_1(\pi^h) = H'(\overline{K}-k_0) < \theta A(\pi^h)/(1+r) && (12)\\
& q_1(\pi^l) = H'(\overline{K}-k_1) = \theta A(\pi^l)/(1+r) && (13)\\
& q_0 = H'(\overline{K}-k_0) + q_1/(1+r), && (14)
\end{aligned}$$

where $q_1 = pq_1(\pi^h) + (1-p)q_1(\pi^l)$ and k_1 is the quantity of asset remaining for investment at date 1. Equation (11) is the participation constraint of the bank which holds in equality in equilibrium. This says the cash flow accrued to the bank without liquidation together with the value of the liquidated asset and the accrued cash flow of the remaining investment should cover the opportunity cost of the bank. Rearranging this expression, we find that it is equivalent to (6).

Equations (12) and (13) are restatements of (9) and (10). They also make use of the fact that the realized date 1 asset price should be equal to the rental rate of alternative use because assets are worthless at date 2. By (1), (5), and (12)-(14), we can solve for the quantity of date 0 investment in terms of date 1 asset prices:

$$k_0 = [1 + \frac{p}{1+r} + \frac{1-p}{1+r}\frac{q_1(\pi^l)}{q_1(\pi^h)}]k_{-1}.$$

If the signal indicates that the realization of π will be the low one π^l, the banks liquidate a fraction or all of the asset depending on the level of π^l. If π^l is low enough, k_1 will be zero. The quantity of investment remaining in investment sector k_1 is implied by equation (13):

$$H'(\overline{K}-k_1) = \theta A(\pi^l)/(1+r). \tag{15}$$

To further investigate asset prices and quantity of liquidation, it is useful to specify the function form of $H(\bullet)$ as

$$H(\overline{K} - k) = \alpha \ln(\overline{K} - k),$$

where α is a constant. Thus, if π^l is realized, a fraction of asset is liquidated and only $k_1 = \overline{K} - \alpha(1+r)/[\theta A(\pi^l)]$ remains. Using $q_1(\pi^l) = \theta A(\pi^l)/(1+r)$, we can solve for the higher asset price $q_1(\pi^h)$. Plugging them back into k_0, we have:

$$k_0 = \frac{\alpha(1+r)(1+r+p) + (1-p)\theta A(\pi^l)\overline{K}}{\alpha(1+r)^2/k_{-1} + (1-p)\theta A(\pi^l)}.$$

Note that only π^l is relevant in determining the level of investment because the decision for liquidation depends entirely upon the level of π^l, but not upon π^h. Finally, q_0 and b_0 are solved by (5) and (14).

We conduct comparative statics analysis to see how initial investment, liquidation, and asset prices respond to model parameters. The results are summarized in Table 2. Increases in the gap between high and low output $z(\equiv A^h - A^l)$, the initial asset endowment of entrepreneurs k_{-1}, the probability π^l, the probability of π being high p and the fraction of output that can be recovered by banks θ will unambiguously lead to higher level of investment and push asset prices up to a higher level. On the other hand, an increase in world interest rate r suppresses initial investment and asset prices. A further interesting result is to see how the quantity of liquidation $(k_0 - k_1)$ changes in case the lower probability of yielding a high output π^l is realized. It is found that a higher initial asset endowment of entrepreneurs k_{-1}, world interest rate r, and the probability p will all lead to a larger quantity of liquidation in case the interim signal indicates that π^l will be realized. This underlies the basic findings of our model.

[Insert Table 2 here]

Proposition 1 *Either an initial over-optimism (high p) or larger initial holding of collateralized assets by entrepreneurs (high k_{-1}) will result in a greater amount of lending and a higher level of asset prices. However, when the interim signal indicates that the lower probability of yielding high output (π^l) is realized, the initial boom leads to a larger quantity of liquidation.*

The condition for $q_1(\pi^l)$ to be less than $q_1(\pi^h)$ is

$$\pi^l < \frac{\alpha(1+r)}{z\theta(\overline{K} - (2+r)k_{-1}/(1+r))} - \frac{A^l}{z} \equiv \widehat{\pi}^l.$$

