Balance-Sheet Contagion

By NOBUHIRO KIYOTAKI AND JOHN MOORE*

Japan has been in a slump for the past decade. After GDP had been growing by on average 4 percent during the 1980's, the growth rate dropped to 1 percent in the 1990's. Asset prices also fluctuated significantly: capital gains on stocks and real estate in the 1980's, followed by capital losses in the 1990's, were both on the order of a few years' worth of GDP, even after taking inflation into account.

Together with production and asset prices, the fraction of nonperforming loans fluctuated substantially. These are by no means all bank loans. For the nonfinancial corporate sector in Japan, the ratio of financial assets to total assets is about 40 percent, much higher than in the United States. Such financial assets include loans to and securities of other private agents. That is, nonfinancial institutions simultaneously borrow from and lend to each other on a significant scale. Many nonperforming loans are interlocked, paralyzing the financial system.

It is important to recognize that these swings have been experienced by almost all sectors of the Japanese economy. Yet in other countries, comparable movements in asset prices have had less widespread consequences. For example, the recent fluctuations in the NASDAQ index in the United States have been no smaller than those of asset prices in Japan, but the damage appears to be contained to closely related sectors. Although U.S. equity-holders, particularly pension funds, have lost value, the level of nonperforming loans is relatively limited up to now.

The question is: Why does there appear to be more contagion in some countries than in others? Has contagion anything to do with the nature of financing or the extent to which there are inter-locking loans? In this theoretical paper, we examine two different mechanisms by which contagion may occur. In both cases, propagation is through balance-sheet effects. First, through the indirect effects that fluctuations in asset prices have on collateral values. Second, through the direct effects that default on or postponement of debt repayments have when there are chains of credit.[1]

I. Indirect Balance-Sheet Contagion

In Japan, traditionally one of the most important ways of financing business investment is through bank loans secured by fixed assets such as real estate. When a firm borrows against its fixed assets, its borrowing capacity depends upon the collateral value: quantity times "collateral price." The collateral price is typically a fraction of the current price (or expected future price) of the assets. The firm's outstanding debt obligation is the result of its past borrowing. Hence, there is a leverage effect: the firm's net worth is vulnerable to changes in asset prices. Most importantly, if firms in the economy use similar assets as collateral, then the effect on net worth of changes in asset prices will cause sector-specific shocks to spread out across sectors, even when firms are not directly linked through production.

In order to illustrate this contagion mechanism, consider an economy with a single homogeneous asset, in fixed aggregate supply. All firms use this asset as the only factor of production, and production takes one period. Creditors cannot force debtors to repay unless debts are secured by the asset. Some firms are credit constrained, and others are not. Consider a constrained firm that retains all return on its assets.

* Kiyotaki: Department of Economics, London School of Economics, Houghton Street, London, WC2A 2AE, United Kingdom; Moore: Departments of Economics, University of Edinburgh, 50 George Square, Edinburgh EH8 9JY, United Kingdom, and London School of Economics.

[1] For alternative approaches to contagion, see, for example, John Geanakoplos and William Zame (1995), Jean-Charles Rochet and Jean Tirole (1996), Albert Kyle and Wei Xiong (1999), Franklin Allen and Douglas Gale (2000), and Xavier Freixas et al. (2000).

Between the start and the end of a period, its flow-of-funds constraint is

$$(1)\quad \text{asset price} \times \left(\begin{matrix}\text{assets held}\\ \text{at end}\end{matrix} - \begin{matrix}\text{assets held}\\ \text{at start}\end{matrix}\right) = \begin{matrix}\text{return}\\ \text{on assets}\end{matrix} + \begin{matrix}\text{debt outstanding}\\ \text{at end}\end{matrix} - \begin{matrix}\text{debt outstanding}\\ \text{at start}\end{matrix}$$

The firm's borrowing constraint binds when

$$(2)\quad \begin{matrix}\text{debt outstanding}\\ \text{at end}\end{matrix} = \text{collateral price} \times \begin{matrix}\text{assets held}\\ \text{at end}\end{matrix}.$$

From (1) and (2), it follows that the firm's asset demand is

$$(3)\quad \begin{matrix}\text{assets held}\\ \text{at end}\end{matrix} = \frac{\begin{matrix}\text{return}\\ \text{on assets}\end{matrix} + \left(\begin{matrix}\text{asset}\\ \text{price}\end{matrix} \times \begin{matrix}\text{assets held}\\ \text{at start}\end{matrix}\right) - \begin{matrix}\text{debt outstanding}\\ \text{at start}\end{matrix}}{\text{asset price} - \text{collateral price}}$$

The numerator in equation (3) is the firm's net worth, and the denominator is the downpayment required to purchase one unit of asset. The firm uses its net worth to finance the gap between the asset value and the collateral value of the assets it holds at the end of the period. Notice that if the stock of debt outstanding at the start is large relative to the flow of returns, then net worth is very sensitive to the asset price: the numerator of (3) moves more than proportionally. This reflects the leverage effect of debt overhang. The required downpayment is likely to be less sensitive. For example, if the collateral price is a constant fraction of the asset price, then the denominator of (3) only moves proportionally. In these circumstances, the asset demand of the constrained firm is an *increasing* function of the asset price!

