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EFFECTS OF EXPECTED FUTURE GOVERNMENT DEFICITS  
ON CURRENT ECONOMIC ACTIVITY

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by

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I. Introduction

There has recently been considerable discussion about current and expected future federal government budget deficits. While many people are worried about the large size of the deficits, there is little clarity about the ways in which the deficits affect the economy. One obvious answer is that the deficits have no direct effects on individual and government decisions, that they are merely the consequence of these decisions. In a typical macroeconomic model, for example, the government surplus or deficit is determined by an identity, and it does not appear as an explanatory variable in any of the stochastic equations. If this is all there is to it, one should not worry about the deficits per se. One should merely be concerned about the standard target variables like real output, the rate of inflation, the unemployment rate, and the size of the capital stock.

The purpose of this paper is to consider the possibility that expected future government deficits directly affect economic decisions, in particular the decisions of the Federal Reserve. Some evidence is presented in Section II that indicates that the behavior of the Fed may be influenced

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by expected future deficits. The economic consequences of this behavior are examined in Section III.

## II. Fed Behavior

The question considered in this section is whether expected future government deficits affect Fed behavior. I have an equation in my U.S. macroeconomic model (Fair (1984)) that explains Fed behavior. This equation is an interest rate reaction function. It is a "leaning against the wind" equation in the sense that as real economic activity or inflation or money supply growth increases, the Fed is estimated to respond to this by raising short term interest rates. The hypothesis that Fed behavior is also influenced by expected future deficits can be tested by adding a variable measuring expected future deficits to this equation. If the variable is significant, this is evidence in favor of the hypothesis.

Let  $D_t$  be the ratio of the federal government deficit (NIA definition) to GNP in quarter  $t$  (both in current dollars).<sup>1</sup> This is the measure of the size of the deficit used in this study. Let  $D_{t+i}^e$  denote the Fed's expected value of  $D_{t+i}$  ( $i = 0, 1, \dots$ ), where the expectation is based on information available through quarter  $t-1$ .

Since the interest rate reaction function is part of a complete model, one could consider estimating the entire model by full information maximum likelihood (FIML) under the assumption that the expectations of the Fed are rational. All the equations in the model would be the same except for the interest rate reaction function, which would have the additional variable  $D_{t+i}^e$  on the right hand side, where  $i$  is chosen ahead

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<sup>1</sup>In terms of the notation in Fair (1984),  $D_t = -S_{gt}' / \text{GNP}_t$ , where  $S_{gt}'$  is the federal government budget surplus and  $\text{GNP}_t$  is nominal GNP.

of time. Given a set of expectations of future exogenous-variable values for each quarter of the estimation period, the method in Fair and Taylor (1983) could be used to obtain the FIML estimates. (The simplest assumption about exogenous-variable expectations is to assume that the expected values are the actual values, although other assumptions are possible.) Under the assumption that the Fed is using my model in forming its expectations of future deficits, the FIML estimates account for all the nonlinear restrictions that are implied by the rational expectations hypothesis. The constraints built into the estimation procedure are that the Fed's expectations of the future deficits (given the exogenous-variable expectations) are the model's predictions. One could estimate the model for alternative values of  $i$  to see which choices, if any, resulted in a significant estimate of the coefficient of  $D_{t+i}^e$ .

The Fair-Taylor method is expensive for a model of my size (30 stochastic equations and 98 identities), and no attempt has been made to use it here. Instead, the limited information methods of Hayashi and Sims (1983) and Hansen (1982) have been used to estimate the interest rate reaction function. Because these methods are recent and have not been widely used, the exact steps that were followed to apply the methods in the present case will be explained.

The interest rate reaction function is nonlinear in variables but linear in coefficients, and so it can be written

$$(1) \quad Y_t = Q_t b_1 + D_{t+i}^e b_2 + v_t, \quad t = 1, \dots, T,$$

where  $Y_t$  is the short term interest rate,  $Q_t$  is a vector of explanatory variables other than  $D_{t+i}^e$ ,  $b_1$  is a vector of unknown coefficients,  $b_2$  is an unknown coefficient multiplying  $D_{t+i}^e$ , and  $v_t$  is an error

term. Some of the variables in  $Q_t$  are nonlinear functions of the basic endogenous and predetermined variables in the model. Let  $\epsilon_{t+i}$  be the Fed's expectation error:

$$(2) \quad \epsilon_{t+i} = D_{t+i} - D_{t+i}^e, \quad t = 1, \dots, T.$$

Substituting (2) into (1) yields:

$$(3) \quad \begin{aligned} Y_t &= Q_t b_1 + D_{t+i} b_2 + v_t - \epsilon_{t+i} b_2 \\ &= X_t b + u_t, \quad t = 1, \dots, T, \end{aligned}$$

where  $X_t = (Q_t \ D_{t+i})$ ,  $b = \begin{pmatrix} b_1 \\ b_2 \end{pmatrix}$ , and  $u_t = v_t - \epsilon_{t+i} b_2$ . In what follows  $X_t$  is assumed to be of dimension  $p$ .