We assume that $\overline{K} > (2+r)k_{-1}/(1+r)$. This condition is also equivalent to $k_1 < k_0$ because $q_1(\pi^l)/q_1(\pi^h) = (\overline{K} - k_0)/(\overline{K} - k_1)$. Next, the critical value for π^l whereby the entire asset is wiped out ($k_1 = 0$) is

$$\widehat{\widehat{\pi}}^l = \frac{\alpha(1+r)}{z\theta\overline{K}} - \frac{A^l}{z} < \widehat{\pi}^l.$$

If $\widehat{\widehat{\pi}}^l < \pi^l < \widehat{\pi}^l$ banks will call in a positive amount of loans and if $\pi^l \leqq \widehat{\widehat{\pi}}^l$ there will be a complete run on entrepreneurs' projects and all asset investments are interrupted ($k_1 = 0$).

4 Asset Liquidation and Financial Crisis

We are ready for the case where the probability that the project yields high output. π follows the continuous density function $g(\bullet)$. The purpose is to investigate the critical value of π, that is π^*, below which banks start to downsize outstanding loans by liquidating collateral. We show that there exists an "incomplete run" equilibrium in which banks-foreign creditors allow a part of the debt to roll over.

Given the critical value π^*, the optimization problem of a representative entrepreneur is

$$\begin{aligned}
Max \quad & (1-\theta)\{\int_{\pi^*}^{\overline{\pi}} A(\pi)k_0 dG(\pi) + \int_{\underline{\pi}}^{\pi^*} A(\pi)k_1 dG(\pi)\} && \text{(P3)}\\
s.t. \quad & (1), (5)\\
& \theta\int_{\pi^*}^{\overline{\pi}} A(\pi)k_0 dG(\pi) + \theta\int_{\underline{\pi}}^{\pi^*} A(\pi)k_1 dG(\pi)\\
& \quad + (1+r)\int_{\underline{\pi}}^{\pi^*} (k_0 - k_1)q_1(\pi)dG(\pi) \geq (1+r)^2 b_0 && (16)\\
& q_1(\pi \mid \pi > \pi^*) = H'(\overline{K} - k_0) < \theta A(\pi \mid \pi > \pi^*)/(1+r) && (17)\\
& q_1(\pi \mid \pi \leqq \pi^*) = H'(\overline{K} - k_1) = \theta A(\pi \mid \pi \leqq \pi^*)/(1+r) && (18)\\
& q_0 = H'(\overline{K} - k_0) + q_1/(1+r), && (19)
\end{aligned}$$

where $q_1 = \int_{\pi^*}^{\overline{\pi}} q_1(\pi \mid \pi > \pi^*) dG(\pi) + \int_{\underline{\pi}}^{\pi^*} q_1(\pi \mid \pi \leqq \pi^*) dG(\pi)$. Using (1), (5), (17)-(19) and using the assumption that the non-investment asset production function takes the logarithm function, we express k_0 as a function of model parameters and π^*

$$k_0 = \frac{\alpha(1+r)[1+r+(1-G(\pi^*)] + \theta\overline{K}\Delta(\pi^*)}{\alpha(1+r)^2/k_{-1} + \theta\Delta(\pi^*)}, \tag{20}$$

where $\Delta(\pi^*) = A^l G(\pi^*) + zE(\pi \mid \pi \leqq \pi^*)$. Results of comparative statics of investment and asset prices resembles those in Table 2. The critical point π^* can be found by equating k_1 to k_0. Using (18) and (20), π^* is implied by the following equation

$$\overline{K} - \frac{\alpha(1+r)}{\theta A(\pi^*)} = \frac{\alpha(1+r)[1+r+(1-G(\pi^*)] + \theta\overline{K}\Delta(\pi^*)}{\alpha(1+r)^2/k_{-1} + \theta\Delta(\pi^*)}. \tag{21}$$

