Understanding Financial Crises

Douglas Gale

September 2000

1 Crisis prevention and crisis management

Financial crises in Southeast Asia, Russia, and elsewhere, have revived interest in models of financial fragility. Recent empirical work on banking and currency crises by Kaminsky and Reinhart (1999) has indicated that the advent of financial liberalisation in many economies in the 1980's has led to "twin" banking and currency crises. Historical evidence provided by Bordo and Eichengreen (2000) suggests that twin crises both in recent decades and prior to the First World War have been particularly disruptive in terms of the depth of ensuing recessions (see Bordo (2000) for an overview of the historical literature on crises).

There is now a growing awareness that globalization, particularly the opening up of previously closed financial systems to global markets, has the potential to increase the exposure of financial systems to new and greater risks. The classical theory of risk-sharing treats risks as exogenous (e.g., as states of nature). The new risks associated with globalization are largely *endogenous*. For example, Bordo and Eichengreen have emphasized that there were no major banking crises during the Bretton Woods era, whereas the post-1971 period has seen numerous banking crises (Kaminsky and Reinhart, 1999). Theoretical models of financial fragility and contagion show that small exogenous shocks, propagating within the financial system, can have a large and perhaps catastrophic impact on the global economy. The traditional tools of financial economics can be used to describe and analyze these risks, but we are not there yet. New models and new kinds of analysis are needed. Economists are now in a position to address questions about the optimal design and regulation of potentially unstable financial systems.

For a long time economic thinking on crises has taken it as axiomatic that crises are best avoided. Recently, there has been some re-thinking of this axiom. This new thinking may be compared to the "fail safe" principle in automobile design. Since we know that accidents will happen, we design cars so that they crumple evenly, preventing secondary collisions that are often more damaging to the occupants than the initial collision. Wouldn't it be better to design our financial systems to be "fail safe", so that if an "accident" happens it doesn't cause unnecessary havoc? Franklin Allen and I have have argued in a number of places that the welfare cost of financial crises is associated with inefficient liquidation of assets and suboptimal risk sharing, and not with crises per se. Hellwig (1994) makes a similar point when arguing that non-contingent deposit contracts misallocate the risk across different classes of depositors. More generally, we argue that positive analysis (what causes crises? what happens when a crisis occurs) needs to be complemented by normative analysis (what is the optimal policy towards crises? what is the optimal institutional structure when crises can occur?). Macroeconomic analyses have often focused on mistakes in government policy. A microeconomic approach emphasizes how the financial system works and why and presents crises as one aspect of a general account of financial activity. Welfare-oriented questions about the optimal design of financial systems and the nature of an optimal policy are are naturally posed in a microeconomic framework.

Another question that arises naturally in a microeconomic approach to financial crises is the role of the central bank. Historical evidence suggests that central banks have been important in controlling financial crises. Theoretically, we are faced with the question: What can the central bank or the government do that private institutions and the market cannot do? To answer this question requires attention to the fine detail of microeconomic modeling.

One caveat to this more benign view of financial crises is provided by the notion of *financial fragility*, that is, the idea that a financial crisis may rage out of control and bring down the entire economic edifice. The memory of the Great Depression and earlier crises is still with us and it powerfully reinforces belief in financial fragility. Still, there is much to be learned from a welfare analysis that aims at minimizing the cost of a crisis rather than avoiding it at all costs. In these notes, we review some of the theoretical lessons that we have learned from new approaches to financial crises and suggest where they might lead us in the future.

2 Risk sharing

First generation models of financial crises were developed in the 1980s, beginning with seminal work on bank runs by Bryant (1980) and Diamond and Dybvig (1983) (hereafter DD). Important contributions were also made by Chari and Jagannathan (1988), Chari (1989), Champ, Smith, and Williamson (1996), Jacklin (1986), Jacklin and Bhattacharya (1988), Postlewaite and Vives (1986), Wallace (1988; 1990) and others. DD is at the core of most models in the literature on bank-centered financial crises. A typical DD-style model has three dates $t = 0, 1, 2$ and a large number of identical consumers. Each consumer is endowed with one unit of a homogeneous consumption good. At date 1, the consumers learn whether they are early consumers, who only value consumption at date 1, or late consumers, who only value consumption at date 2. Consumers' uncertainty creates a preference for liquidity.

An individual can invest in a combination of long-term (illiquid) investments, yielding high returns, and short-term (liquid) assets, yielding low returns. The short-term asset pays a return of one unit after one period and the long-term asset pays a return $r < 1$ after one period or $R > 1$ after two periods. The long asset has a higher return if held to maturity, but liquidating it in the middle period is costly, so it is not very useful for providing liquidity. An individual investor faces a difficult choice between return and liquidity. If he holds the long asset and turns out to be an early consumer, he will lack liquidity. If he holds the short asset and turns out to be a late consumer, his returns will be low. What he really wants is insurance against his uncertain demand for liquidity, but this he cannot provide by holding a mixture of the two assets.

