# Threshold Lending Rate, Excess reserves and Stabilization during the 2007-2008 Financial Crisis

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**Abstract**

This paper posits that a threshold loan rate, identified by a flat long-term demand curve for excess reserves, is a minimum mark-up lending rate. At the threshold rate the risk adjusted marginal revenue is equal to the marginal cost of extending loans. An excess reserves-loan (RL) equation, which embeds the mark-up rate, is proposed to link excess reserves and aggregate output. The RL equation is combined with an IS equation, emphasizing the loan rate rather than the government bond rate, to obtain equilibrium output. The output gap is then introduced as a forcing process in a dynamic equation that allows for the analysis of the impact of excess reserves on inflation at the loan interest threshold. The simulation exercises suggest that the Federal Reserve's policy of injecting unprecedented levels of excess reserves was successful in stabilizing the dynamic output multiplier, while eliciting a negative response in inflation once the threshold loan rate is binding.

**JEL Codes**: E41, E43, E52 and G21

**Key words**: excess reserves, mark-up lending rate, stabilization

## 1. Introduction

A recent consensus in macroeconomics holds that the central bank has a policy interest rate which reacts to inflation and output gap. In this framework the role of money is not clear. Yet during the recent economic downturn the Federal Reserve injected over $1.5 trillion of reserves into the U.S. banking system. Most of this infusion is held as excess reserves in banks (Keister and McAndrews 2009). Concomitant with the change in the policy rate is the need to manage bank reserves (Dow 2001). It was found that such reserves can engender liquidity effects (Carpenter and Demiralp 2008). Therefore, if the central bank reduces its interest rate target it is likely to inject liquidity so as to maintain a credible target; on the other hand, to increase the target rate the central bank must drain liquidity from the system. This paper analyzes monetary policy in the presence of long-term aggregate bank liquidity preferences. In order to achieve this task, the paper takes into consideration the stylized fact of a bank excess reserves preference curve that becomes flat at a loan rate substantially above zero. At the flat segment of the curve, the risk adjusted marginal revenue of loans equals the marginal cost of making loans. Therefore, banks accumulate reserves voluntarily at the threshold. Although not identical to the thesis of this paper, a similar notion is found in Frost[1] (1971). Frost proposed a stable bank excess reserves curve that is kinked at a Treasury bill rate close to zero (between 0.3 and 0.5 percent). According to Frost, profit-maximizing banks incur brokerage fees (or transaction costs) which are higher than the market rate earned on Treasury bills – thus the curve is kinked at this point to signal a more elastic accumulation of excess reserves.

Keynes (1936, pp. 207-208), of course, noted the possibility that the broad monetary aggregate and government bonds could become perfect substitutes once the bond interest rate reaches zero. In contrast, the modern incarnation of the liquidity trap thesis holds that expectations play a critical role in determining the effect of monetary policy at the lower bound interest rate (Krugman 1998). Monetary policy could still be effective at stimulating aggregate demand at the lower bound once the central bank can maintain credibility by sticking to a relatively higher inflation target. However, expectations of future inflation must be backed by the ability to pay today. Therefore, when banks hoard excess reserves, and not make loans, the ability to pay today is diminished. Furthermore, given the integration of commodity markets with financial

[1] Mounts et al (2000) reviewed the literature on the demand for excess bank reserves.

markets and the preponderance of propriety trading desks, banks might speculate in commodity markets thereby pushing up commodity prices. Oligopolistic non-financial firms will then mark-up their prices over marginal cost. Thus the monetary injections could engender cost-push inflation (backward shift of the marginal cost curve), which does not solve the output problem[2].

In contrast, this paper posits that the aggregate bank liquidity preference curve becomes horizontal at a loan rate substantially above zero. This reflects a minimum threshold loan interest rate, which can be derived as an oligopolistic mark-up rate similar to the derivation process performed by Frexias and Rochet (2008)[3]. The threshold rate is a mark-up over a benchmark interest rate (the Federal funds rate for instance), which represents the marginal cost of funds. Therefore, it can be said that at the flat threshold rate excess reserves is seen as a perfect substitute for interest-earning loans. Moreover, this perfect substitution occurs above a zero nominal interest rate. At the threshold, banks demand excess reserves voluntarily as the risk adjusted marginal revenue is equal to the marginal cost. However, when market loan rate rises above the threshold, the risk adjusted marginal revenue is now greater than marginal cost (the downward segment of the liquidity preference curve). Any demand for excess reserves here is involuntary and banks will seek to substitute interest-earning assets for excess reserves.

The paper presents a model which links excess reserves and loans. The model demonstrates that monetary policy expansions engender a decline in the loan interest rate until the threshold oligopolistic (or mark-up) rate is binding. It is noted in the paper that

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[2] This point is the focus of another research paper.

[3] See appendix 1 for a modified version of the derivation presented in chapter 3 of Frexias and Rochet (2008).

the threshold rate itself could decrease because of the liquidity effects from the injection of reserves.

This presentation also takes into consideration loan interest rate rigidity; however, previous studies have tended to emphasize the deposit rate rigidity (Hannan and Berger 1991; Neumark and Sharpe 1992). The implicit proposition in this paper is the loan rate is subjected to monetary policy liquidity effects over some ranges but becomes rigid when the threshold oligopoly rate is binding[4]. At the threshold loan rate all monetary policy liquidity effects have evaporated and market loan rate is now equal to the marginal cost of funds – in this case the benchmark Federal funds rate. Thus banks accumulate excess reserves passively at this point. Another contribution of this paper is that it provides an analytical framework by which one could study the effect of excess reserves on aggregate output and prices once the threshold lending rate (at a flat liquidity preference curve) is binding.

Several authors have recently explored the reasons for the build-up of excess reserves in the banking system. For instance, Heider et al (2009) attribute the hoarding of reserves to the existence of counterparty risk, while Freixas and Jorge (2008) propose asymmetric information problems as the determining factor in the significant build-up of excess reserves in the interbank market[5]. In a related literature, Adrian and Shin (2009) examine liquidity as the ability of financial institutions to fund the steep discounts in market-based security prices during financial stress. In their set up the shock to security

[4] The current macroeconomic consensus recognizes wage and commodity price rigidity (Gordon 1990).

[5] In contrast to Heider et al (2009) and Freixas and Jorge (2008), this article proposes a long-term thesis of the demand for liquidity by banks. Their analyses tend to focus on the break down of the interbank market over a short period of time. On the other hand, the analysis herein looks at the demand for reserves using at least two decades of data in order to identify threshold lending rates.

prices requires reducing leverage through rapid sales of financial assets or through borrowing. A liquidity crisis ensues as many financial market participants try to so sell assets simultaneously and rapidly.

