The Fed's Effect on Excess Returns and Inflation is Bigger Than You Think [*]

Shingo Goto[a]
The Anderson School
University of California, Los Angeles

Rossen Valkanov[b]
The Anderson School
University of California, Los Angeles

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[a] The Anderson School; University of California, Los Angeles; 110 Westwood Plaza; Los Angeles, CA 90095-1481; Phone: (310) 397-8456 ; Fax: (310) 206-5455; Email: shingo.goto@anderson.ucla.edu.

[b] The Anderson School; University of California, Los Angeles; 110 Westwood Plaza; Los Angeles, CA 90095-1481; Phone: (310) 825-7246; Fax: (310) 206-5455; Email: rossen.valkanov@anderson.ucla.edu. The latest version of the paper can be found at: http://www.personal.anderson.ucla.edu/rossen.valkanov/page1.htm

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Abstract

We find that between 20 and 25 percent of the negative covariance between excess returns and inflation is explained by shocks to monetary policy variables. The finding is robust to changes in the monetary policy rule that have occurred during the 1966-2000 period. The result contradicts the theory that money supply shocks induce a positive correlation between inflation and returns. Our findings also cast doubt on models that explain the negative correlation in a money-neutral environment (Boudoukh, Richardson, and Whitelaw (1994)), and on models that account for this correlation as being due solely to money demand shocks (Fama (1981), Marshall (1992)). We argue that contractionary monetary policy lowers excess stock market returns through various channels. Furthermore, if Fed shocks raise the borrowing costs of firms or if the Fed has some private information about future inflation, then a contractionary monetary shock will be followed by an increase in inflation, in the short run. The combined effect is a negative inflation/excess returns correlation. The results lend support to the argument that if asset pricing models are to capture the observed negative correlation, they must incorporate monetary policy effects.

JEL: G10, G12, E44, E51, E61, C32

1 Introduction

> "Greenspan and the powerful Open Market Committee can raise short-term interest rates to keep the economy from overheating. When they raise short-term rates, bonds and money market mutual funds look more attractive relative to stocks. And companies must pay higher rates on their borrowing, which reduces corporate earnings. Both of which, in theory, should bring stock prices down,..."
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> —USA TODAY, March 27, 2000.

People outside of academia take it for granted that the actions of the Federal Reserve Board (Fed) have a considerable impact on stock market returns, but a consensus amongst economists has yet to emerge. However, most economists will agree that if monetary policy is to have an effect on real returns, it must be either by influencing future net cash flows or by affecting the discount factor, at which the cash flows are capitalized. In either case, monetary policy must be "non-neutral," i.e. it must have an influence on real quantities, such as real dividend growth, in order to affect real returns. The focus of this paper is on the effect of monetary policy on excess stock returns and on the correlation between those returns and inflation. Ours is a very natural direction of research, since the Federal Reserve System was founded by Congress precisely to promote price stability and to stimulate long-run economic growth.[1] To the extent that Fed policy is successful in fulfilling those goals, it must have an effect on excess returns and on the correlation between excess returns and inflation.

The effect of monetary policy on stock returns is of clear interest, as demonstrated by the constant analysis of Alan Greenspan's comments and the actions of the Federal Open Market Committee (FOMC) by economists, the media and Wall Street. After the influential papers by Lucas (1976) and Sims (1980), the impact of monetary policy on financial and real variables has most often been evaluated using "weakly identified" vector autoregressions[2] (VARs) – large dynamic linear systems, allowing us to explore the statistical features of the data. If appropriate restrictions are placed on a VAR, its results might be given a structural interpretation, providing us with guidelines on what features asset pricing models should possess. Under the paradigm that only unsystematic monetary policy should have an effect on real variables (Lucas (1996), Sims (1980)), the emphasis has often been placed on analyzing the dynamic effects of shocks on the estimated system. The VAR literature has recently produced results that conform to prior belief and economic theory, but monetary policy shocks have only been able to explain no more than 20% of the variation in real activity (Cochrane (1994), Bernanke et al. (1997)). Moreover, since real variables account for no more than half of the variation in stock returns (Geske and Roll (1983), Fama (1990)), it is not surprising that only a small percentage of the total variation of equity returns are explained by unanticipated policy shocks, as shown by Patelis (1997), Thorbecke (1997), and corroborated by our own results.

The negative correlation between excess returns and inflation has received independent interest, since this finding was published by Fama and Schwert (1977). The result is surprising in a money-neutral world, because if stocks are claims against real assets, the correlation must be *zero*. But the result is even more surprising if we allow monetary policy to have an effect on real activities. A successful contractionary monetary policy, implemented for instance by raising the short-term interest rate, must be followed by decreasing inflation and excess returns, resulting in a *positive* correlation between those two variables. Starting with Fama's (1981) "proxy" hypothesis, many people have tried to explain the observed negative correlation. Surprisingly, most explanations focus either on money demand effects (Fama (1981), Marshall (1992)), or on money-neutral environments (Boudoukh et al. (1994)). The effect of monetary policy on the relationship between returns and inflation has been given much less attention. The papers by Geske and Roll (1983) and Kaul (1987, 1990) consider the effect of systematic money supply shifts through various channels. The focus here is more in line with the current macroeconomics literature, that only *unanticipated* monetary policy will have an effect on excess stock returns and inflation. Moreover, the identification of monetary policy and its systematic effects on returns and inflation is also different from those in Geske and Roll (1983), and Kaul (1987).

We make the following contributions. Using a VAR analysis, we show that unexpected monetary policy results in a negative correlation between excess returns and inflation. In fact, during the 1966-2000 period, between 20% and 25% of the covariance of inflation and excess returns can be explained by monetary supply shocks. To reach this conclusion, we assume that monetary policy shocks are identified in a recursive system, where the Fed follows a simple interest rate rule. More specifically, the policy instrument of the central bank is the Federal Funds rate, which responds systematically to inflation, output growth, and is subject to exogenous policy shocks. Then, we introduce a covariance decomposition which allows us to find the percentage of the inflation/excess returns covariance that is explained by those shocks.

To understand why a monetary shock causes a negative returns/inflation correlation, we look at the separate effect of a Federal Funds rate shock on excess returns and inflation. Unexpected contractionary policy leads to a decrease in excess returns, as is to be expected if monetary shocks have real effect and as stocks are claims against real assets. We discuss several channels, commonly thought to provide a transmission mechanism of monetary shocks onto real variates. We also observe that a contractionary monetary policy shock leads to a temporary increase in inflation, a fact that has been labeled the "price puzzle" by Sims (1992). Despite the usual precautions and variable selection in our VARs (such as including the price of commodities), the price puzzle is a robust feature of the data.

There might be several reasons for the price puzzle. One possible explanation is that monetary policy shocks impact the supply side of the economy, in addition to their aggregate demand effects. For example, a contractionary monetary policy will tend to increase the borrowing cost of firms that have to finance their working capital (inventories, outstanding receivables, etc.). Such short-run increases in financing the production cycle will be passed on to consumers, at least partially, in the short run. Barth and Ramey (2001) argue that this "cost channel" dominates the decline in demands following the shock and results in higher, rather than lower, prices. Another explanation of the price puzzle rests on the assumption of asymmetric information between the Fed and the public. If the central bank has more information about future inflation than other players in the economy, then it follows immediately that contractionary monetary policy shocks will be followed by seemingly anomalous increases in prices. This hypothesis is consistent with Romer and Romer (2001) who provide a direct test of the Fed's superior information in forecasting inflation. While we cannot distinguish between the two explanations in the VAR, such is not the goal of our paper. We discuss those mechanisms only to make the point that there probably are economic reasons behind the so-called "price puzzle."