Banks have a comparative advantage in providing liquidity insurance. The bank can offer each depositor a superior contract, promising a combination of liquidity and high returns that an individual investor cannot match. For simplicity, assume that the fraction of early consumers is constant. Thus, there is no uncertainty about the aggregate demand for liquidity. There is only uncertainty about which individuals will demand liquidity at the intermediate date. At the first date, consumers deposit their endowments in the banks, which invest them on behalf of the depositors. In exchange, depositors are promised a fixed amount of consumption at each subsequent date, depending on when they choose to withdraw. The banking sector is perfectly competitive, so banks offer risk-sharing contracts that maximize depositors' ex ante expected utility, subject to a zero-profit constraint.

DD provides a simple explanation of bank runs. The optimal insurance scheme requires the bank to promise depositors a fixed payment if they withdraw early. If too many depositors withdraw, the bank is unable to meet its promises without liquidating assets. Under some conditions, if most or all of the early depositors withdraw early, there will be nothing left for those who withdraw late. Thus, a bank run becomes a self-fulfilling prophecy: if a depositor believes that others will withdraw their deposits from the bank, it becomes optimal for the depositor to withdraw his deposits too.

There are two Nash equilibria of this "game", one in which only the early consumers (those who have received a liquidity shock) withdraw early and one in which everyone withdraws early. The former is incentive-efficent, the latter is not. What determines which equilibrium is observed? Market psychology? Animal spirits? Sunspots? We return to this point in Section 7 below.

Here we want to emphasize the importance of DD as a contribution to the microeconomic theory of intermediation. Apart from its usefulness as a model of bank runs, the DD model is remarkable for providing an account of what banks do and why they are needed. The insurance function (converting liquid liabilities into illiquid assets) is interesting in its own right, because it provides a theory of bank behavior based on rational optimizing behavior and opens it up to microeconomic analysis. The same approach can be extended to the welfare analysis of monetary and banking policy and that has been one of the motivations for our work.

3 Optimal financial crises

Gorton (1988) finds evidence from the U.S. during the National Banking Era which is consistent with the view that banking panics are related to the business cycle. The five worst recessions, as measured by the change in pig iron production, were accompanied by panics. In all, panics occurred in seven out of the eleven cycles. Using the liabilities of failed businesses as a leading economic indicator, Gorton finds that panics were systematic events: whenever this leading economic indicator reached a certain threshold, a panic ensued. The stylized facts uncovered by Gorton thus suggest banking panics are intimately related to the state of the business cycle. Calomiris and Gorton (1991) consider a broad range of evidence and reach similar conclusions.

Starting from this point of view, Allen and Gale (1998) (hereafter AG) construct a model in which financial crises are driven by fundamentals. An economic downturn will reduce the value of bank assets, raising the possibility that banks are unable to meet their commitments. If depositors receive information about an impending downturn, they will anticipate financial difficulties in the banking sector and try to withdraw their funds. This attempt will precipitate a crisis.

The main objective of AG is to analyze the welfare properties of the model and understand the role of central banks in dealing with panics. Bank runs are an inevitable consequence of the standard deposit contract in a world with aggregate uncertainty about asset returns. Furthermore, they play a useful role insofar as they allow the banking system to share these risks among depositors.

The basic assumptions about technology and preferences have become the standard in the literature since the appearance of DD. AG retains many of the standard assumptions model but it differs from DD in important ways.

- There are aggregate shocks to asset returns. More precisely, banks hold long-term (illiquid) assets that earn a random return $\tilde{R}$ at date 2. Moreover, the returns to the risky assets are perfectly correlated across banks. Uncertainty about asset returns is intended to capture the impact of the business cycle on the value of bank assets. Information about returns becomes available before the returns are realized and when the information is bad it has the power to precipitate a crisis.

- The long-term asset is completely illiquid: none of the returns from this asset are available for sharing out among the early consumers. This is different from assuming that $r = 0$ in the DD model. Here the long asset cannot be touched in the short run. The "winding up" of an insolvent bank must take time and, more importantly, there will be something left for late withdrawing depositor.

- AG does not impose the first-come, first-served assumption. (This assumption has been the subject of some debate in the literature as it is not an optimal arrangement in the basic Diamond-Dybvig model; see Wallace, 1988, and Calomiris and Kahn, 1991). Instead, an insolvent bank shares its liquid assets equally among the early withdrawers. Those who do not withdraw early have to wait to obtain their funds and, again, they share the remaining assets equally.

