Bank Runs with Classroom Experiments

by

Todd Kaplan
University of Exeter

Abstract: Once relegated to cinema or history lectures, bank runs have become a modern phenomenon that captures the interest of students. We use a simple classroom experiment based upon the Diamond-Dybvig Model (1983) to demonstrate how a bank run, a seemingly irrational event, can occur rationally. We then present possible topics for discussion including various ways to prevent bank runs and moral hazard.

Introduction
The subprime crisis has led to spectacular events in the world of finance. Bank runs, once relegated to cinema or history lectures, have become a modern phenomenon. For the UK, the queues formed during the Northern Rock bank run have been imprinted on our memory. The run and subsequent suspension of payments of Icelandic banks has led to widespread losses. These dramatic events have generated interest among students wishing for understanding. In this paper, we offer a teaching experiment based upon the Diamond-Dybvig (1983) model that will help the students better understand bank runs and hence the current crisis.
Description and Analysis of the Diamond-Dybvig Model

Our experiment is based upon the Diamond-Dybvig model (1983), which captures several elements of what a bank does. Our experiment focuses on the conversion of long-term loans (mortgages) into short-term deposits. It is this conversion that leads to the inherent problem of bank runs.

In the model, there are depositors and a bank. There are three time periods: yesterday, today and tomorrow. Depositors placed money (say £1000) in a bank (yesterday) before learning when they need the money (their preferences). Depositors either need their money today (are impatient) or tomorrow (are patient). There is a 50% chance of needing the money at either time. The depositors that need money today get relatively very little utility for the money tomorrow. The depositors that need their money tomorrow can always take the money today and hold onto it.

The bank has both a short term and a long term investment opportunity for the money. The short term investment (reserves) is equivalent to locking the money in the vault. This investment returns the exact amount invested. The long term investment returns an amount R tomorrow. It is illiquid and returns only L<1 today.

The depositors that invested £1000 yesterday have a contract with the bank. They can withdraw their money today and receive £1000 or wait until tomorrow and receive R*£1000. Note, the bank needs to offer a contract contingent upon withdrawal time, since it does not know which depositors are patient and which are impatient, just the overall fraction.

The bank that received deposits yesterday had to decide how to meet the potential demands of today and tomorrow. How does the bank meet this contract? The bank can divide the money into two parts. Take half and keep it as reserves. Take the other half and put it in the long term investment. Say there are 10 depositors: 5 impatient and 5 patient. If the 5 impatient depositors withdraw today and the 5 patient depositors withdraw tomorrow, the demands are 5*1000 today and 5*R*1000 tomorrow. If the bank puts £5000 in the vault and invests £5000, then the bank has 5000 today and R*5000 tomorrow and can fulfil the demands.

What the above shows us is that if all the depositors withdraw the money according to their types, then the bank will meet all the demands. In this case, each depositor has incentive to indeed withdraw according to his true type. An impatient depositor prefers 5000 today to R*5000 tomorrow. A patient depositor prefers R*5000 tomorrow to 5000 today. Hence, all impatient depositors withdrawing today and all patient depositors withdrawing tomorrow is a Nash equilibrium.

---

1 The Diamond Dybvig model also captures a risk-sharing aspect of banking, namely, insuring depositors against needing money earlier rather than later. The contract used in our experiment is not the optimal risk-sharing contract, but one chosen to best illustrate the potential of bank runs.
2 We should also note that we are assuming that the bank makes zero profit (the industry is competitive).
3 An astute reader will note that a bank may not be able to pay the R*5000 tomorrow if 6 depositors withdraw tomorrow since it will only have 1000 from its reserves and R*5000 from the long-term asset; however, if the impatient depositor prefers 5000 today to R*5000 tomorrow, then he would also
While the contract is fulfilled in this Nash equilibrium, in other cases the bank cannot always remain solvent. If too many depositors try to withdraw today, it won’t be able to meet the contract tomorrow. For instance, if 7 out of 10 depositors withdraw today, then the bank can pay 5000 out of reserves. It then must sell its illiquid long-term asset to meet the rest of the needs. The amount that must be liquidated is X such that \( X \cdot L = 2000 \). The remaining amount to pay the 3 depositors tomorrow is \((5000 - (2000/L)) \cdot R \). If, for instance, \( R = 2 \) and \( L = .5 \), then this amount is 2000. Per depositor, this is less than the expected amount paid for withdrawing early. If a patient depositor thought 7 of the other depositors would withdraw early, then he would do better withdrawing early and receiving on average \((5000 + 5000 \cdot L) / 8 = 937.5 \) rather than waiting until tomorrow and receiving on average \( 2000 / 3 = 667 \).

