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Dynamic Interactions among the Stock Market, Federal Funds Rate, Inflation, and Economic Activity

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Abstract

This paper examines the dynamic interactions among the equity market, economic activity, inflation, and monetary policy under three monetary policy regimes using bivariate and multivariate vector autoregressive cointegrating specifications. The bivariate results for the real stock returns-inflation pair weakly support a negative correlation in the 1970s and 1980s. While the bivariate findings suggest a weak, negative relationship between real returns and the federal funds in the 1970s and 1980s, the multivariate findings strongly support short-term linkages in the 1970s. There appears to be no consistent dynamic relationship between monetary policy and stock prices in that the relationship differs across monetary regimes.

Keywords: monetary policy, equity market, inflation, economic activity, VAR, cointegration, Granger causality

JEL Classifications: E52, E44, G10

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1. Introduction

Understanding how monetary policy is transmitted to the economy by the way it affects the stock market and other macroeconomic magnitudes remains one of the most important challenges among economists. The significance of this issue is underscored by the following scenario. Assume a change in one of the monetary policy instruments such as the money supply or the instrumental rate (i.e., the federal funds rate [FFR]). Such a change leads to changes in market interest rates which, in turn, forces investors to revalue their equity holdings. This happens because the value of their wealth, given by the sum of the discounted future cash flows (or dividends), is affected by an easing or tightening of monetary policy through either expected earnings or through the discount rate. Therefore, a shift in monetary policy stance will induce changes in the consumption patterns of individuals and in the investment plans of firms, causing changes in real economic activity and ultimately affecting inflation. Simply put, the transmission of monetary policy via changes in the short-term interest rates influences asset prices which, in turn, affect borrowing costs, private wealth, and ultimately real economic activity.

There are several theories about how monetary policy and the stock market interact (see Bordo and Wheelock, 2004, for a survey). The traditional view contends that an expansionary monetary policy increases the demand for (and prices of) assets and stimulates the general economy. A second view suggests that asset price imbalances are more likely to occur during a low and stable inflationary environment. Yet another view argues that financial instabilities stem from the failure of the monetary authorities to credibly stabilize the price level. Equity prices are closely watched because they are considered to be very sensitive to economic conditions and swing widely, leading to concerns about potential financial instability or bubbles with adverse economic effects. The Federal Reserve could respond to such concerns by making pre-emptive changes to the fed funds rate to alter the course of the economy.

The linkage between the stock market and inflation is also of interest in that they both interact with monetary policy. Early research, beginning with Fama (1981), seems to indicate a negative correlation between inflation and stock returns but subsequent research did not support these findings. Nonetheless, it is well understood that if the stock market continues to record advances, due to a favorable interest rate climate, then asset prices will begin to increase and inflation will also increase, thus prompting the Fed to take decisive action to curtail (or contain) inflationary pressures.

In view of the above considerations and given the mixed evidence on the linkages among stock returns, inflation, real activity, and monetary policy in the literature, this paper investigates whether significant dynamic interdependencies exist among these variables from the 1970s to recent years. This paper is the first, to our knowledge, that examines all four variables in a multivariate setting and by Federal Reserve regime.

The first issue concerns the role of monetary policy. The following questions are addressed. First, is monetary policy influenced by movements in the stock market or vice versa? Second, has monetary policy during the last three decades been mostly neutral with respect to movements in the equity market? After all, the financial markets pay attention to the comments of the Fed's chairman that soaring equity prices generate imbalances in economic activity, thereby creating unstable prices that can endanger the sustainability of long-run economic growth. Finally, is the Fed's policy response directed primarily toward taming inflationary pressures, as the Fed contends, thereby indirectly affecting the stock market?

The second issue deals with the relationship between equity returns and inflation. In view of the Fisher hypothesis and the notion that stocks should be a good hedge against inflation, the above findings to the contrary are indeed perplexing and worth investigating further. The last issue is the relationship between real activity and equity returns, in light of the varied evidence that stock returns are not always a leading indicator of future economic activity. The particular questions addressed here are whether the stock market and economic activity are closely related and whether the stock market has contributed to real economic growth since the 1970s.

This paper exploits recent econometric advances, including cointegration, causality, and error-correction (EC) methods via the means of bivariate and multivariate Vector Autoregressive (VAR) or multivariate Vector Error-Correction (VEC) models. Another distinctive feature of this paper is the use of subperiods. Analysis by subperiods reveals how stock prices, inflation and real activity respond to the frequent changes in the Fed's monetary policy regimes (see subsection 3.1). The paper also is innovative in considering the dynamic interdependencies between monetary policy and the stock market. The issue of whether and how monetary policy affects real activity and inflation through the stock market is of interest to central bankers.

2. Literature review

Few studies address the linkages among monetary policy, the stock market, inflation, and real economic activity (e.g., Fama, 1990; Bulmash and Trivoli, 1991; and Lee, 1992), all of which imply that macroeconomic fundamentals have predictive power for the stock market, although they do not agree about the predictive power of stock prices for the economy.

Several theoretical and empirical studies attempt to explain the puzzling negative relationships between inflation and real equity returns (e.g., Fama, 1981; Geske and Roll, 1983; Stultz, 1986; Kaul, 1987; and Lee, 1992), between inflation and real interest rates (e.g., Fama and Gibbons, 1982), and between inflation and real economic activity (e.g., Kaul, 1987; Barro, 1990; Fama, 1990; and Gallinger, 1994) in the postwar period. For instance, Fama (1981) assumes that the negative correlation between inflation and stock returns is a proxy for the positive relationship between stock returns and real economic activity brought by the negative relationship between real activity and inflation. Lee finds that stock returns appear to explain economic activity but not inflation, in the presence of interest rates, and that inflation does not seem to explain variations in real economic activity. Fama (1990) reports that the relation between stock returns and production growth reflects information about future cash flows embedded in stock prices. Finally, Gallinger finds that the stock market helps explain future changes in wealth and real economic activity and one-way causality between real stock returns (RSR) and real activity.

A study by Park and Ratti (2000) is the first to examine all four magnitudes (i.e, stock prices, interest rates, inflation, and real activity) concurrently. The authors apply a rolling VAR model to the 1955–1998 period and subperiods. They find that shocks to monetary tightening generate movements in inflation and (expected) real returns and that favorable output shocks produce monetary tightening. Overall, the authors conclude that during a period of high volatile interest and inflation rates, an "anticipation" hypothesis is in effect.

The evidence regarding the causal linkages between monetary policy, stock returns, and inflation is mixed. For instance, some researchers (e.g., Bernanke and Gertler, 1999) contend that the central bank should pay attention to asset price inflation since targeting inflation, by properly setting interest rates, will stabilize asset prices in turn. Cogley (1999) goes farther, suggesting that intentional attempts to deflate asset bubbles may actually destabilize the economy. In a similar vein, Bordo and Jeanne (2002) and Fair (2000) argue that traditional monetary policy actions may be unable to correct asset price disturbances.

Another strand of research on the linkages between monetary policy and the equity market examines whether monetary policy can improve economic performance by paying attention to asset prices. Here again, the evidence is varied. For instance, while some authors (e.g., Cecchetti, 1998 and Chami, Cosimano, and Fullenkamp, 1999) find that central bankers can contribute to economic stability and growth by targeting asset prices, others (e.g., Filardo, 2000) do not. Moreover, Bernanke and Kuttner (2003) show that the response of stock prices is driven by the impact of monetary policy on expected future excess returns (and future dividends) and that different industries react differently to monetary policy shocks. Bjornland and Leitemo (2005) find "a substantial degree of independence between monetary policy decisions and stock prices" and their results appear to be robust during the 1980s and 1990s.

Another thread of the literature attempts to measure the reaction of monetary policy to asset prices. Bernanke and Gertler (1999) report that the response of interest rates to stock returns is negative for the United States and Japan, whereas Rigobon and Sack (2002) find a positive reaction of monetary policy to stock market movements.

The evidence concerning the causal relationship between the stock market and real economic activity is also varied. For example, while Fama (1990, 1991) and Geske and Roll (1983), among others, point out that a large portion of stock return variations are explained by future changes in real economic activity, more recent evidence (e.g., Laopodis and Sawhney, 2002) either finds the opposite or reports that such a relationship does not hold during every decade since the 1970s.

In sum, in view of the above relatively inconclusive evidence on the intertemporal linkages among the four magnitudes, and the observation that there is no clear empirical consensus on the usefulness of stock market information on monetary policy and vice versa, there could still be several arguments for why stock prices and monetary policy should influence each other. Perhaps the lack of a unifying theoretical framework to examine the diverse impacts of different variables, or the use of several different methods or even samples, may account for the fragmented empirical findings. We investigate the simultaneous, dynamic interactions among the four variables over different monetary policy regimes to determine whether the regimes have different impacts on the linkages among the variables.

3. Methods and preliminary statistical investigation

3.1. Data construction and preliminary statistical investigation

Monthly data for 1970–2004 on the FFR, the S&P 500 index (SP), the Consumer Price Index (CPI), and the industrial production index (IP) come from Thomson Datastream and the Federal Reserve's FRED database. Recent studies typically use the FFR to examine the effects of monetary policy actions on interest rates, foreign exchange rates and stock prices (see Bernanke and Blinder, 1992; Lobo, Darrat and Ramchander, 2006 and the references therein). We analyze continuous nominal, gross monthly nominal stock returns:

$$NSR_t = \ln(\mathrm{SP}_t/\mathrm{SP}_{t-1}) \tag{1}$$

where SP_t is the value of the S&P 500 index at the beginning of month t. To find real returns, monthly stock prices are deflated by the CPI, and the rate of inflation measure is $INF_t = \ln(\mathrm{CPI}_t/\mathrm{CPI}_{t-1})$.[1] The proxy for real economic activity, IPX_t, is the Federal Reserve's Board Index of IP; its rate of change, IP_t, is analogous to Equation (1).

We split the sample period into three subperiods to detect potential changes in the dynamic linkages between the variables over time. In general, the characteristics of each subperiod include various disturbances such as oil shocks in the 1970s, periods of expansion and recession during the 1980s, a prolonged expansion during the 1990s, and several changes in the Fed's targets for monetary policy (for instance, the FFR was not the main monetary policy instrument in the late 1970s and early 1980s).

The subperiods coincide with the terms of the three Federal Reserve Board chairmen, Arthur Burns (1970–1978), Paul Volcker (1979–1987), and Alan Greenspan (1988–2005). Under Burns, inflation in the United States increased from 5% in 1970 to about 9% in 1980.[2] Burns chose to accommodate the building of inflationary expectations by allowing the money supply to grow rather than accept a costly recession. Several researchers (e.g., Orphanides, 2002 and Spencer, 2004) conclude that the Fed under Burns systematically misinterpreted the state of economy (i.e, it had serious misperceptions about the output gap). Under Volcker's chairmanship, the Federal

[1] Using the GDP deflator instead of the CPI as the proxy for inflation produces substantially similar results for all tests. See Jones and Wilson (2006) for an analysis of alternative inflation measures.

[2] G. William Miller was chairman from March 1978 to August 1979.