It is this liquidity crisis, central to the analysis of Adrian and Shin (2009), which necessitated that the Federal Reserve intervene in unconventional ways to pump massive amounts of reserves[6] into the banking system. This paper, therefore, proposes the notion that the aggregate liquidity preference of banks – that is a long-term demand curve for excess reserves – has implications for monetary policy stabilization. This paper emphasizes several themes that have heretofore not been looked at by the literature. It therefore underscores the liquidity preference of banks rather than the demand for broad monetary aggregates. This is important in light of the steep decline in the money multiplier and its general validity in monetary economics (Carpenter and Demiralp 2010). Therefore, this paper will incorporate in its analysis the following themes: (i) There is an oligopolistic threshold loan rate. (ii) The loan rate is introduced explicitly in the macro analysis of output determination[7]. In order to accomplish this task, an excess reserves-loan (EL) equation is proposed. This is then combined with an IS equation that also emphasizes the loan rate as a function of aggregate output (instead of the government bond rate). The determination of output allows for the study of the dynamic effect on prices by solving for the time path of a linear difference equation with the output gap as a forcing process.

[6] If we use total reserves (required reserves + excess reserves) almost identical liquidity preference curves are obtained.

[7] Traditional IS/LM models tend to present the interest rate as a government bond rate.

The paper is organized as follows. Section 2 presents some stylized facts to motivate the thesis of a flat bank excess reserves function. Section 3 presents an aggregative model linking excess reserves and national output. Section 4 uses the equilibrium output to examine the effect of excess reserves on inflation dynamics. Section 5 provides some concluding comments.

**2. Stylized facts**

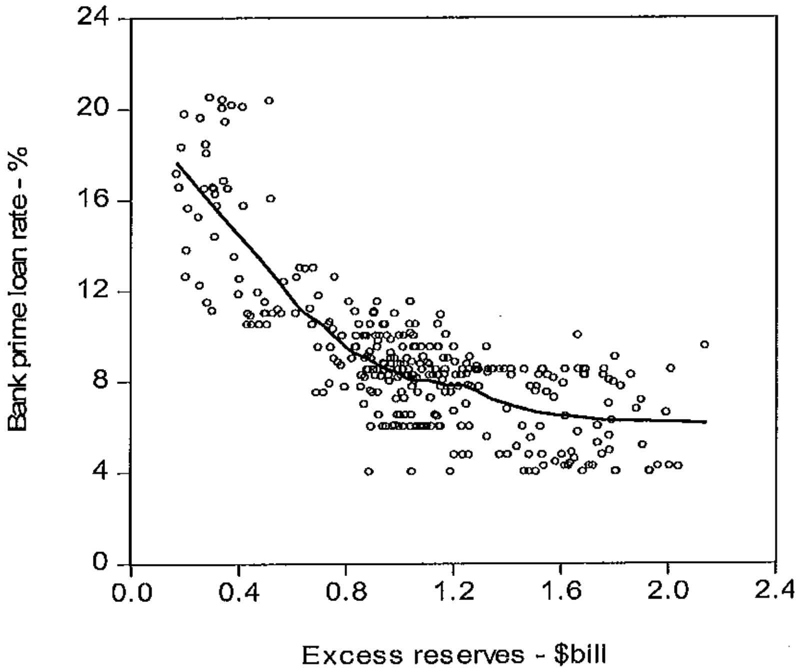
This section utilizes the method of locally weighted least squares regressions, as outlined by Cleveland (1993; 1979), to extract aggregate bank liquidity preference curves[8]. Two curves are fitted over different time periods. The first is for the pre-financial crisis era over the period 1980 to 2006 (using monthly data). The second curve is fitted using data from January 1980 to Aug 2010. A chronicle of the events surrounding the 2007-2008 financial crisis could lead one to start the crisis period at around June 2007 (see Brunnermeier 2009 for a review of these events).

Figure 1 presents the pre-crisis aggregate liquidity preference curve. Two outliners were removed from the data when fitting this curve – those are September 2001 and August 2003. It should be noted that removing the two outliners does not distort the flat curve; the flat section of the curve is actually lengthened if the two outliners are included. Nevertheless, this figure suggests a threshold (or minimum) rate of approximately 7% as the curve becomes flat around that point. Over the entire sample crisis period the liquidity preference curve has a similar pattern but the flat segment occurs at a lower lending rate of approximately 4% (figure 2). This outcome could be suggesting that the minimum rate itself is subject to shift over time. Later in the article, it

[8] Robust weights are used to minimize the effects of outliners on the curve. Following Cleveland (1993, p. 93) a smoothing parameter of 0.3 was also used in order to fit the curves.

is postulated that the minimum rate could shift owing to a change in the benchmark interest rate.

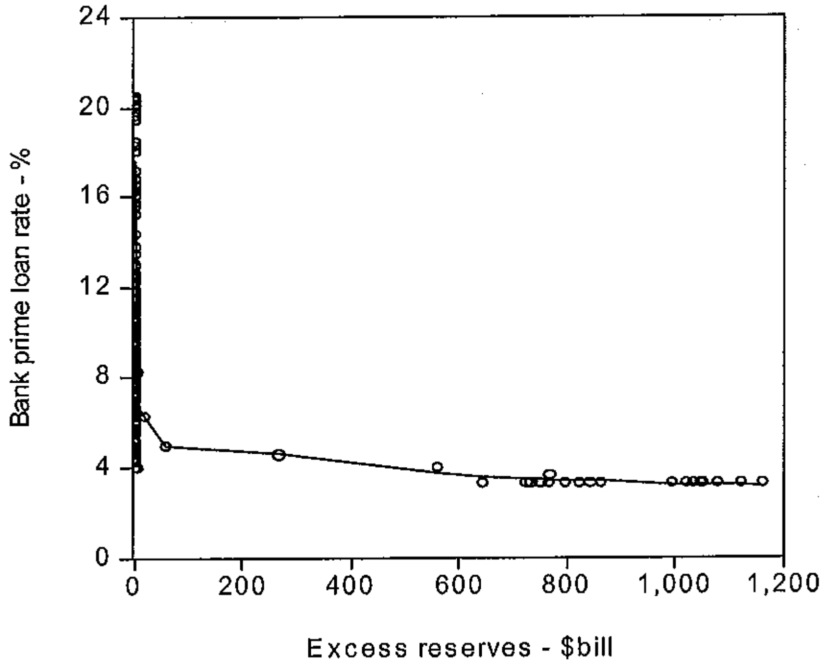
Figure 1. Pre-crisis bank liquidity preference – monthly data Jan: 1980 to Dec: 2006




Data source: Federal Reserve Economic Data (http://research.stlouisfed.org/fred2/)