The above arguments are based on the assumptions that only unsystematic monetary policy shocks can have real effects, that those shocks are correctly identified, and that the monetary policy rule has remained unchanged during the entire sample period. All of those assumptions have received some attention in recent years. However, some assumptions are more untenable than others. For example, it is highly unlikely that monetary policy has remained unchanged for more than 30 years. Changes in Fed chairmen, other FOMC members, and knowledge of the economy must have resulted in different monetary policy rules over the years (Clarida et al. (1999)). In order to take the changing monetary policy into consideration, we split the sample into two periods, 1966-1979 and 1983-2000, corresponding to tenures of FOMC chairmen, known to have conducted monetary policy in different fashions.[3] Indeed, the estimated monetary policy rule is very different in the two sub-samples. We re-estimate the VAR and analyze the effects of monetary policy on excess returns and on the correlation between excess returns and inflation during those two periods. This is a crude way of allowing the VAR policy parameters to change, without taking a stance on the provenance of those changes. A monetary policy does have an effect on the inflation/excess returns correlation in both periods, although the effects are less pronounced during 1983-2000. The price puzzle is remarkably stable during both periods. [4]

The paper is structured as follows. Section 2 introduces the data. In section 3, we present the Fed policy function, and elaborate on the effect of monetary disturbances on stock returns and inflation. In section 4, we lay out the VAR toolbox and present a useful extension: the covariance decomposition. In section 5, we present and discuss the empirical results. Section 6 offers concluding remarks.

2 Data

We work with a system of eight variables, available at monthly frequency: industrial production growth (IPG), consumer price inflation (INF), commodity price inflation (DPCOM), Federal Funds rate (FF), growth of non-borrowed reserves (DNBRD), default premium (DEFP), term spread (TERM), and excess market return (EP). The exact data description and sources can be found in Appendix A. The use of IPG as a proxy for theoretical dividend growth has been motivated by Fama (1981, 1990), Geske and Roll (1983), and Boudoukh et al. (1994).[5] As forward-looking variables, DEFP, TERM, and EP enable the VAR to span larger information set than usually considered in this literature. The power of these spreads to predict future economic activity and inflation is well documented in the literature (e.g., Chen et al. (1986), Stock and Watson (1989)).

The sample period runs from 1966:01 to 2000:12. The Federal Funds rate was not the main instrument of monetary policy before 1966. We also divide the sample into two periods: (i) 1966:01 to 1979:06 (pre-Volcker), and (ii) 1983:01 to 2000:12 (post-Volcker). The first three and a half years of the chairmanship of Volcker (1979:07 – 1982:12) are omitted, because of substantial changes in the Fed's operating procedure.

3 Fed Policy, Excess Returns, and Inflation

In this section, we explain why monetary policy shocks contribute to the negative returns/inflation correlation. First, we define what we mean by a Fed policy shock. Second, we discuss several explanations for the opposite responses of inflation and excess returns to those shocks. The main goal of this paper is on demonstrating that part of the negative covariance between excess returns and inflation is due to unanticipated monetary policy. Hence, we focus on establishing that Fed shocks do have an effect on excess returns and inflation and in providing several explanations for the results. The more daunting task of identifying the exact channels through which unanticipated monetary policy affects the covariance of interest is left for further research.

3.1 Fed Policy Function and Fed Shocks

In recent years, a lot of attention has been devoted to the issue of how to conduct monetary policy. This increased interest can be credited to the success of recent empirical papers showing that monetary shocks do have an impact on the course of the real economy.[6] A virtual consensus in this literature is that monetary policy can be characterized by looking at the Federal Funds rate rather than at monetary aggregates, such as M0, M1, or M2. Therefore, in this study, we take the Federal Funds rate to be the main policy instrument of the central bank. In this respect, our analysis differs from the ones in Geske and Roll (1983) and Kaul (1987, 1990) who look at the growth of monetary aggregates.

On the theoretical side, the monetary policy literature has enriched the dynamic general equilibrium models, developed in the real business cycles field, by introducing frictions, such as nominal price rigidities. A significant product of this literature is the development of specific rules of Fed policy that are justified by general equilibrium considerations, and supported by the data. A popular class of rules are the simple linear interest rate functions, also known as "Taylor rules," after the article by John Taylor (1993). In the same spirit, Clarida et al. (1999) propose a "forward looking" version of the Taylor rule that also exhibits interest rate smoothing, often observed in the Fed's behavior. The feedback rule, proposed by Clarida et al. (1999) is:

$$r_t^{ff} = \alpha + \phi r_{t-1}^{ff} + (1-\phi)\left[\gamma E\left((\pi_{t+1} - \pi^*)\,|I_t\right) + \eta x_t\right] + v_t \qquad (1)$$

where r_t^{ff} is the Federal Funds rate, π_t is the level of inflation, π^* is the target inflation, x_t is the log deviations of GNP from its trend, and v_t is a policy shock. The parameter ϕ captures the degree of interest rate smoothing. Expectations are taken with respect to the information set I_t available to everyone in the economy. In what follows, we assume that the Fed's systematic policy is specified by a Taylor rule, as in (1). A contractionary policy shock is captured by a positive innovation, v_t. In our VAR, which includes r_t^{ff}, π_t, and other conditioning variables x_t (see below), the Federal Funds rate equation represents a generalized version of the Taylor rule (1). The identification of v_t is discussed at length below.

3.2 The Response of Real Variables and Stock Returns to Fed Policy Shocks

The effects of the policy shock v_t onto real economic variables and excess returns can be categorized into two main channels. The first one is a traditional IS-LM or a "money" channel. Brainard and Tobin (1963), and later Fama (1980), convincingly argue that the impact of monetary policy on the economy can be analyzed through its effect on investor portfolios. Suppose that we are in a Fama (1980) banking world, where banks are merely a medium of rebalancing portfolios. The analysis can be conducted with only two financial assets: "outside" money, provided monopolistically by a central bank, that serves as the numeraire good and as a medium of exchange, and "bonds." We assume that money and bonds are not perfectly substitutable, and that there is a non-zero demand for money. In an unexpected contractionary move, the central bank decreases the quantity of money. Households must then hold more bonds and less money in their portfolios. If there is price-rigidity in some sectors of the economy, prices do not fully (or instantaneously) adjust to changes in money supply, and the fall in money holdings represents a decline in real money balances. To restore equilibrium, the real return on bonds must increase. Thus, fewer projects are available at higher real interest rates–investment and industrial production decrease. This mechanism hinges on the central banks's ability to control the supply of outside money, and on prices being somewhat rigid. Since, both of those assumptions are uncontroversial for the US, most researchers would agree that monetary policy is not neutral, at least in the short run.

Imperfections in capital markets provide additional mechanisms of translating monetary policy actions into variations in real variables, and can account for the empirical observation that VARs produce "protracted, hump-shaped and large" responses of real variables to unexpected monetary shocks. In the extensive "capital markets imperfections" literature, monetary policy impacts the difference in cost between external funds (issuing equity or debt) and internal funds (retained earnings), known as the external finance premium. For instance, an increase in interest rates weakens the financial conditions of consumers and firms by directly impacting their cash flows, net worth, and assets. For example, higher rates of interest will result in lower present discounted value of a firm's assets (equipment, buildings, etc.), which are often used as a collateral for loans. Therefore, a contractionary monetary action will exacerbate any existing agency and information costs of issuing credit and will result in the firm having a reduced access to bank loans. Such "*balance sheet*" constraints also lead to lower investment and, ultimately, decreasing rates of return (Bernanke et al.(1994)). Alternatively, a reduction in bank reserves by the Fed also reduces bank deposits and, hence, banks' loanable funds. If bank loans are imperfect substitutes for other forms of financing (such as commercial paper), a reduced supply of bank loans will lower economic activity by bank-dependent borrowers. As an example, consider a company, whose primary source of short-term debt financing are bank loans. A contractionary monetary policy, resulting in a reduction of loanable funds, will compel this firm to look for credit in the commercial paper market. To the extent that bank loans and commercial paper are not perfectly substitutable, and if the commercial paper market is not sufficiently "deep," then a contractionary monetary policy will result in an increase of commercial paper rates and in the total cost of short-term debt financing of the firm. Therefore, the cash flow of indebted firms will decrease, resulting in lower stock returns. This is often referred to as the "*bank lending*" channel (Bernanke and Blinder (1988) and Kashyap et al. (1993)).

