

# Introduction to the Special Issue on the Diamond-Dybvig Model

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Edward Simpson Prescott

This special issue of the *Economic Quarterly* is dedicated to the 1983 model of bank runs developed by Douglas Diamond and Philip Dybvig.<sup>1</sup> Their model has been a workhorse of banking research over the last 25 years and during the recent financial crisis it has been one that researchers and policymakers consistently turn to when interpreting financial market phenomena.

The Diamond-Dybvig model has three basic elements:

- Long-term investments that are more productive than short-term investments;
- A random need for liquidity on the part of an individual; and
- Private information about an individual's need for liquidity.

With these elements, Diamond and Dybvig (DD hereafter) show that it is desirable for people to pool their funds and jointly invest in productive long-term investments, while allowing individuals to withdraw their funds on demand, even before the end of the life of the long-term investments. Furthermore, they show that it is also desirable to set payouts for early withdrawals high enough so that if every person in the pool withdrew his funds early, there would not be enough funds available to meet every withdrawal.

DD interpreted this arrangement as a bank because it contains two important characteristics that are typically identified with banks. First, it performs

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■ The views expressed do not necessarily reflect those of the Federal Reserve Bank of Richmond or the Federal Reserve System.

<sup>1</sup> The paper appeared in the *Journal of Political Economy*. The full citation is in the references as Diamond and Dybvig (1983). A freely available reprint is Diamond and Dybvig (2000). For a simple exposition of this model, see Diamond's 2007 *EQ* article.

maturity transformation, that is, it backs short-term liabilities with long-term illiquid assets. Second, it issues liabilities that are payable on demand, that is, bank deposits.<sup>2</sup>

According to DD, while this arrangement is effective at increasing output and providing liquidity insurance, it is also susceptible to a bank run. In their environment, there is a coordination problem among depositors. If too many people withdraw early, then the long-term investments are liquidated early causing a loss in output. DD show that there is such an equilibrium in that depositors who do not need early liquidity will still withdraw early because they think that other depositors without an early liquidity need are going to withdraw early. This inefficient allocation is an equilibrium (as is the efficient allocation) even if the bank is solvent.

Diamond and Dybvig also discuss several mechanisms for eliminating the run equilibrium. These include deposit insurance, suspension mechanisms, and central bank lending. All of these mechanisms have been used to various degrees over time. The United States has had federal government-provided deposit insurance since 1933. The precursors to central banks, the clearing-houses, often would suspend payments during a financial crisis (Timberlake 1984). Finally, the lender-of-last-resort justification of central bank lending has been used heavily in this crisis and it was heavily used historically. For example, Bagehot (1873), when writing about the Bank of England, gave his famous dictum that to prevent a financial panic, a central bank should freely lend at a penalty rate on good collateral.

## **1. DIAMOND-DYBVIG AND THE RECENT FINANCIAL CRISIS**

Until recently, bank runs were not considered a major problem in the United States. The introduction of deposit insurance in the 1930s was considered to have essentially solved this problem. There had been very few bank runs since then.<sup>3</sup> Much of the academic literature instead focused on the sizeable costs of moral hazard that can come with a deposit insurance system, as was seen in the savings and loan crisis of the 1980s (see, for example, White [1991]).

What the academic and policy worlds missed was just how much some of the newer (since the 1970s) financial arrangements were starting to resemble banks in that they performed maturity transformation and financed assets with

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<sup>2</sup> The other characteristics typically identified with banks are delegated monitoring and payment services. For a theory of the former, see Diamond (1984). As for the latter, there is an extensive literature on payments and monetary economics, a portion of which uses models closely related to DD. In this issue, Cavalcanti and Jack, Suri, and Townsend discuss this literature.

<sup>3</sup> The bank runs that did happen tended to be isolated and on a small scale. For example, in 2005, there was a run on Abacus, a small bank in Chinatown, New York (Campbell 2005). In the 1980s, there were runs on some savings and loans, but these operated under state-sponsored insurance schemes (Todd 1994).

liabilities that resembled demand deposits. Many of these arrangements ran into trouble during the financial crisis when they could not roll over their short-term debt. Whether these episodes match the DD equilibrium in which a solvent bank is run because of a panic is still a topic of debate. After all, a run on a bank is also perfectly consistent with a bank being insolvent.

What we do have now, however, are data that are much higher quality than are available on historical runs.<sup>4</sup> Furthermore, as we will see, these financial arrangements differ along dimensions such as how excess short-term withdrawals are managed. My conjecture is that these sources of variation along with the data will provide an important source of information for not only evaluating the DD model, but also evaluating methods for dealing with a potential run.

### **Bank Runs**

In the recent crisis, there were several runs on traditional banks. In the United Kingdom, Northern Rock bank was unable to roll over its wholesale funding in the fall of 2007, and that led to large withdrawals by retail depositors who, at that time, were not protected by deposit insurance.<sup>5</sup> In the United States, there were large withdrawals from IndyMac, a bank that specialized in alt-A mortgages, many of which were made in California (Office of the Inspector General 2009). Washington Mutual experienced large withdrawals in July 2008 and shortly after the failure of Lehman Brothers in September 2008 (Grind 2009).

