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DOES THE FEDERAL RESERVE AFFECT ASSET PRICES?

by

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ABSTRACT

The Federal Reserve is probably one of the institutions most closely monitored by investors. This indicates that investors believe the actions of the Fed have implications for asset prices. However, studies detect no empirical relation between money growth and interest rates. To this date, the trading activities of the Fed in the financial markets have not been examined to see whether the Fed has the ability to influence asset prices. Using daily data on Open Market Operations (OMOs) and asset prices, this study fills this void. One finding of the paper is that OMOs Granger-cause both short and long term interest rates. Judging by the impulse response paths, the effects of monetary policy appear to be confined to the short run. Furthermore, the sign of the relationship confirms the existence of the much hypothesized liquidity effect. Additionally, daily OMOs appear to have some impact on exchange rates, but not on stock prices. This paper also investigates the impact of monetary policy on asset return volatility. The evidence indicates that OMOs have a dampening effect on volatility in some of the financial markets examined.

1. INTRODUCTION

This paper investigates the empirical link between Open Market Operations (OMOs) and asset prices. Additionally, the connection between OMOs and the volatility of asset returns is also examined. While the primary emphasis of the paper is the impact of OMOs on both short and long term interest rates, the influence of OMOs on the stock and the foreign exchange markets are also analyzed.

Whether or not the Fed has the ability to influence asset prices is of prime interest to macroeconomists that investigate the connection between monetary policy and the real economy. The issue is also important to investors who are concerned with the value of their portfolios.

Recent papers by Bernanke (1990), Bernanke and Blinder (1990), Kuttner and Friedman (1991), Stock and Watson (1989), and Strongin (1991), demonstrate that interest rates are very informative about future movements of real macro variables. In particular, they find that the Federal funds rate, various short term interest rate spreads, and the spread between the short and long term rates perform very well as predictors of business cycles. If indeed there is such a link between interest rates and the real sector of the economy, the implication of these findings is that monetary policy can be used to influence output, provided the Fed has the ability to influence interest rates. However, attempts to empirically document the much hypothesized negative correlation between monetary policy and interest rates (the liquidity effect) has met with failure. In a survey paper, after updating some of the empirical studies on this topic, Reichenstein (1987) reaches the conclusion that since at least April 1975, there is no empirical support for the existence of the liquidity effect. However, the failure of previous studies to document the liquidity effect may have been due to their research design. In particular, a strong case can be made that the impact of money growth on interest rates is not the appropriate nexus for the empirical examination of the liquidity effect.

This paper provides strong evidence for the contention that daily Open Market Operations influence asset prices. Furthermore, the sign of the relation is as hypothesized by the liquidity effect: Injection of reserves into the system lowers interest rates, and reserve withdrawals increase interest rates. Taken together with the evidence linking interest rates to real macro economic activity, this finding supports the view that monetary policy influences the real sector of the economy.

The finding that the actions of the Fed influence asset prices probably does not come as a surprise to most investors. In fact managers in the financial sector of the economy must be so convinced of this that all major banks, as well as brokerage houses, employ economists as "Fed watchers", to monitor the activities of the Fed. By employing these individuals their employers must be hoping to receive information about the "correct" interpretation of the Fed's transactions. This in return, presumably, leads to potentially profitable trading strategies, or avoidance of losses on portfolio values.

In addition to the impact of the Fed's actions on asset prices, this paper empirically examines the connection between daily OMOs and the volatility of asset returns. Volatility of asset returns is crucial to investors for asset pricing considerations. It is also likely that volatility has a bearing on the real sector of the economy by influencing capital budgeting and consumption decisions. There is a substantial body of papers that document the time variation of asset return distributions. While the form of volatility of asset returns is well documented by statistical conditional variance models, the sources of volatility has not been investigated as extensively.[1] Monetary policy may be an important factor in asset return volatility. However, it is not clear, on theoretical grounds, whether monetary policy would dampen or magnify the volatility of asset returns.

2. MONETARY AUTHORITY AND ASSET PRICES

There are some theoretical models in the literature that demonstrate that the monetary authority, by conducting open market operations, can influence interest rates. Grossman and Weiss (1983) and Rotemberg (1984) show that in a world where money is needed to execute transactions both in the goods and financial markets, a one time unanticipated sale of bonds by the central bank will raise interest rates. In Grossman and Weiss, the agents that trade with the central bank go to the bank to withdraw cash at fixed intervals. As a result, they hold a small portion of the money supply at any one time. Given this, the open market sale raises interest rates, not because it changes inflationary expectations or the real rate, but because the traders do not have the ability to obtain more money, i.e. they are liquidity constrained.

Lucas (1988) developed a model along the same lines. In his model, the agents that trade in goods and securities face separate liquidity constraints, but are members of the same family, bound by a household utility function. The representative household has three members, an endowment of goods, and an initial cash balance. The initial cash balances are allocated to the purchase of goods and securities at the beginning of the period. The only shock to the system in this model is in the form of an open market operation. This shock takes place after the allocation of the family's funds among the two purchasing activities has already been made. Furthermore, this shock is observed only by the agents that trade in the securities market. As a result, the shock in question affects neither the distribution of cash balances between financial market and goods market purchases, nor the prices in the goods market. The only response to open market operations shocks takes the form of changes in bond prices. Given that the cash raised from the sale of family endowments is not available in the current period, and that the goods market is unaware of the shock, bond prices need to change for the markets to clear. The marginal rate of substitution in this model is constant. Bond prices change due to the liquidity constraint, and not due to inflationary expectations implications of the unanticipated open market transaction.

The Keynesian concept of liquidity is somewhat different. In a Keynesian world, goods prices do not respond to open market transaction shocks because prices in the goods market are "sticky". However, unlike the case in the models discussed above, the real rate changes as a result of the unanticipated open market operation. The Keynesian model typically is not cast in the context of the individual consumer. However, presumably individuals hold money for purposes of executing goods and securities transactions. Faced with an unanticipated open market sale, in order for the individual to be convinced to hold more securities (thus, consume less today), he has to be offered a higher real rate. This means that, in a Keynesian world, the nominal rate changes are triggered by changes in the real rate when the monetary authority engages in a bond sale.

Differences in what is meant by the liquidity effect not withstanding, both the Keynesian model and the models discussed above agree on the sign of the interest rate response to open market transactions: security purchases by the monetary authority lower interest rates, while security sales cause the rates to be higher. However, empirical studies fail to confirm the existence a negative correlation between money growth and interest rates.[2]

In a recent study, using data from the Fed funds rate targeting operating procedure period, Cook and Hahn (1989) show that changes in the Fed funds rate target caused changes in other interest rates. They find that during September 1974 through September 1979, changes in the Fed funds rate caused large movements in the short term rates and small but significant movements in the longer term rates. While this is not direct evidence of the existence of the liquidity effect in the sense of a negative correlation between money and interest rates, it indicates that the Fed has the ability to influence interest rates. Additionally, the findings of the money supply announcements literature also implies that the Fed has the ability to influence asset prices. These studies document the reaction of interest rates to money announcement surprises. While the interest rate response is consistent both with the expected liquidity effect and possible changes in inflationary expectations, recent evidence (Strongin and Tarhan (1990), Hardouvelis (1987)) support the contention that interest rates respond due to expected liquidity considerations.[3] If indeed the response of interest rates is triggered by anticipations of the Fed's reaction to the money figures (expected liquidity effect), the failure to document the actual liquidity effect may just be indicative of a problem in empirical test design.

The relationship between OMOs and interest rates may prove to be a better forum in which to investigate the existence of the liquidity effect than examining the link between money and interest rates. One difference between this study and the previous studies is that, in this paper, the relationship examined is the one between open market operations and asset prices, and not the one between money and asset prices. Since the question investigated in this study is the ability of the Fed to affect interest rates, the causal link between asset prices and a variable over which the Fed has direct control is the appropriate avenue of inquiry.

The Fed has the ability to control the level of reserves in the system by its conduct of open market operations (OMOs). Changes in the level of reserves triggered by OMOs translate into changes in money, via the multiplier process, as investors and financial institutions respond to the Fed's actions. Thus, OMOs capture the intentions of the Fed more accurately than the growth rate of money, which is jointly determined by the Fed, the public, and the financial institutions. Additionally, OMOs have the advantage of being events that are readily observed by market participants as soon as they are executed.[4] In contrast, it is not clear exactly when investors observe the growth in money. In fact, empirical studies show that interest rates respond to money announcements even though the money growth that is being announced had already been determined ten days prior to the announcement.[5] This may indicate that investors do not observe money growth when it takes place. OMOs are free of this problem.

The sample period in this study (October 2, 1979 - December 31, 1984) covers the October 1979 - October 1982 period. On October 6, 1979, the Federal Reserve announced changes in its operating procedures. Prior to this date, the short term focus of monetary policy centered on maintaining the Fed funds rate within a narrow target range. The new procedures changed the focus of operating policy from targeting Fed funds, to a policy that attempts to accomplish monetary policy objectives by targeting reserves. Specifically, the desk was directed to set and maintain a target path for nonborrowed reserves consistent with long term money growth targets.[6] In the late Fall of 1982, the Federal Reserve again changed its operating procedures. The post-1982 regime can best be characterized by a set of procedures that targets borrowed reserves.[7]

Using data from the post October 1979 period is ideal for the empirical question examined in this paper. If the period studied was characterized by a regime that targets interest rates, the power of empirical tests conducted would be potentially low. To see this, assume that in fact the Fed can affect interest rates by its actions. As the Fed funds rate starts to diverge from its target range, the Fed will supply reserves to or drain reserves from the system in order to prevent rates from changing. If the Fed indeed has the ability to control interest rates, the data will show substantially more variation in OMOs than in interest rates. In fact, in the extreme, if the Fed had a point target rather than a range, and is successful in achieving its target, there will be no variation in interest rates. In such a scenario, the empirical tests will detect no causality between OMOs and interest rates, when in reality the Fed will have perfect control over interest rates.