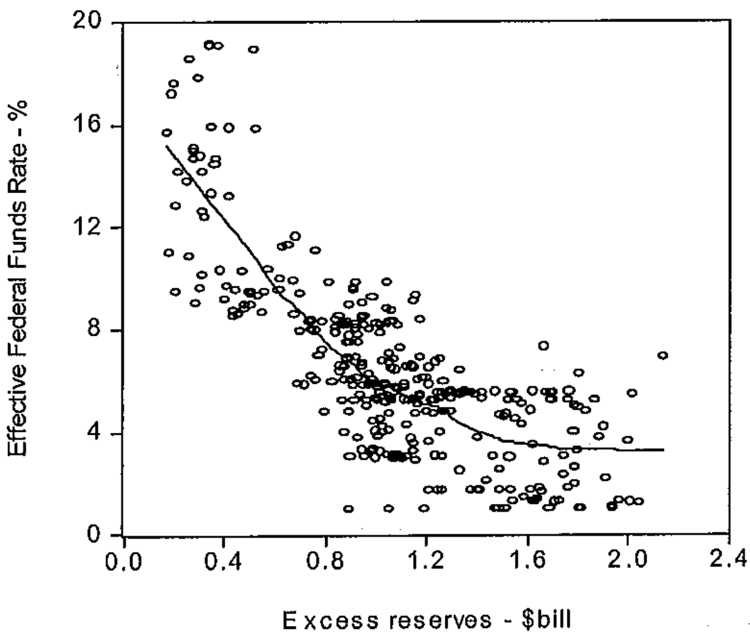
The threshold loan rate, which is derived in appendix 1 (equation A7), has embedded in it the benchmark interest rate. The benchmark is taken to be the effective Federal funds rate. The effective rate is itself subjected to liquidity effects of reserve management by the central bank (Carpenter and Demiralp 2008). This is demonstrated in figures 3 and 4 below. It is clear that the flat segment of the pre- and post-crisis curves occurs below the threshold obtained when the prime lending rate is used. This reflects the fact that the Funds rate represents the marginal cost of funds for making loans. This article does not pretend to explain what determines the horizontal segment of the curves in figures 3 and 4 as it is exogenous in the derivation of the mark-up threshold lending rate.

Figure 2. Liquidity preference curve for entire sample – monthly data Jan: 1980 to Aug: 2010



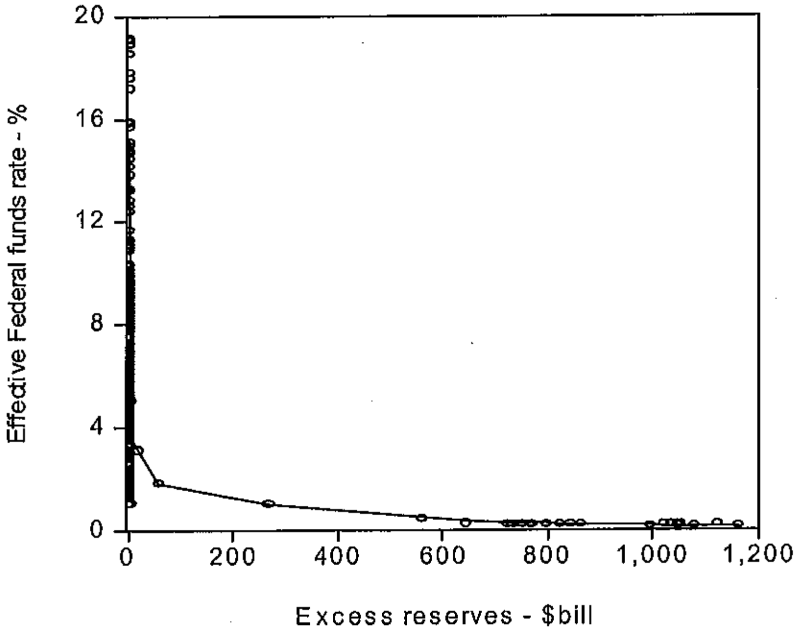

Data source: Federal Reserve Economic Data (http://research.stlouisfed.org/fred2/)

Figure 3. Pre-crisis Federal funds market liquidity preference – monthly data Jan: 1980 to Dec: 2006




Data source: Federal Reserve Economic Data (http://research.stlouisfed.org/fred2/)

Figure 4. Federal funds market liquidity preference – monthly data Jan: 1980 to Aug: 2010




Data source: Federal Reserve Economic Data (http://research.stlouisfed.org/fred2/)

Table 1 shows regression results combining monetary policy shocks with the identified threshold lending rates for the pre-crisis and entire sample period. The shocks were identified for the period Jan: 1990 to Aug: 2010. The method of Bernanke and Blinder (1992) was used to identify the monetary policy shocks within the context of a vector autoregression (VAR). The shocks were then inserted into a simple dynamic regression of the form:

$$X_t = \phi_0 + \phi_1 M_t^S + \phi_2 M_t^S \times T_t + \phi_3 X_{t-j} + \varepsilon_t$$

Where $X_t$ = inflation, unemployment, growth of stock indices, and growth of total deposits and loans (in real terms). $M_t^S$ = the identified monetary policy shock at time $t$ and $T_t$ = the loan interest threshold at 4% and 7%. $T_t$ is a dummy variable that takes the value 0 when the actual loan rate is above the identified threshold and 1 otherwise. The interaction term ($M_t^S \times T$) enables us to study the effect of monetary policy when the threshold binds. The regression is estimated by using ordinary least squares.

Table 1. The effects of monetary policy shocks at different threshold lending rates

| | Threshold Interest = 4% | | Threshold Interest = 7% | |
|---|---|---|---|---|
| | MP shock | MP shock × Thr 4 | MP shock | MP shock × Thr 7 |
| S&P 500 | -1.1 (0.513) | 5.4 (0.411) | -4.7 (0.051) | 7.4 (0.024) |
| NASDQ | -2.3 (0.394) | 7.2 (0.510) | -6.4 (0.088) | 8.7 (0.081) |
| Total deposits | -1.3 (0.001) | -1.4 (0.403) | -0.2 (0.737) | -0.21 (0.007) |
| Total loans | -0.5 (0.093) | -0.8 (0.523) | -0.2 (0.631) | -0.7 (0.120) |
| Inflation | 0.3 (0.012) | 0.1 (0.743) | 0.2 (0.189) | 0.2 (0.529) |
| Unemployment rate | 1.7 (0.568) | 2.3 (0.061) | 1.5 (0.722) | 3.1 (0.605) |

Notes: numbers in parentheses are P-Values
Source: Author's calculations

Several of the results are intuitive. A tightening of monetary policy reduces the S&P 500 and NASDQ by -1.1% and -2.3%. However, when the threshold rate of 4% is binding, the same monetary policy shock increases the indices by 5.4% and 7.2% respectively. A similar pattern is found at the threshold of 7%. This would imply when the loan market contracts – owing to the contraction of monetary policy – monetary policy succeeds in stimulating stock prices. The findings with respect to total deposits and loans also tend to be consistent with a binding interest threshold; this is, as the threshold takes effect the broad money aggregate and loans decline. The findings relating to CPI inflation is consistent with the anticipatory nature of monetary policy whereby the central bank tightens monetary policy when inflation is expected to increase. We find that a positive monetary policy shock (a contraction) is associated with a positive growth of consumer prices at both thresholds. When the threshold rates binds the relation is still positive, albeit statistically insignificant. The unemployment rate responds in an economically significant manner, although statistically insignificant. The results show that the percentage increase of the unemployment rate rises when the thresholds are binding.

