EXPLAINING THE INTERBANK LOAN CRISIS OF 2008: A TEACHING NOTE

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ABSTRACT

This teaching note examines one aspect of the financial crisis: the month-long turmoil in the interbank loan market, which began with the bankruptcy of Lehman Brothers on September 15, 2008 and ended with the U.S. Treasury Department's $250 billion bank recapitalization on October 14, 2008. We model the crisis as a prisoner's dilemma in which banks with excess reserves play a game of Loan or No Loan with each other. The initial game results in a Nash equilibrium where each bank chooses No Loan and both are worse off. The second game incorporates the U.S. government's recapitalization program. It is argued that the program solves an asymmetric information problem that revives lending in the interbank loan market.

INTRODUCTION

One unintended consequence of the financial crisis of 2008 is a heightened student interest in economics. Having recently given a student-requested afternoon symposium on the topic to a standing-room-only crowd (a new experience for these economists), we find ourselves in a teaching moment – where students are getting a glimpse at the importance of economics in their lives, and demanding a reasoned explanation of the crisis. The intent of this note is to supply a response to our students' demand.

In this paper, we examine one aspect of the financial crisis: the month-long turmoil in the interbank loan market. The crisis began with the bankruptcy of Lehman Brothers on September 15, 2008 and ended with the U.S. Treasury Department's $250 billion bank recapitalization on October 14, 2008. At the industry-wide level, the crisis was characterized by historic spikes in the federal

funds rate (hereafter *ffr*), a shrinking of the deposit multiplier, and the hoarding of excess reserves. At the individual bank level, the crisis was evidenced by unprecedented increases in the market for insurance against bank defaults on debt, known as credit default swaps. All this occurred despite massive injections of reserves by the Federal Reserve Bank (hereafter the Fed) and a 25 percent decrease in the target *ffr* from 200 basis points to 150.

We model the dysfunction as a prisoner's dilemma in which banks with excess reserves play a game of Loan or No Loan with each other. The initial game results in a Nash equilibrium where each bank chooses No Loan and both are worse off. The second game examines government intervention to revive interbank lending through the lens of an asymmetric information problem. The recapitalization program by the U.S. Treasury department (hereafter the Treasury) is discussed within this context. Two immediate benefits arise from this exercise. First, the model illustrates the key insight of John Nash that rational behavior at the individual level can lead to irrational outcomes in the aggregate. This outcome is particularly prevalent in financial markets where transactions depend significantly upon trust between participants. Second, students get a simple framework in which to analyze proposed government solutions to financial crises. Because financial crises follow similar patterns, this model can be applied to other time periods – such as the U.S. banking crisis during the Great Depression – and other countries – such as the 1992 financial crisis in Sweden. This approach should have broad appeal to economists because no finance or advanced economic theory is required and much empirical evidence supports the results.

BACKGROUND

To understand the economic theory behind the interbank loan crisis, first consider the usual monetary policy prescriptions for a tight credit market. To stimulate lending, the Fed injects reserves into the banking system to lower the *ffr*. The *ffr* is the interest rate banks charge one another for overnight lending of excess reserves – that is, reserves above what banks are required to hold against their deposits. These excess reserves are crucial during credit contractions as they provide insurance for banks against deposit withdrawals and declines in the value of bank assets. The *ffr* changes as banks supply and demand excess reserves from each other. A lower *ffr* reduces borrowing costs for banks that demand reserves while the injection of reserves expands the supply available. The Fed intervenes in the market every day by buying and selling treasury notes from and to banks to

maintain the Fed's target *ffr*. The Fed's effectiveness is evidenced by the small deviations of the daily high *ffr* from the Fed's target *ffr* which averaged 32 basis points for the six years between November 1, 2002 and September 14, 2008.[1]