The other critical value of π, π^{**}, at which the entire collateralized assets are liquidated is implied by equation (18) by setting $k_1 = 0$:

$$\overline{K} - \frac{\alpha(1+r)}{\theta A(\pi^{**})} = 0. \tag{22}$$

The solution is $\pi^{**} = [\alpha(1+r)/(\theta\overline{K}) - A^l]/z$. Comparing equation (21) and (22), it is obvious the RHS of (21) is positive while that of (22) is zero. Since $A(\pi)$ is an increasing function of π, to equilibrate both sides, it must be true that

$$\pi^{**} < \pi^*.$$

If the signal indicates that π will locate in the area (π^{**}, π^*), the quantity of liquidation is a positive number but less than k_0. Define the quantity of asset being liquidated as k^l, $k^l \equiv k_0 - k_1 > 0$. It can be verified that k^l is monotonically decreasing in π within the region (π^{**}, π^*) and is convex to the origin. The quantity of k^l is drawn against the probability π in Figure 1. The upper limit of k^l is k_0 for realization of probability below π^{**}. At the point $\pi = \pi^{**}$ (denoted C), $k^l = k_0$, the entire durable asset employed for investment is liquidated and the asset price crashes to its lowest possible level $q_1(\pi^{**}) = H'(\overline{K})$.

[Insert Figure 1 here]

Proposition 2 *When the signal of π is located between (π^*,π^{**}), there exists an incomplete run (liquidation) equilibrium in which banks-foreign creditors liquidate only a fraction of the collateralized assets and allow the rest of the debt to roll over so that the returns from liquidating an additional unit of asset this period equals the returns from their loan repayments the next period.*

The key point of this result is that the liquidation value of the collateralized asset is endogenous. Too much liquidation may depress the value of assets to such a low level that it is not worthwhile to sell an additional unit of the assets.[11]

Using equation (21) and (22) again, we can determine the movements of the two critical values (π^{**}, π^*) in response to exogenous variables. The results are presented in Table 3. An increase in the gap between high and low output z or the world interest rate r pushes both critical points to higher levels ($\pi^{*\prime}$,$\pi^{**\prime}$) and narrows the spread between $\pi^{**\prime}$ and $\pi^{*\prime}$. Thus, it becomes more likely that banks pull out all of their money when the bad signal hits. Also, a greater initial holding of durable assets by entrepreneurs (larger k_{-1}) or a shift in the distribution of π in the sense of first-order stochastic dominance (FSD) indicating that initially the public is more optimistic about the prospects of project outcomes, pushes π^* to a higher level and makes it more likely to start liquidating asset, but it does not affect π^{**}. To see this, observe that if the distribution of π shifts upward in the sense of FSD, both $G(\pi^*)$ and $E(\pi \mid \pi \leqq \pi^*)$ are lowered given π^*. This increases date 0 investment k_0. To rebalance equation (21), π^* must be higher (see Figure 1). Proposition 3 and 4 summarize our findings.

[Insert Table 3 here]

Proposition 3 *Either an increase in the gap between high and low output z or the world interest rate r pushes both critical points π^* and π^{**} to higher levels so that it becomes more likely to start liquidation and it also becomes easier to wipe out all collateralized assets. Furthermore, the spread between the new critical values becomes smaller. This means that the critical point π^{**} increases faster than π^* does so that it gets more likely to liquidate the entire asset investment.*

[11]This may explain the causal observation that some bank managers might be willing to roll over a fraction or all of the non-performing loans in bad times, rather than seizing the collateral of little value.

Proposition 4 *An increase in the initial asset endowment of entrepreneurs k_{-1}, or more optimism about the prospects of project outcomes (that is, an upward shift in the distribution of π in the sense of First Order Stochastic Dominance (FSD)) produces greater booms initially, but makes it easier to start liquidating the asset (higher π^*).*

In sum, a larger gap between high and low output z, over-optimism (FSD), or greater initial holding of durable assets by entrepreneurs (larger k_{-1}) not only allow greater amount of collateralized lending but also bid up asset prices at date 0. However, the initial booms in the credit market and asset market make it vulnerable to bad news and eventually cause its own crash.

5 Government Guarantee

Another important feature of financial institutions is that they are more or less protected by the government. This is particularly prevalent in emerging countries. This "implicit guarantee" by the government, as emphasized by Krugman (1998) and others, may help explain the severity of the moral hazard problem in the intermediaries$'$ sector and the huge boom-bust cycle of asset prices as we have observed in East Asian countries. The concept of government guarantee should be understood broadly: safety nets, deposit insurance, implicit promises and explicit announcements that relate to how the government deals with financial crises in the past or how it will handle similar episodes in the future. Given government guarantees these financial institutions would ignore the expected losses that may occur if lower output is realized at the time in making investments. A typical symptom of this moral hazard problem is over-borrowing, over-investment and shifting to a higher risk investment so as to take advantage of the benefit of high returns if they are lucky, while they would have no losses in case of failure.

