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The Japanese Banking Crisis and Economic Growth: Theoretical and Empirical Implications of Deposit Guarantees and Weak Financial Regulation

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Abstract

An endogenous growth model with financial intermediation is used to show how government policies towards the financial sector can lead to banking crises and persistent growth slumps. The model shows how government deposit guarantees and regulatory forbearance can lead to permanent declines in the growth rate of the economy. The effects of inadequate prudential supervision on asset price dynamics under perfect foresight are also derived in the model. The policies that are used in the analysis are based on essential features of Japanese financial regulation. The implications of the model are compared to the experience of the Japanese economy and financial system during the 1990s. We find that the dynamics predicted by our model are generally consistent with the recent behavior of economic aggregates, asset prices and the banking system for Japan. A policy implication of the model is that the impact on future economic growth depends upon the length of time the government fails to enforce loan-loss reserving by banks.

Note: This is a substantial revision of our earlier paper entitled, “Financial Intermediation, Agency and Collateral and the Dynamics of Banking Crises: Theory and Evidence for the Japanese Banking Crisis,” presented at the Federal Reserve Bank of San Francisco Conference on “Financial Issues in the Pacific Basin Region,” September 26-27.

1. Introduction

The persistent weakness of the Japanese financial sector and its contribution to the poor growth performance of the Japanese economy are among the most important current challenges to macroeconomics. The high levels of non-performing assets held by Japanese banks have led to a credit contraction and contributed to declines in economic growth. The current difficulties faced by the government in resolving the banking crisis echo a recent history of weak prudential regulation and supervision that are a primary source of the banking crisis in the first place. This paper considers the possibility that public policy towards the financial system is a root source of the Japanese growth crisis. The model presented here shows how a banking crisis can evolve endogenously and lead to a long-run drop in the growth rate. It implies that the longer the government allows banks to carry non-performing assets on their balance sheets, the further the growth rate falls.

We develop a simple endogenous growth model with financial intermediation and solve for its equilibrium dynamics. The model incorporates three simple stylized facts about the Japanese financial system. Investment is financed primarily by bank loans and equity issues. The government guarantees the bank deposits of domestic savers. The government allows banks to raise its deposit insurance liability over time through weak prudential supervision and regulatory forbearance. This is represented in the model by the accumulation of non-performing loans against deposit liabilities when the government fails to monitor additions to bank loan-loss reserves.

Production in the theoretical model displays constant returns to a single accumulable factor, capital, and is subject to idiosyncratic productivity shocks. Under standard informational assumptions, bank finance dominates direct lending by savers to firms, and bank loans are constrained optimal contracts. Productivity shocks are independent across a continuum of firms at each date and over time. There is no aggregate uncertainty, and both banks and households (as holders of corporate equity) hold perfectly diversified portfolios. This framework focuses the analysis on the role of government deposit guarantees (more generally, government bailouts) and inadequate enforcement of loan-loss reserves in a developing banking crisis and persistent growth decline.

If the government continuously requires loan-loss reserving by banks, then the growth rate is constant over time in the model. With regulatory forbearance, the output growth rate declines gradually as non-performing assets held by the banks rise. The long-run growth rate falls towards zero with the length of time that the government forbears. If the government fails to intervene before a critical date, the banks will become unable to meet the deposit withdrawal demands of households for consumption and a banking crisis occurs. At moment of a crisis, the growth rate of consumption suddenly falls. The model allows us to solve for the equity value of banks and of output-producing corporations and how these change before and after the banking crisis. It also predicts a collapse in the market for collateral at the moment of the crisis.

The dynamics for output, consumption and investment predicted by the model under regulatory forbearance and deposit guarantees are compared to the recent experience of Japan. We also compare the implications of the model for the stock market value of corporations and for banks, non-performing loan accumulations by the banking system and the value of collateral assets. The strict interpretation of the model in terms of the data requires us to date the onset of the banking crisis. However, a maintained hypothesis of the model is that savers and investors have perfect foresight. The possibility that households receive information about the state of the banking system suddenly with government announcements in the early 1990s is discussed in our interpretation of the data. We also test the relationships in our model using structural vector autoregressions following, for example, Tornell and Westermann [2002].

We argue that the data are consistent with the simple dynamic model but recognize that some of the relationships are consistent with other explanations. A special feature of our model is that it implies that the ratio of the value of bank equities to the overall stock market declines before the crisis and ahead of other macroeconomic aggregates. We incorporate this equilibrium relationship in a structural vector autoregression as an orthogonality condition. From the calculated impulse responses, we find that the data supports the predictions of our theoretical model quite well.

Our model of a banking crisis complements the traditional view of Japan's banking crisis in the 1990s. The traditional view puts the blame for Japan's banking crisis on the pattern of deregulation that started in the mid-1970s.[1] Briefly, as alternative financial instruments were introduced, higher quality customers (that is, large, internationally-oriented firms) moved to raise funds directly in the domestic and foreign bond markets. When large banks started to lose their large clients in the late 1980s, they began lending to small- and medium-sized firms. As the asset-price boom in Japan in the late 1980s collapsed, the Japanese economy slumped into prolonged stagnation. The small- and medium-sized firms had difficulty paying back their loans and the non-performing assets of the banking system rose rapidly. Japan, however, continues to be a model of a bank-centered financial system despite a modest rise in direct corporate borrowing. Cargill, Hutchison, and Ito [1997] and Cargill [1999] emphasize, as we do, the importance of explicit and implicit deposit guarantees and regulatory forbearance in the crisis, although they do not propose a formal model of credit market dynamics.[2]

Our model is one of the few general equilibrium models that analyze the Japanese financial and growth crisis of the 1990s. The Japanese banking crisis has affected investment and growth, while the weak growth of the Japanese economy has aggravated the banking crisis. Because of the endogenous dynamics between banking crises and growth, partial equilibrium models are severely limited. Two other papers analyze the Japanese economy in the 1990s using a general equilibrium framework. Hayashi and Prescott [2002] build and calibrate a real business cycle model for Japan and show that the fall in hours and total factor productivity growth can account for the decline in growth in the 1990s. Hayashi and Prescott argue that credit constraints were not important in lowering investment but suggest that weakness of the banking sector may have played a role in lowering investment productivity, although they offer no empirical evidence. As in our paper, Barseghyan [2002] emphasizes delays in government bailouts of the banking system. In his overlapping generations model, the government postpones the actual bailout but insists that banks honor their obligations to depositors. Banks use new deposits to pay old depositors, as in a Ponzi scheme, leading to an immediate contraction in investment. Barseghyan calibrates his model to Japanese data and finds a favorable comparison to Japanese growth in the 1990s.

The next section discusses the stylized facts about the Japanese financial system that motivate the simple assumptions of our analysis. Section 3 presents the endogenous growth model and its equilibrium. The following two sections derives the pattern of equilibrium growth and evolution of banking crises under regulatory forbearance. The comparisons with data for Japan and econometric analysis are discussed in Sections 6 and 7, respectively. The last section concludes.

2. Three Characteristics of the Financial System of Japan

The theoretical model of this paper incorporates three characteristics of the Japanese financial system into its assumptions. These assumptions are central to the dynamics of economic growth and domestic financial markets before and after a banking crisis that are derived in the model. The first is the predominance of commercial bank intermediation of corporate finance, modeled as arising from the informational advantage of banks over other lenders. The second is the prospect of government-provided deposit insurance, or public sector bailouts of the domestic banking sector. The third is supervisory forbearance and the absence of effective prudential regulation of the banking sector. In this section, we review these three aspects of the financial system of Japan to support the use of our assumptions.

2.1 Corporate Reliance on Domestic Bank Borrowing

Post-war Japan provides the picture of a bank-centered financial system. Until the mid-1980s, the ratio of bank borrowing to total corporate finance was steady at over 80 percent. The remainder of corporate finance was almost entirely met by issuing new equity. In the mid-1980s, restrictions on the issuing of corporate bonds were relaxed leading to a rise in domestic and foreign bond financing. By 1995, however, the share of bank financing in the total was still just under 75 percent. This is a much higher ratio than for the United States and for developing countries such as Korea, where the ratio was 50 percent in 1997 (see Dekle and Kletzer, [2002a]).

Typically, only large, well-capitalized firms could raise funds in the bond markets. Small- and medium-sized domestic firms continued to rely on bank financing (see Hoshi and Kayshap, [2001]). The fraction of small- and medium-sized business loans to total loans increased from 73 percent over the period, 1977-86, to 78 percent over the period, 1987-1990, as reported by Ogawa and Kitasaka [2000]. The reliance on bank financing was especially prevalent for small- and medium-sized firms in the service, construction and real estate industries. Between 1987-1990, while bank loans to the manufacturing industry increased by 1 percent, loans to the service, construction, and real estate industries increased by 14 percent, 7 percent, and 18 percent, respectively (Ogawa and Kitasaka [2000]).

2.2 Government Explicit and Implicit Guarantees of Domestic Liabilities

Japanese bank deposits have been implicitly guaranteed by the government, traditionally through the "convoy system" or the "purchase and assumption" rescue, in which a healthy bank is encouraged by the government to provide assistance to a troubled one. Recently, however, the government has provided implicit guarantees through direct injections of capital to troubled banks.

The origins of the "convoy system" can be traced to the forcible merger of weak commercial banks with strong ones in the 1930s. During the 1960s and 1970s, the rescues took the form of healthy banks offering not only financial support, but also personal assistance to a failing bank. For example, in 1965, Takachiho Sogo bank suffered an increase in its holdings of non-performing loans. The government decided to intervene and forced Nishi-Nihon Sogo bank to provide financial support, personnel assistance, and business support to Takachiho Sogo bank.