Consider first the two-stage least squares (2SLS) estimation of equation (3). Let  $Z_t$  be a vector of dimension  $k$  of first stage regressors. A necessary condition for consistency is that  $Z_t$  and  $u_t$  be uncorrelated. This will be true if both  $v_t$  and  $\epsilon_{t+i}$  are uncorrelated with  $Z_t$ . The requirement that  $Z_t$  and  $v_t$  be uncorrelated is the usual 2SLS requirement. The requirement that  $Z_t$  and  $\epsilon_{t+i}$  be uncorrelated involves an additional assumption, which is that the Fed has used the variables in  $Z_t$  (perhaps along with others) in forming its expectation of  $D_{t+i}$ . Note that this assumption does not require that the Fed's expectation be rational. It merely requires that the Fed use all the information contained in the  $Z_t$  variables. Given this assumption (and the other standard assumptions that are necessary for consistency), the 2SLS estimator of  $b$  in equation (3) is consistent. This estimator (denoted  $b_{2SLS}$ ) is:

$$(4) \quad b_{2SLS} = (X'Z(Z'Z)^{-1}Z'X)^{-1}X'Z(Z'Z)^{-1}Z'Y,$$

where  $b_{2SLS}$  is  $p \times 1$ ,  $X$  is  $T \times p$ ,  $Z$  is  $T \times k$ , and  $Y$  is  $T \times 1$ . The application of the 2SLS estimator to models of the present type is due to McCallum (1976).

If  $u_t$  in (3) is homoscedastic and serially uncorrelated, the estimated covariance matrix for  $b_{2SLS}$  is

$$(5) \quad \hat{\sigma}^2 (X'Z(Z'Z)^{-1}Z'X)^{-1},$$

where  $\hat{\sigma}^2$  is the estimated variance of  $u_t$ . The problem in the present case for  $i$  greater than 0 is that  $u_t$  will be serially correlated even if  $v_t$  is not. If, for example,  $i$  is 2, an unanticipated shock in period  $s$  will affect  $\varepsilon_{s-2+i}$ ,  $\varepsilon_{s-1+i}$ , and  $\varepsilon_{s+i}$ , and so  $u_t$  will be a second order moving average. In general,  $u_t$  will be a moving average of order  $i$  if  $v_t$  is serially uncorrelated.<sup>2</sup> If  $v_t$  is serially correlated, the process for  $u_t$  will in general, of course, be more complicated than simply a moving average.

Let  $V$  be the covariance matrix of  $u = (u_1, \dots, u_T)'$ .  $u$  is  $T \times 1$  and  $V$  is  $T \times T$ . The idea of Hayashi and Sims (HS) is to find an upper triangular matrix  $W$  such that  $WVW' = I$  and then to transform the data using  $W$ . Let  $Y^* = WY$  and  $X^* = WX$ . The HS estimator of  $b$  (denoted  $b_{HS}$ ) is simply 2SLS applied to  $Y^*$  and  $X^*$ :

$$(6) \quad b_{HS} = (X^{*'}Z(Z'Z)^{-1}Z'X^*)^{-1}X^{*'}Z(Z'Z)^{-1}Z'Y^*.$$

The estimated covariance matrix for  $b_{HS}$  is

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<sup>2</sup>Note that it is assumed here that expectations are based on information through period  $t-1$ , not  $t$ . If information through period  $t$  were used, the order of the moving average would be  $i-1$ .

$$(7) \quad (X'Z(Z'Z)^{-1}Z'X^*)^{-1} .$$

Taking  $W$  to be upper rather than lower triangular means that the transformations are with respect to current and future values rather than current and past values. This allows the transformed error term  $Wu$  to remain uncorrelated with all the current and past values of the variables in  $Z$ .