In a number of countries and historical time periods, banks have had the right to delay payment for some time period on certain types of account. This is rather different from the first-come, first-served assumption. Sprague (1910) recounts how in the U.S. in the late nineteenth century people could obtain liquidity once a panic had started by using certified checks. These checks traded at a discount.

In the simplest version of the model, which serves as a benchmark for the rest of AG, there are no costs of early withdrawal, apart from the potential distortions that bank runs create for equilibrium risk-sharing and portfolio choice. In this context, a laisser-faire banking system which is vulnerable to crises can actually achieve the first-best allocation of risk and investment. The incentive-efficient allocation can be identified with an optimal mechanism-design problem in which the allocation can be made contingent on a leading economic indicator (e.g., the return on the risky asset), but not on the depositors' types. By contrast, a standard deposit contract cannot be made contingent on the leading indicator. However, depositors can observe the leading indicator and make their withdrawal decisions contingent on it. When late-consuming depositors observe that returns are high, they are content to leave their funds in the bank until the last date. When the returns are low, they attempt to withdraw their funds, causing a bank run. The somewhat surprising result is that the optimal deposit contract produces the same portfolio and consumption allocation as the first-best allocation. The possibility of equilibrium bank runs allows banks to hold the first-best portfolio and produces just the right degree of contingency to provide first-best risk sharing.

Next AG introduces a real cost of early withdrawal by assuming that the storage technology available to the banks is strictly more productive than the storage technology available to late consumers who withdraw their deposits in a bank run. In these circumstances, where crises are costly, appropriate central bank intervention can avoid the unnecessary costs of bank runs while continuing to allow runs to fulfill their risk-sharing function. A bank run, by forcing the early liquidation of too much of the safe asset, actually reduces the amount of consumption available to depositors. In this case, laisser faire does not achieve the first-best allocation. This provides a rationale for central bank intervention. The central bank can intervene with a monetary injection that implements the first-best allocation. Suppose that a bank promises the depositor a fixed nominal amount and that, in the event of a run, the central bank makes an interest-free loan to the bank. The bank can meet its commitments by paying out cash, thus avoiding premature liquidation of the safe asset. Equilibrium adjustments of the price level at the two dates ensure that early and late consumers end up with the correct amount of consumption at each date and the bank ends up with the money it needs to repay its loan to the central bank. The first-best allocation is thus implemented by a combination of a standard deposit contract and bank runs.

Finally, AG considers the role of markets for the illiquid asset in providing liquidity for the banking system. The first two versions of the model have the very special feature that the risky, long-term asset is completely illiquid. There is no way of liquidating the risky asset to meet the claims of the early consumers, and this plays an important role in the "equilibration" of a bank run. In reality, even assets that are physically illiquid can be sold to other investors and this is the way in which assets are usually liquidated in practice. However, it takes time to realize the value of many assets. This fact is captured in the first two versions of the model by making the extreme assumption that the asset market is completely illiquid in the very short run, so that banks have to wait a full period to realize any value.

In the third version of the model, we assume that there is a (somewhat liquid) market for the risky asset at date 1. The asset market provides a means of liquidating the long-term asset. Somewhat surprisingly, the introduction of an active asset market leads to a Pareto *reduction* in welfare in the laisser faire case. Once again, though, central bank intervention allows the financial system to share risks without incurring the costs of inefficient investment.

4 Market provision of liquidity

It is worth dwelling on the role of asset markets in some detail, since it has broad methodological implications for the analysis of crises. In both DD and AG, assets are represented by investment technologies. The short-term (liquid) asset is represented by a storage technology and the long-term (illiquid) asset is represented by a two-period investment technology. In the DD model, the possibility of premature liquidation of the long-term assets is also represented by a technology. If the long-term asset is liquidated prematurely, it yields a return of only $r < 1$ per unit invested. The difference in returns, $R - r$, is the cost of liquidation. The costly liquidation technology reflects the assumption that, when financial institutions have to realize the value of their assets in a hurry, they are typically unable to realize the full value that they would receive if they could wait until maturity. This loss of value is one of the costs of a financial distress. However, the use of a reduced-form "liquidation technology" obscures a number of interesting features that are highly relevant for understanding the welfare economics of financial crises.

It is easy to see why the introduction of an asset market might amplify the effects of a bank run. By making all assets liquid, the new market allows the bank to liquidate all its assets in an attempt to meet the claims of the early withdrawers. Now the banks may be forced to liquidate their illiquid assets in order to meet their deposit liabilities. However, by selling assets during a run, they force down the price and make the crisis worse. This destroys the equilibrating mechanism of the earlier versions of the model in which the returns to the illiquid asset were untouchable at date 1.