To begin with, it is necessary to describe what actually the government guarantees in our framework. The government is expected to protect intermediaries from withdrawal of funds by creditors so that long-term investment would not be interrupted. This may be due to an implicit contract between the government and domestic debtors. In effect, it is a promise that bank loans will be rolled-over at date 1 no matter what the interim

signal indicates. If the signal indicates that $\pi = \pi_a < \pi^*$, and the banks decide to liquidate a fraction of collateral, then the expected returns of borrowers will definitely be lower (because only k_1 investment is left). Therefore, it is also equivalent to protecting domestic borrowers.

When bank loans will be rolled-over at date 1 in any case, the economic agents would effectively ignore the possible realizations of low output when they make investment decision at date 0. The optimization problem of a representative entrepreneur becomes

$$\begin{aligned} Max \quad & (1-\theta)\int_{\pi^*}^{\overline{\pi}} A(\pi)k_0 dG(\pi) && \text{(P4)} \\ s.t. \quad & (1),(5) \\ & \theta\int_{\pi^*}^{\overline{\pi}} A(\pi)k_0 dG(\pi) \geq (1+r)^2 b_0 && (23) \\ & q_1(\pi \mid \pi > \pi^*) = H'(\overline{K}-k_0) < \theta A(\pi \mid \pi > \pi^*)/(1+r) && (24) \\ & q_0 = H'(\overline{K}-k_0) + q_1/(1+r), && (25) \end{aligned}$$

where π^* is the critical value implied by (21) from the last section and $q_1 = \int_{\pi^*}^{\overline{\pi}} q_1(\pi \mid \pi > \pi^*)dG(\pi)$. Using (1), (5), (24) and (25), we solve for the quantity of asset employed in the investment sector under government guarantee k_0^G in terms of model parameters and π^*

$$k_0^G = [1 + \frac{1-G(\pi^*)}{1+r}]k_{-1}, \tag{26}$$

where the superscript G denotes the variable under government guarantee. It is straightforward to show that under government guarantee, the amount of lending, investment and asset prices are all higher:

$$k_0^G > k_0,\ b_0^G > b_0,\ q_0^G > q_0, \text{ and } q_1^G > q_1.$$

This is because government guarantee bids up the value of the net worth of entrepreneurs and enables them to borrow more to feed on their investments. With a guarantee the banks are willing to lend more and thus entrepreneurs can acquire more assets from landlords. This raises both date 0 and date 1 asset prices. At the same time, higher collateral value enables entrepreneurs to borrow more for investment giving the same quantity of asset.

Therefore, this results in more lending and investment, and generates an artificial asset price "bubble."

Suppose at date 1 the market comes to believe that the government is not capable of stopping liquidation either due to lack of foreign reserves or external pressure (from IMF, for example). Therefore, banks-foreign creditors are forced to reconsider the loan renewal decision. The critical point π, denoted π^{G*}, can be found by equating k_1 to k_0:

$$\overline{K} - \frac{\alpha(1+r)}{\theta A(\pi^{G*})} = [1 + \frac{1 - G(\pi^*)}{1+r}]k_{-1}. \tag{27}$$

The RHS of (27) is the amount of investment which has been determined at date 0, based on the presumption that there is government guarantee. Compare this expression with equation (21). Note that the RHS of (27) is larger than that of (21), thus the LHS of (27) must be larger as well. This can only be possible if π^{G*} is larger:

$$\pi^{G*} > \pi^*.$$

Therefore, the critical value that triggers asset liquidation under government guarantee has increased, raising the likelihood of early liquidation. This implies that government guarantee will result in an initial greater boom in the credit market and asset market than otherwise, but it is also more likely for the economy to suffer capital flight and an asset price crash. This may partly explain the differential scales of crises that occurred in the past.

Let$'$s see when happens if the distribution of π becomes riskier. Consider a mean preserving spread (MPS) in the distribution of π. If the lower tail of the distribution on the interval $[\underline{\pi}, \pi^*]$ is affected, $G(\pi^*)$ is lowered given π^*. The effects of an MPS to lending, investment and asset prices are similar to those of an FSD. Again, the threshold value π^{G*} must increase to equilibrate equation (27). Proposition 5 summarizes the results.

