DID THE FED RECOGNISE THE IMPENDING LIQUIDITY CRISIS OF 1929? NEW EVIDENCE FROM NON-LINEAR ANALYSIS*

Olivier Damette and Antoine Parent

The October 1929 crash lead to a complete freeze of New-York open markets. By means of a policy reaction function in a non-linear framework, using credit spreads between open market rates and the Fed's instrument rates as a proxy for liquidity risk, we present econometric evidence that the Fed was well aware of such risks as early as 1930, reacted to the financial stress and altered its monetary policy in consequence. Historical evidence from the Fed's minutes corroborates these findings. Our outcomes revisit conventional wisdom about the presumed passivity of the Fed throughout the thirties.

JEL codes: N12, N22, G01, E52, E58, C22.

Keywords: Crisis of 1929, monetary policy, monetary cliometrics, central banks, non-linear STR models.

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Introduction

Our purpose in this study is to test whether the Fed had recognised the impending liquidity crisis of 1929 and whether its policy was consistent with this danger through time (up to March 1933). Our intuition is that the Fed was well aware of liquidity risks and attempted to repel their occurrence. With this in mind, we shall simulate an augmented Fed reaction function over the period 1921–1933. Using a reaction function for the Fed appears relevant here, since it is a commonly accepted view that during the interwar period '*virtually all governors used the level of market interest rates as an indicator of current policy*' Meltzer (2003, p. 295). Obviously, as depicted by Chandler (1958), it is likely that the Fed pursued various policy goals. Moreover, controversy among contemporary policymakers may cast doubt about the pursuit of an unique goal. Nonetheless, regardless of historical context and epoch, central banks have always permitted discretion to affect their decisions. Therefore, these arguments should not prevent us from adopting a retrospective econometric analysis to assess the meaning of the Fed officials' decisions over this period. Our work should be seen as an addition and a complement to the pioneering econometric work of Wheelock (1989, 1990).[1] To this end, we deliberately use nominal variables only and address these issues using a non-linear framework in order to determine the driving forces behind the Fed's policy reaction function over the interwar years. To test whether the Fed was actually receptive to financial stress, we shall introduce into our model the variable 'Liquidity shortage' (an indicator of open market tensions) as a transition variable in order to test its influence on the instrument rate.

Indeed, in October 1929, the US open markets endured a panic with a run in the sale and repurchase agreement market, which provided financing for a wide range of securitisation activities and financial institutions. We argue that activity in these transactions was the nexus of the crisis. We assess the spread between open market interest rates and instrument rates as a proxy for liquidity risk. Concerns about the liquidity of markets for the bonds used as collateral led to increases in open market interest rates. The risk of declining asset values and increasing market interest rates constituted a threat to the US banking system, which became effectively insolvent with banks failures in the early thirties. The banking system could not honour these demands because the cash had been lent out and the loans were illiquid. We suggest here that increases in open market interest rates can drive the banking system to

[1] As developed in Section 4, our work more precisely extends Wheelock (1990), in which, using a regime-switching model, this author estimates a model of the demand for discount window loans as a non-linear function of the spread between a market interest rate and the discount rate, the change in non-borrowed reserves and a measure of economic activity.

insolvency through the following mechanism: these spreads reveal higher uncertainty due to lower collateral values. Indeed, selling the underlying collateral drives asset prices down, which then reinforces the cycle: lower prices, less collateral, runs on money market funds, more concern about solvency.[2] Our purpose is to assess how the Fed's reaction function responded to the influence of liquidity shortage episodes. In order to measure the influence of liquidity shortage on policy conduct, we use spreads between market rates (namely call loans, commercial paper, short term Treasury notes, for unsecured open market borrowing) and instrument rates of the Fed (the discount rate and the bankers' acceptance rate) for the risk-free rate. An increase in these spreads (market rates minus instrument rates) reveals a rise in tension and rapid deterioration in open markets. These increased spreads are equivalent to a price decrease, which represents a fall in the value of collateral used in transactions. Of particular interest will be the period between 1927 and 1929, when these spreads first signalled danger in the open markets and announced the October crisis.

In this article we address the following issues: Did the Fed monitor such signals and subsequently adapt its behaviour? Does historical and narrative evidence corroborate the conjecture that liquidity shortage episodes induced a shift in the Fed's reaction function? Must we necessarily conclude that policy was systematically flawed?

Our article is organised as follows: Section 1 surveys the existing explanations of the 1929 crisis; Section 2 presents the characteristics of the US Open Markets in the interwar period; Section 3 presents data; Section 4 explains the Smooth Transition Regression (STR) methodology. Section 5 delivers our findings: We provide new econometric evidence that 'Liquidity shortage' plays the role of a transition variable that provoked the dramatic change in the policy rule of the Fed immediately after the 1929 crisis was triggered. Section 6 provides historical evidence extracted from the minutes of the Fed's Open Market Committee between 1927 and 1933 corroborating the econometric evidence that the Fed was well aware of the risk of liquidity crisis as early as 1928-1929, wanted to combat it, and indicates that 1930 should be considered as the relevant turning point to date the shift in monetary policy. In

[2] We assume in our study that these spreads mainly account for the appraisal of liquidity risk. In their analysis of the 2007 crisis, Gorton and Metrick (2010) contend that the spread between short-term market interest rates and risk-free rate could be used as a measure of counterparty risk of the banking system. Schwarz (2009) shows that this spread reflects, first market liquidity risk and, extensively, counterparty risk. Indeed, a high and positive spread implies an underlying risk of declining asset values for the collateral and possible future runs on money market funds. Evidence of insolvency is provided by bank failures between 1930 and 1933. We do not assume that the Fed's officials already had in mind in 1928-1929 correct expectations of insolvency risks that were to occur in the early thirties. We refer to 'Liquidity shortage' as a proxy for liquidity risk, but we do not ignore that the 1929 crisis led to the insolvency of the US banking system. Extensively, this spread can reveal the existence of underlying insolvency risk, as in Gorton and Metrick (2010) and in Schwarz (2009).

a final section, we conclude. Our findings contrast with conventional wisdom regarding the presumed passivity and inactivity of the Fed during the thirties and deliver a more balanced assessment of the near unanimous judgment of flawed policy.

1. 1929 crisis explanations: a survey

Hsieh and Romer (2006, p. 140) qualify the Fed's failure to respond to the banking panics during the Great Depression as 'one of the great mysteries of the 1930s.' This issue has received considerable attention in the literature, in which two main explanations of the Fed's behaviour during the depression can be distinguished: the first one, most notably defended by Friedman and Schwartz (1963), insists on the erroneous understanding of monetary conditions, as well as an erroneous implicit model of the economy by Fed's officials. Using domestic monetary aggregates rather than interest rates, Friedman and Schwartz (1963) argue that the Great Depression was caused by domestic monetary contraction and that the Fed could have prevented and even reversed it with an appropriately expansionary monetary policy. They contend that the Fed's refusal to fight against the monetary contraction was a monumental policy mistake. This judgment became the dominant view thereafter. Bordo, Choudhri and Schwartz (2002) added support to this monetarist conviction by developing a counterfactual analysis of expansionary monetary policy in the US during the thirties. They found that the US, the largest country in the world, having massive gold reserves, was not constrained from using expansionary policy to offset banking panics, deflation and declining economic activity. Expansionary open market operations by the Fed at two critical junctures —from Oct. 1930 to February 1931 and from September 1931 to January 1932— would have been successful in averting the banking panics that did occur. Had expansionary open market purchases been conducted in the 1930s, the contraction would not have led to the international crises that followed.

The second principal explanation puts forward international causes of the crisis and emphasises the will of the Fed officials to defend the gold standard: the US adherence to the gold standard acted as the fundamental constraint on monetary policy that was thought to have impeded the Fed to act. Chandler (1958, p. 199) argues that both domestic and international goals were important in 1924 and 1927, and Wheelock (1991, chap. 2) finds empirical support for this view. Eichengreen, Temin and Bernanke suggest that the Fed did not undertake expansionary monetary policy in the aftermath of the crisis because, under the

constraint of the gold standard, such an expansion would have led to devaluation. In this view, the Great Depression is not the consequence of domestic policy mistakes, but the consequence of the credible commitment of the Fed to the gold standard. Hsieh and Romer (2006) called into question this view. They test whether expectations of devaluation forbid the Fed from continuing the 1932 open market purchase programme. To that end, they use two indicators, the three-month forward premium exchange rates of the dollar against a panel of currencies and interest rate differentials to measure devaluation expectations. Their conclusion is that regardless of the indicator, no expectations of devaluation could be found in 1932. According to them, their analysis of the 1932 open market purchase programme supports the view the American Great Depression was largely the result of inept policy, not the result of gold standard adherence: 'We are inclined to agree with Friedman and Schwartz that the Fed's failure to act was a policy mistake of monumental proportions, not the inevitable result of the US adherence to the gold standard' (Hiesh and Romer, 2006, p. 175). This refutation of international causes affecting the conduct of the Fed's policy invites us to focus on domestic causal factors of the crisis in the remainder of this article.

Why did Fed officials supposedly fail to respond appropriately to the crisis? Wheelock (1992) surveys all existing approaches and alternative views about the incidence of monetary policy on the development of the crisis. He identifies some core questions that still shape the debate today: were domestic monetary conditions easy or tight? What was the impact of Strong's death? What was the consistency of the Fed's strategy? Was there a shift in monetary policy driven by a change in policy tools after the crisis was triggered?