Table 1

Descriptive statistics of monthly stock returns, interest rates, inflation, industrial production growth, and money supply growth by Federal Reserve chairmanship subperiod, 1970–2002

NSR and RSR are the nominal and real S&P 500 stock index returns, respectively; FFR is the federal funds rate; INF is the rate of inflation based on the CPI; IP is real industrial production growth; M1G is the growth rate in M1. All variables are monthly percentages; NSR, RSR, INF, IP, and M1G are in continuously compounded form. J-B is the Jarque-Bera statistic for normality.

Variable	Mean	SD	Skewness	Kurtosis	Min	Max	J-B
				1970–1978			
NSR	0.4810	4.6104	0.0330***	3.0707***	−12.2351	15.5371	4.89
RSR	−0.0665	4.7152	−0.0537***	3.9296***	−13.6293	14.7496	3.44
FFR	6.6589	2.2245	0.8346***	2.7776***	3.2901	12.9280	12.04
INF	0.5475	0.3185	0.8341	4.2722***	0.0010	1.7933	19.32***
IP	0.2812	0.9421	−1.2857	6.9321***	−3.6083	2.3421	99.75***
				1979–1987			
NSR	1.4790	4.3323	0.0398	3.2542***	−10.2531	12.6333	0.26
RSR	0.9641	4.4277	−0.0029	3.2523***	−11.5124	12.0071	0.19
FFR	10.8709	3.4056	0.8451***	2.8747***	5.8501	19.1004	11.44***
INF	0.5134	0.4286	0.2229	2.4083***	−0.4584	1.5003	2.65
IP	0.0812	0.8221	−0.1557	3.7121***	−2.5083	2.0421	2.75
				1988–2002			
NSR	1.2341	4.4417	−1.4299***	9.3592***	−24.6151	12.6230	161.77***
RSR	0.9653	4.4712	−1.4126***	9.1639***	−24.5617	12.0086	136.95***
FFR	5.7915	1.6916	0.3270***	2.7093***	2.9200	9.8500	3.06
INF	0.2717	0.2007	0.7317***	3.8716***	−0.1204	1.0256	20.66***
IP	0.2872	0.5111	−0.1757	3.3323***	−1.2383	1.8521	1.75
				1970–2002			
NSR	1.0420	4.4412	−0.6676***	6.1475***	−24.2532	15.5372	17.43***
RSR	0.6306	4.5155	−0.6770***	5.8554***	−24.5145	14.5596	175.45***
FFR	7.3544	3.1980	1.3519***	5.0814***	2.9200	19.1004	154.23***
INF	0.4160	0.3341	0.8723***	3.9634***	−0.4584	1.7937	82.76***
IP	0.2372	0.7411	−0.8957***	6.7923***	−3.6083	2.3421	143.75***

***Statistical significance at the 0.005 level.

Reserve Board reduced inflation by lowering the monetary growth rate, which, in turn, sharply increased interest rates. In other words, Volcker put more emphasis on stabilizing the growth rate of the money supply over that of the real economy. As a result of his inflation-fighting strategies, which were highly successful, the growth in the CPI was reduced to just below 4% from about 14% from 1980 to 1982. Finally, in the 1990s, Alan Greenspan's idea of monetary policy was to carefully balance its use to offset adverse shocks to the economy and the anxiety that monetary policy should not be too expansionary (so as to build inflationary expectations which may become self-fulfilling).

Table 1 reports descriptive statistics for the sample period and three subperiods, 1970–1978, 1979–1987, and 1988–2002. The risk-return characteristics of the stock (nominal, NSR, and real, RSR) returns vary over time with the 1980s exhibiting greater returns with lower risk. The 1980s also have the highest FFR (19.1%) and the highest subperiod average FFR (10.87%). The rate of inflation, *INF*, is highest in the 1970s, declines a bit in the 1980s, and more notably in the 1990s. Finally, *IP* declines steadily since the 1970s.

To determine if the variables are stationary, each is checked for unit roots via the Augmented Dickey-Fuller (see Dickey and Fuller, 1987) and the Phillips-Perron (1988) tests. The univariate results (available upon request) provide strong evidence in favor of the presence of a unit root in the series (including the nominal and real stock prices).[3] Because each of the four series contains a unit root, we check for cointegration.

3.2. Cointegration tests and results

We check for cointegration using the method of Johansen and Juselius (1991). The method yields two likelihood ratio statistics for the number of cointegrating vectors, namely the maximum eigenvalue and the trace statistics. Given the small sample sizes in this study, we use finite-sample critical values obtained by the method of Cheung and Lai (1993).[4]

Table 2 presents the results of the Johansen cointegration procedure. Panel A gives the results of the bivariate relationships of interest in this paper, and panel B those of the multivariate cointegration test. The variable pairs of interest are RSR and real activity (represented by IP growth), RSR and fed funds rate, and RSR and inflation.[5] Panel A reports that the RSR-IP pair exhibits no cointegration in any subperiod. The stock returns-fed funds rate pair does not exhibit cointegration in the first or the second subperiod but it does in the third. Finally, the third variable pair—stock returns-inflation—displays bivariate cointegration in the first and third subperiods.

The multivariate cointegration results in panel B of Table 2 show that one or no common stochastic trend exists that binds the FFR, the S&P500, the inflation rate, and IP in the long run. Specifically, during the 1970s and the 1990s (albeit a marginal significance, based on the trace statistic) it can be interpreted that there is a single common stochastic trend that binds the four variables together in the long run but not in the 1980s. Consequently, the estimation of the dynamic linkages among the variables must include an EC term in the first and third subperiods to explicitly model the previous period's disequilibrium relationship.

[3]The results are similar using the Kwiatkowski, Phillips, Schmidt and Shin (1992) test.

[4]Cheung and Lai (1993) obtain the finite-sample critical values by adjusting the asymptotic critical values for the loss of degrees of freedom due to the estimation of parameters representing the short-term dynamics (see Table 1, p. 318, in their paper). We thank an anonymous referee for pointing this out.

[5]Using nominal stock returns in place of real stock returns produces quantitatively and qualitatively similar results.

Table 2

Cointegration tests

The tests assume a linear deterministic trend; lag interval (in first differences) in the VAR/VEC specifications: 1–4; CE(s) indicates cointegrating equation(s); CVs are the sample-size adjusted (per Cheung and Lai, 1993) critical values; 'none' means one cointegrating relationship binding all variables.

Hypothesized No. of CE(s)	Trace Statistics	5% CV	1% CV	Max-Eigenvalue Statistics	5% CV	1% CV
Panel A: Bivariate tests						
Real stock returns and real activity (industrial production growth)						
1970–1978						
None	3.4166	12.53	16.31	3.1816	11.44	15.69
At most one	0.2349	3.84	6.51	0.2349	3.84	6.51
1979–1987						
None	11.5875	12.53	16.31	10.3542	11.44	15.69
At most one	1.2333	3.84	6.51	1.2333	3.84	6.51
1988–2002						
None	6.4010	12.53	16.31	6.3989	11.44	15.69
At most one	0.0020	3.84	6.51	0.0020	3.84	6.51
Real stock returns and federal funds rate						
1970–1978						
None	10.5436	12.53	16.31	6.0596	11.44	15.69
At most one	4.4840	3.84	6.51	4.4840	3.84	6.51
1979–1987						
None	9.5565	12.53	16.31	9.3200	11.44	15.69
At most one	0.2365	3.84	6.51	0.2365	3.84	6.51
1988–2002						
None	8.4540	12.53	16.31	8.3310	11.44	15.69
At most one	0.1230	3.84	6.51	0.1230	3.84	6.51
Real stock returns and inflation						
1970–1978						
None	13.4566*	12.53	16.31	12.0006*	11.44	15.69
At most one	1.4560	3.84	6.51	1.4560	3.84	6.51
1979–1987						
None	10.5875	12.53	16.31	10.3792	11.44	15.69
At most one	0.2083	3.84	6.51	0.2083	3.84	6.51
1988–2002						
None	14.7710*	12.53	16.31	10.4190	11.44	15.69
At most one	1.3520	3.84	6.51	1.3520	3.84	6.51

(*continued*)

3.3. VEC model and causality tests

In view of the evidence of cointegration, the Engle-Granger (1987) representation theorem and the Johansen procedure would suggest that the dynamic relationships among the four cointegrated variables can be examined in an EC model. This approach

Table 2 (*continued*)

Cointegration tests

Hypothesized No. of CE(s)	Trace Statistics	5% CV	1% CV	Max-Eigenvalue Statistics	5% CV	1% CV
Panel B: Multivariate tests						
Real stock returns, real activity (industrial production growth), inflation, federal funds rate						
1970–1978						
None*	43.553*	44.67	51.50	20.707	26.60	32.22
At most one	12.236	21.72	27.20	29.750	19.90	25.69
At most two	2.048	14.03	18.21	2.127	12.74	17.89
At most three	0.023	4.30	7.77	0.023	4.30	7.77
1979–1987						
None	36.918	44.67	51.08	19.505	26.60	32.22
At most one	17.412	21.72	27.20	11.439	19.90	25.69
At most two	5.972	14.03	18.21	4.475	12.74	17.89
At most three	0.682	4.30	7.77	0.682	4.30	7.77
1988–2002						
None*	44.708*	44.67	51.08	39.775*	26.60	32.22
At most one	19.412	21.72	27.20	14.933	19.90	25.69
At most two	5.709	14.03	18.21	4.479	12.74	17.89
At most three	1.230	4.30	7.77	1.230	4.30	7.77

**Statistical significance at the 0.01 level.
*Statistical significance at the 0.05 level.

can capture the short- and the long-run equilibrium dynamics among the time series. It provides a convenient way to examine Granger causality among the variables, which provides the short-run dynamic adjustments required by the levels of the variables to equilibrate in the long run.

