The Federal Reserve's Operating Procedure, Nonborrowed Reserves, Borrowed Reserves and the Liquidity Effect

Authors	Daniel L. Thornton
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The Federal Reserve's Operating Procedure, Nonborrowed Reserves, Borrowed Reserves and the Liquidity Effect

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Abstract

Recently, there has been considerable interest in identifying the exogenous policy actions of the Fed and a number of identification methods have been proposed. This paper deals with one of these, namely, using nonborrowed reserves in a recursive structural vector autoregression (VAR). A number of researchers [Christiano, Eichenbaum and Evans (1994ab, 1996, 1997), Evans and Marshall (1997), Strongin (1995), Pagan and Robertson (1995) and Brunner (1994) find evidence of a statistically significant liquidity effect using nonborrowed reserves in a VAR. The success in finding the liquidity effect with nonborrowed reserves in the VAR is attributed to innovations to nonborrowed reserves reflecting supply shocks while innovations to total reserves primarily reflect shocks to demand. The purpose of this paper is to demonstrate that the opposite is true. Evidence of the liquidity effect in recursive structural VARs depends critically on the existence of a negative covariance between the federal funds rate and nonborrowed reserves. Under a variety of operating objectives, the Trading Desk of the Federal Reserve Bank of New York has offset changes in bank-initiated discount window borrowing when implementing the Federal Open Market Committee's policy directive. This practice has created a negative contemporaneous covariance between nonborrowed reserves and the funds rate that has been incorrectly attributed to the liquidity effect. Once the Desk's practice is accounted for, there is no evidence of a statistically significant liquidity effect.

JEL Classifications: E40, E52

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1. Introduction

The liquidity effect – the decline in real and nominal short-term interest rates associated with an unanticipated expansionary monetary policy – which plays a central role in the conventional view of the transmission of monetary policy, has been elusive [e.g., Cagan and Gandolfi (1969), Melvin (1983), Mishkin (1982), Thornton (1988b), Reichenstein (1987) and Leeper and Gordon (1992)]. It is generally believed that the lack of empirical support for the liquidity effect stems from a failure to isolate the exogenous policy actions of the Fed. Recently, a variety of methods for identifying the exogenous policy actions of the Fed have been proposed.[1] This paper deals with one of these, namely, using nonborrowed reserves in recursive structural vector autoregressions (VARs).

A number of researchers [Christiano, Eichenbaum and Evans (1994ab, 1996, 1997), Evans and Marshall (1997), Strongin (1995), Pagan and Robertson (1995) and Brunner (1994)] find evidence of a liquidity effect in recursive structural VARs using innovations to nonborrowed reserves as the policy shock. Christiano, Eichenbaum and Evans (1996, p. 18), argue that this is because, "innovations to nonborrowed reserves primarily reflect exogenous shocks to monetary policy, while innovations to broader monetary aggregates primarily reflect shocks to money demand." The purpose of this paper is to demonstrate that the opposite is true. I show that under a variety of operating objectives, free reserves, the federal funds rate, borrowed reserves and nonborrowed reserves, the Trading Desk has implemented the Federal Open Market Committee's

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[1]Romer and Romer (1989) and Boschen and Mills (1992) use the narrative approach. This approach has been criticized by Hoover and Perez (1994) and Bernanke and Mihov (1997ab). Bernanke and Blinder (1992) and Sims (1986) prefer innovations to the federal funds rate, which has been criticized by Faust (1997), who attempts to side step the identification issue, and Cecchetti (1995). Rudebusch (1996) has criticized the entire VAR approach. For the response to these criticisms, see Sims (1996).

(FOMC's) policy directive, innovations to nonborrowed reserves reflect both supply shocks and the Desk's reaction to demand shocks. Hence, the negative covariance between the federal funds rate and nonborrowed reserves, upon which evidence of the liquidity effect in recursive structural VARs depends, is due either to the liquidity effect or the endogenous response of the Fed.[2]

A model of the Trading Desk's operating procedure in implementing the FOMC's policy directives is developed. Using this model, I show why under a variety of operating objectives—free reserves, the federal funds rate, borrowed reserves and nonborrowed reserves—the Trading Desk has offset changes in bank-initiated discount window borrowing. The model reveals how the practice of offsetting discount window borrowing produces a negative contemporaneous covariance between nonborrowed reserves and the funds rate that is independent of the liquidity effect.

After presenting evidence that the Desk has acted to offset bank-initiated changes in discount window borrowing, evidence is presented from a variety of sources showing that this practice created the negative contemporaneous covariance between nonborrowed reserves and the funds rate which has been incorrectly identified as the liquidity effect. In addition, I show why the "liquidity effect" in the VAR *vanished* [Pagan and Robertson (1995) and Christiano (1995)] in the mid- 1980s, and why the period of nonborrowed reserves targeting is so important for empirical estimates of the liquidity effect [Pagan and Robertson (1995)].

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[2]A contemporaneous negative covariance is not required for simultaneous structural VARs. For example, by imposing overidentifying restrictions, Gordon and Leeper (1994) decompose a small positive correlation between innovations to total reserves and the funds rate into a negative estimate of the funds rate elasticity of reserve demand. Gordon and Leeper's results are somewhat fragile. Also, see Pagan and Robertson (1998) for a critical analysis of the liquidity effect obtained by Gordon and Leeper and other nonrecursive structural VARs.

2. The Trading Desk's Operating Procedure

While the *Policy Directive* of the FOMC to the Trading Desk has undergone a metamorphosis, it has always been nonspecific and deliberately so [see Meulendyke (1990)].[3] It has been the job of the Trading Desk of the Federal Reserve Bank of New York to translate the unspecific policy directive into specific open market operations. In general, directives have contained a reference to money market, credit market or reserve market conditions. For example, since 1983 the operational phraseology has been to increase, decrease or maintain the *degree of pressure on reserve positions.*

Given that open market operations directly affect the supply of reserves, it is not surprising that the Trading Desk has implemented the FOMC's policy directive by monitoring and attempting to alter various measures of reserve market conditions – free reserves, borrowed reserves or the federal funds rate [Meulendyke (1990)]. These measures have served both as indicators of reserve market conditions and as intermediate operating targets.

Over the years, the emphasis placed on one or another of these measures in evaluating and implementing monetary policy has changed. From the Accord to the early 1970s, the emphasis was on free reserves. From the early to late 1970s, the emphasis shifted to the federal funds rate. From the late 1970s to the early 1980s, nonborrowed reserves was used. In the early 1980s borrowed reserves became the intermediate target/indicator. By the mid- to late-1980s, the emphasis had shifted back to the federal funds rate. These shifts in emphasis in implementing the FOMC's policy directive are generally referred to as changes in the Fed's operating

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[3]The FOMC broke this practice in August 1997 when it changed the wording of its policy directive to include an explicit target for the federal funds rate.

procedure. While such changes are considered to be significant, they have a relatively small effect on the fundamental way the Desk operates.

One reason why such changes in emphasis have a relatively small effect on Desk operations is that these indicator/target variables are highly interrelated. For example, Meulendyke (1990) notes that the borrowed reserves operating procedure is essentially the same as a free reserves operating procedure when excess reserve demand is stable. Thornton (1988a) has shown the equivalence between borrowed reserves and federal funds rate targeting when the demand for borrowed reserves is stable.

Perhaps the most significant change in the Desk's operating procedure occurred in 1979 when nonborrowed reserves became the Desk's focus in implementing the FOMC's policy directive. To see a more basic reason why such changes in emphasis have a relatively small effect on Desk operations and to see the effect of the 1979 change, consider the following structural model of the reserve market. The demand for reserves, R^d, is derived from the demand for reservable deposit liabilities of banks and the demand for excess reserves. Hence, total reserves, TR^d, demand is given by,

$$TR_t^{\,d} = \tau[f(i_t,\, x_t) + v_t]\;, \qquad (1)$$

where i denotes a short-term interest rate that represents the opportunity cost of holding such deposits, x denotes a vector of the other determinants of the demand, v denotes an iid random innovation and τ, $0 < \tau < 1$, denotes the reserve requirement which the Fed imposes on banks.

Open market operations directly affect the supply of reserves. For simplicity, assume that the r.h.s. of the Fed's balance sheet consists solely of reserves and that the l.h.s. is composed of three items, the Fed's holdings of government debt, B_t, borrowed reserves, BR_t, and a composite factor, F_t, that reflects a number of other factors that affect reserve supply, e.g., Treasury balances at the Fed, the float, etc. Given these assumptions, the supply of total reserves is given by the balance sheet identity:

$$TR_t^s \equiv B_t + BR_t + F_t \,. \qquad (2)$$

Banks meet their reserve requirements on average over a maintenance period.[4] Consequently, on average over the maintenance period the following condition must hold

$$\tau[\, f(i_t, x_t) + v_t \,] = B_t + BR_t + F_t \,. \qquad (3)$$

Because the Desk does not know precisely the demand for reserves, it has relied on various measures of reserve market conditions. For example, if reserve supply was inadequate, banks might reduce their holdings of excess reserves, increase discount window borrowing or both, i.e., free reserves would decline. Hence, free reserves was used both to gauge reserve market pressure and to implement monetary policy in the early post-Accord years. The emphasis placed on various measures changed with the Fed's belief about the information such measures conveyed about reserve market conditions. For example, the federal funds rate was not used as a primary gauge of reserve stringency until the 1970s. This was due in part to the fact that, prior to that, the discount rate was an effective ceiling for the federal funds rate. Once the funds rate rose

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[4]The maintenance period was one week for large banks and two weeks for small banks prior to February 1984 and two weeks for all banks since. Moreover, prior to the Monetary Control Act of 1980 not all banks, let alone all depository institutions, were subject to these same requirements.

to the level of the discount rate, it ceased to provide additional information about the degree of reserve market pressure. Hence, it was believed that better information about reserve market pressure could be obtained from the behavior of borrowing and excess reserves.

With the exception of the Fed's holdings of government debt, the Desk does not know all of the factors that affect supply at the time it must act. Consequently, it relies on estimates and assumptions. To see how this basic procedure is implemented, consider Feinman's (1993, p. 234) description of the Fed's current operating procedure:

> *Each day the staff estimates the period-average demand for reserves by projecting required reserves against deposits and the desired excess reserves of the banking system. Subtracting the FOMC-specified level of discount window borrowing from this forecast of reserve demand yields the nonborrowed reserve path, the Desk's prime objective. Each morning the staff's forecast of nonborrowed reserves owing to market factors beyond the Fed's control (for example, Treasury balances at the Fed, float, etc.) is subtracted from the path to produce an estimate of the quantity of reserves that must be added or subtracted, on a period-average basis, to reach the objective.*

According to Feinman, the Fed's projected holdings of government securities, B^*, or what he calls the Fed's *nonborrowed reserves path*, is:

$$B_t^* = \tau E_{t-1} f(i_t, x_t)|i_t^{f*} - BRAS_t - E_{t-1}F_t \,, \qquad (4)$$

where E_{t-1} denotes the expectation operator conditional on information up to the start of the period, i^{f*} denotes the Fed's target for the federal funds rate and *BRAS denotes* the FOMC's borrowed reserves assumption. When B is less than B^*, there is a need to add reserves, when B is greater than B^*, there is a need to drain reserves.

Discount window borrowing is done at the initiative of banks. *Inter alia* bank borrowing depends on the spread between the federal funds rate, i^f, and the discount rate, i^d. That is,

$$BR_t = \Phi(i_t^f - i_t^d, \eta_t) , \qquad (5)$$

where η_t represents all other factors that determining borrowing. For simplicity, assume that F is partitioned into a time-dependent component, μ_t, and a random error, ϵ_t,

$$F_t = \mu_t + \epsilon_t . \qquad (6)$$

To derive an expression for the nonborrowed reserves path, assume that the Fed sets its borrowing assumption equal to some proportion, $0 \le \xi \le 1$, of the actual level of borrowed reserves. That is,

$$BRAS_t = \xi \ BR_t . \qquad (7)$$

Furthermore, assume that the Fed's forecast of other factors that affect reserve supply is

$$E_{t-1}F_t = \mu_t . \qquad (8)$$

Substituting Equations 5-8 into Equation 4, yields an expression for the nonborrowed reserves path, $B*$. The actual quantity of reserves supplied, however, is

$$R_t^s = B_t^* + BR_t + F_t .$$

Substituting in for $B*$ yields a general representation for reserves:

$$TR_t^s = \tau E_{t-1} f(i_t, x_t) | i_t^{f*} + (1 - \xi) \ \Phi(i_t^f - i_t^d, \eta_t) + \epsilon_t . \qquad (9)$$

Subtracting the actual level of borrowed reserves from Equation 9 yields a general expression for nonborrowed reserves, *NBR*,

$$NBR_t^s = \tau E_{t-1} f(i_t,\ x_t) | i_t^{f*} - \xi \Phi(i_t^f - i_t^d,\ \eta_t) + \epsilon_t\ . \qquad (10)$$

Equation 10 shows that nonborrowed reserves is necessarily negatively related to the part of borrowing that the Fed offsets. The portion of borrowing that the Fed does not offset is reflected in total reserves.

Feinman's description of the current operating procedure is based on targeting the funds rate, but the basic procedure is independent of the Fed's operating objective. For example, during the period of nonborrowed reserves targeting open market operations were directed at achieving a specific growth rate for money, so long as the funds rate stayed within a relatively wide band, frequently 400 basis points or more. To this end, the staff made an estimate of total reserves required to achieve the FOMC's money growth objective, called the total reserves path. To arrive at the path for nonborrowed reserves, the Desk subtracted its estimate of bank borrowing, then called the *initial borrowing assumption*, IBA.[5] Hence, instead of estimating the demand for reserves consistent with a target for the federal funds rate, the reserves objective was based on the FOMC's target for money growth.[6]

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[5]Meulendyke (1990, p. 467) notes that the staff estimates of borrowing were made from a modified versions of staff's money demand models and borrowed reserves equations. In these equations, borrowed reserves was determined primarily by the spread between the federal funds and discount rate. The Fed acknowledged, however, that these estimates took "into account the actual borrowing in previous weeks." Federal Reserve Bank of New York (1981), p. 64.

[6]The details of this operating procedure were carefully spelled out by the Fed at the time, e.g., Gilbert and Trebing (1981) and references cited therein. The typical operating directive for this

When borrowing differed from its estimate, the Desk could either ignore it and miss its money stock objective, or offset it. Later it is shown that the Desk faced this situation frequently, and frequently chose to offset unexpected borrowing rather than miss the FOMC's money growth objective.