'*Most Fed officials felt that money and credit were plentiful. Short-term market interest fell sharply after the stock market crash of 1929 and remained at very low levels throughout the 1930s. Exceptionally low yields on short-term securities have suggested to many observers an abundance of liquidity*' (Wheelock, 1992, p. 9). The proponents of the Austrian theory of the business cycle such as Hayek (1932), and Adolph Miller and George Norris among the Fed's officials, argued that conditions were 'easy', that excessively easy monetary policy in the 1920s had fostered the depression, and they believed that 'artificial' increases in the money supply in response to the depression (as in 1932) were mistakes. Other indicators of monetary conditions, however, suggest the opposite conclusion: the money stock fell by one third from 1929 to 1933. Irving Fisher (1932) argued that the Fed should prevent deflation by increasing the money supply. Friedman and Schwartz (1963, p. 375) contend that '*it seems paradoxical to describe as "monetary ease" a policy which permitted the stock of*

money to decline […] *by a percentage exceeded only four times in the preceding fifty-four years and then only during extremely severe business-cycle contractions*.' Keynesians tend to support the idea that monetary ease prevailed during the depression. Temin (1976, p. 169) asserts: '*There is no evidence of any effective deflationary pressure from the banking system between the stock market crash in October 1929 and the British abandonment of the gold standard in September 1931*. […] *There was no rise in short-term interest rates in this two-year period.* […] *The relevant record for the purpose of identifying a monetary restriction is the record of short-term interest rates*.' But at the same time, this author denounced the inability of the Fed to combat bank failures, which counterbalances the view that monetary conditions were patently easy. More recently, Field (1984) and Hamilton (1987) emphasized that the real interest rate increased sharply during the depression in contrast with the apparent signal of nominal interest rates, which suggest that monetary conditions were far from easy.[3]

The impact of the death of the Fed's chairman Benjamin Strong divides the community of scholars as well. Friedman and Schwartz (1963) consider Strong's death in 1928 as a decisive event that provoked a dramatic change in policy orientation that was harmful to the country due to ignorance of the underlying model of the economy and the abandonment of aggressive policy. Wicker (1966), Brunner and Meltzer (1968), Temin (1989), contend that Strong's death was a minor event and caused no change; there was simply a continuation of erroneous policies. Chandler (1958) and Friedman and Schwartz (1963) defend the view that under Strong's leadership the Fed stimulated economic activity during recessions by promoting monetary ease. In contrast therefore, Strong's death would imply a systematic contractionary bias to monetary policy during the depression. Wheelock (1992), however, called this assertion into question. Underlying the ambiguity of several of Strong's quotations, this author stressed 'the difficulty of inferring what policies he would have pursued in the 1930s' (p. 14). Wheelock's thesis is that there was no fundamental change in regime after the death of Benjamin Strong and that '*Fed errors seem largely attributable to the continued use of flawed policies'* (p. 27).

[3] Another set of explanations (namely interest group pressure explanations of the Fed behaviour) departs from the others, maintaining that the Fed's contractionary policy was deliberate and that the Fed's officials were well aware that tight monetary conditions prevailed during the depression. '*Epstein and Ferguson (1984) and Anderson, Shughart and Tollison (1988) contend that Fed officials acted only to promote the interests of commercial banks rather than economic recovery, notably in aiding its member banks. They argue that monetary policy was designed to cause the failure of non-member banks…* ', quoted by Wheelock (1992, p. 4).

Was the Fed's policy simply inept, or consistent with some clear objectives? Chandler (1958, p. 199) argues: '*By 1924 Federal Reserve officials had developed three major objectives or considerations that were to shape their policies for about a decade. These were: 1) promotion of high and stable levels of business activity and employment and stability of price levels; 2) curbing excessive use of credit for stock market speculation, and 3) assistance to monetary reconstruction and stability abroad.*' Wicker (1966) and Brunner and Meltzer (1968) argue that there was no inconsistency in Fed policy. They contend that the Fed employed a strategy that focused on the volume of discount loans and nominal interest rates as policy guides, and since these variables fell sharply in 1930-1931, Fed officials inferred that money was easy and that open market purchases were unnecessary. According to Wicker (1966, pp. 172-184) and to Chandler (1971, pp. 198-204), the Fed measured the effects of its purchases by the excess reserve position of New York banks, and by mid-1932 had begun to set explicit targets for excess reserve. Thus, to evaluate credit conditions, the Fed's strategy seems to have slightly evolved from focusing on the discount loan volume to focusing on 'free reserves', i.e., excess reserves less borrowed reserves.

Consequently, Wheelock (1989) suggests focusing on Federal Reserve Credit (FRC). The FRC was the sum of holdings of federal government securities, bankers' acceptances and discount loans to member banks. '*Open market operations, gold flows, changes in the public's currency holdings and other causes of reserve flows affected the extent to which banks turned to the Fed for credit, either in the form of discount loans or through acceptance sales to the Reserve banks.*' (p.466). This author describes the Fed's policymaking as follows: '*The Fed had three policy tools: open market operations in government securities, the discount rate and the buying acceptance rate. In general, the three tools were used consistently with another, i.e. open market purchases (sales) were made in conjunction with discount acceptance buying rate reductions (increases).*' (Wheelock, 1989, p. 454).

In the literature, there is a debate about how these instruments were coordinated: Trescott (1982) and Epstein and Ferguson (1984) treat the Fed's operations in government securities and its operations in bankers' acceptances as pure substitutes. Friedman and Schwartz (1963) and Wicker (1966) note that some Fed officials did not view operations in government securities and bankers' acceptances as perfect substitutes. Wheelock (1989) acknowledges that while probably not perfect substitutes, operations in government securities and acceptances could be seen as 'somewhat interchangeable' (p. 459). Very interestingly, he suggests that '*Most often, the Fed's directives did not specify specific targets for interest rates*

or loans. At most, the Fed used these variables as "*indicators*" *of credit conditions, rather than* "*targets*" ' (p. 459). In his analysis, the most relevant indicator to capture the driving forces of Fed officials' decisions remains the stock of non-borrowed reserves: '*The change in unborrowed reserves accurately measures the Fed policy intent if open market operations were to be used to offset undesired changes in the gold and currency stocks and in acceptance sales to the Fed*' (p. 464). He states that '*it may be that open market operations did not reflect the Fed's policy intent as well as the flow of unborrowed reserves'* (p. 464) and concludes that in the thirties, the Fed '*continued to rely on bank reserve positions and market interest rates as policy guides*' (p. 473). In light of these elements, it seems doubtful for this author that a significant change in regime did in fact occur after the crisis had begun.

Wheelock's work (1989) must be acknowledged as pioneering since he proposed the first econometric regression of the Fed's policy reaction function to be based on the *volume* of federal government security holdings, bankers' acceptance holdings and discount loans to member banks. Nevertheless, some reservations apply. Notably, Toma (1989) challenges this view: he contests the use of total volume of Federal Reserve Credit (FRC) outstanding as a relevant guideline for monetary policy. Open market operations produced opposite changes in the volume of discount loans. His analysis showed that changes in discount loan volume offset open market operations dollar for dollar. As Toma's study implies, the Fed's response to its policy goals could not be reflected in the evolution of FRC. Because they were offset by the other forms of FRC outstanding, open market operations did not produce systematic changes in bank reserves or in supply of money. This means that FRC does not reflect the Fed's response to its policy goal. For this reason, we shall not focus in this study on indicators in volume, which are misleading, but on nominal values, namely interest rates. A second major reason reinforces this choice: as reported by Wheelock (1992, p. 9), data on excess reserves before 1929 are not available. Lack of data on volume over a long period forbids performing econometric tests on quantities. Thus, in the remainder of the article we shall refer to nominal interest rates as the preferred indicators in evaluating the consistency of the Fed's policy over the period. In accordance with Hiesh and Romer (2006), we assume that the Fed responded mainly to domestic objectives.

2. The Functioning of the US Money Market in the Interwar Period

In order to describe the functioning of the US money markets over the interwar period, four core sources have been consulted: Myers (1931), Banking and Monetary Statistics of the Fed, Ferderer (2003) and Bordo and Wheelock (2011). For a full description of the Fed's operating strategy, one can also refer to Riefler (1930) and to Burgess (1946). Our purpose is to identify which interest rate to choose for calculating the spread between pure market interest rates and instrument rates, our proxy for liquidity risks.

Instrument Rates

Bordo and Wheelock (2011) provide a comprehensive view of the use of the instrument rates by the Fed from the Federal Reserve Act of 1913 to 1933. They stress that '*the Federal Reserve Act permitted member banks to rediscount eligible paper with Federal Reserve Banks in exchange for currency (Federal Reserve notes) or reserve deposits. Federal Reserve notes were asset-backed in the sense that the Reserve Banks were required to hold reserves in the form of eligible commercial paper or gold equal to their outstanding note issues* […]' (p. 16). The Fed Act restricted '*the types and maturities of loans and securities that member banks could rediscount with the Reserve Banks* […]' The Act authorised '*rediscounting of* "*notes, drafts, and bills of exchange arising out of actual commercial transactions"*, but prohibited "*rediscounting of loans or securities covering merely investments or issued or drawn for the purpose of carrying or trading in stocks, bonds or other investment securities, except bonds and notes of the Government of the Unites States"* '[4] (p. 16). Thus, the founding Act of the Fed introduced a restriction in discount window practice since only those specific loans with a term to maturity shorter than a 90 day maximum were eligible for rediscount.[5]

In addition to using the discount window, the Reserve Banks also managed to set bill buying rates on acceptances they purchased in the open market. In this market, the Reserve

[4] Note that according to Chandler (1971, p. 232), '*This narrow definition of eligible assets contributed to bank closing and to liquidation of credit by banks that succeeded in remaining open*.'

[5] Hackley (1973, p. 100) reminds us that the Glass-Steagall Act of 1932 came to amend the Federal Reserve Act so as to enable the Fed to extend loans on the basis of any satisfactory collateral in emergency situations. Bordo and Wheelock (2011, p. 28) stress that '*the Fed Act was amended in February 1932 to add section 10(b), which permitted Federal Reserve Banks to lend to any member bank on the basis of any satisfactory assets, whether or not technically eligible for rediscount, in exceptional and exigent circumstances*.' Section 10(b) was set to expire in March 1933, but was extended for one year by the Emergency Banking Act of 1933. Thus, from February 1932 to March 1933, this amendment permitted discount window loans on any satisfactory assets of the borrowing bank.