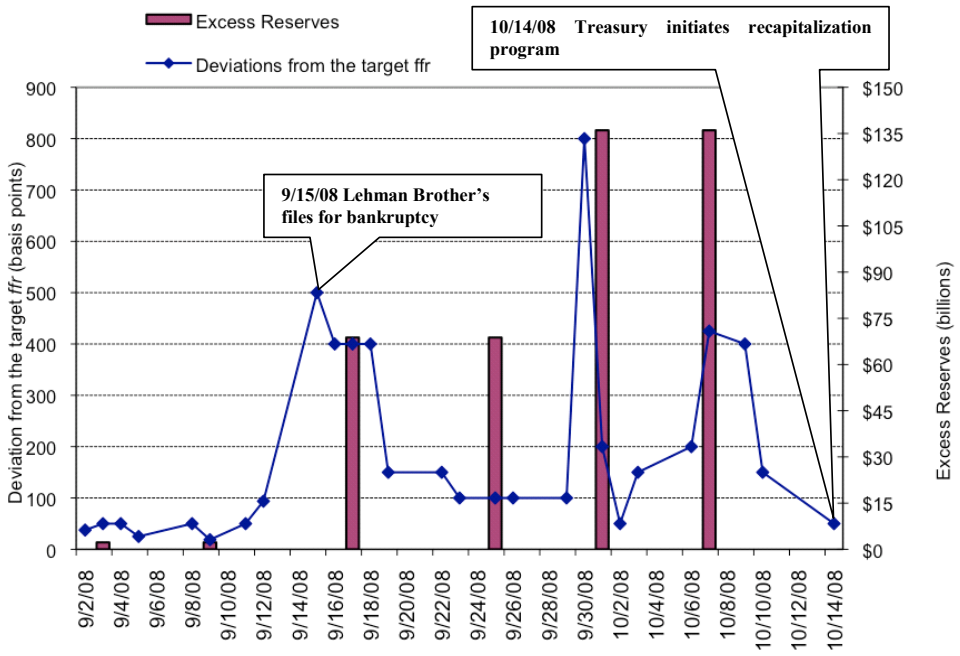
In addition to lowering the *ffr* and increasing the supply of available funds for the interbank loan market, an intervention by the Fed has a multiplier effect by which an increase in one bank's reserves, *R*, can lead to multiple deposits being created throughout the banking system.[2] Under normal credit conditions, the injection of reserves into a bank, call it Bank A, induces it to lend to its customers. As customers spend these loans, the money returns as deposits in another bank, say Bank B. Bank B uses the deposits to generate its own loans which lead to more deposits throughout the banking system. The deposit multiplier, α, measures the total increase in deposits created by each $1 injection of reserves. Although neither bank would claim to create money, each one unintentionally, as if lead by an *invisible hand*, contributes to the creation of deposits equal to the amount $\alpha * R$.

Now imagine bankers are overcome with fear. Fear that commercial and real estate loans will default. Fear that depositors will withdraw their savings. Fear that fellow banks won't repay interbank loans. Fear that banks are hiding credit risk from the market with off-balance sheet securities such as mortgage-backed securities and credit default swaps.[3] Even fear that their own assets (perhaps some of which are backed by subprime mortgages) will become worthless. If banks perceive the situation to be severe enough, they will stop providing interbank and customer loans (they may even call in loans) and hoard excess reserves to bolster their balance sheets. Because of these sources of fear, the *ffr* rises and the deposit multiplier decreases. Thus, the very actions banks take to protect themselves will reduce the deposit base on which they depend. This is what occurred during the month following the bankruptcy of Lehman Brothers on September 15, 2008. Figure 1 illustrates.