In view of the existence of one cointegrating relationship among the variables in $X_{t,}$ the causal relationship among the four variables can be determined by estimating the following general VEC model:

$$\Delta X_t = \alpha + \gamma\beta X_{t-1} + \Sigma_{j=1}^{k}\Gamma_j \Delta X_{t-j} + \varepsilon_t \tag{2}$$

where α is an $n \times 1$ constant vector representing a linear trend, and γ and β denote respectively the speed of adjustment and the cointegration vector. The vector of X_t consists of real stock returns, RSR_t, the federal funds rate, FFR_t, the inflation rate, INF_t, and the industrial production growth rate, IP_t. Consequently, following the Granger representation theorem, four cointegrated variables have the following joint VEC representation under a single cointegrating relationship:

$$\Delta FFR_{i,t} = \alpha_1 + \gamma_1\varepsilon_{t-1} + \sum_{i=1}^{n1} \beta_{1,i}\Delta FFR_{i,t} + \sum_{i=1}^{n2} \beta_{2,i}\Delta RSR_{j,t} + \sum_{i=1}^{n3} \beta_{3,i}\Delta INF_{i,t} + \sum_{i=1}^{n4} \beta_{4,i}\Delta IP_{j,t} + \mathrm{e}_{1,t} \tag{3}$$

$$\Delta RSR_{j,t} = \alpha_2 + \gamma_2\varepsilon_{t-1} + \sum_{i=1}^{m1} \delta_{1,i}\Delta FFR_{i,t} + \sum_{i=1}^{m2} \delta_{2,i}\Delta RSR_{j,t} + \sum_{i=1}^{m3} \delta_{3,i}\Delta INF_{i,t} + \sum_{i=1}^{m4} \delta_{4,i}\Delta IP_{j,t} + e_{2,t} \quad (4)$$

$$\Delta INF_{i,t} = \alpha_3 + \gamma_3\varepsilon_{t-1} + \sum_{i=1}^{l1} \phi_{1,i}\Delta FFR_{i,t} + \sum_{i=1}^{l2} \phi_{2,i}\Delta RSR_{j,t} + \sum_{i=1}^{l3} \phi_{3,i}\Delta INF_{i,t} + \sum_{i=1}^{l4} \phi_{4,i}\Delta IP_{j,t} + e_{3,t} \quad (5)$$

$$\Delta IP_{j,t} = \alpha_4 + \gamma_4\varepsilon_{t-1} + \sum_{i=1}^{p1} \theta_{1,i}\Delta FFR_{i,t} + \sum_{i=1}^{p2} \theta_{2,i}\Delta RSR_{j,t} + \sum_{i=1}^{p3} \theta_{3,i}\Delta INF_{i,t} + \sum_{i=1}^{p4} \theta_{4,i}\Delta IP_{j,t} + e_{4,t} \quad (6)$$

where Δ is the first difference operator, and $e_{1,t}, \ldots, e_{4,t}$ are stationary random error terms. The ni's, mi's, li's, and pi's, $(i = 1, \ldots, T)$ are the optimal orders of the autoregressive process for a given variable. Finally, the ε_{t-1} magnitudes are the EC terms obtained from the cointegrating equations, so that changes in the four variables are partly driven by the past values of ε_t.

Under cointegration, Equations (3)–(6) make up an appropriate system for evaluating the dynamic short- and long-run interactions among the four variables. The short-run dynamics between two variables, say *FFR* and *RSR*, are captured by the $\beta_{2,i}$ and $\delta_{1.i}$ coefficients. If one or more of the $\beta_{2,i}$ coefficients is nonzero and significant, then movements in the stock market have a short-run effect on the FFR. Similarly, if one or more of the $\delta_{1,i}$ coefficients is nonzero and significant, then movements in the FFR have a short-run effect on the stock market. On the other hand, the existence of a long-run relationship between the FFR and the stock market depends upon the statistical significance of γ_1 and γ_2 coefficients. Given that the *FFR* and *RSR* are cointegrated, the ε_t term that represents the divergence from the long-run relation must incorporate both variables and either γ_1 or γ_2 is expected to be negative and statistically significant. Nonetheless, we also examine the lagged influences(s) of each variable by estimating coefficients of $\beta_{1,i}$ and $\delta_{2.i}$.

Because explaining several lags of all four variables in the system may become tedious, we summarize the effects of the short- and long-run causal relationships between the FFR and the stock market using four key hypotheses. These hypotheses, which formalize the objectives stated in the introduction, are:

Hypothesis 1: RSR Granger-cause the FFR; the null is no causality: H_0: $\gamma_1 = 0$ and $\beta_{2,i} = 0$ for all i and all subperiods.

Hypothesis 2: The FFR Granger-causes RSR; the null is no causality: H_0: $\gamma_2 = 0$ and $\delta_{1,i} = 0$ for all i and all three subperiods.

Hypothesis 3: RSR Granger-cause inflation; the null is no causality: H_0: $\gamma_3 = 0$ and $\phi_{2,i} = 0$ for all i and all three subperiods.

Hypothesis 4: RSR Granger-cause real economic activity; the null is no causality: H_0: $\gamma_4 = 0$ and $\theta_{2,i} = 0$ for all i and all three subperiods.

If we reject the null hypotheses, lagged values of one variable can explain variations in the other variable. If the lag structure is misspecified, the empirical results could be biased, so we use Akaike's (1969) minimum final prediction error (FPE) criterion to determine the optimal lag structure of the *ni*'s in Equations (3)–(6).

4. Bivariate results and discussion

4.1. Granger causality and correlations

Before we move to the estimation of the multivariate VAR/VEC models among the four variables, we present bivariate estimates for pairs of variables. The Granger-causality estimates appear in Table 3; the optimal lag length is two months, based on the FPE criterion. For the first 1970s, the only significant bidirectional Granger-causality relationship is between the FFR and RSR. The 1980s contain one strong reciprocal relationship, for the pair of industrial production IP-FFR, and four marginal unidirectional ones: FFR-INF, RSR-IP, RSR-INF, and INF-IP. The 1990s exhibit two significant bidirectional causality results: IP-FFR and INF-IP.

The above findings resemble those of other studies that use somewhat different approaches. The causality from stock returns to IP is similar to Gallinger (1994) and Laopodis and Sawhney (2002). Domian, Gilster, and Louton (1996) find Granger causality from interest rates to stock returns; like this paper, they report the results to be robust to the 1987 crash period.

Some observations are in order for the bivariate correlations in Table 3. First, there is a moderate negative correlation between RSR and FFR in the 1970s, and it becomes stronger in the 1980s. Second, the correlations in general keep the same signs across subperiods, with the exception of INF-FFR, which becomes negative in the 1990s. The highest correlation (0.3121) is between FFR and IP in the 1990s, and the lowest correlations (0.0124 and 0.0141) are FFR-INF and IP-RSR in the 1970s and 1990s, respectively. Overall, the correlations do not suggest strong comovements among the variables in any period and some of the signs are puzzling.

The above results are not directly comparable to other studies due to different periods and variables. However, one result that stands out is the presence of causality between RSR and IP, which is in line with studies such as those by Fama (1990), Lee (1992), and Gallinger (1994).

Table 3

Bivariate Granger causality tests and correlations

RSR = real S&P 500 stock index return; IP = real industrial production growth; FFR = federal funds rate; INF = inflation rate. RSR, IP, and INF are monthly rates in continuously compounded form. Arrows (→) show the direction of Granger causality tested; *p*-values are in parentheses.

Subperiod	Granger causality test			Correlation
1970–1978	RSR → FFR	F-stat = 6.5471*	(0.0001)	−0.3164
	FFR → RSR	F-stat = 5.3387*	(0.0003)	
	IP → FFR	F-stat = 1.0437	(0.3844)	0.2014
	FFR → IP	F-stat = 0.2443	(0.9441)	
	INF → FFR	F-stat = 0.7447	(0.9145)	0.0141
	FFR → INF	F-stat = 3.1312**	(0.0245)	
	IP → RSR	F-stat = 0.7440	(0.5366)	0.0243
	RSR → IP	F-stat = 0.8442	(0.5271)	
	INF → RSR	F-stat = 2.3446**	(0.0588)	−0.2247
	RSR → INF	F-stat = 0.7561	(0.5899)	
	INF → IP	F-stat = 1.2776	(0.3094)	−0.2144
	IP → INF	F-stat = 0.4328	(0.8443)	
1979–1987	RSR → FFR	F-stat = 1.3221	(0.2344)	−0.1384
	FFR → RSR	F-stat = 1.1237	(0.3336)	
	IP → FFR	F-stat = 6.8443*	(0.0001)	0.2215
	FFR → IP	F-stat = 6.6443*	(0.0001)	
	INF → FFR	F-stat = 1.7444	(0.1322)	0.0916
	FFR → INF	F-stat = 3.4444**	(0.0115)	
	IP → RSR	F-stat = 0.5440	(0.6214)	0.0287
	RSR → IP	F-stat = 4.5558**	(0.0435)	
	INF → RSR	F-stat = 0.6546	(0.6242)	−0.1074
	RSR → INF	F-stat = 5.9776**	(0.0260)	
	INF → IP	F-stat = 3.2778**	(0.0145)	−0.1970
	IP → INF	F-stat = 1.6870	(0.1223)	
1988–2002	RSR → FFR	F-stat = 0.4498	(0.8641)	−0.2573
	FFR → RSR	F-stat = 1.3448	(0.2782)	
	IP → FFR	F-stat = 3.6644**	(0.0270)	0.3121
	FFR → IP	F-stat = 4.6659*	(0.0032)	
	INF → FFR	F-stat = 0.6578	(0.6234)	−0.0122
	FFR → INF	F-stat = 2.6678**	(0.0336)	
	IP → RSR	F-stat = 1.7440	(0.1433)	0.0124
	RSR → IP	F-stat = 4.1199**	(0.0133)	
	INF → RSR	F-stat = 1.5987	(0.1738)	−0.2355
	RSR → INF	F-stat = 4.6471**	(0.0136)	
	INF → IP	F-stat = 2.8087*	(0.0035)	−0.1457
	IP → INF	F-stat = 3.6195*	(0.0036)	

**Statistical significance at the 0.01 level.
*Statistical significance at the 0.05 level.

4.2. Bivariate VAR/VEC estimates

Panels A, B, and C of Table 4 display the bivariate VAR/VEC estimates between RSR paired with IP, interest rates, and inflation. Again, the FPE criterion is used to select the optimal lag length (a dashed line in the estimates denotes insignificance for that lag). We also report the adjusted R^2 and some residual diagnostics implying absence of (non)linearities and heteroscedasticity in them as seen by the Ljung-Box portmanteau Q-statistics and Lagrangian multiplier values. The table also presents variance decompositions and impulse response functions.

4.2.1. RSR and real activity

The estimates for 1970–1978 indicate that two significant lags for the changes in RSR predict changes in IP, which appear to become a bit stronger over time (judging from the size of the estimated coefficients). However, the equation for real returns does not reveal any impact of either variable's past changes on stock returns. The variance-decomposition results reveal that for up to nine periods, the forecast error variance of the stock returns is almost exclusively accounted for by their own innovations (over 97%), while the IP forecast variance is partly influenced by its own (90%) and partly by the innovations in the stock returns (of about 9%) in the two-variable system. Figure 1, panel A, presents impulse response graphs (IRG) showing that the response of RSR to shocks in IP is initially positive, then becomes negative and takes seven to eight months to die out. The responses of IP to shocks in RSP, on the other hand, are strongly positive up to the first four months beyond which the effect is negligible. This is consistent with the view that the stock market rationally leads to changes in real economic activity and that the relationship between stock returns and IP is positive, as put forth by Fama (1981) and Geske and Roll (1983), and this finding is supported by Lee (1992) and Gallinger (1994).

The estimates for 1979–1987 show that the only significant impact on IP comes from its own past changes; and that changes in RSR have no influence on IP. The results make sense in relation to the Table 3 results of no Granger causality and weak correlation between the two variables. The variance-decomposition results indicate that more than 98%of the forecast error variance in the stock returns and about 96% of that in IP are accounted for by own innovations. The IRGs in panel B of Figure 1 show that the responses of stock returns to shocks in IP are negative and take six months to stabilize, while the responses of IP to innovations in stock returns are positive and seem to decay very slowly, taking up to eight months to die out.

At this point, one might suspect that the results are driven by the stock market crash in October 1987. However, rerunning the regression with a dummy variable for October 1987 produces very similar results (available from the author), with the dummy coefficient negative and statistically significant in the real stock-returns equation.