Banks were allowed to purchase all the eligible acceptances offered to them at their set bill buying rates.

Ferderer (2003) contends that acceptance buying rates played a core role in managing liquidity: '*In essence, the reserve banks served as the market maker of last resort and promoted the private supply of immediacy by limiting the risk borne by the dealers*' (p. 678). Nonetheless, referring to the volume of operations, Bordo and Wheelock (2011) note that the US acceptance market remained small and fell off sharply during the depression: '*Bankers acceptance never became the core instrument of the US money market*' (p. 33). According to these authors, '*the acceptance market was small and highly concentrated in New York City, which limited the usefulness of Fed purchases in a crisis*' (p. 30).

Thereby, the Fed managed to act through two channels that could both provide support to the banking and financial system: the discount rate at the discount window and the bill-buying rate of bankers' acceptances in the open market. Bankers' acceptance purchases were an alternative to the discount window. This is the reason why we shall test both channels in our regressions in the latter part of this research. Taking into account the remark of Bordo and Wheelock (2011) with respect to the decreasing volume in bankers' acceptances during the depression, we shall mainly focus on the discount rate in our regressions and use the bankers' acceptance rate to verify robustness.

Open Market Interest Rates

The second main source we used is the BMS statistics provided by the Fed. All interest rates of the US monetary markets during the interwar period may be consulted in:
Tables of the Banking and Monetary Statistics (BMS),
http://fraser.stlouisfed.org/docs/publications/bms/1914-1941/section12.pdf.
Note that above the data tables there is a good discussion of the American money markets in Section 12, entitled 'Money rates and security markets'.

What were the different interest rates designated as '*Short-term open market rates in New York City',* according to this statistical source? The New York money market was composed of a number of specialised markets for certain types of loans, and there were usually differences in rates corresponding to the differences in the supply of funds. The most important short-term open market instruments registered were: '*6-month commercial paper*' and four series of rates for loans based on security collateral: '*90-day stock exchange time loans*', '*90-day stock exchange call loans*', '*Average rate on stock exchange call loans*' and

'US call money rates, mixed collateral'. The difference between these rates is due to the types of collateral acceptable for the call loans.

Call loan market

Call loans were financial contracts between private parties (banks and brokerage houses) and did not involve the central bank. They were representative of pure market interest rates. The description of the early money markets given by Margaret Myers (1931) is useful. Chapter 7 discusses precisely the call loan market. The call market was centred largely in New York City because that is where banks throughout the country put their 'bankers' balances'. The reserves created with the deposits made by these other banks were lent out by the big New York City banks to (1) brokers and dealers in the securities markets and (2) to other banks ('*…were dependent on the call loan market for funds in times of crises.*' Myers 1931, p. 126). Funds borrowed for the purpose of purchasing or carrying securities have been variously designated (most frequently) as 'call loans' or 'brokers' loans': they all refer to brokers' borrowings. In the sub-section devoted to the '*nature of the market for brokers' loans*', it is specified that 'most of the time' banks were the lenders, and brokers and dealers were the borrowers. This market was considered as the most active and sensitive of the money markets in the country: '*It is the market where surplus funds of banks, and sometimes of other lenders, could generally be readily placed or from which funds could be quickly withdrawn when needed. Because of the dominance of call loans, the branch of the money market dealing in brokers' loans has been frequently designated as the call money market.*' […] In this market, '*funds in excess of the margins deposited by the customers are largely obtained by the brokers by borrowing from banks; the loans are collateraled with securities held by brokers for customers or for their own account*' (p. 434). This quotation is of the greatest importance because it reveals that the process of securitization and collateralisation constituted the earth of the financial mechanism during the interwar period. Consequently, the 'call money market' is the appropriate and privileged place to observe investors' desire for holding liquid assets and episodes of tensions in liquidity, characterised by excess demands for reserves and high default premiums.

During the speculative frenzy of the late 1920s in the U.S. stock market, the call rate was bid up by brokers and dealers in the stock market; brokers wanted to finance margin buying and dealers wanted to finance their inventory holdings so they borrowed from banks. Thus, the spread rose to choke off the excess demand for reserves. Then the Fed raised its discount rate as a check on speculation. Everything else held constant, this action should have caused

the call rate to rise and to choke off excess demand created by the fall in the supply of reserves. Concerns about liquidity and counterparty default must have also led to the rise in the call rate above the discount rate. This is the reason why, in the latter part of the article, we shall use the spreads between call loan market rates and instrument rates as indicators of tensions in liquidity. Since each of these rates on the open markets bears a specific risk and liquidity premium, we shall use several of them to verify the robustness of 'Liquidity shortage' episodes over the interwar period.

3. Data Set

The period under study covers 1921:8–1933:2 (monthly data). Indeed, from the 6th to the 9th of March 1933, a 'Banking holiday' closed all banks. It coincided with the climax of the depression. We end our period for studying monetary policy at this date since under the Roosevelt Administration, a change in policy goals occurred at this time: in the months that followed, domestic expansion and employment replaced monetary policy as guides to economic policymaking.

We deliberately choose nominal data, and our variables are not corrected by the inflation rate. The commonly accepted view is that the Board of Governors of the Federal Reserve failed to assess the economic activity in real terms (Friedman and Schwartz, 1963; Meltzer, 2003). This view is further corroborated in our tests by the irrelevancy of CPI in the conduct of monetary policy. Therefore, we assume that using only nominal variables correctly reproduces the way the governors on the Board of the Fed behaved during the interwar period.

We take into account five variables: the nominal industrial production index, *IPPG* (Index of Production of Producers' Goods, NBER Series) considered as a proxy for economic activity, the consumer price index, *CPI* (NBER Series), the money supply, *M2,*[6] the discount rate,[7] *r*, and deposits in suspended banks[8] that is used by Bernanke (1983) as a measure of bank failures. Six spreads acting as liquidity shortage indicators are taken into account:

Spread1 = average rate on stock exchange call loans NY – discount rate

Spread2 = average rate on stock exchange call loans NY – US bankers' acceptance rate

Spread3 = commercial paper – bank acceptance rate

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[6] NBER data from Appendix B of *The American Business Cycle: Continuity and Change*, edited by Robert J. Gordon. National Bureau of Economic Research Studies in Business Cycles, Volume 25, University of Chicago Press 1986; http://www.nber.org/data/abc/#

[7] Balke and Gordon (1986), Friedman and Schwartz (1963), BMS.

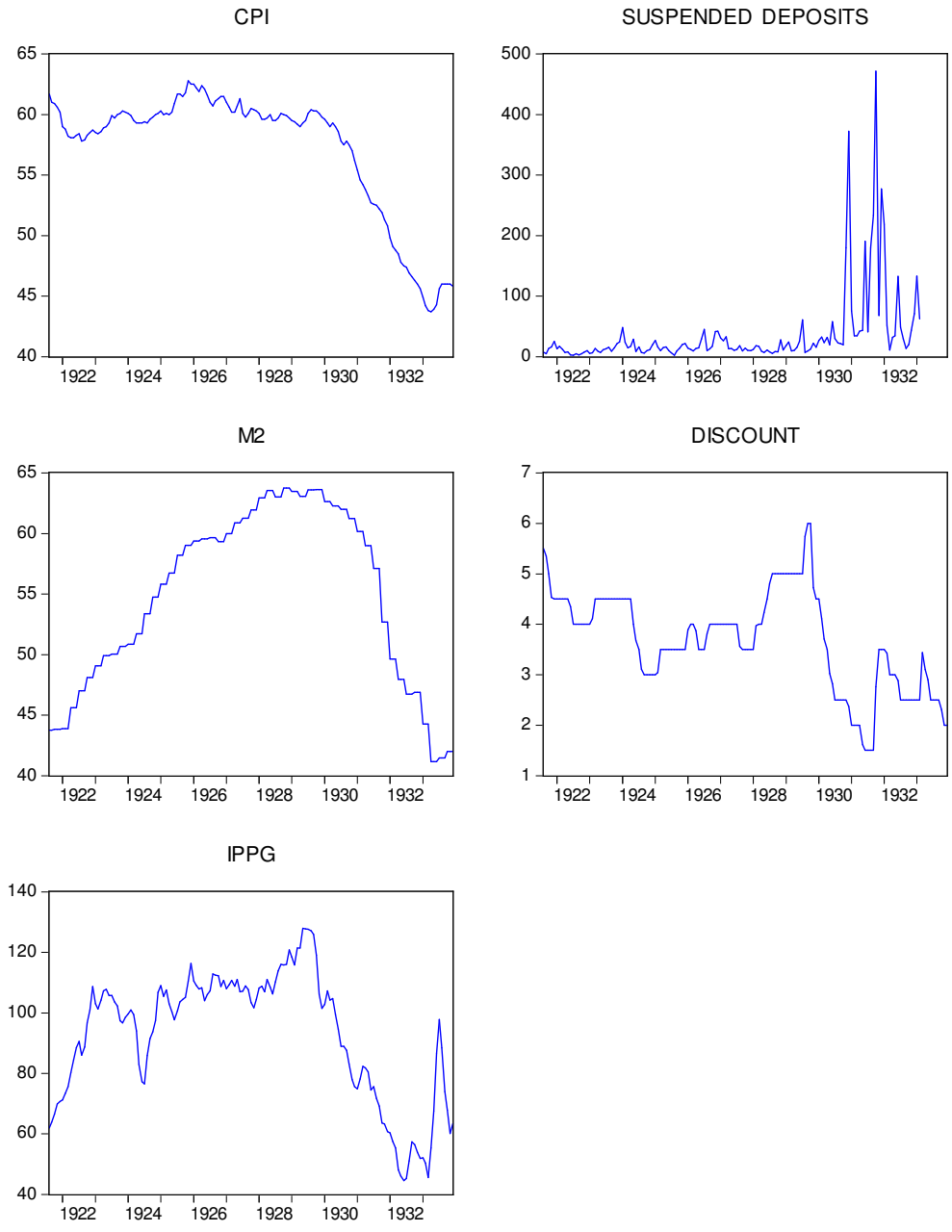
[8] Federal Reserve Bulletin, (http://fraser.stlouisfed.org/docs/publications/bms/1914-1941/section12.pdf).