Proposition 5 *Government guarantee generates over-investment and an asset price "bubble," and subsequently makes it easier to trigger an asset liquidation ($\pi^{G*} > \pi^*$). An increase in the initial asset endowment of entrepreneurs, more optimism (in the sense of FSD), or riskier distribution of π (in the sense of MPS) produce even greater booms initially, but makes it easier to start liquidating assets (higher π^{G*}).*

5.1 Looting

A typical symptom of moral hazard is the behavior of excessive risk-taking on the lender′s side (Kane (1989) and/or on the borrower′s side (Allen and Gale (1998)). These "gamblers" exercise "risk-shifting" by investing in riskier projects to take advantage of the potential huge profit, or simply over-borrow and over-invest under the presumption that the government and the whole society will clear up the mess if losses occur. Akerlof and Romer (1993), however, outline a striking argument with stark evidence that borrowers may have incentives to "go broke for profit" at the society′s expense (to loot) instead of to "go for broke" (to gamble for resurrection). This happens when the borrowers can reap more profit from driving a solvent firm bankrupt. "Poor accounting, lax regulation, or low penalties for abuse give owners an incentive to pay themselves more than their firms are worth and then default on their debt obligations." (p.2) Particularly, looting is more likely when looters can count on the government to bear the losses. In the context of our framework, when the prospects of future output is not good, borrowers may have the incentive to sell off all of the assets before banks move and run away, even though the banks may liquidate only a small part of the assets.

To fix the idea, we relax the assumption that the banks can take full control of a durable asset and allow the borrowers to choose to liquidate assets at date 1 before the banks move.[12] Since it is supposed to be a looting behavior, borrowers will liquidate all of the assets if they choose to. As before the banks can recover a fraction θ of the cash from the sale of the assets.

Firstly, it can be verified that if the news is good enough so that banks roll over all of the loans, then borrowers have no incentive to loot. Because the net profit from looting is lower then the net present value of project return next period. Thus, the critical value under which the borrowers choose to liquidate, π^L, must lie below the critical value under which banks start to liquidate assets. Knowing that the borrowers may loot, the banks

[12]Actually, this is a strong assumption because when a piece of asset such as land or a building are collateralized, lenders are entitled to its ownership. We take a strong position by assuming that somehow the borrower is able to commit this fraud by circumventing the laws. This can happen in an environment where the accounting system is not well established or law enforcement is lax as described in Akerlof and Romer (1993).

take this into account. The objective function and the participation constraint of (P3) respectively are amended as follows:

$$(1-\theta)\{\int_{\pi^{*\prime}}^{\overline{\pi}} A(\pi)k_0 dG(\pi) + \int_{\pi^L}^{\pi^{*\prime}} A(\pi)k_1 dG(\pi) + \int_{\underline{\pi}}^{\pi^L} q_1(k_1=0)k_0 dG(\pi)\},$$
$$\theta\int_{\pi^{*\prime}}^{\overline{\pi}} A(\pi)k_0 dG(\pi) + \theta\int_{\underline{\pi}}^{\pi^{*\prime}} A(\pi)k_1 dG(\pi) + \theta\int_{\underline{\pi}}^{\pi^L} q_1(k_1=0)k_0 dG(\pi)$$
$$+ (1+r)\int_{\pi^L}^{\pi^{*\prime}} (k_0-k_1)q_1(\pi)dG(\pi) \geq (1+r)^2 b_0,$$

where $q_1(k_1=0)$ is the price of the asset when none of the asset survives date 1 liquidation, so $q_1(k_1=0) = H'(\overline{K})$. It can shown that the new critical value under which $\pi^{*\prime}$ has risen:

$$\pi^{*\prime} > \pi^*$$

The borrowers will exercise looting if the yield from liquidating all assets net of the fraction recovered by the banks is higher than the return to the borrower if he chooses not to move and allows the banks to liquidate a fraction of the assets:

