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A VARMA Analysis of the Causal Relations Among Stock Returns, Real Output, and Nominal Interest Rates

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ABSTRACT

Previous research has documented a negative relation between common stock returns and inflation. Recently, Fama [3] and Geske and Roll [6] have argued that this relation results from a more fundamental one between real activity and expected inflation. Stock returns, they argue, signal changes in real activity, which in turn affect expected inflation. However, unlike Fama, Geske and Roll argue that changes in real activity result in changes in money supply growth, which in turn affect expected inflation. Empirical tests have analyzed separately each link in the proposed causal chain. In this article, we investigate simultaneously the relations among stock returns, real activity, inflation, and money supply changes using a vector autoregressive moving average (VARMA) model. Our empirical results strongly support Geske and Roll's reversed causality model.

THERE HAVE BEEN MANY attempts to explain the negative relations observed between stock returns and expected inflation, changes in expected inflation, and unexpected inflation.[1] These phenomena, documented by Fama and Schwert [5], are troublesome because they appear contrary both to Fisher's theory that nominal asset returns are positively related to expected inflation, and to received wisdom that common stocks are hedges against expected as well as unexpected inflation.

Fama [3] suggests an explanation for the observed negative relation between stock returns and inflation based on money demand theory. An increase in anticipated real activity leads, he argues, to an increase in the demand for real money balances. Given the level of nominal money, the increased demand for real money balances must be accommodated by a fall in the price level. Because stock returns are assumed to be positively related to expected future real activity, a negative relation between inflation and stock returns is induced. However, this negative relation is merely a proxy for the more fundamental relation between anticipated real activity and stock returns. Therefore, Fama argues that the observed relation between stock returns and inflation is spurious.

As noted by Fama and others, this line of reasoning cannot explain completely the negative relation between stock returns and inflation. Fama finds that measures of unexpected inflation are significant determinants of monthly stock returns in regressions where anticipated real activity is included as an explanatory variable. In addition, the explanatory power of expected inflation is eliminated

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[1] Geske and Roll [6] discuss several of these explanations.

only when the growth rate of the money base, a variable highly correlated with expected inflation, is included in the regression.

Geske and Roll [6] offer an explanation of the anomalous relation between stock returns and inflation that supplements the explanation provided by money demand theory. They argue that there is a causal link in the observed negative relation between stock returns and changes in expected inflation.[2] However, the direction of causality is reversed from that implied by the regressions of Fama and Schwert. Geske and Roll contend that stock returns signal changes in inflationary expectations because the money supply responds to changes in anticipated real activity. As in Fama's model, stock returns anticipate changes in real activity. In addition, changes in government revenue are assumed to vary inversely with changes in real activity. Since most government expenditures are fixed, changes in revenue lead to opposite changes in the government's deficit. If the deficit is monetized, the change in the money supply results in a change in inflation. If the deficit is not monetized, nominal interest rates (the proxy used for expected inflation) may still increase as a result of an increase in the real interest rate. Since this process is anticipated, stock returns signal changes in expected inflation.

Geske and Roll's argument has several implications. There should be a negative relation between stock returns and unexpected inflation, since changes in inflationary expectations generally result in more than proportionate changes in the actual inflation rate. In addition, if the correct causal link is from stock returns to changes in inflationary expectations, then reversing this relation and regressing expected inflation on stock returns would result in expected inflation appearing to be a significant determinant of stock returns. Thus, Geske and Roll contend that their money supply hypothesis not only is consistent with the observed negative relations between stock returns and various measures of inflation, but also can explain the anomalies that remain after controlling, as Fama does, for the relation between stock returns and real activity.

The empirical evidence Geske and Roll offer in support of their theory is not fully convincing, for two reasons. First, although their money supply hypothesis involves a set of relationships that jointly explains the behavior of certain variables, Geske and Roll separately examine each link in their proposed causal chain. The evidence at each link is suggestive of the proposed relation between variables at that link. However, their equation-by-equation estimation procedure may be inappropriate for what is essentially a system of equations. Because error terms across equations are likely to be correlated, the ordinary least-squares estimates (as well as transfer function estimates) are inefficient, although unbiased.