3. OPEN MARKET OPERATIONS

The operating policy objective of the trading desk is to implement the monetary policy objectives set by the Federal Open Market

Committee (FOMC). The FOMC meets six to eight times a year, and decides on a course for monetary policy. During the 1979-1982 period, the targets for the conduct of monetary policy were expressed in terms of the desired growth for monetary aggregates. The Desk, then, had the responsibility of converting these money growth targets into the implied target path of nonborrowed reserves for the intermeeting period. The next step was for the Desk to conduct OMOs, so as to make the realized level of nonborrowed reserves for the intermeeting period equal the weekly average of the specified target path. An algorithm describing the implementation of the monetary policy during this time period is developed in Spindt and Tarhan (1987).

The first step in converting the FOMC's monetary policy objectives involves the computation of the weekly target for money. The next step is to determine the path of required reserves implied by the projected path for money. Under the lagged reserve accounting regime that was in effect during the sample period, banks' required reserves for a given week were determined on the basis of deposits they held two weeks previously. Given this, the path for required reserves consistent with the intermeeting period targets is obtained by multiplying the average reserve requirement ratio with projected money figure from two weeks earlier. Next, the projections for excess reserves are added to the required reserves path to obtain the desired path for total reserves.
The target path for nonborrowed reserves implied by the FOMC directives, is then calculated by subtracting the level of

discount window borrowing assumed by FOMC ("Initial Borrowing Assumption"), from the total reserves path. The objective of the Desk is to conduct OMOs, such that the realized level of nonborrowed reserves during the intermeeting period equal the average weekly nonborrowed reserves target. The last step in determining the magnitude of the OMOs for a given week involves estimating the exogenous factors that will influence the level of reserves in the system. These projections, then, are netted out from the target nonborrowed reserves path to arrive at the size of OMOs to be conducted during that week.

Among the exogenous factors ("technical operating factors") that the Desk needs to forecast, three are especially important.[8] These factors have considerable size. In terms of forecasting difficulty, the most crucial of these factors is the Federal Reserve float. Float arises due to the fact that the Federal Reserve credits banks for the checks presented, on a shorter time schedule than the time it takes to collect on these checks. Because of unforeseen problems in communication and transportation, the level of float can show substantial variability. During the sample period float projection errors in the magnitude of 500 million to 1 billion dollars per day were not uncommon. In comparison, the average amount of reserves injection needed to sustain a 6 percent annual growth in M1 during 1981 was in the order of 50 million dollars per week.[9]

The second source of uncertainty about the actual level of reserves in the system involves the deposits of the U.S.

Treasury. The Treasury maintains accounts with various commercial banks (Tax and Loan accounts). It periodically transfers funds from these accounts to its checking accounts at the Federal Reserve banks. When this happens, the amount of reserves in the system declines. When the Treasury writes checks against its accounts at the Federal Reserve, on the other hand, reserves are injected into the system once the Fed credits the reserve balances of commercial banks. At times, there can be significant errors in projecting the reserve implications of these transactions.[10]

The portfolio decisions of foreign central banks constitute the third significant exogenous reserve factor. When the Fed accommodates these institutions by becoming a counter party to their trades, it in effect injects or drains reserves. Thus, the desk needs to adjust its OMOs for the expected level of foreign central bank trades with the Fed.

Once the size of the OMO is determined, the Desk must determine how to execute the required trades. On this issue, the Desk has considerable flexibility. The alternatives available to the Desk have three broad characteristics. One decision involves the choice between OMOs that will affect the level of reserves permanently (outright transactions), versus those transactions whose initial reserve implications will be reversed in the near future (repurchase agreements and matched sale-purchases). The second decision that needs to be made is whether to execute trades in the secondary market, with dealers, or with foreign central banks. The third issue involves the type of securities to be used in conducting the OMOs. Here, one choice would be between short-term Treasury securities (Treasury bills), and longer term Treasuries (coupon securities). Another choice would be between Treasuries and Federal Agency securities. The primary concern of the Desk, in comparing the various alternatives, is to select a course of action such that the Fed will not have undue influence in the determination of security prices. As a result, the Fed monitors the security portfolios of dealers, and attempts to conduct OMOs only with those securities that dealers have in sufficient quantities. Thus, even when the Fed wants to influence security prices, it does not want the security prices to change because of market micro structure considerations. In practice, this means that, for the most part, Treasury bills end up as the preferred instrument of OMOs.

An OMO could be in the form of an outright transaction. In the case of an outright purchase (sale), the reserves in the system increase (decrease) permanently. Repurchase agreements (RPs) and matched sale-purchases (MSPs), on the other hand, change the level of reserves for a limited time period. In an RP transaction, the level of reserves increases in the current period, but this increase is drained from the system when the RP matures. A MSP transaction, in essence, is a reverse RP, and thus, the initial decline in the level of reserves is offset at its term.

The sample period for this study is October 2, 1979 to December 31, 1984. Open market operations are measured as the changes in the Fed's portfolio. The daily data on the Fed's portfolio was obtained from the Federal Reserve Board.

4. EMPIRICAL RESULTS: OPEN MARKET OPERATIONS AND ASSET PRICES

The impact of the Fed's actions on asset prices is first examined by conducting bivariate Grange causality tests between interest rates and OMOs. These tests are later repeated for stock returns and returns on foreign exchange market variables.

i. Open Market Operations and Interest Rates

The hypothesis that open market operations (ΔFP_t) do not Granger cause interest rates (r_t) is examined by testing the joint hypothesis that β_i=0 in the following regression.

$$\Delta r_t = \alpha_0 + \sum_{i=1}^{6} \alpha_i \Delta r_{t-i} + \sum_{i=1}^{6} \beta_i \Delta FP_{t-i} + e_t \qquad (1)$$

The interest rates used cover the maturity spectrum from 1 day (the Fed funds rate) to 30 years (the 30 year Treasury bond rate). In addition to these two rates other interest rates examined are the Treasury bills of 3, 6 and 12 month maturities and Treasury bond rates of 1, 2, 3, 5, 10 and 20 year maturities.

The Granger causality test results obtained from estimating (1) for changes in interest rates and the change in the Fed's portfolio (ΔFP_t) are presented in Table I.[11] The results indicate that the null hypothesis that OMOs do not Granger-cause interest rates is rejected . These results show that OMOs affect both short and long term interest rates.

While these results strongly indicate that the actions of the Fed influence interest rates, what needs to be determined is whether or not the sign of the relationship is as predicted by the liquidity effect. To see whether increases in the size of the Fed's portfolio (transactions that inject reserves into the system) result in lower interest rates, impulse response paths to a standard deviation shock in orthogonalized OMO innovations are examined. Cumulative response of interest changes as of 1, 6, and 12 days after the OMO shock are reported in Table II.

These results appear reasonable on various grounds: First, as predicted by the liquidity effect, the sign in all cases is negative, indicating that rates fall in response to reserve injections. Second, as expected, short term rates are affected more than long term rates, and the impact of OMOs decline with maturity. A one standard deviation shock in orthogonalized OMO innovations generate a 7.5 basis point reduction in the Fed funds rate in the first period. The bill rates decline by around 1.2 basis points, and the 30 year rate declines by 0.8 basis points.[12] Cook and Hahn (1989) find that Fed funds rate changes have a constant effect across the 3 months to 12 months horizon. This is confirmed by the results displayed in Table II. However, there are two differences: First, in their case the magnitude of the T-bill response is roughly one half of the change in the Funds rate while here it is around 16 percent. Second, while the initial response is constant across the Treasury bill maturity spectrum, the cumulative response after 6 and 12 days varies with the maturity of Treasury bills. After 6 days the cumulative Fed funds rate response is 13 basis points, and the bill rate responses are in the range of 20 to 30 percent of this magnitude. Cumulative responses after 12 days are similar in relative magnitude to the response after 6 days. One notable exception is that at the longest end of the maturity spectrum (20 and 30 year rates), the cumulative response is close in magnitude to the initial response.

The statistical significance of the impulse responses can be seen in Figures 1 to 4, which display the impulse response paths of selective interest rates (in basis points) to a one standard deviation shock in OMOs over a 20 day horizon (the response paths are bounded by 95% confidence intervals). The interest rates in question are the Fed funds rate, the 3 months bill rate, and the Treasury bond rates of 2, and 20 year maturities. These graphs show that the impact of monetary policy on interest rates is felt very quickly. The adjustment of interest rates to monetary shocks is close to completion within 10 days. Combined with the results of Table II, these figures indicate that the adjustment of interest rates to monetary policy is fast, and also that monetary policy have a lasting impact on interest rates (interest rates stabilize at lower levels following a reserves injection).

Table II also displays the response of OMOs to own shocks. The initial period shock is around 1.9 billion dollars. The initial positive response of OMOs is reversed later on. As a result, the cumulative response after 12 days is in the range of 850 to 870 million dollars.

In order to test whether interest rates Granger cause OMOs, the following equation is estimated:

$$\Delta FP_t = \gamma_0 + \sum_{i=1}^{6} \gamma_i \, \Delta FP_{t-i} + \sum_{i=1}^{6} \delta_i \, \Delta r_{t-i} + u_t \qquad (2)$$

The results obtained from estimating (2) are also displayed in Table I. The null hypothesis of no causality (joint hypothesis that $\delta_i = 0$) cannot be rejected for any of the interest rates. At first glance, this is surprising. After all, the sample period includes the October 1979 to October 1982 period. Spindt and Tarhan (1987) report empirical results that supports the Fed's contention that during this time period the target of monetary policy was nonborrowed reserves and not interest rates. However, the presence of Granger causality running from interest rates to OMOs does not necessarily imply that the Fed was following a leaning-against-the-wind policy with respect to interest rates. In fact, upon examination of the OMO impulse response to innovations in interest rates, it becomes apparent that both the sign and size of the responses are incompatible with an interest rate targeting procedure.