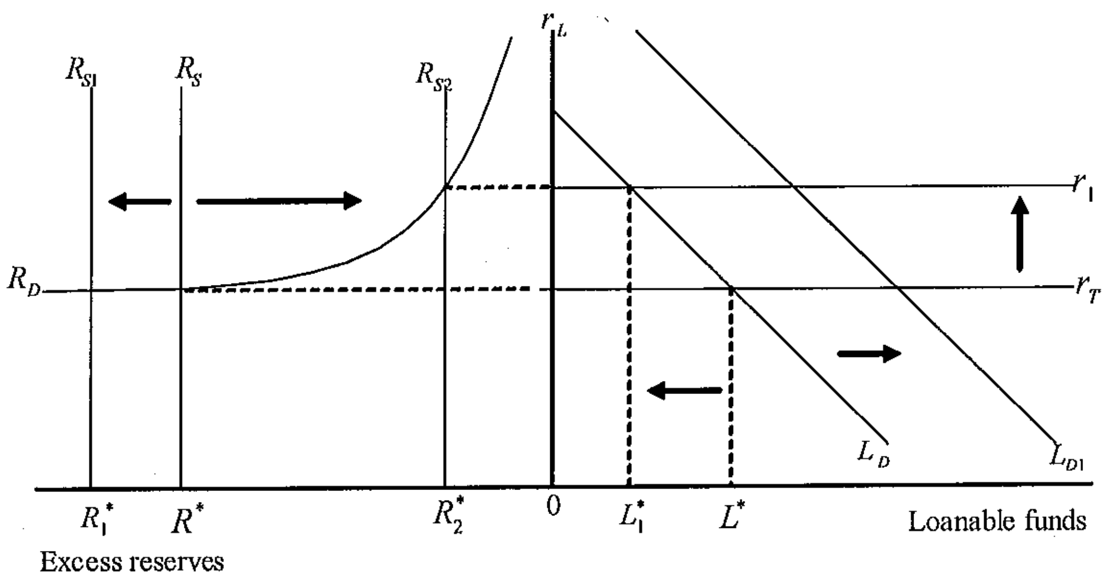
**3. Output stabilization**

This section proposes a diagram which motivates the EL (excess reserves-loan) curve. When combined with the traditional IS equation, the EL equation gives equilibrium aggregate output. Figure 5 shows that the threshold rate occurs at $r_T$. This rate which is determined by market power becomes the effective supply of loans. The threshold rate, which is taken in this paper to be a mark-up rate, is derived in appendix 1. The demand curve for excess reserves is given by $R_D$ and it becomes flat at $r_T$, which represents the effective supply curve (or threshold supply curve) of loans. Moreover, $r_T$ represents the rate at which all liquidity effects have been exhausted by the central bank's monetary expansion. It is postulated here that the rate is determined by banks that possess market power. On the other hand, households and firms accept the rate as given. The commercial banks must, in turn, consider the marginal cost of funds, risk and liquidity conditions.

On the surface, the horizontal depiction of the loan supply curve might suggest borrowers can obtain all credit at the said rate – thus being inconsistent with a credit crunch. However, the horizontal line indicates an asymmetric determination of the lending rate, which the banks determine by market power and the public accepts. For instance, consumers do not determine credit card rates; small and medium sized businesses do not determine the rate at which they borrow. In other words, the banks set the rate with the possession of market power and offer credit at the said rate. An upward shift in the line is an indication of a credit crunch as it leads to an upward movement along the loan demand curve.

The supply of reserves by the central bank is given by $R_S$. When $R_D = R_S$ the equilibrium quantity of reserves is determined as $R^*$. The demand for loans is denoted by $L_D$. The downward sloping curve reflects the idea that an increase in the lending rate decreases the present value of future profit flows of businesses. The converse occurs when the loan rate falls. It also reflects that households' discounted future cash flows fall when the mortgage rate (or the rate on consumer credit) increases. A decline in the mortgage rate has the opposite effect on households. Substituting $r_T$ into $L_D$ gives the equilibrium level of credit ($L^*$).

Figure 5. The threshold rate and loanable funds




A monetary contraction from $R_S$ to $R_{S2}$ leads to an increase in the lending rate above threshold to $r_1$. The latter implies the central bank's liquidity management has liquidity effects only above $r_T$. Embedded in the threshold loan rate is the policy interest rate – $r_F$. Therefore, a decrease in the target $r_F$ is followed by an expansion of bank reserves in order to defend the target. On the other hand, when the $r_F$ target is increased the central bank must diminish bank reserves to keep the target credible. The shocks in excess reserves are demonstrated by a movement of a vertical reserve supply curve (figure 5) along the demand curve.

Consequently, credit is contracted from $L^*$ to $L_1^*$. On the other hand, a monetary expansion from $R_S$ to $R_{S1}$ leads to no further decrease in the lending rate as the minimum threshold rate is now binding. Credit expansion stops at $L^*$ and excess reserves are accumulated passively. Therefore, once the threshold rate is reached credit intermediation would require that policies directly stimulate the demand for loans along this rate. The demand curve for loans shifts out from $L_D$ to $L_{D1}$. As the stylized facts indicate, the threshold interest rate could actually shift downward. The derivation in appendix 1 suggests that this shift could occur when the probability of a systemic bank failure – evidenced by a shortage of excess reserves – rises relative to the probability of the regime of stability in the financial markets. The downward shift could also occur because the benchmark policy rate, itself negatively related to excess reserves (see figure 3 and 4), is included in the derived oligopolistic mark-up threshold interest rate.

As an aside, albeit an important one, borrower surplus – bounded by the area under the loan demand curve and above $r_T$ – increases when the demand for credit shifts outward. However, the surplus would diminish as the interest rate rises above the threshold as liquidity conditions tighten.

Given the stylized facts and the diagrammatic exposition, it is reasonable to express the banks' demand for excess reserves as the following reciprocal model

$$r_L = r_T + \beta\left(\frac{1}{R^*}\right) \quad (1)$$

Note that the threshold minimum rate is the asymptote. $\beta$ is a coefficient and $R^*$ is the equilibrium level of excess reserves as shown in figure 3. From figure 5 it is possible to form the following relationship between excess reserves and the demand for loans

$$r_T + \beta\left(\frac{1}{R^*}\right) = -ar_L + bY \quad (2)$$

The demand for loans is given by the following simple double-log function $L_D = -ar_L + bY$, which is chosen for the purpose of algebraic simplicity. $a$ = the public's elasticity of demand for loans; $b$ = the public's income elasticity of demand for loans; and $Y$ = aggregate output.

