NOTES, COMMENTS, REPLIES

Federal Debt, Tax-Adjusted *q*, and Macroeconomic Activity

A Note by W. Douglas McMillin and Randall E. Parker

1. Introduction

Although the role of government debt in the macroeconomy has been intensively analyzed in recent years, there appears to be no theoretical or empirical consensus regarding the impact of government debt on the macroeconomy. The focus of much of this research has been the validity of the Ricardian equivalence hypothesis, and empirical studies have frequently analyzed the impact of government debt on a particular variable like the interest rate, consumption, or output within a single-equation framework.[1] However, since the question of whether government debt is net wealth clearly has implications for a wide range of macroeconomic variables, it would seem appropriate to analyze empirically the effects of government debt within a small macroeconomic model. This is the aim of this study.

The framework for the analysis is a ten-variable vector autoregressive (VAR) model, and the effects of federal debt are analyzed through the computation of variance decompositions and impulse response functions.[2] This study is distinguished from others by its more comprehensive specification of the financial sector of the model and by the use of a Monte Carlo simulation technique to estimate standard errors for the variance decompositions and impulse response functions. This allows an assessment of the significance of the effects of federal debt on the macroeconomy.

[1]Much of the theoretical arguments and empirical evidence is surveyed in Brunner (1986).

[2]Plosser (1982), Dwyer (1982), McMillin (1985), and Fackler and McMillin (1989) also evaluate the effects of debt within vector autoregressive models. However, Plosser's, Dwyer's and McMillin's samples end prior to the recent record federal deficits. It seems important to include data for the period of recent high deficits. Further, the current study's specification of the financial sector is much richer than that of the four studies listed above.

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In evaluating the financial market effects of deficits, most of the prior research has focused upon the effects of deficits on interest rates. From the perspective of the portfolio model of Tobin (1969), this is too narrow a focus. For example, in a three-asset (money, bonds, and capital) portfolio model, variations in the stock of debt alter the interest rate and the rate of return on capital; as a result, q—the ratio of the market value of the capital stock to its replacement cost—is altered. Changes in q in turn affect investment spending and hence real output and prices. Although an increase in government debt unambiguously raises the real interest rate in this model, the impact on the rate of return on capital and q is ambiguous.[3] If the increase in government debt raises (lowers) the rate of return on capital, q falls (rises) and investment decreases (increases). Thus, within this context, examination of only the effect of government debt on the interest rate may yield a distorted picture of the financial market *and* real sector effects of the change in debt.

The macroeconomic model estimated here incorporates the insights of Tobin's model by including measures of the real rate of interest, the rate of return on capital, and q as separate variables in the model. The remaining seven variables include measures of output, the price level, consumption, supply shocks, real federal government purchases of goods and services, nominal value of privately held federal debt, and the nominal monetary base. It is important to control for the effects of government purchases because, if they were omitted, effects attributable to changes in government purchases might incorrectly be attributed to government debt since purchases and debt are correlated. Further, since much of the literature on Ricardian equivalence focuses upon the impact of government debt on consumption, real consumption expenditures are included in the model.

The VAR technique is chosen since it avoids imposing potentially spurious a priori constraints (such as, for example, econometric exogeneity of federal debt in the real interest rate equation) on the model. Furthermore, it is well suited to an examination of the channels through which a variable operates since few restrictions are imposed on the way the system's variables interact. However, since the VAR is a reduced-form approach, it is difficult to distinguish sharply among structural hypotheses. Other limitations of the approach have been discussed by Cooley and LeRoy (1985). But since the purpose of this paper is to gain some insight into the channels through which debt operates, the VAR technique is well suited to this purpose.

In section 2 of the paper the data and the specification of the VAR are discussed. In section 3 the empirical results are presented, and section 4 provides a brief summary and conclusions.

2. *Data Description and Model Specification*

Quarterly data for the period 1955:1–1987:4 are used in the analysis. The data begin in 1955 in order to allow several years transition from the Treasury-Federal

[3]The direction of effect on the rate of return on capital and q depends upon whether bonds and money are closer substitutes than are bonds and capital and upon the relative magnitudes of the effect of wealth on money and capital demand. For a more detailed discussion see Tobin (1969) and B. Friedman (1978).