3. Forecast Innovations for Total and Nonborrowed Reserves

To derive the forecast errors for *NBR* and *TR*, the model is simplified by assuming

$$f(i_t, x_t) = -\lambda i_t + \gamma x_t \quad \mathit{and} \quad BR_t = \alpha(i_t^f - i_t^d) + \eta_t \, .$$

Letting $i = i^f$, the forecast errors for *TR* and *NBR* are [see the appendix for the complete reduced form],

$$u_{tr} = \psi[\epsilon_t + (1-\xi)\eta_t + (1-\xi)\lambda^{-1}\alpha v_t]$$

$$u_{nbr} = \epsilon_t - \xi\eta_t - \psi\lambda^{-1}\xi\alpha v_t \, ,$$

where

$$\psi = \frac{\tau\lambda}{\tau\lambda + (1 - \xi)\alpha} \, .$$

These expressions are quite different and somewhat more complicated than those postulated by Strongin (1995) and Bernanke and Mihov (1997ab).[7] Moreover, unlike theirs,

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period instructed the Desk to supply reserves consistent with the FOMC's targets for the annual growth rates of various monetary aggregates, with a provison that the federal funds rate traded in a specified range, usually 400 basis points or more.

[7]Strongin asserts that the forecast innovations for total reserves, u_{tr}, and nonborrowed reserves, u_{nbr}, can be expressed as,

supply shocks are reflected in innovations to both *NBR* and *TR*.[8]

More importantly, demand shocks can show up in innovations to *TR*, *NBR* or both, depending on the extent to which the Fed offsets borrowing. The larger is ξ, the more demand shocks are reflected in *NBR* and the less they are reflected in *TR*. Forecast innovations to *TR* are independent of demand shocks if the Fed completely offsets borrowing, i.e., $\xi = 1$. The reason is straightforward. A shock to demand raises the equilibrium funds rate, causing borrowing to rise. The Fed offsets the rise in borrowing with an open market sale, thereby reducing NBR by this amount. The effect of the demand shock on *TR* is neutralized, but the shock is completely reflected in *NBR*, but with the opposite sign. If, on the other hand, the Fed ignored the rise in borrowing, the reverse would be true; the demand shock would be reflected positively in the forecast error for *TR* but not at all in *NBR*.[9]

$$u_{tr} = v_d$$

$$u_{nbr} = \phi v_d + v_s \ ,$$

where v_d and v_s are assumed to be independent shocks to demand and supply, respectively. Strongin defines ϕ to be the "operating procedure determined split in the accommodation between borrowed reserves and nonborrowed reserves in response to a reserve demand shock." The structure proposed by Bernanke and Mihov (1997ab) is somewhat more complicated than that suggested by Strongin, however, it retains Strongin's feature that u_{tr} does not depend on v_s.

[8]That supply shocks are necessarily reflected in innovations to *TR* is easy to see. An exogenous open market purchase increases total reserves unless borrowing falls by an amount as large or larger than the Fed's open market purchase. Baring an unprecedented response in borrowing, supply shocks will be reflected in both nonborrowed reserves and total reserves.

[9]Christiano (1996), argues that if the Fed offset demand shocks to the economy, such as those considered by Coleman, Gilles and Labadie (1996), "*NBR* and *TR* would be negatively related. This implication is at variance with the data."(p. 6). Christiano's analysis ignores the Fed's operating procedure. Note that *NBR* and *TR* need not be negatively correlated in the case where ξ

The Identification of the Liquidity Effect in the VAR

Measures of the liquidity effect in recursive structural VARs depends on the contemporaneous covariance between these reserves measures and the fund rate. These covariances are:

$$Cov(u_{TR}, u_i) = \psi^2[(\tau\lambda)^{-1}(1-\xi)^2\sigma_\eta^2 - (\tau\lambda)^{-1}\sigma_\epsilon^2 + \lambda^{-2}\alpha(1-\xi)\sigma_v^2]$$

$$Cov(u_{NBR}, u_i) = \psi[(\tau\lambda)^{-2}\xi(1-\xi)\sigma_\eta^2 - (\tau\lambda)^{-1}\sigma_\epsilon^2 - \lambda^{-2}\alpha\psi\sigma_v^2]$$

If the Fed does not offset borrowing, i.e., $\xi = 0$, *Cor*(u_{TR}, u_i) may be either positive or negative. The negative covariance associated with the liquidity effect, i.e., shocks to ϵ, may be offset totally or partly by the positive covariance associated with shocks to demand and borrowed reserves.[10] On the other hand, the *Cor*(u_{NBR}, u_i) will be strictly negative solely because of the liquidity effect.

If, other the other hand, the Fed completely offsets borrowing, both covariances are strictly negative. The *Cor*(u_{TR}, u_i) is strictly negative because of the liquidity effect. The *Cor*(u_{NBR}, u_i) is strictly negative for this reason and because of negative covariance associated

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= 1, i.e., Cov(*NBR*, *TR*) = $(1+\alpha)^2\sigma_\epsilon > 0$. The positive covariance stems from the fact that both *NBR* and *TR* depend on shocks to supply.

[10]It should be noted that the effect of a supply shock on the interest rate depends on the interest sensitivity of borrowing, α. If $\xi = 0$, the effect of a pure supply shock on the interest rate would be $-1/(\tau\lambda + \alpha)$, the "liquidity effect" which Bernanke and Mihov (1997ab) claim to be identifying. If $\xi = 1$, however, the effect of a pure supply shock is $-1/\tau\lambda$, the "liquidity effect" of Gordon and Leeper (1994). These two liquidity effects are identical if and only if $\alpha = 0$. Note too that this liquidity effect could be identified using either *NBR* or *TR*; however, the set of conditioning variables would be different.

with the effect of shocks to demand on borrowing which the Fed offsets. The latter covariance stems from the Fed's operating procedure and the fact that borrowing varies positively with the funds rate. In this case, the negative covariance between *NBR* and the funds rate would be larger than that associated with the liquidity effect alone.

The Presumption of a Liquidity Effect

The structural model presented above assumes the existence of a liquidity effect. Specifically, Equation 1 assumes that the demand for reservable deposits is negatively related to the interest rate. The alternative that there is no liquidity effect is impossible. Consequently, it is important to show that the Fed's operating procedure and discount window borrowing can combine to produce a negative covariance between nonborrowed reserves and the federal funds rate even when there can be no liquidity effect.

A sufficient condition for the absence of a liquidity effect is to assume that the interest rate is independent of Fed actions.[11] If the federal funds rate increases independent of policy actions, Equation 10 shows that borrowing will increase and *NBR* will fall if $\xi \neq 0$. The rise in the federal funds rate causes borrowing to increase which the Fed offsets by reducing nonborrowed reserves through open market operations. Hence, there will be a negative covariance between *NBR* and the funds rate, even if there is no liquidity effect. The degree of the association depends on the magnitudes of both ξ and α. If $\xi \neq 0$, the magnitude of the negative

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[11]Coleman, Gilles and Labadie (1996) also make this point and make the interest rate independent of policy by simply assuming that the interest rate is determined solely by real factors, independent of monetary policy. Another motivation is the buffer stock notion of money demand [e.g., Laidler (1984) and Carr, Darby and Thornton (1985)], which argues that costly information makes individuals slow to adjust their money holdings.

association between nonborrowed reserves and the funds rate becomes larger the larger is α, and vanishes if banks simply stop coming to the discount window.

The implication of the above analysis is this. If $\xi \neq 0$, the negative covariance between *NBR* and the federal funds rate can either be the result of the liquidity effect or the Fed's operating procedure. In the latter case, the negative covariance will disappear when banks quit borrowing or when borrowing is unresponsive to changes in the funds rate, i.e., $\alpha = 0$. If the negative covariance is due to the liquidity effect, however, it will not disappear when banks stop borrowing or when $\alpha = 0$. Furthermore, if $\xi = 1$ and if there is a liquidity effect, there should be a negative covariance between the federal funds rate and both *NBR* and *TR*. In this case, evidence of a liquidity effect can be found using *TR* rather than *NBR* in the *VAR*.

4. Does the Fed Offset Changes in Borrowed Reserves?

The extent to which innovations in *NBR* or *TR* reflect exogenous supply shocks critically depends on how *BRAS* is set. To make this point clear, see what happens when Equation 7 is replaced with:

$$BRAS_t = \xi\alpha(i_t^{f*} - i_t^d) \ . \qquad (7')$$

Equation 7′ differs from Equation 7 in that it asserts that the Fed offsets only a portion of borrowing that it anticipates given its target for the funds rate as before. Shocks to demand cause the funds rate to deviate from the targeted level as before. So long as the funds rate target is unchanged, however, the Fed would not offset the change in borrowing associated with the demand shock, even if $\xi = 1$. Demand shocks would be reflected in *TR* and not in *NBR* [see the appendix for details].[12] It is also clear from Equation 10 that *NBR* would be negatively related only to *BRAS*. Shocks to borrowing would show up in *TR*, which would be eliminated from *NBR* when borrowing is subtracted.

This fact provides the basis for testing the extent to which the Fed has offset changes in borrowing and, simultaneously, obtaining an estimate of ξ. This is done by estimating the equation:

$$\Delta NBR_t = \delta - \xi \Delta BRAS_t - \xi' \Delta NBRAS_t + \omega_t , \qquad (11)$$

where borrowing is partitioned into *BRAS* and *NBRAS*, where *NBRAS* = *BR* - *BRAS*.

If the Fed does not attempt to offset shocks to borrowed reserves, ξ' should be zero.[13] If the Fed attempts to completely offset changes in borrowing, the estimate of ξ' should be insignificantly different from unity. Moreover, if the Fed offsets all of borrowing, the hypothesis that $\xi' = \xi = 1$ should not be rejected.

Figure 1 shows the Fed's *BRAS* the period 1982.01-1996.12, alone with adjustment borrowing, *AB,* and seasonal borrowing, *SB*. There is considerable month-to-month variation in *BRAS*, suggesting that intra-month adjustments were frequently made to keep *BRAS* close to the observed level of adjustment plus seasonal borrowing. With adjustment borrowing being all but non existent in recent years, *BRAS* has been kept close to seasonal borrowing.

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[12]The key reason for this result is that the borrowing assumption is fixed, so the Desk only offsets a constant proportion of borrowing.

[13]The reduced form for *NBR* includes the Fed's estimate of the demand for reserves conditional on its funds rate target and other variables that are not directly observable. The first difference is used to lessen the influence of these omitted variables on the parameters of interest.

Data on *BRAS* are not available prior to 1982; however, data on the Fed's target for the funds rate are available for the period 1974.10 - 1979.09. Consequently, estimates of *BRAS* consistent with the funds rate target for this period can be obtained by estimating the equation

$$BR_t = \alpha + \gamma(FFT_t - DR_t) + \eta_t \,, \qquad (12)$$

where the forecasted values of *BR* represent *BRAS* and the estimated errors represent *NBRAS*.

Three interest rates are used: the federal funds rate, *FF*, which is a weighted average of rates on daily transactions for a group of federal funds brokers who report to the Federal Reserve Bank of New York; the discount rate, *DR*, which is the rate that is in effect from the day that discount rate changes are first announced; and the Fed's federal funds rate target, *FFT*, which is provided by the Federal Reserve Bank of New York. Data on *FFT* are available from 1974.10 to 1979.09 and from 1984.02 to 1996.12. All rates are monthly averages of daily figures. Borrowed reserves, *BR*, are seasonal plus adjustment borrowing. The current practice of classifying borrowing into *extended credit*, *seasonal* and *adjustment* borrowing began in May 1973. Prior to that, all borrowing is adjustment borrowing. *NBR* are *TR* less adjustment and seasonal borrowing.

Estimates of Equation 11 are presented in Table 1. Estimates of ξ' are significantly different from zero and the null hypothesis that $\xi = \xi'$ is not rejected at the 5 percent significance level during both periods. Moreover, the null hypothesis that $\xi = \xi' = 1$ is not rejected. The results support Strongin's (1995) claim, based on his own analysis and that of Meulendyke

(1990), that since 1959 the Fed has acted to offset most if not all changes in borrowed reserves.[14]

That the Fed offsets changes in borrowed reserves is less surprising than it might first appear. The borrowing function has been unstable [Clouse (1992, 1994) and Thornton (1988a)]. Consequently, even if the Fed wanted to offset only that part of borrowing associated with the funds rate target, doing so would be difficult. Moreover, the Desk has opportunity because each day it knows the level of discount window borrowing for the previous day. Hence, offsetting borrowing is relatively simple at maintenance-period or monthly frequencies.

That the Desk offsets changes in borrowing that are not reflected in its borrowing assumption may be surprising. It is important to remember, however, that the specific quantitative components of the operating procedure are meant to provide guidance. What the Desk chooses to do depends on a number of things, including larger than expected borrowed reserves.[15]

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[14]The fact that there is a nearly one-to-one negative relationship between NBR and BR suggests that the Desk treated borrowing as a factor affecting reserve supply rather than reserve demand. If the Desk interpreted changes in borrowing or free reserves associated with changes in borrowing as a factor that affected demand, it would have increased the supply of nonborrowed reserves in response to a change in borrowing. That it did not, is probably due to the fact that during much of the period lagged reserve accounting was in effect. Under lagged reserve accounting, reserve demand was determined by deposit liabilities in an early period. Changes in borrowing would have been seen as increasing the supply of reserves relative to an unchanged reserve demand. Hence, it is only natural the Desk moved to offset changes in borrowing. The incentive to do so under nonborrowed reserve targeting was even greater.

[15]This is dramatically illustrated by the Continental Illinois Bank experience. Borrowing by Continental Illinois was initially classified as adjustment borrowing, rather than extended credit borrowing. Consequently, in May adjustment borrowing increased by \$1.71 billion, a good portion of which was borrowing by Continental Illinois Bank. In May *NBR* decreased by \$1.59 billion, despite the unchanged *BRAS* of \$1 billion. When continued borrowing by Continental Illinois was reclassified extended credit borrowing in June, adjustment borrowing declined by \$1.59 billion and *NBR* increased by \$1.88 billion. Again, the *BRAS* was unchanged.

The estimates suggest that $\xi \approx 1$. Additional evidence on the magnitude of ξ can be obtained by analysis of the funds rate and the funds rate target. It can be shown that the funds rate equals the targeted rate plus a random error only if $\xi = 1$ [see the appendix]. Hence, an indirect test of the hypothesis that $\xi = 1$ is obtained by estimating the equation:

$$FF_t = \phi FFT_t + \omega_t , \qquad (13)$$

and testing the hypothesis that $\phi = 1$. Figure 2 shows that during periods of funds rate targeting, the funds rate equals the funds rate target on average. Indeed, ordinary least squares estimates of the funds rate on the funds rate target, presented in Table 2, indicate that the rates are equal up to a random error.[16] These results suggest that $\xi = 1$, during the periods of federal funds rate targeting and borrowed reserves targeting.

Estimates of the Liquidity Effect

Historical analyses of the Fed's behavior and the evidence presented above indicate that the Fed has fairly routinely offset borrowing in the course of implementing the FOMC's policy directive. Moreover, the previous analysis suggests that under this condition, only supply shocks should be reflected in innovations to *TR*, while innovations to *NBR* should reflect both supply and demand shocks. In this case, there should be a "liquidity effect" using either *TR* or *NBR*, but its estimated magnitude should be larger with NBR, since it also reflects the Fed's practice of offsetting demand-shock induced changes in borrowing.

