# Nobel Lecture: Financial Intermediaries and Financial Crises

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## I. Introduction

Financial intermediaries are an important part of the financial system. Intermediaries today include banks, securitization vehicles, and more generally, shadow banks. They stand between investors who want to deploy their savings and borrowers who need funding. While financial markets channel some of this funding directly, even in financially developed economies there remains an important role for financial intermediation. My research on the theory of financial intermediation seeks to understand how financial intermediaries are best structured as well as the benefits and costs of the structure.

This lecture has several goals. First, it describes some of my background that influences my interest and my approach to this area. It goes on to provide a nontechnical explanation of my first two models of intermediaries, as well as their implications. I share my current thinking on these models, in light of subsequent financial disruptions and crises. Next, I provide an overview of some of my subsequent research on financial intermediation (especially that with Raghuram Rajan) and compare my

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research to theories of financial constraints based on the value of collateral. Finally, I describe my research on short-term debt issued by nonfinancial firms.

## II. Background

My research on financial intermediation began when I was a graduate student at the economics department of Yale University. My goal at that time was to understand why banks exist. The answer turned out to show how and why financial intermediaries can write contracts that allow better outcomes than financing directly. Because the results identify some problems that intermediaries solve and what their contracts do, they can be useful for understanding the effects of regulations on the form of these contracts and how intermediaries have macroeconomic effects.

My first exposure to economics was in my third year of high school, in a seminar course on capitalism, where we read Milton Friedman's *Capitalism and Freedom* (Friedman 1962). In my last year of high school, I helped lead discussions of Paul Samuelson's classic textbook, *Economics* (Samuelson 1970). Economics made sense to me, but my plan was to become a molecular biologist. I applied to Brown University in part because I thought that it had good access to undergraduate research in science.

At Brown, I found that I was more interested in (and better at) economics than in biological science. I took an amazing and transformational course in my senior year. In it, we read one of the best books in economics, *A Monetary History of the United States*, written by Milton Friedman and Anna Jacobson Schwartz (Friedman and Schwartz 1971). The book provides detailed descriptions of how monetary policy is made and the effects that it has. The discussion that had the biggest impact on me concerned the United States in the 1930s and the interaction between monetary policy, bank failures, and bank runs. Friedman and Schwartz describe the bank failures of the period and ascribe many of them to the Federal Reserve's unexpected unwillingness to serve as a lender of last resort. Bank failures and tight monetary policy led to a reduced supply of money, and this led to a falling price level. They argued that this was the way that bank failures damaged the economy. This fascinating argument made me curious about the financial system and monetary economics. It is interesting to note that this book also helped to form Ben Bernanke's research interests after Stanley Fischer suggested it to him in graduate school. Discussions with Professor Jerome Stein during and after the course helped me understand the process of economic research. Stein was a monetarist like Friedman, but he was a student of James Tobin, a Keynesian. He had the highest respect for both Friedman and Tobin. He encouraged me to go to Yale to work with Tobin.

I began to study in the economics department at Yale in 1975. Some ideas from the emerging field of financial economics showed up in the first-year macroeconomics courses. James Tobin put financial markets and intermediaries at the center of his models of the effects of monetary and fiscal policy. I soon met Martin Shubik who was working on a theory of money and financial institutions. He pointed out many unsatisfactory predictions of the competitive market general equilibrium theory, as well as many questions that this theory could not address. Nothing could be more useful to someone looking for a topic to study. Martin's research used noncooperative game theory to model trade with money and price formation as a playable game. Banks were important in payments and the price formation mechanism. Although I never succeeded in adopting his methodology, I learned that one could use game theory to reexamine important applied issues in economics.

I learned about progress in financial economics during three summers as a research assistant at the financial studies section of the Federal Reserve Board of Governors. I realized that I could not understand banks unless I had a better understanding of financial markets. After discovering that Yale had no course offerings on financial economics, I arranged to take John Lintner's course at Harvard. Between that course and a careful reading of the detailed lecture notes from Robert Merton's course at the Massachusetts Institute of Technology, I became familiar with a good part of the research in the area. I took my oral field exams in the fields of finance and money, where I first met Steve Ross, who was one of my examiners in finance. He joined the Yale faculty the following fall (1977). I managed to pass the exams. I took Steve's financial economics course that fall and got a much better understanding of financial research. Steve presented one of the first models of optimal contracts between agents and principals in Ross (1973). Steve later became my main advisor and mentor. He taught me how to do research and how to better develop my ideas into transparent models.

Much of the theory in finance was real (nonmonetary) and based on perfectly competitive, informationally efficient markets. Corporate finance researchers were trying to overcome the Modigliani and Miller (1958) result on the irrelevance of capital structure. Incentives provision and agency theory had entered the field, along with studies of markets with private information. There was not much theory about financial intermediaries. Black (1975) argued that information revealed in equity market prices made obsolete many historic roles of banks. This motivated me to seek a possible role for banks in the presence of modern and informationally efficient financial markets.

## III. Why Do We Need a Theory of Financial Intermediation?

I started by asking why one should add a layer between borrowers and investors. The answer in a competitive market must be that the extra layer has benefits that exceed its costs. Before the 1980s, the primary models of financial intermediaries assumed that intermediaries reduce transaction costs. A production function for producing financial assets and liabilities was assumed, and intermediaries with lower transaction costs than individuals were analyzed using neoclassical production theory and trade in financial markets (for surveys see Benston and Smith [1976] and Baltensperger [1980]). Some of the results described in this lecture do result in reduced costs, but the goal is to understand why financial intermediation reduces the costs.

My approach to understanding the role of financial intermediaries has been to think about the mechanisms they design and the contracts they write, and about how these effect real economic outcomes. These mechanisms go beyond what one can do by trading in financial markets. What good things can intermediaries do, and what other effects do they have? I next explore one approach to answering these questions.

## IV. Financial Intermediation and Delegated Monitoring

*Financial Intermediation and Delegated Monitoring*, published as Diamond (1984) but originally from my doctoral dissertation, Diamond (1980), asks the question, If investments in or loans to business borrowers might need monitoring, what is the best way to set up financial contracts? I provide a very simple example of the model, without many details. A more detailed example is in Diamond (1996).