The threshold or mark-up rate can be derived from an oligopolistic model of the banking firm similar to Frexias and Rochet (2008).

$$r_T = \frac{(\theta_2 - \theta_1)r_F(R^*) + \theta_3 r_{SD}}{(1 + \frac{1}{aN})} \quad (3)$$

Where $r_F$ = a benchmark or policy rate of the central bank such as the federal funds rate; $r_{SD}$ = the interest rate banks earn by holding excess reserves at the central bank; $\theta_1$, $\theta_2$ and $\theta_3$ = the regime probabilities[9]; $N$ = the number of banking firms indexed with equal weights for algebraic simplicity; and $a$ = the public's elasticity of demand for loans. The

[9] At this point it would be helpful to read appendix 1 to obtain the motivation and explanation of the threshold interest rate.

expression $r_F(R^*)$ shows that $r_F$ is subjected to liquidity effects in the Federal funds market; a postulation that is based on the stylized facts presented by figures 3 and 4.

Therefore, it is possible to rewrite equation 2 as

$$\frac{(\theta_2-\theta_1)r_F(R^*)+\theta_3 r_{SD}}{(1+\frac{1}{aN})}+\beta\left(\frac{1}{R^*}\right)=-ar_L+bY \tag{4}$$

Equation 4 can be solved for $r_L$ to obtain the RL equation in terms of $Y$, $R^*$ and the exogenous parameters of the model. One of the attractive features of equation 4 is it introduces microeconomic terms into a macroeconomic function.

The conventional IS equation is as follows

$$r_L = A - dY \tag{5}$$

Where $A$ is determined by the autonomous components of consumption and government spending. The parameter $d$ is itself determined by the tax rate, marginal propensity to consume and the interest elasticity of investment[10]. Solving for $r_L$ in equation 4 and setting it equal to the IS equation gives the reduced form solution for output $Y^*$. This is given by equation 6, which shows that excess reserves influence aggregate output via changes in the funds rate and the composite elasticity.

$$Y^*=\frac{(\theta_2-\theta_1)r_F(R^*)+\theta_3 r_{SD}}{a(\frac{b}{a}+d)(1+\frac{1}{aN})}+\left(\frac{\beta}{a(\frac{b}{a}+d)}\right)R^{*-1}+\left(\frac{1}{d+\frac{b}{a}}\right)A \tag{6}$$

In order to obtain the output dynamics, take the total differential of equation 6. Note that $r_F'(R^*)$ is the slope of the bank liquidity preference curve in the Federal funds

[10] The interpretation of these parameters is well known in the literature and in intermediate macroeconomics textbooks; thus they are presented in composite form.

market. This slope is given by $-\alpha / R^{*2}$. Express $dY^*$, $dR^*$ and $dA$ in discrete form, respectively, as follows $\Delta Y^*$, $\Delta R^*$ and $\Delta A$; also note that $\Delta Y^* = Y_t^* - Y_{t-1}^*$. Substituting the slope and the discrete forms will result in equation 8, which is the dynamic equation.

$$dY^* = \frac{(\theta_2 - \theta_1) r_F'(R^*)}{a(\frac{b}{a}+d)(1+\frac{1}{aN})} \cdot dR^* - \left( \frac{\beta}{a(\frac{b}{a}+d)} \right) R^{*-2} \cdot dR^* + \left( \frac{1}{d+\frac{b}{a}} \right) dA \qquad (7)$$

$$Y_t^* = Y_{t-1}^* - \left( \left\{ \frac{\alpha(\theta_2 - \theta_1)}{a(\frac{b}{a}+d)(1+\frac{1}{aN})} + \frac{\beta}{a(\frac{b}{a}+d)} \right\} \frac{1}{R^{*2}} \right) \Delta R^* + \left( \frac{1}{d+\frac{b}{a}} \right) \Delta A \qquad (8)$$

Let $\alpha_1 = -\left\{ \frac{\alpha(\theta_2 - \theta_1)}{a(\frac{b}{a}+d)(1+\frac{1}{aN})} + \frac{\beta}{a(\frac{b}{a}+d)} \right\} \frac{1}{R^{*2}}$

and

$\alpha_2 = 1/(d + \frac{b}{a})$

Let us rewrite equation 8 as follows where $e_t = \Delta R^*$ and $g_t = \Delta A$. Note that $g$ represents the autonomous components of government spending, investment and consumption. Using the solution method of Enders (2004), the time path of $Y_t^*$ is given by equation 10.

$$Y_t^* = Y_{t-1}^* + \alpha_1 e_t + \alpha_2 g_t \qquad (9)$$

$$Y_t^* = \alpha_1 \sum_{i=1}^{t} e_i + \alpha_2 \sum_{i=1}^{t} g_i \qquad (10)$$

The dynamic multipliers are specified by equations 11 and 12.

$$\frac{\partial Y_t^*}{\partial e_t} = \alpha_1 = -\left\{ \frac{\alpha(\theta_2 - \theta_1)}{a(\frac{b}{a} + d)(1 + \frac{1}{aN})} + \frac{\beta}{a(\frac{b}{a} + d)} \right\} \frac{1}{R^{*2}} \tag{11}$$

$$\frac{\partial Y_t^*}{\partial g_t} = \alpha_2 = 1 / (d + \frac{b}{a}) \tag{12}$$

Equation 11 suggests dynamic multipliers that are negative in each period[11]. This result ought not to be a surprise as excess reserves represent funds that are not intermediated through the banking system – thus the negative effect on real output. Some evidence supporting this thesis is presented by figure A1 in appendix 1. The figure shows a negative contemporaneous correlation between spread and GDP growth. The essential issue, however, is output stabilization in times of financial stress. The simulation, presented by figure 6, suggests the central bank has succeeded in reducing the absolute value of the negative multiplier. However, before performing the simulation, the parameters in equation 11 have to be approximated. An important component is the term $(\theta_2 - \theta_1) / (1 + \frac{1}{aN})$, which determines the spread between $r_L$ and $r_F$. Essentially, the spread is determined by risk and market power. Therefore, the difference between the prime lending rate ($r_L$) and the effective Federal funds rate ($r_F$) is used to proxy this term[12].