To investigate the liquidity effect in the recursive structural VAR, Pagan and Robertson's

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[16]Nearly identical results are obtained using the Johansen (1988) method.

preferred specification is used. This specification has six variables, the industrial production index, *Y*, the price level, *P*, as measured by theConsumer Price Index, *CPI*, the Journal of Commerce commodity price index, *JOCCP*, *NBR*, *FF*, and *TR*. With the exception of *JOCCP*, these variables are the same as those used by Pagan and Robertson (1995).[17] Because there is a linear relationship between borrowed and nonborrowed reserves, the variables are in levels.[18] The period is 1959.01 to 1996.12.

A causal interpretation is achieved by imposing a Choleski recursive ordering. In particular, to interpret the impulse response function (IRF) for $NBR \rightarrow FF$ as evidence of a liquidity effect, *NBR* precedes *FF* in the Choleski ordering. Contemporaneous innovations to *NBR* that are uncorrelated with the variables that precede it are taken to represent exogenous policy shocks.[19] To estimate the liquidity effect using *NBR*, the standard Choleski ordering, $\{Y, P, JOCCP, NBR, FF, TR\}^{14}$, was used. The order of the lag is indicated by the superscript at the

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[17]The commodity price index used by Pagan and Robertson, the industrial country commodity price index from the IMF's *International Financial Statistics*, was discontinued in July 1995. Results nearly identical to those obtained by Pagan and Robertson are obtained using *JOCCP* over the period 1959.01-1993.12.

[18]The IRFs using logs or levels are quantitatively and qualitatively similar.

[19]Strongin argues that shocks to supply "can be identified by simply having *TR* immediately precede *NBR* in a standard Choleski decomposition." He argues further that "it would be useful to have an explicit measure of the mix between *NBR* and *TR* as a primary objective of study, since it is this mix that is viewed as the policy control variables." He appears to suggest that the relationship between *NBR* and *BR* can be accounted for if both *TR* and *NBR* are included in the VAR and if they are normalized by dividing both by the level of *TR* in the preceding period. The rationale for this normalization is never precisely stated, and Strongin tried several alternatives. In general, one should be very careful using ratios that are not well specified by economic theory, see Kuh and Meyer (1955). In any event, whether *NBR* or the mix variable is used is relatively unimportant in that the results are very similar as when *NBR* is used, e.g., see Pagan and Robertson (1995).

end of the Choleski ordering.[20] To estimate the liquidity effect using *TR*, the positions of *NBR* and *TR* are switched, i.e., the Choleski ordering, $\{Y, P, JOCCP, TR, FF, NBR\}^{14}$, was used. The estimated IRFs for these two orderings are presented in Figure 3 along with 90 percent confidence intervals obtained by bootstrapping the model using 500 iterations.[21]

Given that ξ is close to unity, innovations in *TR* that are uncorrelated with *Y*, *P*, and *JOCCP* should reflect the federal funds rate's response to exogenous supply shocks. Consequently, the lack of a statistically significant IRF for $TR \rightarrow FF$ suggests that there is no liquidity effect. The IRF for $NBR \rightarrow FF$ is negative and statistically significant, however. The analysis of the Fed's operating procedure reveals that the negative IRF for $NBR \rightarrow FF$ could result either from the liquidity effect or the Fed's practice of offsetting changes in borrowing. Moreover, the lack of a significant liquidity effect for *TR* suggests that the IRF for $NBR \rightarrow FF$ is entirely due to the Fed's behavior and not the liquidity effect.

5. The Source of the Negative Covariance Between the Funds Rate and NBR

The purpose of this section is to provide further tests of the previous finding that the negative and statistically significant IRF with *NBR* is do to the Fed's operating procedure and not to the liquidity effect. In so doing, answers to two questions that have arisen in the literature are provided. The questions are, why did the liquidity effect vanish after the early 1980s [Pagan and

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[20]The order of the lag is relatively unimportant. Qualitatively and quantitatively similar results are obtained with much shorter lag lengths. Nevertheless, following Pagan and Robertson, the lag order is set at 14. As is typical in such studies, the lag lengths are the same for all variables; however, this requirement is unnecessarily restrictive [Thornton and Batten (1985)].

[21]The IRFs reported here are for normalized units of the variables rather than standard deviations. The reason for this approach will be clear later. I would like to thank John Robertson for providing me with the bootstrapping algorithm.

Robertson (1995) and Christiano (1995)] and why is the period of nonborrowed reserves targeting so important [Pagan and Robertson (1995)]?

Recall that if the negative covariance between NBR and the funds rate is due to the Fed's operating procedure, and not to the liquidity effect, it will vary with α, being larger the larger is α and disappearing when $\alpha = 0$. Hence, the important finding in this section will be that the negative, significant IRF for *NBR→FF* disappears when $\alpha \approx 0$. To better understand why this is true, it is useful to see that the IRF for *NBR→FF* is due to the contemporaneous relationship between *NBR* and *FF*. Do see this, consider the following structural model,

$$A\underline{Y} = B\underline{Y}_{-1} + \underline{\epsilon}\,, \qquad (14)$$

where the elements of A are the structural parameters, while the elements of B represent the dynamic response of the structure to exogenous shocks, including monetary policy shocks. The Choleski ordering assumes that A is lower triangular. Because A is full rank, Equation 12 can be rewritten as

$$\underline{Y} = \Gamma\underline{Y}_{-1} + A^{-1}\underline{\epsilon}\,, \qquad (15)$$

where $\Gamma = A^{-1}B$. Successive backward substitution yields,

$$\underline{Y} = A^{-1}\underline{\epsilon} + \Gamma A^{-1}\underline{\epsilon}_{-1} + \Gamma^{2}A^{-1}\underline{\epsilon}_{-2} + \ldots + \Gamma^{n}A^{-1}\underline{\epsilon}_{-n} + \ldots \qquad (16)$$

Differentiating 16 with respect to $\underline{\epsilon}$, assuming a once-and-for-all change in $\underline{\epsilon}$, yields the

system of impulse response functions: [22]

$$\frac{\partial \underline{Y}}{\partial \underline{\epsilon}} = [I + \Gamma + \Gamma^2 + \ldots + \Gamma^n + \ldots]A^{-1} . \qquad (17)$$

In general, the i, jth element, j < i, of A^{-1} is not equal to the i, jth element of A. Therefore, in general, it is not the case that the contemporaneous response in Equation 17 is large just because the corresponding coefficient in A is large. However, given the recursive structure of A and the normalizations, i.e., the diagonal elements of A are unity, it is the case that the i, jth , j < i, element of A^{-1} is equal to minus the i, jth , j < i, elements of A for i-j=1. This is important because *NBR* immediately precedes *FF* in the Choleski ordering. In any event, when these conditions are satisfied, the initial response of the IRF from Equation 17 is exactly equal to the ordinary least squares estimate of the coefficient on NBR in the FF equation in Equation 14.

Because of the persistence in these variables, the estimate of the coefficient on *NBR* in the funds rate equation in Equation 14, which is denoted $\tilde{\omega}$, is very similar to estimate of β from the much simpler equation:

$$\Delta FF_t = \beta \Delta NBR_t + \epsilon_t . \qquad (18)$$

To show that estimates of these parameters are not only of similar order of magnitude but have evolved similarly over the sample period, Figure 4 presents rolling least squares regression estimates of $\tilde{\omega}$ and β for the entire sample for a window of 60 observations. These coefficients behave quite similarly and are nearly identical since the latter part of the 1970s. Hence, the IRF

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[22]The impulse response functions are what Theil and Boot (1962) referred to as "dynamic" and "final form" multipliers.

for nonborrowed reserves is associated with the contemporaneous relationship between ΔNBR and ΔFF. This is particularly true since the late 1970s.

What is equally remarkable, and more important for understanding the source of IRF for $NBR \rightarrow FF$ in the recursive structural VAR, is that the estimates of β are very similar to estimates of $-\zeta$ from the equation:

$$\Delta FF_t = \zeta \Delta BR_t + \epsilon_t' . \qquad (19)$$

Rolling least squares regression estimates of $-\zeta$ and β for a window of 60 observations are presented in Figure 5. Not only do these coefficients follow a similar pattern, but they have been nearly identical since the late 1970s and have been essentially zero in recent years.

The magnitude of the initial liquidity effect is determined by the contemporaneous relationship between the funds rate and *NBR*, which is closely associated with the contemporaneous relationship between the funds rate and borrowing. Hence, it is important to consider how banks have used the discount window. Figure 6 shows the spread between the federal funds and discount rates and *SB* and *AB* over the period 1959.01-1996.12. During the early part of the period, the discount rate was an effective ceiling for the federal funds rate. When market conditions were such that the funds rate was below the discount rate, most banks met their overnight financing needs in the funds market. When market conditions changed and the funds rate rose to the level of the discount rate, many banks turned to the discount window.[23]

In the mid-1960s things changed. The funds rate went above the discount rate and has

[23]The fact that some borrowing occurred when the discount rate was above the federal funds rate suggests that some banks may lack access to the federal funds market.

generally remained above it since. Meulendyke (1990) suggests that the relationship between these rates changed when large banks began using the federal funds as a permanent source of funds to lend.[24] In any event, with the funds rate generally above the discount rate, borrowing began to rise and fall with the spread between the funds rate and the discount rate. As before, however, discount window borrowing all but ceased when the spread became negative.[25]

There was a marked change in the banks' use of the discount window in the mid-1980s, when borrowing dropped off dramatically. Clouse (1992, 1994) shows that the change in borrowing was due to a change in the behavior of large banks, which significantly curtailed their use of the discount window. Clouse argues that this sudden change in behavior stemmed from large banks' concern about being seen at the discount window in the wake of the large borrowing by then troubled Continental Illinois Bank. This hypothesis is consistent with anecdotal evidence suggesting that many large banks do not want to be seen at the discount window.[26] Whatever the reason, banks significantly changed their behavior about this time.

If the significant relationship between the funds rate and borrowing, coupled with the

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[24]Meulendyke (1990), pages 36-7, states that "there was considerable surprise when the funds rate first rose above the discount rate, briefly in October 1964 and more persistently in 1965. As large banks became more active managers of the liability side of their balance sheets, they borrowed funds in the market in a sustained way....Borrowing from other banks through the Federal funds market were free of reserve requirements and interest rate ceilings. Furthermore, they were not subject to the restrictions on prolonged use that were applied to the Federal Reserve's discount window."

[25]It is this feature of borrowing that accounts for much of the reported nonlinearity in the borrowing function [e.g., Peristiani (1991)].

[26]Conversations with reserve account managers of two very large U.S. banks support Clouse's interpretation. Both indicated a strong reluctance by senior management to be seen at the discount window has kept them away.

Fed's operating procedure explains the negative contemporaneous relationship between *NBR* and the funds rate, the relationship should vanish whenever the relationship between borrowing and the funds rate breaks down. On the other hand, if it is due to a true liquidity effect there is no reason that it should vary with the banks use of the discount window.

Pagan and Robertson (1995) and Christiano (1995) have already shown that the IRF of $NBR \rightarrow FF$ vanished about the time that large banks began to shun the discount window. Borrowing was also relatively unresponsive to changes in the funds rate during the period when the discount rate was an effective ceiling for the funds rate. During this period, the spread between the federal funds and discount rate was like a toggle switch. When the funds rate equaled the discount rate, banks borrowed. When the funds rate was below the discount rate, borrowing all but ceased. If the interest responsiveness of borrowing and the Fed's operating procedure account for the liquidity effect with *NBR*, it should vanish during this period as well.

The sensitivity of the estimated liquidity effect to the banks' use of the discount window is illustrated in Figures 7 and 8. Figure 7 shows the IRF for $NBR \rightarrow FF$ for $\{Y, P, JOCCP, NBR, FF, TR\}^4$ for 1965.04-1984.06 and 1965.04-1979.09. The liquidity effect is relatively large and statistically significant during the period 1965.04-1984.06, when borrowing was relatively large and responsive to changes in the funds rate/discount rate spread. The liquidity effect is somewhat smaller when the 1979-82 period is excluded, confirming Pagan and Robertson's (1995) finding of the importance of the 1979-82 period.

Figure 8 shows the IRF for $NBR \rightarrow FF$ for $\{Y, P, JOCCP, NBR, FF, TR\}^4$ for the periods 1959.01-1965.03 and 1984.07-1996.12. The estimated liquidity effect essentially vanished after 1984.06, when large banks turned away from the discount window. The IRF for the period

1959.01-1965.03 also suggests no liquidity effect. The immediate response is large but short lived and the IRF is generally insignificant.[27] The results for these periods are consistent with the implication of the VAR results for *NBR* and *TR*. That is, the IRF of $NBR \rightarrow FF$ reflects the contemporaneous relationship between *NBR* and the funds rate that is caused by the Fed's practice of offsetting demand-shock induced changes in borrowing.

To further investigate this possibility, consider the results for the period 1959.01-1965.03 more carefully. The initial liquidity effect is very large during this period. Indeed, it is larger than that estimated during the period 1965.04-1984.06. Why is the initial response so large? The answer is revealed in Figure 9, which shows ΔFF and ΔBR over this period. The increased variability of ΔFF relative to movement in ΔBR during the early 1960s results in a very large estimate of ζ, and consequently, a very large estimate of $\tilde{\omega}$. To illustrate how sensitive the least squares estimates of ζ are to the increased variability of ΔFF, rolling regression estimates of ζ for a window size of 10 are also presented. While there is only a small tendency for borrowing to vary directly with the funds rate, the large movements in ΔFF result in a large estimate of ζ over this period, 1.80. Nevertheless, this parameter is imprecisely estimated and, consequently, so is the corresponding IRF.

To further demonstrate that the IRF for *NBR* depends critically on the relationship between ΔBR and ΔFF, hypothetical borrowed reserves data, *HBR*, are constructed using the equation:

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[27]The variability of *BR* and *NBR* was very small during this period. Hence, when the IRF is normalized by the standard deviation of *NBR*, even the initial effect is relatively small, at about six basis points.

$$HBR_t = .50 + .35(FF_t - DR_t) , \qquad (20)$$

for the period 1965.04-1996.12. These data are presented in Figure 10, along with *BR*. Note that *HBR* approximates *BR* fairly well up to about 1984. The hypothetical data generated by Equation 20 induces a positive association between borrowing and the funds rate. However, the variability of ΔFF has been relatively low since 1984.07, so *HBR* is capable of inducing only a relatively weak relationship between $\Delta HNBR$ [$HNBR = TR - HBR$] and ΔFF.[28] A stronger relationship can be induced by adding:

$$HBR\mu_t = \mu \Delta FF_t , \quad 0 < \mu < 1 , \qquad (21)$$

to *HBR*.