In the 1980s, the burden on healthy banks increased, as financially strong banks were asked by the government to merge with failing banks. For example, in 1986, the large bank Heiwa Sogo failed, after accumulating a large share of non-performing loans. The government pressured Sumitomo bank, the third largest private bank, to acquire Heiwa and write off all its bad loans. The write-off of these loans cost Sumitomo 111 billion yen in 1986 (compared to Sumitomo's 82 billion yen in profits in 1985) (see Hoshi and Kayshap [2001]).

As problem loans mounted in the 1990s, the frequency of convoy rescues rose dramatically, and the convoy system came to be seen as an arrangement under which stronger banks were forced to bear the cost of bailing out weaker institutions (Hoshi and Kayshap [2001]). Perhaps the most dramatic of these convoy rescues was the bailout of Nippon Credit Bank in 1997. Nippon Credit Bank was rendered insolvent by a huge rise in problem loans that essentially wiped out its capital. The government strongly pressured Nippon Credit's creditor banks and insurance companies to swap the debt for shares. The financial institutions resisted on the basis that these debt-equity swaps would weaken their own financial positions. However, they relented under strong pressure from the government. In the end, the resistance of the financial institutions appears to have been justified. Even with the fresh capital, Nippon Credit was not viable, and the bank was nationalized in December 1998.

The ballooning of problem loans in troubled banks and the low profitability in the banking sector in general meant that by the mid-1990s, the traditional "convoy system" was no longer workable. Foreign banks began to charge higher interest rates for interbank loans to Japanese banks, whether weak or strong. In a departure from the traditional approach, the government resorted to injecting capital directly into the banks. The first instance of an injection of public capital was in 1995, to seven housing loan companies (jusens) that were technically insolvent as a result of the collapse of the real estate bubble. Throughout the 1990s, the jusens borrowed heavily from commercial banks and agricultural cooperatives. The collapse of the jusens meant that the lender banks and agricultural cooperatives, already weakened by their own problem loans, would face further financial difficulties. The write-off combined aspects of the "convoy system" and the new approach of injecting public capital. The lender banks and agricultural cooperatives contributed about 40 percent to the write-offs, while public funds covered the remaining 60 percent (Ito [2000]).

As banking problems worsened, the frequency of public capital injections increased. In late 1998, the government injected capital by nationalizing and recapitalizing the most troubled of the major banks, Nippon Credit Bank and Long-term Credit Bank.[3] Subsequently, the injection of public capital took the form of the almost indiscriminate recapitalization of all the major banks. The government sought to recapitalize all of the major banks due to concerns that all the banks were sufficiently weak and that discriminating among banks would cause depositors to flee from the weaker banks. To this end, in late 1999, the government set aside 43 trillion yen for the nationalization and recapitalization of the banks

(9 percent of GDP), and all but one major bank and some of the weaker smaller (regional) banks were recapitalized.

With regards to explicit guarantees, formal deposit insurance existed in Japan since 1971, but the system was understaffed and underfunded. Following the turmoil in the banking sector in the mid-1990s, the government sharply increased the capitalization of the deposit insurance system, explicitly guaranteeing deposits up to 10 million yen (about 100 thousand dollars). Since larger deposits were not guaranteed, the government in early 1998 issued an explicit "blanket guarantee" of all bank deposits, regardless of size, until April 2003, to preempt an outflow of large deposits from the weaker banks. The government recently extended these "blanket guarantees" indefinitely.

The government's system of explicit and implicit guarantees implies that no deposits, large or small, were ever at risk in postwar Japan. Prior to 1991, the official policy was there would be "no failures of financial institutions." Since 1991, banks have failed; for example, from 1991 to 1995, eleven small banks were formally declared insolvent. However, the guarantees meant that no depositor ever lost any funds.

2.3 Government Prudential Regulations and Enforcement

In our model, the failure of authorities to monitor the accumulation of non-performing assets and holding of loan-loss reserves by banks until the deposit insurance liability of the government has reached either a critical level leads to financial crises and falling GDP growth. Until the late 1990s, the main responsibility for setting up and enforcing the prudential regulations of the banking sector rested with the Banking Bureau of the Japanese Ministry of Finance. Examiners from the Bureau would visit all of the major and regional banks once a year and classify the loans according the examiners perception of collectability. Banks with an increasing amount of irrecoverable loans were put on notice, and if matters did not improve, mergers would be arranged with a stronger bank. All was done very quietly, and behind the scenes.

This system of prudential supervision left wide discretion to the bank examiners and their supervisors in the Banking Bureau. Moreover, many high officials of the Banking Bureau retired into executive positions at commercial banks, where they maintained close contact with and influence over the Ministry of Finance (the amakudari system). The relationship also included lavish entertainment of bank examiners by the banks (Grimes [2001]). Supervisory forbearance seems likely in this regulatory environment.

Awareness of the problems with the existing bank supervisory regime led the government to move financial supervision and examination from the Ministry of Finance to the new independent Financial Supervisory Agency in 1996. The government also tried to replace discretion of supervisors by a rule-based scheme, the Prompt Corrective Action system, in 1998. Under Prompt Corrective Action, regulators are required to intervene quickly at poorly capitalized banks. For example, regulators are required to close a bank if the bank's capital-asset ratio falls below zero.

Initially, these institutional changes led to improvements in prudential supervision and enforcement. The Financial Supervisory Agency moved to examine the books of all banks which led to the immediate closure of five smaller banks. However, as the immediate financial crisis subsided, the regulations were redefined to make them less restrictive. The introduction of the Prompt Corrective Action policy was delayed a year. Accounting standards were changed, so that banks could make their financial statements appear better than they were. Some banks that should have been closed under the statutes were allowed to continue operating because the closure of these banks would add to local unemployment.

3. A Model of Growth and Bank Crises

A simple general equilibrium model of endogenous growth with bank-intermediated investment is used to show how government deposit guarantees and prudential supervisory or regulatory failures affect investment and output growth.

3.1 Production and Bank Lending

Output is produced using capital alone under conditions of constant returns to scale with stochastic productivity. There is a continuum of firms, indexed across the unit interval, and productivity shocks are independent and identically distributed both across firms and over time for each firm. The net output for a typical firm is given by

$$y_t^j = \alpha_t^j k_t^j,$$

where y_t^j, k_t^j and α_t^j denote output, capital stock and realized net productivity for firm j at time t. The rate of depreciation is set equal to zero for simplicity, and investment is also assumed to be irreversible (this only simplifies the exposition of banking dynamics). To keep the exposition simple, α_t can take on either of two values, $\alpha > 0$ and zero, with probabilities, π and $1 - \pi$, respectively. It might be convenient to think of π as close to one. Also, for simplicity, firms are treated as a continuum so that aggregate output is given by

$$y_t = \pi \alpha k_t,$$

where y_t and k_t denote aggregate net output and capital at time t.

Savings is undertaken by households who acquire bank deposits and hold equities in firms and banks. All households are identical and infinitely-lived. Therefore, there will be no trade in equities in equilibrium. There are informational asymmetries that motivate the predominance of bank lending over any other form of investment finance for firms. Firms costlessly observe their productivity each period, but banks can only observe it by incurring a positive cost. Banks are able to make these observations at a lower cost than households so all lending is intermediated by banks in equilibrium. As Townsend [1979] and Diamond [1984] show, the standard loan contract is optimal in this context (in a static setting).[4] The costs of observing a corporate borrower's output is proportional to firm capital, due, for example, to auditing costs that rise with firm size.

The single-period expected net return for a bank loan to an individual firm is

$$E \min \left\{ \ell_t \left(1 + r_t^{\ell} \right), \left(1 + \alpha_t - \gamma \right) k_t \right\} - \left(1 + r \right) \ell_t,$$

where r_t^{ℓ} is the loan rate of interest, r is the deposit rate of interest, γ represents auditing costs and ℓ_t is the size of the loan. Competition among expected profit maximizing banks drive the interest rate on initial loans to

$$r^{\ell} = \alpha - \gamma \tag{1}$$

and the deposit rate to

$$r = \pi r^{\ell} - \left(1 - \pi \right) \gamma = \pi \alpha - \gamma, \tag{2}$$

where loan size, ℓ_t, equals k_t.

If a firm's productivity is zero, then it is unable to service its initial loan. The bank can choose to renegotiate that loan (including forgiving the unpaid interest), lend again, lend more or foreclose. In this environment, the bank will not be able to increase the present value of future repayments by the firm by adding unpaid interest to the loan principal for the next period (so that $\ell_{t+1} > k_{t+1}$). This is because the equilibrium competitive loan rate of interest already absorbs all of the surplus that can be gained by the bank and depositors together from any cumulative investments by the firm. A bank will also be indifferent whether it lends additional capital for period $t + 1$ to a firm that realized productivity equal to α or equal to zero in period t. In either case, the bank's expected returns from relending the existing capital, k_t, plus any portion of new deposits received by the bank are the same.

The aggregate dynamics of this model are easily analyzed in continuous time. The flow of aggregate net output is $\left(\pi \alpha - \left(1 - \pi \right) \gamma \right) k_t$, and the capital stock evolves according to the resource constraint,

$$\dot{k} = \left(\pi \alpha - \left(1 - \pi \right) \gamma \right) k_t - c_t, \tag{3}$$

where c_t is aggregate consumption. The flow profit of all firms is given by

$$d_t = \pi \gamma k_t, \tag{4}$$

which will be the rate at which dividends are paid to households for holding shares of corporate equities.