In sum, a tightening monetary policy shock, working through the "*balance sheet*" and "*bank lending*"channels, reduces the excess rate of return in financial markets and induces a more "protracted" response on economic variables. As a result of their similar effects on real variables, the channels and their nuances are difficult to identify in aggregate data (Friedman and Kuttner (1993) and Bernanke (1995)). However, in our study, we are not focusing on identifying those channels: our aim is to establish that a tighter monetary policy ultimately results in a decrease of excess returns. As a final remark, we view the IS-LM and the capital market imperfection explanations not as competing mechanisms, bur rather as complementing and reinforcing each other.

3.3 The Response of Inflation to Fed Policy Shocks

By specifying the Fed policy function as a Taylor rule, we assume that the FOMC uses the Federal Funds rate as its main monetary policy instrument. In other words, the Federal Funds rate is not a state variable, but rather it is the main control variable of the Fed. From this perspective, an unanticipated *positive* shock to the Taylor rule equation (tighter monetary policy) must result in *lower* future, expected and realized, inflation. However, our empirical results will show that a *positive* shock to the Taylor rule is in fact followed by *higher* future inflation in the short run (which subsequently declines), a finding that has been labeled the "price puzzle" by Sims (1992). To understand the prize puzzle, we must point out that the direct link between positive shocks to the Federal Funds rate and lower future inflation rests on several assumptions. The violation of any one of those assumption might result in positive monetary policy shocks being followed by higher inflation, and thus raise the specter of a puzzle.

Sims (1992) suggests that the price-puzzle obtains because the Fed's reaction function contains information about inflation that is missing from the consumer price index (CPI) and the VAR. To remedy this problem, Sims (1992) proposes to include commodity prices or the producer price index (PPI) in the VAR. Those measures alleviate the problem somewhat, but the price-puzzle is still present at short-horizons, for up to 6-12 months. Our VAR results confirm that, in the short run, a monetary policy shock is followed by an increase in the price level.[7] This evidence, combined with some other recent work (Barth and Ramey (2001), and referenced therein), leads us to believe that the "omitted variable" argument is not the entire source behind the price-puzzle.

Since an econometric misspecification is unlikely to account for the price puzzle, we turn to economic explanations. The first explanation recognizes that monetary policy shocks have an impact on the supply side of the economy, in addition to any other aggregate demand effects. For instance, an unexpected higher Fed Funds rate shock will raise the cost of working capital to all firms. Previous dynamic general equilibrium models (Christiano, et al. (1997)) incorporate this feature by assuming that firms have to finance their wage bill by borrowing working capital. To the extent that working capital is not immediately adjustable, a portion of the higher borrowing costs will be passed on to consumers and thereby will result in a higher price level at short horizons. This mechanism, appropriately labeled the "*cost channel*" by Barth and Ramey (2001), leads us to conclude that a Fed funds rate shock should be positively correlated with future inflation, even when the VAR is correctly specified. The cost channel is very reminiscent of the "balance sheet" and "bank lending" arguments, discussed in the previous section, in the sense that it affects the production side of the economy. It is appealing to think that the same chain of economic events might prove to be behind the lower excess returns and higher inflation following a contractionary monetary policy shock. While our subsequent VAR evidence is only consistent with this hypothesis, but does not establish it conclusively, this is clearly a interesting area to pursue.

The price puzzle might also arise as a result of asymmetric information. If the Fed has some private information about future inflation, then the VAR monetary policy shock v_t will comprise (i) the Fed's endogenous adjustment based on its private information of future inflation, and (ii) exogenous policy disturbances. In a VAR, both (i) and (ii) are identified as unanticipated policy shocks. To the extent that v_t contains some unobserved information about future inflation, it will predict future inflation, by construction. A recent paper by Romer and Romer (2001), showing that the Fed has a considerable amount of private information beyond what is available to commercial forecasters (and everybody else), has lent some support to this hypothesis. The private information story differs from the Sims (1992) explanation, because part of the Fed's information is not publicly known and cannot be proxied by available data.

The cost channel and the asymmetric information hypothesis argue that the short-run response of inflation, following a contractionary monetary policy shock, is not really a puzzle. Given the empirical magnitude of the response, it is likely that a combination of the two mechanisms might be needed to account for its size.

3.4 The Covariance between Excess Returns and Inflation

Summing the effects of unanticipated monetary policy on returns and inflation, we have the desired result. In the short run, a tighter monetary policy, implemented by a positive shock to the Federal Funds rate, induces a decrease in excess rates of return and is followed by an increase in inflation. Hence, such a policy might explain some of the observed negative correlation between excess returns and inflation.

One might argue that our mechanism is one of the many that produce the negative correlation between inflation and returns. However, the reasoning above implies that a big part of the negative correlation between inflation and excess returns must be explained by unexpected shocks to monetary policy variables. This dimension of the correlation is not captured by any other model. As discussed below, we find that between 20% and 25% of the covariance between excess returns and inflation is due to monetary policy shocks. Therefore, models that imply that the negative correlation is entirely due to money demand shocks (Fama (1981), Marshall (1992)) are not supported by the data, since we find that money supply shocks account for a significant fraction of that variation. Moreover, our findings suggest that models that treat money as being completely neutral in the short run also do not offer the complete explanation (Boudoukh et al.(1994)).

4 Methodology: VAR Analysis

Thus far, we argued that contractionary Fed policy shocks have a negative effect on excess returns and a positive effect on inflation, thus significantly contributing toward the observed negative correlation between those two variables. In the following section, we use a VAR analysis to show that, indeed, shocks to Fed policy do have opposite effects on excess market returns and inflation. Specifically, we employ the conditional moment profile (Gallant et al. (1993)) to trace out the effects of a Fed policy shock on the covariance between inflation and excess stock returns. We introduce the *covariance decomposition* analysis as a way to decompose a covariance between two variables into components accounted for by different exogenous economic shocks. This approach enables us to systematically analyze the contribution of Fed policy shocks to the negative covariance between inflation and excess returns. We find that between 20% and 25% of the covariance between the two variables can be traced to shocks in the Federal Funds rate, the primary Fed policy instrument.

4.1 Isolating Monetary Policy Shocks

The aim of this paper is not to write down a fully specified asset pricing model; doing so would require making some restrictive assumptions. Given the apparent lack of fit of available general equilibrium models with the time-series facts, our goal is to impose as little a priori assumptions on the data as possible. In the spirit of recursive weakly-identified VARs, we only assume a contemporaneous recursive relationship between the variables in order to isolate monetary policy shocks. First, we fit an unrestricted VAR system to the data:

$$y_t = \phi + \sum_{l=1}^{m} \Phi_l y_{t-l} + u_t, \quad E\left(u_t u_t'\right) = V \tag{2}$$

where the residuals u_t are assumed to be serially uncorrelated with an unconstrained covariance matrix V, ϕ is a vector of constants, $\{\Phi_l\}_{l=1}^{m}$ are matrices of coefficients, and m denotes the VAR lag order. To give a structural interpretation to the fitted VAR system, we decompose the VAR residuals u_t into unobserved economic shocks, w_t, and assume that the economic shocks are mutually and serially uncorrelated. The relationship between u_t and w_t can be written as $u_t = Gw_t$, where G is a square matrix that imposes the identifying restrictions. We assume a recursive contemporaneous (or Wold) ordering (e.g. Sims (1980, 1986) and Christiano et al. (1996,1998), among others), or G is a unit-diagonal, lower-triangular matrix. Those restrictions imply that economic shocks have a contemporaneous effect only on variables placed at the same level, or lower, in the system.[8]

The ordering of the variables in the VAR is: IPG, INF, DPCOM, FF, DNBRD, DEFP, TERM, and ER. In other words, we treat IPG, INF, and DPCOM as predetermined for monetary policy shocks, as in Christiano et al. (1996, 1998) and Thorbecke (1997). The financial variables DEFP, TERM, and ER are placed below the policy variables, implying that they respond to monetary policy shocks within the same month.[9] In the VAR literature, monetary policy shocks have been identified as innovations in Federal Funds rate or non-borrowed reserves.[10] We use both Federal Funds rate and the growth of non-borrowed reserves as our policy variables, since they both may contain information about the stance of the Fed (Bernanke and Mihov (1998)).