$$(1-\theta)q_1(k_1=0)k_0 \geq (1-\theta)A(\pi)k_1/(1+r). \tag{28}$$

To show that there exists a threshold value such that (28) holds in equality, consider the following two cases: (i) if $k_1 = k_0$, then π is greater than or equal to $\pi^{*\prime}$ and the condition (28) is reversed in strict inequality. In this case there is no looting; (ii) if $k_1 = 0$, then π is smaller than or equal to $\pi^{*\prime}$ and condition (28) always holds with strict inequality. In this case looting occurs. In sum, there exists π^L, $\underline{\pi} < \pi^L < \pi^{*\prime}$, such that if $\pi < \pi^L$, borrowers choose to liquidate themselves. This suggests that the looting behavior of entrepreneurs-borrowers can give rise to a financial crisis.

6 Relations to Other Literature

The results above can be compared to those following the line of Diamond and Dibvig (1983). While the D&D model is concerned with runs by depositors on their banks,

in this paper we are considering the roll-over decisions of loans to borrowers by banks-foreign creditors.[13] In the basic Diamond and Dibvig paradigm, runs on banks result from unexpected changes in expectations, caused by certain exogenous events. A bank run can occur as a self-fulfilling set of beliefs. Some others emphasize sudden, but rational revisions in perceived riskiness of bank deposits when non bank-specific, aggregate information arrives. A bank run occurs when depositors observe a public signal correlated with the value of banking system assets (indicators of recession, decline of net worth of a particular class of bank borrowers). A common feature of these two lines of research is that runs are catastrophic, that is, bank creditors wish to withdraw all their money when runs occur. Thus, long-term assets of the economy are completely wiped out whenever there is a run in a representative bank economy.

Our paper is closer to the second line of models, but a major difference is that in our model there are incomplete runs in the sense that instead of refusing to roll over all of the loans, banks-foreign creditors may only downsize the amount of loans by liquidating a fraction of the collateral.

Recent theoretical works take the D&D model a step forward into an open economy setting. Change and Velasco (1998) presented a model in the line of Diamond & Dibvig (1983) tradition of a small open economy. The focus is on the international illiquidity of the domestic financial system. They discussed the conditions of financial vulnerability under which domestic banks may be subject to runs by domestic depositors and foreign lenders. The refusals to extend new credit and/or to roll over short-term debt increase the financial fragility of the domestic banking system. They also discuss the role of liquidity facing the threat of domestic bank run and/or pressure of a currency devaluation. However, as in the tradition of the D&D model, multiple equilibria arise due to the fears of default and their anticipations become self-fulfilling. As is well known, it takes an exogenous event to trigger the run equilibrium in the D&D model, otherwise the probability of a run approaches zero.

Allen and Gale (1998) constructed a very interesting model where sheer intermediation (using other people′s money to invest) can create an asset price bubble which deviates from

[13]Note that in the line of D&D, firms or entrepreneurs are abstracted from the models so that banks engage in investment directly.

its fundamental value (the value when investors use their own money to invest), without resorting to any other credit market friction or information asymmetry. Intermediation tends to encourage more investment in riskier projects (risk-shifting). The application of "limited liability" to asset pricing is the novelty in their paper. In our paper, incomplete enforcement of financial contract underlies the basic structure of the framework.

Corsetti, Pesenti and Roubini (1998) provide a sensible argument for what triggers financial and currency crises. They argue that the government is expected to assume the private liabilities when the crisis erupts. The government may have to increase money supply, after exhausting other sources of financing, to finance the large amount of foreign debt by the time a crisis erupts. Foreseeing this possibility, a speculative attack on the domestic currency lowers the level of foreign reserves, and thus triggers a financial crisis when the level of foreign reserves falls below outstanding foreign loans. However, the issue of a boom-bust cycle of asset prices is not considered. In our model the value of collateralized assets is endogenous, which can produce larger swings in the credit and asset markets.

Finally, Kim and Lee (1998) construct a model conceptually similar to Corsetti, Pesenti and Roubini (1998), but they give a central role to the collateralized asset. When the value of the asset falls below the amount of cumulated loans, a crisis erupts. What underlies their model is the outright government subsidy to firms, which results in over-investment and a later eruption of a financial crisis. Banks are willing to supply funds to money-losing firms as long as the value of collateral still covers the amount of debt under a perfect capital market setting, thus it allows the government to play the Ponzi scheme for some time. However, why banks are willing to continue to lend until the eruption of the crisis is not well-justified.