Spread4= three-six months Treasury notes – discount rate
Spread5= three-six months Treasury notes – bank acceptance rate
Spread6=commercial paper – discount rate

For the reasons exposed above, spreads 2 to 6 are used to test robustness. The dynamics of these spreads are shown in the figure 2. The analysis of the time series properties of the data is reported in the Appendix 1.

As shown in Figure 1, the industrial production (IPPG) increased from 104 in December 1927 to a peak of 128 in April 1929 and began to decline from May 1929 to 1932:6. The CPI dynamics is remarkably flat from August 1921 to October 1929 (60.3) and then is continuously decreasing until 1933:2 (44.2). After a dramatic increase from 1922 to April 1928, the M2 money supply stabilised for about twenty months leading up to December 1929, then began a steep decrease until the end of our sample in (1933:2). Deposits in suspended banks, i.e. our proxy for bankruptcies, were relatively stable and remained at a very low level until November 1930. All the peaks were concentrated between December 1930 and June 1932. Lastly, four core sub-periods can be identified concerning the level of the discount rate from the mid-twenties. From the beginning of the sample up to September 1927, we note a relative stability around 4 percent. Then, from September 1927 to September 1929, the discount rate rose to 6 percent; from November 1929 to June 1931, the interest rate fell to its lowest level during the interwar period (1.5 percent). Finally, in the fourth period i.e., at the end of the sample, the discount rate remained at a higher level, between 2.5 and 3.5 percent.

Figure 1


CPI
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SUSPENDED DEPOSITS
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0
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M2
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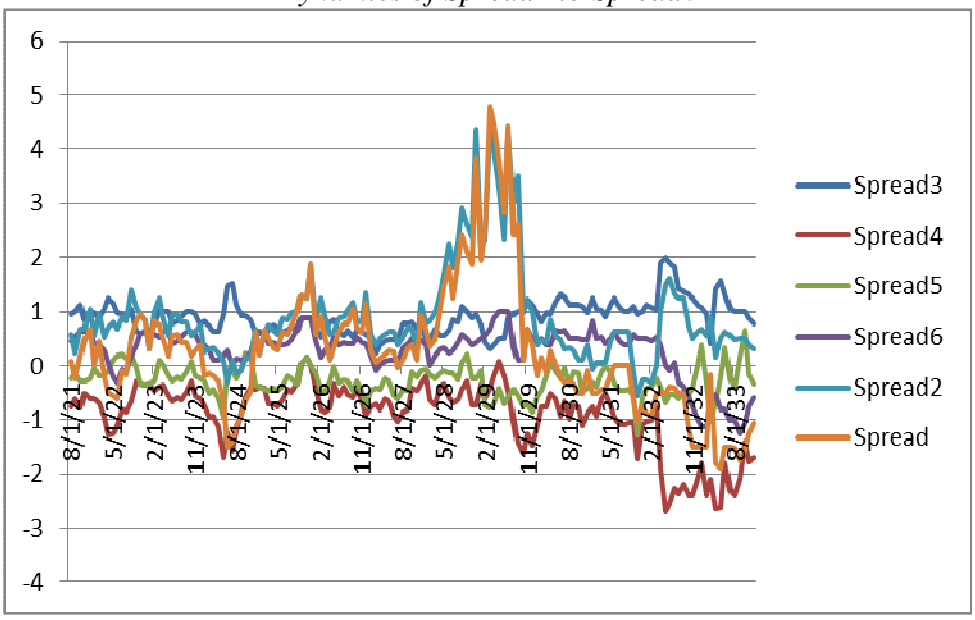
Figure 2

Dynamics of Spread1 to Spread6



4. Methodology: A Central Bank Policy Reaction Function Framework

In order to evaluate the changes in the monetary policy of the Fed over the 1922-1933 period, we estimate an augmented Taylor-type rule in a non-linear framework. For this purpose, non-linear time series models are required. In the econometric literature, there is growing interest for non-linear specifications such as Markov-switching models (Hamilton, 1998), discrete switching models (Hansen, 1999) and Smooth Transition Regression models (Teräsvirta, 1998). Markov-switching models account for exogenous switches, driven by an unobservable process. In other words, the regression coefficients are subject to abrupt modifications. In contrast, discrete switching models and Smooth Transition Regression (STR) models provide explanations for endogenous regime switching: coefficients change from on regime to another according to the level of a threshold variable. Finally, we choose STR models in this study in order to take into account the smoothness of the change in monetary policy. STR models have been well documented in Granger and Teräsvirta (1993), Teräsvirta (1994, 1998) and Van Dijk, Teräsvirta and Franses (2002).

Wheelock (1990) has tested a non-linear relationship between borrowing and the spread based on the estimation, in difference, of the theoretical Golfeld Kane model (1966):

$$\Delta\text{Borrowed Reserves} = \text{function}(\textit{Spread}, \textit{Non-borrowed}, \textit{Stock Adjustment})$$

The borrowed reserves of the Fed are a function of a spread (commercial paper – discount rate), a linear combination of the non-borrowed reserves and a stock adjustment variable. To represent the regime switching in the spread, Wheelock (1990) performed a structural break model: the idea behind this modelling is that when the spread is less than a threshold, OLS is used to estimate the lower regime regression, and when the spread is above an estimated spread value, OLS is used to estimate the upper regime regression. Thus, borrowed reserve demand is different before and after the structural break. A search procedure has been used to locate the spread that maximizes the value of the log likelihood function. In addition, Wheelock (1990) performed a switching/non-linearity test based on a joint hypothesis of no switching (equality of the parameters for upper regime spreads and lower regime spreads) and a linear relationship (nullity of the spreads parameters).

In this study, we extend the work of Wheelock (1990) in the sense that we estimate a non-linear relationship between the discount rate and its drivers. However, in the Wheelock (1990) methodology, structural breaks imply durable and abrupt changes without possible ways back. In the STR (Smooth Threshold Regression) models we used here, the relationship between the discount rate and its covariates can transit from one regime to another in both directions and may be completely non-linear. In addition, the transition between the regimes is smooth and not abrupt.

In various recent articles, linear forms of central policy bank reaction functions, especially Taylor rules, have been revisited in a non-linear framework such as STR models: for instance, Bec *et al.* (2000) using a STAR model, Martin and Milas (2004), Petersen (2007) and Castro (2011), allowing smooth transition to study the impact of low and high inflation regimes on the conduct of monetary policy, and Brüggeman and Riedel (2011) for the case of the UK. In this paper, we use STR models and focus on the importance of the monetary variables during the period under study by estimating an augmented Taylor-type rule.

We estimate a central bank policy reaction function by which the Fed reacts contemporaneously to movements in output, prices level, money supply and suspended deposits. The Taylor-type rule modified by the STR method can be rewritten as in the following reduced-form model:

$$r_t = \beta_1 z_t + \beta_2 z_t G(\gamma, c, s_t) + u_t,$$
$$z_t = (w_t', x_t'), w_t' = (1, r_{t-1}, ..., r_{t-q})'$$
$$x_t' = (y_t, ...y_{t-p}, p_t, ..., p_{t-p}, d_t, ...d_{t-p} m_t, ..., m_{t-p})'$$
$$G(\gamma, c, s_t) = \left(1 + \exp\left\{-\gamma \prod_{k=1}^{K} (s_t - c_k)\right\}\right)^{-1}$$

in which *u* is an *iid* innovation, *z* a vector of explanatory variables which can be decomposed into *q* lagged endogenous variables stacked in a vector *w* (here the lagged discount rate) and in exogenous variables (vector *x*). Thus, r_t is the discount rate, *y* is the output measured by the IPPG proxy, *p* is the CPI, *m* is the monetary supply M2 and *d* denotes the suspended deposits; *l* denotes the number of lags in lagged exogenous variables.[9] *G* stands for a continuous transition function bounded between 0 and 1: as a consequence, the model is able to explain not only the two extreme states but also a continuum of states between the extreme cases. γ is the smoothness or slope parameter, which is an indicator of the speed of transition between 0 and 1. *c* is a threshold parameter referring to the transition variable: it indicates where the transition (the smooth regime switching) takes place.

In the framework of STR methodology, the monetary policy changes according to the dynamics of a transition variable, which we have identified as liquidity shortage or the spread variable. As previously stated, six proxies for liquidity shortage are studied. We focus our analysis on 'spread1' (call loan rate – discount rate) and use the other spreads for robustness checks (see Appendix 2).[10] Before testing, choosing and estimating the appropriate STR model, we need to test the order of integration of all the variables and especially the transition variables. Indeed, the STR methodology we use here is only adapted for stationary variables and can be biased in case of cointegrated variables.[11] Considering the results of the unit root tests (see Appendix 1 concerning the details of the usual unit root tests we performed), CPI, IPPG and M2 variables are differentiated of order one to be able to estimate the STR model. The 'bankruptcies' and 'spread1' are stationary variables and thus are not differentiated.

[9] The optimal lag lengths are chosen using the SC criterion.

[10] As usual in the literature, lagged spreads are used in order to take into account the potential endogeneity between the discount rate and the spread.

[11] In this case, CSTR (Cointegrated Smooth Transition Regression) models have to be used; see for instance Choi and Saikkonen (2004).