Reserve Accord. Data from 1955:1–1957:4 are used as presample data, and the estimation of the system is carried out over 1958:1–1987:4.

The model variables are real GNP (y), the GNP deflator (P), a supply shock variable (ss), the real ex ante three-month Treasury bill rate (r), the rate of return on capital (r_k), q, real federal government purchases (g), real consumption expenditures (c), the nominal par value of privately held federal debt (d), and the nominal monetary base (adjusted for reserve requirement changes) (m). The variable ss is measured as the difference between the rate of change in the producer price index for crude oil and the rate of change in the GNP deflator. r is generated by employing a variant of the technique suggested by Huizinga and Mishkin (1985).[4] r_k is proxied by the dividend/price ratio for Standard and Poor's Composite Common Stock Index.[5] q is a measure of "tax-adjusted" q and is constructed based upon the technique described in Bernanke, Bohn, and Reiss (1988). Tax-adjusted q is employed since Summers (1981) and Hayashi (1982) show that private investment depends upon q adjusted for tax policies. Following Bernanke et al., tax-adjusted q is defined as:

$$q = 1/(1 - U)\{((V - B)/K) - 1.0 + b + ITC + U \cdot Z\}$$

where U = corporate tax rate, V = nominal market value of firms, B = present value of depreciation allowances on the existing capital stock, K = nominal capital stock, b = ratio of debt to capital, ITC = marginal rate of investment tax credit, and Z = present value of a dollar's worth of depreciation allowances.[6]

The par value of government debt, rather than the market value, is employed for the following reason. Changes in the nominal interest rate automatically lead to changes in the market value of debt. Links between the market value of debt and economic variables may thus reflect a relationship between nominal interest rates (which reflect, in part, changes in expected inflation and other expectational effects) and these variables. The results reported below are not sensitive to the use of market value of debt data.[7]

[4]Details of this technique are available on request. As indicated later in the text, the results were essentially unchanged when a series for r, constructed from Walsh's (1987) criticism of the Huizinga-Mishkin technique, is employed.

[5]As indicated later in the text, the results are not sensitive to the use of a more comprehensive measure that adds the real rate of capital gain (loss) to the dividend/price ratio. The rate of real capital gain (loss) is measured in a manner similar to Shapiro (1988).

[6]Details of the construction of the q series are available on request. Some of the data used in the construction of q were provided by DRI. Data for c, y, P, r_k, g, m, the nominal three-month Treasury bill rate, and the producer price index for crude oil are from Citibase. The nominal par and market value of federal debt were provided by W. Michael Cox. A description of the construction of the market value series can be found in Cox (1985).

[7]Hafer and Hein (1988) demonstrate that these concerns are of empirical significance in a bivariate study of the relationship between the par value of federal debt and inflation and the market value of federal debt and inflation. They find no evidence of Granger-causality from the par value of debt to inflation, and they show that Granger-causality from the market value of debt to inflation essentially disappears when they control for nominal interest rates. Results employing the market value of debt are reported in Table 1, column 5.

Prior to specification and estimation of the VAR, it is important to render the data stationary. Tests for first- and second-order unit roots of the type described by Nelson and Plosser (1982) were performed in order to determine the appropriate transformations for the variables. The tests indicated that a first-order unit root could not be rejected for the log levels of c, y, p, d, m, and the producer price index for crude oil and the levels of r, r_k, and q. Because first-order unit roots could not be rejected for both P and the producer price index for crude oil, ss was measured as the difference between the rate of change in the crude oil price measure and the GNP deflator. No evidence of second-order unit roots for any of the variables was found.