Liquidation is obviously self-defeating, in the sense that it transfers value to speculators in the market. The welfare analysis of the market's impact is a bit more subtle, however. The deadweight loss associated with liquidations takes the form of suboptimal risk sharing, not a loss of value per se. Optimal insurance would provide depositors with a positive transfer in bad states, where asset returns are low, and impose a tax or negative transfer in good states, where returns are high. The asset market does the opposite. By making transfers in the worst states, the market provides depositors with negative insurance.

In this case, there is an incentive for the central bank to intervene to prevent a collapse of asset prices, but again the problem is not runs per se but the unnecessary liquidations they promote.

Market provision of liquidity represents an innovation in several respects:

- First, the cost of liquidation is now endogenous. Whether there is a loss of value in selling assets in the intermediate period is determined by the liquidity of the market, that is, by the portfolio choices of the investors and institutions that make up the market.

- Ex post, there is no deadweight loss from selling assets. An asset sale involves a transfer, but the asset's returns are not affected by the sale. This is a major change from the DD model and its successors, in which the returns of the liquidated asset are determined by the technology and assumed to be lower than the asset's returns at maturity.

- Ex ante, liquidation may impose a cost. While the seller's "loss" is the buyer's "gain", ex post, they are both losers ex ante. Liquidation is inefficient ex ante because it does not provide the bank with insurance against changes in the asset price. The bank gets a good price in states where the demand for liquidity is low and a bad price in other states where the demand for liquidity is high.

- The market's provision of liquidity is necessarily inadequate. Because the return on holding the short asset is lower than the return on holding the long asset, investors require some additional incentive for providing liquidity. They obtain this incentive in the form of a capital gain if they can buy the long asset cheaply in the middle period and realize a high return in the last period. This will happen only if there is a distress sale from which they can profit. In other words, the market will be willing to provide liquidity to a distressed institution only if the terms are sufficiently profitable and this means that the assets have to be sold "at a loss". Thus, the amount of liquidity provided in equilibrium will never be adequate to support asset prices at a level that would give optimal risk sharing for banks.

5 Limited market participation and asset-price volatility

The role of liquidity in determining asset prices is explored in a different context by Allen and Gale (1994). When a liquidity shock hits the market, forcing some investors to sell assets quickly, there are two possible regimes. If the amount of liquidity in the market, as measured by holdings of liquid assets, is high then the asset price is determined by the expected future returns to the asset. On the other hand, if the amount of liquidity in the market is low, then the price is determined by the amount of "cash in the market". Of course, the amount of liquidity is itself endogenous, and results from prior decisions by investors. More precisely, it depends on their decisions to participate in the market and on the portfolios they choose to hold. If investors with a strong liquidity preference choose to enter the market, then they will hold a large amount of liquidity, the market will be liquid as a result, and asset prices will not fall too much as a result of a liquidity shock. On the other hand, if these same investors choose not to enter the market, then the market will be less liquid, and there will be more asset-price volatility. The investors with a strong liquidity preference create the very asset-price volatility they fear by opting out of the market. The possibility for multiple, Pareto-ranked equilibria is clear.

There is a connection with the analysis of financial crises. Liquidity providers need a profit to induce them to participate in the market for assets. Speculators have an incentive to hold liquid assets in order to buy up assets only if the price is low enough. So, in some states, the market has to be illiquid and there has to be "cash-in-the-market" pricing.

6 Contagion

The AG framework has also been used to construct a model in which small shocks lead to large effects by means of contagion, more precisely, in which a shock within a single sector can spread to other sectors and lead to an economy-wide financial crisis. Allen and Gale (2000) construct a model in which, under certain circumstances, contagion is unavoidable when the economy is subject to a small shock.

The economy consists of a number of geographical regions. The number of early and late consumers in each region fluctuates randomly, but the aggregate demand for liquidity is constant. This allows for inter-regional insurance as regions with liquidity surpluses provide liquidity for regions with liquidity shortages. One way to organize the provision of insurance is through an interbank market in deposits. Suppose that region A has a large number of early consumers when region B has a low number of early consumers, and vice versa. Since regions A and B are otherwise identical, their deposits are perfect substitutes. The banks exchange deposits at the first date before they observe the liquidity shocks. If region A has a higher than average number of early consumers at date 1 then banks in region A can meet their obligations by liquidating some of their deposits in the banks of region B. Region B is happy to oblige, because it has an excess supply of liquidity in the form of the short asset. At the final date the process is reversed, as banks in region B liquidate the deposits they hold in region A to meet the above-average demand from late consumers in region B.