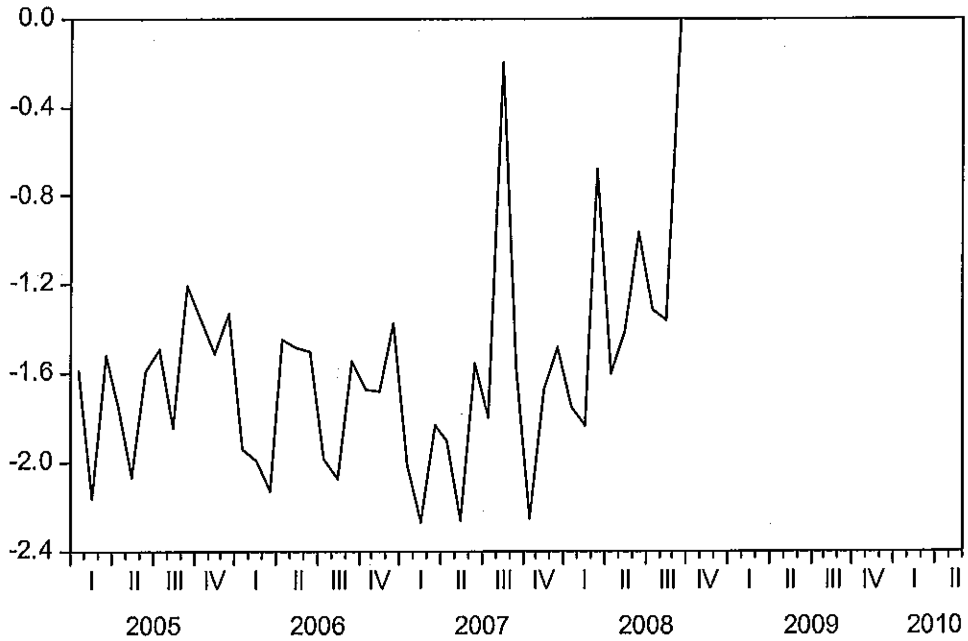
The spread, moreover, acts as a penalty on the multiplier as a higher spread could signal a rise in the desire of banks to increase the mark-up and the concomitant credit

[11] It should be noted that given the nature of the dynamic equation where there is a coefficient of 1 on $Y_{t-1}^*$ term, the dynamic multipliers are the same as taking the one period static multiplier.

[12] The bank prime lending rate and effective Federal funds rate were obtained from the St. Louis Federal Reserve Economic Dataset (FRED).

contraction. Furthermore, in order to simplify the simulation assume that the term $1/a(\frac{b}{a}+d)$ equals to 1. This simplification is unlikely to influence the instability of the multiplier. $\alpha = 5.63$ and $\beta = 2.91$ are obtained by estimating the following regressions $r_F = r_{FT} + \alpha(1/R^*)$ and $r_L = r_T + \beta(1/R^*)$ respectively over the pre-crisis period. Note that $r_{FT}$ is the interest threshold in the Federal funds market. The dynamic multipliers are graphed in figure 6 for the period 2005 to May 2010. The figure suggests that the significant increase in excess reserves served to reduce the fluctuation of the multiplier – thus the output volatility – and push the negative dynamic multipliers very close to zero.

Figure 6. Multiplier showing the effect of excess reserves on real output




Source: Author's calculations

Equation 12 shows a long-term stable positive multiplier for a change in autonomous investment, government spending or consumption. Policies which stimulate these autonomous components will increase output and likely shift outward the demand for bank credit. The extent of the effect is dependent on the income elasticity of demand for loans, interest elasticity of demand for loans, the marginal propensity to consume and the interest sensitivity of private investment.

**4. Inflation dynamics**

There have been some discussions in the media and in academic settings (see Gavin 2009) of the potential inflationary effects of the unprecedented expansion of the Federal Reserve balance sheet owing to the rapid expansion of excess reserves. This section examines this issue by first postulating that the inflation rate evolves according to the following dynamic equation.

$$p_t = \lambda p_{t-1} + \gamma y_t \tag{13}$$

$p_t$ represents the inflation rate and $y_t$ the output gap between trend output ($\overline{Y}$) and equilibrium output given by equation 6; thus $y_t = Y^* - \overline{Y}$. The solution of the time path given an initial value for inflation ($p_0$) is represented by equation 14. Assume that $0 < \lambda < 1$, thus $\lambda^t p_0 \to 0$ as $t \to \infty$. This is a reasonable assumption to make in light of the fact that United States inflation data do not exhibit an explosive hyperinflationary tendency.

$$p_t = \lambda^t p_0 + \gamma \sum_{i=0}^{t-1} \lambda^i y_{t-i} \tag{14}$$

Inserting equation 6 into equation 14 gives

$$p_t = \gamma \sum_{i=0}^{t-1} \lambda^i \left[ \frac{(\theta_2 - \theta_1) r_F(R^*)}{a(\frac{b}{a} + d)(1 + \frac{1}{aN})} + \left( \frac{\beta}{a(\frac{b}{a} + d)} \right) R^{*-1} + \left( \frac{1}{d + \frac{b}{a}} \right) A - \overline{Y} \right]_{t-i} \tag{15}$$

The impact on inflation given the change in excess reserves is obtained by the dynamic multipliers given by equations 15a to 15d; the time graph of these multipliers is the impulse response function (Enders 2004). Equation 15a shows the negative impact multiplier, 15b the one-period multiplier, 15c the two-period multiplier, and 15d the n-period multiplier. A general feature of these multipliers is the variable $R^{*-2}$ stays in the equation each period into the future. Therefore, it is possible to simulate how future periods of inflation respond to different levels of excess reserves given the binding threshold loan rate.

Figure 7 presents the impulse response function (IRF) starting from the initial substantial increase in excess reserves – third quarter of 2008. The IRFs have embedded in them the two non-constant slopes – $-\alpha / R^{*2}$ and $-\beta / R^{*2}$. Thus the simulation allows for these changes over the review period; September 2008 was taken as $t = 0$. The initial response in period $t = 0$ is negative – thus indicating that non-intermediated funds would not stimulate price increases. The contemporaneous scatter (figure A2) plot and simple regression results in appendix 1 support the negative impact response given that the interest spread is embedded in the formula. By the third quarter of 2009, in spite of the continued high excess reserves, the multiplier approaches zero.

Let $\Gamma = -\left\{ \frac{\alpha(\theta_2 - \theta_1)}{a(\frac{b}{a} + d)(1 + \frac{1}{aN})} + \frac{\beta}{a(\frac{b}{a} + d)} \right\} \frac{1}{R^{*2}}$

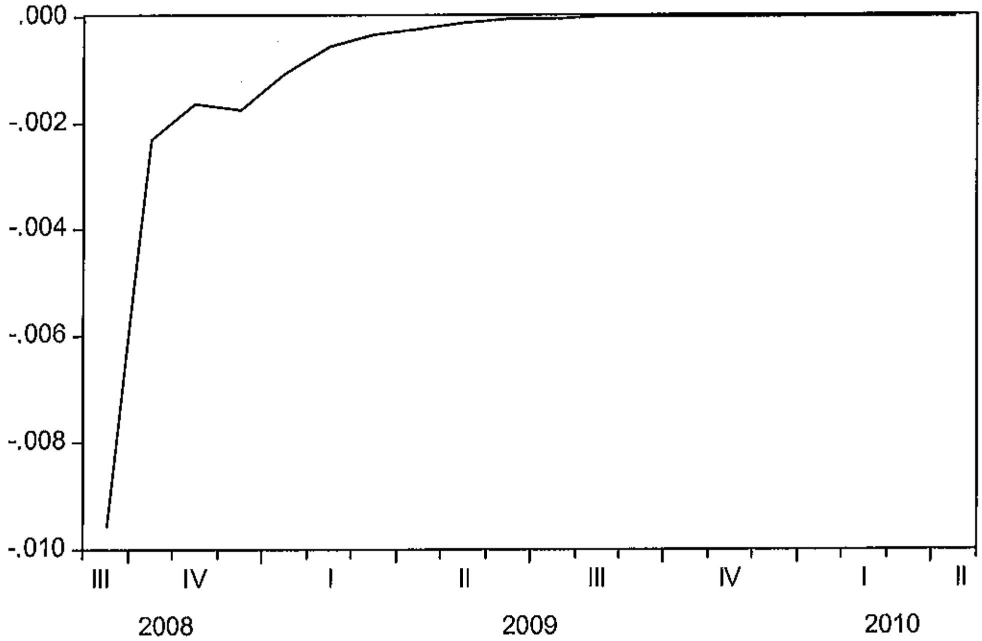
$$\frac{\partial p_t}{\partial R^*} = \gamma \Gamma \qquad (15a)$$