The response of OMOs to innovations in interest rates is displayed in Table III. Comparing the impulse responses to OMO innovations (Table II) with impulse responses to interest rate innovations, two things stand out. First, looking at the initial period responses, the size of the reserve injection triggered by a one standard deviation shock in interest rates is very small in relation to the size of the shock: For example, a 63 basis increase in the Fed funds rate results in a reserve increase in the amount of only 304 million dollars. Whereas, as discussed before, reserve increases in the magnitude of 1.9 billion dollars is required to move the Fed funds rate by 7.5 basis points in the initial period. Perhaps more importantly, while an interest rate increases initially leads to a reserve injection, reserves are withdrawn from the system in the subsequent periods. For example, in the case of a Fed funds rate shock, even though reserves increase initially by 304 million dollars, the cumulative response after 12 days is a reserve decrease of 25.6 million dollars. This pattern holds true for interest rate shocks of all maturities. In all cases small initial increases in reserves in the initial period are reversed in the subsequent periods such that the net response to interest rate increases is a small withdrawal of reserves from the system. The important point here is not that reserves actually decline, but that they do not change by a meaningful amount in response to interest rate increases. Thus, while there is evidence of Granger causality running from interest rates to open market operations, the size and the sign of the cumulative OMO response is not indicative of a central bank policy that targets interest rates.

Figures 5 and 6 show the estimated response of OMOs (in dollars) to a standard deviation shock in two representative interest rates (the Fed funds rate and the 5 year Treasury rate respectively).

The cumulative response of interest rates to own shocks indicate that the initial movement in interest rates persist. By the end of 12 days, initial interest rate shocks in the magnitude of 63 to 12 basis points produce a net <u>increase</u> of 40 to 14 basis in interest rates, but a small <u>decline</u> in the volume of reserves in the system (26 to 135 million dollars).

Figures 7 and 8 enable us to compare the response of interest rates and OMOs to own shocks versus shocks in the "other" variable. Figure 7 graphs how the Fed fund rate reacts to own shocks compared with OMO shocks. Since the unit of measurement for OMOs and interest rates differ, the response paths are scaled by dividing the response of each variable by the square root of its residual variance. Thus, the responses are measured in terms of fractions of standard deviations. Figure 8 displays the reaction of OMOs to own shocks compared with the reaction to a shock in a selective interest rate (6 months T-bill rate). What emerges from figures 7 and 8 is that for both OMOs and interest rates, the reaction to own shocks is more pronounced than their response to innovations in the "other" variable.[13]

ii. <u>Open Market Operations and Other Financial Asset Returns</u>

Open Market Operations could influence the prices of other financial assets by influencing interest rates. The change in interest rates, in return, may change asset prices if it means that the discount rate used in valuing asset cash flow streams change with interest rates. Alternatively, the actions of the Fed may change asset prices by influencing the market risk premia. This also will lead investors to revise their required rates of return. A third possibility is that OMOs may have an impact on asset returns by influencing the real sector of the economy. In addition to interest rates, this paper investigates the influence of OMOs on stock returns, Eurocurrency deposit rates (Eurodollar, Euroyen, and Eurodeutchmark deposits of one month maturity), and spot exchange rates (the U.S. dollar-DM rate and the U.S. dollar-Japanese Yen rate).

Table IV summarizes results obtained from the battery of Granger causality tests conducted. The link between stock returns and OMOs are examined in a bivariate model. Two alternative daily stock return measures are employed: Value weighted CRSP market portfolio (VWRET), and equally weighted CRSP market return portfolio (EWRET). Monetary policy may affect stock prices via the three channels discussed. For example, OMOs indicating a policy of monetary ease may boost stock prices by lowering interest rates and leading investors to revise downwards the discount rates they use in valuing expected equity cash flows. The policy of monetary ease may also reduce investor uncertainty and lower the risk premia, once again increasing stock prices as a result of lower required rates of returns on equity. To the extent lower interest rates are associated with higher expected output in the real sector, stock prices may go up as a result of an increase in expected corporate profits. Monetary policy could have a significant impact on share prices since it can lower equity capitalization rates and increase in expected equity cash flows simultaneously. Investors mention all of these channels in arguing the importance of the actions of the Fed for stock market returns. However, in spite of these arguments, as an empirical matter, at least for the sample period used in this study, there is no evidence that the Fed influences share prices. Table IV also displays the significant results obtained from two vector autoregressions of OMOs and foreign exchange market variables. There are four variables in each VAR. The variables in the first model are OMOs, one month maturity Eurodollar and Euro DM deposit rates (differences), and the spot Dollar-DM exchange rate (DMs per dollar in log differences). The second VAR includes the same variables, but the Japanese yen. is substituted in place of the DM.

One result is that there is evidence for bidirectional causality between OMOs and one month Eurodollar deposit rates. Given, the relationship between OMOs and domestic interest rates, this result is not surprising.

Another significant result is that the two spot exchange rates and OMOs are related. The relationship is bidirectional for the Japanese yen (JY), but in the case of the DM, it Granger causes OMOs but is not caused by OMOs. The fact that both the DM and the JY exchange rates Granger cause OMOs may indicate that stabilization of the value of the dollar is one of the goals of monetary policy. However, it is also possible that the stabilization attempts are confined to the foreign exchange intervention activities of the Fed, and it may be that OMOs appear to be related to the exchange rates due to the sterilization phase of the intervention operations. In fact impulse responses (not reported here) indicate that a shock in the form of an increase in the value of the dollar vis-a-vis both the DM and the JY trigger an Open Market Sale. This will be consistent with an intervention policy of purchasing dollars when the value of the dollar increases, and offsetting the increase in the money supply caused by the intervention by means of open market sales.[14]

Table IV also indicates the presence of Granger causality between exchange rates and Euro deposit rates. This result is consistent with the Interest Rate Parity relationship.

5. EMPIRICAL RESULTS: OMOs AND THE VOLATILITY OF ASSET PRICES

Time conditional volatility of asset returns is a well established empirical phenomena. For example, Baillie and Bollerslev (1989),and Connolly and Taylor (1990) examine the volatility of exchange rates. Volatility in stock returns is analyzed in Baillie and DeGennaro (1990), French Schwert and Stambaugh (1987), Schwert (1989) and Poterba and Summers (1987). Econometric models that document time conditional volatility of financial assets (ARCH, GARCH), do not typically investigate what economic variables could account for observed volatility. Monetary policy may be an important factor in asset return volatility.

First, stabilization of interest rates may be one of the targets of monetary policy. If so, the Fed may respond to volatility in the financial markets. Second, OMOs may affect interest rate volatility. On theoretical grounds, it is not clear whether the activities of the Fed would increase or dampen the volatility in financial markets. There is evidence in the stock market that information flows (for example, in the form of earnings announcements) tend to increase volatility of asset returns. It is conceivable that the actions of the Fed may produce similar results as investors try to extract the policy content of OMOs. On the other hand, if stabilization is a goal of monetary policy, the Fed's actions may signal to the market that it intends to reduce volatility. This, in return may reduce volatility if the Fed has credibility. The general point is that the connection between monetary policy and volatility of asset prices needs to be examined empirically.

The effect of OMOs on the conditional mean and variance of financial assets is examined by:

$$\Delta r_t = b_0 + b_1 OMO_{t-1} + \epsilon_t \qquad (3)$$

$$\sigma_\epsilon^2 = a_o + a_1 \epsilon_{t-1}^2 + a_2(abs(OMO_{t-1})) \qquad (4)$$

Where DT is Open Market Operations. The conditional mean (3) and the conditional variance (4) equations are jointly estimated using the Berndt, Hall, Hall and Hausman maximum likelihood procedure.

The sign of the estimate for the a_2 coefficient would indicate whether OMOs magnify or dampen volatility. When the absolute value of OMOs variable is deleted from (4), the model collapses to a simple ARCH specification. When the simple ARCH model was estimated for the assets under consideration the estimates for a_1 proved to be very highly significant, indicating the presence of ARCH effects. If the results obtained from (3) and (4) show that a_1 becomes insignificant, this would indicate that ARCH effects on asset returns can be explained by OMOs. It is also possible that ARCH effects are not related to policy.

Table V and VI display the results obtained from estimation of the conditional mean and variance equations for assets under consideration. The estimate for b_1 is negative and significant for all the interest rates considered, confirming again, the presence of the liquidity effect since it indicates that increases in the Fed's portfolio (reserve injections) lower interest rates.

Estimates of a_1 continue to be highly significant for all assets considered, indicating that ARCH effects cannot completely be explained by OMOs. The estimate for a_2 is negative and highly significant in the Fed funds equation. Apparently, the Fed has the ability to reduce volatility in this market. The estimate for this coefficient is also significant in the 1 month Eurodollar, and the 30 year Treasury rates. The same coefficient is marginally significant in the 6 month T-bill rate, and the 5 year and 20 year Treasury rates. In all these cases the sign continues to be negative, indicating the actions of the Fed have a stabilizing effect in these markets.

An interesting result that emerges from Table VI is that while OMOs do not appear to have any impact on the level of stock prices, they significantly reduce the volatility of stock returns since a_2 is negative and significant for both stock return measures. In sum, it appears that when OMOs turn out to be a significant explanatory variable in the conditional volatility of asset returns, in all but one case (spot yen/dollar exchange rate), the effect is in the direction of reduced volatility.