Akaike's AIC criterion was used to determine the lag length of the VAR model. Use of this criterion suggested a lag of eight quarters. Because the optimal lag chosen was the maximum considered, the sensitivity of the results to a lag of nine quarters was tested and the results are reported below. Q statistics for each equation indicated no problems with serial correlation.[8]

3. *Empirical Results*

The effects of federal debt are evaluated by examining variance decompositions (VDCs) and impulse response functions (IRFs). VDCs show the proportion of forecast error variance for each variable that is attributable to its own innovations and to shocks to the other system variables. IRFs show the predictable response of each variable in the system to a one-standard deviation shock to one of the system's variables and can be viewed as a type of dynamic multiplier that conveys information about the size and direction of effect of a shock to one variable on the other variables.

The importance of providing estimates of the precision with which the VDCs and IRFs are computed has recently been stressed by Runkle (1987). Consequently, we employ a Monte Carlo integration technique similar to that described in Doan and Litterman (1986) to generate estimates of the standard errors of the variance decompositions. Five hundred draws were employed in the Monte Carlo procedure.

Since no contemporaneous terms enter the equations of the VAR, any contemporaneous relations among the variables are reflected in the correlation of residuals across equations. In calculating the VDCs the variables are ordered in a particular fashion, and the variance-covariance matrix is orthogonalized by the Choleski decomposition. Because of the cross-equation residual correlation, when a variable higher in the order changes, variables lower in the order are assumed to change. The extent of the change depends upon the covariance of the variables higher in the order with those lower in the order.

The orderings considered are based upon theoretical considerations that flow in

[8] Coefficient estimates are available on request. In estimating the VAR, it is assumed, following Sims' (1982) suggestion, that the macroeconomy may be treated as stable over the period of estimation and that policymakers' behavior was consistent over this period.

part from Tobin's portfolio model.[9] The orderings considered are (1) ss, g, d, m, r, r_k, q, c, y, P; (2) ss, m, g, d, r, r_k, q, c, y, P; and (3) ss, g, m, r, r_k, q, c, y, P, d. The rationale for these orderings is based upon the following considerations. ss is placed first based upon the assumption that contemporaneous shocks to the relative price of oil stem more from developments in world oil markets than from shocks to the other variables. In orderings (1) and (2), the policy variables precede the financial market variables; this allows shocks to the policy variables to contemporaneously alter r, r_k, and q, as in Tobin's model. Furthermore, this also is consistent with widely employed policy rules that assume that the information sets that condition the settings of the policy variables contain only lagged values of r, r_k, q, c, y, and P. In ordering (1), g and d precede m; this permits the monetary authority to respond to movements in the fiscal variables, which seems reasonable in light of the relative flexibility of implementing monetary policy as compared to fiscal policy. Ordering (2) reverses the positions of the monetary and fiscal variables. In each ordering, r precedes r_k which precedes q. We thus assume that shocks to ss, g, d, or m initially alter r; changes in r then induce portfolio shifts that affect r_k and q. We regard this as being in the spirit of Tobin's model. Shocks to all the other variables are thus allowed to contemporaneously alter c, y, and P since they appear last. Ordering (3) is similar to ordering (1) except that d is placed last. In this ordering, debt has no contemporaneous effect on any other variable and this is the least "favorable" ordering for debt.

The VDCs are presented in Table 1. Since the focus of the paper is on the effects of debt, only the point estimates of the proportions of the variation in r, r_k, q, c, y, and P explained by d are presented. The estimated standard errors are presented in parentheses next to the point estimates which are judged to be "significant" if the estimate is at least twice the estimated standard error. The first column presents the results for ordering (1). VDCs at horizons of four, eight, twelve, and twenty quarters are provided in order to convey the dynamics of adjustment of the system. Since the results are quite similar across orderings, only the results for ordering (1) are presented.

The results in column (1) suggest that, at best, d has modest effects on r and r_k. There are significant effects of d on r at a horizon of twenty quarters and on r_k at horizons of four, twelve, and twenty quarters. There are no significant effects on q, c, y, or P. However, although several of the effects are significant, they do not appear to be large in an economic sense. In only one case (horizon four for r_k) does the VDC result reach 10 percent. It would be difficult to adduce a major economic role for d from the results in column (1) of Table 1.