3.2 Household Behavior

The representative household seeks to maximize its utility,

$$U_t = \int_t^{\infty} \frac{c_s^{1-\sigma}}{1-\sigma} e^{-\rho(s-t)} ds,$$

with respect to its consumption plan given its flow budget identity,

$$\dot{a} = r_t a_t + d_t + x_t - c_t,$$

the conventional solvency constraint,

$$\lim_{s \to \infty} e^{-\int_t^s r_v dv} a_s \geq 0,$$

and initial deposit holdings, a_t. x_t represents bank dividends. The number of firms and banks is fixed so that equity shares cannot be accumulated in the aggregate, hence by the representative household in equilibrium.

With a continuum of firms and independent productivity realizations across firms, households can completely avoid any corporate dividend income risk by holding a fully diversified portfolio of corporate stocks. Similarly, banks maximize shareholder value by holding fully diversified loan portfolios. In equilibrium at each date, a proportion π of any bank's loans pay interest $r^{\ell} = \alpha - \gamma$ per unit of capital, and a proportion $1 - \pi$ pay no interest while the bank incurs auditing costs equal to γ per unit of capital. The bank's losses at time t, $(1-\pi)(r+\gamma) k_t^b = (1-\pi) \pi \alpha k_t^b$, equal its gains, $\pi \left(r^{\ell} - r\right) k_t^b = \pi (1-\pi) \alpha k_t^b$, where k_t^b is the total capital stock of the bank's debtors. The flow cost of bank intermediation equals the current auditing costs, $(1-\pi) \gamma k_t^b$.

The assumptions that allow complete diversification of productivity risk by households as shareholders and depositors allow us to focus on how lapses in bank monitoring and regulatory forbearance under deposit insurance or implicit bank bailouts affect investment, output growth and asset prices. Introducing incomplete risk diversification opportunities or incentives could increase the social costs of inadequate monitoring and prudential regulation. These are emphasized in the agency models presented in Dekle and Kletzer [2002a and b].[5]

3.3 Equilibrium

As a starting point, consider the case in which the government requires banks to hold reserves against any loan losses they accumulate and enforces this regulation continuously. In equilibrium, each bank's losses on a proportion $1-\pi$ of its loans are exactly offset by surpluses on the remaining proportion π. The household return to savings is constant over time and equal to $r=\pi\alpha-\gamma$. In this case, bank dividends are zero at all dates in equilibrium, and the value of bank equity is always zero. The government accumulates no liabilities associated with deposit insurance or other guarantees to the banking system, implicit or explicit.

The equilibrium path for the economy is found by maximizing representative household utility with respect to the consumption plan given the aggregate resource constraint,

$$\dot{k}=(\pi\alpha-(1-\pi)\gamma)\,k_t-c_t=(r+\pi\gamma)\,k_t-c_t, \tag{5}$$

the predetermined capital stock and the parameter restriction,

$$(r+\pi\gamma)-\left(\frac{r-\rho}{\sigma}\right)>0,$$

to ensure existence of a solution. Under perfect foresight, equilibrium consumption is given by

$$c_t=\left(r+\pi\gamma-\frac{r-\rho}{\sigma}\right)k_t, \tag{6}$$

and the equilibrium growth rate of consumption, capital and output is

$$\frac{\dot{c}}{c}=\frac{\dot{k}}{k}=\frac{\dot{y}}{y}=\frac{r-\rho}{\sigma}. \tag{7}$$

The growth rate remains constant over the entire infinite horizon. Net household savings equals

$$s_t=\frac{r-\rho}{\sigma}k_t=\dot{k}_t. \tag{8}$$

We impose the assumption that $r>\rho$, implying that investment is always positive. Note that the gross earnings on household bank deposits equal rk_t, and net withdrawals from bank deposits equal $\left(r-\frac{r-\rho}{\sigma}\right)k_t$. Bank deposits, a, grow at the same rate as output, $\frac{r-\rho}{\sigma}$.

The aggregate value of corporate equity is given by the present value of dividends, discounted at the household's opportunity rate of interest,

$$V_t^f=\int_t^{\infty}d_s e^{-r(s-t)}ds=\int_t^{\infty}\pi\gamma k_s e^{-r(s-t)}ds=\pi\gamma k_t\left(r-\frac{r-\rho}{\sigma}\right)^{-1}, \tag{9}$$

which rises proportionally with the capital stock and output. Bank equity is zero.

4. Growth with Deposit Insurance and Weak Prudential Supervision

We consider the possibility that banks can accumulate losses on individual loans without reserving against these in the presence of government guarantees of deposits. This will allow a bank to add unpaid interest to a corporate borrower's debt after the firm suffers a low productivity shock without accumulating offsetting loan-loss reserves. In the loan market equilibrium derived for this economy, a bank can never recover the interest that the corporate borrower could not pay at time t if the firm's productivity was zero at time t.[6] In common parlance, these non-performing loans can be evergreened by rolling over the unpaid interest into new principal. While losses on the share $1-\pi$ of the corporate capital financed by the bank are accumulated as assets on the bank's balance sheet, the bank pays dividends to shareholders from the earnings on performing loans, $\pi\left(r^{\ell}-r\right)k_t^b$, minus its operating costs, $(1-\pi)\,\gamma k_t^b$. Bank income before any additions to loan loss reserves is

$$(1-\pi)\,(\pi\alpha-\gamma)\,k_t^b=(1-\pi)\,rk_t^b. \tag{10}$$

Banks might wish to accumulate non-performing assets and pay out dividends from individual loan net income if the liability of shareholders to the holders of bank deposits is limited. In the realistic and conventional case, the value of shareholder equity cannot be driven below zero. The cost of bank evergreening of non-performing loans is borne by either depositors or the government through a depositor bailout. If depositors bear the cost and cannot monitor the bank's accounts[7], then the rate of interest received by depositors will be driven down and the growth rate of the economy falls. Note that the interest rate can be driven to zero in this model, resulting in a negative growth rate.

We consider the case in which the government provides deposit insurance but does not audit the bank loan portfolios or monitor loan-loss reserves. In this case, by accumulating non-performing assets and paying dividends from loan income from performing assets, a bank accumulates a deposit insurance claim against the government. Banks accumulate liabilities equal to the total deposits of savers and assets equal to the sum of the capital stock used by firms net of corporate equity and the deposit insurance claim against the government. That is, the assets of the banking sector that equal deposit liabilities are the sum of k_t and government debt, b_t, so that $a_t=k_t+b_t$ in equilibrium. These government debts are not traded securities issued by the treasury but rather liabilities of the public sector created by the banks.

There are two reasonable institutional constraints on the flow of dividends that a bank can pay at each date. If the bank cannot meet its net withdrawal demand at any time, it is illiquid and we assume that the government immediately intervenes. The second constraint is that banks cannot pay out more than current gross loan income net of operating expenses, which is $\left[\pi\left(r^{\ell}-r\right)-(1-\pi)\,\gamma\right]k_t$. This equals $(1-\pi)\,rk_t$, the deposit cost of loans that do not pay interest at time t. Our institutional assumption is that banks cannot claim larger deposit losses at any time t than the deposit cost of loans that actually did not pay interest at time t.

We first allow banks to accumulate losses for a fixed period of time, from $t = 0$ to T. At time T, the government stops banks from further increasing the share of non-performing loans in their portfolios. In equilibrium, b_T is determined, so that this is equivalent to setting a limit on b_T and determining T in equilibrium. Up to time T, dividends are bounded from above by net household savings. Each bank can accumulate deposit insurance liabilities against the increase in deposits from savers, but needs real earnings from capital to pay the net withdrawals of households that equal consumption net of corporate profits.

The deposit insurance liability of the public sector accumulates according to

$$\dot{b} = rb_t + x_t, \tag{11}$$

for $0 \leq t \leq T$. The value of bank equity evolves according to

$$\dot{V}^b = rV_t^b - x_t. \tag{12}$$

At time T, dividends drop permanently to zero, so that V^b must converge to zero at time T. Initially, deposit insurance liabilities (equivalently, non-performing loans) are zero, so that $b_0 = 0$. The sum, $b + V^b$, grows as

$$\dot{V}^b + \dot{b} = r\left(V_t^b + b_t\right), \tag{13}$$

for $0 \leq t \leq T$. Over this period, the government does not recognize or cover its deposit guarantee liabilities.

Imposing the solvency requirement for the public sector implies that after time T, the government must collect revenue to meet its obligation, b_T. We assume that the government does so by imposing a tax on interest income, that is a tax on deposits, at a constant proportionate rate, τ. The deposit rate of interest from time T on is $\widehat{r} = (1 - \tau)\, r$. The flow-budget identity for the public sector from T on becomes

$$\dot{b} = rb_t - \tau r\left(k_t + b_t\right) = \widehat{r}b_t - \tau rk_t, \tag{14}$$

and the intertemporal budget constraint for the government is given by

$$\int_0^T x_t e^{-rt}dt + e^{-rT}\int_T^\infty \tau rk_t e^{-\widehat{r}(t-T)}dt = e^{-rT}b_T + e^{-rT}\int_T^\infty \tau rk_t e^{-\widehat{r}(t-T)}dt = 0. \tag{15}$$

We let τ be constant for algebraic simplicity only (lots of integrals integrate out). For the same reason, τ is chosen so that the government is solvent and the ratio of government liabilities to deposits stays constant. This keeps the post-tax rate of interest, $\widehat{r}$, and the ratio b/k constant.