Suppose that firms belonging to some *particular* group experience a temporary negative shock to their returns that reduces their net worth. Facing binding credit constraints, the constrained firms in this group are forced to cut back on expenditure, including investment in the asset. For them, smaller investment leads to smaller revenue, net worth, and hence investment, in the future. That is, the negative effects persist: it takes time for these constrained firms to recover their net worth and demand for the asset. The asset market clears only if the unconstrained firms increase their demand, which entails a reduction in the opportunity cost, or user cost, of holding the asset: the difference between the prevailing purchase price and the expected discounted future resale price. But such falls in the current and future user costs lead to a fall in the current price of the asset (see Fig. 1).

This is the source of contagion. The behavior of *all* constrained firms is affected by a fall in the current price. They all experience a capital loss on their asset holdings, which substantially decreases their net worth because of the leverage effect of their outstanding debt. Each is forced to cut back current investment, which in turn leads to smaller revenue, net worth, and hence investment, in the future. To clear the asset market, current and future user costs have to fall further, which feeds back again into the current price. There is an intertemporal multiplier process, working through the asset price, which indirectly affects all the constrained firms, not simply those that directly experienced the shock.

The contagion is of first order, in the sense that the direct effect of the shock is dwarfed by the indirect effect of the asset-price multiplier. Insofar as firms are heavily leveraged, all constrained firms suffer significantly, irrespective of whether they were directly hit by a shock. The effects of a temporary negative shock to a particular group of firms persist, amplify, and spread out to the entire economy. (See section IV of Kiyotaki and Moore [1997] for a more general model of spillovers from one sector to another, where sectors produce differentiated products.)

There are three key ingredients here: history dependence in the behavior of constrained firms; a forward-looking asset market; and the leverage effect of debt. The first two are likely to be robust features of any model in which financing constraints bind. The third is more problematic. To get a big leverage effect in any given period, a firm's outstanding obligations at the start must be fixed, but its obligations at the end (its new overall borrowing limit) must be sensitive to the asset price. In equation (3), if debt outstanding were, say, indexed to the realized asset price, then there would be no leverage effect, and the firm's asset demand would be a conventional decreasing function of price. More generally, the firm might insure against