The above assumptions are just enough to let us recover (or identify) the unobservable economic shocks w_t from the VAR residuals u_t. Let $E\left(w_t w_t'\right) = D$, where D is a diagonal matrix with the variances of the economic shocks on the principal diagonal. Then, we have the set of restrictions

$$V = GDG'$$

It is often convenient to let $P = GD^{1/2}$ or $V = PP'$, where P is the lower triangular Choleski factor of V.

4.2 Dynamic Response of the Covariance between Inflation and Excess Returns

In the VAR literature, impulse response functions are typically used to trace out the effects of innovations in one of the variables on the system. Specifically, we focus on the response of excess returns and inflation to a shock to the Federal Funds rate. The impulse response function is easy to derive if we cast the VAR in (2) as $y_{t+h} = \sum_{s=0}^{h-1} \Psi_s u_{t+h-s} + y_t\left(h\right),$ where $y_t\left(h\right) = \sum_{q=1}^{h} \Phi_q y_{t+h-q}$ ($\Phi_q = 0$ for $q > m$) is the h-period VAR forecast of y_t. Starting with $\Psi_0 = I,\ \Psi_s$ may be obtained from the Φ_s using the recursion $\Psi_s = \sum_{r=1}^{s} \Psi_{s-r}\Phi_r, \quad s = 1, 2, \ldots.$ To simplify notation, we let $\Theta_h \equiv \Psi_h P$, whose (j,k)-th element is denoted by $\theta_h(j,k)$.

We are interested in the impulse response function

$$\frac{\partial y_{t+h}^{(j)}}{\partial w_{t+1}^{(k)}} = \theta_{h-1}\left(j,k\right)$$

The (j,k)-th element of Θ_{h-1} captures the response of $y_{t+h}^{(j)}$ to a one-time impulse $w_{t+1}^{(k)}$, with all other variables dated t or earlier held constant. The entire impulse response function of the j-th variable to a one-standard deviation shock in the k-th innovation is given by the (j,k)-th element of $\Theta_h,\ h = 1, 2, \ldots$.

As a more convenient way of analyzing the impact of unanticipated monetary policy onto the excess returns/inflation relation, we propose a natural extension of impulse response analysis. We can trace out the net effect of monetary shocks on the return-inflation covariance by examining the conditional moment profile (Gallant et al. (1993)). The conditional forecast given a unit impulse in the k-th economic shock is given by $y_t^{(k)}(h) \equiv y_t(h) + \Theta_{h-1}\epsilon_{t+1}^{(k)}$ for $h = 1, 2, \ldots$, where $\epsilon_{t+1}^{(k)}$ is an impulse vector with 1 in the k-th position and 0 in the others. The conditional moment profile for the forecast error covariance matrix, due to unit impulse in the k-th innovation, is

$$E_t\left[\left(y_{t+h} - y_t^{(k)}(h)\right)\left(y_{t+h} - y_t^{(k)}(h)\right)'\right] - \Sigma_y(h) = \theta_{h-1}(\cdot, k)\,\theta_{h-1}(\cdot, k)',\ \ h = 1, 2, \ldots,$$

where $\theta_{h-1}(\cdot, k)$ is the k-th column of Θ_{h-1}. Therefore, we will use the notation

$$\frac{\partial Cov_t\left(y_{t+h}^{(i)} y_{t+h}^{(j)}\right)}{\partial w_{t+1}^{2(k)}} = \theta_{h-1}(i, k)\,\theta_{h-1}(j, k)\,,\ \ h = 1, 2, ... \tag{3}$$

to denote the dynamic responses of the h-period forecast error covariance between i-th and j-th variables to the k-th identified innovation.

Formula (3) is deceptively simple. First, it captures the changes in the covariance between two variables to an orthogonalized shock. In this study, we will use (3) to investigate the response of the covariance between excess returns and inflation to unanticipated Fed policy shocks. Expression (3) is not only straightforward to interpret, but it is also a natural extension of the customary impulse response function. Second, formula (3) is easy to compute by finding the outer product of two impulse response functions. Third, as we will see below, it will allow us to answer the truly interesting economic question: How much of the covariance between excess returns and inflation is explained by monetary policy shocks?

4.3 Covariance Decomposition

In the usual VAR toolbox, the portion of the total variance of an observed variable that is due to the various structural shocks is called "variance decomposition." In a similar fashion, we can find the portion of the total *covariance* between two variables that is due to the various structural shocks. Such a decomposition would be called a "*covariance decomposition*." In particular, we are interested in the fraction of the excess returns/inflation covariance that is explained by monetary policy shocks.

To analyze the effects of monetary policy shocks on the covariance between excess stock returns and inflation, we examine the dynamic response of the covariance to orthogonalized economic shocks. We focus on the causal relationship between the return/inflation correlation and economic shocks identified in our system. Using the fact that w_t are serially and contemporaneously uncorrelated with the identity covariance matrix, the h-period ahead forecast error covariance matrix is simply given by $\Sigma_y(h) = \sum_{s=0}^{h-1} \Theta_s \Theta_s'$.[11] Then the h-period forecast error covariance between i-th and j-th variables, $\Sigma_y^{(i,j)}(h)$ is calculated as $\Sigma_y^{(i,j)}(h) = \sum_{k=1}^{K} \sum_{s=0}^{h-1} \theta_s(i,k)\, \theta_s(j,k)$, where K denotes the number of endogenous variables in the system (8 in our model). The covariance decomposition, i.e. the fraction of the h-period forecast error covariance between the i-th and the j-th variable accounted for by shocks in the k-th variable, is given by

$$\frac{\sum_{s=0}^{h-1} \theta_s(i,k)\, \theta_s(j,k)}{\sum_{k=1}^{K} \sum_{s=0}^{h-1} \theta_s(i,k)\, \theta_s(j,k)}. \tag{4}$$

The covariance decomposition, which nests the variance decomposition for $i = j$, is a rather natural extension to the existing VAR toolbox. However, to the best of our knowledge, it has never been used in the literature. It is also interesting to notice that the covariance decomposition is nothing but a normalized cumulative sum of (3), exactly in the same way that the variance decomposition is a normalized cumulative sum of the impulse response function.

Expression (4) would be employed to measure the exact fraction of the negative excess returns/inflation covariance that could be attributed to monetary policy shocks. It would allow us to decide whether the impact of monetary policy shocks on the correlation is only a theoretical possibility without support in the data, or whether it is economically and statistically important.

5 Results

We estimate an eight-variable VAR and identify the monetary policy shocks as discussed at length in the previous section. The VAR is estimated with a constant and 3 lags, as determined by AIC (Akaike Information Criterion).[12] The main focus of this article is on the dynamic properties of the excess returns/inflation covariance as a result of a Fed policy shock. In section 3, we argued that this negative covariance can be attributed to monetary policy shocks resulting from a short-term decrease in future excess returns and a short-term increase in future inflation. In this section, we use the tools introduced in section 4 to quantify the exact magnitude of monetary policy shocks on the covariance of interest.