Table 4

Bivariate VAR/VEC estimates

Estimates of two-equation systems based on Equations (2) through (6) in the text. The order of variables in the table reflects the estimation. RSR = real S&P 500 stock index return; IP = real industrial production growth; FFR = federal funds rate; INF = inflation rate. RSR, IP, and INF are monthly rates in continuously compounded form. Arrows (→) show the direction of Granger causality; *p*-values are in parentheses. The variance-decomposition table uses the full four-equation system and shows the percentages of variance of a variable accounted for by the variation of the other variables. A dashed line denotes insignificance of a lag based on the FPE criterion. *p*-values are in parentheses.

Panel A: Real stock returns and real activity (industrial production growth)

	1970–1978		1979–1987		1988–2002	
	ΔRSR_t	ΔIP_t	ΔRSR_t	ΔIP_t	ΔRSR_t	ΔIP_t
Constant	0.0142	0.0077	0.0150*	0.0136	0.0133*	0.0220
	(0.112)	(0.067)	(2.258)	(0.010)	(2.933)	(1.522)
ΔRSR_{t-1}	0.0219	−0.0067	0.0855	0.0122	−0.1330	0.1112
	(0.273)	(−0.053)	(0.074)	0.013)	(−1.136)	(1.713)
ΔRS_{t-2}	−0.0226	0.0252**	−0.0789	0.0213	0.0443	0.0349*
	(−0.227)	(1.955)	(−0.063)	(0.024)	(0.036)	(3.033)
ΔRSR_{t-3}	0.0321	0.0447*	—	—	0.0135	0.0233**
	(0.289)	(3.443)			(0.135)	(1.833)
ΔIP_{t-1}	0.3126	0.4254*	−0.7665	0.2443*	1.9331*	0.0239
	(0.249)	(5.553)	(−1.255)	(2.633)	(2.544)	(0.021)
ΔIP_{t-2}	0.1522	0.0643	−0.1665	0.1448*	0.3345	0.1227*
	(0.118)	(1.244)	(−0.264)	(1.933)	(−0.382)	(2.221)
ΔIP_{t-3}	−0.9114**	0.0444	—	—	0.9336	0.2227*
	(−1.889)	(0.036)			(1.283)	(2.333)
Adjusted R^2	0.0459	0.2116	0.0355	0.1544	0.0882	0.1894
Residual diagnostics: Ljung-Box Q-statistic and Lagrangian multiplier						
LBQ(4)	4.6512	(0.3131)	3.5891	(0.6915)	6.0001	(0.1921)
LBQ(8)	24.795	(0.1722)	20.321	(0.5546)	18.3327	(0.4333)
LM(4)	3.3569	(0.4843)	3.0072	(0.3327)	(0.3249)	4.6226
LM(8)	2.3331	(0.6694)	1.9001	(0.5518)	1.8545	(0.7559)

Variance decomposition

	Lags	ΔRSR	ΔIP	ΔRSR	ΔIP	ΔRSR	ΔIP
ΔRSR	3	99.6470	0.6522	98.2811	1.6137	94.5581	5.0116
	6	96.4270	3.1222	98.1053	1.6936	94.3356	5.4143
	9	96.1935	3.4033	98.1042	1.6937	94.2247	5.5252
ΔIP	3	1.6116	97.3044	4.0113	95.9346	9.2253	90.4146
	6	9.1011	90.8955	4.4119	95.5950	12.6230	87.2969
	9	9.8119	90.1660	4.4237	95.5862	12.7238	87.1062

(*continued*)

The estimates for 1988–2002 suggest that the second and third lags of stock returns significantly and positively affect IP but only the immediate past change in IP significantly and positively affects stock returns. Thus, the results for 1988–2002 resemble those for the 1970s and confirm that the real returns-IP relationship

Table 4 (*continued*)

Bivariate VAR/VEC estimates

Panel B: Real stock returns and federal funds rate

	1970–1978		1979–1987		1988–2002	
	ΔRSR_t	ΔFFR_t	ΔRSR_t	ΔFFR_t	ΔRSR_t	ΔFFR_t
E-C	—	—	—	—	1.2231	−1.5431*
					(1.776)	(−6.444)
Constant	0.0005	0.0093	0.0103*	−0.0226	—	—
	(0.005)	(0.007)	(2.028)	(−0.020)		
ΔRSR_{t-1}	−0.0264	1.1006	0.0622	1.2222	0.1124	−2.6022*
	(−0.023)	(1.100)	(0.624)	(1.422)	(0.126)	(−4.223)
ΔRSR_{t-2}	−0.1333	0.0807**	−0.0220	0.0432**	0.1224−	1.8229*
	−1.333)	(1.907)	(−1.023)	(1.844)	(1.126)	(−3.232)
ΔRSR_{t-3}	—	—	—	—	0.1336	−1.0842*
					(1.422)	(−2.912)
ΔFFR_{t-1}	−0.0116	0.3287*	−0.0225	0.4447*	−0.0477*	−0.6319*
	(−0.119)	(3.677)	(−0.020)	(5.336)	(−2.890)	(−6.711)
ΔFFR_{t-2}	−0.0258*	0.3477*	−0.0229	−0.2443*	−0.0339**	−0.2615*
	(−2.558)	(3.765)	(−0.017)	(−3.433)	(−1.822)	(−2.421)
ΔFFR_{t-3}	—	—	—	—	−0.0337	0.2137
					(−0.037)	(1.334)
Adjusted R^2	0.0847	0.3335	0.0322	0.2774	0.0878	0.4020
Residual diagnostics: Ljung-Box Q-statistic and Lagrangian multiplier						
LBQ(4)	3.2242	(0.2237)	4.8813	(0.7570)	3.6711	(0.4413)
LBQ(8)	15.223	(0.1123)	13.8881	(0.9548)	19.6687	(0.4894)
LM(4)	2.2442	(0.1124)	3.2882	(0.5133)	5.6639	(0.2065)
LM(8)	1.2551	(0.3332)	3.0089	(0.5555)	1.7664	(0.8726)

Variance decomposition

	Lags	ΔRSR	ΔFFR	ΔRSR	ΔFFR	ΔRSR	ΔFFR
ΔRSR	3	93.6613	6.1616	98.2474	1.7125	98.9333	1.0836
	6	92.4550	7.5710	98.0500	1.9290	98.3335	1.6744
	9	92.3555	7.6627	98.0610	1.9381	98.0444	1.9455
ΔFFR	3	7.5255	92.4733	5.6773	94.3425	5.0555	94.9864
	6	8.1131	91.9148	6.7824	93.2575	11.4660	88.5779
	9	8.1290	91.8750	6.8902	93.1697	11.7077	88.2984

(*continued*)

continues to be strong and positive. The variance-decomposition results, taken overall, suggest that each magnitude has now a greater degree of explanatory power on the other, compared to the previous two subperiods. Finally, the IRGs (in panel C of Fig. 1) show that the pattern of responses of real returns to innovations in IP resembles those in the 1980s in that they are initially negative, then become positive but stabilize after six months. Similarly, the responses of IP to shocks by real returns are initially strongly positive, and decay very slowly until they die out after nine or ten months.

Table 4 (*continued*)

Bivariate VAR/VEC estimates

Panel C: Real stock returns and inflation

	1970–1978		1979–1987		1988–2002	
	ΔRSR_t	ΔINF_t	ΔRSR_t	ΔINF_t	ΔRSR_t	ΔINF_t
E-C	−0.7739*	−0.1233	—	—	−0.0117	−0.0458*
	(−4.462)	(−1.133)			(−1.321)	(−4.462)
ΔRSR_{t-1}	−0.0969	−0.2336	1.0444*	−0.1872	−0.1422	0.0672
	(−0.563)	(−0.338)	(10.623)	(−0.451)	(−1.333)	(0.483)
ΔRSR_{t-2}	−0.1678	−0.1338	−0.0522	0.1060	0.0334	−0.5929
	(−1.177)	(−0.136)	(−0.043)	(0.372)	(1.032)	(−1.052)
ΔRSR_{t-3}	−0.1841	−0.5436	—	—	—	—
	(−0.111)	(−1.435)				
ΔRSR_{t-4}	−0.0118	−0.9334**	—	—	—	—
	(−0.011)	(−1.955)				
ΔINF_{t-1}	0.0110	−0.7444**	−0.0113	0.6767*	0.0123	−0.1119
	(0.019)	(−1.933)	(−1.120)	(7.966)	(0.013)	(−0.711)
ΔINF_{t-2}	−0.0123	−0.3537*	0.0110	−0.0761	0.0116	−0.1115**
	(−0.018)	(−3.039)	(0.012)	(−0.069)	(0.012)	(−1.811)
ΔINF_{t-3}	−0.0543**	−0.3730*	—	—	—	—
	(−1.922)	(−3.637)				
ΔINF_{t-4}	−0.0118**	−0.3243*	—	—	—	—
	(−1.817)	(−2.257)				
Adjusted R^2	0.5554	0.4365	0.4731	0.4954	0.1223	0.3787
Residual diagnostics: Ljung-Box Q-statistic and Lagrangian multiplier						
LBQ(4)	4.3422	(0.3347)	3.1023	(0.7410)	3.3432	(0.3313)
LBQ(8)	18.9592	(0.2208)	11.2191	(0.8428)	12.4121	(0.2893)
LM(4)	3.9655	(0.4366)	2.7802	(0.3233)	3.5112	(0.2123)
LM(8)	6.2711	(0.1518)	3.0112	(0.2245)	2.6233	(0.1323)

Variance decomposition

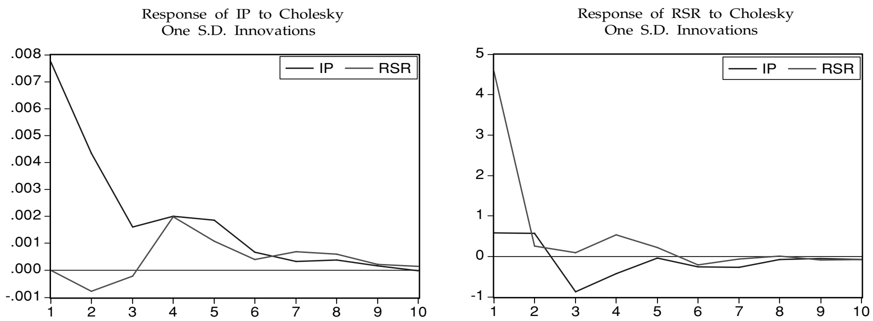
	Lags	ΔRSP	ΔINF	ΔRSP	ΔINF	ΔRSP	ΔINF
ΔRSP	3	99.0027	0.2902	98.2430	1.5569	98.1283	1.4219
	6	94.4071	5.5408	96.3060	3.5638	96.9231	3.0261
	9	94.2056	5.7703	95.4870	4.8756	96.0241	3.9359
ΔINF	3	13.9080	86.0309	2.2473	97.7825	13.3227	86.6472
	6	15.3903	84.6007	2.9477	97.0925	13.9236	86.0563
	9	15.6040	84.3209	3.4425	96.5075	13.2281	85.7618