It can be even worse if foreign debt is unhedged. Devaluation results in even heavier indebtedness in terms of the domestic currency, which takes a larger quantity of liquidation to repay the amount of recalled loans. Studies have shown that financial crises and currency crises very often go hand in hand, and the causes leading to both crises are intertwined. Note that speculative attacks on a currency that lead to losses of foreign reserves and a subsequently drastic devaluation are not considered here. One can model the mechanism that a speculative attack on a currency arises due to accumulation of

foreign debt over foreign reserves held by the government (Kim and Lee (1998)) or due to an increase in future money growth to financing the debt of the government who assumes the liability from the private sector (Corsetti, Pesenti and Roubini (1998)). Within our framework, however, one can be sure that if foreign loans were not hedged, expectations of devaluation that arises at date 1 will increase the burden of indebtedness substantially and this may overturn the no-liquidation condition (4)

$$q_1(\pi) > \frac{\theta A(\pi)}{(1+r)e_2},$$

where e_2 is the date 2 expected exchange rate at date 1, defined as the price of foreign currency in terms of per dollar domestic currency, by normalizing the date 0 exchange rate to 1. When expectations of devaluation is large enough, asset investments can be easily wiped out.

7 Concluding Remarks

In this paper we investigate how the initial booms in an asset market and credit market reinforce each other, leading to credit expansion and appreciation in the value of collateralized assets, and consequently resulting in larger investment and higher asset prices. However, the initial prosperity per se makes itself more vulnerable to changes in economic perspectives. Failure to roll over loans makes asset liquidation unavoidable and causes asset prices to collapse. Greater booms in lending and asset prices caused by initial over-optimism and a larger initial holding of collateralized assets by entrepreneurs fasten the collapse of the booms and generate a larger scale of financial crisis. Government guarantee only makes the problem worse. When the probability distribution that produces higher output becomes riskier, market participants take advantage of its potential huge returns, resulting in over-investment and an asset price "bubble." The explicit or implicit government guarantee has been considered as one of the most important factors contributing to the weakness of financial institutions in Asian countries. We found that this distortion makes it more likely that financial crisis erupts. We also find that a financial crisis can be a consequence of "looting" behavior of entrepreneurs.

It is clear from the analysis that the pro-cyclical nature of the value of collateral is the primary factor, other than distortionary policies, that exacerbates a financial crisis. This suggests a certain type or a combination of collateral with relatively stable value may help contain a crisis.

The simplicity and tractability of the model presented above is a merit, however, durable asset pricing in a finite period model has certain limitations. Since the asset is valueless at the end of date 2, there is no way that the model can generate multiple equilibria as is usually seen in many asset pricing models. Furthermore, the propagation mechanism of a financial crisis cannot be fully exploited under a finite period framework. A next step would be to develop a dynamic model of credit expansion and asset prices in which the propagation mechanism of a financial crisis can be traced through the interaction between changes in credit and asset prices. Kiyotaki and Moore (1997) and Chen (1997) had studied the dynamic interactions between credit and asset prices. However, in both models the shock that generates fluctuations in asset prices and outputs is a zero-probability event, and there is no role for monetary policies. One way to solve the problems at the same time may be to introduce aggregate shocks and explicitly model the behavior of the government, so that external shocks arise naturally and the effects of monetary policies can be analyzed.

Although the option to liquidate assets by the lenders is part of the optimal contract under the given incomplete enforcement structure, there may be some coordination failure that can be avoided by some big agent to improve welfare. It may be desirable to redistribute some borrowers′ returns to banks-foreign lenders in order to persuade them not to liquidate assets.[14] However, what the coordinator can do should be specified carefully.

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[14]Of course, it is because in our model there is no further choice for borrowers to shift to those riskier projects with negative expected returns. If there is a risk-shifting toward riskier type of investments, early liquidation may be better off for the economy as a whole.