Figure 1 plots the impulse response functions of shocks to the monetary policy variable – the Federal Funds rate – to selected variables in the system. We report 68% and 90% Bayesian confidence intervals around the response functions.[13] Panel (a) plots the impulse responses from a VAR estimated using the entire sample, 1966-2000. A 25 basis-points shock to the Federal Funds rate reduces excess returns by about 2% in the month of the shock. As hypothesized above, some of that effect must be due to the short-term effect of monetary shocks on industrial production growth. Indeed, we notice that a 25 basis-points shock in Federal Funds rate leads to a 0.25% decline in the growth of industrial production with 3 months lag. The negative effect lasts for more than a year. Therefore, the immediate decline in excess returns to a monetary policy shock should not come as a surprise, given the decline in expected output growth. There might be other channels through which monetary policy affects excess returns, such as time-varying risk premia. We leave the exact identification of such channels for future work.

In Panel (a) of Figure 1, a 25 basis-points shock in the Fed Funds rate is followed by a short-run increase in inflation by about the same amount. The observed increase in the price level is robust in sub-samples and for various identification schemes, as argued below. In a recent paper, Ludvigson, Steindel, and Lettau (2001) obtain a similar result using a quarterly dataset, a different VAR specification, and different identifying assumptions.

Combining these effects, monetary policy shocks have a significant effect on the short-run negative return/inflation relationship. Our empirical evidence is consistent with the arguments laid out in Section 3. We find that a contractionary policy shock brings about a short-run decline in industrial production growth and short-run increase in inflation rate. Furthermore, we notice that a contractionary shock leads to a significant increase in the default premium with a lag of a few months. This result suggests that the credit channel is an important mechanism of Fed policy transmission. Finally, our results contradict Hess and Lee (1999), who argue that monetary shocks are associated with positive correlation between inflation and real stock returns.

[Figure 1 about here]

Panels (b) and (c) of Figure 1 present the same impulse responses for the sub-samples 1966:01-1979:06 and 1983:01-2000:12. The results are very similar. It must be noted, however, that the effect of monetary policy shocks is more pronounced in the pre-Volcker period, a finding that we address below. A similar set of response functions can be produced for shocks to non-borrowed reserves. The impact of such shocks, while quantitatively similar to Federal Funds rate shocks, is much smaller in magnitude and, hence, omitted.

Figure 2 presents the dynamic response of the covariance between excess returns and inflation to monetary policy shocks, as derived in expression (3). We also report 68% and 90% Bayesian confidence intervals around the response functions. In the full sample, a shock to the Funds rate has a significantly negative impact on the covariance during the first 4 to 6 months. Not surprisingly, this result is in accord with the findings in Figure 1. In the sub-samples, the response of the covariance is still negative and of the same order of magnitude. Given the large number of parameters to be estimated in the VAR, it is not surprising that, in the sub-periods, the negative effect is only marginally significant.

[Figure 2 about here]

The most economically interesting question is: How much of the observed negative correlation between returns and inflation can be attributed to the identified monetary policy shocks? Thus far, we have shown that shocks to the Federal Funds rate have a negative impact on the correlation between returns and inflation. However, how significant is this impact when compared to all other shocks? We find that the response of the covariance to the Funds rate is the most significant, economically and statistically. To quantify this statement, we use the covariance decomposition.[14]

Figure 3 displays the fraction of the covariance between excess returns and inflation that can be explained by Federal Funds rate shocks during the entire sample and the two sub-samples. Approximately 20%–25% of the negative correlation is explained by shocks to the Federal Funds rate. Those results are surprisingly robust to different orderings in the recursive identification (available upon request), because the correlation between the (unrestricted) VAR residuals is small.

[Figure 3 about here]

As a final comment, we discuss the results in the sub-samples. Figures 2 and 3 show that the impact of Fed policy shocks has been more pronounced in the 1966.01-1979.06 period. To investigate the provenance of the differences, we use variance decomposition to find the fraction of the total variance in excess returns and inflation during each sub-sample that can be attributed to the orthogonalized shocks. Figure 4 plots the fraction of excess returns variation that is due to monetary policy shocks across the two sub-samples. During the 1983-2000 period, Fed policy shocks, while still statistically significant, have had an economically smaller impact on the variance of returns. However, most of the difference is traceable to the monetary policy's impact on inflation during the two periods. The variance decomposition of inflation, displayed in Figure 5, exhibits some differences between the two sub-periods. During the pre-Volcker period, significant fraction of inflation variation can be explained by innovations in commodity prices and monetary shocks. In Figure 5, inflation innovations explain only 50% of their own variation in the long run. However, the commodity price innovations and monetary shocks have lost some of their explanatory power in the post-Volcker period, where 80 to 90 percent of inflation variation is explained by its own innovations. Consequently, more of the negative return/inflation relationship is attributable to inflation innovations in the latter period.

[Figures 4 and 5 about here]

The decline in the indicative role of the commodity prices in explaining inflation variation conforms with the finding of Blomberg and Harris (1995) (also Barth and Ramey (2001)), who provide a few explanations for this phenomenon. In particular, they argue that the indicative role of the commodity prices may have been offset by more effective countervailing monetary policy movements. Commodity prices give early signals of an inflationary surge in aggregate demand. This is because any inflationary impetus is first observed in commodity prices which are continuously updated in thick markets, while consumer price inflation is reported with a lag of a few weeks. If the Fed systematically reacts to the inflationary surge observed in the commodity prices in order to offset the early signal of inflation in commodity prices, and to the extent that consumer prices do not adjust to the decline in commodity prices quickly, we may not observe the indicative signal of the commodity prices while the Fed in fact does. If this is correct, the Fed employs more effective policy rule in the latter period to offset inflationary movements in the aggregate demand by reacting to commodity prices. This may imply the importance of systematic policy rules in controlling inflation over the unanticipated policy surprises (Cochrane (1998)). As long as the Fed offsets the inflationary tendencies systematically and quickly, monetary policy shocks may not contain a strong inflationary signal, as they did in the pre-Volcker period.

To summarize the results, we find that not only can monetary policy shocks account for the negative correlation between excess returns and inflation, but also that the impact of such shocks is economically and statistically significant. Between 20% and 25% of the negative correlation can be attributed to Fed policy shocks. Our results argue for a more explicit treatment of Fed behavior in asset pricing models. Since neither the money-neutral explanations (Boudoukh et al. (1994)) nor the money demand explanations (Fama (1981), Marshall (1992)) take Fed policy into account, it seems that more theoretical work is needed in that direction.

6 Conclusion

It is commonly thought that the correlation between excess returns and inflation must be zero, if monetary policy is neutral, or positive, if monetary policy has real effects. We find that about a quarter of the negative correlation between excess returns and inflation is explained by shocks to the monetary policy function. In the short run, a contractionary Fed policy shock, implemented by an increase in the Federal Funds rate, induces lower excess rates of return through its effect on real variables. Such a policy has also been followed by a seemingly anomalous increase in consumer prices, called the price puzzle, thus producing the observed negative correlation between excess returns and inflation. The results are robust to alternative VAR ordering schemes and also hold in sub-samples. We show that the negative correlation between returns and inflation, which contradicts simple economic intuition, is linked to the price puzzle.

A cynical view might be that we have replaced one puzzle with another one. However, we present two simple economic hypotheses–one based on the "cost channel" and the other relying on the Fed's superior information–that might account for the price puzzle. The two hypotheses are consistent with our VAR findings, with some recent work (Barth and Ramey (2001) and Romer and Romer (2001)), and suggest that the price puzzle and the anomalous negative correlation between excess returns and inflation might just be the product of these neglected economic mechanisms. While we are unable to distinguish between the two mechanisms, partly because they are not mutually exclusive, this is not the goal of our paper. Our finding is that monetary policy shocks have always been followed by an increasingly negative correlation between returns and inflation, despite the change of Fed policy function in sub-samples. In that sense, our empirical findings seem to be a robust feature of the data.