**,*indicate statistical significance at the 0.01 and 0.05 levels, respectively.

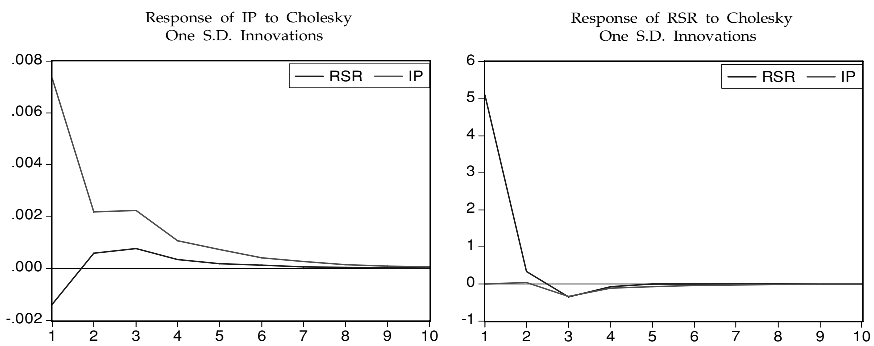
4.2.2. RSR and FFR

Panel B of Table 4 reports the bivariate VAR/VEC estimates for the real returns-interest rate pair for the three subperiods. Focusing on the parameter estimates for the 1970s, one result is the (marginal) positive impact of the two-month lagged real returns on the fed funds rate and the other one is that the two-period lagged fed

Panel A: 1970-1978



Panel B: 1979-1987



Panel C: 1988-2002

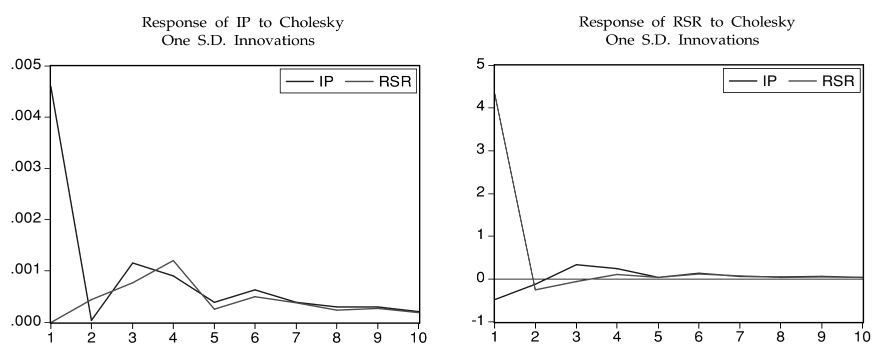


Figure 1

Impulse response graphs: Real stock returns and real activity

Impulse responses of the two-variable VAR system with industrial production growth (IP), the proxy for real activity, and real stock returns (RSR) are orthogonalized recursively in the order in which they appear in the graphs. The VAR system has three lags and a constant term. The responses are shown over 10 months.

funds rate negatively affects the stock market. Specifically, the number −0.0258 (the coefficient of the change in the fed funds rate, ΔFFR) implies that a 50-basis point increase in the FFR results in a mere 0.0130% decline in the S&P 500, in real terms. Therefore, although it appears that a reciprocal, short-run interdependency between the FFR and the stock market exists during the 1970s, the linkage is marginal (this is corroborated by the marginal unidirectional Granger causality and weak inverse correlation findings in Table 3).

The variance-decomposition table indicates that about 92% of the error forecast variance in stock returns is accounted for by own innovations and that about 91% of the forecast variance in the interest rate is due to own past innovations. In both cases, the significance of innovations of each variable on the other ranged from 7% to 8%. Finally, the IRGs, in panel A of Figure 2, show that the responses of stock returns to shocks in the interest rate are consistently negative and decay very slowly (taking up to eight months). The responses of the interest rate to shocks in real returns emerge as negative, initially, but become positive thereafter until they die out after eight or nine months.

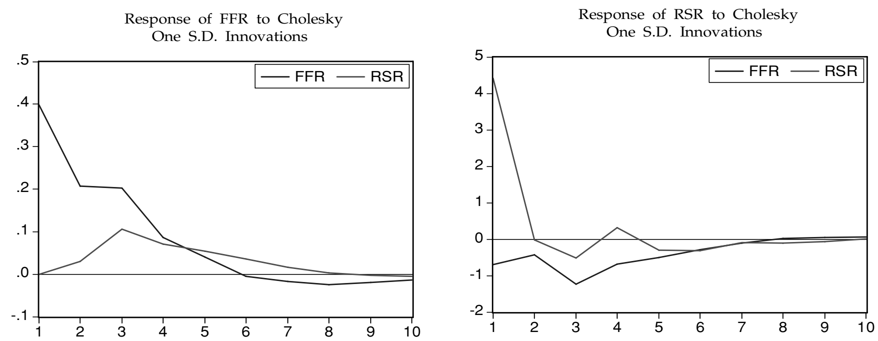
The estimates for the 1980s show no relationship between real returns and interest rates, consistently with Table 3. The variance-decomposition results indicate a higher degree of explanatory power for the error forecast variance for each variable by own innovations, relative to the first decade. Finally, the IRGs (in panel B of Fig. 2) show that the response of real returns to innovations in the FFR is initially negative, then becomes positive and dies out in seven months. The response of the FFR to innovations in stock returns is initially negative, then positive, then negative again before decaying and dying out in eight months.

The estimates for the 1990s show that the EC term is negative and statistically significant in the funds rate equation but not in the RSR equation. The negative coefficient implies that although the FFR and stock returns are bound together in long-run equilibrium, a booming stock market has a negative effect on the FFR. In the short run, one- to two-month lagged changes in the fed funds rate appear to adversely affect the stock market. The result is consistent with the view that if the stock market exhibits significant gains, inflationary pressures can appear, forcing the Fed to pre-empt inflation by increasing the FFR and thus depressing stock prices.

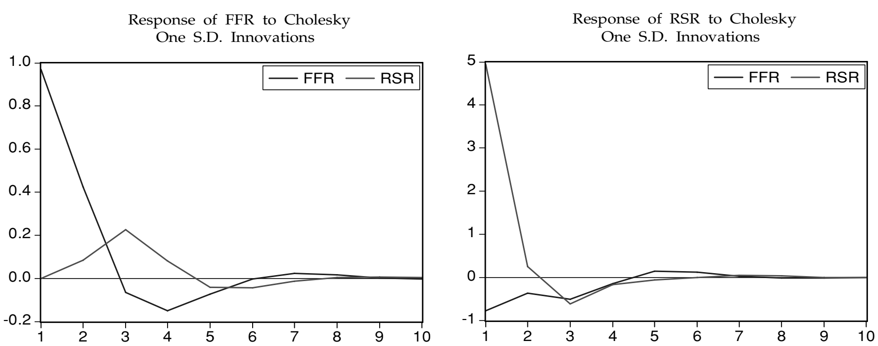
The finding that stock prices respond significantly and negatively to monetary policy actions sides with one strand of the literature. For instance, using various methods, Thorbecke (1997), Lobo (2000), Bomfim (2003), and Rigobon and Sack (2002) find significant responses for the S&P 500; in contrast, Tarhan (1995) reports no statistically significant response. (For a detailed survey, see Sellin (2001).)

The variance-decomposition results indicate that about 98% of the error forecast variance in stock returns is accounted for by its own past innovations and that extent remains constant at various lags. By contrast, the error forecast variance of the interest rate stemming from own innovations starts high but it drops to 88% from the fifth lag and remains at that level thereafter. Finally, the IRGs show that the reactions of RSR to shocks in the interest rate start negative but become positive after the third month

Panel A: 1970-1978



Panel B: 1979-1987



Panel C: 1988-2002

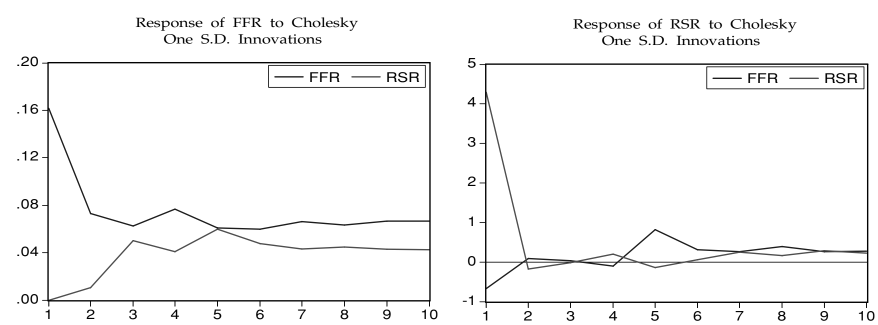


Figure 2

Impulse response graphs: Real stock returns and federal funds rate

Impulse responses of the two-variable VAR/VEC systems with real stock returns (RSR) and the federal funds rate (FFR) are orthogonalized recursively in the order in which they appear in the graphs. The VAR/VEC systems have three lags and a constant term. The responses are shown over 10 months.

and seem to be well behaved until their decay at the tenth month. The responses of the interest rate to shocks emanating from stock returns start as negative but then become positive, and strong in particular at the fifth month, after which they decay very slowly until they die out, taking well over a year.

4.2.3. RSR and inflation

The final relationship in this section is between RSR and inflation. The EC terms for the 1970s and 1990s are negative and statistically significant. The mutual, short-run relationships, however, are not strong or persistent in any subperiod, as seen by the insignificance of most of the lagged coefficients in each equation. The variance-decomposition results suggest that about 94–96% of the error forecast variance in the stock returns is explained by own past innovations and only 3–5% of it is accounted for by innovations in inflation. The IRGs in Figure 3 show that the response of stock returns to inflation shocks is small and initially well behaving, decaying in the sixth month. However, the reaction of inflation to shocks in stock returns is consistently negative and flat.

In sum then, we fail to find causality between stock returns and inflation (such as the results in Lee 1992). Furthermore, we do not find a consistent negative response of inflation to shocks in stock returns nor a consistent negative reaction of stock returns to inflation shocks. These findings add to an already mixed literature. Cohn and Lessard (1981), Gultekin (1983), and Boudoukh and Richardson (1993) find either a negative effect or no significant effect of inflation on stock returns, whereas Firth (1979) and Frennberg and Hansson (1993) report a positive effect.

5. Multivariate results

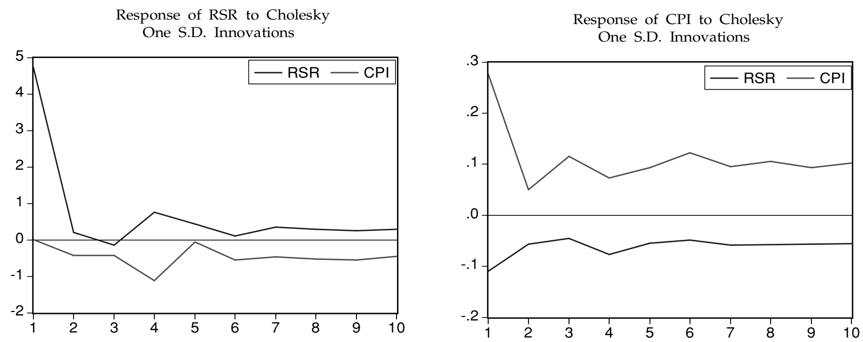
5.1. Granger-causality test results

In this section we consider the dynamic interactions among all four variables. From panel B of Table 2, we infer that all variables in the first and the third subperiods exhibited a single stochastic trend and thus the appropriate model will be a VEC, but in the second subperiod it will be a VAR, in view of absence of cointegration among the four variables. But before we proceed with the estimation of the VEC or VAR models, we must satisfy the problem of variable ordering. We run Granger-causality regressions to establish the degree of relative exogeneity among the variables which, in turn, helps guide the ordering of the variables in a multivariate VAR specification.