The effect of making borrowing vary with the funds rate is demonstrated in Figure 11, which shows the IRFs for $NBR \rightarrow FF$ for the period 1984.07-1996.12 for actual *NBR* and for the three hypothetical series: the one based on Equation 20, *HNBR*, and on two others, *HNBR*25 and *HNBR*50, obtained from Equation 20 plus Equation 21, with $\mu = 0.25$ and 0.50, respectively. Because of the relative stability of ΔFF since 1984, using Equation 20 alone results in a "liquidity effect" that is only modestly larger than that for *NBR*. When a stronger relationship between ΔHBR and ΔFF is induced, an IRF emerges that is more similar to those estimated over the 1965.04-1979.09 and 1965.04-1984.06 periods. The stronger relationship between ΔHBR

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[28]Because ΔHBR is determined by ΔFF and the variance of ΔFF is relatively small during this period, movements in ΔHBR are dominated by ΔTR.

and ΔFF, the larger is the estimated "liquidity effect."[29]

The dependence of the IRF on the variability of ΔFF is part of the explanation of Pagan and Robertson's (1995) finding that the period 1979-82 is so important. During this period the variance of ΔFF was very large by historical standards. Borrowing was also very responsive to changes in the funds rate. The marked rise in the variance of ΔFF, coupled with the interest sensitivity of borrowing, gave rise to a strong positive contemporaneous relationship between ΔBR and ΔFF. The critical factor, however, was that the Fed had a stronger incentive to offset changes in borrowing during this period.

6. Nonborrowed Reserves Targeting

The strong negative contemporaneous relationship between *NBR* and *BR*, the fact that the significant negative IRF of $NBR \rightarrow FF$ appears and disappears with the relationship between *BR* and *FF* and the lack of a significant IRF when TR is used point to the conclusion that the contemporaneous relationship between *NBR* and *FF* is due to Fed responding to demand-shock induced changes in borrowing and not to the liquidity effect. Additional evidence can be

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[29]Similar results can be obtained using Equation 20 and by simply increasing the high-frequency variation of the funds rate. This can be done by creating a hypothetical series for the funds rate:

$$HFF_t = FF_t + \theta\eta_t \ ,$$

where η is distributed Normal (0, 1). When θ is chosen so that the variance of ΔHFF is equal to the variance of ΔFF over the period 1965.04-1984.06, the IRF for the *HNBR* has an initial effect that is nearly identical to that of the 1965.04-1984.06 period. However, adding random noise, that is uncorrelated with the other variables in the system, to the funds rate significantly increases the residual variance of the funds rate equation in the VAR, so the resulting IRFs are insignificant. Moreover, noise knocks out the serial dependence in ΔFF, so that the estimated IRFs return to zero very quickly. The relationship between borrowing and the funds rate is critical, however. Simply making ΔFF more variable is not sufficient.

obtained by carefully examining Fed operations during the period of nonborrowed reserves targeting.[30] This period is important for estimates of the IRF of $NBR \rightarrow FF$. Moreover, since the Fed was targeting nonborrowed reserves, it might seem that it would have no reason to offset changes in borrowing. But this was not the case.[31]

The Fed's objective of the *NBR* operating procedure was money stock control [e.g., Gilbert and Trebing (1981), Spindt and Tarhan (1987), Meulendyke (1990) and Strongin and Tarhan (1990)]. The FOMC's objective for money growth, combined with the staff's estimate of the money multiplier, generated a path for *TR*. The path for *NBR* was obtained by subtracting the IBA. The Desk adjusted the paths for *TR* and *NBR* in unison when the FOMC changed its money growth objective or when the staff revised its multiplier estimate. In addition, the Desk made frequent adjustments to the path for *NBR* independent of the path for *TR*. Such adjustments were equivalent to changing the IBA.

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[30]The precise date when the Fed switched from a *NBR* operating procedure to a *BR* operating procedure is unknown, but it is clear that nonborrowed reserves targeting had ended by October 1982.

[31]Lagged reserve accounting was in effect during this period. Consequently, reserve demand was determined by deposit liabilities held previously. When the Fed reduced reserves through open market operations, it was thought that banks would be *forced* to the discount window to meet their reserve requirements. Because banks are *reluctant to borrow* from the Fed, discount window borrowing increases only when interest rates have risen sufficiently, relative to the discount rate, so that the pecuniary advantage from discount window borrowing offsets banks' reluctance to borrow. Hence, if the Fed reduces *NBR* sufficiently, the federal funds rate and bank borrowing increase simultaneously.

The evidence presented thus far is generally inconsistent with this interpretation. In particular, the relationship between *NBR* and the funds rate disappears when banks decided to stay away from the discount window. This is just the opposite of what this explanation suggests. Indeed, the more reluctant banks are to borrow, the larger should be the increase in the funds rate that is required to get banks to the discount window.

Because the objective was monetary control, the incentive to offset deviations of *TR* from its path was particularly strong under the nonborrowed reserves operating procedure. Unchecked, such deviations would cause money to deviate from its desired path. This is true regardless of the source of the deviation. When borrowing was higher than expected, the Desk could either offset borrowing, thereby missing its path for *NBR* on the low side, reduce its *NBR* path or overshoot its money stock objective. If borrowing was lower than expected, the Desk could either offset borrowing, thereby missing its path for *NBR* on the high side, raise its *NBR* path or undershoot its money stock objective. The Desk was aware of this "dilemma" and faced it frequently.[32] On some occasions the Desk adjusted its nonborrowed reserves path and on others it simply chose to miss it. The instances when the Desk faced this dilemma and chose to miss the FOMC-directed money stock target appear to be rare. Since the effect of either of the first two courses of action are the same for open market operations, it is not clear why one course of action was chosen on some occasions and the other course chosen on others.

In any event, an analysis of Fed documents makes it clear that the Fed made frequent adjustments to its initial borrowing assumption in response to unexpectedly high or low borrowing. Figure 12 presents the initial borrowing assumption and actual weekly borrowing over the period February 7, 1980 to September 30, 1982 obtained from Desk's weekly *Report of Open Market Operations and Money Market Conditions*.[33] During this 33-

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[32]Federal Reserve Bank of New York (1981, p. 65).

[33]The initial borrowing assumption is the difference between the total reserves path and nonborrowed reserves path from the weekly *Report of Open Market Operations and Money Market Conditions*. Beginning with the week ending February 27, 1980, the report included a table indicating all changes in paths and the effective date of the new path. Prior to that, the

month period, the IBA was adjusted 64 times, an average of nearly twice a month. Moreover, these adjustments clearly follow rather than lead changes in borrowing.[34]

That the Fed often adjusted its IBA in response to observed changes in borrowing is documented in Table 3, which presents the IBA, its effective date and the stated reason for the change, on those occasions when the reason can be documented. Unfortunately, reasons for all of the changes cannot be documented. This is particularly true early on, when both the procedure and the reporting of activities were evolving. As both the procedure and the reporting became more routine, the documentation improved.

These documents suggest there were two reasons for changing the initial borrowing assumption or, alternatively and opposite, the nonborrowed reserves path. The first was deviations of total reserves from the total reserves path consistent with the FOMC's money

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initial borrowing assumption is only stated in the text of the document, so it is impossible to tell the precise date that the initial borrowing assumption took effect. Consequently, these data begin on February 7, 1980, the first effective date reported in tabular form in this document. It may also be the case that not all of the changes in the initial borrowing assumption are reported in the tables in this document. For example, according to the recently released complete transcript of the FOMC meeting held on May 18, 1982, in response to a statement by Governor Wallich that he would opt for an initial borrowing assumption of around $1 billion, Chairman Volcker says, "A billion dollars is where we are now in fact." Mr. Sternlight corrects the chairman, stating that "The level implicit in the path is a little over [$1 billion]--about $1044 or $1045 million." Yet the last figure for the weekly report was $1.121 billion effective on May 14, 1982. It is unclear whether there was a nonborrowed reserves path adjustment that is not reflected in the weekly report or whether Sternlight was referring to the level that borrowing would have to be if the Desk were to hit its nonborrowed reserves path. The latter figure was calculated daily, but is not the initial borrowing assumption.

[34]This is confirmed by simple Granger causality tests between changes in borrowing and changes in the IBA. The null hypothesis of no Granger causality running from borrowing to the borrowing assumption is rejected (the F-statistic is 7.67), while the hypothesis of no Granger causality running from the IBA to borrowing cannot be rejected (the F-statistic is 0.53). These results are for a lag length of three. Similar results are obtained for other lag specifications.

growth objective. The second was to offset unexpected borrowing. Hence, the impression given by, Figure 12, that the Fed made frequent changes to the initial borrowing assumption in response to observed changes in borrowing, is borne out by Fed documents.

In addition to the many formal changes in the borrowing assumption to offset borrowing, there were many instances where the Desk simply chose to undershoot or overshoot its nonborrowed reserves path to offset unexpectedly strong or weak discount window borrowing. Such instances are much more difficult to document, but in its summary of Desk operations during 1980, the Fed acknowledged this tendency:

> *"The tendency for nonborrowed reserves to come out below path largely reflected the behavior of borrowing over the year which more often ran above rather than below expectations, especially during periods of rising interest rates. Instead of allowing a huge excess at the end of statement weeks, the Desk at times deliberately chose to undershoot its weekly nonborrowed reserve objective."*[35]

That the Desk did this on a number of occasions in 1981 and 1982 is documented in the New York Fed's annual summaries of Desk operations for those years.[36] Indeed, there were several instances when the Fed changed the initial borrowing assumption and offset the excess borrowing. For example, during May 1981, the Fed increased its borrowing assumption by $205 million to offset the effect of the unusually large borrowing for the week ending May27th. The change in the nonborrowed reserves path was insufficient because borrowing increased to $2.9 billion over the three-day Memorial weekend. Hence, "under these circumstances, the Desk

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[35]Federal Reserve Bank of New York (1981, p. 67).

[36]There were at least five instances in 1981 and three in 1982 when the Desk chose to miss its nonborrowed reserves path in response to higher or lower than expected borrowing.

deliberately sought a level of nonborrowed reserves for the week that was well below the objective."[37] A similar event occurred in January of 1982. Despite adjusting the initial borrowing assumption upward by a total $303 million in three successive moves in January, borrowing rose above the Fed's expectations. Hence, "open market operations accordingly absorbed reserves somewhat more than seasonally over the month."[38]

The tendency to offset unexpected borrowing, either formally or informally, is not surprising given the Fed's objective for money growth. Indeed, this behavior likely accounts for the exceptionally strong negative relationship between changes in nonborrowed reserves and changes in borrowed reserves over this period, presented in Figure 13. At the monthly frequency, the correlation between ΔNBR and ΔBR during this period is -0.90. The strong incentive to offset changes in borrowing naturally carried over to the Fed's borrowed reserves operating procedure which followed [Thornton (1988a)]. This marked increase in the incentive to offset borrowing under nonborrowed reserves targeting likely accounts for the particularly strong correspondence between estimates of β and $-\zeta$ beginning in late 1979, presented in Figure 5.

The documentary evidence for this critical period is consistent with the view that the contemporaneous relationship between nonborrowed reserves and the funds rate, which has been interpreted as evidence of the liquidity effect, is in fact due to the Fed's tendency to offset changes in borrowing under a variety of intermediate operating objectives. The nonborrowed reserves targeting period is particularly important because large changes in the federal funds rate

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[37]Federal Reserve Bank of New York (1982, p. 48).

[38]Federal Reserve Bank of New York (1983, p. 46.)

induced large changes in borrowing which the Desk offset rather than miss the FOMC's money growth objective.

This evidence also accounts for why the "liquidity effect" vanished in the early 1980s. While the Fed continued to offset borrowing, banks borrowed much less at the discount window. Moreover, the borrowing that took place was not motivated by the spread between the federal funds rate and the discount rate as before.

7. *Conclusions*

Recently, a number of researchers have presented evidence of a statistically significant liquidity effect using nonborrowed reserves in recursive structural VARs. Modeling the Fed's operating procedure, I show that the negative covariance between nonborrowed reserves and the federal funds rate, that is crucial for the evidence of the liquidity effect in such recursive structural VARs, can be due to either the liquidity effect or the Fed's practice of offsetting bank borrowing.

The Fed has an incentive to offset borrowed reserves under a variety of operating objectives. Consequently, it is not surprising that the evidence indicates that the Fed has offset most borrowing since 1959. This finding is consistent with historical analyses of the Fed's operating procedures [Meulendyke (1990) and Strongin (1995)].

In addition, consistent with the Fed responding endogenously to demand shocks, I find that the contemporaneous relationship between nonborrowed reserves and the funds rate varies directly with banks' use of the discount window. There is a strong negative association between nonborrowed reserves and the funds rate over periods when there is a strong positive association between borrowing and the funds rate, and no relationship when banks decide to shun the discount window or when borrowing is not interest sensitive.

Indeed, evidence of the "liquidity effect" in the VAR is strongest during the period of nonborrowed reserves targeting, when the Fed's incentive to offset changes in borrowing was particularly strong. Fed documents reveal that when confronted with borrowing that was higher or lower than anticipated, the Desk either changed its nonborrowed reserves objective or deliberately missed it. Because the funds rate was more volatile during this period and borrowing was interest sensitive, the Fed's practice of offsetting changes in borrowing induced a particularly strong negative contemporaneous relationship between nonborrowed reserves and the federal funds rate. It is this and not the liquidity effect that accounts for the importance of the nonborrowed reserves targeting period.[39]

That the negative contemporaneous covariance between nonborrowed reserves and the federal funds rate is due to the endogenous behavior of the Fed also accounts for why the "liquidity effect" vanished in the 1980s. Large banks, which tended to increase their reliance on the discount window when the funds rate increased relative to the discount rate, stopped coming to the discount window in the mid-1980s. Although the Fed continued to offset changes in borrowing, there was no interest sensitive borrowing to offset and, consequently, no negative association between nonborrowed reserves and the funds rate.

Hence, the *vanishing liquidity effect* [Pagan and Robertson (1995) and Christiano (1995)] is not the result of a fundamental, but yet unspecified, change in the Fed's ability to influence interest rates through open market operations. Rather, it stems from the fact that banks,

[39]This conclusion also applies to other "evidence" of a liquidity effect using nonborrowed reserves [Thornton (1988b)].

principally large banks, decided to stay away from the discount window. The question is not why has Fed's ability to influence short-term interest rates changed, but rather why did large banks decide to shun the discount window? No one knows for sure, but Clouse's (1992, 1994) explanation, that large banks were concerned that being seen at the discount window might raise questions about their soundness, would seem to be part of the answer.

Finally, there is no evidence of a liquidity effect in the recursive structural VAR using total reserves. This result is disturbing given the prominence of the liquidity effect in most paradigms of the monetary policy transmission mechanism.[40] Whatever accounts for this result, it is not because total reserves reflects only shocks to demand, as Strongin (1995) and Bernanke and Mihov (1997ab) suggest. An analysis of the reserve market and the Fed's operating procedure shows that total reserves necessarily reflect supply shocks. Consequently, either there is no liquidity effect or innovations to total reserves reflect both policy and non-policy shocks. It appears that identifying policy shocks from innovations to total reserves will be difficult, requiring a considerably more detailed structural analysis of the reserve market. The analysis presented here shows that particular care will have to be given to modeling the institutional structure of the Fed's operating procedure.