Consider a borrower who needs to raise a large quantity of funding. Investors and borrowers are risk neutral, but borrowers have no funds of their own, and each investor's spare funds to invest are small relative to the amount needed to fund the borrower's project. For concreteness, suppose the borrower needs to raise 1, while each investor has $1/m$ units to invest, implying that a borrower needs to raise capital from at least $m$ investors. I assume that $m$ is very large, say $m = 10{,}000$. Each investor requires an expected rate of return of 5%. Therefore, the borrower must offer investors as a whole an expected repayment of 1.05. There is uncertainty about how much the borrower can actually repay. The investors know that if they lend 1 to a borrower, the borrower's project will produce either 2 or 1, and the probability is 1/2 for each outcome. The expected value of the cash that the borrower will have is 1.5. Because this exceeds the expected return that investors require, all investors and the borrower agree that the borrower has a profitable, positive net present value project to fund. Because we will see that one needs to provide incentives for the borrower to repay investors and only the borrower will observe how profitable it turns out to be, it is challenging to design a financing arrangement where the investors will be repaid enough to induce them to invest (providing them an expected repayment of at least 1.05 in total).

### A. *Providing Incentives to Repay via Financial Contracts*

There are many conflicts of interest in finance, but the most important one involves getting borrowers to repay investors when borrowers may prefer other ways to spend the cash flow that the project produces. They could spend it themselves, on various investments and projects that may or may not be profitable, or they could do more nefarious things with it, such as investing in a shady deal with a brother-in-law. How do we provide incentives to overcome these preexisting conflicts of interest? One way, monitoring, requires acquiring detailed information about the borrower's activities and requires decision making by investors. I defer a discussion of that option for now.

The other option to resolve the conflict is to write a contract that imposes a penalty on the borrower who does not repay, or more generally, a contract that sets penalties as a function of how much the borrower repays. This (complete) financial contract specifies in advance the penalties and consequences of each possible payment amount. It depends only on the amount paid and requires no extra information or decision making by investors. I will refer to the penalties as foreclosure, and focus on foreclosure as an example of a penalty, for the following reason. If you do not pay your home mortgage, the lender then has the right to take the house away from you. The lender may not get high recovery from selling the house, but that is only one effect of taking away the house. If you have children, a move might mean they have to go to another school district, which will cause family stress. There may also be stigma from failing to repay. This stress and stigma are penalties to the borrower. The borrower will generally value the loan collateral much more than the lender does, and would be willing to pay more than the lender's value of collateral to avoid foreclosure. To keep this example simple, I assume that the borrower will not repay at all if there will never be a penalty or foreclosure.

The investors would like to impose a penalty for low payments to give incentives for higher payments. There are two possible penalties. The investor can liquidate the collateral if the borrower pays too little, preventing the borrower from absconding with it, or the investor can impose a nonmonetary penalty on the borrower.[1] Bankruptcy in the world today

[1] Diamond (1984) assumes a nonpecuniary penalty on the borrower. Diamond (1996) assumes that liquidation or foreclosure reduces investor and borrower payoffs to zero. Townsend (1979) assumes contractual commitment to judicial verification of the borrower's cash after a default, reducing borrower payoffs to zero, and subtracting a fixed cost from total investor payoffs.

is some combination of these two actions. In ancient history, nonmonetary penalties, such as debtors' prison and physical penalties, were very common. Such sanctions are now illegal, but the loss of reputation of a borrower is similar to a sanction.

Imposing penalties or taking collateral away from its best use is inefficient. Presumably, there was no great joy for an investor in sending anyone to debtors' prison, but the fact that you might face imprisonment served to increase your incentive to repay. The good news about foreclosure is that it makes the borrower repay what is owed, but the bad news is that imposing this penalty is tremendously inefficient. As an investor, you do not want to do it very often, both because it inefficiently hurts the borrower and because it may also reduce what an investor can recover.

The optimal financial contract specifies a constant amount to repay, essentially saying, "If you pay investors this amount, there will not be foreclosure. Pay any smaller amount, and there will be." In the example considered here, the optimal way to impose it produces a simple debt contract without any other covenants or terms.[2] This type of debt is the optimal financial contract. If the penalty is sufficient, the borrower will repay whenever possible. However, if the borrower owes more than 1 and only has 1, the investors will foreclose. This is bad for the borrower. To keep this simple, I assume that the penalty is sufficiently large that the prospect of imposing it will induce the borrower to repay. This may also be bad for the investors (destroying some of the cash of 1).

Let me introduce some notation for readers desiring a bit more precision (feel free to skip this paragraph; I do not use any of this elsewhere). If the borrower has cash of $V$ and pays the investors $P$, the borrower's payoff is $V - P$ if there is no foreclosure specified for paying $P$. Any payment that leads to foreclosure gives the borrower a total payoff of $B$ and the investors as a whole a total payoff of $I$. The borrower will prefer to pay $P$, if possible, instead of a payment that leads to foreclosure whenever $V - P \geq B$. To keep the example simple, assume that $B = 0$ (foreclosure drives borrower payoff to zero). Foreclosure is inefficient when the sum of investor and borrower payoffs from foreclosure is less than the value of cash available, or $I + B < V$. I assume this and for most of the example, I will assume that $I = 0$ and that all cash is destroyed by foreclosure.

If the borrower had a constant amount available to repay, the debt with foreclosure contract would work perfectly: specify an amount below that constant amount of cash and the borrower would pay and the foreclosure would never happen. Recall, however, that there is uncertainty about how much the borrower can actually repay. The investors lend 1

[2] In Diamond (1984) there are many possible realized cash flows. Debt remains the optimal contract in which the size of the penalty depends on the amount repaid and there is no penalty if the debt is fully repaid.

to a firm whose project will produce either 2 or 1 in cash, and the probability is 1/2 for each outcome. Because investors need the borrower to pay back more than 1 (to average 1.05), and the borrower will not always be able to pay the amount that avoids foreclosure, they must write a contract that imposes foreclosure with probability 1/2. That would either cause credit to be tremendously expensive to the borrower, or if investors' recovery is sufficiently reduced by foreclosure, investors would not be willing to lend in the first place. For example, if the investors recover nothing from foreclosure, then half of the time, the investors get at most 2 and the other half they get nothing. Suppose that each investor requires at least a 1.05 expected repayment and therefore would not be willing to lend (their expected repayment would be at most 1).