Testing Linearity and Choosing the Appropriate STR Model

To detect non-linear patterns in the previous equation, we carry out the LM-linearity test discussed in Teräsvirta (1994, 1998). In the same way as in other non-linear models,[12] the STR model is only identified under the alternative hypothesis of non-linearity. This identification problem can be solved by approximating the transition function by a third-order Taylor expansion under the null hypothesis that $\gamma = 0$ (in this case, the transition function G tends to 1/2). The Taylor expansion leads to the following auxiliary regression where r_t is the discount rate:

$$r_t = \beta_0' z_t + \sum_{j=1}^{3} \beta_j' \tilde{z}_t s_t^j + u_t^*, t = 1,...,139$$

$$\text{where } u_t^* = u_t + \underbrace{R_3(\gamma, c, s_t)\theta' z_t}_{remainder}.$$

Under the null hypothesis of linearity, $\beta_j = 0 \forall j$, while under the alternative, $\beta_j \neq 0$. As explained by Teräsvirta (2004), since $u_t^* = u_t$ under the null hypothesis, the asymptotic distribution is not affected if an *LM-type* test is performed. Hence, the test statistic follows an asymptotic χ^2 distribution, but the corresponding *F-distribution* with $3m$ and $T - 4m - 1$ degrees of freedom is recommended instead in moderate samples (see Teräsvirta, 1998; Luukkonen, Saikkonen and Teräsvirta, 1998). We then use the *F-version* of the test in this study. If the null hypothesis is rejected (low *p-values*) for many transition variables, there are several transition candidates, and thus the model is clearly non-linear.

When linearity has been rejected, we then need to choose the type of STR model. As explained below, the choices K=1 and K=2 lead to the LSTR1 and LSTR2 models respectively. The choice between these two kinds of model can be based on the previous auxiliary regression (3). Teräsvirta (2004) has shown that when $c_1 = 0$, $\beta_2 = 0$, the model is then an LSTR2 model. Finally, we only need to test the following sequence:

$$H_{04} : \beta_3 = 0$$
$$H_{03} : \beta_2 = 0 / \beta_3 = 0$$
$$H_{02} : \beta_1 = 0 / \beta_2 = \beta_3 = 0$$

If the H_{03} hypothesis yields the strongest rejection, then the LSTR2 model should be chosen. In all other cases, LSTR1 is the most appropriate.

[12] See Hansen (1996) for a detailed discussion of this issue.

5. Findings

The results of the linearity test are shown in Table 3. The associated p-values are clearly very small and suggest STR-type non-linearities when *lagged spreads* are used as transition variables. The previously described test strategy suggests estimating LSTR1 models.

Table 3
Linearity tests (*p-values*)

s_t	F	F4	F3	F2	Model
$Spread1_{t-1}$ (1)	2.9540e-04	1.1311e-02	4.3628e-02	1.0122e-02	LSTR1
$Spread1_{t-1}$ (2)	3.9077e-04	1.8309e-02	2.2496e-01	1.0558e-03	LSTR1

Note: The symbol - refers to a singularity matrix problem. We choose two lags for the volatility: (1) model with no lags; (2) model with one lag. Spread1= call loan-discount rate spread.

Given the previous linearity and specification tests, we estimate the corresponding LSTR1 (*l*,*q*) models where *p* and *q* denote respectively the lag length of the endogenous and exogenous variables. Considering the conventional information criteria, *l* and *q* will be varied from 0 to 3. Under the assumption of exogenous covariates, the estimation method is non-linear least squares or maximum likelihood under the assumption of normally distributed errors. All the parameters of the different STR models are estimated using conditional maximum likelihood. As explained by Terävirsta (2004), the BFGS (Broyden-Fletcher-Goldfarb-Shanno) algorithm can be used with the numerical derivatives of the log-likelihood function.[13] It is important to choose appropriate starting values for the transition parameters γ and c_1 in the case of a LSTR1 model. After constructing a grid, we can estimate the parameters conditionally on the transition parameters and select the estimates minimising the sum of the squared residuals.

Table 4 presents conditional ML estimates for an LSTR1 model with the lagged call loan − discount spread (spread1) as a transition variable on the period from August 1921 to February 1933. Though we performed a battery of estimations, we only retained the three most relevant models for the spread1 as a transition variable: the LSTR1 (0,0) in column 1, the LSTR1 (1,1) in column 2 and the LSTR (2,2) in the last column.

[13] The Newton-Raphson algorithm can also be used.

Table 4

Estimates for LSTR model
with Lagged Call Loan Spreads as a Transition Variable

	(1)	(2)	(3)
Model (p,q)	LSTR1 (0,0)	LSTR1 (1,1)	LSTR1 (2,2)
s_t	$Spread1_{t-1}$	$Spread1_{t-1}$	$Spread1_{t-1}$
Linear part			
Discount Lagged	-	0.23219** (2.01)	0.39619*** (3.06)
Discount Lagged 2	-	-	-0.38914*** (-2.96)
Constant, $\beta_{0,0}$	-0.15584*** (-4.32)	-0.10482** (-2.52)	-0.19753*** (-3.84)
Deposits, $\beta_{0,1}$	0.00144*** (3.90)	0.00123*** (3.36)	0.00177*** (4.34)
CPI, $\beta_{0,2}$	0.08459 (1.04)	0.12096 (1.47)	0.06471 (0.75)
M2, $\beta_{0,3}$	-0.06366* (-1.91)	-0.08918** (-2.59)	-0.07042* (-1.94)
IPPG $\beta_{0,4}$	0.01915*** (2.92)	0.01769*** (2.52)	0.01143 (1.56)
Non-linear part			
Discount lagged	-	0.04064 (0.23)	-0.16157 (-0.85)
Discount lagged 2	-	-	0.36938* (1.7076)
Constant, $\beta_{1,0}$	-9.816 (-1.58)	0.13173* (1.78)	0.13241* (1.79)
Deposits, $\beta_{1,1}$	-0.00469* (-1.84)	-0.00538** (-1.99)	-0.00616** (-2.27)
CPI, $\beta_{1,2}$	-0.06431 (-0.54)	-0.06955 (-0.56)	0.01670 (0.13)
M2, $\beta_{1,3}$	-0.01365 (-0.1759)	0.03717 (0.47)	0.0422 (0.53)
IPPG, $\beta_{1,4}$	-0.02149* (-1.93)	-0.02180* (-1.90)	-0.01615 (-1.26)
$\gamma / \hat{\sigma}_s$	1.32	1.42	1.65
c_1	0.32264 (4.25)	0.34383 (3.72)	0.34428 (4.52)
Adjusted R2	0.32	0.46	0.55

Note: t-stats are in parentheses. *p* and *q* denote the lag length for the endogenous and the exogenous variables respectively. Lagged exogenous variables coefficients are omitted to save space.

From an econometric point of view, the results we present are very similar across the three models; that is, over the three candidates. For instance, the estimated threshold and the significance of the different parameters across the linear and the non-linear parts are relatively homogenous across the models. However, considering the Adjusted R^2, conventional information criteria and some specification tests, we suggest that the model (3) is the first-best model.

Considering all three estimates, we can distinguish clearly two different regimes over three sub-periods: a linear regime from the beginning of our sample to the end of 1927, followed by a non-linear state up to the end of 1929, then a return to a linear regime from 1930 to the end of the sample. In the linear regime, all the parameters of the reaction function are significant except the price (CPI) parameter. Indeed, over this period, the instrument rate is not correlated with CPI. Under this regime, the coefficients of sensitivity of the interest rate to IPPG, M2, and deposits in suspended banks all conform to theoretical predictions: the interest rate reacts positively to industrial production (IPPG), the central bank raising its discount rate in response to economic recovery. The interest rate reacts negatively to a rise in M2: an increase in the money supply logically implies a decrease in the interest rate. We observe that under this normal regime, the Fed raises its discount rate when bankruptcies increase. This suggests a strategy of eliminating bad banks. Under the non-linear part of the model, signs are reversed, except for CPI which remains, as in the linear part, insignificant. As a consequence, only the IPPG and the deposits variables enter the non-linear part significantly. The discount rate reacts negatively to IPPG and negatively to increasing bankruptcies. Lastly, we note that the non-linear counterpart of M2 tends toward a near-zero coefficient.[14]

Figure 3 shows the threshold value against the dynamics of the spread1 variable (call loan − discount). Figure 4 graphs the linear part and the corresponding non-linear part of the model and Figure 5 graphs the transition function. In this kind of methodology, we need to distinguish between the information coming from the transition variable (threshold values for

[14] Note that this null parameter of the money supply reflects a situation in which the interest rate does not react to variations in the money supply. This feature remarkably evokes a situation of the liquidity trap in the sense of Keynes (1936), when the instrument rate is insensitive to variations in M2. This insensitivity reveals a complete inefficiency of the monetary policy: '*Liquidity preference may become virtually absolute in the sense that almost everyone prefers cash to holding a debt* […] *in this event the monetary authority would have lost effective control over the rate of interest*' (Keynes, GT, p. 207).

'Liquidity shortage', see Figure 3) and the information from the reaction function of the central bank to this transition variable, which decomposes the linear and the non-linear parts of the discount rate dynamics (Figure 4). In this analysis, we assume the transition variable triggers the instrument rate. In this way, we can assess how the central bank reacts to a shock identified here by the transition variable, namely Liquidity shortage. In STR models, the change between linear and non-linear regimes does not take place instantaneously. Figure 5 highlights the evolution from one state to another.