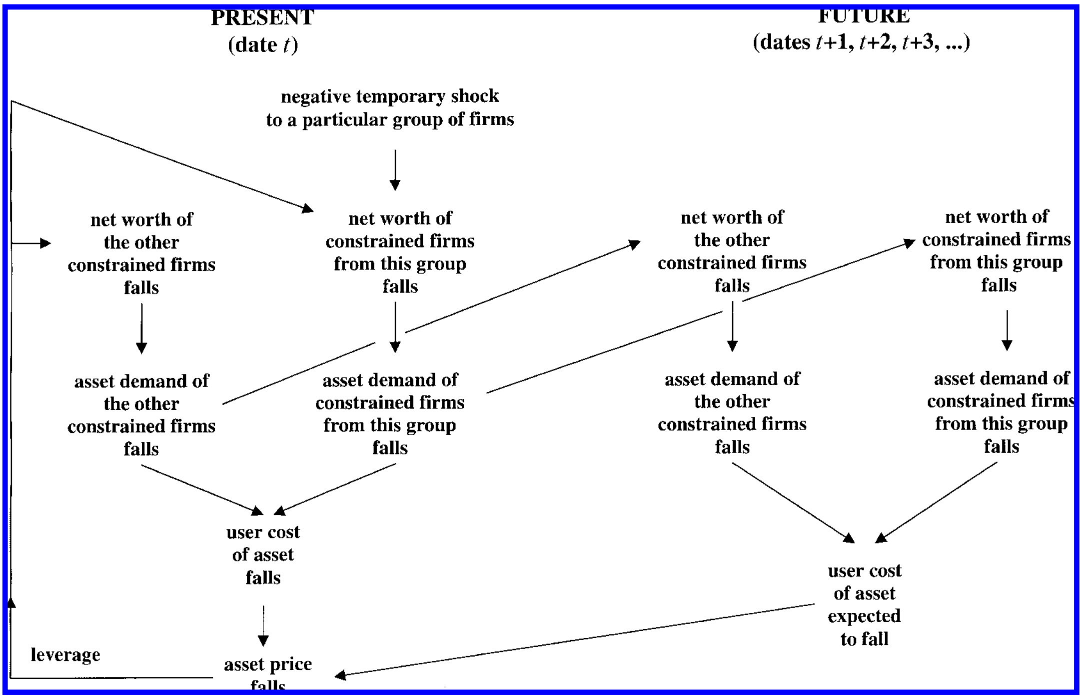

FIGURE 1. INDIRECT BALANCE-SHEET CONTAGION THROUGH THE ASSET MARKET

fluctuations in the economy-wide asset price; or it might borrow against its future return stream (the "inside value"), rather than borrow against the liquidation value of its assets (the "outside value"); or it might issue equity, rather than debt. Given any of these possibilities, the leverage effects would disappear, or at least take a different form.

Such considerations take us into some of the deep issues of corporate finance: the use (or non-use) of state-contingent financial contracts; the role of inside versus outside value; the choice of debt versus equity. In Kiyotaki and Moore (1998) we attempt to generate leverage effects in a context where full indexation is allowed, and where firms can offer either inside or outside value as collateral.

We would argue that in these respects there are key differences between the United States and postwar Japan. As we have said, in Japan one of the most important ways of financing business investment has been through bank loans secured by general fixed assets such as real estate. By contrast, U.S. firms in the NASDAQ raise a large fraction of their funds by selling or mortgaging part of their future revenue stream, rather than by borrowing against fixed assets. Therefore they are not so vulnerable to fluctuations in the general fixed asset price. The spillover effect to other sectors is limited to conventional linkage through sales and purchases.

II. Direct Balance-Sheet Contagion

When many firms simultaneously borrow from and lend to each other, and when these firms are credit-constrained, shocks to the liquidity of some firms may cause a chain reaction in which the other firms also get into financial difficulties. Moreover, if default on or postponement of debt repayment in one link of the chain disrupts production there, then an accumulation of nonperforming loans causes a widespread loss in output.

For this contagion mechanism to operate, we need to address two puzzles. First, why do credit constrained firms lend at all? Or why do they not net out their gross financial positions by selling their financial assets to pay off their liabilities? Second, why should default or postponement disrupt production? To provide answers to these puzzles, we consider the case of interfirm credit.

Moses Abramovitz (1948) divides production into three categories: spot production, production to inventory, and production to order. Typically services are produced spot, and many consumer durables are produced to inventory. However, most capital and intermediate goods are made to order. It usually takes time to produce these goods, and once production has started, the goods in process are often specific to the particular purchaser and supplier involved (i.e., they are customized for this purchaser, and only this supplier can complete production). For such goods, production and payment cannot be synchronized, and the purchaser and supplier are naturally involved in a credit relationship. It is normal for the supplier to be paid something up front, at the time of ordering, to protect her interests; and the purchaser withholds the remaining payment until completion, to protect his interests. This second payment can be interpreted as the repayment of debt. Moreover, given that only this supplier is able to complete production, she would have difficulty selling the loan to a third party. Even if she succeeded, she would typically have to sell at a discount. Thus, despite the fact that she herself may be credit-constrained, she is in effect forced to lend to her purchaser. This is our answer to the first of the two puzzles. (For a full model, see Kiyotaki and Moore [1996, 2001].)

Crucially, if the purchaser runs into a shortage of funds and cannot make the debt repayment at the due date, then he has to postpone, and the supplier withholds completion until she is paid. (To complete without being paid would put her in jeopardy.) Such a delay disrupts production—which is how we resolve the second puzzle. Below we capture the inefficiency caused by disruption by supposing that goods completed at the due date yield the purchaser a future return of α dollars (per dollar of debt repaid), whereas goods completed late yield only $\beta < \alpha$.

Consider a chain of such credit relationships, linking agents A, B, C, ... Suppose A purchases on credit from B. That is, A owes B for the completion of specific goods—goods that, once production has started, can be completed

Assets	Liabilities
Liquid savings (L)	Payments to C (P)
Receipts from A (R)	
Accounts receivable from A sold (AR_S)	
....	....
Accounts receivable from A unsold (AR_u)	Accounts payable to C (AP)
Future returns from P (αP)	Net worth (future consumption) (NW)
Future returns from AP (βAP)	

FIGURE 2. AGENT B'S BALANCE SHEET

only by B, and are customized for A. At the same time, B purchases on credit from C. Given that the agents are credit-constrained, B anticipates having to use the receipts from A, together with her own liquid savings, to pay C. Now suppose A experiences a liquidity shock, so that on the due date he is unable to meet his obligation to B in full. Then B too will be short of funds. Figure 2 presents her balance sheet.