Inter-regional cross holdings of deposits work well as long as there is enough liquidity in the banking system as a whole. If there is an excess demand for liquidity, however, the financial linkages caused by these cross holdings can turn out to be a disaster. While cross holdings of deposits are useful for reallocating liquidity within the banking system, they cannot increase the total amount of liquidity. If the economy-wide demand from consumers is greater than the stock of the short asset, the only way to provide more consumption is to liquidate the long asset. This is very costly (see Shleifer and Vishny (1992) and Allen and Gale (1998) for a discussion of the costs of premature liquidation) so banks try to avoid liquidating the long asset whenever possible. In this case, they can avoid liquidating the long asset by liquidating their claims on other regions instead. This mutual liquidation of claims does not create any additional liquidity, however. It merely denies liquidity to the troubled region and bank runs and bankruptcy may be the result. What begins as a financial crisis in one region can then spread by contagion to other regions because of the cross-holdings of deposits.

The interbank market works quite differently from the retail market. In the latter case runs occur because deposit contracts commit banks to a fixed payment and banks must begin liquidating the long asset when they cannot meet liquidity demand from the short asset. In the interbank market the initial problem is caused by the fact that banks with an excess demand for liquidity cannot get anything from banks in other regions. This is the opposite of the problem in the retail market and unlike there cannot be solved by making the contracts discretionary or contingent since whatever their form they cancel each other out. Instead of being caused by the nature of interbank claims, spillovers and contagion result just from the fall in the value of bank assets in adjacent regions.

Whether the financial crisis does spread depends crucially on the pattern of inter-connectedness generated by the cross-holdings of deposits. If the interbank market is *complete* and each region is connected to all the other regions, the initial impact of a financial crisis in one region may be attenuated. On the other hand, if the interbank market is *incomplete*, each region is connected with a small number of other regions. The initial impact of the financial crisis may be felt very strongly in those neighboring regions, with the result that they too succumb to a crisis. As each region is affected by the crisis, it prompts premature liquidation of the long asset, with a consequent loss of value, so that previously unaffected regions find that they too are affected because their claims on the region in crisis have fallen in value.

It is important to note the role of the free-rider problem in explaining the difference between a complete and incomplete interbank market. There is a natural pecking order among different sources for liquidity. A bank will meet withdrawals first from the short asset, then from holdings in other regions, and only in the last resort will it choose to liquidate the long asset. Cross-holdings are useful for redistributing liquidity, but they do not create liquidity; so when there is a global shortage of liquidity (withdrawals exceed short assets), the only solution is to liquidate long assets. If every region takes a small hit (liquidates a small amount of the long asset) there may be no need for a global crisis. This is what happens with complete markets: banks in the troubled region have direct claims on banks in every other region and there is no way to avoid paying one's share. With incomplete markets, banks in the troubled region have a direct claim only on the banks in adjacent regions. The banks in other regions pursue their own interests and refuse to liquidate the long asset until they find themselves on the front line of the contagion.

The central bank can provide a substitute for completeness of markets. The effect of complete markets in this context is to ensure that spillovers are broadly dispersed throughout the financial system so that they cannot have a disproportionate effect on any component of the system. The central bank can ensure a similar outcome, imposing a small tax on each region in order to provide liquidity to the distressed region.

The notion of a region is intended as a metaphor for categories of banks that may differ along several dimensions. For example, some banks may be better at raising funds while other banks are better at lending them. Or it might be that banks focus on lending to different industries or in different regions and as a result have lending opportunities that are not perfectly correlated with their deposit base. In either case, an interbank market plays an important role in redistributing the funds efficiently. However, the existence of claims between different categories of banks opens up the possibility of contagion when one category is hit by a sudden demand for liquidity.

7 Sunspots or sensitivity?

Theoretical research on speculative currency attacks, banking panics, and contagion have taken a number of approaches. One is built on the foundations provided by early research on bank runs (e.g., Allen and Gale (1998; 2000a; 2000b), Chang and Velasco (1998a; 1998b)) and Peck and Shell (1999)). Other approaches include those based on macroeconomic models of currency crises that developed from the insights of Krugman (1979), Obstfeld (1986) and Calvo (1988) (see, e.g., Corsetti, Pesenti, and Roubini (1999) for a recent contribution and Flood and Marion (1999) for a survey), game theoretic models (see Morris and Shin (1998), Morris (2000) and Morris and Shin (2000) for an overview), amplification mechanisms (e.g., Cole and Kehoe (1995) and Chari and Kehoe (2000)) and the borrowing of foreign currency by firms (e.g., Aghion, Bacchetta and Banerjee (2000)).