The average value of the cash that the borrower has, the expected value, is 1.5. If there were no uncertainty and the borrower always had 1.5, debt contracts enforced by foreclosure would work perfectly. Even with uncertainty about cash to repay, the best financial contract is debt with foreclosure. In this example, it just works so poorly that the investors will not directly lend to the borrower.

### *B. Monitoring*

Another way to overcome the payment conflict of interest involves monitoring. Each investor can continuously monitor a borrower's business to make sure that these conflicts do not arise, and then the borrower will repay without ever having to foreclose. There are many interpretations of this monitoring. One is to be actively involved in decision making and approve or disapprove transactions funding activities that will not lead to repayment (such as using the cash generated by the project to fund illicit deals with one's brother-in-law, or another transaction that does not benefit investors sufficiently). The authority to block such transactions based on monitoring could come from loan covenants restricting certain types of borrower decisions. These covenants are useful only if monitoring allows the lender to observe the transactions. Another interpretation is for the investors to monitor the value of the borrower's operations and learn whether the cash from the project is 1 or 2. Then, instead of inefficiently foreclosing whenever too little is repaid, the investors who monitor can instead use the threat of liquidation and offer to refrain from liquidation so long as the borrower repays as much as possible. The investors can offer to accept 1 when that is the amount of cash available, but not when it is 2. This policy leads the borrower to pay the promised amount when cash is 2 and pay 1 when cash is 1. In this second interpretation, I assume that the investors have all of the bargaining power and will offer to accept less than the amount promised only when cash is 1. In either case, the costly monitoring is an alternative to using foreclosure that destroys value.

Monitoring takes time and resources. There are up-front costs of monitoring, such as learning about the operations of a borrower's business. We will see that it becomes exceedingly costly when the borrower raises funds from many small investors (in our example, 10,000 investors). If it costs $K$ to monitor, the total cost if $m$ investors monitor is $mK$. If the benefit of monitoring to the borrower and investors is less than $mK$, then investors will never monitor. If, in addition, unmonitored lending (with foreclosure to provide incentives) does not provide investors with the expected return they require, then borrowing directly is not feasible. The next section uses the example above to illustrate this.

### C. *Direct Finance without Monitoring*

In the prior example, direct finance without monitoring is not feasible. When foreclosure leads to a zero recovery, then the expected return from investing is at most 1 (receiving at most 2 with probability 1/2 and zero with probability 1/2), and this is below the 1.05 rate of return required by investors. If the borrower instead had a project that was sufficiently more profitable or safer, direct finance without monitoring would be available. For instance, if the project paid either 3 or 1 with equal probability, or if the probability of the project paying 2 were much higher than it paying 1, then direct financing would be possible.

### D. *Direct Finance with Monitoring*

With monitoring, the borrower can repay an expected amount up to 1.5, the full expected value of cash flows. Recall that direct finance involves 10,000 small investors, each making a small investment. Suppose monitoring costs $K > 0$. The cost of direct and duplicated monitoring of each small loan by each investor is incurred when making the loan. The total cost of monitoring is $10{,}000K$ and the expected net expected repayment after monitoring cost is no more than $1.5 - 10{,}000K$. This must exceed 1.05 for investors to be willing to lend, which requires that $K \leq 0.45/10{,}000$. If monitoring costs more than this it would not be profitable for each investor to monitor their loan. Direct finance with monitoring would be too expensive, so the best possible direct lending contract would be an unmonitored debt contract. But, when a borrower faces this volatile cash flow, although the best direct lending contract for this situation is unmonitored debt, this contract works poorly. Neither type of direct finance allows the borrower to raise funding.

Note that if the cost of monitoring were small enough, $K \leq 0.45/10{,}000$, it would allow monitored direct finance, but this would lead to a large duplication of effort. If possible, it would make more sense to delegate the monitoring and incur the cost only one time.

### *E. Delegated Monitoring*

Instead of having all 10,000 investors monitor their loans, we delegate the monitoring to one person called a banker. As it will turn out, the best contract to provide these incentives is the contract that banks use. That is, the bank contract structure is an optimal way to provide incentives for delegated monitoring. This is the main insight of Diamond (1984).

If monitoring of the firm and its cash flows is delegated to a banker, the borrower and the banker will know what was monitored. This monitoring will ensure that the borrower repays the banker. The question is, how do we get the bank to repay the investors? The banker can see, for example, whether the borrower and the brother-in-law are doing a deal, but the investors still cannot see that. Imagine that the banker, the brother-in-law, and the borrower get together and decide to say, "Let's just tell them we only have 1. We're not going to pay them more than that." The investors will only know how much the bank repays them, not the actual amount the borrower could pay to the bank. Without monitoring, we had a conflict of interest between the borrower and investors. With delegated monitoring, we inserted the banker to resolve the problem with the borrower, but it creates an added conflict of interest with the investors.

Just as in the earlier example with direct finance, there is a way to resolve this added conflict of interest. In that case, the borrower had to repay the investors, and if the borrower paid too little, there was a foreclosure. In this case, the bank writes a debt contract that specifies that if it pays too little, the default forces foreclosure on the bank. This threat of bank failure turns out to be a great incentive for the bank to monitor borrowers and to repay investors.

The optimal contract between the bank and investors (in this context, depositors) to provide incentives for delegated monitoring is a debt contract issued by the bank promising to pay the depositors. The bank will fail if it defaults on its contract and pays too little. The bank gets zero if it fails. This forces the bank to pay depositors. In addition, if the bank does not monitor, it will not have enough money to pay investors, and there will be a default. The bank will monitor as long as the value of its residual inside equity claim (a bonus pool from what is left after collecting loans and paying deposits) exceeds the cost of monitoring.

For this contract to provide incentives and be cost effective regarding the delegated monitoring, the bank has to be large and diversified. To understand why diversification is beneficial, consider this extreme example of perfect diversification. Suppose the bank makes many loans, and assume that exactly half of the borrowers' projects will produce a return of 2 and the other half will produce 1. There is no uncertainty about the amount the average borrower is going to pay, and the amount of cash that the bank could collect from the loans will always be up to 1.5. What investors do not know is which borrowers will have 2 and which borrowers will have 1, but it turns out that they do not need to know that.