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[40]It is the case, however, that the liquidity effect has been elusive. See Pagan and Robertson (1995), Thornton (1988b) and Reichenstein (1987) for surveys of the evidence. The exceptions are Cochrane (1989), who finds some evidence of a liquidity effect for some time periods using broader monetary aggregates, Hamilton (1997), who finds that the federal funds rate responds significantly to unanticipated Treasury balances, but only on reserve settlements days.

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APPENDIX

This appendix presents the reduced form expressions for *TR*, i^f and *NBR*. The relevant functions are assumed to be linear, i.e.,

$$f(i_t, x_t) = -\lambda i_t + \gamma x_t \quad and \quad BR_t = \alpha(i_t^f - i_t^d) + \eta_t \ .$$

Given these equations and assuming that $BRAS_t = \xi BR_t$, the reduced-form expressions for i^f, *TR* and *NBR* are:

$$i_t^f = \psi[i_t^{f*} + \frac{\gamma}{\lambda}(x_t - E_{t-1}x_t) + \frac{(1-\xi)\alpha}{\tau\lambda} i_t^d - (1-\xi)(\tau\lambda)^{-1}\eta_t + (\tau\lambda)^{-1}\epsilon_t + \lambda^{-1}\nu_t]$$

$$TR_t = \psi[-\tau\lambda i_t^{f*} + (1-\xi)\alpha\gamma\lambda^{-1}x_t + \tau\gamma E_{t-1}x_t - (1-\xi)\alpha i_t^d + (1-\xi)\eta_t + \epsilon_t + (1-\xi)\alpha\lambda^{-1}\nu_t$$

$$NBR_t = \psi[-(\tau\lambda+\alpha)i_t^{f*} - \alpha\gamma\xi\lambda^{-1}x_t + \gamma(\tau\lambda+\alpha)\lambda^{-1}E_{t-1}x_t - \alpha\xi\lambda^{-1}\nu_t\ ] - \xi\eta_t + \alpha\xi i_t^d + \epsilon_t$$

where

$$\psi = \frac{\tau\lambda}{\tau\lambda + (1-\xi)\alpha} \ .$$

Note that in this case, as in the previous one, the federal funds rate equals the Fed's target plus a random error if and only if $\xi = 1$. *TR* now depends on shocks to demand and *NBR* is independent of shocks to demand regardless of the value of ξ. *TR* is independent of demand shocks if and only if $\alpha = 0$.

Table 1: Estimates of Operating Procedure Determined Accommodation of Borrowed Reserves

Parameter	1974.11 - 1979.09		1982.02 - 1996.12	
δ	0.0470* (2.18)	0.0450* (2.10)	0.2278* (4.22)	0.2272* (4.20)
ξ	0.7716* (6.72)	0.8450* (10.39)	1.0065* (3.96)	0.8988* (10.39)
ξ'	0.9000* (8.87)	--	0.8968* (10.32)	--
Adj R^2	0.6472	0.6483	0.4165	0.4195
s.e.	0.1650	0.1647	0.3600	0.3590
D.W.	2.3936	2.4272	2.0438	2.0425
AR(1)	--	--	0.4707* (6.68)	0.4738* (6.74)
$\xi = 1$ 1/	3.9618*	3.6313	0.6489	1.3688
$\xi' = 1$ 1/	0.9713	--	1.4094	--
$\xi = \xi'$ 1/	0.8250	--	0.2032	--
$\xi = \xi' = 1$ 2/	4.4451	--	1.5625	--

1/ Distributed Chi Square (1)
2/ Distributed Chi Square (2).
*indicates statistical significance at the 5 percent level.
Absolute value of t-statistics in parentheses.

Table 2: The Relationship Between the Funds Rate and the Funds Rate Target

	1974.10 - 1979.10	1984.02 - 1996.12
Const.	-0.0004 (0.02)	0.0733 (1.71)
ϕ	1.0008* (313.17)	0.9976* (166.47)
Adj R^2	0.9994	0.9958
S.E.	0.0502	0.1460
D.W.	1.447	1.224

*Indicates statistical significance at the 5 percent level.
Absolute value of t-statistics in parentheses.

Table 3: The Initial Borrowing Assumption		
Effective Date	Initial Borr. Assumption ($bill)	Description (direct quotes)
Feb. 7, 1980	1.250	NA
Feb. 15, 1980	1.317	NA
Feb. 29, 1980	1.650	NA
March 21, 1980	2.750	Because of uncertainty over the demand for borrowing it was decided to seek nonborrowed reserves consistent with borrowing in the range of about $2.5 to $2.8 billion. DR, 4/2/80
March 28, 1980	2.600	reflecting...a $600 million upward adjustment...to reflect weaker than expected in demand for borrowing, and a $450 million downward adjustment...assumed to be the amount of emergency-type borrowing by one large member bank. BB, 4/18/80. Reflects $150 million upward adjustment...to account for the apparent downward shift in the demand for borrowing. DR, 4/2/80
April 25, 1980	1.375	NA
May 2, 1980	1.526	acceptance of average $251 million borrowing overshoot in first week and raising nonborrowed path by $100 million in second week to speed adjustment. DR, 5/21/80
May 23, 1980	0.100	NA
June 13, 1980	0.111	NA
June 20, 1980	0.100	NA
July 7, 1980	0.073	average borrowing for the period lowered to $73 million. Shooting for $100 million on average would have implied borrowing in the final week of $182 million, an amount that appeared inconsistent with Committee objectives. DR, 7/9/80
July 11, 1980	0.075	NA
Sept. 5, 1980	0.225	In light of the difference between total reserve projected and total reserve path, nonborrowed reserve path was revised down by $150 million... DR, 9/10/80
Sept. 19, 1980	0.750	NA
Oct. 3, 1980	0.950	path lowered by $200 million in light of the persistent strength in projected total reserves compared to the total reserve path. DR, 10/8/80
Oct. 24, 1980	1.300	NA
Nov. 7, 1980	1.400	path was further downward by $100 million because of the strength in total reserves. BB, 11/14/80
Nov. 14, 1980	1.450	path reduced by $50 million in light of increased gap between projected total reserves and total reserves path. DR, 11/19/80
Nov. 25, 1980	1.500	NA
Dec. 1, 1980	1.670	path reduced by $170 million...in light of continuing large gap between demand for total reserves and path. DR, 12/3/80
Dec. 23, 1980	1.500	path adjusted downward by $170 million in view of continuing strength in total reserves. BB, 12/12/80
Jan. 30, 1981	1.780	path lowered by $280 million...to avoid sharp drop in borrowing. DR , 2/4/81. Adjustment downward to reflect the large unexpected rise in demand for borrowing in the week ending January 28. BB, 1/30/81
Feb. 6, 1981	1.300	NA

Feb. 25, 1981	1.466	path revised downward by an average of $166 million ...following the FOMC's telephone meeting on Tuesday. DR, 2/25/81
March 6, 1981	1.300	NA
April 3, 1981	1.150	NA
April 10, 1981	1.183	NA
April 20, 1981	1.150	NA
May 1, 1981	1.400	path adjusted downward another $250 million ...because total reserves were running above target. BB, 5/15/81
May 8, 1981	1.634	path adjusted downward by another $120 million...because total reserves were continuing to run above target. path adjusted downward by another $115 million to prevent shortfall in nonborrowed reserves path in week of May 6 from distorting the subsequent two weekly paths in the same intermeeting period. BB, 5/15/81 $114 million reflecting the deliberate acceptance of a shortfall in nonborrowed reserves in the May 6 week in view of the heavier-than-anticipated borrowing that week. DR, 5/13/81
May 22, 1981	2.101	In view of the very high weekend borrowings, it was decided to allow for a shortfall in nonborrowed reserves. DR, 5/27/81
May 29, 1981	2.306	path was adjusted downward by an additional $206 million to prevent the unexpectedly large borrowing in the week of May 27 from distorting the nonborrowed reserve path in subsequent weeks. BB, 7/2/81
June 19, 1981	1.800	NA
June 30, 1981	1.968	adjusted downward by an offsetting $168 million to prevent unexpectedly large borrowings in the week of June 24 from distorting the nonborrowed reserves path... BB, 7/2/81
July 10, 1981	1.500	NA
Aug. 6, 1981	1.424	adjusted upward by another $76 million to prevent the unexpectedly low borrowings in the week of August 5 from distorting the nonborrowed reserves path...BB, 8/14/81
Aug. 21, 1981	1.400	NA
Oct. 9, 1981	0.850	NA
Nov. 6, 1981	0.794	path adjusted upward by $56 million because of weakness in total reserves. BB, 11/13/81
Nov. 20, 1981	0.400	it was decided to accept borrowing shortfall in the first week and set borrowing over the remaining weeks equal to the average for the period. DR, 12/2/81
Dec. 28, 1981	0.300	NA
Jan. 1, 1982	0.389[1/]	path adjusted downward by $89 million to offset the unusually large borrowing in the Jan. 6 holiday week. 1/29/82
Jan. 15, 1982	0.576[1/]	adjusted downward by $187 million due to strength in total reserves. BB, 1/29/82
Jan. 29, 1982	0.603[1/]	to maintain borrowing near the level expected in the previous week...the NBR path was lowered by an additional $27 million.
Feb. 5, 1982	1.500	Borrowing consistent with achieving the nonborrowed reserves objective rose sharply to about $1.5 billion in the final two weeks of the period [six weeks ending Feb. 3] At its Feb. 1-2 meeting,...The initial borrowing level was continued at $1.5 billion." NY (1983, p. 46).
Feb. 26, 1982	1.600	path adjusted downward by $100 million to offset the unusually large borrowing in the week of February 24. BB, 3/26/82

March 5, 1982	1.500	Open market operations had adjusted to the decline in borrowing which,...ran below path levels. To allow for this, the nonborrowed reserve path was raised by a total of $80 million and, late in the subperiod the path was raised a bit further because of the slow growth of M-2... NY (1983, p. 46).
March 12, 1982	1.479	path adjusted upward by $21 million to offset the unexpectedly low borrowing in the week of March 10. BB, 3/26/82
March 19, 1982	1.420	path adjusted upward by $59 million to offset the reduced demand for borrowing in the week of March 17. BB, 3/26/82
April 2, 1982	1.150	NA
April 16, 1982	1.113	path adjusted upward by $37 million to offset the reduced demand for borrowing in the week of April 14. BB, /14/82
April 30, 1982	1.150	NA
May 14, 1982	1.121	path adjusted upward by $29 million to offset the reduced demand for borrowing in the week of May 12. BB, 5/14/82
May 21, 1982	0.800	the Committee at its May 18 meeting decided to aim for a nonborrowed reserves level consistent with $800 million in borrowing for the week, in line with the average of the first six days. NY (1983, p. 50)
May 28, 1982	0.815	path adjusted downward by $15 million to offset the increased demand for borrowing in the week of May 26. BB, 6/25/82
June 4, 1982	0.830	path adjusted downward by $15 million to offset the increased demand for borrowing in the week of June 2. BB, 6/25/82
June 11, 1982	0.861	path adjusted downward by $ 31million to offset the increased demand for borrowing in the week of June 9. BB, 6/25/82
July 2, 1982	0.800	NA
July 16, 1982	0.715	path adjusted upward by $85 million after taking account of the general trend in the aggregates and existing market conditions. BB, 8/20/82
July 30, 1982	0.700	path adjustment upward by an additional $100 million due the weakness in total reserves. BB, 8/20/82
Aug. 13, 1982	0.639	path adjusted upward by $61 million to reflect the reclassification of adjustment borrowing of one bank to extended credit during the week of Aug. 11. BB, 8/20/82
Aug. 27, 1982	0.350	NA
Sept. 10, 1982	0.633	path adjusted downward by $283 million to take account of the increased demand for borrowings in the Sept. 8 and Sept. 15 statement weeks. BB 10/1/82
Sept. 17, 1982	0.350	NA
Sept. 24, 1982	0.102	path was raised by $248 million to accommodate the acceptably more rapid growth in money. DR, 10/6/82

Sources: DR denotes *Desk Report*, formally the *Report on Open Market Operations and Money Market Conditions*. BB denotes the *Blue Book*, prepared by the Board staff before each FOMC meeting. NY denotes the annual summary of open market operations published by the Federal Reserve Bank of New York. NA denotes that we were unable to document the reason for the change in the initial borrowing assumption from these sources.

[1/] "As the period progressed, the nonborrowed reserve path was lowered in three stages by a total of $303 million...to accommodate temporary bulges in borrowing and to speed the return of money to path." Federal Reserve Bank of New York (1983, p. 46).