Our paper leaves some unanswered questions: First, how can we account for the remaining 75% of the negative covariance? Some of it is surely due to money demand shocks, some of it might be caused by cross-sectional fluctuations in industry output (Boudoukh et al. (1994)), and some of it might even be traceable to effects of fiscal policy. Second, is the VAR framework able to test the propositions of Geske and Roll (1983) and Kaul (1986) that some of this negative covariance might also be caused by *systematic* and endogenous monetary policy actions? We are sympathetic to the view, expressed by Bernanke et al. (1997) and Cochrane (1998), that the VAR literature needs to find ways to incorporate and measure the systematic effects of monetary policy onto financial and real variables. However, no matter what the answers to these questions are, the fact remains that a significant fraction of the negative excess returns/inflation covariance is explained by Fed policy shocks. Therefore, if an asset pricing model is to capture the entire negative correlation, it must find ways to account for the policy of the Fed.

Appendix

The eight variables are obtained in monthly frequency from 1966 to 2000. The variables are listed in the order of the Wold causal ordering employed in our VAR analysis.

Name	Description	Source	Mnemonic
IPG	The log difference of the Industrial production, seasonally adjusted, 1987=100.	DRI	IP
INF	The inflation rate, defined by the log difference in the Consumer Price Index, all items, seasonally adjusted.	DRI	PUNEW
DPCOM	The log difference of spot market index for all commodities.	DRI	PSCCOM
FF	The Federal Funds rate, average of business day figures.	DRI	FYFF
DNBRD	Minus the log difference in non-borrowed reserves plus extended credit.	DRI	FMRNBC
DEFP	The spread of Baa-rated over Aaa-rated corporate bond yields.	DRI	FYAAAC, FYBAAC
TERM	The spread between 1-year and 3-month Treasury bill rates, converted to continuously compounding basis.	DRI	FYGM3, FYGMYR
ER	The excess return, obtained by subtracting the one-month T-bill rate (Ibbotson) from the total return on the CRSP value-weighted portfolio.	CRSP Ibbotson	VWRETD Tbill

Notes: DRI stands for the DRI Basic Economics database.

Notes

[1]The original Federal Reserve Act of 1913, signed by President Woodrow Wilson, was much narrower in scope. However, the Banking Act of 1935, the Employment Act of 1946, the Full Employment and Balanced Growth Act of 1978 (a.k.a the Humphrey-Hawkings Act) established the objectives of the Federal Reserve System to be price stability, economic growth, a high level of employment, and moderate long-term interest rates.

[2]Sims (1980,1986), Bernanke and Blinder (1992), Lee (1992), Cochrane (1994), Christiano et al.(1996,1998), Thorbecke (1997), Patelis (1997), etc.

[3]During the first three and a half years of Volcker, 1979-1983, also known as the "Volcker experiment", the Fed pursued a vastly different monetary policy. For more details, see the discussions in the paper.

[4]Moreover, as argued by Bernanke (1995) and Bernanke and Gertler (1995) monetary shocks can affect both the aggregate demand and the aggregate supply. Therefore, identifying aggregate demand and aggregate supply shocks and interpreting the former as money supply shocks might not be the best way to identify monetary policy.

[5]Replacing the industrial production data with interpolated GNP/GDP data constructed as in Bernanke et al. (1997), Bernanke and Mihov (1998) did not change our qualitative results.

[6]For example, Bernanke and Blinder (1992), Bernanke and Mihov (1998), Christiano et al.(1996, 1998), and Leeper et al.(1996).

[7]Most studies that use commodity prices to alleviate the price-puzzle, still exhibit an increase, albeit insignificant, of prices to contractionary monetary policy (Sims (1992), Cochrane (1998), Bernanke et al.(1997), and Ludvigson, et al. (2001))

[8]Lee (1992) uses a VAR in a similar context and finds no causal relationship between real stock returns and inflation. However, his analysis is limited to the lead-lag (causal) relationships among variables, and hence does not explain what shocks account for the negative correlation. This point has been taken up in Hess and Lee (1999) who use long-run identification assumptions (Blanchard and Quah (1989)) to decompose stock returns and inflation into transitory demand components and permanent supply components and argue that the money supply shocks lead to positive correlation between real stock returns and inflation. Although Hess and Lee (1999) interpret the aggregate demand disturbances as money supply shocks, monetary shocks can affect both the aggregate demand and the aggregate supply as argued by Bernanke (1995), and Bernanke and Gertler (1995). Moreover, given the instability of the policy function, it is questionable whether long-run restrictions can really identify monetary policy shocks.

[9]In other words, monetary policy variables respond to innovations in financial variables only with a one-month decision-lag. We do not consider this as restrictive since we use the Federal Funds rates are taken to be monthly averages.

[10]Strongin (1995), Bernanke and Mihov (1998), and Christiano et al.(1998) provide institutional details of the banking system to justify these approaches.

[11]If the VAR system is stable, the h-period forecast error covariance matrix converges to the unconditional covariance matrix as $h \to \infty$, though we do not make any assumption on the stability of our system.

[12]The Schwartz (Bayesian) information criterion (BIC), and Hannan and Quinn (HQ) criterion selected a VAR with 2 lags, and the final prediction error (FPE) criterion selects 3 lags.

[13]In simulating posterior distribution, we assume a multivariate t-distributed innovations to account for the highly leptokurtic nature of VAR residuals observed for most macroeconomic and finance time series data. Using the fact that a K-dimensional t-distributed errors $u_t \sim t_K(0, \Sigma, \nu)$ can be decomposed as $u_t \equiv \varepsilon_t / \sqrt{\varkappa_t / \nu}$ with $\varepsilon_t \sim N_K(\mu, \Sigma)$ and $\varkappa_t \sim \chi^2_\nu$, we can easily simulate the Bayesian posterior bands using a Gibbs sampling algorithm. Assuming a Jeffery's prior and assuming a fixed value for $\nu = 6$, we run the Gibbs sampler for $1,200$ iterations and discard the first 200, leaving $1,000$ posterior samples of each VAR coefficient for our analysis. We then calculate impulse responses and covariance decompositions for each posterior draw and extract the probability bands as in Sims and Zha (1999). Throughout this paper, we report point estimates and intervals with coverage probability 0.68 (one standard error, if Gaussian) and 0.90.

[14]The response of the covariance between excess returns and inflation to all 8 shocks in the VAR is available upon request.

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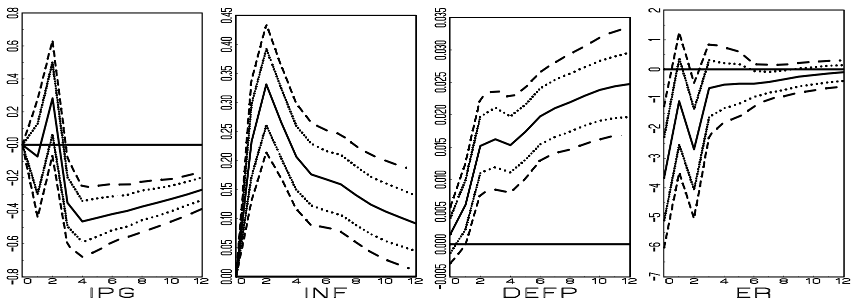
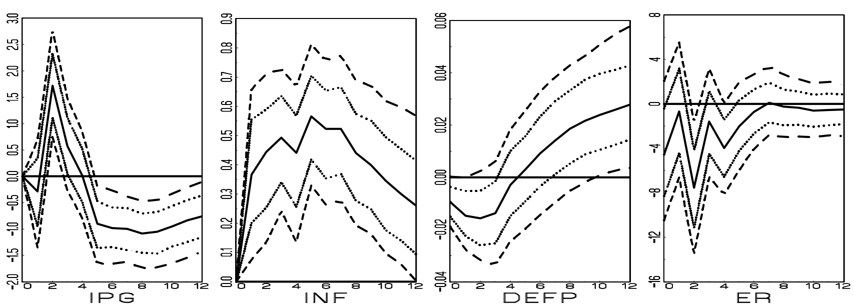
Figure 1: Responses of variables to a +0.25% Federal Funds rate shock