7. CONCLUSIONS

Even though the Federal Reserve is one of the most closely monitored institutions by investors, the impact of OMOs on asset prices has not been investigated empirically. Using data from a period during which the Fed did not peg interest rates, this study examines this issue in the context of Granger-causality tests. The major findings of the study are the following: 1) OMOs Granger-cause interest rates across the maturity spectrum. 2) The sign of the relationship confirms the existence of the much hypothesized liquidity effect. 3) As expected, the magnitude of the response of the interest rates decay with the term to maturity. 4) Interest rate response to monetary policy appears to be very fast. 5) While there is Granger causality running from interest rates to OMOs, this does not appear to be indicative of interest rate targeting. 6) Monetary policy appears to effect some asset returns in the foreign exchange market but not the stock market. 7) When monetary policy influences the conditional volatility of asset returns, it is in the direction of reducing volatility, indicating that the actions of the Fed have a stabilizing influence. 8) Finally, combined with the evidence that show that there is a link between interest rates and the real sector of the economy, this paper's finding that the OMOs affect interest rates indicate that monetary policy influences the real sector.

ENDNOTES

1. One paper that examines the influence of policy on volatility is Connolly and Taylor (1990). They investigate the connection between spot Japanese Yen exchange rate volatility and central bank intervention. Another paper, Lastrapes (1989), looks at the volatility of exchange rates under different monetary regimes. Other papers examined the connection between trading volume and volatility.

2. The earlier tests on this topic were conducted by Gibson (1970), Cagan (1972) and Cagan and Gandolfi (1969). These studies provide results supporting the liquidity effect. However, later tests on this topic reached a different conclusion. For example, Mishkin (1981) and (1982) finds no empirical support for the liquidity effect that has the correct sign in the case of both the short and long term rates. More recent studies also do not detect the existence of a negative correlation between money growth and interest rates. See for example, Melvin (1983), Makin (1983), and Wilcox (1983). In this survey paper, Reichenstein (1987) concludes that since at least April 1987 there is no empirical support for the much hypothesized liquidity effect.

3. Strongin and Tarhan (1990) examine the reaction of interest rates to money announcements. Their model discriminates between the two hypotheses by directly taking into account investor expectations regarding the Federal Reserve's monetary stance. Their results strongly support the expected liquidity hypothesis. Hardouvelis (1987), on the other hand, investigates the reaction of interest rates to reserves announcements. His results show that during the May 1980 - October 1982 period real interest rates reacted to unanticipated nonborrowed reserves announcements. To the extent reserves announcements provide information about future money supply changes, the interest rate reaction indicates the presence of the liquidity effect.

4. Actually they are observed even before they are executed. When the Fed is about to execute an OMO, it asks for bids and offers from the primary government securities dealers. Then it decides which of the bids and offers to accept.

5. The figures regarding the level of the monetary base are released ten days prior to the announcement. Thus, the information being revealed by the money supply announcement is information regarding the value of the multiplier. The observed reaction of interest rates to the announced money figure in reality captures the response of interest rates to the fact that the multiplier implied by the money figure was different than expected.

6. Spindt and Tarhan (1987) examine the October 1979 - October 1982 period, to determine whether or not the Fed indeed changed its operating procedures. Some critics of the Fed claim that the new policy still amounted to a procedure that pegged interest rates. If during this period the Fed was targeting nonborrowed reserves, it should be the case that innovations in money Granger cause innovations in borrowed reserves. An empirical finding that indicates a causal link between money and nonborrowed reserves, on the other hand, would be indicative of a policy that targets the Fed funds rate. Their results show the existence of causality running from money to borrowed reserves. Thus, it appears that the focus of monetary policy during this time period was what the Fed claimed it to be.

7. Tests conducted in this paper were repeated for two sub sample periods: October 1979 - October 1982 and October 1982 - December 1984. However, the results for the sub sample periods were not materially different from the full sample period results. Thus, only the full sample period results are reported here.

8. For a detailed description of the daily activities of the Federal Reserve trading desk during the sample period, see Meek (1981), and Melton (1985).

9. See Meek (1981), Chapter 7.

10. Even though the Treasury accounts normally are exogenous to the activities of the Desk, at times, these balances can become a tool of reserve management to the Fed. For example, when the Desk wants to drain reserves from the system, if it feels it is not receiving 'good' bids from the dealers for security sales, it may request that the Treasury transfer funds from its Tax and Loans accounts to its accounts at the Fed. This will have the same reserve drainage implication as the sale of securities from its portfolio.

11. Consistent estimates of the covariance matrix of estimated coefficients was obtained by using Robusterrors procedure of RATS version 3.0.

12. The decline in the size of the coefficients is not monotonic with maturity. In fact, the decline in the 1 year Treasury rate is actually larger than the decline in the 1 year T-bill rate. Strongin and Tarhan (1990) find a similar response to money announcement shocks. Their explanation of this is that the 1 year Treasury bond, because it is a coupon paying security, has a shorter effective maturity than a 1 year discount security like the Treasury bill.

13. Figures 7 and 8 are representative of the relative impulse responses for all interest rates examined. The finding that own innovations ara a bigger source of variation in both the OMOs and interest rates is confirmed by variance decompositions. Except for the Fed funds rate, own innovations in interest rates account for

over 90 percent of the forecast errors in interest rates (20 day horizon). Similarly, over 90 percent of the OMO variation is OMO specific. In the case of the Fed funds rate, OMO innovations account for 24 percent of the variation and the Fed fund innovations account for the remaining 76 percent. These results are not sensitive to the order of othogonalization.

14. To understand the Granger causality running from OMOs to the Japanese exchange rate, impulse response to a one standard deviation shock in OMOs was examined. Impulse responses indicate that an increase in the U.S. money supply lowers the value of the dollar. While this could also be intervention related, it is also possible that the decline in the value of the dollar is due to lower domestic interest rates (via the interest rate parity) or due to higher expected U.S. inflation rate (via purchasing power parity).

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TABLE I

Granger Causality Tests of Open Market Operations (OMO_t) and Interest Rates (r_t)

	OMO_t Does Not Granger-cause r_t	r_t Does not Granger-cause OMO_t
	Chi-Square Statistic (Marginal Significance level)	Chi-square Statistic (Marginal Significance level)
Interest Rate		
Fed Funds	29.45 (0.000)	31.10 (0.000)
3 mos. T-bill	10.56 (0.103)	31.16 (0.000)
6 mos. T-bill	14.44 (0.025)	44.42 (0.000)
12 mos. T-bill	16.83 (0.010)	40.99 (0.000)
1 yr Treasury	19.16 (0.004)	40.16 (0.000)
2 yr Treasury	22.13 (0.017)	34.50 (0.000)
3 yr Treasury	22.60 (0.001)	34.43 (0.000)
5 yr Treasury	15.35 (0.017)	29.15 (0.000)
10 yr Treasury	17.55 (0.007)	24.69 (0.000)
20 yr Treasury	21.27 (0.002)	25.69 (0.000)
30 yr Treasury	15.06 (0.020)	23.09 (0.000)

Notes: Each equation contains a constant term, 6 lags of the forecasted variable, and 6 lags of the variable that is suspected to be Granger-causing the forecasted variable. The first marginal significance levels are for omitting 6 lags of the open market operations variable from the unrestricted OLS prediction equation for the interest rate in question. The second marginal significance level is for omitting 6 lags of the interest rate variable from the unrestricted OLS prediction equation for open market operations.

Interest rates are in first differences. Open Market Operations (OMO_t) are measured as the first difference of the Fed's total portfolio of securities.

The data is daily. The sample period is October 2, 1979 to December 31, 1984.

TABLE II

Impulse Responses to a One Standard Deviation Shock in OMO Innovations

Interest Rate	Interest Rate Response in the Period after the Shock (Basis Points)	Cumulative Interest Rate Response (Basis Points) After 6 days	Cumulative Interest Rate Response (Basis Points) After 12 days	Cumulative OMO Response to own shock 12 days After (Million Dollars)
Fed funds	-7.49	-13.00	-11.29	878.9
3 Mos T-bill	-1.12	-4.21	-3.63	873.1
6 Mos T-bill	-1.21	-3.38	-2.79	857.1
12 Mos T-bill	-1.20	-2.76	-2.15	858.8
1 yr Treasury	-1.61	-3.72	-2.94	956.1
2 yr Treasury	-1.29	-2.94	-2.29	858.2
3 yr Treasury	-1.23	-2.01	-1.51	852.3
5 yr Treasury	-1.00	-1.84	-1.35	858.8
10 yr Treasury	-0.92	-1.60	-1.13	858.5
20 yr Treasury	-0.94	-1.24	-0.76	854.7
30 yr Treasury	-0.78	-1.18	-0.78	855.5

NOTE: The magnitude of the initial OMO shock is in the range of \$1910 million. The response coefficients are significant for all interest rates. Confidence intervals for the response paths for selected interest rates are shown in Figures 1-4.

TABLE III

Impulse Responses to One Standard Deviation Shock in Interest Rate Innovations

Interest Rate Shock (Basis Points)	OMO Response in the Period after the Shock (Million Dollars)	Cumulative Response 12 days after (Million Dollars)	Cumulative Interest Rate Response to own Shocks after 12 days (Basis Points)
Fed-Funds (63BP)	304.8	-25.9	40.3
3 Mos. T-bill (22.3)	153.5	-112.6	28.8
6 Mos. T-bill (19.9)	222.8	-98.8	24.6
12 Mos. T-bill (16.9)	217.0	-102.1	21.1
1 yr. Treasury(20.5)	218.8	-99.0	25.6
2 yr. Treasury(17.3)	212.4	-109.6	22.6
3 yr. Treasury(16.1)	212.1	-129.0	20.3
5 yr. Treasury(14.8)	205.7	-103.0	18.6
10 yr. Treasury(13.3)	175.6	-125.6	16.3
20 yr. Treasury(12.6)	163.9	-132.7	14.5
30 yr. Treasury(12.2)	157.1	-135.3	14.1

Notes: The numbers in parentheses in the first column are the first period interest rate responses to own shocks.
OMO responses are significant at the 5 percent level in the case of all interest rates. The interest rate response to own shocks is also significant at the same level of significance.
Confidence intervals of the response of OMOs to selective interest rates are shown in Figures 5-6.