Figure 1: Borrowing and the Borrowing Assumption (1982.01 - 1996.12)

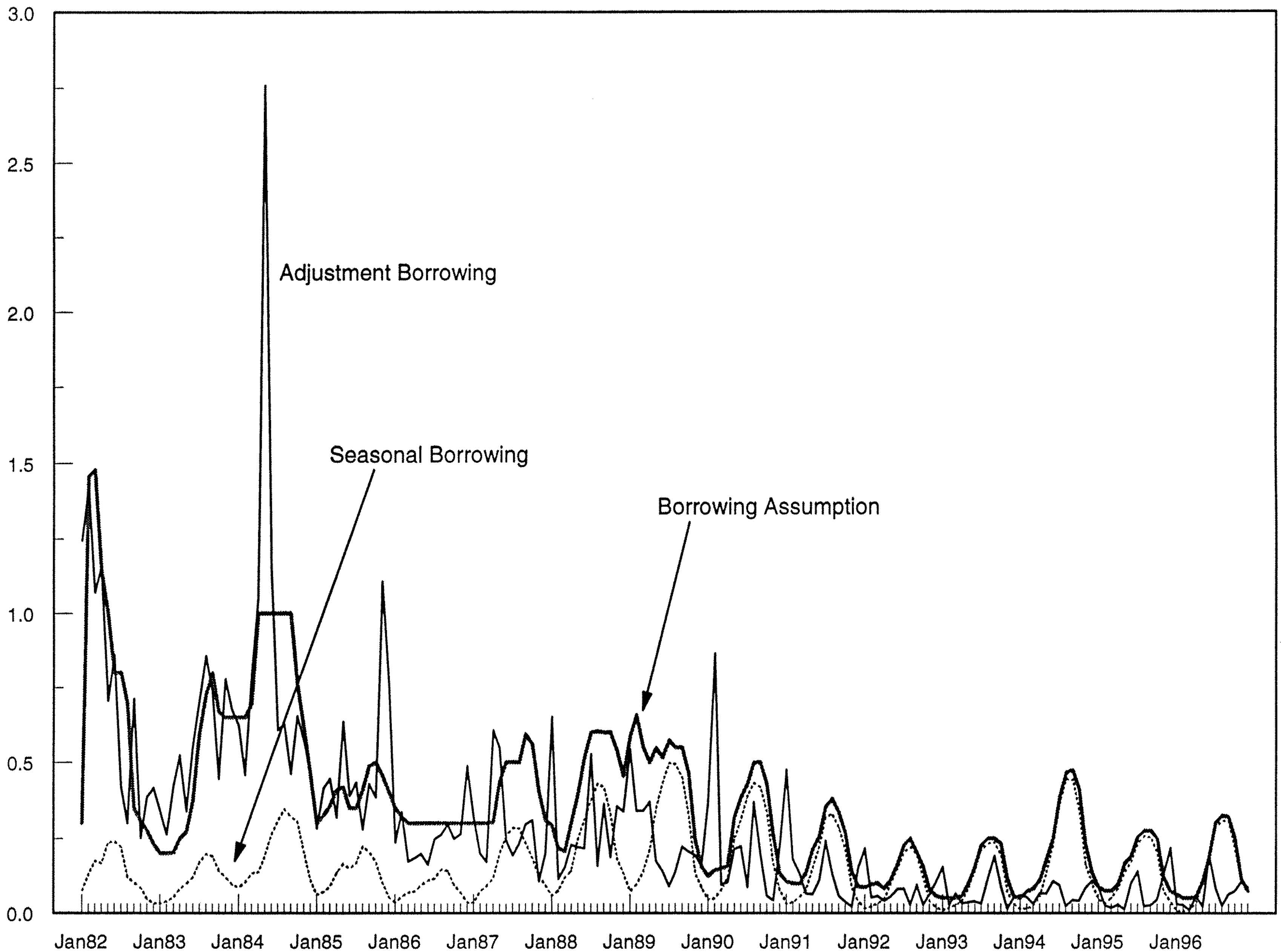
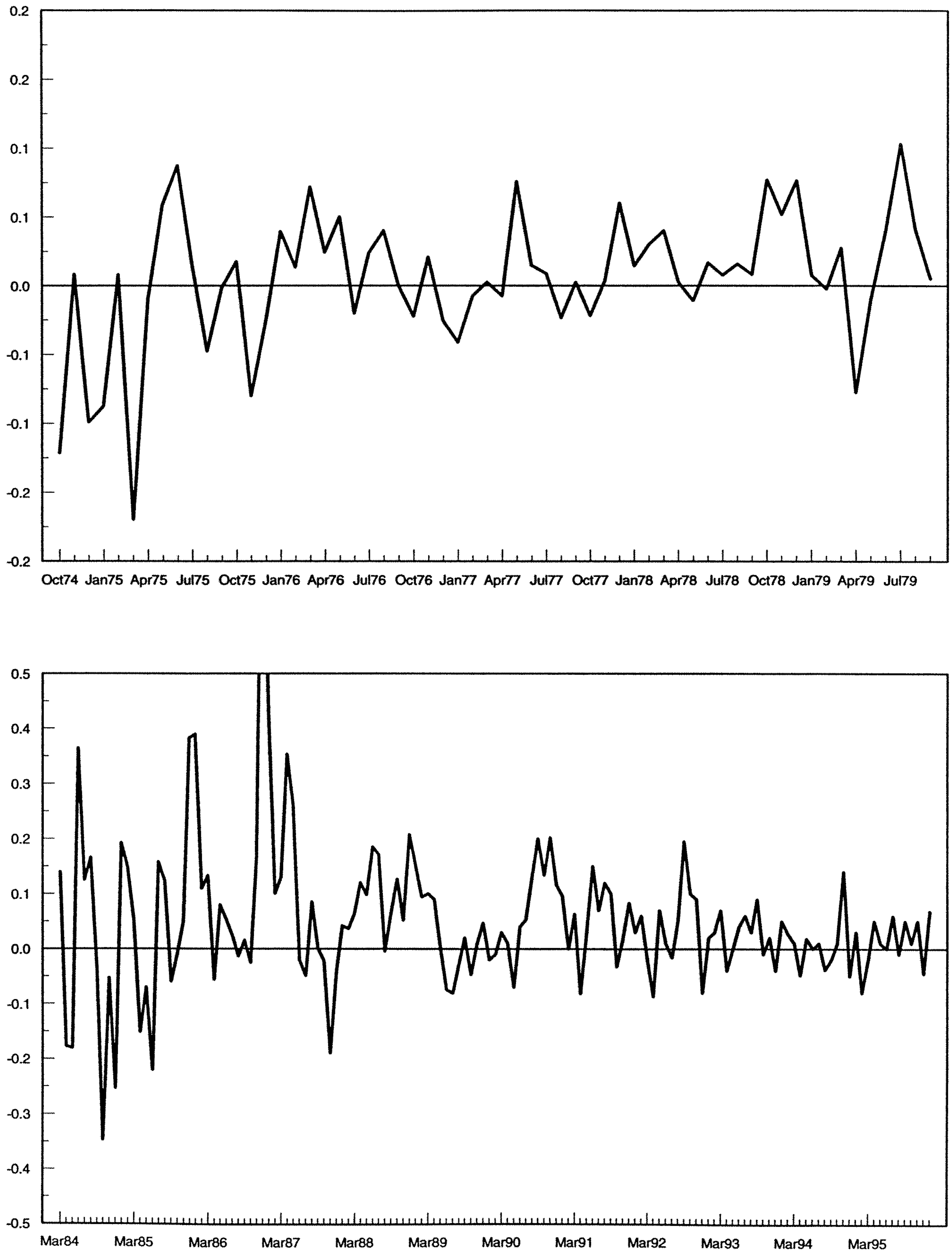


Figure 2: Spread between the FF and the Fed's Funds Rate Target



Note: The December 1986 value (0.92) is above the scale in the lower panel.

Figure 3: Impulse Response Functions (1959.01 - 1996.12)

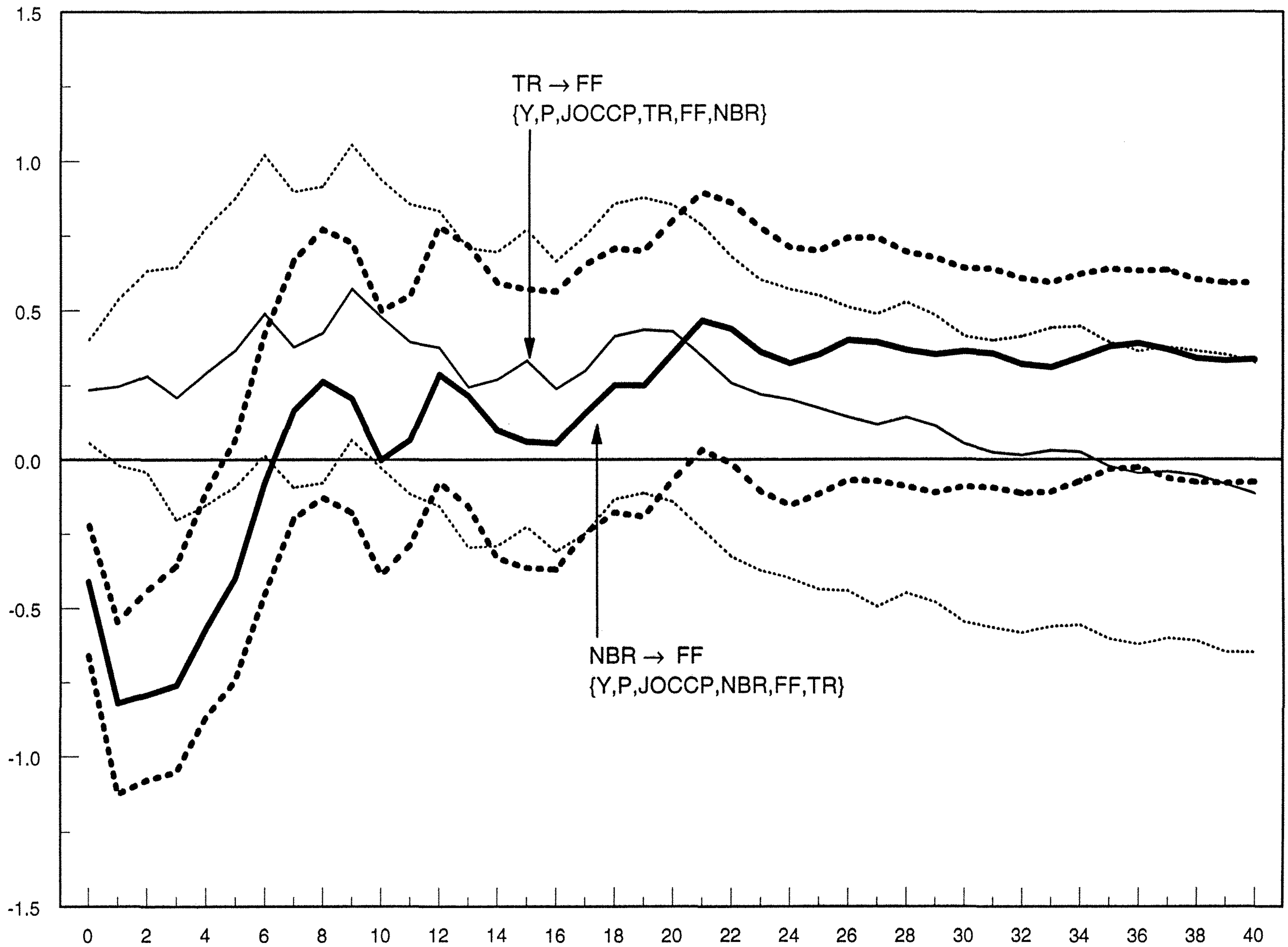


Figure 4: Estimates of the ϖ and β (1964.04 - 1996.12)

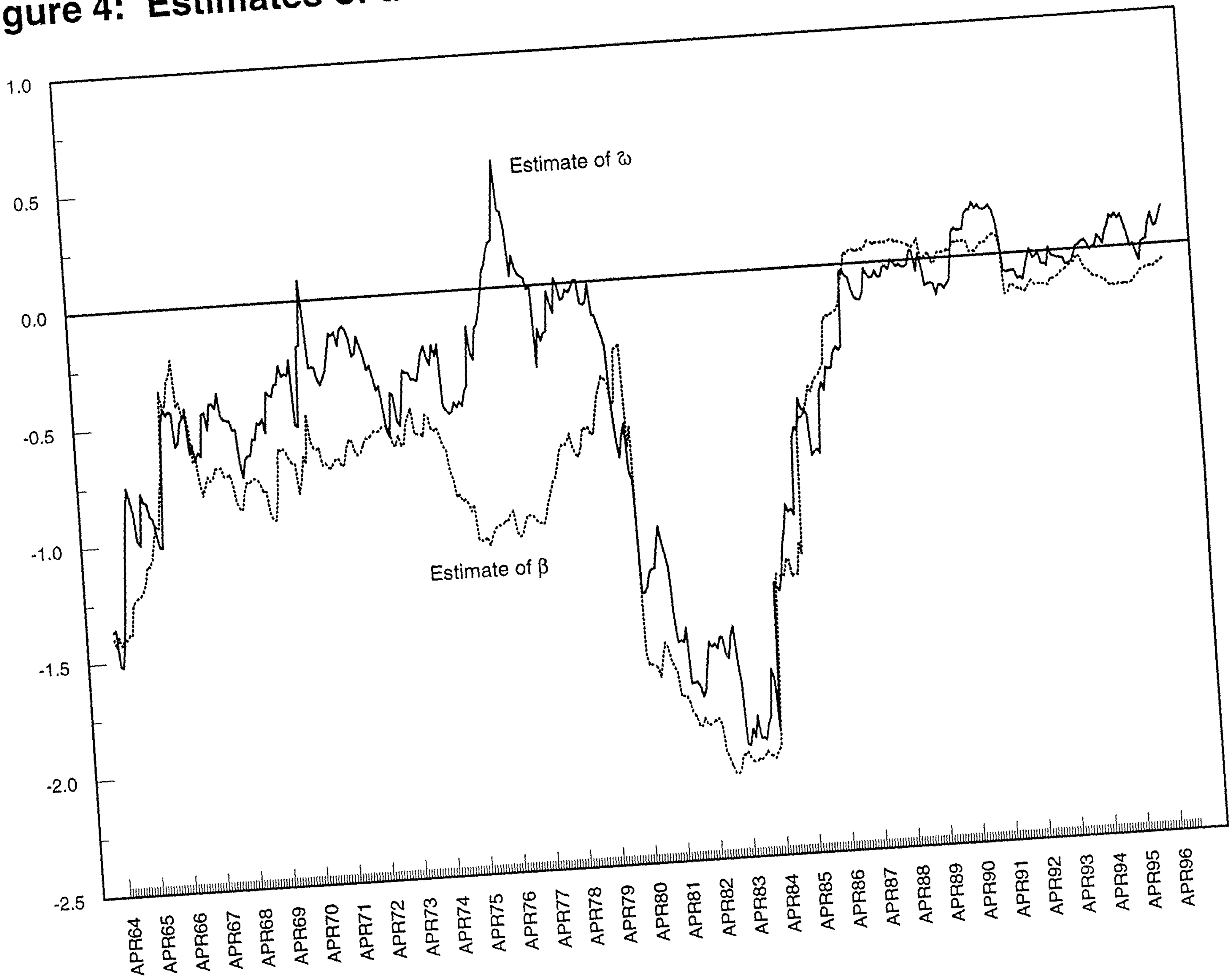


Figure 5: Estimates of $-\zeta$ and β (1964.04 - 1996.12)

