Pathology of a Heart Attack: The LIBOR Market*

Jagjit S. Chadha†

November 2008

Abstract

Understanding developments in interbank lending markets is the key to this financial crisis. The rates at which banks perceive they can borrow on an unsecured basis at term from other banks should be broadly equivalent to overnight interest rate swaps over the same term. But risk premia in term LIBOR spreads over these expected overnight rates has increased significantly since 2007 and have subsequently remained at an elevated level. In this note, we outline the scale of the shock to LIBOR rates, consider candidate explanations and suggest a couple of solutions including guarantees for interbank lending and the provision of data on the quantity of lending in the interbank market.

JEL Classification: E43, G12, G15.
Keywords: LIBOR rates, OIS rates, Stiglitz-Weiss.

1. Introduction

One of the first indicators of the significance of emergent financial market turmoil in August 2007 was the sudden increase in reported interbank lending rates.

*Acknowledgements: I am grateful for comments and discussion of this issue with the Global Markets Economics team at BNP Paribas and discussions with Alain Durre, Katsuyuki Shibayama and points of clarification from Mark Deacon at the UK's Debt Management Office.

†Professor of Economics, Chair in Banking and Finance, University of Kent, Canterbury, CT2 7NP, UK. E-mail: jsc@kent.ac.uk.

Normally an arcane aspect of commercial bank activity,[1] interbank lending rates and their spreads over overnight policy or overnight index-swaps (OIS) had been stable for a considerable period and not generally felt to be worthy of comment. But interbank markets have been severely impaired since August 2007, initially as concerns about US subprime losses mounted, and subsequently, following the collapse of Lehman Brothers in September 2008, on the realisation that losses might lead to failures of *any* major financial institution. The problems in the interbank market have been reflected in the large shock to LIBOR lending rate spreads and have acted as the main conduit of this financial crisis to the real economy.

In fact, the stability of the spreads was not only through time but also over the term structure. Chart 1 shows, for example and indicates well the scale of the problem in other markets, the US$ LIBOR (London Interbank Offered Rate) spread over OIS at 1-month, 3-month and 6-month maturities and we can see that, prior to the crisis, spreads were incredibly stable.[2] In fact such was the stability that many commercial banks increasingly based their funding decisions on the continuing availability of wholesale funding from interbank markets at wafer thin margins. For example, by 2007 the median UK bank was funded some 50% by wholesale depositors, as opposed to less than 30% in 2001.[3]

The correct policy reaction to the shock in LIBOR spreads depends on whether the cause was simply a drive to hold liquidity and thus inducing a rational re-pricing upwards in the spread in funding over cost. Or whether because of an

[1] In reality most short term bank funding seems to come from non-bank financial sources, for example, money market funds, investment funds and central bank foreign exchange reserves, see IMF 2008.

[2] The median spread of LIBOR over OIS spreads at 1-month, 3-month and 6-months in the year to the crisis was 6bp, 8bp and 8bp with a standard deviation of 1.4bp, 1bp and 1.5bp, respectively, in the year to the commencement of the crisis.

[3] See Bank of England, Financial Stability Review, pp.13 2007. The perceived elasticity of supply of interbank funds is likely to have played a role in funding decisions or models.

absence of robust information on individual bank health (or some collective loss of confidence) the market had stopped functioning and allocating liquidity at all. In the former case, monetary conditions might be said to have tightened and there may some case for an offset from changes in policy rates but in the latter case more fundamental aspects of market support or reform may be required.[4]

Normally central banks set short term interest rates for their operations with commercial banks. Subsequently, short term lending between commercial banks irons out any idiosyncratic levels of liquidity.[5] This lending thus sets the floor for other market interest rates. The rates, over a given term, at which liquidity-poor banks can borrow on an unsecured basis from liquidity-rich banks (or other financial institutions) should be near to the OIS over the same term. But the risk premium, reflecting commercial bank credit and liquidity concerns, in term LIBOR spreads has increased significantly since 2007 and subsequently remained at an elevated level and rather than merely signalling an increase in the demand for funds, higher spreads seem, on occasion, to have been associated with lending atrophy.[6] Such an atrophy is likely to have been a market failure.

In this note, we provide a simple analysis of how liquidity concerns may drive the spread between short and longer term assets, that is explain the upward slope in the term structure. We assess the scale of the shock to LIBOR spreads and link the pattern of spreads and lending rates to the Stiglitz-Weiss framework in which higher spreads may be associated with lower levels of lending.[7] Prospective

[4] I develop a Stiglitz-Weiss type argument below.