The Hansen estimator of  $b$  (denoted  $b_H$ ) is

$$(8) \quad b_H = (X'ZM^{-1}Z'X)^{-1}X'ZM^{-1}Z'Y ,$$

where  $M$  is some estimate of  $\lim T^{-1}E[Z'uu'Z]$ . The estimated covariance matrix of  $b_H$  is

$$(9) \quad T \cdot (X'ZM^{-1}Z'X)^{-1} .$$

Hayashi and Sims show that without more information on the determination of  $Z$ , it is not in general possible to determine the relative efficiency of  $b_{HS}$  and  $b_H$ . Both estimators are consistent under fairly general regularity conditions. Hayashi and Sims show that consistency of  $b_{HS}$  is retained when the population  $V$  is replaced with a consistent estimate and that consistency of  $b_H$  is retained when the population  $M$  is replaced with a consistent estimate.

Computing  $b_{HS}$  is straightforward once an estimate of  $V$  is available. Given  $V$ ,  $W$  can be computed numerically, and the rest is simply matrix calculations. For the work in this paper the best results were obtained using  $D_{t+4}$ , and so  $u_t$  in (3) was assumed to be a moving average of order 4. Initial estimates of  $u_t$  were obtained from the 2SLS estimates:

$$(10) \quad \hat{u}_t = Y_t - X_t b_{2SLS} , \quad t = 1, \dots, T .$$

The diagonal elements of  $V$  were taken to be  $T^{-1} \sum_{t=1}^T \hat{u}_t^2$ . The elements once removed from the diagonal were taken to be  $(T-1)^{-1} \sum_{t=2}^T \hat{u}_t \hat{u}_{t-1}$ , and so on through the elements removed four places from the diagonal, which were taken to be  $(T-4)^{-1} \sum_{t=5}^T \hat{u}_t \hat{u}_{t-4}$ .

Computing  $b_H$  is also straightforward once an estimate of  $M$  is available. The general way of computing  $M$  is as follows. Let  $f_t = u_t \otimes z_t$ . Let  $R_j = (T-j)^{-1} \sum_{t=j}^T f_t f_{t-j}'$ , where  $j = 0, 1, \dots, J$ . The estimate of  $M$  is  $(R_0 + R_1 + R_1' + \dots + R_J + R_J')$ . For the work in this paper  $J$  is taken to be 4.

An alternative estimate of  $M$  is available under the assumption that

$$(11) \quad E[u_t u_s' | z_t, z_{t-1}, \dots] = E[u_t u_s'] \quad \text{for } t \geq s,$$

which says that the contemporaneous and serial correlations in  $u$  do not depend on  $z$ . The HS estimator is based on this assumption. This assumption is implied by the assumption that  $E[u_t z_s'] = 0$  for  $t \geq s$  if normality is also assumed. Under this assumption  $M$  can be estimated as follows. Let  $a_j = (T-j)^{-1} \sum_{t=j}^T \hat{u}_t \hat{u}_{t-j}'$  and  $B_j = (T-j)^{-1} \sum_{t=j}^T z_t z_{t-j}'$ , where  $j = 0, 1, \dots, J$ . The estimate of  $M$  is  $(a_0 B_0 + a_1 B_1 + a_1 B_1' + \dots + a_J B_J + a_J B_J')$ . Again,  $J$  was taken to be 4 for the work in this paper.

The HS and Hansen methods were used to estimate equation (3).<sup>3</sup> The results of the estimation work for the interest rate reaction function are presented in Table 1. The data set used for these results is the same as

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<sup>3</sup>The HS and Hansen methods have been programmed into the Fair-Parke program, which is available for distribution. This program has been used for all the results in this paper, including the solution results in Section III.



TABLE 1. Estimates of the Interest Rate Reaction Function

$RS_t$  is the left hand side variable. Estimation period is 1954 I - 1981 III (111 observations)

Estimation Technique	Cmst	$RS_{t-1}$	$\dot{P}D_t$	$JJ_t^*$	$GNPR_t$	$M1_{t-1}$	$DD793_t \cdot \dot{M}1_{t-1}$	$D_{t+4}$	SE	$R^2$	DW
2SLS 1.	-9.63 (3.10)	.910 (22.74)	.0478 (1.40)	.0297 (3.06)	.0699 (3.51)	.0267 (1.46)	.104 (3.36)	--	.661	.951	1.82
2SLS 2.	-15.40 (3.80)	.835 (17.02)	.0133 (0.36)	.0482 (4.02)	.0902 (4.26)	.0306 (1.66)	.117 (3.71)	24.4 (2.64)	.664	.950	1.71
HS, MA4 3. <sup>a</sup>	-15.81 (3.97)	.885 (17.94)	-.0068 (0.18)	.0492 (3.90)	.0798 (4.22)	.0351 (2.42)	.078 (3.08)	22.1 (2.41)	.666	.950	1.72
Hansen, MA4 4.	-16.35 (3.97)	.873 (16.75)	-.0091 (0.24)	.0509 (3.91)	.0840 (4.19)	.0370 (2.23)	.0806 (2.86)	24.2 (2.51)	.669	.950	1.70
HS, MA4 5. <sup>b</sup>	-15.72 (4.08)	.880 (18.97)	--	.0489 (4.02)	.0799 (4.21)	.0340 (2.50)	.0786 (3.11)	21.9 (2.50)	.665	.950	1.72
Hansen, MA4 6.	-16.17 (4.07)	.866 (17.55)	--	.0504 (4.01)	.0841 (4.17)	.0359 (2.30)	.0812 (2.89)	23.9 (2.58)	.667	.950	1.70