### **Auction Rate Securities**

Auction rate securities (ARS) are long-term debt securities that are transformed into short-term securities through regular periodic auctions.<sup>6</sup> The auctions set the short-term interest rate and allow for the transfer of ownership. If a holder wants to sell the bond, he places a sell order, and if there are enough bids in the auction, he sells his security. If there are not enough bids, then he keeps the security and the issuer of the bond pays a predetermined rate in the contract, often one that is relatively high. ARS are issued by municipalities, student loan pools, and closed-end mutual funds.

At first glance, ARS look like any other security with varying liquidity. They were, however, marketed and treated as cash-like securities.

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<sup>4</sup> There was a debate about whether the runs in the 1930s were due to a DD-like bank run equilibrium occurring for a solvent bank or whether they occurred because the bank was insolvent. See Calomiris and Mason (1997).

<sup>5</sup> For a description of the Northern Rock run, see Shin (2009).

<sup>6</sup> Information in this section is from Han and Li (2008).

Furthermore, if there were not enough bids to clear an auction, the sponsoring entity, which was either a large bank or investment bank, would often provide enough bids to clear the market.<sup>7</sup> However, in the spring of 2008, the sponsoring banks started pulling their support. This contributed to a sizeable demand by investors to pull out of the market, and there was a large increase in the number of auction fails. Han and Li (2008) interpret this event as a run.

### **Special Purpose Vehicles**

Another group of bank-like entities that developed are trusts that hold securities and are financed by a mix of short- and long-term debt (along with a small amount of equity occasionally). These trusts, set up by banks and investment banks, are also known as structured investment vehicles and collateralized debt obligations. Many of these trusts hold long-term securities, such as mortgage-backed securities, and finance part of their investment with commercial paper, which is a short-term, cash-like liability. The commercial paper issued by these trusts is similar to bank deposits in that a lender who chooses to roll over the commercial paper is analogous to a depositor who withdraws his deposit from a bank.

Covitz, Liang, and Suarez (2009) use daily data from August 2007 to December 2007 on the ability of these vehicles to roll over their commercial paper. They found that specific features of the programs, such as the existence of liquidity support, affected the ability to roll over commercial paper. They also found difficulties in rolling over debt that are not explained by these differences and conclude that this is evidence of a bank-like run caused by a panic.

### **Repo Markets**

Repo transactions are short-term agreements to sell and repurchase securities. They are essentially short-term collateralized loans. The loans are often made by wholesale institutions such as money market funds, corporations, hedge funds, and other entities that have a lot of cash to invest. Since their cash holdings are too large to benefit from deposit insurance, they instead make these collateralized loans.

The broker-dealer investment banks (e.g., Bear Stearns, Lehman Brothers, Merrill Lynch, Morgan Stanley, and Goldman Sachs) partially financed their investments with these repo transactions. They would invest in long-term

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<sup>7</sup> Tender option bonds and variable rate demand obligations are similar to auction rate securities in that they are fundamentally long-term bonds that have a short-term interest rate determined through an auction mechanism. Unlike owners of ARS, owners of these securities have the option of putting the security back to the originator or marketer.

assets, often through securities, and partially finance the investment with the cash lent as part of the repo transactions. Gorton and Metrick (2009) argue that these repo transactions looked a lot like demand deposits. The lender could withdraw all his funds by not rolling over the repo or even partially withdraw his funds by requiring a large haircut on the valuation of the collateral. Gorton and Metrick also argue that there was a wide-scale panic in these markets as investors began to doubt the quality of collateral and shifted their funds to safer forms such as Treasury securities. Partly because of this movement, the five large investment banks either failed or converted into banks.

### **Money Market Mutual Funds and Other Investment Pools**

Money market mutual funds (MMMFs) are investment pools that invest in short-term liquid assets such as Treasury securities, commercial paper, repos, and certificates of deposit. Unlike other mutual funds, however, they use an accounting method that allows them to keep a constant net asset value (NAV) per share of one dollar. This convention makes MMMFs easier to use for transaction purposes and thus a close substitute for bank deposits. In September 2008, after Lehman Brothers failed, there were sizeable withdrawals from MMMFs. The immediate cause was losses to the Reserve Primary MMMF, which had a sizeable exposure to Lehman Brothers commercial paper. This loss led the fund to “break the buck,” that is, the NAV of the fund dropped below one dollar.<sup>8</sup> There were large withdrawals from this fund, followed soon after by large withdrawals from some other MMMFs. According to the Investment Company Institute (2009), there was a large shift of money market funds by institutional investors from prime MMMFs—those that could invest in nongovernment securities—to government MMMFs.<sup>9</sup>

One reason that the institutional investors ran is that money market fund accounting in certain cases can give an incentive to run. In order to preserve their stable NAV, MMMFs are not continuously marked to market. Instead, most use the “amortized cost” method to value their assets (Cook and Duffield 1993). This method values a security at its acquisition cost and accrues interest uniformly over the security’s remaining maturity. If the probability of a security defaulting goes up or, worse, if a default occurs, the value of an MMMF share will be temporarily less than the NAV of one. Selling shares in anticipation of such an event would let an investor in the pool receive the NAV of one, leaving other investors to bear the full drop in value of the securities.