With deviations from the target *ffr* on the left-side vertical axis, excess reserves on the right-side vertical axis, and the date on the horizontal axis, Figure 1 shows a spike in the average daily deviation from the target *ffr* of 193 basis points. The deviations from the *ffr* exceeded 100 basis points on 13 of the days, 200 basis points on 7 of the days, 400 basis points on 3 of the days and reached a peak of 800 basis points on September 30, 2008 when the *ffr* spiked to 10%. On that day, banks were so wary of lending excess reserves to each other *overnight* that they required a lending premium 400% higher than the Fed's target rate.[4] Over this period the deposit multiplier fell from its prior six-year average of 7.24 to 2.88 for the week of September 15.[5] The credit default swap market saw similar spikes for individual

banks over this period. The price of insurance against a bond default from Morgan Stanley rose approximately 500 basis points, while the price for Goldman Sachs and Citigroup rose approximately 200 and 100, respectively (Bloomberg data). The fact that these events all occurred while the Fed injected massive amounts of liquidity into the banking system – evidenced by the unprecedented jump in weekly excess reserves from a six-year average of $1.8 billion to $69 and then $133 billion within the month – indicates the impotence of monetary policy and magnitude of the crisis.

Figure 1: Deviations from the *ffr target* & Excess Reserves



Source: www.newyorkfed.org

LOAN OR NO LOAN: A GAME THEORETIC EXPLANATION

Such market dysfunction was well articulated by the Nobel-prize winning mathematician John Nash. The key insight of Nash was that rational behavior at the individual level might lead to irrational outcomes in aggregate. The interbank loan crisis exemplifies such outcomes and can be understood by means of a game called Loan or No Loan played over a one-month period between two banks, Bank A and Bank B. The payoffs in Figure 2 are the expected profits for each bank. Bank A chooses a row and Bank B chooses a column. The number to the left of the comma gives the payoff to Bank A while the number to the right gives the payoff to Bank B.[6]

Figure 2
The Loan or No Loan Game

		Bank B: No Loan	Bank B: Loan
Bank A	No Loan	-10,-10	15,-15
	Loan	-15,15	10,10

If both banks choose Loan, the supply of interbank loans increases, the *ffr* falls, and deposits expand via the deposit multiplier process. With low borrowing costs and a sufficient number of deposits, lending is robust and generates an expected profit of $10. If both banks choose No Loan, interbank lending decreases, the *ffr* rises, and deposits contract. With high borrowing costs and fewer deposits created, banks turn their focus from profit expansion to capital protection. Lending is cut in favor of hoarding reserves and banks incur expected losses of $10 each. It

is clear from Table 1 that the socially optimal result – i.e., the Pareto optimal result – is for each bank to choose Loan.

Banks, however, are not in the business of making socially optimal decisions; they're in the business of making individually optimal decisions. Consider Bank A's decision making process. If Bank A thinks that Bank B will not provide interbank loans, Bank A's best response is to select No Loan. The logic is the following: If Bank A loans its excess reserves and Bank B hoards its reserves, the *ffr* remains high and deposit expansion is stymied. These results occur because each bank contributes to the deposit multiplier process, although no single bank can unilaterally affect α. With fewer reserves and little deposit growth, Bank A's likelihood of failure increases and its expected loss is \$15. If Bank A does fail, Bank B captures market share and may benefit from a fire-sale purchase of Bank A generating an expected profit of \$15.[7] Bank A doesn't like that scenario and so chooses No Loan. If Bank A thinks that Bank B will provide interbank loans, Bank A's best response is again No Loan. By loaning, Bank B takes on more risk without significantly affecting the *ffr* or total deposits in the banking system. If Bank B fails, Bank A may acquire its assets and gain market share thus providing an expected profit of \$15. In each case, regardless of what Bank B chooses, Bank A's best response – or in game theory terms, its *dominant strategy* – is to select No Loan. Because this game is symmetric, the same dominant strategy of No Loan applies to Bank B. These dominant strategies lead the banks away from the socially optimal result toward the No Loan equilibrium where both suffer a loss of \$10. The cell corresponding to No Loan, No Loan represents a *Nash equilibrium* in which neither player has an incentive to deviate unilaterally once at that equilibrium. Students will recognize the result of this Loan or No Loan game as a version of the classic prisoner's dilemma where all players are made worse-off. The only way to incentivize the players toward the social optimum is to change in the payoffs themselves.