[5] See Allen *et al* (2008) for a formal analysis.

[6] It is difficult to find high frequency evidence on the quantity of interbank lending. The IMF points to the fall in unsecured European Bank Borrowing (p76) for 2007 on a year earlier. Bearing in mind that the crisis started in August 2007, this represents some indication of the early impact of the crisis.

[7] Unpublished work cited by the IMF, see Annex 2.1, does not find a role for identifiable factors such as VIX volatility, swaption volatility, on-the-run off the run spreads, forex swaps or Repo rates in the explaining the LIBOR spread, preferring to assign the cause to a 'joint probability of default'. This could be interpreted as something extraneous and related to general confidence

policy rate cuts may reduce the level of LIBOR but not necessarily the spread of LIBOR over OIS i.e. the marginal cost of funding. We conclude by assessing a number of possible solutions. Liquidity-rich banks perhaps should be thought of as in the same way as retail depositors and so a (partial) guarantee should be offered to those depositors, at least in the short term. An alternate solution would be to allow the central bank to conduct operations to offset directly the liquidity premium (rather than any credit risk) but the extent of the liquidity premium is still difficult to measure. The British Bankers' Association (BBA) should certainly expand its information gathering role (i) to ensure that surveyed rates represent both the distribution and level of actual rates available to banks; (ii) expand their sample to encompass all liquidity suppliers and (iii) publish data on the quantity of lending undertaken so that we can more easily understand the evolution of risk premia across currencies and at different terms. At the very least, the stress placed on the LIBOR markets has exposed a considerable lack of information about these important markets.

2. The Basic Facts

LIBOR interest rates represent the trimmed average rates at which a panel of banks surveyed by the BBA estimate they can source interbank liquidity from overnight to up to 12 months in 10 major currencies. The results of the simple average of this survey, once the highest and lowest quartile rates have been removed, are announced by the BBA at around 11.00 London time every business day. Note that the published rates do not necessarily represent the rates obtained by those or similar banks surveyed or correspond to a given quantity of borrowing

in the banking system or the possibility that lenders might not be able to distinguish between individual banks very well and just expect lower profitability even if interest rates are higher.

at those interest rates. And as we also do not have aggregate or individual bilateral time series on actual lending rates we have to be careful in interpreting what amounts to survey data on what rates banks are prepared to admit they can obtain liquidity. The BBA publishes the average LIBOR rate of the central two quartiles of the surveyed banks.

Interbank interest rates represent the cost of liquidity offered to commercial banks at term against no collateral or security. In principle, interbank lending at term should be close to the interest rates on OIS interest rate swaps of the same term. Any difference should represent any differences in liquidity or credit risk for individual banks over any that may be reflected in OIS.[8]

We can measure the evolution of these premia by examining the term structure of the spread of LIBOR rates over OIS. Figure 2 plots the premia in the US$, similar results could be shown for both the UK and the Eurozone. Both charts show the median premia at each maturity for three time periods, the year prior to the financial crisis, the first three months of the crisis and the subsequent year. The median spread thus captures both the likely expectation of the spread prior to the crisis (around 10bp), the initial escalation in the spreads across maturities (to around 50bp) and the continuing elevation (to 80bp or more at 6 months).

How can we explain such a persistent elevation in risk premia? There have been some estimates to measure the contribution to changing LIBOR risk premia from various measures of risk premia such as credit default swaps on the corresponding banks in the LIBOR panel to estimate the credit risk component of LIBOR spreads, employ various measures of expected interest rate volatility and liquidity.[9] Figure 3 offers the following decomposition of the US$ BOR/OIS spread at 12 months into the credit risk faced by those banks and all other factors. The median

[8] Michaud and Upper (2008) suggest that the counterparty risk and liquidity premia of OIS rates should be small.

[9] See IMF (2008) and Michaud and Upper (2008), for example.

credit risk of the banks on the panel is proxied by the median of the 12 month credit default swap prices of the banks on the US$ BBA panel. There is a story of sorts here with an initial non-credit shock (arguable liquidity) leading to a credit shock and in the most recent stage of the crisis some move together in both credit and non-credit factors. But some problems remain, such as the overshoot of credit risk over the spread in March 2008, which implies others factors contributed negatively to BOR/OIS spreads that month or that LIBOR quotes obtained by the BBA were underestimates because of the need to avoid signalling any adverse market opinion on a bank's borrowing ability.