Two main perspectives on financial crises can be discerned in this literature. One is that they are *random events,* unrelated to changes in the real economy. The classical form of this view suggests that crises are the result of "mob psychology" or "mass hysteria" (see, e.g., Kindleberger (1978)). The modern version, developed by DD and others, is that bank runs are self-fulfilling prophecies. Given the assumption of first-come, first-served and costly liquidation of some assets there are multiple equilibria. If everyone believes that a banking panic is about to occur, it is optimal for each individual to try to withdraw his funds. Since each bank has insufficient liquid assets to meet all of its commitments, it will have to liquidate some of its assets at a loss. Given first-come, first-served, those depositors who withdraw initially will receive more than those who wait. On the one hand, anticipating this, all depositors have an incentive to withdraw immediately. On the other hand, if no one believes a banking panic is about to occur, only those with immediate needs for liquidity will withdraw their funds. Assuming that banks have sufficient liquid assets to meet these legitimate demands, there will be no panic. Which of these two equilibria occurs depends on extraneous variables or "sunspots". Although "sunspots" have no effect on the real data of the economy, they affect depositors' beliefs in a way that turns out to be self-fulfilling. (Postlewaite and Vives (1987) have shown how runs can be generated in a model with a unique equilibrium).

An alternative to the "sunspot" view is that financial crises are a natural outgrowth of the *business cycle*. An economic downturn will reduce the value of bank assets, raising the possibility that banks are unable to meet their commitments. If depositors receive information about an impending downturn in the cycle, they will anticipate financial difficulties in the banking sector and try to withdraw their funds. This attempt will precipitate the crisis. According to this interpretation, panics are not random events but a response to unfolding economic circumstances. Mitchell (1941), for example, writes (p.74)

> "when prosperity merges into crisis ... heavy failures are likely

> to occur, and no one can tell what enterprises will be crippled by them. The one certainty is that the banks holding the paper of bankrupt firms will suffer delay and perhaps a serious loss on collection."

In other words, panics are an integral part of the business cycle.

A number of authors have developed models of banking panics caused by aggregate risk. Wallace (1988; 1990), Chari (1989) and Champ, Smith, and Williamson (1996) extend Diamond and Dybvig (1983) by assuming the fraction of the population requiring liquidity is random. Chari and Jagannathan (1988), Jacklin and Bhattacharya (1988), Hellwig (1994), and Alonso (1996) introduce aggregate uncertainty which can be interpreted as business cycle risk. Chari and Jagannathan (1988) focus on a signal extraction problem where part of the population observes a signal about future returns. Others must then try to deduce from observed withdrawals whether an unfavorable signal was received by this group or whether liquidity needs happen to be high. Chari and Jagannathan are able to show panics occur not only when the outlook is poor but also when liquidity needs turn out to be high. Jacklin and Bhattacharya (1988) also consider a model where some depositors receive an interim signal about risk. They show that the optimality of bank deposits compared to equities depends on the characteristics of the risky investment. Hellwig (1994) considers a model where the reinvestment rate is random and shows that the risk should be born both by early and late withdrawers. Alonso (1996) demonstrates using numerical examples that contracts where runs occur may be better than contracts which ensure runs do not occur because they improve risk sharing.

Whichever view one takes of the causes of financial crises, there is a consensus that financial systems are *fragile*. The threat of a financial crisis lies in the possibility that it will propagate through the economic system causing damage disproportionate to the original shock. This notion of financial fragility is most easily seen in the sunspot model: the impact of extraneous uncertainty is equivalent to financial fragility, since shock that "causes" the crisis has no effect on the fundamentals of the economy. Financial fragility can also be captured in a real business cycle model, where crises result from exogenous shocks. In this context, financial fragility is interpreted as a situation in which very small shocks can tip the economy over the edge into a full blown crisis. In other words, financial fragility is an extreme case of excess sensitivity to small shocks.

In terms of causation, the difference between sunspots (sensitivity to extraneous uncertainty) and excess sensitivity (extreme sensitivity to real exogenous shocks) is not great. The first could be thought of as a limiting case of the second. However, there are important differences between the two approaches. The sunspot theory does not predict crises; it allows for the possibility of crises. Furthermore, the sunspot theory also depends on fundamentals. Weak fundamentals are not sufficient for a crises, but in the presence of weak fundamentals, self-fulfilling expectations may be sufficient for a crisis.

An approach that spans both the real business cycle approach and the sunspot theory is represented by AG, who call a crisis *essential* if, for certain parameter values, every equilibrium of the model is characterized by a crisis. The AG model allows for multiple equilibria and sunspot phenomena in principle, but the analysis does not rely on it. Instead, AG assumes that a non-crisis equilibrium is selected if it exists and finds conditions under which a crisis cannot be avoided. Restricting attention to situations in which crises are essential gives the theory greater predictive power.