FINANCIAL INNOVATION AND ASYMMETRIC INFORMATION

The symptoms of the interbank loan market crisis of 2008 are clear: 1) heightened fear led banks to charge overnight loan rates that greatly exceeded the target *ffr* and 2) banks rationally decided to hoard excess reserves in an effort to bolster their balance sheets. When combined, these symptoms caused a substantial decrease in the bank deposit multiplier, which in turn magnified the crisis. But what caused these symptoms? If we were to put our economic stethoscope on the pulse

of the crisis we would hear: asymmetric information, asymmetric information, asymmetric information.

Financial markets arise out of asymmetric information. Unlike product markets, financial markets facilitate the exchange of guarantees not goods. These guarantees are promises a borrower makes to repay a lender. Information is *asymmetric* because the borrower has much greater knowledge about his ability to repay than the lender. The greater the asymmetric information, the higher the degree of trust required among participants. Banks exist to assume the risk of asymmetric information by specializing in assessing loan risk and serving as intermediaries between borrowers and lenders. Banks profit from the difference between the interest rates they charge borrowers and the rates they pay depositors. But banking is a tricky business. Most bank assets (loans and securities) have long-term maturities while their liabilities (deposits) can be withdrawn at a moment's notice (Krugman 2009, p. 158). Because banks and their depositors assume this major liquidity risk, banks are required to meet regulations on the amount of reserves held against their deposits and the capital that must be held against their assets. These rules provide a cushion for banks against potential losses in the value of their assets. For many years, these strict regulations and long-proven methods of risk assessment made banks particularly adept at assessing interbank loans and minimizing asymmetric information.

Recent financial innovations changed all that. Instead of banks holding loans on their balance sheets, they began to package them into securities to be sold to off-balance sheet financial entities such as Structured Investment Vehicles (SIVs).[8] Though still affiliated with the originating banks, SIVs avoid capital-to-asset regulations because they fund their purchases with short-term debt (typically, asset-backed commercial paper) rather than deposits. Though the securities often consist of subprime mortgages, the affiliated banks provide credit lines to their SIVs to ensure a AAA credit rating.[9] Because banks have zero capital requirements for providing such credit lines, SIVs enable banks to originate more loans without a commensurate increase in required capital. Asymmetric information increases significantly because the credit risk of the loans remains with the bank and is obscured by the process of securitization. Assets of SIVs and other entities in the so-called "shadow banking system" totaled approximately $10.5 trillion in early 2007 compared to traditional banking sector assets of about $10 trillion.[10] Lehman Brothers was a major participant in the shadow banking system with "exposure to at least $2.6 billion in SIVs" by December 2007.[11] When Lehman failed, fear of

these off-balance sheet vehicles spiked, trust among banks evaporated, and the banking sector found itself within the prisoner's dilemma previously described.

GOVERNMENT INTERVENTION: THE TROUBLED ASSET RELIEF PROGRAM

One way to escape the prisoner's dilemma is for an outside agent to create a trust mechanism among the players. In terms of the payoff matrix, greater trust raises the expected profits of lending and, if done sufficiently, can move the Nash equilibrium to the social optimum of Loan, Loan. Governments have often played the role of outside agent in providing trust mechanisms for markets rife with asymmetric information, and with some success. Consider the used car market.

Sellers of used cars always know more than buyers of used cars. This form of asymmetric information tends to drive all the good, higher priced used cars out of the market. This is so because buyers only consider the lowest priced used car, and sellers have no *trustworthy* mechanism to reveal the quality of their good used car to a potential buyer. Thus, at the end of day, only lemons (or bad used cars) are left on the market.

Many state governments have "lemon laws," which provide consumers with a money back guarantee if their used car turns out to be a lemon.[12] The lemon law increases the level of trust in the marketplace, and it creates real value because it has the effect of bringing the good used cars back into the market.