The non-linear part becomes relevant when the spread transition variable surpasses the threshold line (c1=0.34). Hence, the non-linear part comes into play from December 1927 (see Figure 3). Given the transition speed parameter ($\gamma = 14.98$ for the model 2 and 15.33 for the model 3), such a change is not accomplished instantaneously. Once the transition totally realised, the non-linear regime is fully at work at the beginning of summer 1928 (see Figures 4 and 5) and ends in January 1930. From this date onward, the transition variable passes below its threshold value (Figure 3), but the change is not accomplished instantly, so the reaction function smoothly goes back to its normal linear regime. Let x be the difference between the transition variable and the estimated threshold value $s_{t-1} - 0.34428 = x$, then the smooth path from the linear to the non-linear regime (model 3) is:

$$\left(\beta_0 + \beta_{1,t}\right)\left(1 + \exp\{-15.326(x)/1.137\}\right)^{-1}$$

where 15.326 is the value of gamma, and 1.137 the standard deviation value of the transition variable. The corresponding figures (3, 4, 5 and 6) below summarize the different steps between the transition variable, the reaction function and the transition speed.

In light of these developments, we provide evidence of different regimes in monetary policy over the period studied. We identified three clear-cut periods: a linear period from August 1921 to the end of 1927, a non-linear state from mid-1928 to January 1930, then a return to a linear period from January 1930 to March 1933 in which the reaction function recovers the same signs as in the first period. As previously mentioned, the coefficients in the linear periods are correctly oriented and confirm theoretical predictions.

We turn now to the economic interpretation of our results over the non-linear period. Due to the non-linearity of the model, the coefficients are made up of the linear and the non-linear parts. We found that the coefficient of IPPG assumes a negative value between the summer of 1928 and October 1929, the industrial production continuously rising, which means that changes in output lost their influence on the normal conduct of monetary policy.

Should we interpret the negative sign of this coefficient as a consequence of a type of trade-off by the Fed between economic activity and financial speculation? This is what the Fed minutes suggest (see the next section). Indeed Governor Harrison, referring to the years 1928 and 1929, regrets that the Fed raised its discount rate too late and not enough. Concerning the deposits in suspended banks variable (Bernanke effect), their coefficients turn negative as well. What is the economic meaning of such a shift? Since between 1928 and 1929 bankruptcies were just emerging, this negative sign might then be interpreted as a decision by the Fed to restrain the increase in the discount interest rate in order to moderate the impact of the disease caused by bankruptcies.[15] It could just as well merely illustrate the regime switching.

As mentioned above, the CPI is always not significant, whatever the period (linear or not). This can be viewed as evidence that the Fed did not act in reaction to changes in real values but to changes in nominal values. This fully corroborates our choice of considering only nominal values for analysis over the period under study.

Lastly, the results concerning the relationship between the discount rate and the money supply (M2) are rich and well balanced. Indeed, the coefficient ($\beta_{1,3}$, see Table 4) which reveals that the non-linear part in the relation between the instrument rate and the money supply equals zero. On the one hand, this result characterises a situation of liquidity trap (in the sense of Keynes, see footnote 14). On the other hand, our findings support the view that the Fed in 1928 and 1929 did not adjust contemporaneously its monetary policy in light of this liquidity-trap episode. As a matter of fact, the overall coefficient

$$(\beta_t = \beta_{0,t} + \beta_{1,t} G(\gamma, c, s_t) = -0.07 + 0 = -0.07)$$

remains unchanged since the non-linear contribution is zero. Hesitations among the Board members in 1928 and 1929 about the correct policy to implement, as Meltzer (2003) pointed out, are in line with our findings.

Nevertheless, as early as the very beginning of 1930, we identify a clear-cut shift in monetary policy regime. The usual transmission channels are again at stake; as prior to the end of 1927, *M2* acts negatively, *IPPG* positively, and the proxy for bankruptcies positively on the instrument rate. This switch proves that the Fed policy was far from passive and

[15] Obviously, these outcomes do not mean that the Fed behaved as a lender of last resort during the depression. It is well-known that the Federal Reserve Act granted access to the Fed's discount window only to member banks, which excluded non-member banks. It is clear that for institutional reasons, notably the exclusion of non-member banks and the Fed's decentralized structure as reported by Bordo and Wheelock (2011), the Fed could not and did not act as a lender of last resort.

inactive as suggested by Meltzer (2003). Actually, through its reaction function, the Fed did not act simultaneously against the liquidity trap episode but tried to restore monetary efficiency as coefficients reversed signs: Figure 5 explicitly highlights that the non-linear part vanished and that as early as 1930, only the linear part was in play. These outcomes are corroborated using other indicators of liquidity shortage (see Appendix 2 for the results).

Figure 3

Call loan Spread Dynamics and Threshold Values: model (3)

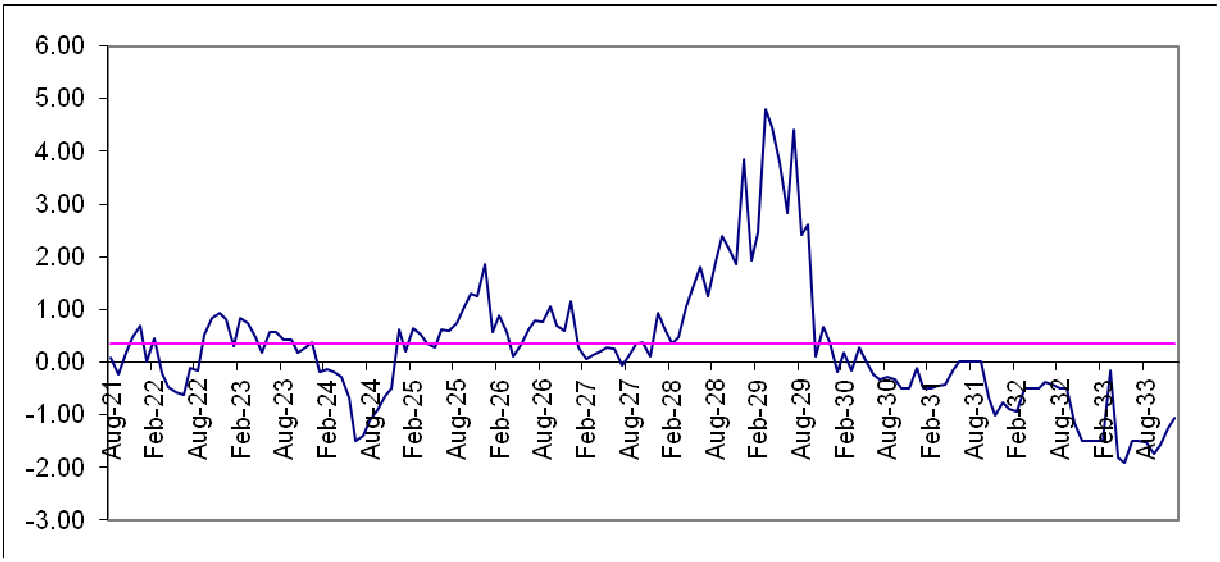


Figure 4

Linear Part and Non-Linear Part from the Estimation of the Model (3)