Broadly speaking the tentative results of the published work to date is that the drivers of BOR/OIS spreads seem to be in the residual. That is factors for which markets do not trade assets. In some sense the problem here is that we do not have quantity data, which would allow us to identify separately demand and supply factors from the regressors.[10] And in any case it is not clear whether the regressors can be linked solely to one factor or another, for example, liquidity problems eventually become credit problems and so credit premia may easily also reflect liquidity concerns. And so let us first go back to basics.

3. A Simple Analysis

Let us sketch a simple model of a bank that lives for three periods. The bank seeks to generate profits, π_i, in every period, $i = 1, 2, 3$, and has the choice in period 1 to lend its liability endowment, L, for one period as loans of reserves, R_t,

[10] Imagine a shock on a day that raises liquidity and drives out the supply curve but is associated with an increase in volatility and hence demand for liquidity, it is entirely possible for these shocks not to impact on the LIBOR spread at all but just on increasing quantity. Equally on some other day, liquidity may fall and volatility rise leading to an increase an unambiguous increase in spreads and thus no clear pattern might be found between liquidity and spreads.

at interest rate, RIB, or for a two period loan of working capital, k_t. that will payoff χ in two periods. The bank knows that in each period that some fraction of the liabilities, θ $(0 < \theta < 1)$, may be asked for by the depositors at an interest rate, $r_0^{1,2}$, which we might think of as the policy rate, that will have to be paid in period 1 or 2. It also knows that all the liability endowment must be returned in period 3. We can solve this model for the spread of the two period loan to the one period loan and ask simply what drives the spread and what action might a central bank undertake to offset the spread?

The bank thus maximises its three period profits,

$$\max U = U(\pi_1, \pi_2, \pi_3), \tag{3.1}$$

subject to the following inequalities in each period:

$$\begin{aligned} \pi_1 + R_t + k_t &\leq L, \\ \pi_2 &\leq \frac{(1 + RIB)\, R_t}{(1 + r_0^1)\, \theta}, \\ \pi_3 &\leq \frac{(1 + \chi)\, k_t}{(1 + r_0^1)\,(1 + r_0^2)\,(1 - \theta)}. \end{aligned} \tag{3.2}$$

We can form the bank's constrained optimisation problem as follows:

$$\mathrm{L} = U(\pi_1, \pi_2, \pi_3) + \lambda \left[\begin{array}{c} L - \pi_1 - \frac{\pi_2}{(1+RIB)}\,(1 + r_0^1)\,\theta \\ -\frac{\pi_3}{(1+\chi)}\,(1 + r_0^1)\,(1 + r_0^2)\,(1 - \theta) \end{array} \right], \tag{3.3}$$

and state some of the first order conditions:

$$\frac{dU(\cdot)}{d\pi_1} = \lambda$$

$$\frac{dU(\cdot)}{d\pi_2} = \lambda \frac{(1+r_0^1)\theta}{(1+RIB)}$$

$$\frac{dU(\cdot)}{d\pi_3} = \lambda \frac{(1+r_0^1)(1+r_0^2)(1-\theta)}{(1+\chi)}.$$

At the optimum the bank will be indifferent between one and two-period lending in terms of its contribution to profitability in period 1 and so:

$$\frac{dU(\cdot)}{d\pi_2} / \frac{dU(\cdot)}{d\pi_1} = \frac{dU(\cdot)}{d\pi_3} / \frac{dU(\cdot)}{d\pi 1},$$

which allows us to state the ratio of the returns from one to period lending as follows:

$$\frac{(1+\chi)}{(1+RIB)} = \frac{(1+r_0^1)(1+r_0^2)(1-\theta)}{(1+r_0^1)\theta} \tag{3.4}$$

$$= \frac{(1-\theta)}{\theta}\left(1+r_0^2\right). \tag{3.5}$$

We can interpret the ratio on the right hand side as the spread between two period and one-period loans. Note that the ratio will fall (increase) as the probability of withdrawals in earlier periods increases (decreases). This is because

an increase in this probability (of early withdrawals) will raise the required return on one-period loans compared to two-period loans. The term structure of interest rates will thus tend to be downward sloping if $\theta > 0.5$, given no expected change in short term interest rates in period 2, $r_0^2 = r_0^1$. And upward sloping, only if it seems more likely that there will be calls on liquidity in the future rather than immediately, which is the pattern that has emerged since the inception of the financial crisis.