Investors require a 5% expected rate of return, and this implies that the bank must promise depositors collectively at least 1.05 per borrower. The bank can always collect up to 1.5 per borrower, so any promised payment to depositors above 1.05 and below 1.5 per borrower can be made with certainty and will attract deposits. The promised payment from the borrower to the bank must be set a bit above 1.05 to leave a sufficient bonus payment to the banker to provide incentives to monitor and to avoid defaulting on the deposits. The bank will never fail. In this best case, bank diversification means foreclosure will never be needed, but will only be a threat. The bank issues perfectly safe deposits.

This is perfect diversification, but in the real world and Diamond (1984), banks have imperfect diversification. Banks are going to fail sometimes—maybe because they are small or exposed to a common source of risk such as the prospects of single industry, or maybe because they are very large but still extremely exposed to macroeconomic aggregate risks.

It is important that banks diversify and limit their exposure to aggregate risks. Banks can hedge some aggregate risks in markets. Banks might not have a sufficiently strong incentive to stay diversified and hedged if no one could see the choice. Because banks do not (or cannot) commit contractually to stay diversified and hedge aggregate risks; bank supervisors and regulators need to make sure they do both in order to make banks safe and efficient. Even if banks could contractually commit to diversification and hedging, there is an added role for supervision if there are negative external effects of their failure on other parts of the financial system. There has been a focus on diversification and hedging in supervision and regulation, but since the 2008–2009 financial crisis, stress tests have explicitly looked at the aggregate risks on bank balance sheets. They measure how exposed a financial institution is to large aggregate macroeconomic shocks that might bring down a diversified bank or even the financial system. In addition to measuring and limiting these risks, enforcing substantial diversification within a large bank is essential for banking to work well.

This contract structure provides optimal incentives for delegated monitoring using diversification of assets and issuing debt claims to investors. A modern name for it is pooling and tranching. Pooling is just another name for diversification: take a large number of imperfectly correlated loans and put their returns into a pool from which to pay claims to investors. Tranching refers in this context to giving investors senior claims, and having the banker retain some junior (inside) claims on the diversified pool to incentivize monitoring and payment. This structure also resolves many other financial conflicts of interest, such as the costly screening out of bad loans at the origination stage. DeMarzo (2005) presents a more general model of this. Most securitizations of financial assets use this contract structure, replicating this structure first used by banks.

As mentioned before, diversification does not work perfectly to eliminate risk, particularly when asset returns become highly correlated. We saw this in the housing crisis of 2008–2009: when house prices went down worldwide and in the United States in particular, the correlation between mortgage defaults increased dramatically. The diversification effect from pooling almost disappeared, and senior mortgage-backed securities became, unexpectedly, much riskier.

Nonetheless, in most situations, implementing delegated monitoring with pooling and tranching is an important and widely used financial technology. It provides incentives for bankers to take actions to increase the repayments of loans they make. These loans represent the intermediary's assets. Section V describes a contracting technology that improves the characteristics of an intermediary's liabilities.

Bernanke (1983) presents empirical evidence that bank failures in the 1930s led to adverse effects on subsequent access to credit. His interpretation of this finding is that the failures removed institutions with the ability to distinguish good and bad borrowers. A related interpretation is that a given bank's failure would destroy information. This would make it difficult for the bank's existing borrowers to get monitored finance, forcing some of them to raise costly direct finance or lose all access to finance.

### *F. The Choice between Bank Loans and Directly Placed Debt*

A borrower with a sufficiently profitable project with low volatility of cash can use the threat of foreclosure to commit to repaying debt without frequently incurring the costs of foreclosure. Such a borrower would prefer direct finance to bank loans. There is a related point based on lending dynamics. New borrowers without good reputations will borrow from banks, whereas those that survive and get better credit ratings will issue directly placed debt.

Diamond (1991b) considers bank monitoring that can resolve an added conflict of interest where borrowers with limited liability may prefer risky projects (which is sometimes referred to as risk shifting; see Fama and Miller [1972] and Jensen and Meckling [1976]). Young borrowers without a good reputation have poor incentives; they would prefer to choose excessively risky projects if not monitored, and must borrow from banks. Some of these borrowers always have risky projects, even when monitored. A borrower who repays monitored bank loans for a long time without default acquires a reputation consistent with not always choosing risky projects and this reputation would be lost on default. Once this reputation is acquired, it deters the borrower from choosing risky projects (reputation loss is a penalty that overcomes limited liability) and the successful borrower then issues unmonitored direct finance: directly placed debt.

## V. Bank Runs, Deposit Insurance, and Liquidity

Diamond and Dybvig (1983), which I wrote with Phil Dybvig, studies another reason why it is beneficial to have banks (or other intermediaries) in the middle between asset holdings and investors, and why the intermediaries use particular financial contracts. The focus is on the bank's liabilities, specifically on why banks issue so much short-term debt to finance long-term illiquid assets. We asked why do the banks choose to write contracts that leave them subject to runs if runs are so bad?

We assume that the bank's assets are long term and safe if held to maturity, but illiquid. We show why the bank's liabilities, its deposits, should be short-term debt and more liquid than its assets. This will imply that an investor who holds assets through a bank has an advantage relative to an investor who holds the same assets directly.

Bank deposits end up being more liquid than bank loans. The bank offers a deposit whose one-period return is higher than the return from holding and then liquidating a bank loan after one period. Bank deposits then provide some insurance against needing to get out fast. That is the first part of our model. We also demonstrate that banks *should* do this because sufficiently risk-averse investors prefer the liquid assets to illiquid ones. Investors prefer liquid assets because they do not know how long they will want to hold those assets. They might hold them for one period, or they might not need them right away and hold them for two periods. There is an important liquidity risk: even though these assets are safe, each investor holding directly faces the risk that they might need to get out early and get a low value, despite the fact that they will get a high value if they can hold to maturity. Liquidity is a form of insurance against the low payoff caused by an early need for funds.

I now reconsider and illustrate the ideas in Diamond and Dybvig (1983) and its simplified version in Diamond (2007).

There is an illiquid but safe asset that the investor or the bank could invest in. If the investor directly invests 1 in this asset, they can hold it for two periods and get 2, or instead hold it for one period and get only 1 back. In other words, if the investor is patient and holds to maturity, they double their investment, but if they get out early, they destroy half of that value. So there is a large loss of return if they get out early. There is also a one-period investment available that returns 1 per unit invested, but it is no better than holding the illiquid asset for one period.