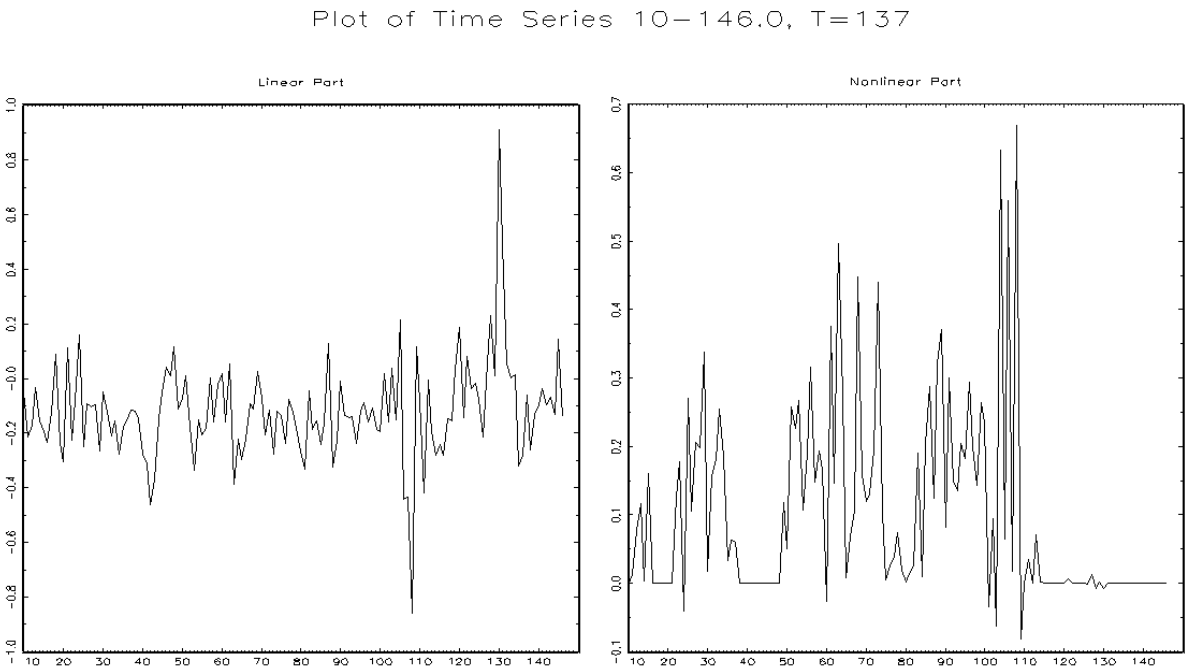


Figure 5
Transition Function Dynamics

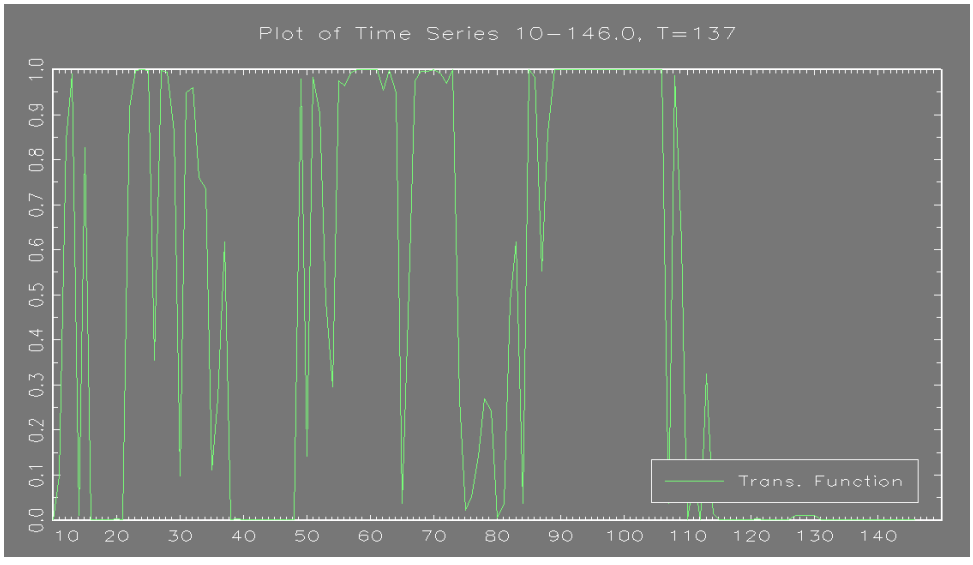
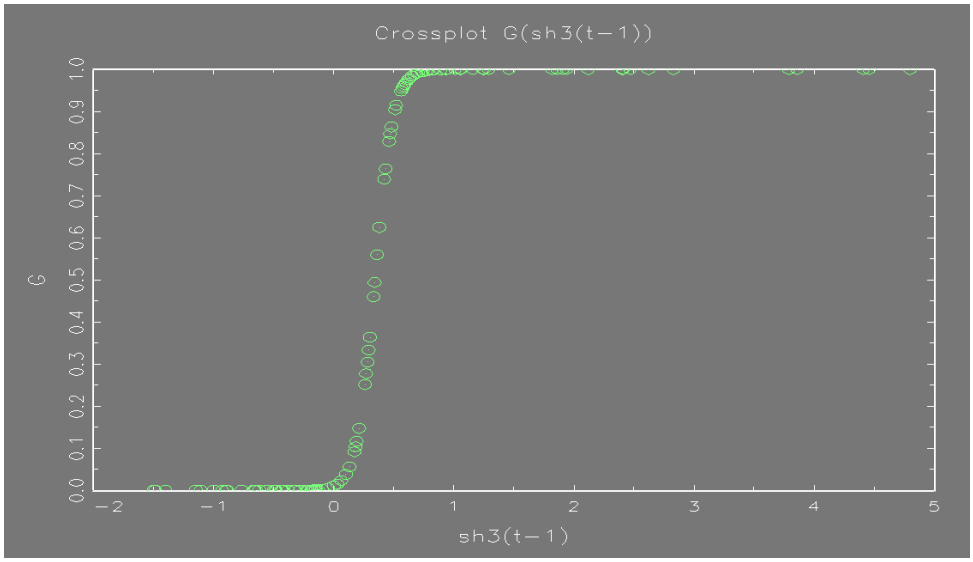


Figure 6
Estimated Transitions Function for Model (3)



6. Historical Evidence

In this section, we review quotations extracted most notably from the Fed's minutes corroborating that 'repelling the liquidity crisis' constituted the driving force of the Fed's decisions immediately after the crisis had been triggered. Our conclusion goes beyond that of Friedman and Schwartz (1963) for whom, at least from 1924 to 1929, the first goal of the Fed was to limit stock market speculation. Through our indicator, 'Liquidity shortage', which plays the role of transitional variable in our model, we have provided evidence that the Fed was concerned about liquidity risks and tried to repel the liquidity crisis, which is more than simply monitoring speculation. The quotations below illustrate the consistency and constancy of this goal.

The dominant view insists on inaction, passivity, delay, hesitation and paralysis of the Fed during the interwar period. Meltzer (*A History of the Federal Reserve*, 2003) cites many examples concerning conflict between stock prices and the level of interest rates at the Board of Governors of the Federal Reserve between 1927 and 1928 and gives several illustrations that up to the early 1930s, even after the Open Market Investment Committee (OMIC) was replaced by the Open Market Policy Conference (OMPC), the Board vacillated between the fear of speculation and harming business conditions.

It is acknowledged by Meltzer (2003) that the governors in agreement with Strong 'did not disagree that preventing speculation was part of their mandate' (p. 246). More precisely, in the Fed's *Annual Report* (1929, 3) appeared for the first time explicitly: '*A bank is not within its reasonable claims for rediscount facilities when borrowing to make or maintain speculative loans.*' Governor Harrison (who replaced Strong) acknowledged two mistakes in

1928-1929: '*First, we raised our rate the first time too late, and, second we did not raise it enough. I mean that had we had at that time the light of the experience we have since had, it would have been better perhaps to have raised the rate 1% in December of 1927*' (Senate Committee on Banking and Currency, 1931, p. 66). '*When credit expands faster than trade or business, the Federal Reserve System should raise rates, whether the expansion is due to speculation in real estate, securities, or commodities, or whether it is due to abnormal growth of business*' (Governor Harrison, Senate Committee on Banking and Currency, 1931, p. 55).

In January 1930, the OMIC was replaced by the new OMPC, and according to Meltzer (2003), the dominant view of the Board continued to be that additional purchases and discount rate decreases would continue to fuel speculative growth and would fail to revive the economy. '*Since* [from the beginning of 1930] *short-term market interest rates had fallen* […]*, most governors saw little reason for the Federal Reserve to "interfere" or to hasten the decline in rates. Words like "artificial stimulus" and "inevitable decline" reflect the dominant view* [of the Board] *that speculative excesses had to be purged'* (Meltzer, 2003, p. 295).

According to us, this is the evidence that the Federal Reserve had drawn the lessons from the episode of 1928-1929 and wished to avoid the extension of liquidity risks by systematically targeting a reversed sign of the liquidity shortage spread: repelling liquidity risks appears to be the essence of this new belief and priority of the OMPC. What Meltzer (2003) qualifies as inaction, passivity, misinterpretation of current economic conditions proved to be a deep understanding of the damage caused by the liquidity shortage episodes of 1928-1929.

Progressively, the minutes of the Fed cease to mention speculation but speak of risks of paralysis of the system: in 1931 and 1932, direct references to 'idle reserves' and 'currency hoarding' appear for the first time in the OMPC minutes: at the June 1931 OMPC meeting, Governor '*Harrison referred to currency withdrawals,* […] *Governor Meyer reported that the Board's staff estimated that from $300 million to $375 million of currency "was now hoarded"* ' (Meltzer, 2003, p. 334). At the August 1931 OMPC, Governor Harrison '*introduced a motion to authorise the executive committee to buy up to $300 million "when they thought it was necessary"*, *but he indicated that the time for purchase had not yet come because* "*the attitude of the banks and investors was such that funds thus made available would be held* idle" ' (p. 342).

Other evidence of the Fed's awareness of 'liquidity shortage' risks can be found in the 1931 OMPC minutes: '*A program of purchases would not be effective if it added to the excess*

reserves of the member banks. […] *he desired standby authority to offset the effect of larger than usual demands for currency*' (Harrison, August 1931 OMPC meeting). Harrison '*had discussed with bankers and they indicated that "any increase in excess reserves would remain* idle*"* ' (cited by Meltzer, p. 342).

In 1931-1932, Meltzer (2003, p. 345) reports: '*President Hoover called a meeting of nineteen bankers on October 4, 1931 at Mellon's apartment to prevent bank failures: the Memo interpreted bank failures as the fact that bankers and public had lost confidence in the banking system and preferred to* hoard currency.*'*[16] The Memo prepared for October 26, 1931 OMPC meeting paid attention to '*the renewed bank failures and currency "hoarding".'* Debate at OMPC November 1931 meeting wonders '*What action is appropriate to combat the heavy domestic withdrawal of currency continuing a movement of almost a year's duration*' (Preliminary Memorandum, November 1931). On January 4, 1932, Harrison stated: '*We must be on relatively safe ground before we embark on a program of government security purchases, which is not the case at the moment when banks are failing and the renewal of currency hoarding is a probability*' (Memo, January 1932).

If we now refer to the vast programme of open market purchases that lasted five months and ended in July 1932, we note that undoubtedly the evolution in language and justification for decisions by Fed's officials is striking: references to speculation had disappeared and were being replaced by fear of insolvency of the banking system.

Very interestingly, in the *Commercial and Financial Chronicle* of April 1932 (p. 3142), Treasury secretary Ogden Mills declared that '*the Federal Reserve program of buying government securities could be fully justified on the ground of replacing exported gold and* hoarded currency.' Why did the Fed end the monetary expansion after only five months of experience? The Harrison papers indicate on May 12, 1932 that '*the best yardstick to use* [for measuring the success of monetary policy] …*would be the figures of member bank reserves'* (Harrison Papers, Memorandum: Meeting of Board of Directors, p. 218). On 26 May, Harrison added that '*excess reserves of member banks are now at about the point where it had been thought they should be maintained*.' In these words, Harrison blatantly explains that the programme should be stopped because excess bank reserves remaining idle, continued expansion would impede any economic recovery. This quotation is simply fascinating because what Harrison describes as the factor that prevents the Fed from continuing

[16]Again in February 22, 1933, Hoover asked the Board to pay attention to '*hoarding of currency and to some minor extent of gold, that has now risen to unprecedented dimensions'* (Hoover to the Board, Board of Governors File, box 2158, February 1933).

expansionary monetary by open market purchase is nothing else than the situation Keynes, later on, was to describe as a liquidity trap. What Harrison (1932) explains is that monetary expansion is ineffective when banks hold excess (i.e. idle) reserves. Already in May of the same year, Governor Harrison affirmed the dangers of the underlying mechanisms of the liquidity trap, as the following quotation seems to prove: '*There is no sense* […] *in our purchasing Government securities merely as* an offset to currency hoarding. *That is an impossible task and an inversion of our program, which was based on a revival of confidence in the banking and credit structure*' (Harrison Papers, Memorandum: Meeting of Board of Directors, May 26, p. 230). Since the programme induced only unemployed reserves, it should be stopped, believed many members of the Board: '*Young had talked to several of the Chicago directors and reported: "They say what is the use of going ahead if bank failures are to continue and hoarding of currency to be renewed"*.' (Harrison Papers, Memorandum: Meeting of Board of Directors, 14 July 1932, p. 273). These quotes tend to prove that Fed's officials had in mind the underlying mechanisms of the liquidity trap and that this constituted the driving force of their policy behaviour in the early 1930s.