Faced with this distortion to the spread between one- and two-period paper, a central bank can eliminate this distortion by introducing open-market operations to iron out this distortion. Specifically, if $\theta > 0.5$, the central bank might discount any excess reserves loans made in the first period so that any depositors seeking their funds would be met with sufficient funds at the bank: this operation could be made on an repurchase basis so that bank would repay the loan in the next period. Analogously, if $\theta < 0.5$, the central bank could sell government securities and buy them back in the second period to supply liquidity. In principle, therefore a liquidity-providing bank should be able to smooth one and two-period market rates, so that they reflect the term structure and the costs of central bank liquidity provision rather than any short term liquidity issues. In the specific context of an upward sloping term structure of BOR/OIS spreads, the central bank might consider operations to increase the incentives of wholesale depositors to hold their deposits at banks over a longer term.

4. A Collapse in Intermediation?

Figures 4 and 5 offer a further explanation as to the cause of the crisis in the interbank market. Banks that are liquidity rich offer liquidity to other banks that are liquidity poor at an interest rate, R, which represents a spread over the cost

of funding and corresponds loosely to RIB in Section 2. For small, R, banks operate with a normal upward sloping supply curve. But what if liquidity rich banks expect their returns to fall with interest rates beyond R^*? We can then consider what might happen if there is a backward-bending supply curve at higher interest rates.

There are a number of reasons why higher interest rates might be associated with a lower supply of funds. If lending banks cannot discriminate across banks and there is partial information about borrowing banks' riskiness, then lending banks may perceive the risk of any lending to rise with the level of interest rates in the market place. Furthermore under high interest rates, lending banks may be concerned that funds may not be returned and so they may have to enter the market in future periods to offset the loss in liquidity. We assume a normal demand curve for loans from banks in need of interbank liquidity.

Figure 4 shows the usual equilibrium, I. At this point the LIBOR spread is low and the market for interbank liquidity clears with a buoyant level of lending. Now let us imagine a large shock to the demand for liquidity, as borrowing banks seek precautionary balances. Clearly in an interbank market such as this, we would simultaneously observe a leftward shift in of the supply curve as liquidity supplying banks also seek to increase their precautionary balances. But for the moment let us assume no change in the supply curve.

Figure 5 shows that in this case, because of the backward bending supply curve, there are two possible equilibria, II and III. The former corresponds to a normal response in a market to higher demand, the LIBOR spread rises as does lending. Small changes in BBA-quoted interest rates here lead to a return to equilibrium as to the right (left) of the equilibrium, supply is greater (less) than demand and so rates will fall (rise) again. In some sense this equilibrium corresponds to that perceived by early commentators on the financial crisis, that the increase in

LIBOR spreads was simply a market determined re-pricing of risk.[11]

Now examine the alternate equilibrium for a large enough shock to LIBOR spreads, III. In this case, the level of lending is not significantly higher than in case III but LIBOR spreads are significantly higher. Note also that any small increase in quoted BBA rates from this point will lead to a situation where the demand for liquidity will be greater than the supply and so LIBOR rates will continue to rise and lending will dwindle (constrained by the supply curve), ultimately to zero. In fact if rates go much beyond the level implied by equilibrium III, we are faced with the complete collapse of liquidity in this market.[12] Those who argued about the need for action by central banks either to supply liquidity against less than gilt-edged collateral or indeed go further and lend on an unsecured basis are really arguing this because they take seriously the possibility of a fragile equilibrium at III or rationing of credit as the demand curve shoots off past the supply curve.[13]

5. Some Empirics

Because we cannot observe the extent of interbank borrowing or lending it is difficult to distinguish whether equilibrium II or III (or both at various times) obtained after the onset of the financial crisis. But we can observe prices and quantities in the commercial paper market, which is in some sense the next market along from the interbank market, as it measures loans to corporates from the financial sector and seems likely to contract or expand along with the beat of the interbank market. Total commercial paper outstanding measures the quantity of

[11] See the Governor of the Bank of Englands's open letter to the Treasury Committe on moral hazard (King, 2007).

[12] In fact, the Governor of the Bank of England described the near collapse of the financial system in early October, (King, 2008).

[13] The discussion here of Stiglitz-Weiss is motivated by the treatment in Friexas and Rochet (1997).

loans outstanding to the US corporate sector, typically short term debt, and we can examine the spread of these loans at, say, one month, over the equivalent one month T-bill.