Now, we solve for the equilibrium growth path under perfect foresight. That is, households correctly anticipate the future tax on interest earnings beginning at time T. The flow-budget identity for the representative household is given by

$$\dot{k}+\dot{b}=r\left(k_t+b_t\right)+x_t+d_t-c_t, \quad \text{for } 0 \leq t \leq T, \tag{16}$$

and

$$\dot{k}+\dot{b}=\widehat{r}\left(k_t+b_t\right)+d_t-c_t, \quad \text{for } T \leq t. \tag{17}$$

Household utility maximization yields the equilibrium growth rates of consumption,

$$\frac{\dot{c}}{c}=\frac{r-\rho}{\sigma}, \quad \text{for } 0 \leq t \leq T, \tag{18}$$

and

$$\frac{\dot{c}}{c}=\frac{\widehat{r}-\rho}{\sigma}, \quad \text{for } T \leq t. \tag{19}$$

The equilibrium consumption level is given by

$$c_t=\left[\left(1-e^{-\theta(T-t)}\right)\theta^{-1}+e^{-\theta(T-t)}\left(\theta+\frac{r-\widehat{r}}{\sigma}\right)^{-1}\right]^{-1}k_t, \quad \text{for } 0 \leq t \leq T, \tag{20}$$

where

$$\theta=r+\pi\gamma-\frac{r-\rho}{\sigma},$$

and

$$c_t=\left(\theta+\frac{r-\widehat{r}}{\sigma}\right)k_t, \quad \text{for } T \leq t. \tag{21}$$

Consumption as a share of the capital stock rises monotonically, while the national savings rate falls, over time up to date T.

The capital stock grows as

$$\dot{k}=(r+\pi\gamma)-c_t$$

or

$$\frac{\dot{k}}{k}=(r+\pi\gamma)-\left[\left(1-e^{-\theta(T-t)}\right)\theta^{-1}+e^{-\theta(T-t)}\left(\theta+\frac{r-\widehat{r}}{\sigma}\right)^{-1}\right]^{-1} \equiv \varphi\left(T-t,\tau\right), \quad \text{for } 0 \leq t \leq T, \tag{22}$$

and

$$\frac{\dot{k}}{k}=\frac{\widehat{r}-\rho}{\sigma}, \quad \text{for } t \geq T. \tag{23}$$

The function, $\varphi\left(T-t,\tau\right)$, is decreasing in t for $t \leq T$, equals $\frac{\widehat{r}-\rho}{\sigma}$ for $t \geq T$ and converges to $\frac{r-\rho}{\sigma}$ as $T-t$ goes to infinity. Under perfect foresight, the investment rate and growth rate of output fall as non-performing bank assets accumulate.

Because banks cannot pay dividends after date T, shareholder value is maximized if banks pay out the largest dividends possible up to time T. These dividends equal $(1-\pi)\,rk_t$. The constraint that banks must remain liquid before date T is not binding if $\widehat{r}-\rho>0$.[8] In the next subsection, we consider the possibility that this inequality does not hold. The stockmarket value of the banking sector under perfect foresight equals

$$V_t^b = \int_t^T (1-\pi)\, rk_s e^{-r(s-t)} ds = (1-\pi)\, rk_t \int_t^T e^{\int_t^s (\varphi(T-v,\tau)-r)dv} ds. \tag{24}$$

Differentiation of equation (24) shows that the ratio of bank equity to the current capital stock, $\frac{V_t^b}{k_t}$, or to gross domestic output, $\frac{V_t^b}{(\pi\alpha-(1-\pi)\gamma)k_t}$, falls monotonically to zero up to time T. The total value of bank equity (expressed in terms of the initial capital stock),

$$V_t^b = (1-\pi)\, rk_0 \int_t^T e^{\int_0^s \varphi(T-v,\tau)dv} e^{-r(s-t)} ds, \tag{25}$$

falls as t approaches T, but will rise initially (as k_t rises) before falling if the horizon, T, is sufficiently long. This is verified by differentiating equation (25).

The total stockmarket value of corporations can be calculated as

$$\begin{aligned} V_t^f &= \int_t^T d_s e^{-r(s-t)} ds + e^{-r(T-t)} \int_T^\infty d_s e^{-\widehat{r}(s-T)} ds \qquad (26) \\ &= \int_t^T \pi\gamma k_s e^{-r(s-t)} ds + e^{-r(T-t)} \int_T^\infty \pi\gamma k_s e^{-\widehat{r}(s-T)} ds \\ &= \pi\gamma k_t \left[\int_t^T e^{-\int_t^s (r-\varphi(T-v,\tau))dv} ds + \left(\widehat{r} - \frac{\widehat{r}-\rho}{\sigma} \right)^{-1} e^{-\int_t^T (r-\varphi(T-v,\tau))dv} \right]. \end{aligned}$$

After date T, the value of corporate equity grows at the same rate as the capital stock and output, $\frac{\widehat{r}-\rho}{\sigma}$. Before date T, it also grows proportionately with k_t and output for $\sigma = 1$, but grows faster than k_t if $\sigma > 1$ and more slowly than k_t for $\sigma < 1$. For the standard assumption in calibrated growth models of an intertemporal elasticity of substitution, $1/\sigma = 0.5$, the stockmarket value of corporations rises faster than gross domestic output up to date T.[9] Under perfect foresight, the value of corporate equity is continuous at T, but the growth rate of corporate equity suddenly falls at time T to $\frac{\widehat{r}-\rho}{\sigma}$ for $\sigma > 1$. This is verified by differentiating equation (26).[10]

Therefore, this simple model predicts that the value of bank equity will rise more slowly than gross domestic output before the government realizes the losses in the banking sector (although it may rise faster far ahead of the government's assumption of these non-performing loan losses). The value of corporate equity rises faster than output, and its growth rate suddenly drops to that of gross domestic output at time T. A decline in the value of bank equities foreshadows the banking crisis, but a decline in corporate equity does not under perfect foresight.

5. Banking Crises under Perfect Foresight

By accumulating non-performing loans without offsetting loan-loss reserves on their balance sheets, banks accumulate a claim against the government in the form of unrealized deposit insurance liabilities. These public sector liabilities are the assets held by the banks to balance the difference between their total liabilities to depositors and the real assets (capital) of corporate debtors. By paying out dividends from what would otherwise be loan-loss reserves, the banks are making transfer payments from the government to the shareholders. Eventually, the government must raise tax revenue to pay for these transfers and in the model economy, does so by taxing depositors. The transfers come about because the government provides either explicit or implicit bailouts of depositors without adequately monitoring and controlling the accumulation of deposit claims and non-performing assets by banks with positive equity value.[11]

Our interpretation of the fiscal policy adopted is that the government fails to monitor loan-loss reserves and non-performing loan accumulations by publicly-insured banks until its insurance liability reaches a threshold. This is a caricature of the policies of many governments that have faced banking crises. It is clearly not an optimal policy if monitoring is costless. Under perfect foresight, banks are able to meet deposit withdrawals, given by equation (20), for $\widehat{r} \geq \rho$, no matter how long it takes the government to stop the accumulation of deposit insurance liabilities. However, the longer the government waits, the lower the investment rate and growth rate of output after date T. The tax rate depends on T. The government's intertemporal solvency constraint (from equation (15)) gives,

$$\begin{aligned} 0 &= e^{-rT}b_T + e^{-rT}\int_T^{\infty} \tau r k_t e^{-\widehat{r}(t-T)}dt && (27)\\ &= e^{-rT}b_T + e^{-rT}k_T\int_T^{\infty} \tau r e^{\frac{\widehat{r}-\rho}{\sigma}(t-T)}e^{-\widehat{r}(t-T)}dt && (28)\\ &= e^{-rT}b_T + e^{-rT}k_0 e^{\int_0^T \varphi(T-v,\tau)dv}\tau r\left(\widehat{r}-\frac{\widehat{r}-\rho}{\sigma}\right)^{-1}. && (29)\end{aligned}$$

This can be rewritten using the solution for $e^{-rT}b_T$ from integrating the deposit insurance liability equation (11) to get

$$e^{-rT}b_T = \int_0^T (1-\pi)\, r k_s e^{-r(s-t)}ds = (1-\pi)\, r k_0 \int_0^T e^{\int_t^s (\varphi(T-v,\tau)-r)dv}ds. \tag{30}$$

The solvency constraint becomes

$$(1-\pi)\, r\int_0^T e^{\int_t^s (\varphi(T-v,\tau)-r)dv}ds + e^{\int_0^T (\varphi(T-v,\tau)-r)dv}\tau r\left(\widehat{r}-\frac{\widehat{r}-\rho}{\sigma}\right)^{-1} = 0, \tag{31}$$

where $\widehat{r} = (1-\tau)\, r$, which can be differentiated with respect to T and τ to show that τ is an increasing function of T. The long-run growth rate,

$$\frac{\dot{y}}{y} = \frac{\dot{k}}{k} = \frac{\widehat{r} - \rho}{\sigma},$$

falls as the government waits longer and accumulates more deposit insurance losses to handle.

If government regulators are lax for long enough, then the tax rate must be raised so that the long-run growth rate becomes negative to maintain public sector solvency. Because household savings will be negative, banks will need to reduce gross lending to corporations and corporations will need to scrap capital. Our assumption that investment is irreversible, as a simple example of downward capital stock adjustment costs, can impose an upper bound on τ, and hence on T. The growth rate, given by equation (22), decreases continuously (under perfect foresight) up to time T to its long-run level, $\frac{\widehat{r}-\rho}{\sigma}$. If $\widehat{r} < \rho$, then the growth rate falls to zero before T, at some time $\overline{T}$. At time $\overline{T}$, the banks can just meet the withdrawal demands of their depositors from the net earnings of capital minus the costs of intermediation,

$$c_{\overline{T}} = \pi\alpha - (1 - \pi)\,\gamma.$$

After $\overline{T}$, the banks cannot meet withdrawal demand without demanding repayment of principal, $k^b_{\overline{T}}$, by their corporate borrowers. Because every bank faces net withdrawal demands at $\overline{T}$ in equilibrium, no firm can repay the principal on its loan by borrowing from another bank.[12] Raising the deposit rate of interest will not work to temporarily clear the market because the deposit rate of interest, $r = \pi\alpha - \gamma$, already equals the highest value that allows zero expected profits on a loan. This is a “bank crisis” in this economy. At date $\overline{T}$, the government faces a banking crisis, so that the upper bound for the tax rate and time to intervention is given implicitly by $\widehat{r} = (1 - \tau)\,(\pi\alpha - \gamma) = \rho$.