These results appear robust. The results are essentially the same when lags of nine quarters are employed (column 2, Table 1), when a measure of r_k that adds real capital gains (losses) to the dividend/price ratio is substituted for the dividend/price

[9]Bernanke (1986) has also argued that theoretical considerations should be employed in computing the VDCs. However, he has suggested an alternative method of orthogonalizing the residuals to the Choleski decomposition.

TABLE 1

VARIANCE DECOMPOSITIONS

Relative variation in	Horizon (quarters)	Explained by innovations in federal debt						
		1	2	3	4	5	6	7
r	4	0.5 (1.4)	1.0	0.2	0.9	0.7	1.9	0.6
	8	3.0 (3.2)	1.7	2.7	5.7	5.1	5.7	6.4†
	12	6.3 (3.4)	3.1	6.0	6.2	6.9	8.1	7.4
	20	6.7 (3.3)*	2.4†	6.4	6.1	8.3	7.8	6.1
r_k	4	10.0 (4.9)*	6.5	5.4	10.3	5.1	11.3	6.4
	8	7.9 (4.2)	5.3	4.9	7.9	5.6	8.2	5.3
	12	8.7 (4.2)*	6.5	7.4	7.6	10.3	7.0	6.3
	20	8.3 (4.0)*	4.6	8.2	9.3	8.2	7.5	7.3
q	4	4.9 (3.4)	4.0	3.0	4.5	1.2†	7.1	2.0
	8	3.7 (2.8)	3.1	2.6	3.6	7.1†	5.6	1.7
	12	6.1 (3.3)	3.7	8.7	4.6	8.5	5.6	2.8
	20	5.6 (3.4)	3.0	6.8	5.2	8.0	5.9	3.4
c	4	4.3 (3.1)	7.3	3.2	2.3	1.4		1.0†
	8	4.0 (2.7)	5.0	3.6	2.5	1.6		2.2
	12	3.4 (2.8)	3.9	3.3	2.4	4.4		2.9
	20	5.7 (3.1)	5.8	5.1	3.7	5.3		4.4
y	4	5.2 (3.7)	2.8	3.9	7.3	6.9	9.2†	
	8	4.8 (3.0)	4.0	3.6	6.8	9.4†	8.5†	
	12	5.9 (3.3)	5.2	5.6	6.8	8.4	8.2	
	20	5.9 (3.4)	4.8	5.2	7.3	8.1	8.6	
P	4	4.0 (3.2)	4.2	4.7	3.5	2.3	2.8	2.8
	8	3.8 (3.0)	3.4	3.6	4.8	3.9	4.1	4.5
	12	5.8 (3.6)	5.7	6.2	5.6	8.3	4.1	6.3
	20	6.5 (4.1)	5.1	7.2	5.8	10.5	4.2	7.4

NOTES: Column 1 presents the results for ordering (1) for the basic system. The standard errors are in parentheses. An * indicates the point estimate is at least two standard deviations greater than the standard error. Standard errors are calculated only for the basic model. Column 2 presents the results for ordering (1) for the nine-lag system. Column 3 presents results for the system with the alternative measure of r_k. Column 4 presents results for the alternative measure of r. Column 5 presents results for the system with the market value of debt. Column 6 presents results for a nine-variable model that drops c. Column 7 presents results for a nine-variable model that drops y. In columns 2 through 7, † indicates that the point estimate is more than one, but less than two, standard deviations of that in column 1. All the others were within one standard deviation.

ratio (column 3), when a measure of r that incorporates Walsh's (1987) criticism of the Huizinga-Mishkin technique is employed (column 4), and when the market value of debt is substituted for the par value (column 5). Additionally, when c is dropped from the model, the results (column 6) are, with two exceptions, within one standard deviation of those in column 1. The exceptions are within two standard deviations of the results in column 1. Similar results are found when y is dropped and c is retained (column 7).