TABLE IV

Granger Causality Tests of Open Market Operations and Stock Market and Foreign Exchange Market variables

Relationship examined	The First Variable does not Granger-Cause the Second Variable Chi-Square Statistic	The Second Variable does not Granger-Cause the First Variable Chi-Square Statistic
OMOs, Equally Weighted Stock Returns	2.66 (0.850)	2.26 (0.894)
OMOs, Value Weighted Stock Returns	1.47 (0.961)	2.67 (0.849)
OMOs, Spot Deutche Mark (DM)	8.35 (0.214)	36.38 (0.000)
OMOs, 1 mos. Eurodollar Int. Rate	18.84 (0.004)	43.97 (0.000)
OMOs, 1 mos. Euro DM Int. Rate	12.39 (0.054)	7.77 (0.256)
1 mos. Eurodollar, 1 mos Euro DM Int. Rate	9.18 (0.163)	10.57 (0.102)
Spot DM, 1 mos. Euro DM Int. Rate	27.61 (0.000)	10.87 (0.092)
Spot DM, 1 mos. Euro Dollars Int. Rate	48.62 (0.000)	8.74 (0.189)
OMOs, Spot Japanese Yen (JY)	13.21 (0.039)	17.90 (0.006)
OMOs, 1 mos. Euro Dollar Int. Rate	17.81 (0.007)	42.47 (0.000)
OMOs, 1 mos. Euro Yen	1.63 (0.950)	10.81 (0.094)
1 mos Euro Dollar 1 mos Euro Yen Int. Rate	6.39 (0.381)	10.63 (0.100)
Spot JY, 1 mos Euro Yen Int. Rate	9.19 (0.163)	5.19 (0.519)
Spot JY, 1 mos Euro Dollar Int. Rate	36.20 (0.000)	6.19 (0.402)

Notes: The numbers in parentheses are marginal significance levels. The daily stock returns are the equally and value weighted CRSP portfolio returns.
The Granger Causality tests reported in rows 3 to 8 are obtained from vector autoregressions with 6 daily lags of OMOs, spot DM exchange rate (DMs per dollar), the interest rate on one month Eurodollar deposits, and the interest rate on one month Euro DM deposits. The Granger Causality tests reported in rows 9 to 14 are obtained from vector autoregressions with 6 daily lags of OMOs, spot Japanese Yen exchange rate (JYs per dollar), the interest rate on one month Euro JY deposits.
The exchange rates are in log differences, interest rates are in first differences. See Table I for additional notes.

TABLE V

Open Market Operations and ARCH Effects on Interest Rate Variances

$$\Delta r_t = b_o + b_1 OMO_{t-1} + \epsilon_t$$

$$\sigma_\epsilon^2 = a_o + a_1 \epsilon_{t-1}^2 + a_2(abs(OMO_{t-1}))$$

Interest rate	b_o	b_1	a_o	a_1	a_2	Log L
Fed Funds	-0.02	-0.003	2502	0.66	-0.25	-5970.39
	(0.02)	(14.27)	(27.46)	(13.2)	(5.76)	
3 mos T-bill	0.29	-0.0004	328.9	0.55	-0.0009	-4680.25
	(0.60)	(13.07)	(22.19)	(12.50)	(0.77)	
6 mos T-bill	0.20	-0.0005	364.3	0.16	-0.011	-4566.85
	(10.37)	(2.19)	(24.05)	(5.30)	(1.60)	
12 mos T-bill	0.22	-0.0007	253.6	0.14	0.054	-4358.6
	(10.47)	(3.04)	(23.71)	(4.47)	(0.75)	
1 yr T-bond	0.23	-0.0008	371.04	0.12	0.084	-4604.4
	(0.41)	(2.99)	(23.89)	(4.18)	(1.08)	
2 yr T-bond	0.40	-0.0007	268.7	0.14	0.0003	-4382.6
	(0.82)	(2.92)	(26.47)	(5.41)	(0.06)	
3 yr T-bond	0.48	-0.0007	215.9	0.205	-0.0003	-4269.1
	(1.05)	(3.6)	(24.7)	(7.45)	(0.07)	
5 yr T-bond	0.40	-0.0006	191.48	0.19	-0.005	-4158.2
	(0.98)	(3.37)	(24.79)	(5.83)	(1.52)	
10 yr T-bond	0.52	-0.005	147.7	0.23	-0.004	-4013.1
	(1.40)	(3.41)	(20.03)	(6.54)	(1.27)	
20 yr T-bond	0.40	-0.0005	147.8	0.13	-0.004	-3959.5
	(1.1)	(3.33)	(20.5)	(4.60)	(1.65)	
30 yr T-bond	0.30	-0.0004	145.3	0.08	-0.006	-3909.6
	(0.87)	(2.90)	(22.03)	(3.31)	(2.28)	

Notes: Interest rates (r_t) are in first differences. The line in parentheses under the coefficient values gives t-statistics see tables I and III for additional notes.

TABLE VI

Open Market Operations and ARCH effects on Exchange Rate, Euro Interest Rates and Stock Return variances.

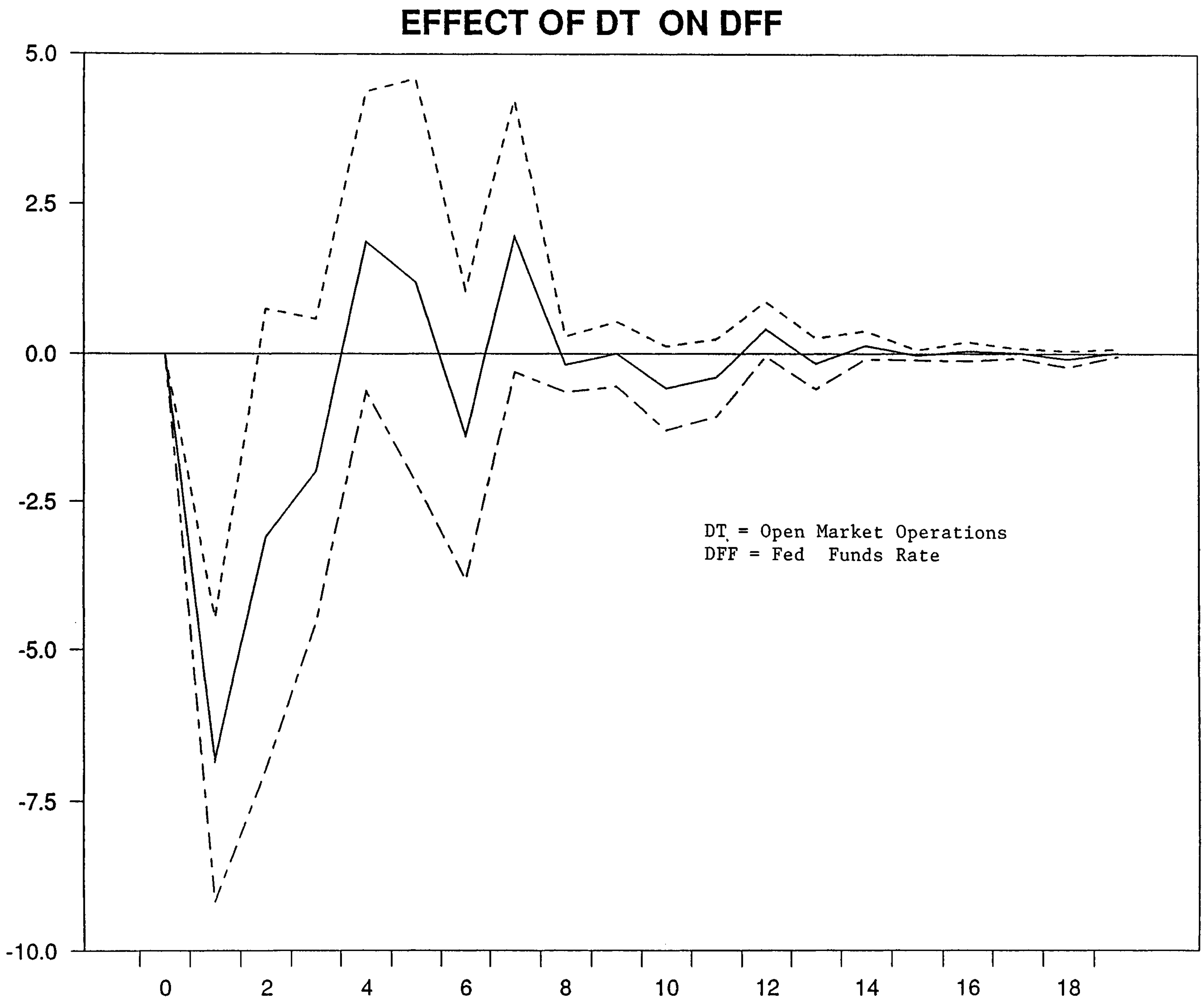
$$\Delta r_t = b_o + b_1 OMO_{t-1} + \epsilon_t$$

$$\sigma_\epsilon^2 = a_o + a_1 \epsilon_{t-1}^2 + a_2(abs(OMO_{t-1}))$$

Variable Examined	b^0	b_1	a_0	a_1	a_2	Log L
1 mos Euro$	-0.008	0.000009	0.14	0.95	-0.00001	282.64
	(0.97)	(2.80)	(32.10)	(13.06)	(10.55)	
1 mos EuroDM	-0.005	0.000007	0.009	1.16	-0.0000	1959.5
	(2.62)	(8.41)	(36.02)	(24.22)	(0.41)	
1 mos EuroJY	-0.002	0.000002	0.03	0.87	-0.000003	1323.3
	(0.54)	(0.82)	(59.6)	(18.59)	(7.12)	
Spot DM	1.69	-0.0004	2239.3	0.20	-0.0004	-5744.0
	(1.23)	(0.60)	(18.1)	(6.04)	(0.008)	
Spot JY	3.61	-0.0002	1403.7	0.16	0.074	-5473.6
	(3.22)	(0.42)	(19.5)	(4.58)	(2.69)	
Equally Wtd.	0.45	0.00006	79.25	0.07	-0.005	-3478.8
Stock Ret.	(1.85)	(0.56)	(23.3)	(2.96)	(3.78)	
Value Wtd.	0.09	0.00001	0.39	0.32	-0.00003	-132.2
Stock Ret.	(5.06)	(1.52)	(26.2)	(7.17)	(4.56)	