Conclusion

In this research, we have assessed the incidence of the liquidity shortage variable in the policy reaction function of the Fed, in order to deal with the issue of the Fed's policy consistency over the interwar period. We have identified three clear-cut periods: a linear period from 1922 to the end of 1927, a non-linear state from mid-1928 to January 1930, then a return to a linear period from January 1930 to March 1933 in which the reaction function recovers the same signs as in the first period. We have found that the Fed did not act simultaneously counter the liquidity trap episode that we identified in 1928-1929, but tried to restore monetary efficiency with little delay as early as 1930. In fact, econometric evidence provided here suggests there had been a shift in the Fed monetary policy in the early thirties.

Is it then really necessary to conclude in concert that the Fed policy was necessarily flawed? One of the surprising outcomes of our study is that the Fed reinstated the policy reaction function that prevailed before the crisis had been triggered. This behaviour reveals the consistent use of a single strategy over the entire interwar period (except during the turmoil of 1928-1929 characterised by non-linear patterns).

The importance and statistical significance of the variable 'Liquidity shortage', which acts as the transitional variable in our model, lead us to name this strategy: 'liquidity crisis avoidance'.

Both historical and narrative evidence confirm that Fed officials were well aware of the dangers of liquidity crisis and targeted indicators of tension in the open markets. Since liquidity and solvency crises actually did occur in early thirties, at least the diagnosis of the crisis risks by the Fed did not prove to be erroneous. Indeed, it would seem that critiques of systematically flawed monetary policy ought to be reconsidered.

APPENDIX 1: Properties of the data

Considering our time series framework, we need to compute unit root tests to determine the order of integration of the series. The usual unit root tests: Augmented Dickey-Fuller (ADF, 1979) and DF-GLS from Elliot, Rothenberg and Stock (ERS, 1996) are performed using the usual selection criteria (LR, AIC, SC, HQ). Note that the last one is the most powerful and has been found to dominate the others under certain conditions. Regarding Table 1 below, all series appear clearly integrated of order one at the 10% level of significance, except the suspended deposits variable which is stationary. As a consequence, all the variables will be differentiated of order one, except the suspended deposits variable in our STR model in the following section.

Table 1

Unit Root Tests without breaks

Test	Variables	Lags *k*	Stat	Tabulated value (10%)
ADF	Discount	1	-2.233	-2.577
	CPI	1	-2.665	
	IPPG	3	-1.239	
	Suspended Deposits	1	-4.428	
	M2	3	-1.13	
DF-GLS	Discount	1	-0.745	-1.615
	CPI	1	-1.334	
	IPPG	3	-1.123	
	Suspended Deposits	1	-4.299	

	M2	3	-0.925	

KPSS	Discount	-	0.618	0.347
	CPI	-	0.341	
	IPPG	-	0.617	
	Suspended Deposits	-	0.732	
	M2	-	0.334	

Bold critical values denote rejection of the unit root hypothesis (ADF and DF-GLS).

Table 2

Unit Root Tests with breaks (need to be introduced)

Furthermore, the usual unit root tests are applied to the six potential transition variables used in our non-linear framework. The results concerning the call loan spreads are summarised in Table 3.

Regarding the figure 2, it is clear that the spread variables are weakly stationary. At the least, they are stationary around a structural break at the end of 1929. To substantiate this *a priori*, we first conduct the three usual unit root tests. With the notable exception of two statistics (in bold), the two series appear to be I(0) at the 10% significance level. Considering the presence of a potential structural break in 1929 due to the emergence of the economic crisis, we re-evaluate the time series properties of our transition variables by performing the Lee and Strazicich unit root with structural break test (2004). To save space, only the results concerning the first spread are presented.[17] This test is an extension of the LM unit root test developed by Schmidt and Phillips (1992). As compared with the Zivot and Andrews (1992) test assuming no break under the null, the Lee and Strazicich test allows for breaks both under the null and the alternative hypothesis. The results of the LM unit root test with two structural breaks are reported in Table 2. According to this test, the unit root of the call loan - discount spread is rejected at the 10% level. Hence, the unit root test of Lee and Strazicich (2004) provides evidence in favour of the stationarity of this variable.

[17] Others results are available upon request.

Table 3

Unit Root Tests Concerning the Call loans-Discount rate spread

Test	Variables	Lags k	Stat	Tabulated value (10%)
ADF	Call loans-Discount rate spread	1	-2.030	-2.577
KPSS	Call loans-Discount rate spread	-	0.285	0.347
DF-GLS	Call loans-Discount rate spread	1	-2.042	-1.615
Lee and Strazicich	Call loans-Discount rate spread	1	-3.385	-3.21

APPENDIX 2: Robustness Analysis

Given the previous linearity and specification tests, we estimate the corresponding LSTR1 models with the Spread 2, Spread3, Spread4 and Spread6 as a transition variable. The results concerning the model with the Spread5 as a transition variable are not reported because we can not reject the linearity hypothesis in this case. For each model, the most relevant specification is chosen.

Spread1 = average rate on stock exchange call loans NY – discount rate
Spread2 = average rate on stock exchange call loans NY – US bankers' acceptance rate
Spread3 = commercial paper – bank acceptance rate
Spread4=three-six months Treasury notes – discount rate
Spread5=three-six months Treasury notes – bank acceptance rate
Spread6=commercial paper – discount rate

LSTR1 (0,0), LSTR1 (2,1) LSTR1 (0,0) and LSTR1 (1,1) specifications seem to be the more relevant models considering the Adjusted R2 and conventional information criteria, the level of significance of the smoothness parameter and some diagnostics tests (normality tests, tests again autocorrelation, parameter constancy test and test against non remaining nonlinearity).

Considering the models as a whole, we find some evidence that all the variables except the CPI one enter the linear part significantly in the same line than spread1. Deposits are always significantly positive at 5% level, IPPG is always significantly positive and M2 is

always negative (except for the model (3)). In contrast, CPI and M2 variables enter the nonlinear part non significantly, Deposits are significantly negative in the nonlinear part (except for model (3)). Finally, the smoothness coefficient is bigger in the two first models than in the two last ones: with spreads 2 and 3, the transition is faster. As a consequence, the results are very similar to the one derived with spread 1 as a transition variable. Thus, our results are robust to the transition variable that is to the financial stress proxy we used.

Table 5. Robustness Analysis

	(1)	(2)	(3)	(4)
Model (p,q)	LSTR1 (0,0)	LSTR1 (2,1)	LSTR1 (0,0)	LSTR1 (1,1)
s_t	Spread2(t-1)	Spread3(t-1)	Spread4(t-1)	Spread6(t-1)
Discount Lagged	-	0.11479*** (3.26)	-	0.35704*** (3.18)
Discount Lagged 2	-	-0.23050** (-2.09)	-	-
Constant, $\beta_{0,0}$	-0.07955*** (-3.10)	-0.02860 (-0.99)	-0.17049*** (-2.68)	-0.08765** (-2.11)
Deposits, $\beta_{0,1}$	0.00123*** (3.41)	0.00153*** (2.75)	0.00191*** (2.76)	0.00266*** (2.89)
CPI, $\beta_{0,2}$	0.10807* (1.91)	0.07562 (1.23)	0.11690 (1.34)	0.03176 (0.59)
M2, $\beta_{0,3}$	-0.05616* (-1.76)	-0.11313*** (-2.70)	-0.05270*** (-1.29)	-0.07768* (-1.93)
IPPG $\beta_{0,4}$	0.01715*** (2.94)	0.01552*** (2.60)	0.02236*** (2.72)	0.01997*** (3.29)
Discount lagged	-	-0.12672 (-0.61)	-	0.21148 (0.39)
Discount lagged 2	-	0.23779 (1.16)	-	-
Constant, $\beta_{1,0}$	0.23779*** (3.55)	-0.00805* (-0.09)	0.54746* (1.81)	0.67721** (2.08)
Deposits, $\beta_{1,1}$	-0.00461**	-0.00148*	-0.00798*	-0.01777***

	(-2.57)	(-1.69)	(-1.43)	(-3.03)
CPI, $\beta_{1,2}$	-0.04370 (-0.18)	-0.01532 (0.93)	-0.16171 (-0.62)	0.10812 (0.43)
M2, $\beta_{1,3}$	0.11650 (1.05)	0.09612 (1.30)	-0.04801 (-0.25)	0.06040 (0.20)
IPPG, $\beta_{1,4}$	-0.03288** (-2.38)	-0.01274 (-0.82)	-0.05050 (-1.47)	-0.07771** (-2.21)
$\gamma / \hat{\sigma}_s$	150.21	37.85	2.23	3.13
c_1	1.25535 (42.10)	1.06209 (40.94)	-0.42476 (-1.54)	0.70367 (8.39)
Adjusted R2	0.24	0.40	0.30	0.48

Note: t-stats are in parentheses. p and q denote the lag length for the endogenous and the exogenous variables respectively. Lagged exogenous variables coefficients are not outlined to keep space.

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