Suppose that the bank issues deposit claims backed by the illiquid, safe asset. The bank deposit offers depositors a choice between 1.81 after two periods or 1.28 after one period. The key point is that if a depositor holds the illiquid asset directly, they only get 1 if they liquidate early after one period, whereas if they hold the bank deposit, they get 1.28. What matters in this example is that the 1.28 available from a deposit after one period is a number bigger than 1. This is creating liquidity because the bank gives investors a greater return over the short one-period horizon. It is not free for the investor, who has to give up some return over the long two-period horizon, but it is a form of insurance against the need for liquidity. If this liquid asset could be created, investors would prefer it to holding the illiquid, safe asset directly. We now show how a bank can create this liquid asset.

Suppose there are 100 investors and we know for sure 25 of them will need their money after one period (call them early investors) and the remaining 75 will need their money after two periods (call them late investors). While we know the proportions of the two investor types, we do not know exactly which ones will need their money early. For each risk-averse investor, there is uncertainty about when the funds are needed.

Suppose that the only people who pull their money out of the bank after one period are the 25 early investors who actually need their money then. In this case, we give 25 people 1.28, and we have to liquidate 32 illiquid assets to do so. This leaves just enough assets (or actually a few extra assets because I did some rounding) to pay 1.81 to the 75 people who leave their money in for two periods. If everybody is clear on this point, there will not be a run on this bank. The bank can create more-liquid deposits out of less-liquid assets. We can actually create liquidity here, which is good. If everyone forecasts that 25 will withdraw, this is a self-fulfilling prophecy. If this is the outcome, all investors are happy. They gladly put all of their money into the bank.

The trouble is that if the bank creates liquidity—which is to say, it pays more than 1 to the people who take their money out after one period—there is also a self-fulfilling prophecy that the bank is going to fail.

How does the bank pay 1.28 to the people who withdraw? It has to liquidate a larger fraction of the assets than the fraction of people who withdraw. If 25% of the depositors withdraw, the bank liquidates 32% of the assets. The deposits are paid on a first-come, first-served basis. If 100% of the people withdraw, though, the bank cannot liquidate 128% of the assets because it has only 100% to start with. It cannot give 100 depositors 1.28 each. So if the depositors think that everyone will ask for their money after one period, everybody making this prediction will rush to get their money out of the bank—because anyone who leaves money in the bank will get zero after two periods.

If you are a depositor and get there quickly enough after one period, you will get 1.28, but if everybody else has the same plan, there will soon be nothing left. If a run is expected, the bank will fail. If the bank is expected to fail, that will cause a run. This is a self-fulfilling prophecy, a Nash equilibrium. This is why short-term-debt runs can bring down a solvent financial intermediary. This is the main insight of Diamond and Dybvig (1983).

If you expect a run, you will want to get out early, and if you do not expect a run, you will not. These multiple self-fulfilling prophecies are one way of thinking about why the financial system is somewhat unstable. You could eliminate bank runs by paying depositors 1, the value of liquidating a loan to depositors after one period, but that would remove the value banks add from creating liquidity. There are only a few ways of getting liquidity creation without runs.

It is useful to provide an overview of why we structured the model as it is. We take solvency off the table as a reason for bank failures, for simplicity and clarity. Depositors all know that if it holds the long-term assets to maturity, the bank will be solvent. Because future insolvency is not the reason for a run, we will see that bank failures can be caused purely by the potential for runs.

One point I have emphasized in most presentations to non-economists over the last 15 years is that private financial crises are everywhere and always due to the problems of short-term debt.[3] Runs are not peculiar to banks; in fact, banks are just an example of the many types of financial institutions financed by short-term debt. We saw runs on money market mutual funds in 2008 and March 2020, on Lehman Brothers in 2008, on the stablecoins Terra and LUNA in 2022, and on short-term securitizations called asset-backed commercial paper in 2007; all of these things involve borrowing short and lending long and illiquid. All had runs, even though none were commercial banks.

If an institution borrows short and lends long and illiquid, it might create liquidity but will be subject to a run. This instability from runs is not only due to fractional reserves (less than 100% cash) in the commercial banking system. We have already understood that if the bank has to give you currency when you take your money out, and there is not enough currency in the vault for everybody to take their money out, a run will make a bank fail. That is the story in the movie *It's a Wonderful Life* (Capra 1946). As the film's protagonist, George Bailey, explains to his neighbors, their money is in Joe's house, not back in the vault. That is true. If everybody demands all of their money, the bank will fail. However, this is not the only model for policy makers and investors to think about when they are wondering where there may be a self-fulfilling run. It is not just about commercial banks and currency. It is about short-term debt. Lehman Brothers did not have to pay cash on demand to its investors, yet a run brought it down.

[3] I say private financial crises because governments have many ways to cause problems, and sovereign financial crises can come from fiscal policy and foreign exchange rates, for example. In Diamond (2008) and some earlier presentations, I omitted the word "private."

How does one prevent bank runs? Sometimes the contract can be varied a bit to deter runs by suspending withdraws if too many withdraw (this is called suspension of convertibility by banks or gates by mutual funds). Diamond and Dybvig (1983) show that this does not work to deter runs in general. Whenever the number of depositors who need to withdraw can fluctuate, a suspension might actually occur, and depositors may rush to get out before it does. Alternatively, a very solvent government (not all governments are) can provide deposit insurance that will stop this feedback loop. Another way is for a central bank to commit to lend to allow banks to survive a run. The commitment to lend is necessary, but sometimes absent in practice. The Federal Reserve did not lend to banks in the 1930s. In addition, even these solutions are not perfect because run risk migrates out of the regulated and insured sector to shadow banks (see Diamond and Dybvig [1986]).

The next sections describe some interpretations and applications of the model. This is in no sense a literature review. The intent is to provide my perspective on how the model can be used to understand some important issues.

### A. *Multiple Equilibria and Coordination Based on News*

Some might conclude that a model with multiple Nash equilibria has no predictive power and is irrefutable because one does not know which equilibrium will be selected. See Dybvig (2023) for a discussion of why one might disagree with this general point. In the context of Diamond and Dybvig (1983), there can be contracts that have desirable characteristics in some but not all Nash equilibria. It is useful to understand the possible ways to address the issues caused by using these kinds of contracts. In addition to considering social mechanisms to avoid runs (such as deposit insurance), there are implications for policy makers and the managers of private institutions without deposit insurance that are financed with short-term debt.