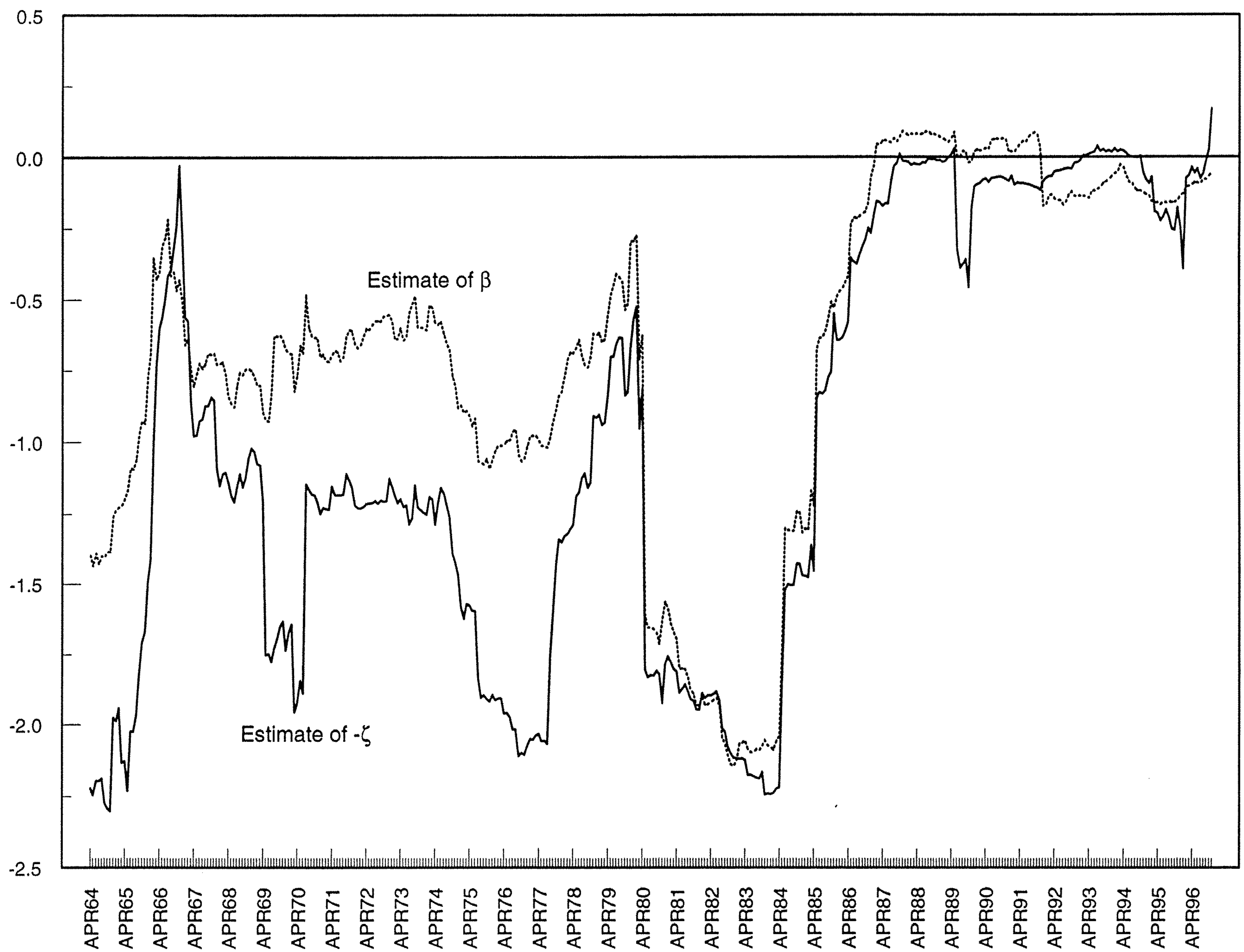


Figure 6: Seasonal and Adjustment Borrowing and the Federal Funds Rate - Discount Rate Spread

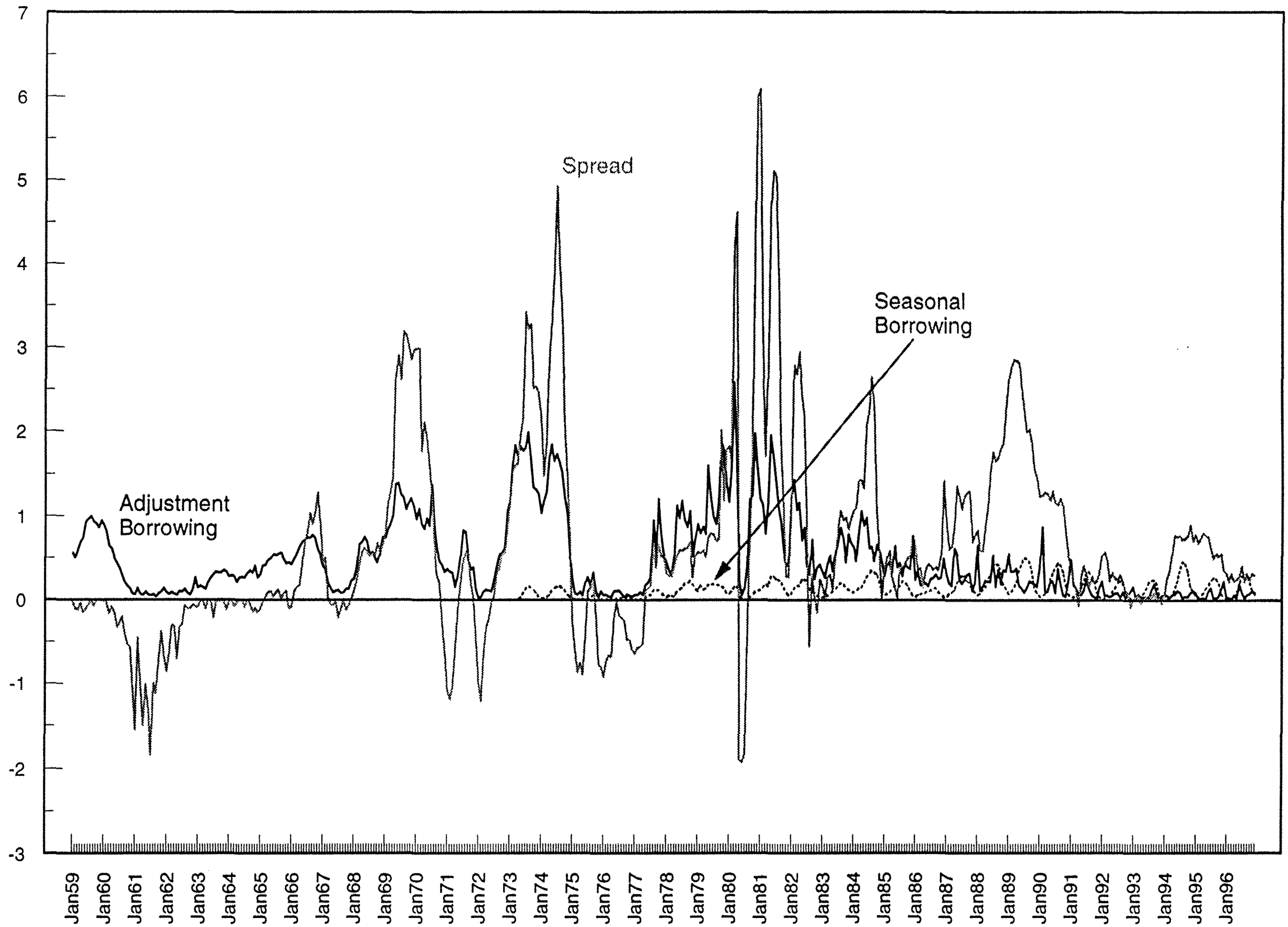


Figure 7: IRF, NBR → FF {Y,P,JOCCP,NBR,FF,TR}

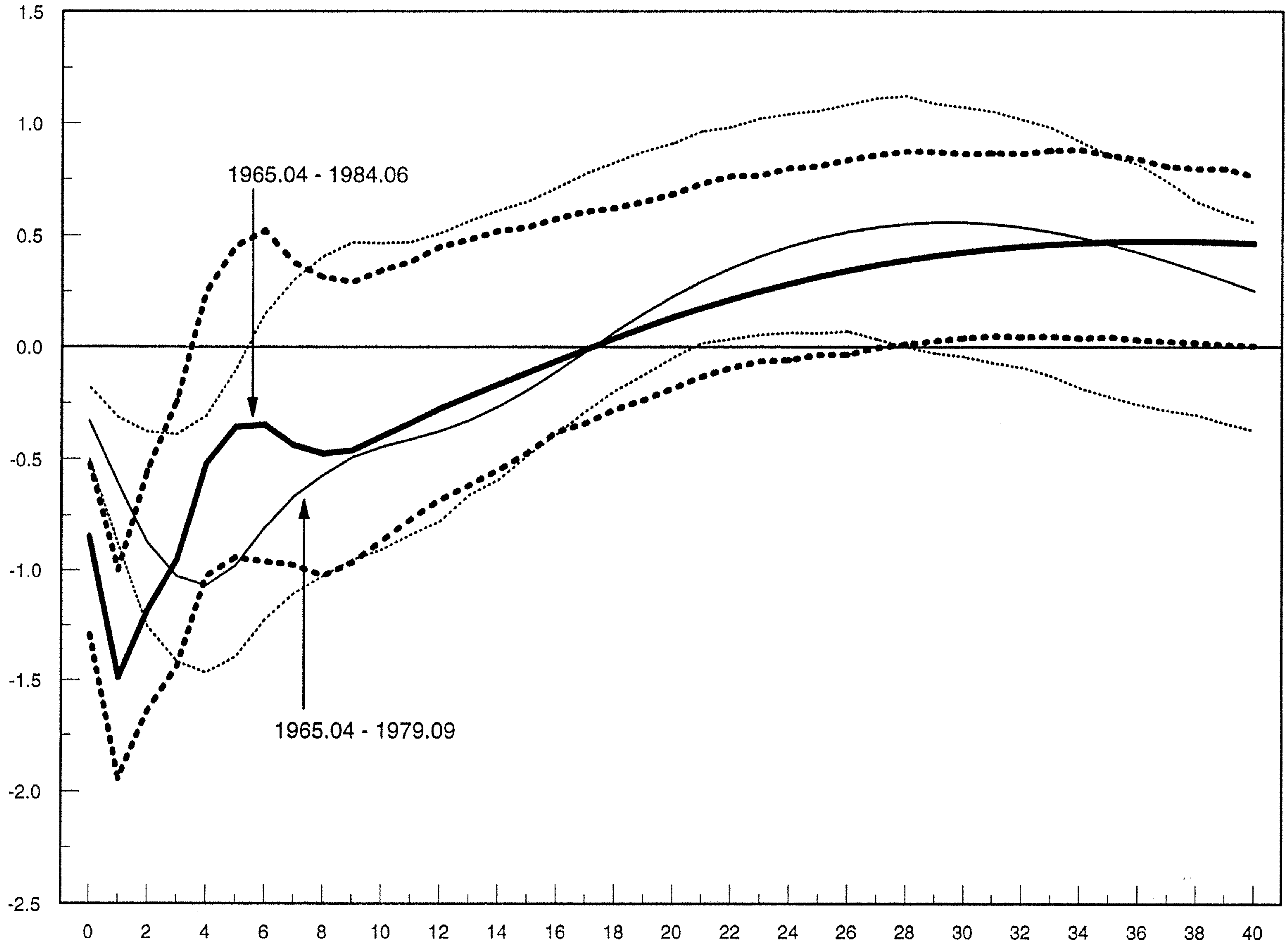


Figure 8: IRF, NBR → FF {Y,P,JOCCP,NBR,FF,TR}

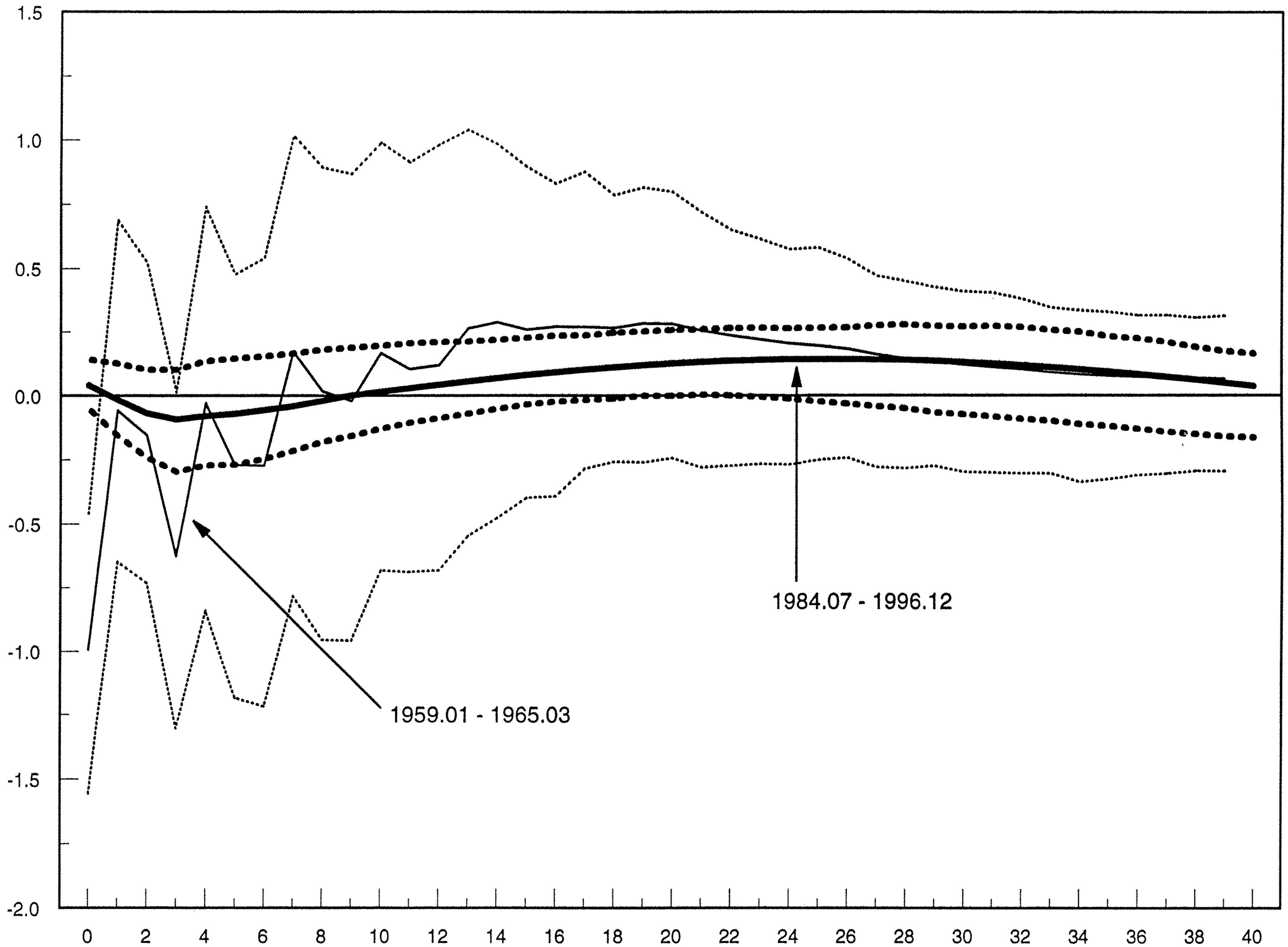
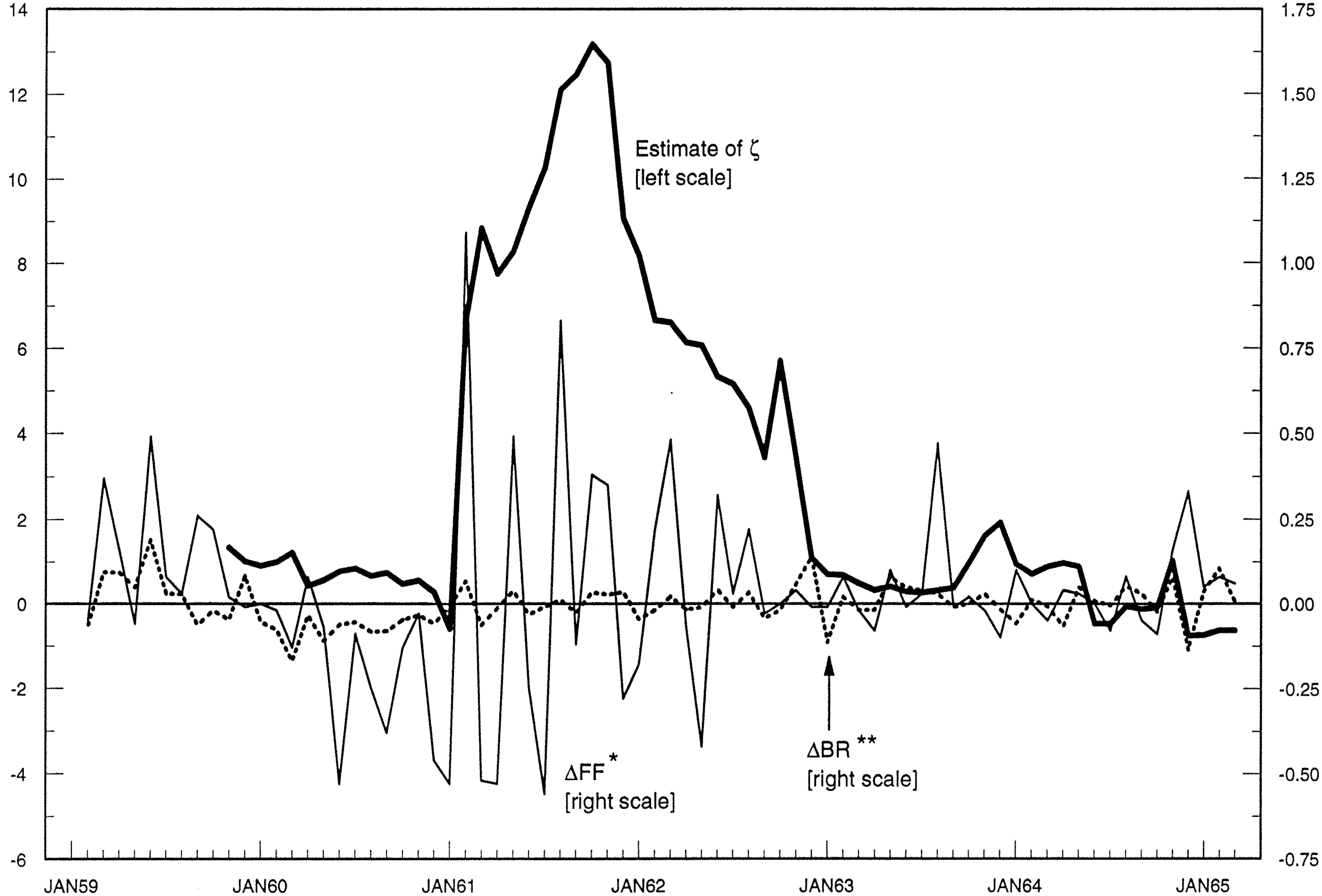