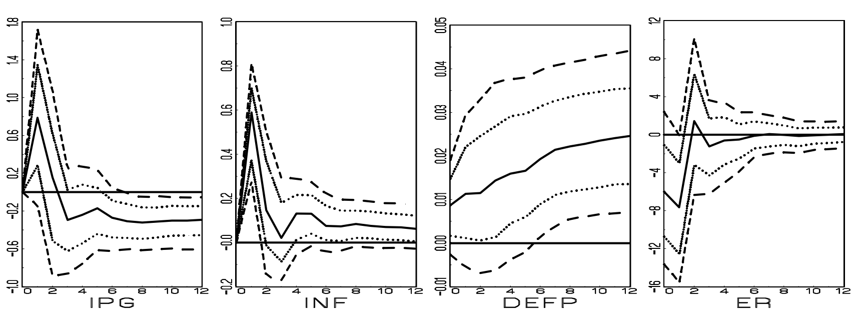
(a) Whole sample period (1966:01–2000:12)



(b) Pre-Volcker period (1966:01–1979:06)

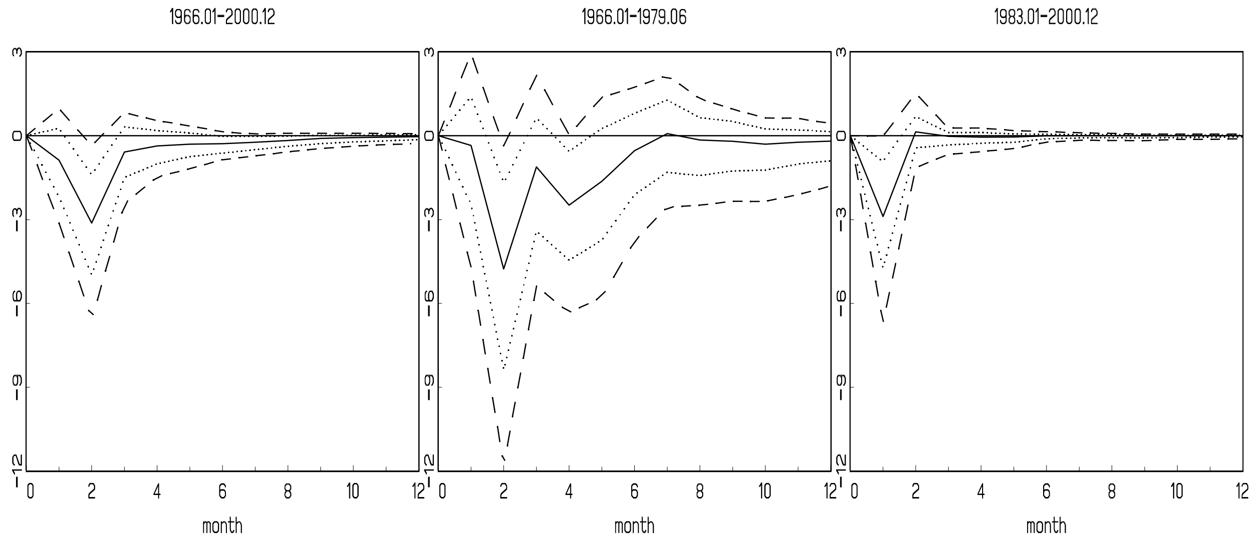


(c) Post-Volcker period (1983:01–2000:12)



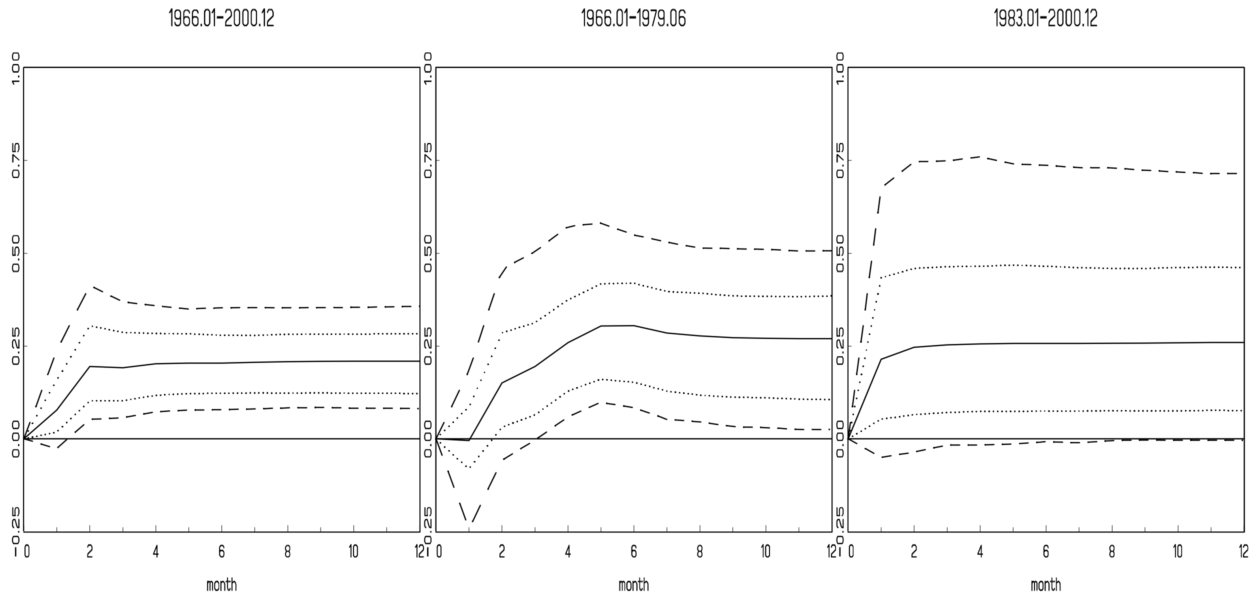
Notes: Effects of monetary policy shocks on non-policy variables in our system, plotted for (a) the full sample period (1966:01–2000:12), (b) the pre-Volcker period (1966:01–1979:06), and (c) the post-Volcker period (1983:01–2000:12). Each graph shows impulse response functions of IPG, INF, DEFP, and ER to a +0.25 percent identified shock to the Federal Funds rate, over a 12-month horizon following the shock. The scale on the vertical axis represents the magnitude of responses in annual percentage points. Solid lines are point estimates, dotted lines are 68% posterior bands, and dashed lines are 90% posterior bands, estimated point by point. The posterior bands are simulated assuming multivariate t distributed (d.f.$=$ 6) innovations.