Because moving away from a good equilibrium with no run requires a large change in the beliefs of many depositors, the initiation of a run when none is expected requires something that most depositors see (and believe that others see). Suppose that we continue to assume that assets are safe but illiquid, and the only source of runs is a pervasive fear of a run. An inaccurate newspaper story that the bank is performing poorly could cause a run that includes withdrawals by those who know the story is inaccurate, because they may believe that many others will decide to withdraw based on the story. Widely disseminated news of runs on other institutions could also lead to runs. These commonly observed variables are referred to as sunspots by Cass and Shell (1983) when they contain no other information. One idea discussed by bank managers that can be interpreted as seeking to reduce sunspot-based runs is the use of diversified funding sources. Diversified sources can be taken to mean that each depositor sees a different bit of news so that there are few commonly observed information sources seen by a large number of depositors. Getting funding from depositors in different regions (with different news sources) may reduce run risk. Similarly, for shadow banks, raising uninsured funding largely from small retail investors (who may not observe the news or be aware of prospective panics) as opposed to institutional investors may reduce run risk. Retail investors, even if uninsured, are less likely to see things that forecast when others will run and thus are less prone to run. There is some evidence for this in Schmidt, Timmermann, and Wermers (2016) from runs on prime money market funds in 2008. Runs were much larger and more rapid for funds targeting institutional investors than for funds targeting retail investors. This was true even though the two types of funds held very similar assets.

When only a fraction of investors see the information that can cause coordination on a run, there can be partial runs where only some deposits are withdrawn. Preventing a self-fulfilling partial run does not require a bank to hold as much liquidity as preventing a full run. This is explored in Diamond and Kashyap (2016) in the context of studying reasons to regulate bank liquidity holdings.

### *B. Different Information about Solvency Observed by Different Depositors*

When depositors observe differing pieces of information about the long-run solvency of bank assets, this may cause them to have differing forecasts of the number of other depositors who will run. There are some very interesting analyses of runs in this context. Morris and Shin (2000) and Goldstein and Pauzner (2005) introduce risky illiquid assets and privately observed diverse information about the long-run value of these assets. Diverse information means that investors see information correlated with solvency that is informative but each sees a different informative signal. This information is useful for predicting both long-run solvency and the probability distribution of the quantity of withdrawals from the bank. It can predict withdrawals because the worse the news, the larger the payoff from withdrawing for any given number of withdrawals by others. The information on long-run solvency then also predicts short-run solvency due to the losses from liquidation of illiquid assets due to withdrawals. This approach is useful because it provides a way to think about the effects of solvency information on runs caused in part by illiquidity. It may also sometimes provide a unique equilibrium distribution of beliefs about long-run values and withdrawals once one takes a position on the risk of the assets and the information observed by depositors. Dávila and

Goldstein (2023), characterize optimal deposit insurance levels when there are runs caused by forecasts of runs on illiquid banks with risky assets.

### C. *More General Cost Advantages for Financial Intermediaries*

Diamond and Dybvig (1983) assume that the long-term asset can be liquidated after one period with no loss of initial investment and that this one-period return is equal to the one-period return on short-term liquid assets. We made this assumption because it allows the model to abstract from the bank's initial portfolio choice to focus on the sharing of liquidity risk. Another consequence of this assumption is that financial intermediaries do not have any cost advantage over investors in holding short-term assets. When long-term assets are even more illiquid (and can be liquidated early only at a loss of some of the initial investment amount compared to no loss for a one-period holding of liquid assets), an intermediary has an additional advantage over direct holdings of assets. An intermediary then has a lower opportunity cost of obtaining liquidity. An extreme version of this is an illiquid asset that cannot be sold or liquidated at all before maturity (and thus has value only at maturity). In this case, the only way an individual could earn the one-period return of short-term assets would be to invest in them exclusively. An intermediary that wants to offer the one-period return of short-term assets and knows the fraction of depositors who will withdraw early would only need to put that fraction of its portfolio into short-term assets. This value of sharing the returns from holding an inventory of liquid assets is referred to as the asset management of liquidity.[4] This asset management and shared inventory advantage of banks is implicit in Edgeworth (1888) and is present in the models of Bryant (1980), Cooper and Ross (1998), and Allen and Gale (2004), among many others.

### D. *Deposit Insurance and Solvency-Based Runs with Risky Assets*

Bryant (1980) studies runs and deposit insurance using an overlapping-generations model of an endowment economy. Some investors will receive private information about their need for liquidity early within a generation. There is a role for banks because long-term assets (bank loans and government bonds) are very illiquid and holding cash or reserves as liquidity is a lower-cost way of getting early liquidity. This is the asset

[4] When intermediaries can provide this better access to liquidity, it raises the question of what causes the low prices for selling long-term assets in the market. One approach is in Diamond (1997), based on limited participation in asset markets.

management and shared inventory advantage described above. Banks lead to efficient outcomes if long-term assets are safe, due to their superior opportunity set as compared to individuals. The social goal is to provide the short-term rate of return equal to that of holding money at the lowest opportunity cost. When long-term assets' resale value is risky (due to the risk of low endowments of the next generation who will buy them) and some depositors have private information about that endowment, there can be runs by informed depositors who know the bank must be insolvent. These information-based runs, which occur only if some depositors know that the bank will be insolvent even without a run, can be eliminated by government deposit insurance in some cases and this may be desirable. This is another role for deposit insurance. In some sense, this role of deposit insurance is the mirror image of that in Diamond and Dybvig (1983), where it prevents liquidity-based runs on banks known to be solvent absent a run. In practice, deposit insurance serves both roles.

## VI. Incomplete-Contract Models of Commitment to Repay Based on Collateral

A frequently used model of the maximum that a borrower can commit to repay an investor is the value to the investor of the collateral that can be pledged. In turn, the limit on what can be repaid limits the amount that can be borrowed. Important examples of this collateral constraint model include Hart and Moore (1994) and Kiyotaki and Moore (1997). This value of collateral is what an investor can obtain once they have foreclosed given a default. In these incomplete-contract models, the borrower is allowed to renegotiate debt but the investor can foreclose and obtain the value of collateral. This puts a floor on what the investor can receive. Conversely, the borrower can renegotiate any contract that will give the lender more than the collateral value, and the borrower can never commit to repay the lender more than this amount.