The IRFs for shocks to d for ordering (1) for the basic model are presented in Figure 1. In each diagram the point estimate of the IRF is plotted as the dotted line while the solid lines represent a two standard deviation band around the point estimate. The effects are judged to be insignificant if the two standard deviation band includes zero. We see from Figure 1 that a one standard deviation shock to d has no significant short- or long-run effects on r, q, c, or y. There are marginally significant short-run effects on r_k in periods 3 and 4, and on P in period 1. In all cases, the significant effects are negative. Thus, the IRFs, like the VDCs, provide no support for the view that government debt has major consequences for macroeconomic performance.

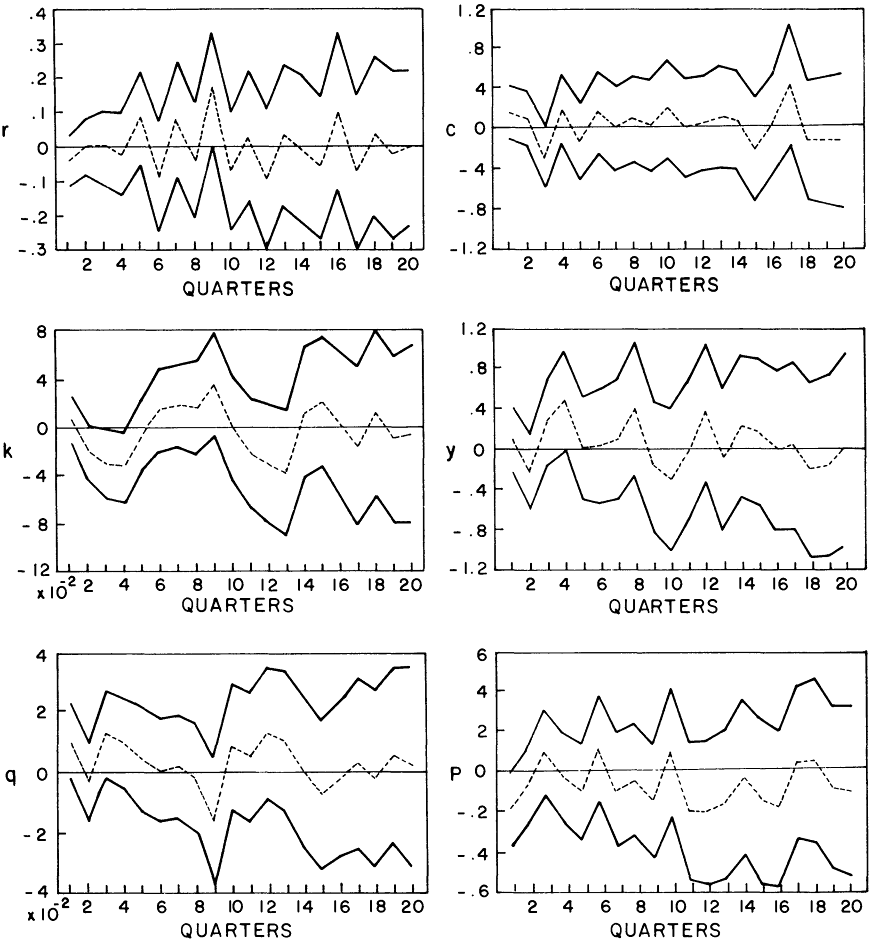

FIG. 1. Impulse Response Functions for a Shock to *d*

Although government debt does not importantly affect macroeconomic activity in our model, real government purchases (g) have significant effects on r, r_k, q, y, and P but insignificant effects on c. For example, VDCs for g (not presented in order to conserve space) indicate that shocks to g explain 16 to 21 percent of the variation in r. For r_k, the significant effects range from 7 to 10 percent while for q the significant effects vary from 8 to 14 percent. Shocks to g explain about 7 percent of the variation in y while the significant effects on P range from 9 to 13 percent. It thus appears that shocks to g have substantially more important effects on the macroeconomy than do shocks to d.