Figure 6 shows the weekly evolution of corporate paper-bill spread and the quantity of corporate loans outstanding.[14] The level of corporate loans and the corporate paper-bill spread was stable at around US$1.5Tn and under 10bp or so until 2005. When we then observe is a sharp increase in corporate paper growth, which reached a peak of US$2.2Tn at the end of July 2007. Subsequently, with the onset of the credit crunch, there has been a sharp fall and the most release records the stock of outstanding corporate loans back to just above US$1.5Tn.

Before examining the supply curve for corporate lending, we scatter the corporate paper bill spread against the BOR/OIS spread since January 2006, until the creation of the CPFF. There are essentially two regimes, the pre-financial crisis regime where the corporate spread varied in a small range from around 0-100Bp and the BOR/OIS spread was fairly stable at around 10Bp. And the regime after the crisis when both BOR/OIS and the corporate paper bill spread moved closely together. In fact it is difficult to reject the hypothesis of equiproportional changes in the two spreads. And so the spreads in the corporate paper bill market during the period of loan deceleration rose in line with BOR/OIS spreads.[15]

If the lending markets have been dominated by shifts in the demand for liquidity then the scatter of quantity data against spreads should yield the shape of the supply curve. We undertake this exercise for the corporate loans market in Figure 8. And we find some evidence to suggest some backward bend in the supply function. Note also that the extreme dislocation in the financial markets

[14] This data covers the period up to the introduction of the Federal Reserve Bank of New York's new Commercial Paper Funding Facility (CPFF), which was introduced in the second half of October 2008.

[15] Cecchetti (2008) motivates the re-examination of corporate paper market in the US.

earlier this month seems broadly indicative of a market where spreads were rising and loans were falling. In the schemata of Figure 5, an unstable equilibria – or market failure occurred. If the behaviour of quantities in the interbank market resemble those of the corporate market, and it seems likely that quantities have fallen by at least as much, the ongoing possibility of a market failure may need to be addressed.

6. Conclusion

If the analysis of the LIBOR market is correct, that the term structure has been tilted upwards by a liquidity squeeze and that the interbank market has tended to an unstable equilibrium with rising interest rates and lower quantities of funds actually lent, then what are the options facing the authorities? The recent guarantees offered to banks by various governments for their debt issuance do not apply in full to interbank lending.[16] And, with continuing financial market volatility generating large idiosyncratic claims against financial institutions, it still seems to be the case that banks cannot distinguish with any real clarity the level of counterparty risk they run by conducting interbank lending.

The basic cause of the increase in BOR/OIS spreads seems to be an increase in the expectation of calls now and in the future on the liquidity supply from liquidity-rich commercial banks and other financial institutions. These banks are thus loathe to lend out their funds because they cannot screen potential borrowers perfectly or because they may need these funds themselves in the near future and

[16]The UK Bank Recapitalisation Plan offers the main banks the chance to purchase a government guarantee for any short term debt issuance at a rate of the relevant bank's credit default swap in the year to 7th October plus a premium of 50bp. Unsecured interbank lending is not covered and neither is leading from non-bank financials to banks.

do not wish to pay any kind of adverse signalling premia. That is why the term structure of BOR/OIS spreads has been upward sloping.

As these interbank loans are essentially deposit taking activities, we may even need to consider a comparable system to that which operates for retail depositors. With depositing banks offered some form of (partial) guarantee, to be paid for by some levy on the overall level of interbank activity. Such a response would increase the spreads in this market and reduce the level of liquidity in normal times, and so may not be a popular solution, but may offer, nevertheless, a reasonable trade-off by reducing the possibility of extreme volatility in abnormal times. By offering a guarantee for the interbank lending market that would deliver funds back quickly to any depositing institutions, banks or other financial institutions would be more likely to lend now.

An alternative is for the central bank itself now to extend its operations to banks on an uncollaterallised basis. In this case, the central bank also becomes the *central interbank*, as it will have to net its supply of liquidity to the interbank market against the future return of that liquidity. The difference here with normal liquidity injections is that the loans in this case would be made against no collateral and the central banks would thus be directly acting to reduce a market interest rate other than its own policy rate.

Whatever the solution, we should certainly know in near-real time what the level of interbank lending is. We should also sample the rates offered by other financial institutions that lend into the interbank market. Information on the quantity of interbank lending both in aggregate and on a bank by bank basis is probably required. We have discovered rather painfully that the quantity and price of lending in this market is so important that we cannot just gauge its health by taking its temperature in a daily survey. We need to be better able to distinguish shocks to demand and supply for interbank liquidity and quickly

diagnose any future heart attacks.