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Figure 1　The Critical Values to Liquidating Assets

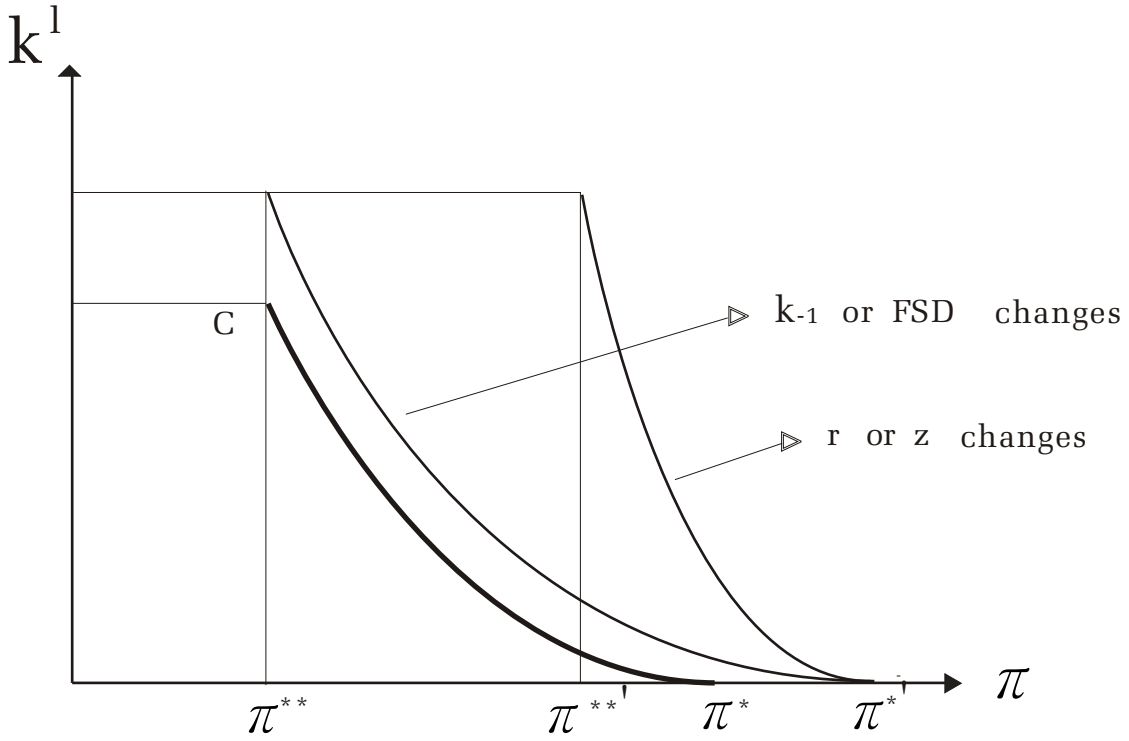

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Table 1. Comparative Statics: Without Interim Signal

	q_0	q_1	k_0	b_0
$k_{-1} \uparrow$	$+$	0	$+$	$+$
$\overline{K} \uparrow$	$-$	0	$+$	$+$
$\theta \uparrow$	$+$	$+$	$+$	$+$
$r \uparrow$	$-$	$-$	$-$	$-$

Table 2. Comparative Statics: A Two-State Example

	q_0	$q_1(\pi^l)$	$q_1(\pi^h)$	k_0	$k_0 - k_1$	b_0
$z \uparrow$	$+$	$+$	$+$	$+$	$-$	$+$
$r \uparrow$	$-$	$-$	$-$	$-$	$+$	$-$
$k_{-1} \uparrow$	$+$	0	$+$	$+$	$+$	$+$
$\overline{K} \uparrow$	$-$	0	$-$	$+$	$-$	$+$
$\pi^l \uparrow$	$+$	$+$	$+$	$+$	$-$	$+$
$\pi^h \uparrow$	0	0	0	0	0	0
$p \uparrow$	$+$	0	$+$	$+$	$+$	$+$
$\theta \uparrow$	$+$	$+$	$+$	$+$	$-$	$+$

Table 3. Critical Values That Trigger Liquidation

	π^{**}	π^{*}	$\pi^{*}-\pi^{**}$
$z\uparrow$	$+$	$+$	$-$
$r\uparrow$	$+$	$+$	$-$
$k_{-1}\uparrow$	0	$+$	$+$
$\overline{FSD}$	0	$+$	$+$
$\overline{K}\uparrow$	$-$	$-$	$-$
$\theta\uparrow$	$-$	$-$	$-$