$$\frac{\partial p_t}{\partial R^*} = \gamma \lambda \Gamma \qquad (15b)$$

$$\frac{\partial p_{t+2}}{\partial R^*} = \gamma\lambda^2\Gamma \tag{15c}$$

$$\frac{\partial p_{t+n}}{\partial R^*} = \gamma\lambda^n\Gamma \tag{15d}$$

Figure 7. Impulse response function showing price response to changes in excess reserves




Source: Author's calculations

Let $\Phi = 1/(d + \frac{b}{a})$. The dynamic multipliers showing the effect of $\Delta A$ on price are obtained as follows (16a to 16d). Taking $\lambda$ to be 0.6 and assume different values for $\Phi$, the impulse response functions are graphed in figure 8. The price response is higher for larger values of $\Phi$. The third quarter of 2008 was taken to be $t = 0$.

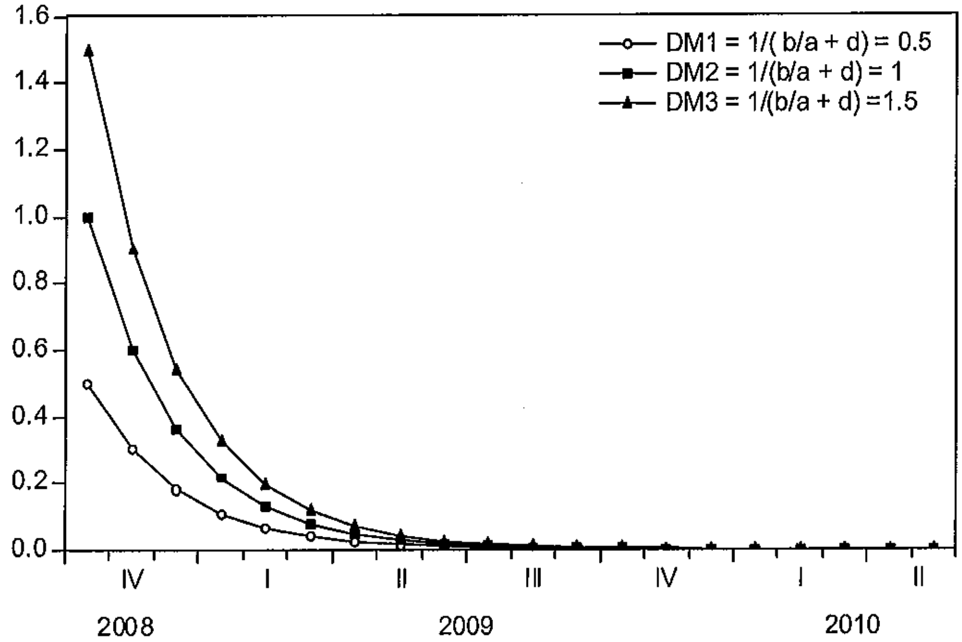
$$\frac{\partial p_t}{\partial(\Delta A)} = \gamma\Phi \tag{16a}$$

$$\frac{\partial p_{t+1}}{\partial(\Delta A)} = \gamma\lambda\Phi \tag{16b}$$

$$\frac{\partial p_{t+2}}{\partial(\Delta A)} = \gamma\lambda^2\Phi \qquad (16c)$$

$$\frac{\partial p_{t+n}}{\partial(\Delta A)} = \gamma\lambda^n\Phi \qquad (16d)$$

Figure 8. Impulse response function showing price response to changes in autonomous expenditure




Source: Author's calculations

## 5. Conclusion

This paper tried to illustrate the effects of monetary management in the presence of aggregate bank liquidity preference and a mark-up threshold loan rate. Although there is a large literature on various monetary transmission mechanisms, this line of exploration does not exist in the present literature. Moreover, this paper takes the loan rate as being determined by oligopolistic forces instead of a competitive loanable funds mechanism. This line of exploration comes in the presence of unprecedented expansion of excess bank reserves by the Federal Reserve in spite of the conventional wisdom which holds that the Federal Reserve uses the Federal funds rate as its main instrument since the late 1980s (Meulendyke 1998). The paper analyzes how a monetary expansion would fare when a threshold lending rate, identified by a flat bank liquidity preference curve, is binding. Therefore, instead to focusing on the demand for broad monetary aggregates, this study underscores that the behavior of banks, as it relates to interest rate mark-up and liquidity preference, is critical for the functioning of the monetary transmission mechanism. Moreover, using a long data set, long-term liquidity preferences are identified; thus distinguishing this study from those which perform short period analyses of the liquidity build-up in the interbank markets of Europe and the United States.

It was also noted that the threshold rate could change owing to the expansion of excess reserves that decrease the effective Federal funds rate, which is embedded in the derived threshold oligopolistic interest rate. The simulation exercises – based on a proposed model linking excess reserves and loan demand – suggest that the Federal Reserve's policy of injecting unprecedented levels of excess reserves was successful in stabilizing the dynamic output multiplier, while eliciting a negative inflation response once the threshold loan rate is binding. However, policies that stimulate the autonomous components of consumption, private investments and government spending would tend to have a larger output effect and a more substantial effect on financial intermediation.

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## Appendix 1

Deriving the mark-up rate

This section derives the mark-up loan rate utilizing the Cournot model as presented by Freixas and Rochet (2008). However, the basic model is augmented to include the risk of being in a shortage of excess reserves. Let us assume the representative bank could be in three excess reserves states. State 1 – a shortage of reserves relative to required, thereby requiring the bank to borrow from the Federal funds market or the discount window. Without losing the basic conclusion assume only one penalty interest rate for state 1 – the Federal funds rate, $r_F$. The probability of being in a reserve deficit is denoted by $\theta_1$. This probability is obviously related to the risk of a systemic crisis such as a run on the banks. State 2 – there is a surplus of reserves, which allows the bank to lend in the Federal funds market. Again the bank lends at $r_F$. The probability of being in state 2 is $\theta_2$. State 3 – the bank has such a large build-up of excess reserves it can hoard funds in special deposits at the central bank. This is the contemporary situation where banks are paid interest on special deposit of excess reserves at the Federal Reserve (Keister and McAndrews 2009). The banks earn the rate of interest, $r_{SD}$, on these special deposits. The probability – which is influenced by policy – of being in state 3 is $\theta_3$. Given that $\theta_1 + \theta_2 + \theta_3 = 1$, the expected return on excess reserves is $r_E = (\theta_2 - \theta_1)r_F + \theta_3 r_{SD}$.