IRFs for shocks to g for ordering 1 are presented in Figure 2 and can be in-

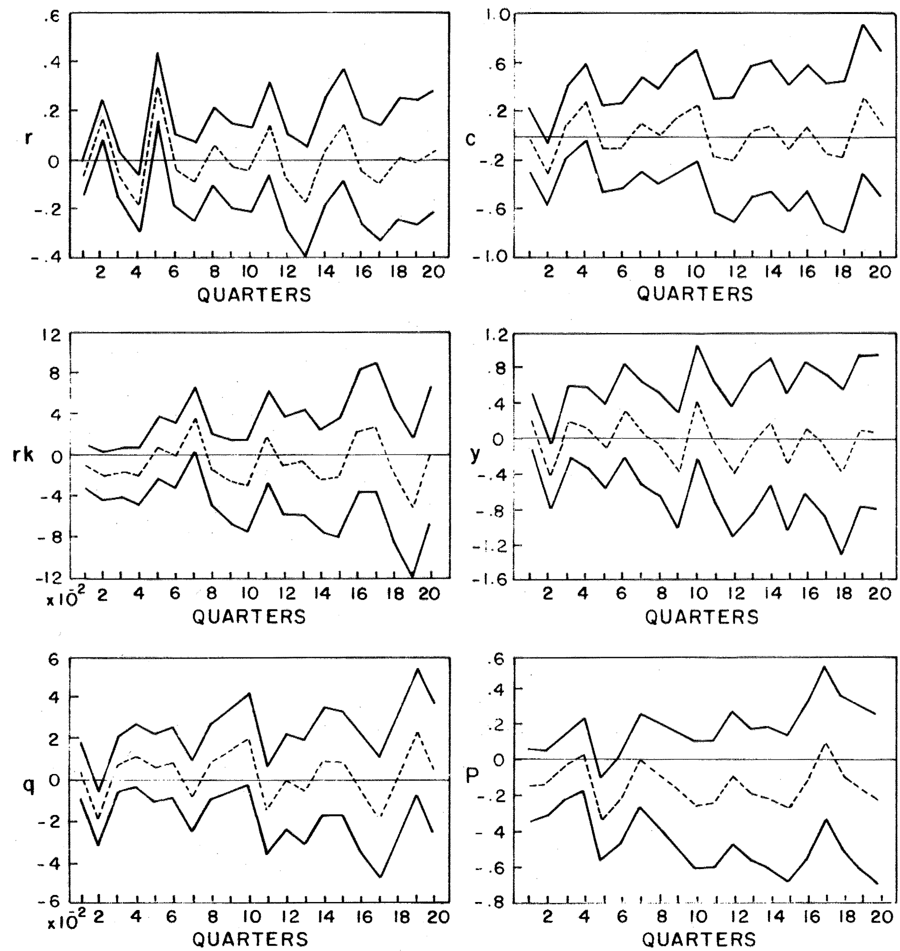

FIG. 2. Impulse Response Functions for a Shock to *g*

terpreted in the same fashion as Figure 1. As expected, there are no significant long-run effects of a one-time shock to g. However, there are short-lived, significant effects on r, q, c, and y in period 2 and on P in period 5. There are also significant effects on r in periods 4 and 5. We observe a significant positive shock to r and a significant negative shock to q in period 2. The negative effect on q would be expected given the conventional, positive effect on r. The second period effect on c is negative and significant, a result consistent with Kormendi (1983), who hypothesized that government consumption may substitute, to some degree, for private consumption. The significant effects on y and P are also negative, a result apparently not consistent with standard macro models. The negative effects on y and P

may reflect the possibility that negative effects on investment due to the increase in *r* and decrease in *q* and the negative effects on *c* outweigh the stimulatory effects of an increase in *g*. The longer delay in the effect on *P* may reflect rigidities in prices. The IRFs, like the VDCs, indicate a more important role for shocks to *g* than to *d*. The IRF results, especially for *y* and *P*, also suggest more detailed future research on the macro effects of *g* is warranted.