Notes: t-statistics are in parentheses.

2SLS = two stage least squares.

HS, MA4 = Hayashi-Sims method, fourth order moving average error term.

Hansen, MA4 = Hansen method, fourth order moving average error term. M estimated under assumption (11) in the text.

<sup>a</sup>Correlation coefficients for  $\hat{u}_t$  and  $\hat{u}_{t-i}$  : .137 for  $i=1$ , -.314 for  $i=2$ , .157 for  $i=3$ , .239 for  $i=4$ .

<sup>b</sup>Correlation coefficients for  $\hat{u}_t$  and  $\hat{u}_{t-i}$  : .139 for  $i=1$ , -.307 for  $i=2$ , .165 for  $i=3$ , .239 for  $i=4$ .

Notation: RS = three month Treasury bill rate.

$\dot{P}D$  = percentage change (annual rate) in the price deflator for domestic sales.

$JJ^*$  = measure of labor market tightness.

$GNPR$  = percentage change (annual rate) in real GNP.

$M1$  = percentage change (annual rate) in M1.

$DD793$  = dummy variable that is 1 from 1979 III on; 0 otherwise.

$D$  = ratio of the federal government deficit to GNP.

See Table A-4 in Fair (1984) for a more complete description of the variables.

the data set used in Fair (1984). This data set contains observations for the 1952 I - 1982 III period, and the basic estimation period in Fair (1984) was 1954 I - 1982 III. In the present case the estimation period must end in 1981 III rather than in 1982 III because the last four quarters of the data set are needed for the observations for  $D_{t+4}$ .

Equation 1 in Table 1 is the regular version of the reaction function, estimated by 2SLS. The first stage regressors that were used for the estimation are listed in Table 6-1 in Fair (1984). Thirty-six variables were used. They represent the main predetermined variables in the model. Equation 2 in Table 1 has  $D_{t+4}$  added to it. It has been estimated by 2SLS. For these estimates and for the estimates of equations 3-6, two variables have been added to the set of first stage regressors:  $D_{t-1}$  and  $D_{t-2}$ . Although the estimates of equation 2 are consistent under standard assumptions, the estimated standard errors and thus the t-statistics are wrong because the addition of  $D_{t+4}$  has introduced serial correlation into the error term.

Equation 3 is the same as equation 2 except that it has been estimated by the HS method under the assumption of a moving average error term of order 4. These estimates have accounted for the serial correlation properties of the error term. Equation 4 is the same as equation 2 except that it has been estimated by Hansen's method. The general way of estimating  $M$  for Hansen's method (for  $J = 4$ ) did not result in a positive definite matrix (a not uncommon problem), and so estimates for this case could not be obtained. The alternative way discussed above of estimating  $M$  (again for  $J = 4$ ) did result in a positive definite matrix, and the estimates for Hansen's method in Table 1 are based on this estimate of  $M$ . These estimates have also accounted for the serial correlation properties of the

error term.

All summary statistics in Table 1 (SE,  $R^2$ , and DW) are based on estimates of  $u_t$ , not of some transformation of  $u_t$ . In other words, the transformations that are implicit in the HS and Hansen methods were not used in calculating the estimated error terms for the summary statistics.

The coefficient estimates for equation 1 are similar to those in Fair (1984). The main difference that the loss of the last four observations has made is that the coefficient estimate of the inflation variable  $\dot{P}D_t$  has been lowered from .0687 to .0478, and the t-statistic has been lowered from 2.11 to 1.40 (see equation 30 in Fair (1984) for the original estimates).

The coefficient estimates for equations 2, 3, and 4 are similar. All show that  $D_{t+4}$  is significant by conventional standards. Although the t-statistics in equation 2 are not correct, the bias seems to be fairly small in this case. Likewise, the differences between the results for the HS method and Hansen's method seem small.