References

[1] Allen, F., E. Carletti and D. Gale. (2008). Interbank Market Liquidity and Central Bank Intervention. *Mimeo.*

[2] Bank of England. (2007). *Financial Stability Report.* Issue 22.

[3] Buiter, W. (2008). Now do something about the interbank market - directly. Maverecon.

[4] Cecchetti, S. G. (2008). Monetary Policy and the Financial Crisis of 2007-8. CEPR Policy Insight No 21.

[5] Friexas, X and J. C. Rochet. (1997). *Microeconomics of Banking.* MIT Press.

[6] IMF. (2008). *Global Financial Stability Report.*

[7] King, M. A. (2007). Turmoil in Financial Markets: What Can Central Banks Do?. Letter to Treasury Committee.

[8] King, M. A. (2008). *Speech* to To the CBI, Institute of Directors, Leeds Chamber of Commerce and Yorkshire Forward at the Royal Armouries, Leeds.

[9] Michaud, F. L. and C. Upper. (2008). What drives interbank rates? Evidence from the LIBOR panel. *BIS Quarterly Review*, pp. 47-58.

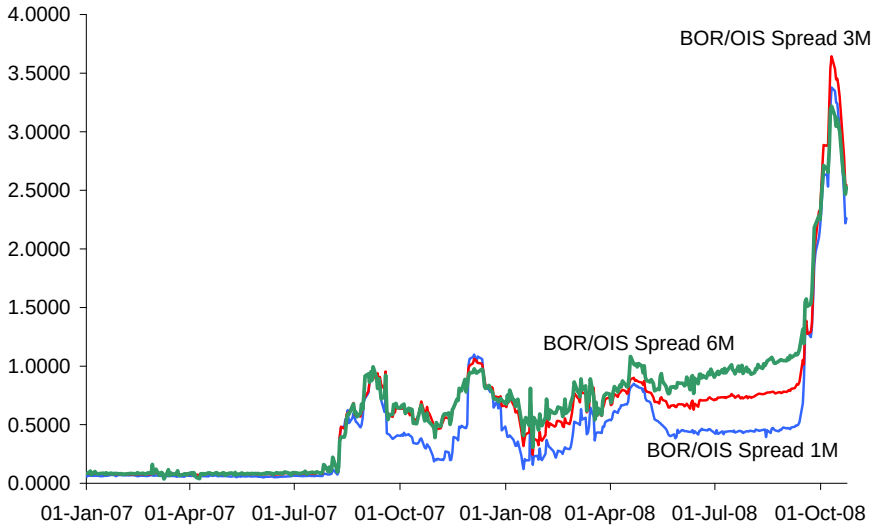


Figure 6.1: BOR/OIS Spreads US$

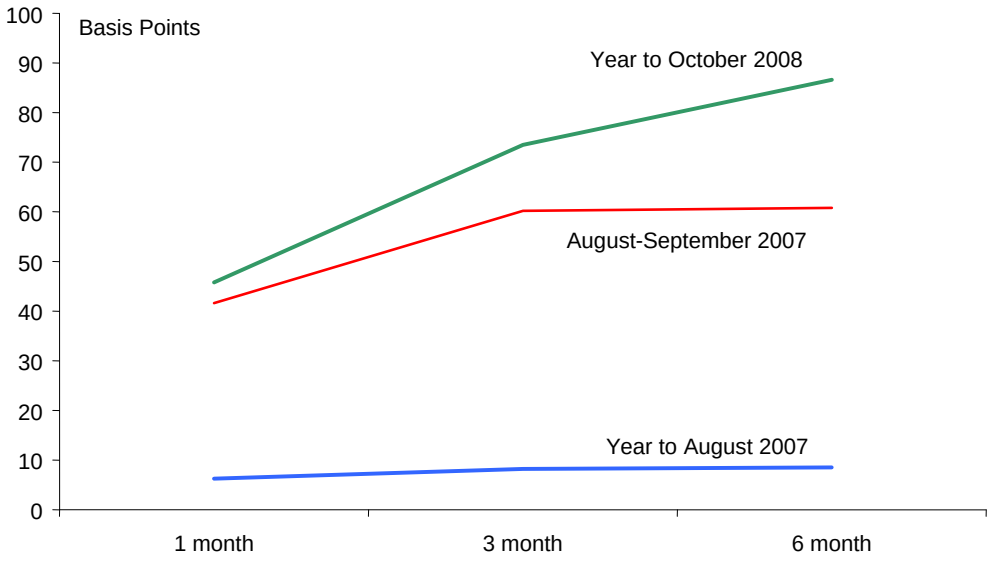
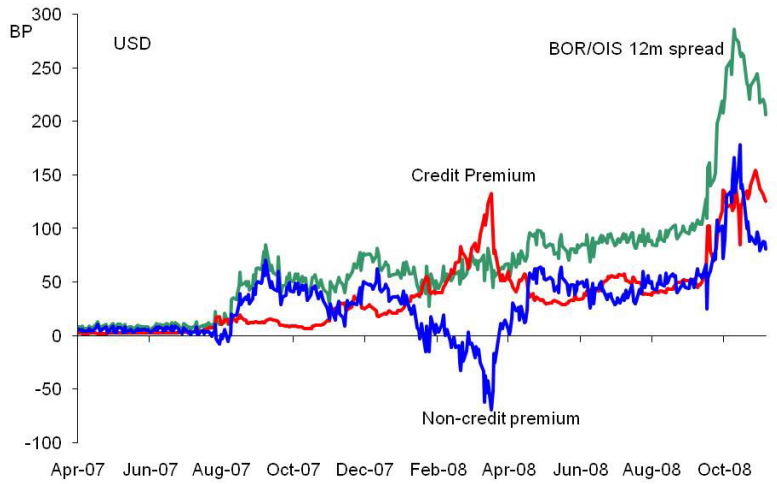