We can see that this leads to multiple (Nash) equilibria which are inherent in banking. One of the equilibria is the bank-run equilibrium. It is fairly easy to see this by looking at the equilibria with 2 impatient depositors and 2 patient depositors. Yesterday, each of the 4 depositors invested £1000. The bank then invests £2000 in the short-term investment and £2000 in the long-term investment. Today, two of the depositors learn they are impatient and withdraw the money today (it is their dominant strategy). The remaining two patient depositors have to decide whether to withdraw their money today or tomorrow. We can model their behaviour in a 2x2 normal form game.

Let us look at this game when \( R = 1.5 \) and \( L = .5 \). If both patient depositors wait until tomorrow they would both receive £1500. If one withdraws today and the other tomorrow, the one withdrawing today receives £1000; however, the one withdrawing tomorrow will receive 0 because the bank needs to liquidate all its long-term investment to meet the extra demand of £1000 today (\( £2000 \cdot L = £1000 \)). If both try to withdraw today, then the bank still needs to liquidate all of its long-term assets. Now the bank doesn’t have enough to fulfil the extra £2000 demanded by its contract. How much can the bank pay out? It has £2000 in the short term investment and £1000 from liquidating its long-term. It has to divide this among the 4 depositors withdrawing today (two patient and two impatient). Thus, on average, each would receive £750. All these payoffs form the normal form game presented below:

prefer 5000 today to whatever amount the bank can pay tomorrow, since that amount is less than \( R \cdot 5000 \).
There are two pure-strategy Nash equilibria of this game: both patient depositors withdrawing today and both patient depositors withdrawing tomorrow. The bank run equilibrium is where both withdraw today. While this equilibrium is Pareto inferior, both have incentive to withdraw today since single-handedly deviating to withdrawing tomorrow will yield a payoff of zero. Hence, we theoretically demonstrate that while damaging, a bank run can be a rational, equilibrium phenomena. In the next section, we show how one can also demonstrate a bank run in the laboratory.
Results from a computerized session

The following figure shows the results of a classroom experiment run in Exeter on a single group of 18 students. Investor types (roles) were randomly re-allocated at the start of every round, with 9 students being type A (impatient) investors and 9 students type B (patient) investors. The experiment lasted 23 rounds and there were 3 treatments. In the first treatment, lasting 8 rounds, conditions were set for R=2 and L=.5 (we call this ‘normal conditions’). Toward the last few rounds of this treatment, the students settled into the normal equilibrium. Type A’s withdrew today and type B’s withdrew tomorrow. In the second treatment, lasting 10 rounds, we had R=1.1 and L=.11. We might refer to this as a ‘credit crunch’. Tight conditions for the bank: not much leeway if depositors try to withdraw early. In this treatment, there was a run on the bank. In the third treatment, lasting 5 rounds, we also had R=1.1 and L=.11, but payments were halted after 9 depositors withdrew from the bank early. This suspension stopped the run on the bank. There was an instant effect that steadily improved.

Discussion

---

4 There were 18 computer terminals and the students were paired up with an average of two to a computer.
As mentioned before, it is desirable to run the experiment before the lecture. I then like to show video clips from two Hollywood movies: Mary Poppins and It’s A Wonderful Life. These can really liven up a lecture. Mary Poppins is able to show how runs can start from rumours and how banks close their doors to stop further withdrawals. It’s A Wonderful Life shows how a systemic risk can cause a run. Jimmy Stewart also explains how a bank works by borrowing short and lending long. The movie also explains why a suspension can cause significant damage to depositors (some need money to live).

After this, one can start explaining the Diamond-Dybvig model as described above. If the students have studied normal form games, the reduced version of the game between two patient depositors captures the intuition of how there are two (pure-strategy) equilibria.

After explaining the model, one can bring up some of the many examples of modern bank runs. After this, one can explain possible policies that could help prevent bank runs in the future and what is missing from the model.

**Modern Bank Runs.**

We first started developing this classroom experiment before the Northern Rock bank run, so it is surprising in some sense to see many examples of modern bank runs. Here is a selection of some of the major ones.

**Northern Rock**
The most visible bank run in the UK was the 2007 run on Northern Rock. There were long queues of depositors outside the bank. As we learned, it was perfectly rational for depositors to want to withdraw their money early. Northern Rock did not follow the Diamond-Dybvig model precisely by taking money from depositors and investing part of it in the long-term investment. Instead, they invested amounts far beyond their levels of deposits. Naturally, this money had to come from somewhere and Northern Rock met this shortfall by borrowing from other banks. In essence, other banks became the depositors. When the subprime crisis hit, the mortgages that Northern Rock made were still performing, the problem was that these other banks acting as depositors became impatient and “withdrew” their money.