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<sup>8</sup> Drops in the NAV have happened before to other funds, but the sponsor of the fund had always made a transfer to the fund to raise the NAV to one.

<sup>9</sup> Retail investors did not run their funds.

This was a factor in the large withdrawals from the Reserve Primary MMMF. Withdrawals from other funds may have been driven by similar concerns as well as a general concern that assets in prime MMMFs would end up illiquid or in default. Some funds suspended withdrawals and at least one liquidated in order to distribute its proceeds equally among its investors (Investment Company Institute 2009). Withdrawals from these funds were stopped with the government introduction of insurance for the MMMFs. Interestingly, according to Swagel (2009), a significant motivation in providing the insurance was the concern that *issuers* of commercial paper would not be able to roll it over and would be forced to make large draws on their lines of credit from banks, assuming they even had them.

Similar to MMMFs are government investment pools. Many states offer funds to their municipalities in which they can pool their funds to invest in cash-like instruments (Cook and Duffield 1993). The Florida investment pool ran into trouble when it took losses on its securities and some became illiquid. This led some of the Florida municipalities that participated in the fund to withdraw their investments. The Florida fund was unable to meet these redemptions, so it partially suspended redemption and worked out a long-term scheme to distribute its assets to its members (Evans 2007; Evans and Preston 2007).

The wide variety of financial arrangements that experienced run-like behavior demonstrate that the DD model is just as relevant today as it was historically. These arrangements also provide important data for evaluating the DD model and will motivate much future work on it.

## 2. THE ARTICLES IN THIS ISSUE

Since DD, a lot of work has gone into developing a better understanding of what is essential to Diamond and Dybvig's fragility result and what can be done to prevent it. This literature is large, spans a long period of time, and is often technical. The article by Huberto Ennis and Todd Keister gives people unfamiliar with DD a nontechnical overview of this literature. They pay special attention to the roles of sequential service and uncertainty about aggregate liquidity needs.

The article by Edward Green focuses on a more specific issue. He examines the role of limited liability and the optimality of bailouts for partially financing illiquid investments. He defines a bailout as a combination of early liquidation along with taxes and transfers that relax the limited liability constraint. In an economy with limited liability, he finds that state-contingent payments from the taxpayer to the banking system are part of an optimal allocation. He is careful to point out that he does not address moral hazard, which could significantly alter this conclusion.

Green's focus on the limited liability constraint is important, not only because of its implications for bailouts, but also because relaxing limited liability

was an important part of historical banking arrangements. Until the 1930s, equity owners of national banks in the United States had “double liability,” that is, they could be required to contribute up to the par amount of their equity to meet the bank’s obligations (Macey and Miller 1992). Furthermore, in the 18th and 19th centuries, many Scottish banks had unlimited liability (Cowen and Kroszner 1989). As we consider how to redesign the financial system, limited liability rules may be one direction worth exploring.

The final two articles are about monetary theory. Historically, monetary and banking economics are deeply connected. Circulating bank liabilities are often called “inside money,” that is, circulating debt that is backed by private assets. Despite this connection, money and banks are often modeled in isolation. The article by Ricardo Cavalcanti bridges monetary and banking theory by providing some recent history of thought about the two areas. He discusses the precursors to the Diamond-Dybvig model in which the traditional strategy, still found in textbooks, was to append a banking sector onto a market model. Cavalcanti argues that one of DD’s main contributions was to take the different strategy of mechanism design theory, which focuses on information frictions and does not take the market structure as exogenous. He then proceeds to connect this strategy with monetary theory, in particular, the random matching models in which related information and commitment issues make fiat money valuable. He concludes by pointing out how recent models in this literature are altering information assumptions in order to incorporate bank-like organizations.

The article by William Jack, Tavneet Suri, and Robert Townsend continues the monetary economics theme by describing the recent development of mobile phone banking in Kenya and juxtaposing these developments with monetary theory. One advantage of this strategy is that, by looking at an economy that is simpler on some dimensions than that of the United States, it is easier to measure and understand the forces at work. Indeed, a developing country economy can be viewed as a laboratory for understanding more complex environments, much like biologists study animal biology to understand human biology.

This line of research is very fruitful. Not only does it raise important monetary and banking policy questions for Kenya, but it also points to parallels with the United States. In Kenya, mobile phone e-money looks like inside money, just as some of the financial liabilities created by the U.S. financial sector, such as repos, also look a lot like inside money. One implication of the monetary theories that they describe is that there is not a simple monetary policy that is robust across the various classes of models. This has implications not only for Kenyan monetary policy but also for evaluating financial reform proposals in the United States.

### 3. CONCLUDING COMMENT

We in the research department of the Federal Reserve Bank of Richmond have been fortunate to have Doug Diamond as a visiting scholar for the last 20 years. Personally, I always look forward to his visits. He is full of ideas and energy and is a delight to talk to. This special issue is dedicated not only to honor his famous article with Philip Dybvig, but also Doug's many contributions to our research department and this journal over the years.

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