Figure 6.2: Term Structure of BOR/OIS spreads



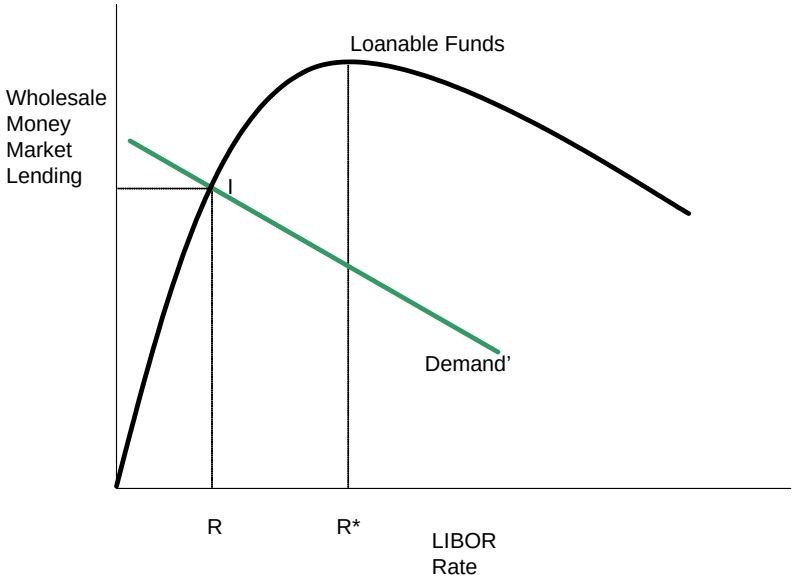


Figure 6.3: Interbank Lending Market

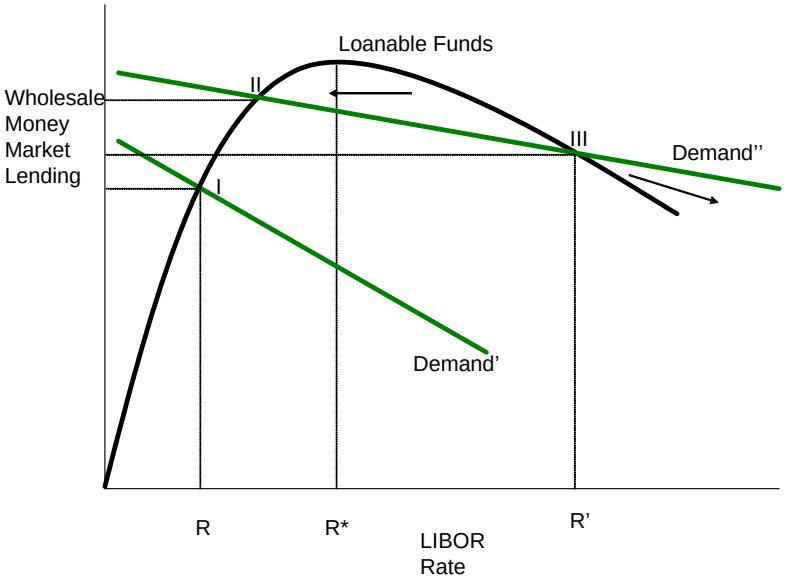


Figure 6.4: Interbank 'Market Failure'