A related approach is represented by the work of Morris and Shin (1998), Morris (2000) and Morris and Shin (2000), who study models with multiple equilibria but use equilibrium selection arguments based on small amounts of asymmetric information about parameter values to predict which equilibrium will be chosen.

In recent unpublished work, Allen and I have been investigating the connection between contagion as a form of financial fragility and the existence of sunspot equilibria. It appears that the connection is very close. In the model of contagion discussed in Section 6, contagion spread because a real cost of liquidation reduced the value of one region's claims on the banks of another region. Small shocks were seen to lead to large consequences, but only if there was a network of claims that channeled the spillover effects in a special way. Contagion can also occur in markets, where the spillover effect from liquidation of assets by (type of) bank is channeled to other banks through the price of assets in the market. What is crucial for understanding this phenomenon is the fact that the system minimizes liquidity to be the minimum needed for preventing a crisis in certain states. If the demand for liquidity rises above this level, there will be a sharp fall in the price of assets. This drop in asset prices may force other banks into insolvency and exacerbate the crises. Although all of these things happen simultaneously in equilibriu, yet it is intuitive to use the word contagion in this context, because the pecuniary externalities, to use the technical term, from one set of agents forces another much larger set into bankruptcy. In other words, a small shock (to liquidity demand) can have a large effect. In the limit, when the initial shock that causes the crisis becomes vanishingly small, we have something that looks very much like a sunspot equilibrium. However, the approach is different, since it does not not rely on multiple equilibria.

In the end, the interesting question seems to be the source of financial fragility, whether it is represented by a sunspot equilibrium or a classical equilibrium. In any case, theories with sharp predictions are to be preferred on Popperian grounds to those that have weak predictive power.

8 Future research

Just as the general equilibrium theory of asset markets tends to ignore financial institutions, the theory of banking largely ignores asset markets. For the most part, first-generation models of financial crises analyze the behavior of a single representative bank, are partial equilibrium in nature, and consist of a contracting problem followed by a coordination problem. In order to understand the origins of financial crises, we need models that describe complex, decentralized, financial systems comprising both financial insitutions and financial markets.

References

Aghion, P., P. Bacchetta and A. Banerjee (2000). "Currency Crises and Monetary Policy in an Economy with Credit Constraints," working paper, University College, London.

Allen, F. and D. Gale (1998). "Optimal Financial Crises," *Journal of Finance* **53,** 1245-1284.

Allen, F. and D. Gale (2000a). "Financial Contagion," *Journal of Political Economy* **108,** 1-33.

Allen, F. and D. Gale (2000b). "Optimal Currency Crises" *Journal of Monetary Economics*, Carnegie-Rochester Series on Public Policy, to appear.

Allen, F. and D. Gale (2000c). "Bubbles and Crises," *The Economic Journal* **110** (2000) 236-256

Alonso, I. (1996). "On Avoiding Bank Runs," *Journal of Monetary Economics* **37**, 73-87.

Bensaid, B., H. Pages, and J.-C. Rochet (1996). "Efficient Regulation of Bank's Solvency," unpublished working paper, Institut d'Economie Industrielle, Toulouse.

Bernanke, B. (1983). "Non-monetary Effects of the Financial Crisis in the Propagation of the Great Depression," *American Economic Review* **73**, 257-263.

Bernanke, B. and M. Gertler (1989). "Agency Costs, Net Worth, and Business Fluctuations," *American Economic Review* **79**, 14-31.

Bhattacharya, S. and D. Gale (1987). "Preference Shocks, Liquidity and Central Bank Policy," in William Barnett and Kenneth Singleton, eds., *New Approaches to Monetary Economics* (Cambridge University Press, New York, NY).

Bryant, J. (1980). "A Model of Reserves, Bank Runs, and Deposit Insurance," *Journal of Banking and Finance* **4,** 335-344.

Bordo, M. (2000). "The Globalization of International Financial Markets: What Can History Teach Us?" working paper, Rutgers University.

Bordo, M. and B. Eichengreen (2000). "Is the Crisis Problem Growing More Severe?" working paper, Rutgers University.

Calomiris, C. and G. Gorton (1991). "The Origins of Banking Panics, Models, Facts, and Bank Regulation," in Glenn Hubbard, ed., *Financial Markets and Financial Crises* (University of Chicago Press, Chicago, IL).

Calomiris, C. and C. Kahn (1991). "The Role of Demandable Debt in Structuring Optimal Banking Arrangements," *American Economic Review* **81**, 497-513.

Calvo, G. (1988). "Servicing the Public Debt: The Role of Expectations," *American Economic Review* **78**, 1411-1428.

Champ, Bruce, Bruce Smith, and Stephen Williamson, 1996. "Currency Elasticity and Banking Panics: Theory and Evidence," *Canadian Journal of Economics* **29**, 828-864.