Corporate capital stocks are interpretable as collateral in this economy. Before the crisis ($t < \overline{T}$), capital can be sold by firms to other firms and loan principal can be repaid at full value. There is a market for collateral, and the equilibrium price of collateral (which is Tobin’s q) equals one. With the crisis, a bank that attempts to reduce its corporate loans will discover that its debtors cannot repay because they cannot find new loans. If the bank forecloses a loan, it cannot sell the collateral at a positive price because no firm can borrow to purchase it. There is no demand for collateral at a positive price in the crisis.

The collapse in the market for collateral might be smoothed into a transition if banks are heterogenous and become liquidity constrained in sequence. One way to generate bank heterogeneity in this respect would be introduce assumptions that lead to incomplete diversification by banks (for example, that there are a finite number of firms and increasing returns to scale in banking) so that the deposit insurance liability and current earnings of each bank depend on the particular history of productivity realizations for its corporate borrowers. As time progresses, some banks will earn less from their loan portfolios than others and may eventually not be able to meet the consumption withdrawal demands of depositors from the net returns to lending. Suppose that the law of large numbers still works in the aggregate (so that net output equals $(\alpha\pi - (1-\pi)\gamma)\,k_t$ with certainty). The earnings of banks with portfolios that do well will offset the losses of banks with portfolios that do poorly. The banks that do well can make loans to ex-borrowers of banks that do poorly.

With deposit insurance and regulatory forbearance, banks that do well face a finite horizon over which to pay out dividends to shareholders. Current loan income can be paid out as current dividends or lent to new corporate borrowers. Making new loans can only generate future dividends for shareholders until time T. This suggests that the value of collateral should begin to fall as more and more banks become insolvent before the crisis is declared at time T. With continuously enforced loan-loss reserves, shareholders will realize future expected dividends over an infinite horizon if banks lend profit income to corporate borrowers that need to move. In equilibrium, bank shareholders should be just indifferent between receiving the dividend stream from reinvested profits and those profits as current dividends. The price of collateral, q, will remain equal to one when the government perfectly monitors bank loan loss reserves.

For several years, Japan dealt with the problem of troubled banks through the "convoy system," in which weak banks would be merged with strong banks. Bank heterogeneity would allow some banks to have positive equity value while others become insolvent. An interpretion of the convoy system is that the deposit insurance claim of a weak bank is absorbed by the shareholders of the strong bank. That is, the shareholders of the strong bank acquire an asset of negative value. Under the convoy system, the dividends that were paid to the shareholders of the weak bank become transfers from the shareholders of the strong bank rather than from taxpayers.

This simple observation has two implications. The first is that the shareholders of the strong banks have the same incentives for accumulating deposit insurance claims as did the shareholders of the weak banks. Their bank's portfolio did well in a lottery and on net they realize higher asset income than do the shareholders of the weak bank. Or, keep the assumption of the model that households hold fully diversified equity portfolios. Then the shareholders of both banks are the same and no present value transfer has been made, yet. Dividends are paid and the government's total deposit insurance liability rises as the strong banks become weak until the government intervenes at time $T < \overline{T}$ or the banking crisis hits at time $\overline{T}$.

The second implication can be drawn under the exact assumptions of the model economy (and, also, with bank heterogeneity introduced). The convoy system transfers value from the equity of one bank to another bank's equity. The value of the equity of a bank falls if the bank becomes a convoy leader. To maximize the value of shareholder equity, a bank's management will want to finish paying out all the dividends it can no later than any other bank. All banks pay the maximal dividends they can up to time T. Banking crises take time to evolve because the flow of dividends is bounded at each date (by $(1-\pi)\, rk_t$).

The regulatory and fiscal policy response used in the analytical model kept the tax rate, τ, and, hence, the ratio b/k constant forever after date T. Other possible policy responses include imposes taxes so that b stays constant as the economy grows or b is reduced to zero over some finite horizon. In these cases, the tax rate varies over time. For example, if the tax policy is chosen so that $b_{t'} = 0$ at a particular time $t' > T$, then the tax rate must satisfy

$$b_T = \int_T^{t'} \tau_t r k_t e^{-\int_T^s (1-\tau_t) r ds} ds = r k_T \int_T^{t'} \tau_t e^{-\int_T^s \left((1-\tau_t) r - \frac{(1-\tau_t) r - \rho}{\sigma}\right) ds} ds. \tag{32}$$

The tax rate must be higher over the finite horizon than it is for the example in which the tax rate is constant over an infinite horizon. The growth rate of output will be lower temporarily during the resolution of the banking crisis, but recover at date t' to its original level, $\frac{r-\rho}{\sigma}$.

6. Application of the Model to Japan

The theoretical model shows how a banking crisis and growth collapse endogenously develops in an economy with no aggregate production risk in the presence of ineffective prudential regulation. Idiosyncratic production risk leads to loan losses that can be exactly offset by profits on other loans, but which are not if banks can use these loan losses to transfer resources from the government to shareholders. We argue that the practice prudential supervision and regulation in Japan matches this interpretation very well.

The model predicts dynamics for investment, consumption, output bank credit growth, asset prices and the value of collateral assets before and after the crisis that can be compared to the data. Some empirical implications of the model are:

1. As the banking system accumulates a deposit insurance claim in the form of non-performing corporate loans against which dividends were paid, the growth rate of output decreases steadily to its post-crisis level and consumption rises as a share of output under perfect foresight.

2. The stockmarket value of the corporate sector can grow more rapidly than output before the crisis

is realized for the empirical plausible case of inelastic intertemporal substitution ($\sigma > 1$).

3. The stockmarket value of the banking sector will decline before the crisis, implying that we should observe a decrease in the value of bank stocks relative to the aggregate value of the stock market before the banking crisis.[13]

4. The value of collateral in the model equals $q_t k_t$ which grows proportionately with output until output growth falls to zero in a banking crisis and the market for collateral collapses.[14]

Of the many simplifying assumptions of the model, two basic ones may interfere with a comparison. The first is the assumption of perfect foresight. In the equilibrium for the model economy, investment declines gradually to its lower share in output (and consumption rises gradually to its higher share) before the crisis hits. If, instead, households and firms are imperfectly informed and receive information over time regarding the magnitude of bank losses and future policies under rational expectations, then investment and GDP growth rates will change suddenly as information revealing the deterioration of the banking system becomes available. The second is that aggregate productivity for Japan fluctuates. A temporary adverse aggregate productivity shock will lead to a permanent rise in non-performing assets held by the banks in the model, advancing the date of onset of a crisis. As a consequence, under forward-looking investment and savings behavior, it will have permanent effects on GDP growth.

Dating the onset of the banking crisis in Japan is tricky. There are at least two candidate dates. In 1992, the Japanese Ministry of Finance first admitted the presence of rising bad loans. In fact, the early 1990s represent a turning point in the Japanese economy, with indicators such as GDP growth and investment sharply deteriorating. The second candidate period is 1997 to early 1998, when several financial institutions, including banks (Nippon Credit Bank and Hokkaido Takushoku) and major securities companies (Sanyo and Yamaichi securities) collapsed. This period overlaps with a major aggregate international shock, the East Asian Financial Crisis of 1997-98. We must remain agnostic about the dating of the onset of the banking crisis. The realization that banks have large and growing non-performing assets in the early 1990s could be the onset of the crisis or the revelation of information that starts investment and output growth on the adjustment path predicted by the model towards the major bank collapses.

6.1 GDP growth, consumption and investment

In equilibrium for the model, the output growth rate declines leading up to the crisis. Figure 1 shows a significant decline in the GDP growth rate for Japan over the three years, 1990 through 1992. As noted, we cannot assess when the future costs of bank bailouts were recognized by investors and savers, but the decline in the growth rate to lower levels that persist (and worsen) to the present is consistent with the model.

The growth rate of consumption does not fall before the 1990s, but does fall as the GDP growth rates fall in the 1990. Figure 1 also shows a slight rise in consumption as a share of GDP beginning in 1990. This is consistent with the model because it implies that consumption growth is not falling quite as much as output growth. In response to the weak economy of the 1990s, the government of Japan also increased transfer payments to households which could contribute to a smaller contraction in household consumption as a share of GDP and may impact consumption growth. Hayashi and Prescott [2002] point out that regulatory changes made in the 1980s reduced household labor supply, increasing leisure consumption by about 20 percent. If consumption of goods and leisure are complements, then these changes could raise the share of consumption in output but do not suggest a rising share of consumption in output as output growth rates fall.

Figure 1 shows that investment growth does not decline before 1990 as it would in the model for an anticipated crisis occurring in the early 1990s. It does show the decline in the share of investment in GDP after 1990 as predicted by the model. This is consistent with an interpretation that the news of the impending banking crisis arrives after the 1980s are over. Interestingly, the investment share of GDP grows in the late 1980s leading up to Japan's growth crisis. This is not predicted by our simple model, but it is implied by our agency model (Dekle and Kletzer [2002a and b]. That model is not solved out, but the suggested extension of the present model to add adverse selection by investors could generate the rise in capital growth just before a crisis.