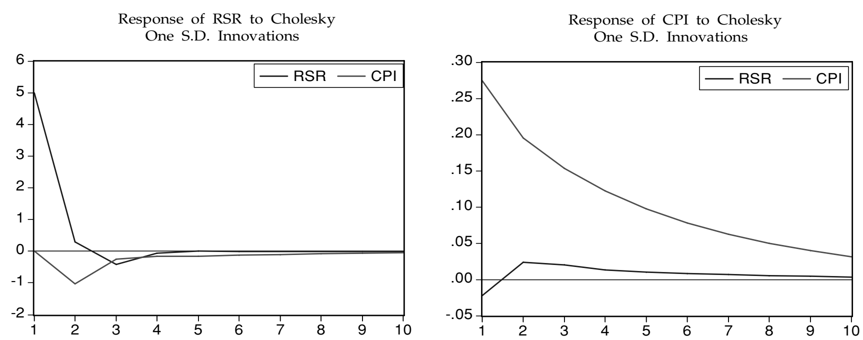
Table 3 reports the Granger-causality test results. We can make the following principal observations.

Granger causality between RSR and FFR: mutually strong in the 1970s only.
Granger causality between IP and FFR: significant and reciprocal in 1980s and 1990s.

Panel A: 1970-1978



Panel B: 1979-1987



Panel C: 1988-2002

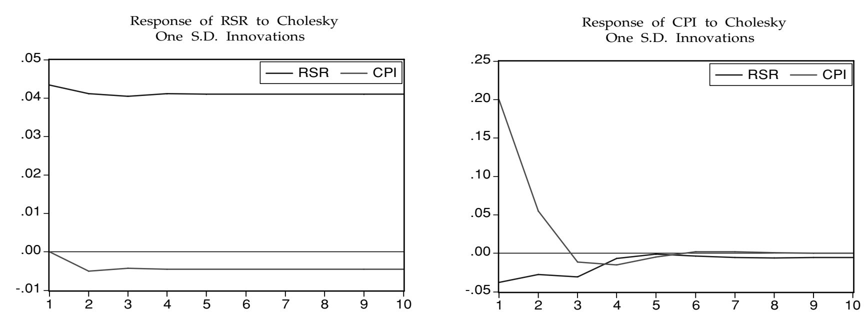


Figure 3

Impulse response graphs: Real stock returns and inflation

Impulse responses of the two-variable VAR/VEC systems with real stock returns (RSR) and inflation (INF) are orthogonalized recursively in the order in which they appear in the graphs. The VAR system has four lags and a constant term, whereas the VEC system has two lags and a constant term. The responses are shown over 10 months.

Granger causality between INF and FFR: unidirectional from FFR to INF in all subperiods.

Granger causality between IP and RSR: strong and unidirectional from RSP to IP in the 1980s and 1990s.

Granger causality between INF and RSR: unidirectional from INF to RSP in 1970s.

Granger causality between INF and IP: unidirectional from INF to IP in the 1980s, but reciprocal in the 1990s.

It appears that these Granger-causality results exhibit different recursive structures (or causal orderings) over time. For the 1970s, it seems that the FFR causes stock returns, which in turn causes the rate of inflation and finally the IP. Thus, the ordering scheme should be FFR, RSR, INF, and IP. The 1980s and the 1990s present a different picture. The stock market and the fed funds rate seem to cause both the inflation rate and the IP index, which cause each other. Therefore, based on these conclusions the ordering of the variables should be RSR, FFR, or FFR, RSR, followed by INF and IP.

5.2. Multivariate VEC/VAR estimates

Panel A of Table 5 presents the empirical estimates from the VEC model for 1970–1978. The EC estimates for the FFR and inflation rate are statistically significant while those for the stock returns and IP are not. The FFR EC term has the correct sign (i.e., it is negative) but the inflation rate's EC term does not. This result implies that the FFR adjusts downward to correct "errors" whenever it gets too high relative to the inflation rate. Although two EC terms are not statistically significant, one cannot simply assume that these magnitudes, other than the federal funds and the inflation rates, are noncausal since some short-run channels are still present. For example, fluctuations in the FFR negatively affect stock returns and positively affect the IP variable. Further, past changes in inflation negatively affect the FFR, but not the other way around. Finally, although a two-month lag in stock returns positively affects the FFR, a two-month lag in the latter negatively affects the former.

To see how the variables respond to various shocks to the system, we again examine variance decompositions and IRGs. The variance-decomposition results at the bottom of Table 5 show that the FFR is influenced by all other three variables. IP is affected by stock returns; stock returns and inflation are affected by the other variables, but only marginally by IP. Stock returns and inflation significantly affect each other. The IRGs in panel A of Figure 4 show much longer impacts of the variables on each other. Furthermore, from the first graph in the first column, it appears that the FFR exhibits a more explosive behavior relative to the other variables, and inflation is the most turbulent variable initially, but it stabilizes after six months (see the second graph in the second column).

One more notable result appears in the IRGs. First, recall from Table 3 that the sample correlation between stock returns and inflation for the 1970s is −0.2247. The

Table 5

Multivariate VAR/VEC estimates

Estimates of the system of Equations (2) through (6) in the text. RSR = real S&P 500 stock index return; IP = real industrial production growth; FFR = federal funds rate; INF = inflation rate. RSR, IP, and INF are monthly continuously compounded rates. The order in the table reflects the estimation. The variance-decomposition table shows the percentage of variance of each variable accounted for by the variation in the others. *p*-values are in parentheses.

Panel A: VEC estimates; 1970–1978

	ΔFFR_t	ΔRSR_t	ΔINF_t	ΔIP_t
E-C	−0.0670*	0.0233*	−0.0765*	0.0010*
	(−5.462)	(2.133)	(−2.081)	(3.920)
ΔFFR_{t-1}	0.4129*	−0.0736*	0.0444*	0.0572*
	(3.563)	(−2.338)	(2.623)	(3.451)
ΔFFR_{t-2}	0.3248*	−0.0330*	0.0322*	0.0060*
	(2.177)	(−3.136)	(2.043)	(2.372)
ΔRSR_{t-1}	0.8231*	0.0636*	0.7019*	0.0123*
	(3.211)	(2.435)	(2.442)	(2.772)
ΔRSR_{t-2}	2.2118*	−0.1234*	0.5312*	0.0321*
	(3.234)	(−2.545)	(2.998)	(2.887)
ΔINF_{t-1}	−0.6210*	0.0344*	−0.0213*	0.0067*
	(−2.019)	(2.553)	(−2.120)	(2.966)
ΔINF_{t-2}	−0.4453*	0.0337*	0.1110*	0.0061*
	(−2.118)	(2.039)	(2.012)	(2.069)
ΔIP_{t-1}	3.4420*	0.3644**	0.3113*	0.5767*
	(3.019)	(1.933)	(2.120)	(4.966)
ΔIP_{t-2}	4.3323*	−0.6637	0.6610	0.0761*
	(4.218)	(−1.039)	(1.012)	(3.069)
Adjusted R^2	0.4554	0.3665	0.3031	0.5954

Residual diagnostics		*Variance decomposition*	Lags	ΔFFR_t	ΔRSR_t	ΔIP_t	ΔINF_t
Q(4)	36.3251 (0.2351)	ΔFFR_t	3	94.2471	2.1681	1.1645	1.4298
Q(8)	43.2242 (0.3282)		6	79.9682	5.8679	6.1732	8.9890
LM(4)	10.4432 (0.8013)		9	71.3180	8.5671	9.9556	11.0611
LM(8)	22.2322 (0.1114)	ΔRSR_t	3	11.3355	84.3607	1.7514	0.1622
			6	20.8462	71.9658	1.5549	2.6628
			9	26.8562	64.5636	1.0510	5.1635
		ΔIP_t	3	0.6697	1.7625	96.2508	0.3668
			6	1.4708	4.8639	91.9338	0.8613
			9	1.5842	6.2630	90.2735	0.9692
		ΔINF_t	3	10.4992	9.3615	1.1689	77.1603
			6	28.2097	7.3646	3.9480	58.4669
			9	37.3712	6.2674	7.5459	46.6651

(*continued*)

graphs show that in response to a real activity shock, the FFR and inflation have an upward trend while stock returns have a downward trend. Therefore, the increase in real output depresses real stock prices, which implies that inflation and real activity are positively related but IP and stock returns are negatively related. This conclusion

Table 5 (*continued*)

Multivariate VAR/VEC estimates

Panel B: VAR estimates; 1979–1987	ΔFFR_t	ΔRSR_t	ΔINF_t	ΔIP_t
ΔFFR_{t-1}	1.2329*	−0.0056	0.0494**	−0.0072**
	(3.223)	(−0.355)	(1.813)	(−1.751)
ΔFFR_{t-2}	−0.3558*	−0.0030	−0.0222	−0.0042**
	(−2.557)	(−0.333)	(−0.143)	(−1.822)
ΔRSR_{t-1}	0.5431	0.9726	0.0889	0.0073
	(1.441)	(1.433)	(0.422)	(2.772)
ΔRSR_{t-2}	1.7318*	−0.0674	−0.1912	0.0021**
	(3.443)	(−0.525)	(−1.498)	(1.887)
ΔINF_{t-1}	0.5410	0.0144	0.5513*	−0.0017
	(1.449)	(0.523)	(2.150)	(−0.266)
ΔINF_{t-2}	0.1953*	0.0067	−0.0210	0.0021
	(2.558)	(0.239)	(−0.112)	(0.129)
ΔIP_{t-1}	1.6620	−1.1144	7.3113	1.5767*
	(1.669)	(−1.333)	(1.120)	(4.366)
ΔIP_{t-2}	−2.6553	1.6637	−2.6630	0.1761*
	(−1.228)	(1.119)	(−1.012)	(3.169)
Adjusted R^2	0.8554	0.8665	0.9031	0.6054

Residual diagnostics		*Variance decomposition*	Lags	ΔFFR_t	ΔRSR_t	ΔIP_t	ΔINF_t
Q(4)	22.1222 (0.2122)	ΔFFR_t	3	94.9171	2.2381	1.3305	0.4248
Q(8)	63.3432 (0.3325)		6	83.2902	10.3879	4.8352	0.6354
LM(4)	11.1172 (0.7836)		9	76.3370	19.4211	9.1806	1.0499
LM(8)	15.2554 (0.1044)	ΔRSR_t	3	11.3325	88.5197	0.1324	0.4552
			6	19.2312	79.6988	0.1059	0.8645
			9	27.8318	71.7006	0.3856	0.7717
		ΔIP_t	3	0.7330	0.8145	98.1198	0.1828
			6	0.9361	0.9609	98.0568	0.2973
			9	5.6386	0.7448	94.0261	0.2002
		ΔINF_t	3	7.8366	8.2295	1.1734	80.7003
			6	15.9345	8.9236	2.6117	71.3600
			9	19.2360	10.4128	5.2633	67.0778

(*continued*)

seems to contradict Fama's (1981) proxy hypothesis, which says that inflation and real activity are negatively related but real activity and RSR are positively related. A potential explanation for the conflict is that more good news for a robust economy may signify overheating in the near future, resulting in higher inflation and interest rates which, in turn, would lower real equity prices.