**Etrade**
In the era of Internet banking, a bank run takes a whole new form. While Etrade may have had sufficient insurance to cover almost all of its deposits, there was a run on the bank (participated in by one of the authors) since it was easier to transfer money out than to read in detail the deposit insurance description. Etrade survived (so far), but suffered significant damage in both reputation and by the necessity of having to liquidate billions in assets. Now Etrade makes sure their deposit insurance is well known.

**Bear Stearns**
Bear Stearns was an investment bank founded in 1923 and in 2007 had 14,000 employees. It focused on stock investments, hedge funds and brokerage (based upon the historical division of banks). Customers were firms and professionals. The market cap was at $20 billion in 2007 ($170 per share). Two hedge funds lost
billions in 2007. On March 11, 2008, there was a “bank run”. Money was withdrawn from accounts, within two days capital balance went from $17 billion to $2 billion. They couldn't sell assets instantly to cover demand and needed to borrow $30 billion. On Friday, March 14th, 2008, the Fed guaranteed a loan of $30 billion from JP Morgan to Bear Sterns. On Sunday, March 16th, 2008 it was announced that JP Morgan would buy the company for $2 a share (200 million total) later raised to $10/share. This is about the value of their building on Wall Street (worth more than 1 billion dollars).

As Krugman (2007) points out, in today’s financial world, a modern bank run does not have to be standing in a queue nor even have to happen at a bank. It can happen at hedge funds and many other financial institutions that borrow short-term and lend long-term.

Iceland
At the beginning of 2008, Iceland had a GDP of about 20 billion pounds (population of 300,000). Icelandic banks had deposits of 120 billion pounds (in foreign currencies). They lent the money to groups that bought assets. There was a run on Iceland and the country had to nationalize the three main banks. They suspended payments to a half million depositors: including many UK city councils (almost 1 billion pounds worth) and universities. The Icelandic government was only responsible for the first 15,000 pounds, but still is struggling to pay this amount.

Lehman Brothers
On September 15, 2008, Lehman Brothers with over 600 billion in assets filed for bankruptcy. The US government decided to let it fall. It isn’t clear whether there was a solvency or a liquidity problem. Still, this decision was controversial and may be considered a mistake of the magnitude of when the Fed allowed the Bank of the United States to fail in 1930 with 400,000 depositors, of which Friedman and Schwarz (1963) say helped steer the US into the great depression. History will help tell us how large the contagion effect was from the collapse of Lehman and whether avoiding this would have been worth a bailout. As for the Bank of the United States, it eventually paid 80 cents on the dollar and that was in the Great Depression.

Washington Mutual
On September 25, 2008, Washington Mutual went bankrupt after a 10-day bank run with withdrawals of $17 billion. This was the largest US banking failure to date. Washington Mutual had assets of $330 billion and 50,000 employees.

Prevention:
Now one can explain possible ways to help avoid a bank run or lower the effect.

Signalling. One of the older techniques was to put money in the windows of the bank. This is sending a signal that the bank has enough money so there is no need to panic. There are modern day equivalent of signals such as getting a large investment from Warren Buffett (as Goldman Sachs did).
Suspension of payments. What was done in the past was to suspend payments. This is closing the doors and preventing further withdrawals. We saw this was effective in the experiment, but there is a problem when the number needing money today is uncertain. One may also want to discuss when a partial suspension may help (lowering payments the larger the number that try to withdraw). Also, instead of a suspension, a bank may try to slow down payments.

Coordination. Another way to avoid a bank run is when there are a limited number of depositors. We can have what is called creditor coordination. We saw this with Long Term Capital Management, a large hedge fund that ran into trouble in 1998. Their problems were similar to a bank run, in that all the creditors demanded their money, which suppressed the value of LTCM’s assets. This run was stopped by a legendary meeting organized by the NY FED with the creditors. Another famous creditor coordination meeting was held by JP Morgan (himself) in the 1907 banking panic.

Lender of Last Resorts. Another solution is using the lender of last resort. Central bank steps in and loans the bank money to replace deposits. This should work with depositors in the case of a problem with simple liquidity. The danger is that it creates a moral hazard problem (see below). For instance, in 2007 both Northern Rock and Countrywide ran into problems. Countrywide had bothered to secure lines of credit ahead of time (at an expense) if it ran into trouble. Myopic Northern Rock did not. If the Bank of England simply lent Northern Rock money, it might encourage other banks not to bother obtaining lines of credit in the future.

One needs to be careful about using this facility. In 1975, April 14th, Credit Suisse announced that it had lost some money in one of its branches. It didn’t mention details. April 25th, The Swiss Central Bank announced it was willing to lend money. This had the opposite result causing share price to tumble 20%.

Narrow banking.
We said that bank runs are inherent if the bank serves to convert short term demands into long term investments. Another idea which dates back to Milton Friedman (1948) (also see Shy and Stenbacka, 2008) is for narrow banking, that is where each bank keeps 100% of its deposits as reserves. This has the advantage of preventing bank runs, but then consumers would have to pay more for banking services.