Another way to look at investment is to consider technological progress. Investment in new technologies may generate returns over longer average horizons than aggregate capital formation. In Japan, between 1970-80 and 1990-98, total factor productivity (TFP) growth rates dropped from 1.1 percent per annum to 0.2 percent per annum. (All data are from Fukao, Inui, Kawai, and Miyagawa [2002]). The decline in TFP was especially sharp in manufacturing, where TFP growth dropped from 4.9 percent to 0.5 percent per annum. With regards to other measures of productivity, return on equity fell from 12 percent in 1980 to 4 percent in 1998; and the return on invested capital fell from 6 percent in 1980 to 4 percent in 1998. These compare with 1998 returns on equity and invested capital in the United States of 22 percent and 14 percent respectively.

6.2 Credit growth and sectoral shifts in lending

Total bank credit in the model economy equals the sum of the capital stock of firms and the deposit insurance claims accumulated by banks, K+B, which equals the total deposits held by households. These are growing as a share of GDP up to the crisis. After the onset of the crisis, bank credit should stop rising as a share of GDP and will decline if the deposit insurance liabilities of the government will be cleared over a finite horizon. These patterns appear in the data as shown in Figure 2 for Japan with a distinct turning point in the growth rate occurring in 1991. This provides some support for dating the beginning of the crisis in the early 1990s with a worsening as the GDP growth rate falls further in 1997.

A possible, but small, shift in bank lending is also shown in Figure 2. There is only a single good in the model economy, but it is easy to introduce two goods, traded and non-traded, following textbook models. A rise in the share of consumption in output will correspond to a rise in the share of non-traded goods in output in standard models, which should correspond to an increase in the proportion of bank lending to the service sector. This rise does not disappear when construction services are excluded from non-traded goods, implying that lending did not expand to a sector in which borrowing is likely to be collateral constrained. This is consistent with the lending contraction and collapse of the market for collateral implied by the model.

6.3 Deterioration of Bank Portfolios and Fall in Land Prices

The model implies that the stock market value of domestic banks should be declining, before the advent of the crisis. It also implies that the stock market value of corporations should be growing faster than GDP before the crisis and drop to the growth rate of GDP after the crisis. This decline would be indistinguishable from the collapse of the Nikkei bubble. Evidence in favor of the model will include a significant decline in the ratio of the value of domestic bank equities to the value of the entire stock market. Figure 3 shows the ratio of bank stock values to the total stock market. Consistent with our model, this ratio started to decline sharply in 1987, at least 3-4 years before the beginning of the crisis. That the ratio of bank stock values to total stock values leads other macroeconomic aggregates is a unique prediction of our model, and distinguishes it from others. Because asset prices are very responsive to new information regarding future dividend growth and real interest rates, they may offer better evidence in favor of a model based on rational expectations than consumption or investment which are smoothed in the forward-looking model.

In our model, prospective government bailouts lead to a steady decline in the quality of bank portfolios leading up to the crisis, rather than a sudden rise in non-performing assets due to exogenous financial or real shocks. The share of non-performing loans (NPLs) to total loans should be rising before the crisis. Unfortunately, reliable NPL data are available only after 1992, when the Ministry of

Finance first recognized the NPL problem. Figure 3 depicts the trend in the ratio of non-performing loans to total loans. Non-performing loans rose sharply from 2 percent of GDP in 1992-94 to about 5 percent of GDP in 1996, and then to 7 percent of GDP in 2000.

The model does not include land which serves as collateral for a significant portion of bank borrowing, but it does include irreversible capital as loan collateral which represents a fixed asset very well after the start of the crisis. With a banking crisis, the value of collateral suddenly falls in the model economy and the suggested extensions of it. The enormous fall in the value of land in the 1990s is consistent with the collapse of the market for collateral assets predicted by the model. Figure 5 shows that land prices in Japan declined by about 60 percent between 1992 and 2000. Between 1980 and 1995, about 40 percent of all corporate borrowing was secured by land (Ueda [2000]). It is often alleged that the sharp rise in land prices in the 1980s helped fuel the expansion in bank credit, which boosted physical investment and economic growth (Ogawa and Kitasaka [2000], Ueda [2000]). However, these narratives often ignore the fact that the price of land is an endogenous variable and is determined jointly with other macroeconomic variables.

7. Structural Vector Autoregression Estimates

Our model yields relationships between the ratio of the value of bank stocks to the total stock market value and subsequent investment, output growth and bank credit growth. This forward-looking ratio depends upon the future increase in non-performing assets and, hence, deposit insurance claims that the banking sector can accumulate. For example, a tightening of prudential supervision and regulatory enforcement will reduce b_T and T. This immediately lowers the bank equity ratio, V_t^b/V_t^f, and subsequently raises the path of investment (as a ratio of GDP), lowers the growth rate of bank credit to GDP and the present value of collateral assets (as a ratio of GDP).[15]

We use the theoretical implication that future paths of investment, bank credit and the value of collateral respond to shocks to the ratio V_t^b/V_t^f but not the converse as an identifying restriction in a structural VAR to test our model. The procedure that we use to estimate the effects of exogenous shocks to the bank equity ratio is equivalent to computing the impulse response function of a macroeconomic variable to a particular shock in an identified VAR[16]. Our structural VAR is formed using four variables, the bank stock to total stock market value ratio, the investment to GDP ratio, the bank credit to GDP ratio and an index of land prices. Although we have not modeled land prices directly, we do model the value of loan collateral which becomes a fixed asset in a crisis. We use land prices as a proxy for all collateral assets.[17]

We estimated the VARs imposing the Wold ordering that current investment, credit, and land prices are exogenous to shocks to the bank equity ratio. The theoretical model implies that shocks to investment, bank credit and land prices are contemporaneously correlated. Therefore, we tried all six combinations of orderings amongst these variables and found that the orthogonalized impulse responses were virtually identical.

Figure 5 displays the impulse responses of investment (INVEST), land prices (LANDPRIC), and bank credit (CRED) to a unit shock to the bank equity ratio (BSTS). Solid lines represent our point estimates while dashed lines denote plus-one and minus-one standard-deviation bands. The initial impact of an increase in the bank equity ratio is an expansion in bank credit, which persists for at least 8 or 9 quarters. The effect on land prices is small, but positive, and investment responds negatively on impact but eventually rises. These results are roughly consistent with the model.

Figure 6 displays the impulse responses of investment, land prices and the bank equity ratio to a unit shock to bank credit. Both investment and land prices respond strongly to a bank credit expansion. This is consistent with the view that changes in investment and in land prices during the 1980s and 1990s were caused by changes in bank credit. It is interesting that the effect of a bank credit shock on the bank equity ratio is negative for about 2 years implying that an expansion of credit has a negative effect on the market value of bank equity.

Figure 7 displays the impulse responses of investment, bank credit and the bank equity ratio to a unit shock to land prices. Investment responds strongly for the first 5 quarters and then declines. Bank credit falls on impact, then rebounds slightly and remains essentially unchanged thereafter. The bank equity ratio is flat initially then rises, implying that an increase in land prices has a positive impact on the market value of bank equities.

The responses shown in Figures 6 and 7 may address another hypothesis about Japan in the 1990s. The “credit crunch” hypothesis suggests that if bank loans and other means of investment finance are not perfect substitutes, then a decline in bank credit constrains investment. This hypothesis usually attributes the fall in bank credit to an exogenous decline in land prices because land is important as loan collateral.[18] We find that bank credit impacts investment, but that the value of land does not appear to affect bank credit. Land prices and investment appear to be simultaneously determined, consistent with models in which land prices (as asset prices), and investment (as a forward-looking variable) respond to the correlated future fundamentals.

Figure 8 displays the impulse responses of land prices, bank credit and the bank equity ratio to a unit shock to investment. Land prices respond strongly for the first six to seven quarters and then decline. The response pattern of land prices to investment shocks is close to the response pattern of investment to land price shocks, suggesting that land prices and investment are simultaneously determined. Bank credit contracts in response to an investment shock, implying that banks appear to cut credit when investment is robust. The bank equity ratio also responds negatively to an investment shock, implying that an increase in investment has a negative impact on bank equity values.

The result shown in Figure 8 can be related to our model if we consider persistent shocks to aggregate productivity which can be modeled as a rise in the probability of the high productivity state. Such a shock would lead to increases in investment and the value of collateral and to decreases in bank credit expansion and the ratio of bank equity values to total stock market value.

8. Conclusions and Extensions

The model is stripped down to reveal the relationship between deposit guarantees, prudential supervision and economic growth that comes about when transfers to bank shareholders or depositors are financed by the public sector through future taxes. In the model, banks can effectively transfer future resources from taxpayers to shareholders through inadequately monitored government-backed deposit guarantees. A banking crisis can be interpreted as either the sudden realization of deposit insurance liabilities by authorities or a simple liquidity crisis in which banks cannot meet the withdrawal demands of depositors due to irreversible investment.[19] The qualitative dynamics for the growth rates of gross domestic product, investment, consumption and stockmarket values for the model compare very well to the Japanese experience of the 1990s.

Our analysis of how deposit insurance liabilities affect economic growth emphasizes a simple policy failure. If the government required banks to hold loan-loss reserves against accumulations of non-performing assets, the banks would not have the ability (hence, incentive) to accumulate deposit insurance claims against the public sector. The model also shows that the longer the government waits to intervene in the banking sector and stop the accumulation of unrealized deposit insurance liabilties, the lower the long-run growth rate that results. It can also be shown easily that letting the deposit insurance cost of the crisis accumulate after the crisis lowers the long-run growth rate in our representative agent model. The model supports the serious implementation of Prompt Corrective Action by the Japanese government at any time.

In the representative agent model, shareholders and depositors are identical. Deposit insurance under regulatory failure affects economic growth because deposit insurance liabilities are paid by taxes on the interest earned by depositors. An alternative approach would be to use an overlapping generations model so that the transfer scheme redistributes from future generations to current households, even with lump-sum taxation. This approach is taken by Barseghyan [2002], but with two-period lifetimes, many of the dynamics of our model are lost.