Second, although their argument is based on a hypothesized direction of causality between stock returns and changes in expected inflation, in estimating their final reversed causality model Geske and Roll impose this structural model on the data, rather than allowing the data to determine the existence and direction of any causal relations. Although the estimates of their reversed causality model appear reasonable, their methodology does not have the power to identify the

[2] The term "causal" is used here in the econometric sense of Granger [7].

appropriate direction of causality between stock returns and changes in inflationary expectations.[3]

A logical next step is to examine simultaneously the causal links connecting stock returns, real activity, the money supply, and inflation. We investigate the relations among these variables using a vector autoregressive moving average (VARMA) model. A VARMA model can be viewed as a set of reduced-form equations associated with a simultaneous system of linear structural equations. Importantly, the procedure does not preclude any causal structure *a priori*, since it allows feedback among the variables. Thus, the VARMA approach allows whatever causal relations exist to emerge from the data.

We find evidence of linkages between real activity and stock returns, as well as between real activity and inflation. This evidence is consistent with the explanations of both Fama and Geske and Roll. There is, however, one feature that distinguishes the two models. Geske and Roll argue that the money supply changes in response to expected changes in real activity. Fama's model implies that the money supply is passive with respect to changes in expected real output. We find that stock returns signal changes in the monetary base. Since stock returns also signal changes in expected real activity, this suggests a link between the money supply and expected real activity that is consistent with the money supply explanation offered by Geske and Roll.

The remainder of the paper is organized as follows: in Section I, we discuss briefly the causal relations proposed by Fama and by Geske and Roll. In Section II, we describe our data. The methodology is discussed and our results are reported in Section III. Concluding remarks are presented in Section IV.

I. Hypothesized Causal Relations

The causal linkages among stock returns, real activity, and inflation suggested by Fama and by Geske and Roll are similar in many respects. Both models imply that: (i) changes in expected real activity are exogenously determined; (ii) changes in anticipated levels of real activity cause changes in stock returns; and (iii) there is a negative relation between expected real activity and inflation.

The difference between the two models lies in the assumptions concerning the role of the money supply process. Geske and Roll argue that the money supply responds to changes in expected real activity. Because stock returns forecast real activity, stock returns signal changes in the money supply. Money supply changes, in turn, signal changes in expected inflation. In Fama's model, there is no causal linkage between stock returns and money supply growth. Therefore, there is no causal relation between stock returns and expected inflation.

An additional implication of Geske and Roll's model is a strong contemporaneous negative correlation between ex-post stock returns and changes in short-term interest rates. Because nominal interest rates forecast inflation, anticipated real sector shocks will have a contemporaneous effect on short-term interest rates.

[3] Solnik [13] examines the relation between stock returns and inflation for nine countries and finds evidence consistent with Geske and Roll's reversed causality model. However, Solnik imposes a structural model on the data, as do Geske and Roll.

II. Data

The data we used to examine the causal relations between stock returns and inflation are similar to those employed by Fama and by Geske and Roll. As a measure of common stock returns, we compounded continuously the nominal return on the Standard and Poor's 500 stock index (RS_t), obtained from Ibbotson and Sinquefield [8]. As a proxy for the change in expected inflation, we used the change in the return of one-month Treasury bills ($RF_t - RF_{t-1}$), obtained from Ibbotson and Sinquefield. Our measure of the change in expected inflation is identical to the measures used by Fama and Schwert and by Geske and Roll.

Using the change in Treasury bill returns as a measure of expected inflation ignores the possibility that nominal interest rates may also change because of a change in the real rate of interest. However, Fama and Gibbons [4] find that real rate changes follow a random walk and are a small component of changes in Treasury bill returns. Moreover, since the reversed causality model proposed by Geske and Roll is formulated in terms of stock returns and nominal interest rate changes, we utilized Treasury bill returns in our analysis.

We measured anticipated real activity by the annual growth rate of industrial production (CIP_t), constructed by calculating the change in industrial production for the year beginning in month t.[4] This is the same measure of expected future real activity used by Fama. The index of industrial production is compiled by the Federal Reserve Board and was obtained (without seasonal adjustment) from Data Resources Incorporated (DRI).

Finally, we measured changes in the money supply by the annual rate of change in the adjusted monetary base (MB_t) for the year ending with month t. We obtained monthly monetary base data from DRI and adjusted them for effective reserve requirements using the method employed by the Federal Reserve Bank of St. Louis. This measure of money supply growth is identical to the money supply variable employed by Fama and by Geske and Roll. All series were obtained for the period 1962 through 1981.[5]

The first step in our analysis is to document that the negative relations between stock returns and various measures of inflation actually characterize our data. This is done because there are slight differences in the time period we analyze and the data we use, relative to those employed by Fama or by Geske and Roll.