The next section describes my work with Raghuram Rajan that uses and generalizes these incomplete-contract collateral-based lending models to study relationship-based lending and liquidity creation by financial intermediaries. These structures allow a borrower to commit to repay more than the value of collateral. We will show in section VIII that the financial intermediation contracts presented above also allow borrowers to commit to repay more than the value of collateral.

## VII. Liquidity Risk, Liquidity Creation, and Financial Fragility

Diamond and Rajan (2001) show how financing with short-term deposits, subject to a run, can allow a bank or shadow bank to use its relationship lending skills to lend more than the collateral value of its loans to borrowers (referred to as entrepreneurs) and simultaneously borrow more from depositors than the collateral value of its loans. Instead of monitoring, we consider a relationship lender who develops skills to redeploy the entrepreneur's collateral assets more efficiently than unskilled lenders do. Let us define the collateral value of a borrower's assets as the amount that an unskilled (nonrelationship) lender can obtain by redeploying or selling them.

Similar to the collateral constraint model in Hart and Moore (1994), an entrepreneur can commit to repay the relationship lender the value this lender can obtain by redeploying the entrepreneur's assets. An entrepreneur who borrowed from unskilled lenders would be able to commit to repaying them less (the value of collateral to them). As a result, the relationship lender can lend more to the borrowers than the value of collateral. However, when the relationship lender needs funding from unskilled lenders, there is an issue of how the relationship lender commits to use relationship skills on their behalf.

Diamond and Rajan (2001) explain why the relationship lender can commit if it issues short-term bank deposits, paid on a first-come, first-served basis, to unskilled lenders; that is, it becomes a bank. The bank thus creates liquid deposits out of illiquid loans, and by issuing demandable deposits, can borrow more against the loan than it could sell the loan for on any date. This creates more liquidity than in Diamond and Dybvig (1983). Consider the example from section V where the bank paid 1.28 to each of 25 depositors (32 in total) who withdrew at date 1. It liquidates or sells underlying assets at the value that anyone could obtain. In Diamond and Rajan (2001), the bank can commit to pay this amount (1.28 each) even when the bank assets are each worth much less than 1 if sold. The bank can, once committed to doing so, use its relationship skills to collect the loan to pay depositors.

Importantly, the threat of a bank run commits the bank to honor the obligation to pay depositors what is promised without attempting renegotiation, even if the promised payment is above the collateral value of the loans. In a run, depositors foreclose on the bank and force all the loans to be sold or liquidated, leaving the banker with nothing. The threat of such a harsh punishment ensures the bank will commit to repay deposits whenever possible. In sum, short-term debt gives the bank a stronger commitment to pay than long-term debt. This is another reason why banks and shadow banks finance long-term illiquid assets with runnable short-term deposits when the reason for illiquidity is relationship lending (or more generally, any value they add to lending due to monitoring or other private information). In addition to allowing a bank to commit to pay deposits now, short-term debt commits it to use skills to pay them in the future, allowing it to issue new deposits to pay off depositors who want repayment even when the bank could not sell its assets today for the amount raised by deposits.

There is a more subtle point in Diamond and Rajan (2001), which explains why the punishment a bank suffers when defaulting on short-term debt is harsh relative to that experienced by an entrepreneur defaulting on short-term debt. The reason is that the banker's loan collection skill merely transfers value from the borrowing entrepreneur to unskilled lenders. In contrast, entrepreneurs actually add value by operating the firm. This means that after a run, entrepreneurs and bankers will face very different outcomes. After a bank run, depositors have seized the loan the bank has made to the entrepreneur. The depositors' threat of hiring the banker to collect the loan will by itself commit the entrepreneur to pay the loan. Since the banker does not generate independent value, the banker's payoff will be reduced to zero after a run. In contrast, after a run by a nonfinancial firm's investors, if the entrepreneur is still the best manager for the firm's assets, the firm will be reorganized with the entrepreneur still in charge (and still being compensated for skills in adding value). As a result, short-term debt disciplines intermediaries, not firms.[5]

In sum, banks and shadow banks create additional liquidity by financing with short-term debt, with the threat of run as a commitment to collect relationship-based loans on behalf of unskilled depositors. They can borrow the full value of their loans, but can only sell them for the low (collateral based) value that unskilled lenders can collect.

In Diamond and Rajan (2001), the relationship loans are risk free but illiquid because they require relationship lending skills to collect. When all loans are free of risk, the bank can raise all of its outside funding with short-term demand deposits, and this can commit the bank to collect the loans without earning any rent. Diamond and Rajan (2000) consider risky relationship loans in this framework. In that situation, the banks finance with a combination of outside equity (bank capital), to absorb some of the loans' risk, and short-term demand deposits, to use the threat of runs to commit the bank to collect loans without earning extreme rents. Using more capital increases rents to the banker and optimal bank capital trades off the stability from higher loss-absorbing capital against the increase in rents. This implies an optimal level of bank capital.

Short-term demand deposits paid on a first-come, first-served basis are a disciplinary device for relationship banks with unskilled depositors in Diamond and Rajan (2001). This is complementary to the role of demand deposits in Calomiris and Kahn (1991), where they provide incentives for depositors to monitor the bank and detect trouble early. The depositors

[5] Diamond (2004) shows that short-term debt runs on firms can commit investors to imposing a legal mechanism, similar to bankruptcy, which is costly both to them and to the entrepreneur, in order to discipline the entrepreneur.

who detect trouble and withdraw quickly, before the bank fails, get a higher return than those unaware of trouble. One interpretation of depositors who will monitor is interbank deposits. Diamond and Rajan (2001) allow for discipline from less-informed unskilled depositors, who run when they are faced with publicly observed threats of losses.

*Applications of Diamond and Rajan (2001).*—Raghuram Rajan and I have used our framework to analyze several important issues in financial intermediation and its regulation. Diamond and Rajan (2005) use the model to study contagious bank or shadow bank failures due to runs induced by sharing a common pool of liquidity available to pay depositors. Diamond and Rajan (2006) examine nominal deposits, money, and their impact on runs. Diamond and Rajan (2011) show how fears of an elevated risk of short-term debt runs can lead to a freeze in the markets for assets such as mortgage-backed securities, as well as reduced lending. Diamond and Rajan (2012) study central bank interest rate policy and show how excessive provision of liquidity (committing to very low short-term interest rates for long periods) can give banks incentives for excessive short-term debt that might undermine financial stability.