Figure 2: Dynamic effects of a Federal Funds rate shock on the conditional covariance between inflation and excess returns



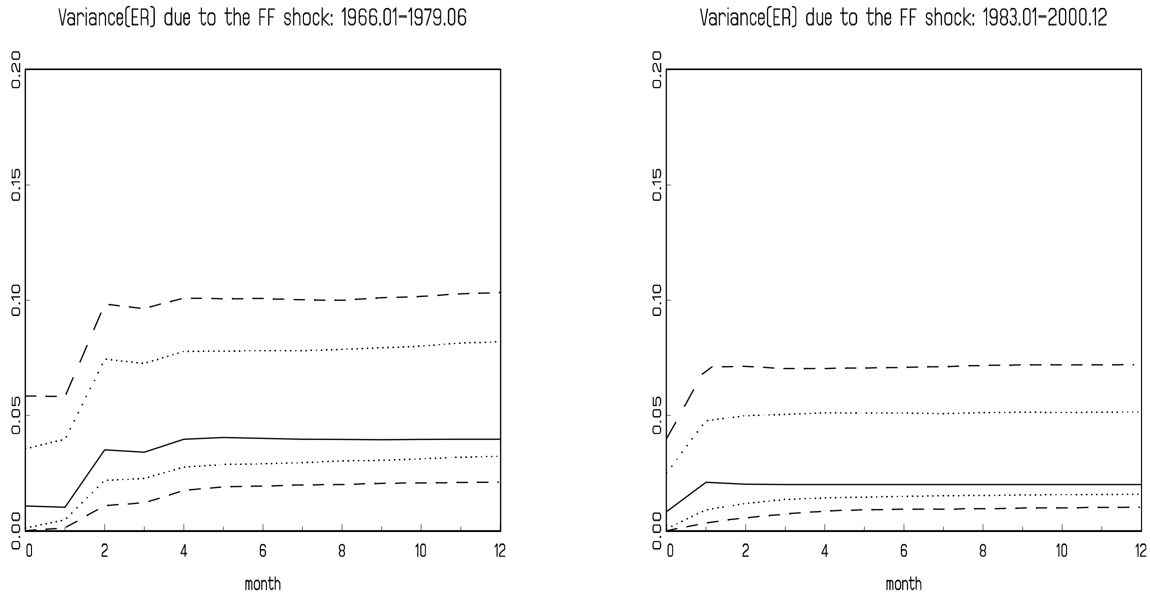
Notes: Effects of monetary policy shocks on the covariance between inflation (INF) and excess returns (ER) for the full sample period (1966:01–2000:12; left panel), pre-Volcker period (1966:01–1979:06; center panel), and post-Volcker period (1983:01–2000:12; right panel). Each graph is the response of covariance between INF and ER to a one-standard-deviation identified shock to the Federal Funds rate, plotted over a 12-month horizon following the month of the shock. The vertical axis scales represent deviation in the forecast error covariance between inflation and excess returns. Solid lines are point estimates, dotted lines are 68% posterior bands, and dashed lines are 90% posterior bands, estimated point by point. Posterior bands are simulated assuming multivariate t distributed (d.f.=6) innovations. Responses of the h-period forecast error covariance between i-th and j-th variables to the k-th identified innovation is given by $\theta_{h-1}(i,k)\,\theta_{h-1}(j,k)$, $h = 1, 2, ...$, where $\theta_{h-1}(i,k)$ is the (i,k)-th element of the impulse response matrix Θ_{h-1} after the triangular identification assumptions have been imposed.

Figure 3: Covariance Decomposition: Proportion of Cov(INF,ER) explained by FF shocks



Notes: Decomposition of the covariance between inflation (INF) and excess returns (ER) for the full sample period (1966:01–2000:12; left panel), the pre-Volcker period (1966:01–1979:06; center panel), and the post-Volcker period (1983:01–2000:12; right panel). Each graph is the cumulative response of conditional covariance between INF and ER to a one-standard-deviation identified shock to the Federal Funds rate, plotted over a 12-month horizon following the month of the shock. Solid lines are point estimates, dotted lines are 68% posterior bands, and dashed lines are 90% posterior bands, estimated point by point. Posterior bands are simulated assuming multivariate t distributed (d.f.=6) innovations. The covariance decomposition, i.e., the percentage that h-period forecast error covariance between i-th variable and j-th variable accounted for by shocks in k-th variable, is given by $\frac{\sum_{s=0}^{h-1}\theta_s(i,k)\theta_s(j,k)}{\sum_{k=1}^{K}\sum_{s=0}^{h-1}\theta_s(i,k)\theta_s(j,k)}$ for $h = 1, 2, ...$, where $\theta_s(i,k)$ is the (i,k)-th element of the impulse response matrix Θ_s after the recursive (triangular) identification assumptions have been imposed.

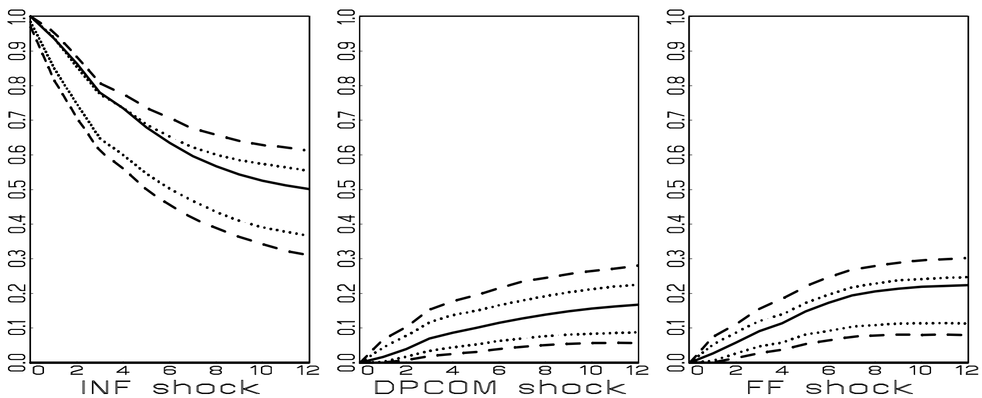
Figure 4: Variance decompositions of excess returns (ER) due to Federal Funds rate shocks



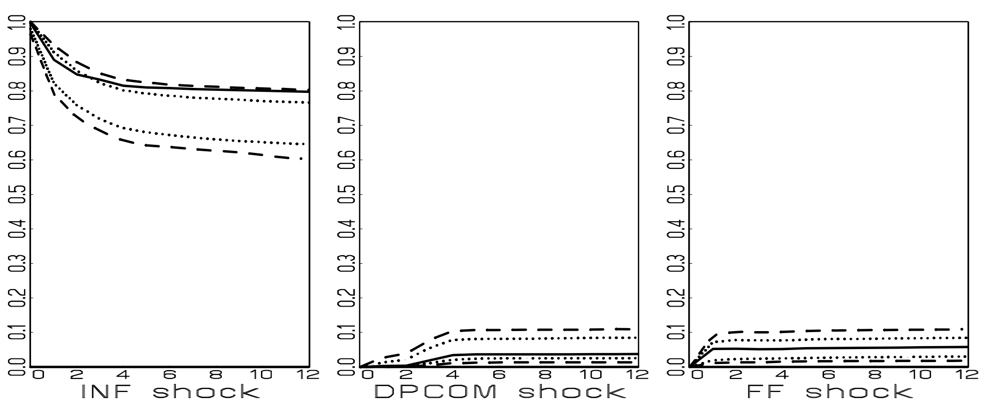
Notes: Variance decomposition of excess returns (ER) for the pre-Volcker period (1966:01–1979:06; left panel) and the post-Volcker period (1983:01–2000:12; right panel), explained by identified federal funds rate (FF) shocks. Each variance decomposition is plotted over a 12-month horizon following the month of the shock. Solid lines are point estimates, dotted lines are 68% posterior bands, and dashed lines are 90% posterior bands, estimated point by point. Posterior bands are simulated assuming multivariate t distributed (d.f.=6) innovations.

Figure 5: Variance decomposition of inflation (INF)

(a) Pre-Volcker Period (1966:01–1979:06)



(b) Post-Volcker Period (1983:01–2000:12)



Notes: Variance decomposition of inflation (INF) for (a) the pre-Volcker period (1966:01–1979:06) and (b) the post-Volcker period (1983:01–2000:12), explained by triangularly orthogonalized innovations in INF, DPCOM, and FF. Each variance decomposition is plotted over a 12-month horizon following the month of the shock. Solid lines are point estimates, dotted lines are 68% posterior bands, and dashed lines are 90% posterior bands, estimated point by point. Posterior bands are simulated assuming multivariate t distributed (d.f.=6) innovations.