First, we estimated the relation between stock returns (RS_t) and both expected inflation (RF_{t-1}) and changes in expected inflation ($RF_t - RF_{t-1}$) using ordinary least-squares (OLS) regression analysis. This regression is estimated by Fama and Schwert and by Geske and Roll. Our results are presented below (standard errors are given in parentheses):

$$\begin{aligned} RS_t &= \underset{(0.004)}{0.014} - \underset{(0.889)}{1.530}\, RF_{t-1} - \underset{(3.065)}{9.323}\, (RF_t - RF_{t-1}) \\ R^2 &= 0.051 \qquad F = 7.06 \end{aligned}$$

[4] We use annual growth rates because monthly changes in industrial production are highly seasonal (see Fama [3]).

[5] Because of the lead and lag structures used and the use of annual growth rates, the reported estimates are based on 199 observations.

We find a negative and statistically significant relation between stock returns and both expected inflation and changes in expected inflation, consistent with the results of Fama and Schwert and Geske and Roll.

Next, we estimated the relation between stock returns (RS_t) and expected inflation (RF_{t-1}), growth in real activity (CIP_t), money growth (MB_t), and changes in expected inflation ($RF_t - RF_{t-1}$). Our results are presented below (standard errors are in parentheses):

$$\begin{aligned} RS_t = \underset{(0.005)}{0.009} + \underset{(1.687)}{0.705}\, RF_{t-1} + \underset{(0.026)}{0.071}\, CIP_t - \underset{(0.117)}{0.124}\, MB_t - \underset{(3.347)}{12.213}\,(RF_t - RF_{t-1}) \\ R^2 = 0.07 \qquad F = 6.42 \end{aligned}$$

Our results are similar to those reported by Fama. We find no significant relation between expected inflation and common stock returns when growth in real activity and money growth are included in the model. The relation between changes in expected inflation and stock returns is negative and statistically significant.[6] In summary, the phenomena that Fama and Geske and Roll attempt to explain also are observed in our sample.[7]

III. VARMA Estimates of the Relations Between Stock Returns and Inflation

A. Characteristics of VARMA Processes

The causal relations discussed above are examined using a VARMA model. VARMA models provide an unbiased test of Granger causality and can detect feedback relationships between series being analyzed. In this section, we present a brief description of VARMA processes. For a more rigorous treatment, see Tiao and Box [15] and Tsay [16].

A VARMA process has the following form:

$$\underset{(K \times K)}{\underline{\underline{\phi}}(B)} \quad \underset{(K \times 1)}{\underline{Z}_t} \quad = \quad \underset{(K \times K)}{\underline{\underline{\theta}}(B)} \quad \underset{(K \times 1)}{\underline{a}_t} \tag{1}$$

where $\underline{Z}'_t = (Z_{1t}, Z_{2t}, \cdots, Z_{Kt})$ is a stationary vector of K time series containing n observations and $\underline{a}'_t = (a_{1t}, a_{2t}, \cdots, a_{Kt})$ is a vector of random shocks which are independently, identically, and normally distributed with mean zero and

[6] The model we estimate differs from the model estimated by Fama. Fama uses the residuals from a Treasury bill model of inflation as a measure of unexpected inflation. However, as Geske and Roll argue, the two measures of unanticipated inflation are highly correlated and therefore yield similar results.

[7] We also replicated Fama's regression of inflation on money demand and real activity (regression (1) of his Table 1), in order to document the negative relation between inflation and real activity underlying his analysis. For the inflation series, we used the continuously compounded monthly rate of change in the consumer price index (CPI_t). The results presented below are similar to Fama's (standard errors are in parentheses).

$$\begin{aligned} \mathrm{CPI}_t = \underset{(0.000)}{0.000} - \underset{(0.003)}{0.015}\, CIP_{t-12} - \underset{(0.003)}{0.031}\, CIP_t + \underset{(0.011)}{0.106}\, MB_t \\ R^2 = 0.583 \qquad F = 92.40. \end{aligned}$$

covariance $\underline{\underline{\Sigma}}$. The $(K \times K)$ matrices $\underline{\underline{\phi}}(B)$ and $\underline{\underline{\theta}}(B)$ have finite polynomial elements in the lag operator B, defined as $B^j Z_{i,t} = Z_{i,t-j}$, and are assumed to be of full rank. $\underline{\underline{\phi}}(B)$ is a matrix of autoregressive (AR) parameters, and $\underline{\underline{\theta}}_j(B)$ is a matrix of moving average (MA) parameters.