Panel B of Table 5 reports the VAR estimates for the second subperiod.[6] One cannot see much interaction among the magnitudes from the results, but one can

[6]Re-running the four-equation system with the FFR before the RSR produces no qualitative or quantitative difference in the results for the second or third subperiod.

Table 5 (*continued*)

Multivariate VAR/VEC estimates

Panel C: VEC estimates; 1988–2002	ΔFFR_t	ΔRSR_t	ΔINF_t	ΔIP_t
E-C	0.0104*	−0.0633*	−0.0165*	−0.0011*
	(4.462)	(−2.136)	(−2.181)	(−3.330)
ΔRSR_{t-1}	−0.2629*	0.3356	−0.0694*	0.0192*
	(−3.003)	(1.335)	(−2.663)	(2.491)
ΔRSR_{t-2}	−0.0158*	0.7730	−0.0422*	0.0092
	(−2.227)	(1.233)	(−2.243)	(1.392)
ΔFFR_{t-1}	−0.0231**	0.2626*	0.0349*	0.0273*
	(−1.721)	(2.233)	(2.442)	(2.722)
ΔFFR_{t-2}	0.0118**	0.3174*	0.1912*	0.0921
	(1.843)	(2.515)	(2.698)	(1.187)
ΔINF_{t-1}	0.0810	−0.3644	−0.3513	0.0057
	(1.229)	(−1.523)	(−1.130)	(0.256)
ΔINF_{t-2}	0.0453	0.1767	0.2710*	−0.0011
	(1.258)	(1.239)	(2.512)	(−0.019)
ΔIP_{t-1}	−2.2620*	3.1344*	−1.3113*	0.0767*
	(−3.229)	(2.355)	(−3.110)	(2.366)
ΔIP_{t-2}	−0.8853*	1.8637**	−2.2630*	0.1741*
	(−4.888)	(1.819)	(−3.112)	(3.149)
Adjusted R^2	0.3153	0.2443	0.2548	0.2443

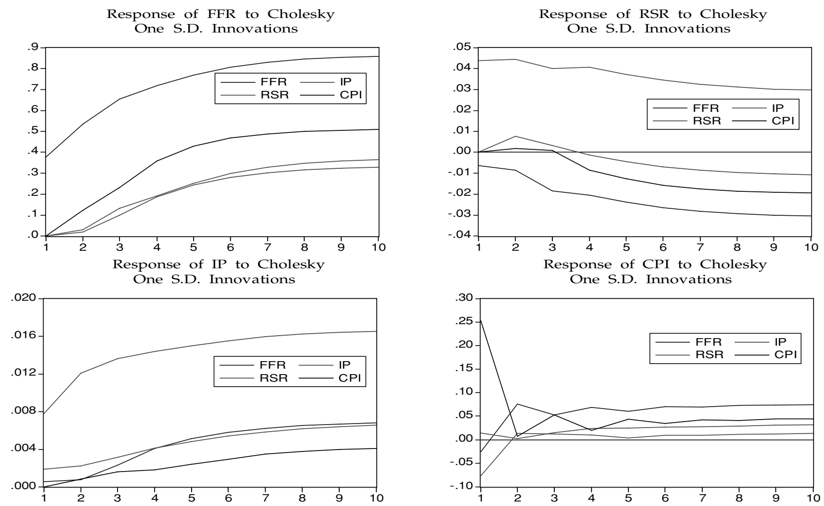
Residual diagnostics		*Variance decomposition*	Lags	ΔFFR_t	ΔRSR_t	ΔIP_t	ΔINF_t
Q(4)	41.1651 (0.0787)	ΔFFR_t	3	87.2271	2.5275	1.6485	4.1765
Q(8)	91.4132 (0.5578)		6	90.6682	2.6409	1.6792	5.4195
LM(4)	16.3656 (0.5362)		9	90.8696	2.8196	1.7230	5.1709
LM(8)	9.6660 (0.8857)	ΔRSR_t	3	0.1626	99.1397	0.8194	0.4882
			6	0.1638	99.3636	0.9912	0.5611
			9	0.9664	99.4825	0.0849	0.6260
		ΔIP_t	3	3.8601	1.5822	86.3876	7.7499
			6	4.6673	1.6921	81.3879	11.8825
			9	4.9695	1.7218	80.3115	13.9671
		ΔINF_t	3	8.1602	4.8761	4.1090	82.7243
			6	11.9666	3.9102	11.0492	73.7338
			9	14.8638	3.4228	15.1462	68.7770

**indicates statistical significance at the 0.01 level.
*indicates statistical significance at the 0.05 level.

clearly see that the FFR negatively affects IP (albeit marginally) but positively (and marginally) the inflation rate. The relative exogeneity of IP that appears in the 1970s seems to carry on through the 1980s. Also as in the 1970s, RSR contain no information about the funds rate, inflation rate, or future economic activity.

The variance-decomposition results are more informative. An increasing percentage of the error forecast in the FFR is explained by both stock returns and IP. The

Panel A: 1970 - 1978



Panel B 1979 - 1987

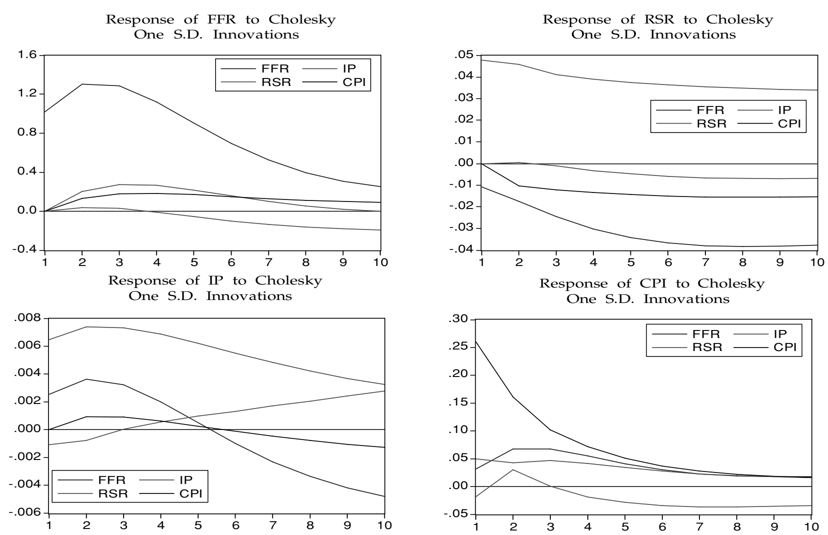


Figure 4

Impulse response graphs: Federal funds rate, real stock returns, inflation, and real activity

Impulse responses of the four-variable VAR/VEC system where the federal funds rate (FFR), real stock returns (RSR), inflation (INF), and the real activity proxy (IP) are orthogonalized recursively in the order in which they appear. The VEC systems in the first and third subperiods have two lags for each variable and the error correction terms. The VAR system in the second subperiod has two lags for each variable (the constant term is insignificant). The responses are shown over 10 months.

Panel C: 1988 - 2002

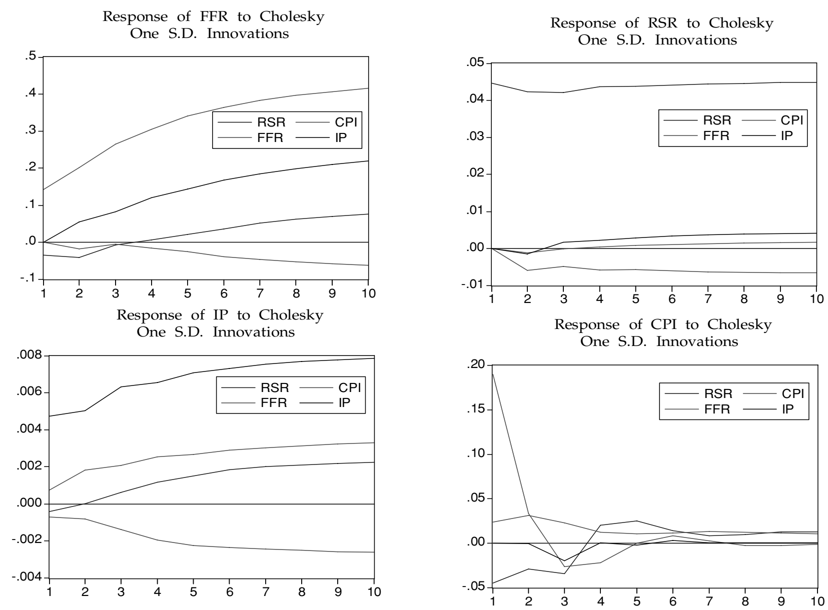


Figure 4

Continued.

FFR explains a significant and increasing portion of the error forecast variance of stock returns and inflation, and to a lesser extent, IP. Only IP seems to be an exogenous variable in the sense that no other variable but itself explains its forecast variance.

The IRGs in panel B of Figure 4 indicate an explosive behavior of the FFR to shocks from other variables, and it takes 24 months to die off. By contrast, the remaining three variables appear to behave well and settle within a few months after some mild initial turbulence. The decline in stock returns is consistent with the prediction of the standard present-value equity valuation model, in which an increase in the interest rate decreases the present value of expected equity cash flows.

The VEC estimates for the third subperiod appear in panel C of Table 5. Notice that only one EC term, stock returns, has the wrong sign (positive), whereas the other three terms are significant and have the correct sign. This means that the three variables except stock returns bear the brunt of short-run adjustment to restore long-run equilibrium in the system. Two lagged values of IP affect stock returns negatively but the FFR positively. The rate of inflation does not influence any variable strongly or persistently. Stock returns seem to negatively and weakly impact inflation. This corroborates Geske and Roll's (1983) finding that stock returns are negatively related to (expected) inflation.

The variance-decomposition results generally suggest the following. First, the relative exogeneity of stock returns and the FFR are most noticeable, because very little of them is explained by the other variables in their respective variance decomposition. Second, a large percentage (about 12% on average) of the variance decomposition of IP is explained by the rate of inflation followed by the fed funds rate (which explains about 4%). Third, greater percentages of the error forecast variance of the inflation rate are explained by the fed funds rate and IP (approximately 12% for each) and a smaller one (about 3%) is explained by stock returns. The IRGs reveal an interesting pattern in the responses of each variable to shocks from another variable in that they are quite long lasting but not all that turbulent. This means no variable experiences initial or subsequent volatility following a shock, but the responses to shocks are persistent.

Two other observations can be made from these graphs. The first concerns the reactions of stock returns to shocks from all other variables, which start and remain negative throughout the period, and the second one pertains to the IP, which seems to be the most well-behaved variable in terms of exhibiting little volatility persistence in response to inflation shocks.

Table 6 presents the F-test results for the four hypotheses in section 3.3. Regarding the linkages between stock returns and the FFR, one can see that such a relationship is present and reciprocal in the 1970s. It disappears in the 1980s but resurfaces in the 1990s only in the stock returns Granger-causing the funds rate. As far as the linkages between stock returns and inflation rate or IP are concerned, the former linkage emerges only in the 1990s whereas the latter is absent in all three decades.