Similar to the implementation of a lemon law, the Treasury created the $700 billion Troubled Asset Relief Program (TARP) in an effort to stabilize financial markets.[13] The first $250 billion of these funds, after much input was given by the economic community, was used to recapitalize qualifying banks through direct purchases of bank stock in two steps. First, $125 billion was provided on October 13 to the nine largest U.S. banks in return for bank stock. Though some of the nine banks did not want to partake in the program, Treasury Secretary Henry Paulson persuaded all to join telling them "[t]he system needs more money, and all of you will be better off if there's more capital in the system".[14] The second step requires all other banks to "apply" for a capital injection. After an arduous evaluation, the Treasury approves the applications of qualified banks.[15] This *de facto* seal of approval by the Treasury has become a trustworthy bank sorting mechanism that has decreased asymmetric information and produced an increased level of trust among approved banks.

In terms of the Loan or No Loan game, the TARP raises the lending bank's expectation of loan repayment among approved banks and thus the profitability of interbank loans.[16] Given the numerical values in Table 1, the government program only needs to raise expected profitability of interbank loans by $6 to change banks' decisions at the margin. Figure 3 illustrates.

Figure 3
The Loan or No Loan Game Redux

		Bank B: No Loan	Bank B: Loan
Bank A: No Loan		-10,-10	15,-9
Bank A: Loan		-9,15	16,16

In this version, if Bank A loans its excess reserves and Bank B hoards its reserves, the *ffr* remains high and deposit expansion remains stymied, but Bank A's likelihood of failure is lower because the perceived probability of repayment is higher. The bank's expected loss is only $9 rather than the original $15. If Bank A does fail, Bank B may still capture market share and benefit from a fire-sale purchase of Bank A leaving the expected profit of $15 unchanged. If both banks choose Loan, the supply of interbank loans increases, the *ffr* falls, deposits expand via the deposit multiplier process but the expected profits are higher by $6 with the higher perceived probability of repayment. Each bank has a dominant strategy of Loan and the Nash equilibrium in the game is Loan, Loan. By altering the institutional rules through the recapitalization program, the competitive Nash equilibrium result is now simultaneously the socially optimal result. It is important to note that the interbank loan market is revitalized not by the government guaranteeing repayment but merely changing loan profitability at the margin.

Has the TARP been successful? As of now, the TARP has yielded mixed results. With respect to the interbank loan crisis, it has been successful in stabilizing the market and revitalizing lending. As Tim Bond of Barclays Capital said in mid-October referring to interbank loans, "compared with [late September], borrowing volumes are up by as much as ten times."[17] *The Economist* magazine stated that "American banks including JPMorgan Chase and Citigroup have, in [mid-October], made loans to European counterparts for up to three months. And Europe's biggest bank, HSBC, is lending billions to other banks."[18] The TARP has not, however, lead to a substantial increase in consumer or business lending. For this reason, many politicians and pundits have considered it a failure.[19]

CONCLUSION

Since the day the recapitalization plan was announced, interbank loan rates declined dramatically and lending increased significantly. Deviations from the target federal funds rate remained below 75 basis points over this period. The Treasury's aggressive intervention to make banks "better off" effectively dealt with the deficiency of trust among banks caused by increased asymmetric information and has stabilized the interbank loan market. It is hoped that when the broader financial market stabilizes, private markets will augment the level of trust in the financial system by providing better credit rating agencies or other yet-to-be-discovered entrepreneurial tools to effectively value assets in the financial marketplace – much like private certifications of used vehicles offered by private automobile dealers guarantee the quality of their vehicles. Until that time arises, governments may continue to play a role in providing stability in financial markets.

ENDNOTES

1 Data exclude the final day of each reserve period when the federal funds rate characteristically strays from its target.

2 By focusing on the deposit, rather than the *money*, multiplier we ignore changes in currency demand. For intermediate courses, instructors may wish to include this aspect of M1 and the money multiplier as it reinforces our story and introduces other crisis phenomena such as the "breaking of the buck" that occurred in money markets.

3 Credit default swaps provide a real-time estimate of a bank's financial condition. As of 2007, the market was estimated to be $62.2 trillion of which banks sold 44%

of the total. A good exposition can be found in "The Great Untangling," *The Economist*, November 6, 2008.