In general, the VARMA process (1) may be viewed in the following manner: $\underline{a}_t$ is a stochastic input to the process for which the output is $\underline{Z}_t$. The matrix $\underline{\underline{\theta}}(B)$ represents the persistent influence of $\underline{a}_t$ over a series of time periods, while the matrix $\underline{\underline{\phi}}(B)$ represents the adjustment pattern to these shocks. The process in Equation (1) is stationary if the roots of the determinantal equation, $\underline{\underline{\phi}}(B) = 0$, are outside the unit circle. If the roots of the determinantal equation, $\underline{\underline{\theta}}(B) = 0$, are outside the unit circle, then the process is said to be invertible.

If the $\underline{Z}_t$'s in (1) can be arranged so that $\underline{\phi}(B)$ and $\underline{\theta}(B)$ can be written as lower triangular matrices, then system (1) can be thought of as being a system of transfer function equations which can be estimated independently of each other (see Box and Jenkins [1]).[8] Granger causality between two series can be readily checked using (1). For example, for the statement "Z_2 does not cause Z_1" to hold for pure AR or MA structures, $\underline{\underline{\phi}}(B)$ or $\underline{\underline{\theta}}(B)$, respectively, must be lower triangular, whereas for mixed structures the condition

$$\phi_{12}(B)\theta_{12}(B) - \phi_{22}(B)\theta_{12}(B) = 0 \tag{2}$$

must be satisfied (see Eberts and Steece [2]).[9] Instantaneous causality, i.e., "feedback" at lag 0, can be detected in VARMA models by checking the significance of the off-diagonal values in the error correlation matrix. If a third process, Z_3, is of interest, conditional relationships between Z_1 and Z_2 in the presence of Z_3 can also be considered.

For example, in the VARMA (1, 1) structure,[10]

$$\begin{bmatrix} 1-\phi_{11}B & 0 & 0 \\ -\phi_{21}B & 1-\phi_{22}B-\phi_{23}B \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} z_{1t} \\ z_{3t} \\ z_{2t} \end{bmatrix} = \begin{bmatrix} 1-\theta_{11}B & 0 & 0 \\ -\theta_{21}B & 1-\theta_{22}B & 0 \\ 0 & 0 & 1-\theta_{33}B \end{bmatrix} \begin{bmatrix} a_{1t} \\ a_{2t} \\ a_{3t} \end{bmatrix}$$

with covariance

$$\Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} & 0 \\ \sigma_{21} & \sigma_{22} & 0 \\ 0 & 0 & \sigma_{33} \end{bmatrix}$$

[8] Relationships between transfer functions and linear simultaneous systems have been discussed by Zellner and Palm [19], Wallis [17], and by Koreisha [10].

[9] If $\underline{\underline{\phi}}(B)$ or $\underline{\underline{\theta}}(B)$ are block triangular, then unidirectional relationships exist between sets of component series (see Pierce and Haugh [11]).

[10] In a VARMA (p, q) model, p is the number of autoregressive parameters, and q is the number of moving average parameters.

Z_3 is exogenous in relation to Z_1 and Z_2, and Z_1 is exogenous to Z_2 (see Tsay [16]).

B. VARMA Analysis

Initially, we analyze each of the four time series separately. The results indicate that all the series are stationary, with the exception of the growth in the monetary base. The first difference of the monetary base series (∇MB_t) is stationary and therefore is used in the subsequent analysis.

For reporting purposes, the following VARMA structure is used:

$$\underline{\underline{\phi}}(B)\begin{bmatrix} RS_t \\ \nabla MB_t \\ \nabla RF_t \\ CIP_t \end{bmatrix} = \underline{\underline{\theta}}(B)\begin{bmatrix} a_{1t} \\ a_{2t} \\ a_{3t} \\ a_{4t} \end{bmatrix}$$

where

∇MB_t = first difference in the growth in the money base, and
∇RF_t = first difference in the Treasury bill rates.

The methodology for constructing VARMA models consists of three stages.[11] These are: (1) tentative specification, where sample cross-correlation and partial cross-correlation matrices are used to specify the order of the VARMA process; (2) estimation, where efficient parameter estimates are obtained by maximizing the likelihood function; and (3) diagnostic checking, where model deficiencies are identified by a cross-correlation analysis of the residual series.