Notes: Interest rates are in first differences exchange rates are in log differences. The line in parentheses under the coefficient values gives t-statistics.
See Tables I and III for additional notes.

Figure 1


EFFECT OF DT ON DFF
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0.0
-2.5
-5.0
-7.5
-10.0
0
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4
6
8
10
12
14
16
18
DT = Open Market Operations
DFF = Fed Funds Rate

Figure 2

EFFECT OF DT ON D03

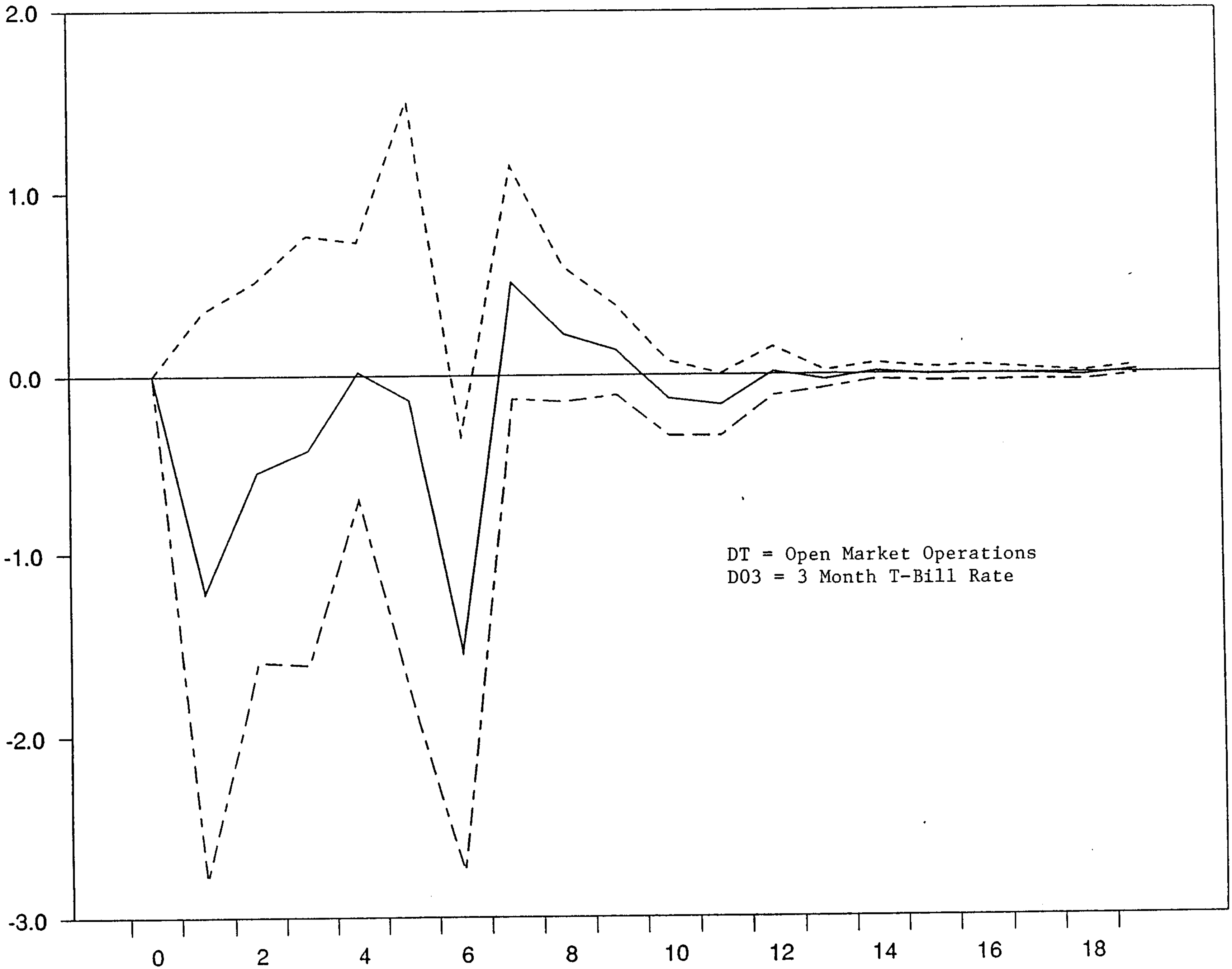


Figure 3

EFFECT OF DT ON D24

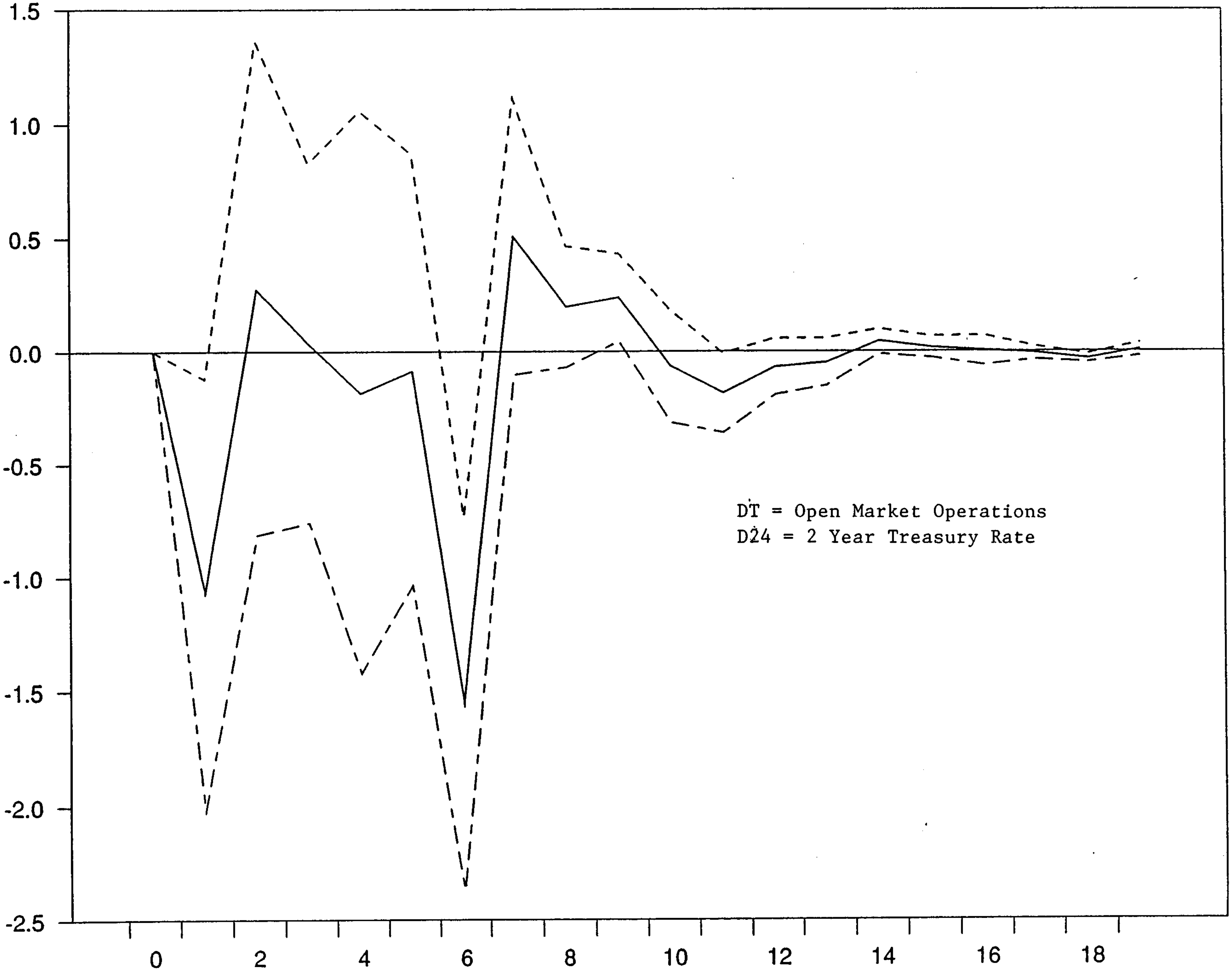


Figure 4

EFFECT OF DT ON D240

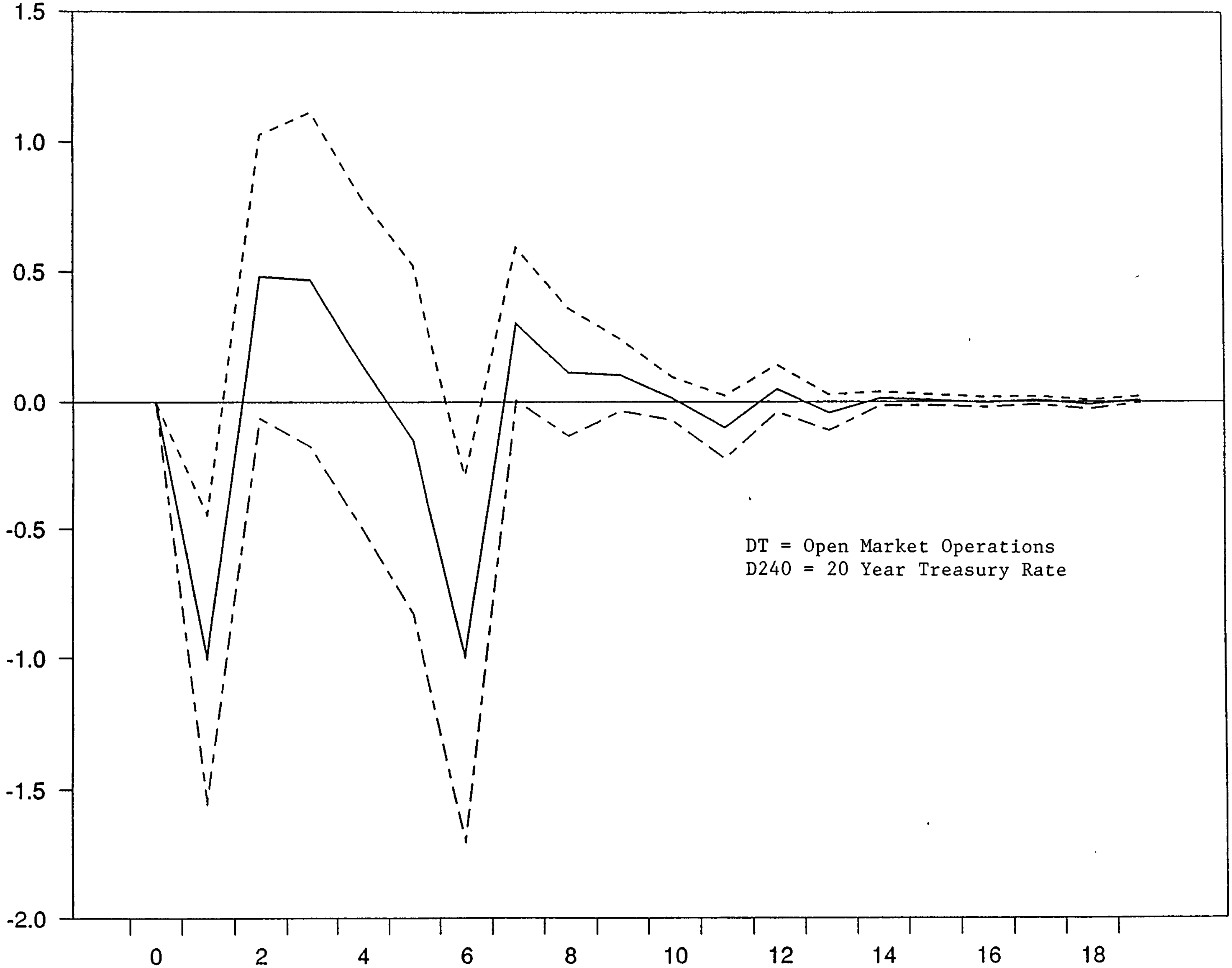


Figure 5

EFFECT OF DFF ON DT

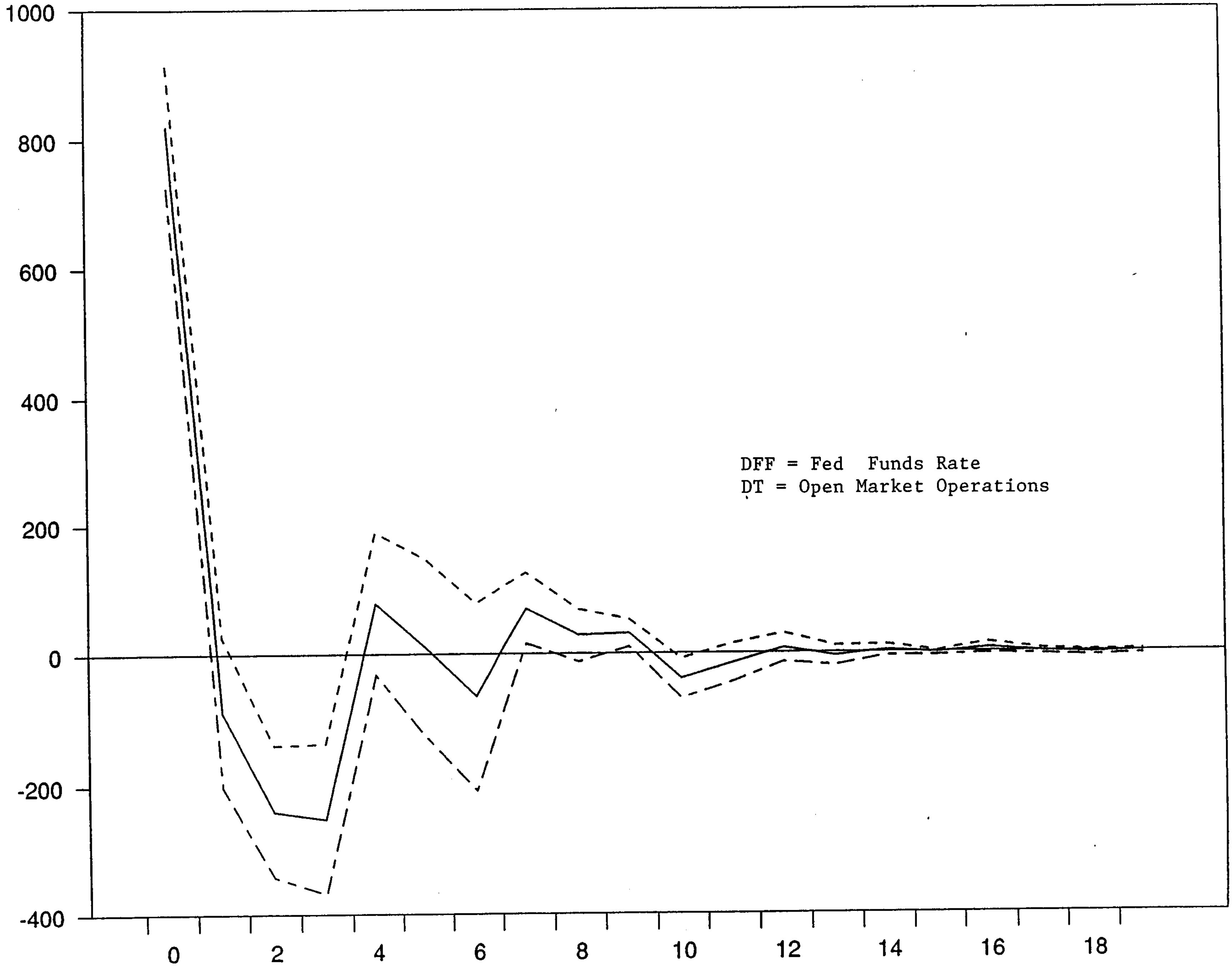


Figure 6

EFFECT OF D60 ON DT

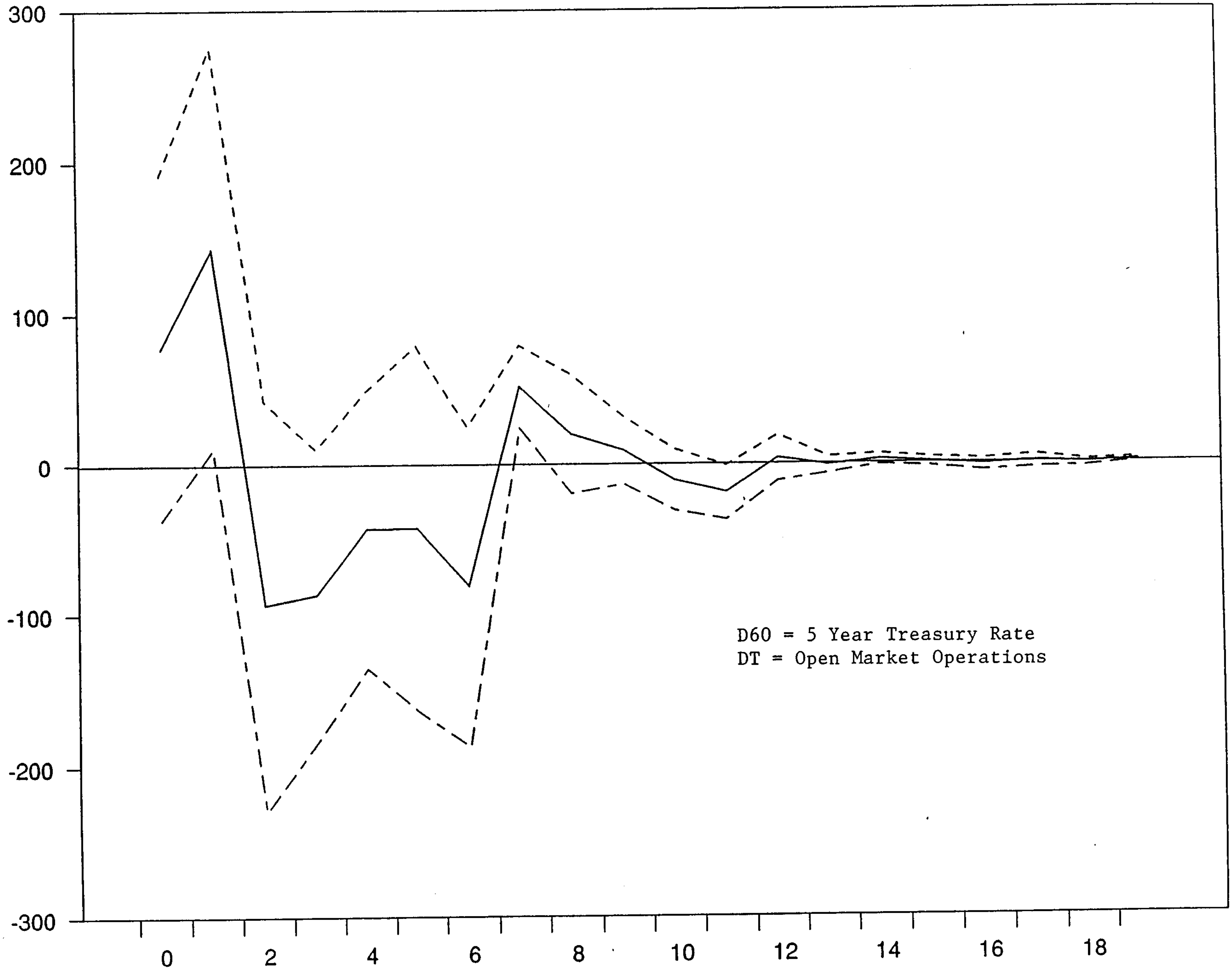
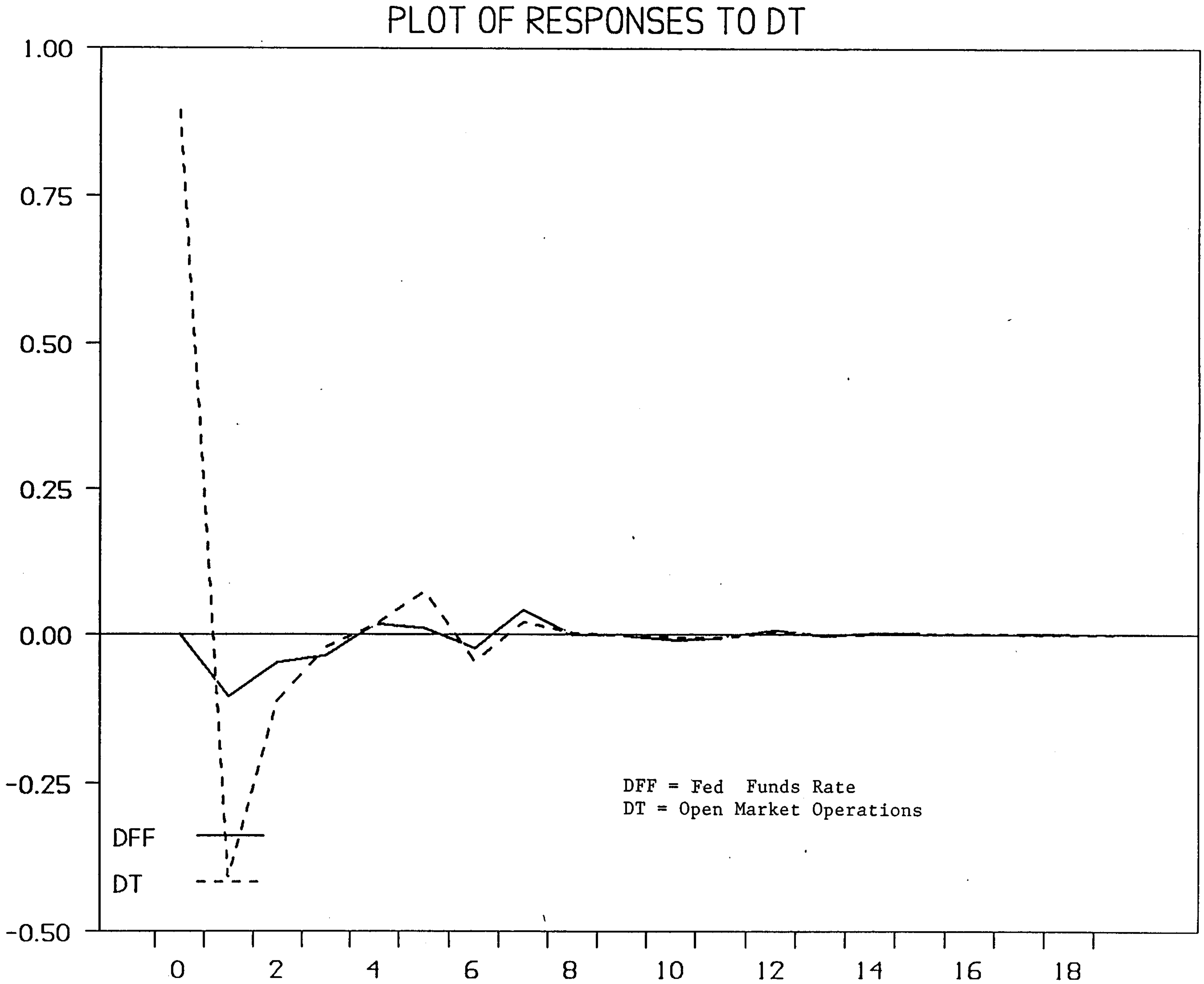


Figure 7