Deposit Insurance.
The final tool that is useful to prevent bank runs is Deposit Insurance. If the amount you have in the bank is fully insured, you have no incentive to try to withdraw early. However there may be a delay before one gets payment. Also, the deposit insurance scheme may not be foolproof. As with Iceland, even if a government backs the scheme, there is still the possibility of sovereign debt default. Also, usually, deposit insurance is not 100% of all deposits. It can be capped and as we saw in the UK it was only partially covered until the cap. This still left open the possibility of a rational bank run.

Missing from the model.
The Diamond-Dybvig model is beautiful in its simplicity, but this simplicity comes at a cost. It is also worthwhile to discuss what is not captured in the model. Two important elements missing from the model are uncertainty and moral hazard.

Uncertainty. There may be uncertainty in depositors’ preferences. So far we assumed there was no aggregate uncertainty, that is, there is exactly one impatient depositor for every patient depositor. In reality, there may be changing macroeconomic conditions that cause more than the usual number of depositors actually to need the money today. This makes a suspension less desirable as a mechanism to stop bank runs since the bank would also be preventing those that actually need the money from withdrawing.

Another thing lacking from the basic model is the riskiness in the long-term investment. There can be riskiness in R. Perhaps sometimes there really isn’t enough money to meet demand tomorrow. In such cases, it will be worthwhile to withdraw money independent of what others do. Thus, sometimes a bank run will be unique. This also brings us the issue of opacity of the investment and how much of the true return is known to depositors (see Kaplan 2006). With the sub-prime crisis we saw that the return from mortgage based derivatives was indeed risky and at least for a while the status of the investments was unknown to the depositors.

There can also be riskiness in L. Perhaps, at times of a systemic problem, the liquidation value is lower. At Long Term Capital Management, the mere fact that LTCM owned an asset lowered that asset’s value (see Lowenstein 2000).

Moral hazard. Probably the most important element missing from the model is moral hazard. The basic idea comes from insurance. Say you buy theft insurance for a laptop. Because you buy the insurance, you may be more likely to leave the laptop in your car when you pick up the milk on the way back from work. Ideally, you would like to commit to not leaving the computer in your car (computer thieves love to hang around convenience stores waiting for prey). Sometimes, we can contract on it (most current theft insurance for laptops do not cover theft if it is left in a car). Other times, we can’t.

It is thought that a moral hazard problem is created when there is deposit insurance (see Kane, 1989). In the 1980s over a thousand Savings and Loan banks in the US went bankrupt. They originally lent money out at fixed rates of 6% and paid deposits 3%. However, starting in the mid 1970’s high inflation rates forced the banks to pay interest rates upwards of 10% (higher than 6%). Since their balance sheets were in trouble, they decided to take higher risk in an attempt to overcome their deficits. They lent money to riskier clients such as Latin American countries. Ultimately, the Savings and Loans crisis cost US taxpayers $120 billion.

The banks were able to take high risk due to the deposit insurance. In most cases, depositors did not care whether or not their bank took risks since they knew their deposits were insured. This in essence has the insurance corporation subsidize the risky behaviour. It is possible that for this reason, deposits in the UK were not fully
insured and why in many cases the insured amount is capped. Bearing some risk would give the depositors incentive to be wary of banks taking on excess risk. (One may ask whether depositors are able to check the riskiness of a bank’s portfolio and whether this should be their job.) Unfortunately, while a co-pay insurance may reduce the moral hazard problems, it keeps the multiple equilibrium problem, as the UK discovered. At least one way to ameliorate the problem is to base deposit insurance premiums upon risk. The US did just that with Federal Deposit Insurance Reform Act of 2005, allowing the FDIC to charge premiums based upon risk.

Conclusion

In this paper, we demonstrated how bank runs can occur in a simple classroom experiment and that they are inherent in any institution which borrows short term and lends long term. We end the paper how we would end a lecture. In the episode “The PTA Disbands” of The Simpsons, the bank run of It’s A Wonderful Life is parodied. Bart Simpson starts a bank run and the Jimmy-Stewart-like bank manager explains how he doesn't have the money: “It’s at Bill’s house and Fred’s house!” Moe sees Fred and says, “What the heck are you doing with my money in your house?”, and punches him. Hopefully, after this lecture the nature of banking and bank runs will not be so confusing to your students.

5 Before the subprime crisis, the UK had 100% of deposits covered up to £2000 and 90% of those between £2000 and £33000. At that time, the US had FDIC insurance of $100,000. Since then the UK has increased the insurance to 100% of the first £50,000 and the US increased the insurance to $250,000.
References