The profit function, taken to be concave in loans ($L_i$) and deposits ($D_i$), of the representative bank is given by equation A1. The bank's balance sheet identity is given by A2. $R_i$ = excess reserves, $zD_i$ = required reserves (where $z$ = required reserve ratio), and $D_i$ = deposits. The inverse function forms $r_L(L)$ and $r_D(D)$ are used in the derivation process.

$$\Pi_i = r_L(L)L_i + r_E R_i - r_D(D)D_i \qquad \text{A1}$$

$$zD_i + R_i + L_i = D_i \qquad \text{A2}$$

Solving the balance sheet constraint for $R_i$ and substituting into equation A1 gives the profit function A3. In the Cournot equilibrium the *i*th bank maximizes profit by taking the volume of loans and deposits of other banks as given. In other words, for the *i*th bank, $(L_i^*, D_i^*)$ solves equation A3. The conditions A4 denote the aggregate quantity of loans and deposits demanded, respectively, by the entire banking sector.

$$\Pi_i = [r_L(L) - r_E]L_i - [r_D(D) - r_E(1-z)]D_i \qquad \text{A3}$$

$$L = L_i + \sum_{i \neq j} L_j \; ; \; D = D_i + \sum_{i \neq j} D_j \qquad \text{A4}$$

The first order after maximizing the profit function is given by A5. The market demand curve the bank faces is downward sloping, hence the elasticity of demand denoted by A5-2. The symbol $a$ is the elasticity of demand for loans. There is a unique equilibrium in which bank $i$ assumes $L_i^* = L^* / N$, where $N$ denotes the number of commercial banks that makes up the banking sector[13]. The expression $r_L'(L)$ represents the first derivative of the loan rate with respect to $L$ and it is simply the inverse of $L'(r_L)$.

$$\frac{d\Pi_i}{dL_i} = r_L(L) + r_L'(L)L_i - r_E = 0 \qquad \text{A5}$$

$$r_L'(L) = 1 / L'(r_L) \qquad \text{(A5-1)}$$

[13] The use of $N$ weighs each bank equally. This is clearly an unrealistic assumption for the purpose of making the mathematics tractable. Nevertheless, the simplification does not change the conclusion of the model.

$$a = r_L \cdot L'(r_L) / L \qquad \text{(A5-2)}$$

Substituting A5-1 and A5-2 into A5 gives the expression (A6) from which the minimum threshold rate ($r_T$) is obtained. The mark-up is dependent on the inverse of the product of *N* and the market elasticity of demand ($a$) for loans. As $N \to 1$ there is the case of a monopoly and the mark-up is highest, while as $N \to \infty$ one bank has an infinitesimal share of the market; the equilibrium approaches the purely competitive state in which the mark-up approaches zero.

The model suggests that as risk of a bank run or systemic collapse rises ($\theta_1 > \theta_2$) the threshold rate falls. The Federal Reserve assuaged this risk by pumping large quantities of excess reserves into the banking system and paying a small rate of interest on excess reserves in special deposits. In the threshold loan rate equation, $r_F$ is subjected to liquidity effects and therefore can be written as $r_F(R)$ with the effect being measured by the slope $r_L'(R)$. This scenario could have accounted for the downward shift in the aggregate bank liquidity preference curve during the recent financial crisis.

$$r_L(1+\frac{1}{aN}) = r_E \text{ or } r_L(1+\frac{1}{aN}) = (\theta_2 - \theta_1)r_F + \theta_3 r_{SD} \qquad \text{A6}$$

$$r_T = \frac{(\theta_2 - \theta_1)r_F + \theta_3 r_{SD}}{(1+\frac{1}{aN})} \qquad \text{A7}$$

<u>Auxiliary stylized facts</u>

This section provides some evidence that spread is negatively related to GDP growth and inflation. The scatter plots are done using quarterly data from 1980:Q1 to 2010:Q1. Quarterly interest rate data were sourced from the IMF's *International Financial Statistics* (electronic access). Quarterly real GDP, in levels, came from the St.

Louis Federal Reserve Economic Database (FRED). Presented along with the charts are simple OLS bi-variate regressions. Figure A1 shows the relationship between spread and GDP growth. The accompanying OLS regression is $GrGDP = 1.47 - 0.306spread$ with $R^2 = 0.07$ and a p-value, estimated with Newey-West standard errors, on the spread coefficient of 0.042. Although not presented here very similar regressions results and scatter plot were obtained when the growth of industrial production is regressed or graphed against spread over the same time period.

Inflation, measured as CPI inflation, is also negatively related to the spread between the lending rate and the Federal funds rate. The estimated regression, where the standard errors were corrected by the Newey-West method, is

$Inflation = 1.92 - 0.563spread$ with accompanying $R^2 = 0.06$. The p-value on the spread coefficient is 0.063.

Figure A1. GDP growth and interest rate spread

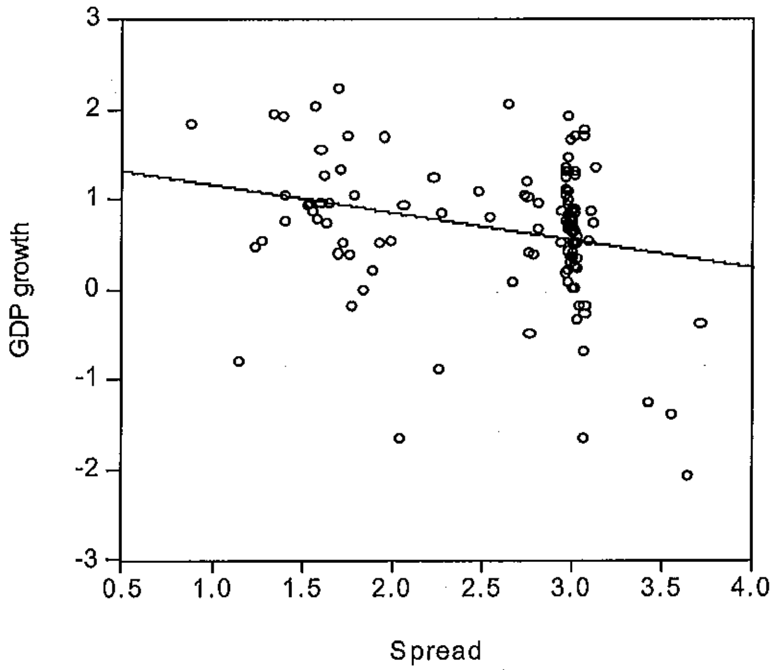

Figure A2. CPI inflation and interest rate spread