## VIII. Contracts and Institutions to Commit to Repay More than the Value of Collateral

Financial intermediaries described in Diamond (1984) and Diamond and Dybvig (1983) also allow borrowing more than the value of collateral to investors. While there are overlapping insights, the mechanisms for achieving this outcome are different.

Monitoring by the banker in Diamond (1984) allows the borrower to commit to repay the banker more than the value of collateral by shutting down the ability to redeploy funds to activities other than debt repayment. The threat of bank failure, induced contractually by default and not a choice made by depositors, provides incentives for the bank to pay its deposits.

The link of Diamond and Dybvig (1983) to borrowing more than the value of collateral is different. The value of the collateral is low if liquidated early: in the example the bank assets can be liquidated either for 1 after one period or for 2 after two periods. When the bank creates liquidity, it offers those who withdraw at date 1 more than 1 (it offers 1.28 in the example). The bank actually liquidates assets to make the payments on date 1. The bank can remain solvent despite this promise (and payments will not exceed the value of collateral) if only a fraction of depositors withdraw. In the example, this fraction is 0.25 when only the 25 early depositors withdraw, but the bank is insolvent if all withdraw. This example highlights the link between liquidity creation, by promising to pay more than the value of collateral on a given date, and the possibility of runs on short-term financing. The deposit contracts reshuffle liquidation payoffs across periods to create more liquid deposits. The only contract that is free of runs is one where the payoffs are identical to the asset liquidation payoffs on both dates, with no reshuffling, never borrowing more than the value of collateral.

## IX. Short-Term Debt Issued by Nonfinancial Firms

Commercial paper is short-term debt issued as a security to investors (as opposed to issued as a private placement to be held by financial intermediaries, e.g., bank loans). Financial intermediaries such as banks and securitization vehicles issue the vast majority of commercial paper in the United States. Nonfinancial firms issued less than 23% of the total commercial paper outstanding at the end of 2022.[6] My research discussed above shows that producing short-term debt issued to investors is an important service of financial intermediaries. I have done some research on the role of short-term debt issued by nonfinancial firms. It helps explain why most nonfinancial firms do not issue commercial paper.

Diamond (1991a, 1993) presents an analysis of the maturity choice of firms issuing debt securities. Short-term debt matures before cash flows are realized and must be rolled over. Only firms with high credit ratings will choose to issue short-term debt, and its default risk will be low. This is a description of the issuers of commercial paper. Firms with somewhat lower "middle" credit ratings will choose to issue long-term debt and low-rated firms will have no choice but to issue risky short-term debt (which can be interpreted as bank loans if banks can restructure defaults at lower cost than individuals). There are two forces that yield these implications. The first is a preference for long-term debt, if available, by all firms due to the possible liquidity risk of losing access to financing when rolling over debt. This loss of access occurs if future bad news lowers their credit rating sufficiently that investors will not refinance maturing short-term debt. The investors foreclose even when the firm's total future value (including any non-pledgeable portion that investors cannot get their hands on) exceeds the liquidation value they can obtain. This liquidity risk is similar to that in Holmström and Tirole (1997, 1998) and Bernanke and Gertler (1989). Importantly, low-rated firms cannot raise initial funds unless they issue short-term debt that gives the investors liquidation rights when it cannot be rolled over. However, higher-rated firms can get investors to lend long-term debt, removing this right to liquidate soon. This protects them from foreclosure that destroys the non-pledgeable part of firm value. The second force is borrowers' private information about their own

[6] Commercial paper data are at https://www.federalreserve.gov/releases/cp/outstanding.htm.

creditworthiness. Borrowers who know that the market underrates them when issuing debt know that their credit rating will increase on average (but may decrease). Issuing short-term debt reduces their financing costs on average, because when there is good news, it will reduce the interest rate when they succeed in refinancing their debt. This makes short-term debt attractive to high-rated borrowers who have a very small probability of sufficiently bad news that would cause them to be liquidated. This leads them to prefer short-term debt even though they could issue long-term. If they had no private information, they too would choose long-term debt.

Diamond and He (2014) show that short-term debt can reduce investment incentives (have more debt overhang over investment payoffs to equity) than long-term debt, once refinancing dynamics are considered, if asset volatility is higher in bad economic conditions than in good conditions.

## X. Conclusion

My research studies financial intermediaries as optimal mechanisms to resolve problems caused by private information about liquidity or by conflicts of interest. The problems that I analyze yield financial contracts that closely resemble those used by intermediaries in the world. This allows one to use the results as a lens to understand the financial system. In particular, the results provide a reason why particular contracts are written and how they shape outcomes to preexisting problems.

An aim of this research is to build and analyze models that policy makers, scholars, and managers in the financial system can use to interpret the world in real time. They provide a way to interpret the events in the credit crisis of 2007–2009. At the same time, crisis events of the past provide a way to access the validity of the models by looking at what they say about the unfolding of economic and financial outcomes and the effects of policies implemented by central banks and governments in response to these outcomes.

My research focuses on the pooling and tranching contract and the short-term debt contract. The pooling and tranching contract structure describes banks and modern securitization vehicles. Short-term debt is a key product of financial intermediaries, both as their liability and as their asset in the form of short-term bank loans and lines of credit.

Short-term debt serves many functions, and some of them are in conflict. Short-term debt issued by financial intermediaries is valued as a liquid claim by investors. The side effect that it is subject to runs is a source of instability in Diamond and Dybvig (1983) and both a desirable commitment device and a source of instability in Diamond and Rajan (2001). This makes the design of regulations and policies about short-term debt difficult and necessarily quantitative. One should not simply outlaw short-term debt or leave it as an unregulated choice of financial intermediaries, especially when the government or central bank intervenes when there is trouble. Short-term debt is an important source of benefits from the financial system but also a large reason for its instability. A goal of my research program with my coauthors is to frame these issues in a way that allows them to be seen more clearly and precisely.

One of the first times that I presented Diamond and Dybvig (1983), a member of the audience suggested that since the world had learned how to avoid financial crises in financially developed economies, the presentation would be better suited for the economic history workshop. The world had not learned how to avoid crisis even in 2008, and as a result this area attracted more research after 2008, and policies were changed. Since it is unlikely that we understand completely the role of the financial system and its impact on economic stability, the door remains open for important future research advances.

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