In an earlier paper, Dekle and Kletzer [2002a], we explore the consequences of expected government bailouts of depositors, implicit or explicit, with weak prudential supervision in an agency-based model of bank-centered financial intermediation. The first version of this paper (Dekle and Kletzer [2002b]) elaborated that model and applied it to the Japanese context. In that agency model, self-financing of a portion of corporate investment by a firm's shareholders reduces the risk of low productivity performance. With limited liability and deposit insurance, banks have incentives to renegotiate loans when current interest cannot be paid. In the process of doing so, the riskiness of a firm's investment rises as self-financing declines in proportion to the firm's capital. Over time, the growth rate of non-performing assets rises over time. The agency model can be added to the current model to include the extra dynamics of non-performing asset accumulation by banks discussed in our previous papers.

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Endnotes

[1]This interpretation is explained at length in Cargill, Hutchison, and Ito [1997], Hutchison [1998], Hoshi and Patrick [2000], Hoshi and Kashyap [1999], Hoshi and Kashyap [2002].

[2]Cargill, Hutchison, and Ito [1997] draw a more comprehensive picture of what caused the banking crisis in Japan. In particular, they emphasize the role played by monetary policy in precipitating the banking crisis. Monetary policy was easy between 1986 and 1988 and asset prices lost touch with fundamentals. The sudden shift to tight money in 1989 was responsible for the start of the asset deflation process. Since most bank loans were made using land as collateral, the collapse in land prices led to a surge in non-performing loans.

[3]Eventually, the government sold Nippon Credit to a software company and Long-Term Credit Bank to a foreign hedge fund.

[4]The derivation of simple loan contracts is explained in Freixas and Rochet [1997].

[5]This version of the agency model is first proposed in Chinn and Kletzer [2001] for the East Asian crisis.

[6]This is because the (competitive) equilibrium interest charged to firms borrowing capital, k_t, equals $r^{\ell}k_t = (\alpha - \gamma) k_t$, and the interest paid to depositors equals $rk_t = (\pi\alpha - \gamma) k_t$.

[7]Depositor monitoring of each bank's accounts would allow reputational equilibria, for example.

[8]Perfect foresight is responsible for this conclusion. To see this, suppose taxes were non-distortionary (lump sum) so that Ricardian equivalence held. All dividend income would be saved as deposits against future taxes implying that the increase in deposit liabilities generated by bank accumulations of non-performing assets would be entirely saved. Without perfect foresight, households would consume a portion of the deposit insurance liability of the government before date T and consumption would outgrow net output. Adding the tax distortion just increases the cost to savers of banks accumulating deposit claims against non-performing assets.

[9]For example, Hayashi and Prescott [2002] assume that $1/\sigma = 0.5$ in their calibrated model for Japan.

[10]It may be useful to point out that the calculation of corporate equity does not leave out the debt burden of corporations. Each period, the corporate sector pays $\pi \left(r^{\ell} - r\right) k_t$ which just equals $(1 - \pi) rk_t$, the additions to corporate borrowing due to the evergreening of interest payments for firms with low productivity realizations. The expression for V_t^f, present value of the corporate sector equity, nets out the addition to corporate debt at every date. The present value of corporate debt at any date equals the capital stock, k_t.

[11]In our model, positive bank equity values also result from this policy combination because it allows banks to pay out dividends against uncollected corporate interest.

[12]An existing or new firm could not buy all or part of the firm's capital either, since it could not obtain a loan from the banks to do so.

[13]Under perfect foresight, corporate stock values grow in proportion to gross domestic product after the crisis for a constant tax rate. If the tax rate varies over time (for example, to eliminate the deposit insurance liability, b, in finite time), the growth rate of the value of the stock market will be different than the growth rate of output during the transition to the long-run simply because the value of equity is a forward-looking variable. Therefore, it should not be taken as a prediction of our model that the value of the stock market grows with output after time T because its behavior will depend on the policies adopted to resolve the crisis or private sector expectations with respect to these policies.

[14]Investment irreversibility is used in the model for analytical simplicity. If smooth adjustment costs to disinvestment were introduced, then a banking crisis would result in corporate bankruptcies and a falling price of capital, q_t. While the model shows that transactions in collateral should drop to zero in a crisis, it also implies that under more general adjustment costs the value of collateral should fall below the growth rate of output in a crisis.

[15] This statement allows for costly capital stock adjustment.

[16]This is explained in Hamilton [1994], pp. 327-329.

[17]All the data are quarterly and are from the Statistics Bank on the webpage of the Bank of Japan. We use data from the first quarter of 1980 to the second quarter of 2002. Stationarity tests showed that all four variables are non-stationary in levels, and stationary in first-differences. However, we estimate our S-VARs in levels, since as Hamilton [1994, Ch. 18] shows, a VAR with unit roots can always be written as a VAR representation in which the coefficient distributions are asymptotically Gaussian. Thus, standard t-tests and F-tests of the coefficients would apply. The lag length of 12 was chosen by the Akaike Information Criterion.

[18]Kwon (1998) and Bayoumi (2001) use VAR analyses and conclude that fluctuations in asset prices affect investment through bank lending.

[19]We could introduce gestation lags in investment to achieve the same thing, but the multiple equilibrium models of liquidity panics unnecessarily embellish the model. In contrast to models based on Diamond and Dybvig [1983], crisis in our model occurs deterministically as a unique equilibrium outcome under given regulatory and fiscal policy.