6. Discussion of the findings and forecasts

6.1. Discussion of the findings

We observe both short-run and long-run interdependencies among all four magnitudes in the 1970s and 1990s but only short-run ones in the 1980s. The bivariate results (but not the multivariate results, except perhaps for the 1990s) weakly confirm the surprising negative correlation between RSR and inflation reported by Fama and Schwert (1977), Schwert (1981), and Solnik (1983). This contrasts with the widely held view that stock returns are a hedge against inflation. Ely and Robinson (1997) also use VAR/VEC specifications and, in many instances, reject stock returns as short-run hedges against inflation. Park and Ratti (2000) also fail to support the proxy hypothesis.

In regard to the relationship between RSR and the FFR, the bivariate results suggest a negative and unidirectional relationship (from stock returns to the fed funds rate) in the 1990s but a very weak one in the 1970s. The multivariate results, however, support these short-run linkages in the 1970s along with the same unidirectional linkage between the two in the 1990s. Although we did not explicitly test for it here,

Table 6

Granger-causality tests

Tests use the four-equation system:

$$\Delta FFR_{i,t} = \alpha_1 + \gamma_1\varepsilon_{t-1} + \sum_{i=1}^{n1} \beta_{1,i}\Delta FFR_{i,t} + \sum_{i=1}^{n2} \beta_{2,i}\Delta RSR_{j,t} + \sum_{i=1}^{n3} \beta_{3,i}\Delta INF_{i,t} + \sum_{i=1}^{n4} \beta_{4,i}\Delta IP_{j,t} + e_{1,t}$$

$$\Delta RSR_{j,t} = \alpha_2 + \gamma_2\varepsilon_{t-1} + \sum_{i=1}^{m1} \delta_{1,i}\Delta FFR_{i,t} + \sum_{i=1}^{m2} \delta_{2,i}\Delta RSR_{j,t} + \sum_{i=1}^{m3} \delta_{3,i}\Delta INF_{i,t} + \sum_{i=1}^{m4} \delta_{4,i}\Delta IP_{j,t} + e_{2,t}$$

$$\Delta INF_{i,t} = \alpha_3 + \gamma_3\varepsilon_{t-1} + \sum_{i=1}^{l1} \phi_{1,i}\Delta FFR_{i,t} + \sum_{i=1}^{l2} \phi_{2,i}\Delta RSR_{j,t} + \sum_{i=1}^{l3} \phi_{3,i}\Delta INF_{i,t} + \sum_{i=1}^{l4} \phi_{4,i}\Delta IP_{j,t} + e_{3,t}$$

$$\Delta IP_{j,t} = \alpha_4 + \gamma_4\varepsilon_{t-1} + \sum_{i=1}^{p1} \theta_{1,i}\Delta FFR_{i,t} + \sum_{i=1}^{p2} \theta_{2,i}\Delta RSR_{j,t} + \sum_{i=1}^{p3} \theta_{3,i}\Delta INF_{i,t} + \sum_{i=1}^{p4} \theta_{4,i}\Delta IP_{j,t} + e_{4,t}$$

where RSR is real stock returns, INF is inflation, IP is industrial production, and FFR is federal funds rate.

Hypothesis 1: Real stock returns Granger-cause the federal funds rate H_0: $\gamma_1 = 0$ and $\beta_{2,i} = 0$ for all i		
1970–1978: F(2,117) = 4.819*;	**1979–1987:** F(2,117) = 5.432*;	**1988–2002:** F(2,117) = 4.361*
Hypothesis 2: Federal funds rate Granger-causes real stock returns H_0: $\gamma_2 = 0$ and $\delta_{1,i} = 0$ for all i		
1970–1978: F(2,117) = 4.653*;	**1979–1987:** F(2,117) = 4.879*;	**1988–2002:** F(2,117) = 1.987
Hypothesis 3: Real stock returns Granger-cause inflation rate H_0: $\gamma_3 = 0$ and $\phi_{2,i} = 0$ for all i		
1970–1978: F(2,117) = 2.972;	**1979–1987:** F(2,117) = 2.124;	**1988–2002:** F(2,117) = 5.087*
Hypothesis 4: Real stock returns Granger-cause real economic activity H_0: $\gamma_4 = 0$ and $\theta_{2,i} = 0$ for all i		
1970–1978: F(2,117) = 2.443;	**1979–1987:** F(2,117) = 1.434;	**1988–2002:** F(2,117) = 2.359

*indicates statistical significance at the 0.05 level.

it can be inferred that stock returns do not respond positively to monetary easing, which took place during the 1990s, or negatively to monetary tightening, which happened during parts of 1970s and most of the 1980s, as reported in the literature. We also find that the portion of the stock return forecast error variance explained by monetary policy (shocks) is large during the 1970s and 1990s but small during the 1980s. These results, however, differ from those of Patelis (1997), Thorbecke (1997), and Lastrapes (1998).

Third, although the bivariate results for stock returns and IP uncovers a weak and mixed relationship in the 1970s and a positive and reciprocal one in the 1990s, the multivariate results imply a strong relative exogeneity of IP in the 1970s and 1980s, which emerges as a significant influence on stock returns and the FFR in the 1990s. However, lagged values of the other three variables do not seem to affect IP during the 1990s, although the FFR influences it during the 1970s and 1980s. These conflicting findings do not support the view that stock returns signal changes in future real activity, as earlier research suggests. A possible interpretation is that each decade, and particularly the 1970s and 1990s, has produced different economic

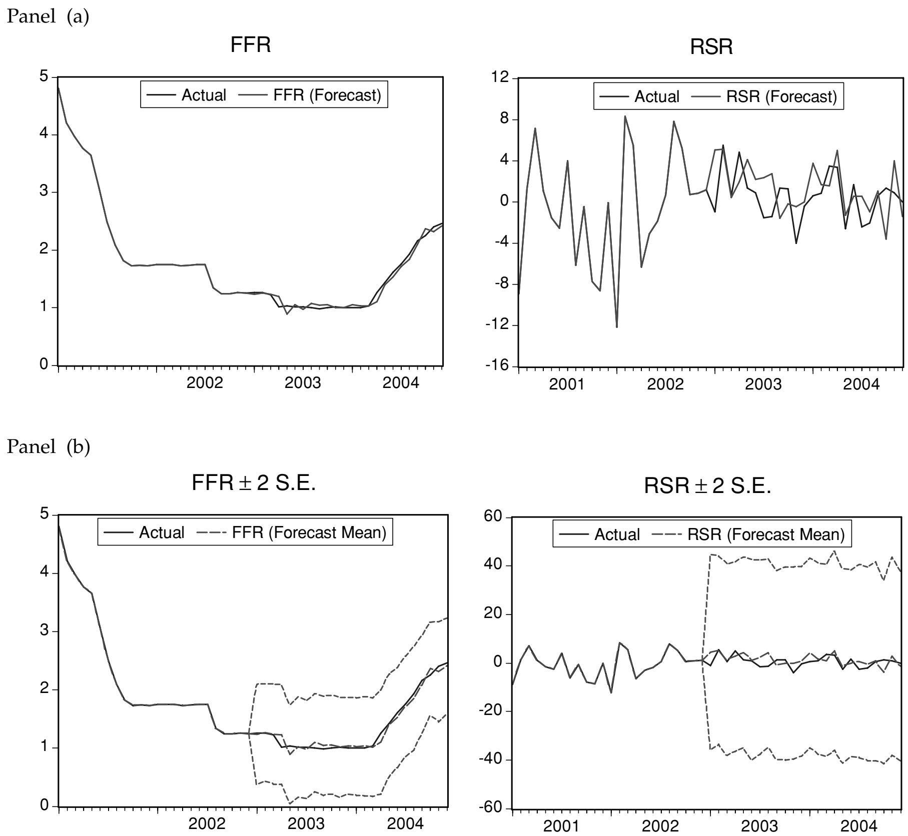


Figure 5

Forecasts of the federal funds rate (FFR) and real stock returns (RSR), 2003–2004

Each panel shows some out-of-sample forecasts for the federal funds rate (FFR) and real stock returns (RSR) for the 2003–2004 period. Each graph in panel (a) shows the actual and forecast values of a variable. In panel (b) the graphs show the forecast and the ± two standard error bands around it.

fundamentals such as high inflationary periods with supply shocks and speculative bubbles that loosened the link between the stock market and economic activity.

6.2. Forecasts

Figure 5 shows out-of-sample forecasts of FFR and RSR for 2003–2004. As a one-step-ahead predictor, the model seems to perform well for the fed funds rate (panel A). However, in the case of the stock market, the results show deviations from the actual outcomes. This suggests that it would still be difficult to predict the stock market (based on the estimated model specification used here) but not so the Fed's future actions (i.e, changes in the fed funds rate). An alternative way to validate this conclusion is to perform a stochastic simulation of the model (again, omitting the inflation and the IP variables from the graphs) to add error bounds to the predictions. Panel B of Figure 5 displays the two variable forecasts with error bounds. The bounds for the stock market are much wider than those of the fed funds rate, which again is consistent with considerable uncertainty surrounding the future path of the stock market.

To sum up, we see that the disconnection between monetary policy actions and movements in the stock market continues to date.

7. Conclusions

This paper examines the dynamic linkages among the stock market, economic activity, inflation, and monetary policy. The analysis, conducted on three subperiods from 1970 to 2002 to reflect changing monetary policy regimes, uses bivariate and multivariate VAR and VEC models exploiting the presence of cointegration. The bivariate, but not the multivariate, results weakly support a negative correlation between RSR and inflation for the 1970s and 1980s, in contrast to the widely held view that stocks are an inflation hedge. The bivariate and multivariate results also show a negative relationship between stock returns and the FFR in the 1970s and 1980s but a unidirectional one in the 1990s. The bivariate results uncover a weak and negative relationship between stock returns and IP in the 1970s and 1990s but a positive one in the 1980s. The multivariate results, however, reveal strong exogeneity of IP in the 1970s and 1980s; it emerges as a significant precursor to stock returns and the FFR in the 1990s. It is not possible to conclude that there is a consistent dynamic relationship between monetary policy and the stock market, since the nature dynamics differ so much across subperiods.

Overall, the absence of a systematic relationship among the variables since the early 1990s could mean that the economy's structure or fundamentals have changed (such as the shift from manufacturing into financial services and the rapid advances in technology) and that the upswings and downswings in stock prices since the mid-1990s come from nonfundamental factors (irrational exuberance). Alternatively, perhaps the Fed's policies have had no noticeable impact on the equity market because the market has learned to anticipate future policy moves (say, via the fed funds future market) and thus to neutralize adverse effects.

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Queries

Q1 Author: Please provide page range for the references “Bulmash, S.B. and G.W. Trivoli, 1991” and ‘Lobo, B.J., A.F. Darrat and S. Ramchander, 2006.’

Q2 Author: Please provide complete page range for the reference ‘Cohn, R. A. and D. R. Lessard’.

Q3 Author: Please note that the reference ‘Jones, C.P. and J.W. Wilson, 2006’ is not cited in the text.

Q4 Author: Please provide publisher location for reference ‘Spencer, 2004.’