Figure 9: ΔBR, ΔFF and ζ (1959.01 - 1965.03)



* Change in the Federal Funds Rate measured in percentage points.

** Change in borrowing measured in billions of dollars.

Figure 10: BR and HBR (1965.04 - 1996.12)

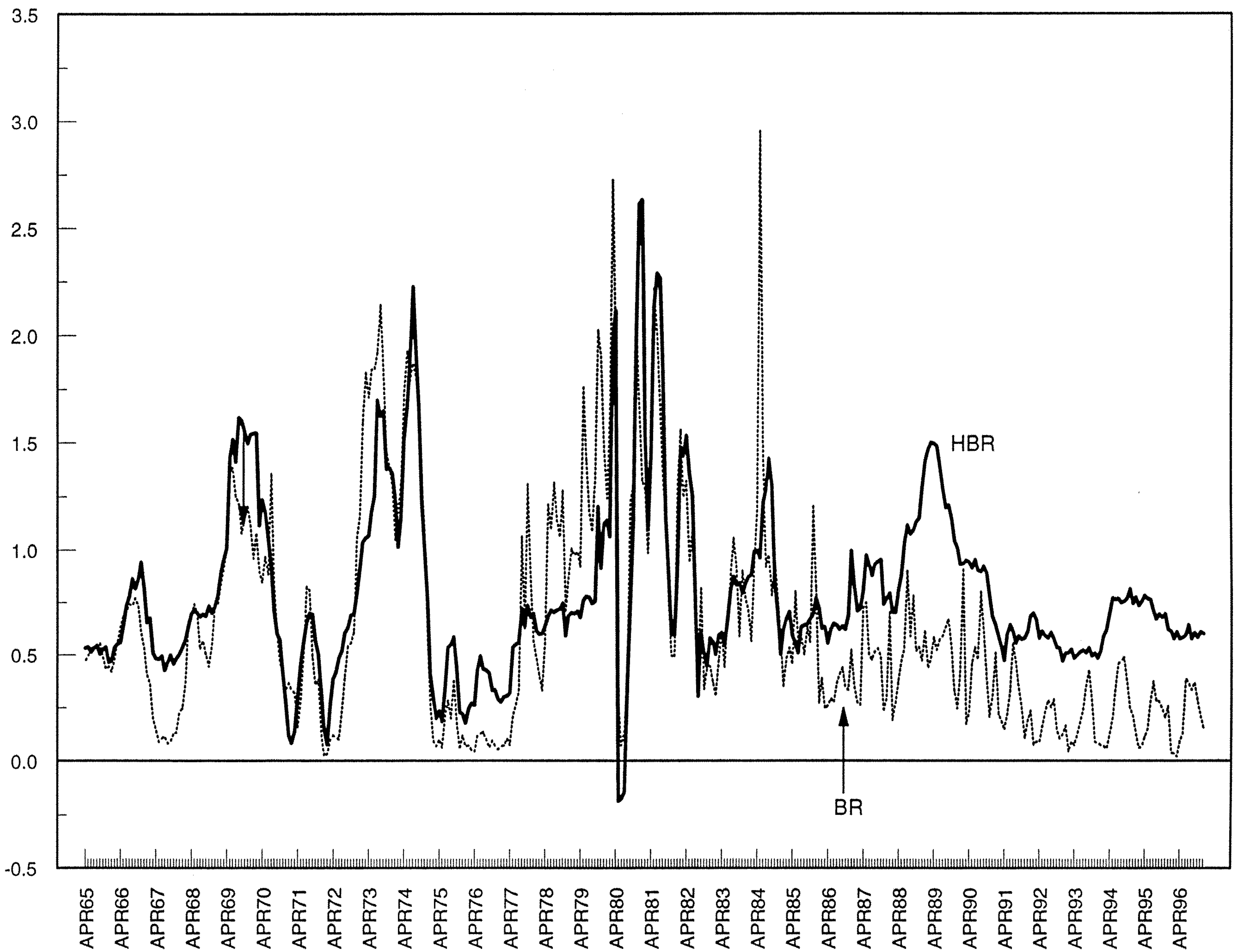


Figure 11: IRF, NBR → FF {Y,P,JOCCP,NBR,FF,TR} (1984.07 - 1996.12)

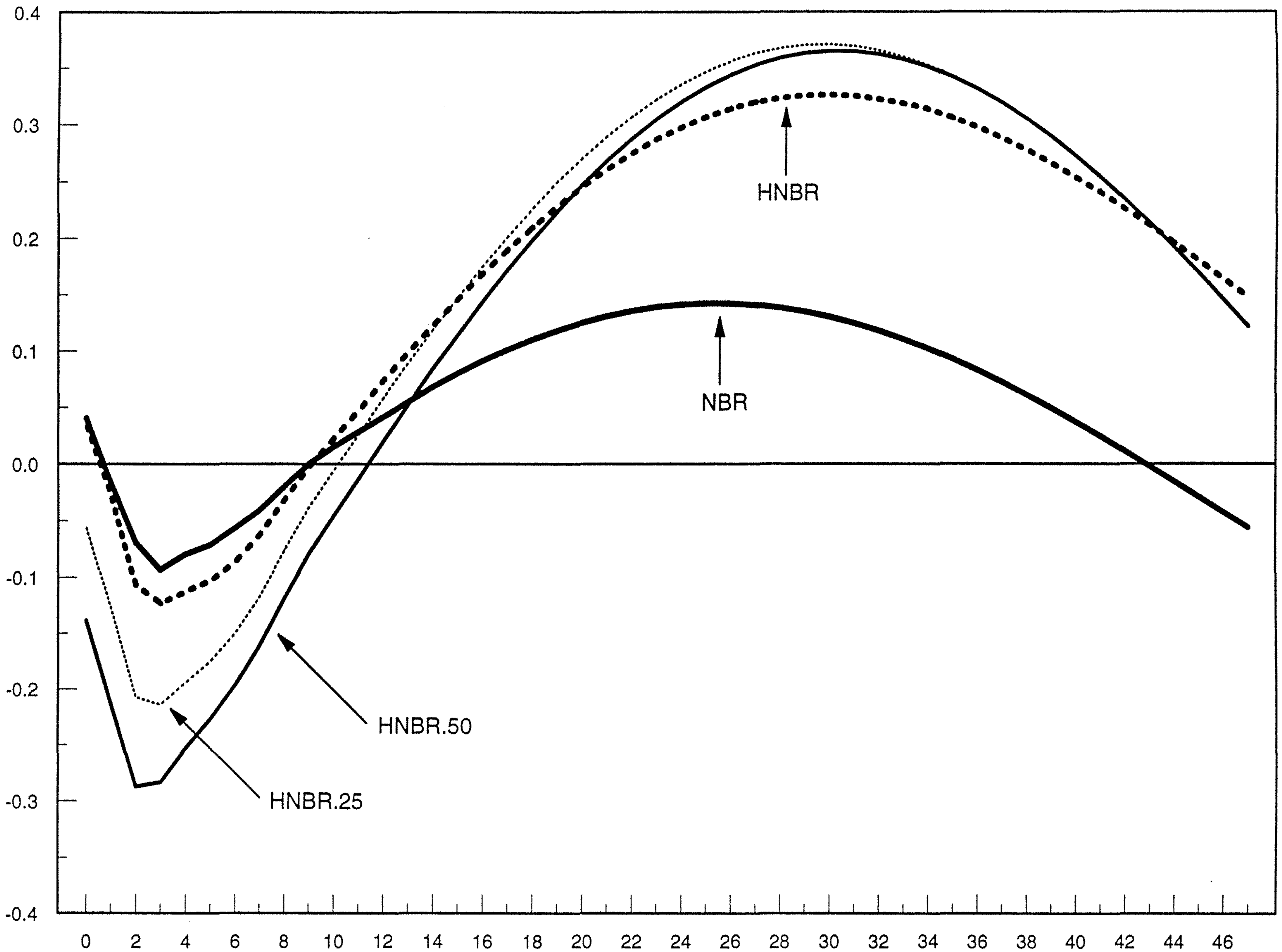


Figure 12: Borrowing and Initial Borrowing Assumption

Maintenance Period Data

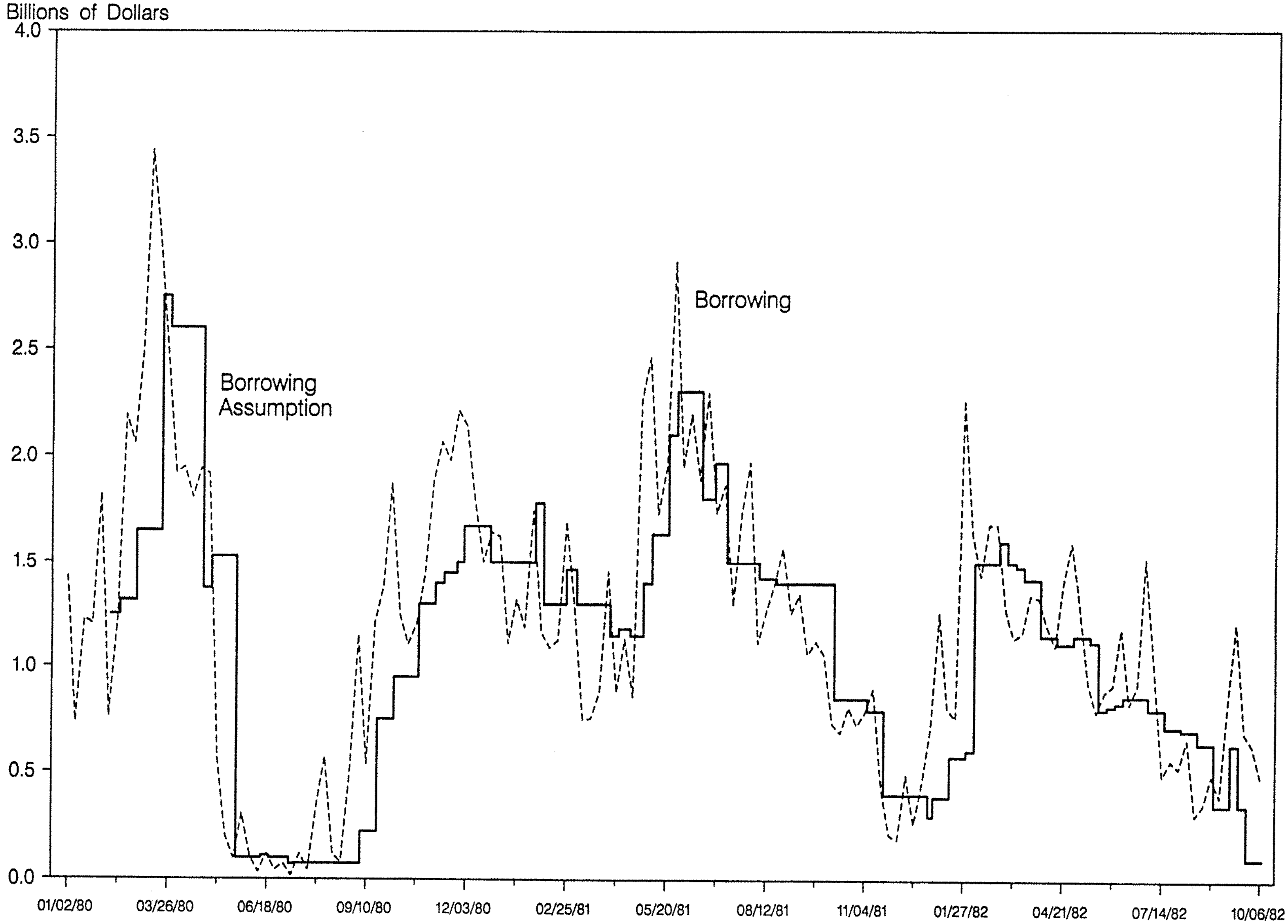


Figure 13: -ΔBR and ΔNBR (1979.10 - 1982.10)