Figure 1: Consumption, Investment, and GDP Growth Rates

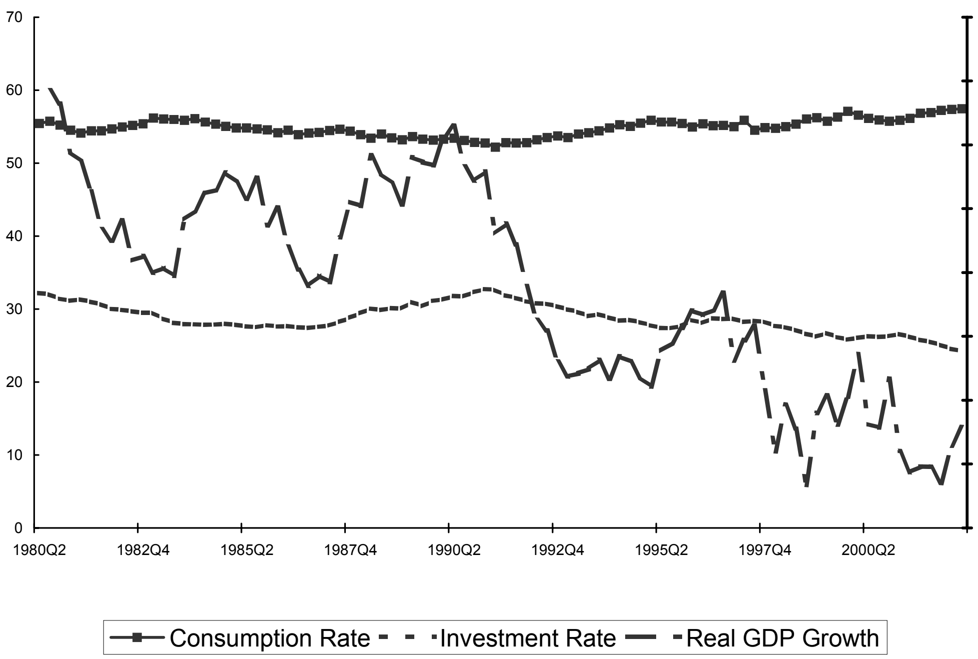


Figure 2: Credit Growth and Sectoral Shifts in Bank Lending

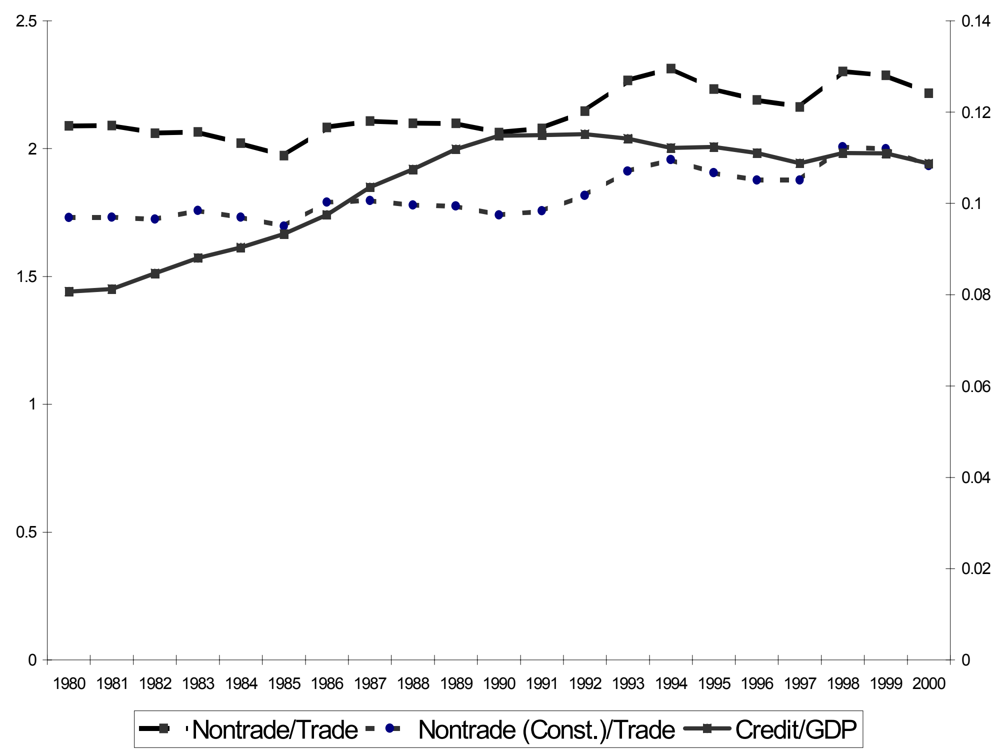


Figure 3: Ratio of Bank Stocks/Total Stock Market

Figure 4: Non-performing Loans and Land Prices

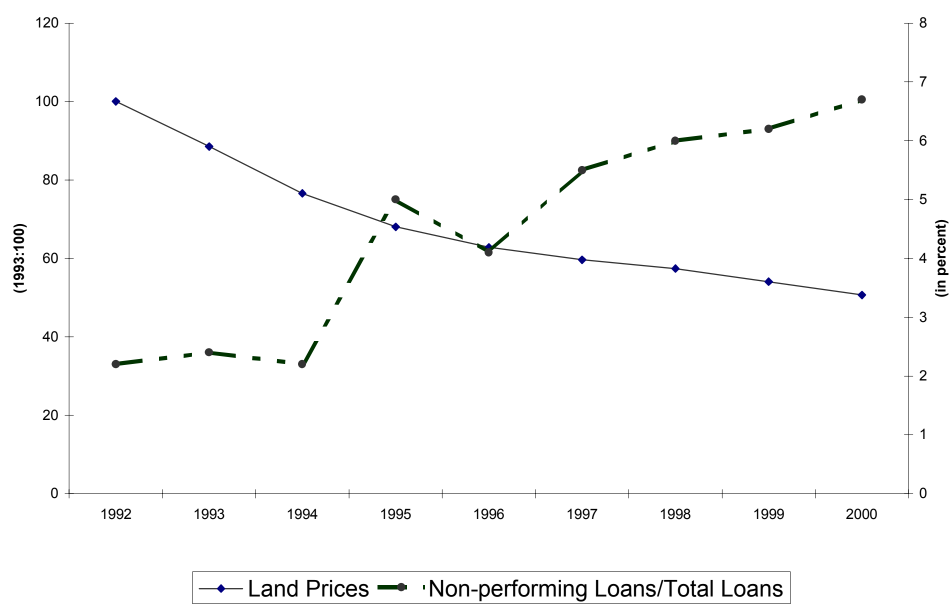
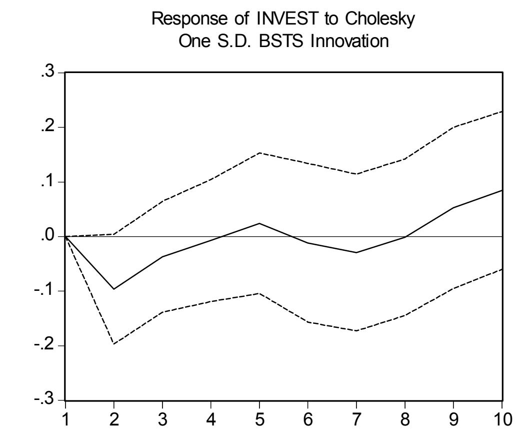
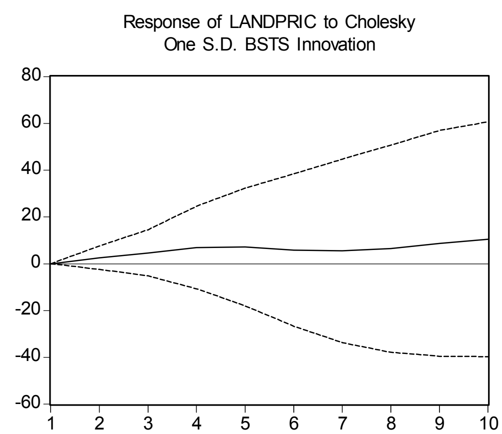


Figure 5: Responses of Investment, Land Prices, and Credit
To Bank Stock Price Shocks





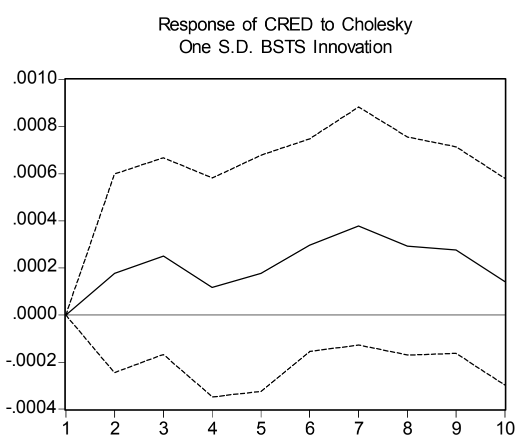


Figure 6: Responses of Investment, Land Prices, and Bank Stocks
To Credit Shocks

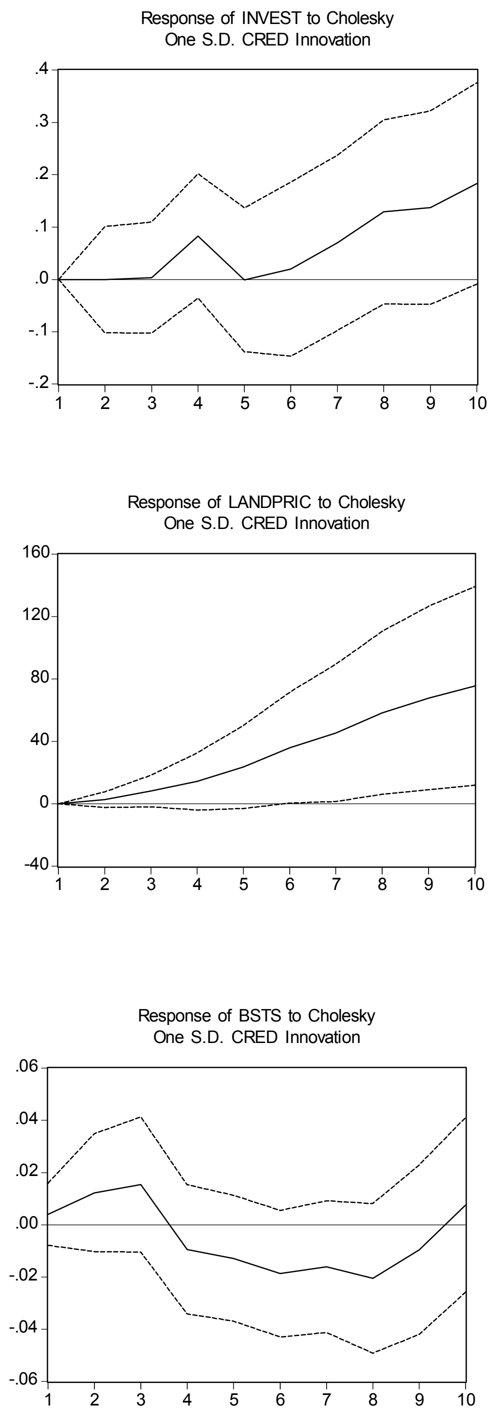


Figure 7: Responses of Investment, Credit, and Bank Stocks
To Land Price Shocks

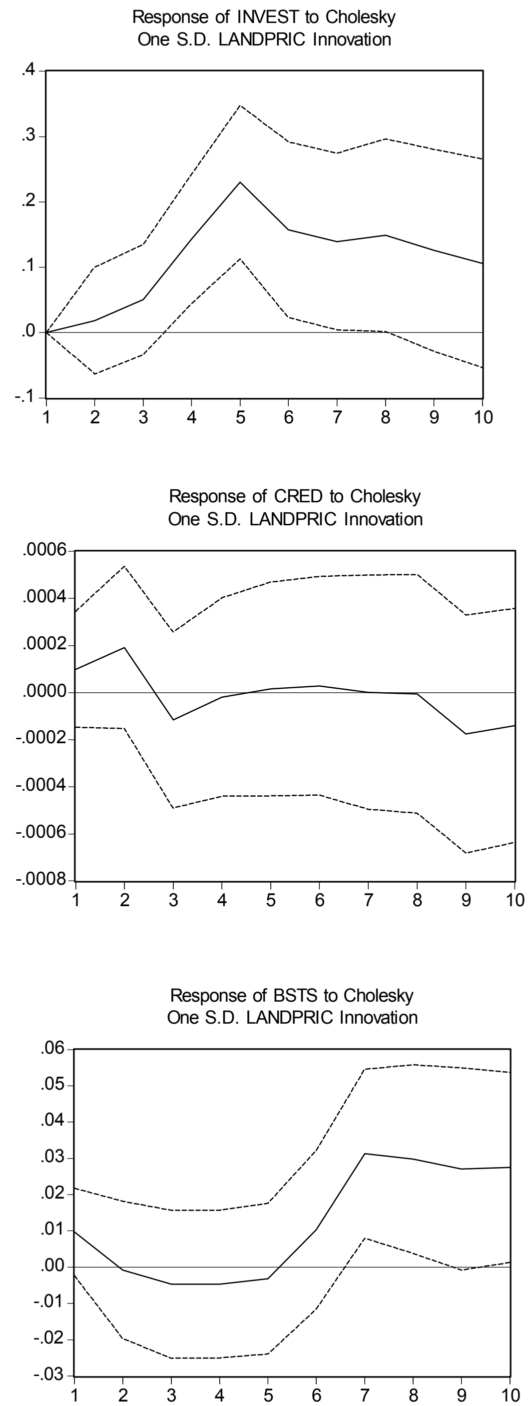


Figure 8: Responses of Land Prices, Credit, and Bank Stocks
To Investment Shocks