Analysis of the cross-correlation and partial autoregression patterns suggest a VAR(3) structure with a seasonal component as a tentative specification. Estimates of this model are reported in Table I.[12] Because of the possible nonstationarity of the industrial production series, we also estimated a VARMA model using first differences of the industrial production series (∇CIP_t).[13] Results of this estimation, presented in Table II, are very similar to the results in Table I.[14]

The results in both Tables I and II are consistent with the causal relations that are common to both Fama's and Geske and Roll's models. For convenience, we focus our discussion on the results in Table II. Equation (1) indicates that expected real activity is exogenous to the model, in that there is no significant transfer component in the industrial production series. Equation (2) suggests

[11] See Tiao and Box [15].

[12] VARMA estimates are obtained using maximum likelihood procedures. Maximum likelihood estimates are consistent and have an asymptotic normal distribution. Therefore, for large samples, usual inferences concerning parameter significance are appropriate (see Wilson [18] and Judge et al. [9]). However, small sample properties of maximum likelihood procedures generally are not known. The WMTS programs (see Tiao et al. [14]) were used to estimate the parameters. The residual cross-correlations associated with the estimates in Table I (not shown for the sake of brevity) corroborate the adequacy of the model. Aside from a few correlations at high lags, all cross-correlations are small and within two standard errors of zero.

[13] The possibility of nonstationarity in the industrial production series is indicated in Equation (4) of Table I. The sum of the lagged coefficients for CIP is approximately equal to one.

[14] Expansion of the difference operator in Equation (1) of Table I essentially yields (1) in Table II. The remaining equations in both tables are for practical purposes identical.

Table I

VARMA Estimates of Causal Relations Among Stock Returns, Real Activity, Money Growth, and Expected Inflation[a] (1962–1981)

A. Model Estimates[b,c]

$$(1)\ CIP_t = \underset{(0.001)}{0.001} + \underset{(0.059)}{1.566}\, CIP_{t-1} - \underset{(0.058)}{0.591}\, CIP_{t-2} + a_{1,t} - \underset{(0.052)}{0.688}\, a_{1,t-12}$$

$$(2)\ RS_t = \underset{(0.003)}{0.001} + \underset{(0.209)}{0.703}\, CIP_{t-2} - \underset{(0.204)}{0.554}\, CIP_{t-3} + a_{2,t}$$

$$(3)\ \nabla RF_t = \underset{(0.000)}{0.000} + \underset{(0.012)}{0.030}\, \nabla MB_{t-1} - \underset{(0.069)}{0.212}\, \nabla RF_{t-2} - \underset{(0.004)}{0.015}\, CIP_{t-2} + \underset{(0.004)}{0.015}\, CIP_{t-3} + a_{3,t}$$

$$(4)\ \nabla MB_t = \underset{(0.000)}{0.000} + \underset{(0.067)}{0.294}\, \nabla MB_{t-1} - \underset{(0.004)}{0.011}\, RS_{t-2} + \underset{(0.067)}{0.241}\, \nabla MB_{t-3} + a_{4,t} - \underset{(0.046)}{0.788}\, a_{4,t-12}$$

B. Error Cross-Correlation Matrix[d]

	CIP_t	RS_t	∇RF_t	∇MB_t
CIP_t	1.00			
RS_t	−0.02	1.00		
∇RF_t	−0.08	−0.25	1.00	
∇MB_t	−0.05	−0.08	−0.08	1.00

[a] The VARMA process estimated is a VAR(3) with a seasonal component.

[b] Standard errors are in parentheses. For industrial production, Equation (1), and the money base, Equation (4), the significant error terms at lag 12 suggest the presence of a seasonal component.

[c] Variables are defined as follows:

CIP_t = change in industrial production for the year beginning in month t;

RS_t = the stock returns for month t, as measured by the continuously compounded nominal return on the Standard and Poor's 500 stock index;

∇RF_t = the change in expected inflation, as measured by the change in the return on one-month Treasury bills; and

∇MB_t = the first differences in the annual rate of change for the adjusted monetary base, for the year ending in month t.