4. Conclusion

This paper has examined the macroeconomic consequences of federal government debt within vector autoregressive models. Since these models are reduced forms, it is difficult to distinguish sharply among alternative structural models. However, variance decompositions and impulse response functions indicate that federal debt has no major effects on the macroeconomy. Although some of the variance decomposition results are significant, they appear to be small in an economic sense. Likewise, the impulse response functions indicate, at best, weak transitory effects of debt shocks on some of the variables in the system. The direction of effect on these variables is generally inconsistent with the predictions of a model in which debt is a positive component of wealth.

LITERATURE CITED

Bernanke, Ben S. "Alternative Explanations of the Money-Income Correlation." *Carnegie-Rochester Conference series on Public Policy* 25 (Autumn 1986), 49–99.

Bernanke, Ben S., Henning Bohn, and Peter C. Reiss. "Alternative Nonnested Specification Tests of Time Series Investment Models." *Journal of Econometrics* 38 (March 1988), 293–326.

Brunner, Karl. "Fiscal Policy in Macro Theory: A Survey and Evaluation." In *The Monetary Versus Fiscal Policy Debate: Lessons from Two Decades,* edited by R. W. Hafer, pp. 33–116. New Jersey: Rowman and Allenheld, 1986.

Cooley, Thomas F., and Stephen F. LeRoy. "Atheoretical Macroeconometrics: A Critique." *Journal of Monetary Economics* 16 (November 1985), 283–308.

Cox, W. Michael. "The Behavior of Treasury Securities: Monthly, 1942–1984." *Journal of Monetary Economics* 16 (September 1985), 227–50.

Doan, Thomas A., and Robert B. Litterman. *User's Manual RATS,* Version 2.00. Minneapolis: VAR Econometrics, 1986.

Dwyer, Gerald P., Jr. "Inflation and Government Deficits." *Economic Inquiry* 20 (July 1982), 315–29.

Fackler, James S., and W. Douglas McMillin. "Federal Debt and Macroeconomic Activity." *Southern Economic Journal* 55 (April 1989), 994–1003.

Friedman, Benjamin M. "Crowding Out or Crowding In? Economic Consequences of Financing Government Deficits." *Brookings Papers on Economic Activity* 3 (1978), 593–641.

Hafer, R. W., and Scott E. Hein. "Federal Government Debt and Inflation." *Economic Inquiry* 26 (April 1988), 239–51.

Hayashi, Fumio. "Tobin's Marginal *q* and Average *q*: A Neo-Classical Interpretation." *Econometrica* 50 (January 1982), 213–24.

Huizinga, John, and Frederick S. Mishkin. "Monetary Policy Regime Shifts and the Unusual Behavior of Real Interest Rates." National Bureau of Economic Research Working Paper no. 1678, August 1985.

Kormendi, Roger C. "Government Debt, Government Spending, and Private Sector Behavior." *American Economic Review* 73 (December 1983), 994–1010.

McMillin, W. Douglas. "Money, Government Debt, *q*, and Investment." *Journal of Macroeconomics* 7 (Winter 1985), 19–37.

Nelson, Charles R., and Charles I. Plosser. "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications." *Journal of Monetary Economics* 10 (September 1982), 139–62.

Plosser, Charles I. "Government Financing Decisions and Asset Returns." *Journal of Monetary Economics* 9 (May 1982), 325–52.

Runkle, David E. "Vector Autoregressions and Reality." *Journal of Business & Economic Statistics* 5 (October 1987), 437–42.

Shapiro, Matthew D. "The Stabilization of the United States Economy: Evidence from the Stock Market." *American Economic Review* 78 (December 1988), 1067–79.

Sims, Christopher A. "Policy Analysis with Econometric Models." *Brookings Papers on Economic Activity* 1 (1982), 107–52.

Summers, Lawrence H. "Taxation and Corporate Investment: A *q*-Theory Approach." *Brookings Papers on Economic Activity* 1 (1981), 67–140.

Tobin, James. "A General Equilibrium Approach to Monetary Theory." *Journal of Money, Credit, and Banking* 1 (February 1969), 15–29.

Walsh, Carl E. "Testing for Real Effects of Monetary Policy Regime Shifts." National Bureau of Economic Research Working Paper no. 2116, January 1987.