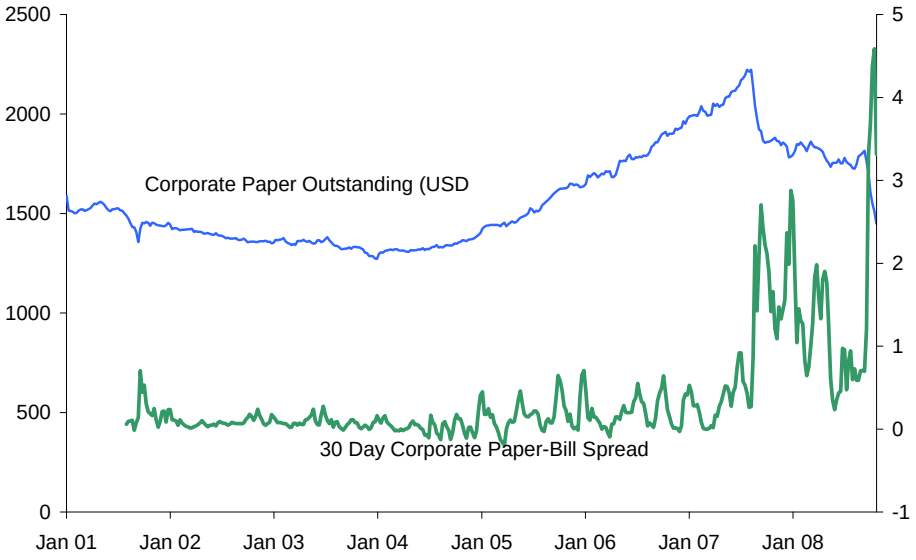
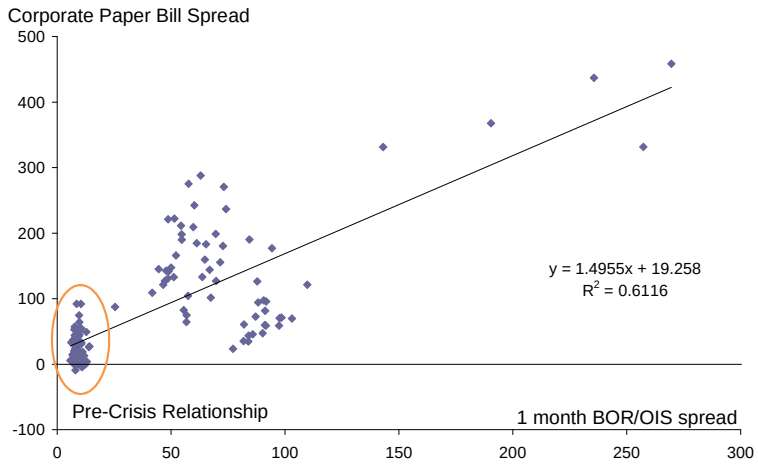


Figure 6.5: Short-Term Corporate Borrowing Market

6



7.*pdf*

Figure 6.6: Corporate and Interbank Spreads

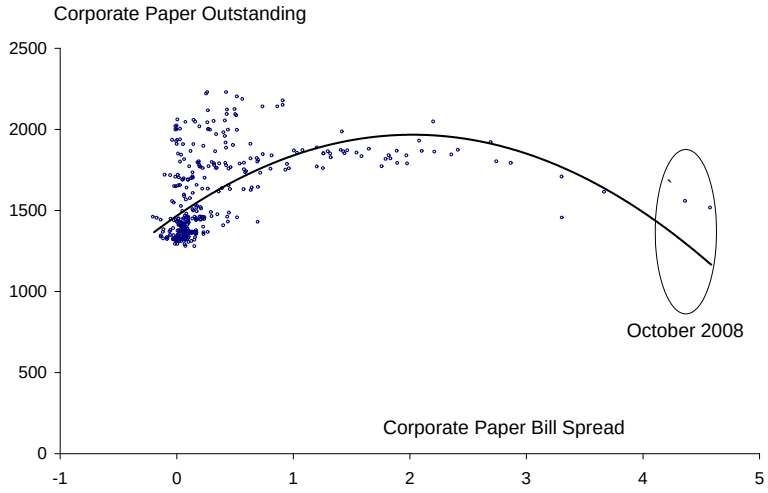


Figure 6.7: Supply Curve for Corporate Funds