Chang, R. and A. Velasco (1998a). "Financial Fragility and the Exchange Rate Regime," working paper, New York University.

Chang, R. and A. Velasco (1998b). "Financial Crises in Emerging Markets: A Canonical Model," working paper, New York University.

Chari, V. (1989). "Banking Without Deposit Insurance or Bank Panics: Lessons From a Model of the U.S. National Banking System," *Federal Reserve Bank of Minneapolis Quarterly Review* **13** (Summer), 3-19.

Chari, V. and R. Jagannathan (1988). "Banking Panics, Information, and Rational Expectations Equilibrium," *Journal of Finance* **43**, 749-60.

Chari, V. and P. Kehoe (2000). "Financial Crises as Herds," working paper, Federal Reserve Bank of Minneapolis.

Cole, H. and T. Kehoe (1995). "Self-fulfilling Debt Crises," *Journal of International Economics* (forthcoming).

Corsetti, G., P. Pesenti and N. Roubini (1999). "Paper Tigers? A Model of the Asian Crisis," *European Economic Review* **43**, 1211-1236.

Diamond, D. (1997). "Liquidity, Banks and Markets," *Journal of Political Economy* 105, 928-956.

Diamond, D. and P. Dybvig (1983). "Bank Runs, Deposit Insurance, and Liquidity," *Journal of Political Economy* **91**, 401-419.

Flood, R. and N. Marion (1999). "Perspectives on Recent Currency Crises Literature," *International Journal of Finance and Economics* **4**, 1-26.

Gorton, G. (1988). "Banking Panics and Business Cycles," *Oxford Economic Papers* **40**, 751-781.

Hellwig, M. (1994). "Liquidity Provision, Banking, and the Allocation of Interest Rate Risk," *European Economic Review* **38**, 1363-1389.

Jacklin, C. (1987). "Demand Deposits, Trading Restrictions, and Risk Sharing," in E. Prescott and N. Wallace, eds., *Contractual Arrangements for Intertemporal Trade* (University of Minnesota Press, Minneapolis, MN).

Jacklin, C., and S. Bhattacharya (1988). "Distinguishing panics and information-based bank runs: Welfare and policy implications," *Journal of Political Economy* **96**, 568-592.

Kaminsky, G. and C. Reinhart (1999). "The Twin Crises: The Causes of Banking and Balance-of-Payments Problems," *American Economic Review* **89**, 473-500.

Kindleberger, C. (1978). *Manias, Panics, and Crashes: A History of Financial Crises* (Basic Books, New York, NY).

Krugman, P. (1979). "A Model of Balance-of-Payments Crises," *Journal of Money Credit and Banking* **11**, 311-325.

Mitchell, W. (1941). *Business Cycles and Their Causes* (University of California Press, Berkeley, CA).

Morris, S. (2000). "Contagion," *Review of Economic Studies* **67**, 57-78.

Morris, S. and H. S. Shin (1998). "Unique Equilibrium in a Model of Self-Fulfilling Currency Attacks," *American Economic Review* **88**, 587-597.

Morris, S. and H. S. Shin (2000). "Global Games: Theory and Applications," working paper, Yale University.

Obstfeld, M. (1986). "Rational and Self-Fulfilling Balance of Payments Crises," *American Economic Review* **76**, 72-81.

Peck, J. and K. Shell (1999). "Bank Portfolio Restrictions and Equilibrium Bank Runs," working paper, Cornell University.

Postlewaite, A. and X. Vives (1987). "Bank Runs as an Equilibrium Phenomenon," *Journal of Political Economy* **95**, 485-491.

Prescott, E. and R. Townsend (1984). "Pareto Optima and Competitive Equilibria with Adverse Selection and Moral Hazard," *Econometrica* **52**, 21-45.

Rochet, Jean-Charles and Jean Tirole, 1996, Interbank Lending and Systemic Risk, *Journal of Money, Credit, and Banking* 28, 733-762.

Shleifer, Andrei and Robert Vishny. "Liquidation Values and Debt Capacity: A Market Equilibrium Approach." *Journal of Finance* 47 (1992): 1343-66

Sprague, Oliver, 1910, *A History of Crises Under the National Banking System* (U.S. Government Printing Office, Washington DC).

Wallace, N. (1988). "Another Attempt to Explain an Illiquid Banking System: The Diamond and Dybvig Model with Sequential Service Taken Seriously," *Federal Reserve Bank of Minneapolis Quarterly Review* **12** (Fall), 3-16.

Wallace, N., (1990). "A Banking Model in which Partial Suspension is Best," *Federal Reserve Bank of Minneapolis Quarterly Review* **14** (Fall), 11-23.