[d] The approximate standard error of the cross-correlation estimates is 0.07.

that expected real output has a positive and significant effect on stock returns, at a lag of two months. The results in Equation (3) are also consistent with both models. Changes in the monetary base have a positive and significant effect on changes in inflation; changes in industrial production (at lag 2) have a negative and significant effect on expected inflation. Given the money demand model of Fama, one would expect to observe a positive relation between expected inflation and monetary growth, and a negative relation between inflation and real activity.

The results in Equation (4) are consistent with the reversed causality model of Geske and Roll. There is a negative and significant relation between growth in base money and stock returns. Since stock returns can be considered an indicator of expected real activity, Equation (4) provides evidence of a causal link between real activity and money supply growth. This link distinguishes Geske and Roll's model from Fama's.

Additional support for the reversed causality model is obtained from inspection of the error cross-correlation matrices in Part B of Table II. There do not appear to be any significant off-diagonal elements that would indicate the presence of

Table II

VARMA Estimates of Causal Relations Among Stock Returns, Real Activity, Money Growth, and Expected Inflation Using Transformed Industrial Production Series[a] (1962–1981)

A. Model Estimates[b,c]

$$(1)\ \nabla CIP_t = \underset{(0.000)}{0.000} + \underset{(0.059)}{0.576}\ \nabla CIP_{t-1} + a_{1t} - \underset{(0.052)}{0.689}\ a_{1,t-12}$$

$$(2)\ RS_t = \underset{(0.003)}{0.006} + \underset{(0.212)}{0.630}\ \nabla CIP_{t-2} + a_{2,t}$$

$$(3)\ \nabla RF_t = \underset{(0.000)}{0.000} + \underset{(0.012)}{0.030}\ \nabla MB_{t-1} - \underset{(0.069)}{0.209}\ \nabla RF_{t-2} - \underset{(0.004)}{0.014}\ \nabla CIP_{t-2} + a_{3,t}$$

$$(3)\ \nabla MB_t = \underset{(0.000)}{0.000} - \underset{(0.067)}{0.291}\ \nabla MB_{t-1} - \underset{(0.004)}{0.011}\ RS_{t-2} + \underset{(0.068)}{0.241}\ \nabla MB_{t-3} + a_{4,t} - \underset{(0.046)}{0.784}\ a_{4,t-12}$$

B. Error Cross-Correlation Matrix[d]

	∇CIP_t	RS_t	∇RF_t	∇MB_t
∇CIP	1.00			
RS_t	−0.04	1.00		
∇RF_t	−0.07	−0.25	1.00	
∇MB_t	−0.04	−0.07	−0.04	1.00

[a] The VARMA process estimated is a VAR(3) with a seasonal component.

[b] Standard errors are in parentheses. For industrial production, Equation (1), and the money base, Equation (4), the significant error terms at lag 12 suggest the presence of a seasonal component.

[c] Variables are defined as follows:

∇CIP_t = the first differences of the change in industrial production for the year beginning in month t;

RS_t = stock returns for month t, as measured by the continuously compounded nominal return on the Standard and Poor's 500 stock index;

∇RF_t = the change in expected inflation, as measured by the change in the return on one-month Treasury bills; and

∇MB_t = the first differences of the annual rate of change for the adjusted monetary base, for the year ending in month t.

[d] The approximate standard error of the cross-correlation estimates is 0.07.

contemporaneous feedback, with the exception of the negative correlation between stock returns and changes in Treasury bill rates. However, the significant negative contemporaneous correlation between changes in short-term interest rates and stock returns is predicted by Geske and Roll. Since real shocks are negatively related to changes in the deficit, changes in short-term rates will be negatively related to real shocks, as represented by stock returns, either through a change in expected inflation (if the debt is monetized), or through changes in the real rate (if the deficit is not monetized).

IV. Conclusions

We investigated the causal linkages among stock returns, real activity, money growth, and expected inflation. VARMA estimation techniques were used to examine the validity of models that attempt to explain the observed negative relation between stock returns and inflation. The evidence presented here is consistent with the reversed causality model proposed by Geske and Roll [6].[15] In particular, we find a strong link between stock returns, a proxy for expected real activity, and the growth rate in the monetary base. Moreover, we find that expected changes in real activity and money supply growth are important predictors of changes in expected inflation. The evidence presented here, therefore, strongly supports the hypothesis that stock returns signal changes in expected inflation and nominal interest rates.

[15] Our results are also consistent with the findings of Solnik for other industrialized countries. An interesting extension of our analysis would be to examine, using VARMA techniques, whether the causal relations we observe are consistent across countries.

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