[4] These spikes occurred throughout OECD nations as evidenced by the overnight LIBOR (London Interbank Offer Rate) rising to 6.44 percent on September 16 and falling to 1.94 percent on October 16. By November 6, the rate stood at 0.33 percent (Bloomberg data).

[5] The deposit multiplier is calculated as Demand Deposits at Commercial Banks divided by Total Reserves. Both figures are provided weekly and are seasonally adjusted. *Board of Governors of the Federal Reserve System*.

[6] For a review of the basics of non-cooperative game theory see Frank and Bernanke (2009), Mankiw (2009), or Hubbard and O'Brien (2008).

[7] Consider JP Morgan's purchase of Bear Stearns, Bank of America's purchase of Merrill Lynch and Barclay's purchase of Lehman Brothers' assets.

[8] SIVs profit from these securities – typically, Collateralized Debt Obligations, CDOs – by slicing them into different risk-based *tranches* that are sold off to other investors. Because many of these investors are other banks themselves, the credit risk remains within the banking sector.

[9] These credit lines are also referred to as "liquidity backstops".

[10] "By early 2007, conduits, structured investment vehicles and similar entities that borrowed in the commercial paper market and bought longer-term asset-backed securities, held roughly $2.2 trillion in assets, according to the Fed's Geithner. Another $2.5 trillion in assets were financed overnight in the so-called repo market, Geithner said. Geithner also highlighted big brokerage firms, saying that their combined balance sheets held $4 trillion in assets in early 2007. Hedge funds held another $1.8 trillion, bringing the total value of asset in the "non-bank" financial system to $10.5 trillion, he added. That dwarfed the total assets of the five largest banks in the U.S., which held just over $6 trillion at the time, Geithner noted. The traditional banking system as a whole held about $10 trillion, he said" (June 20, 2008, "Brokers threatened by run on shadow bank system" *MarketWatch).*

[11] Ibid.

[12] In many cases, private markets can solve the asymmetric information problem by developing for-profit solutions. For example, in the used car market, it is in the best

interests of Audi, BMW, and the like to offer their own binding inspection certification systems, which guarantee that the dealership will fix a problem with the vehicle for free for a specified period of time.

[13] The mafia is always a clear example of how institutions can change the incentive structure in a prisoner's dilemma game: members of the mafia end up "swimming with the fishes" in the long run if they rat out other members of the mafia in the short run. Because the former changes the incentive structure on the margin, members of the mafia are less likely to rat out other members of the mafia.

[14] Damian Paletta, Jon Hilsenrath and Deborah Solomon, "At Moment of Truth, U.S. Made Bankers Blink," *The Wall Street Journal*, October 15, 2008.

[15] Those banks deemed unqualified were "recommended" by the Treasury to "withdraw [their] application" and were persuaded to "find a buyer". To incentivize consolidation among banks, the government effectively subsidized the bank acquisitions by relaxing accounting rules to let banks benefit from the accumulated tax losses of banks they acquired. Fitzpatrick, Dan and Sidel, Robin "Federal Aid? Not for Us, Proclaim Some", *Wall Street Journal*, November 17, 2008, and Francis, Theo "How Uncle Sam is Reshaping Banking" *Business Week,* December 8, 2008.

[16] The Treasury's initial plan was to increase capital in the banks by purchasing their troubled (or "toxic") assets. The important difference between the programs is the information that they provide. Capital injections through equity stakes signal that the government deems the receiving bank to be of a particular quality. Purchases of troubled assets might only signal the poor asset management at the receiving bank. Thus the latter could raise uncertainty among banks and unintentionally lower the expected profits of interbank loans.

[17] "Thawing Out" *The Economist*, October 23, 2008.

[18] Ibid.

[19] The Wall Street Journal estimated that by December 30, 2008, the TARP program had a return of 4% since its inception, which corresponds to an annualized rate of 16%. Moore, Heidi, N. "Smartest Guy In the Room?" *Wall Street Journal*.

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