PLOT OF RESPONSES TO DT
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0.25
0.00
-0.25
-0.50
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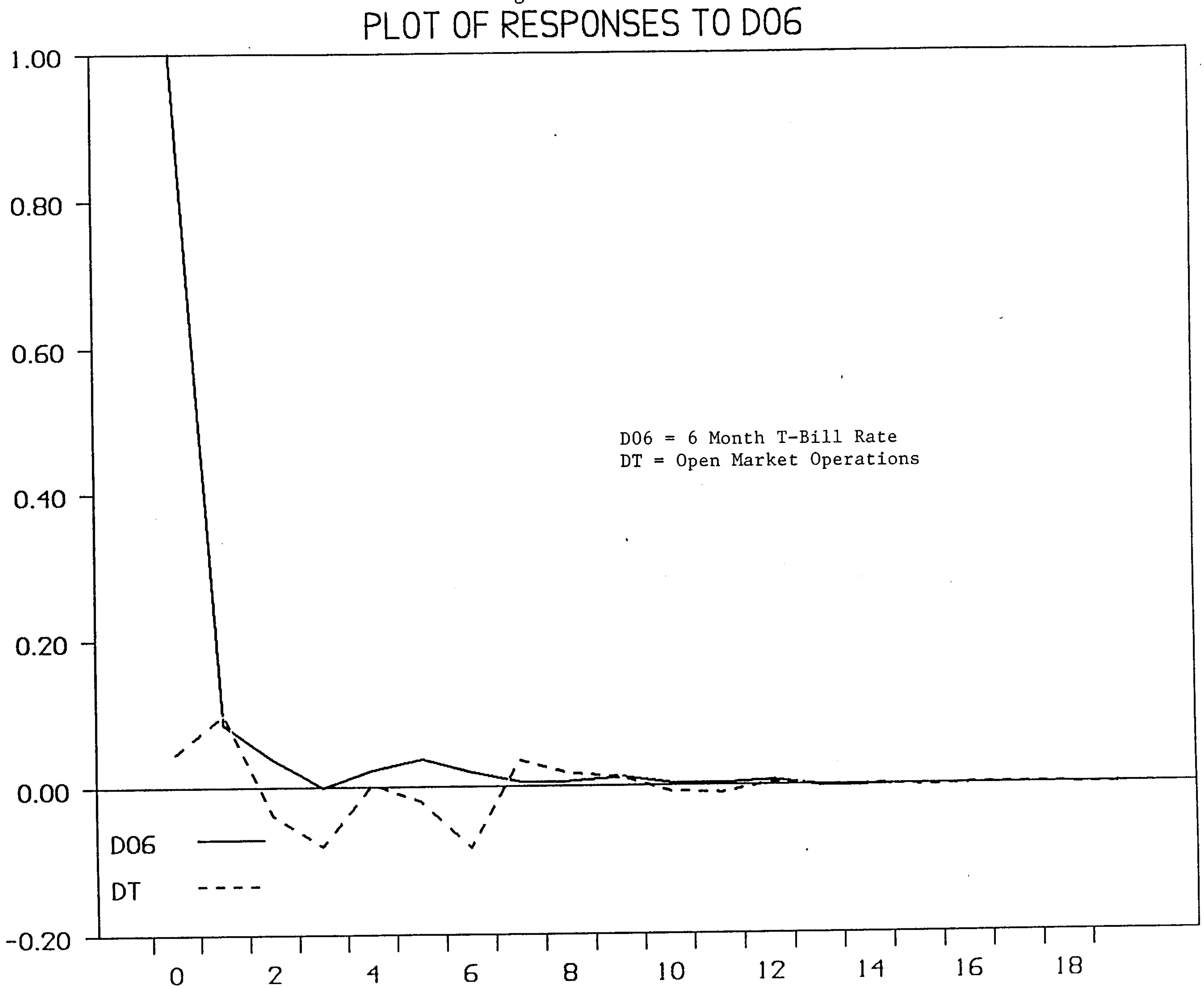
4
6
8
10
12
14
16
18
DFF
DT
DFF = Fed Funds Rate
DT = Open Market Operations

Figure 8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0.00
-0.20
0
2
4
6
8
10
12
14
16
18
D06 = 6 Month T-Bill Rate
DT = Open Market Operations
D06
DT