The receipts R from A, together with her own liquid savings L, are not enough for B to pay for all the goods that she ordered from C. Ideally, she would like to sell the remaining accounts receivable from A. But the security for these accounts receivable is in the form of goods that are customized for A, and which only B can easily complete. Hence, it is difficult for B to sell. However, at a cost, a third party could acquire the necessary skill. This cost corresponds to the discount B loses when selling her accounts receivable to the third party. Suppose the first units of accounts receivable can be sold at a small discount, but the subsequent units are increasingly heavily discounted. Then B will choose to sell an interior fraction, AR_s.

B uses all her liquid assets (L plus R plus AR_s [above the dotted line in her balance sheet]) to make a payment P to C for partial completion of the goods she ordered. This yields a future return αP. The remaining accounts payable, AP, will be postponed, and C will delay completion, with the result that those goods will yield only βAP. We assume that these future returns, αP and βAP, cannot be mortgaged, so they are both below the dotted line: they are illiquid. B's net worth corresponds to her future consumption.

In general terms, the idea is that a typical agent like B in a chain of credit holds gross financial positions. Crucially, her assets are not equally liquid. She can choose what fraction of her assets to liquidate, taking into account that the higher the fraction, the greater is the discount on the marginal asset sold.

This brings us to the crux of the argument. Notice that, in our A–B–C chain, when B chooses what part of her accounts receivable from A to sell, she directly affects C. The more B sells, the greater is the payment P that she makes to C, which means that C will have more liquidity in hand with which to repay *his* debts. To put it the other way, the less B sells, the more she postpones her debt repayments to C, and the greater are C's accounts receivable, which he can only liquidate at a cost. In short, by choosing not to sell the marginal unit of her accounts receivable from A, B imposes a negative externality on C: given that C is also credit-constrained, C is likely to have to postpone his debt repayments too. Indeed, to the extent that agents further along the chain are constrained, B imposes an externality not just on C, but on C's creditors, and on their creditors, and so on.

The relevance of this form of direct balance-sheet contagion to aggregate welfare is that postponement leads to disruption and loss of output. However, as soon as the shock reaches someone who is not credit-constrained, the propagation stops. Thus the scale of the damage is related to the length of the chains of credit between *constrained* agents. Arguably, in a recession, such chains are longer because more people suffer negative shocks to their flow of funds.

In Kiyotaki and Moore (2001), we show how a benevolent government may be able to ameliorate the contagion by lowering the interest rate. A lower interest rate induces agents to sell more of their accounts receivable. However, leaving aside any direct distortions associated with lowering the interest rate, such a policy also dilutes agents' *ex ante* incentives to hold liquid savings. On balance, though, the *ex post* gains from a judicious government intervention to reduce contagion can outweigh the *ex ante* dilution of incentives.

It is tempting to reinterpret B as a bank, given that, by definition, banks and other financial intermediaries hold gross financial positions. However, it is a major theoretical challenge to model such institutions. We have chosen to model interfirm credit because we can be explicit about our assumptions. In broad terms, we think that the mechanism of direct balance-sheet contagion is likely to apply to bank credit too.

REFERENCES

Abramovitz, Moses. "The Role of Inventories in Business Cycles." National Bureau of Economic Research (New York) Occasional Paper No. 26, 1948.

Allen, Franklin and Gale, Douglas. "Financial Contagion." *Journal of Political Economy*, February 2000, *108*(1), pp. 1–33.

Freixas, Xavier; Parigi, Bruno and Rochet, Jean-Charles. "Systemic Risk, Interbank Relations, and Liquidity Provision by the Central Bank." *Journal of Money, Credit, and Banking*, August 2000, *32*(3), pp. 611–40.

Geanakoplos, John and Zame, William. "Default, Collateral, and Derivatives." Mimeo, Yale University, 1995.

Kiyotaki, Nobuhiro and Moore, John. "Credit Chains." Mimeo, Walras-Bowley Lecture to the North American Meeting of the Econometric Society, Iowa City, IA, 1996; revised, Clarendon Lectures, Oxford, U.K.: University of Oxford, 2001.

______ . "Credit Cycles." *Journal of Political Economy*, April 1997, *105*(2), pp. 211–48.

______ . "Indexation and Insurance." Unpublished Plenary Lecture (in note form) to the Annual Meeting of the Society for Economic Dynamics, Philadelphia, PA, 1998.

Kyle, Albert and Xiong, Wei. "Contagion as a Wealth Effect." Mimeo, Duke University, 1999.

Rochet, Jean-Charles and Tirole, Jean. "Interbank Lending and Systemic Risk." *Journal of Money, Credit, and Banking*, November 1996, *28*(4), pp. 733–62.

This article has been cited by:

1. Yue Ma. 2009. External Shocks, Balance Sheet Contagion, and Speculative Attack on the Pegged Exchange Rate System. *Review of Development Economics* **13**:1, 87-98. [CrossRef]