The introduction of  $D_{t+4}$  to the equation has essentially lowered the coefficient estimate of  $\dot{P}D_t$  to zero. The effects on the other coefficients are smaller, and all estimates are significant in equations 3 and 4 except for those for  $\dot{P}D_t$ . The coefficient estimate of 22.1 for  $D_{t+4}$  in equation 3 means that the one-period impact on the short term interest rate of an increase in the deficit of 1 percent of GNP is 22.1 basis points. The long-run impact is  $22.1/(1 - .885) = 192.2$  basis points, or about 2 percentage points.

Since the estimates of the coefficient of  $\dot{P}D_t$  in equations 3 and 4 are of the wrong sign and highly insignificant, the equations were re-estimated with  $\dot{P}D_t$  dropped. These equations are 5 and 6 in Table 1. It is clear that dropping  $\dot{P}D_t$  has had little effect on the other

coefficient estimates.

The value of the lead for  $D$  that gave the best results was 4. It is interesting to note that the use of  $D_t$  or  $D_{t-1}$  in place of  $D_{t+4}$  results in coefficient estimates of the  $D$  variable that are insignificant and of the wrong sign. The coefficient estimate for  $D_t$  was -7.3 with a t-statistic of 1.05, and the coefficient estimate for  $D_{t-1}$  was -3.6 with a t-statistic of 0.55. (The estimation technique in these two cases was 2SLS.  $D_t$  and  $D_{t-1}$  were entered separately.) There is thus no evidence that the Fed responds to the current or lagged value of the deficit.

In summary, the results seem supportive of the hypothesis that expected future deficits affect Fed behavior. The expected future deficit variable is significant in the interest rate reaction function. The results are, however, quite tentative, and they should be taken with considerable caution. First, I have searched for the value of the lead for  $D$  that gave the best results, and so there is an element of data mining here, which always warrants caution. Second, this work is based on the assumption that the interest rate reaction function is an estimate of Fed behavior, and some may feel that this is not a good approximation. Trying to explain Fed behavior is more difficult than trying to explain the aggregate behavior of the household and firm sectors because the Fed is run by a relatively small number of people. There may be fairly abrupt changes in Fed behavior if the people with influence change their minds or are replaced by others with different views. Finally, at the time of this writing the future deficits seem likely to be on average larger than the deficits used for the estimates in Table 1, and after more time has passed, one will need to re-estimate the equation using the new, more extreme data to see if the significance of  $D_{t+4}$  is retained.

### III. Fiscal Policy Effects

The question considered in this section is how much difference it makes to the economy whether or not Fed behavior is affected by expected future deficits. In particular, the sensitivity of fiscal-policy effects to alternative assumptions about Fed behavior is examined. My U.S. model is used for this purpose. The following is a discussion of the experiments that were performed.

There are 5 assumptions that can be made about monetary policy in my model: 1) the short term interest rate exogenous, 2) the money supply exogenous, 3) nonborrowed reserves exogenous, 4) the amount of government securities outstanding exogenous, and 5) the interest rate reaction function used. Under the fifth assumption monetary policy is endogenous. One can examine the sensitivity of fiscal-policy effects to the alternative monetary policy assumptions, and this has been done in Fair (1978) and in Chapter 9 in Fair (1984). The results show that fiscal-policy effects are quite sensitive to the alternative assumptions. The reason for this is simple. The different assumptions lead to different values of the short term interest rate for a given fiscal-policy change, and the short term interest rate has important direct and indirect effects on consumption and investment. The experiments in this paper are concerned with the sensitivity of fiscal-policy effects to different interest rate reaction functions, in particular to the inclusion of  $D_{t+4}^e$  in the functions.

Three versions of the interest rate reaction functions were used, all based on the coefficient estimates of equation 5 in Table 1. For the first version the coefficient of  $D_{t+4}$  was taken to be zero, for the second version equation 5 was used as is, and for the third version the coefficient of  $D_{t+4}$  was taken to be half its estimated value. Since the versions are

the same except for the coefficient of  $D_{t+4}$ , they allow one to examine the differences in fiscal-policy effects that are due solely to how the Fed reacts to expected future deficits.

The fiscal-policy experiment consisted of a sustained increase in federal government purchases of goods in real terms of 1.0 percent of real GNP beginning in 1970 I. The results of this experiment are presented in Table 2 for selected variables in the model. The row 1 results are for the reaction function without the deficit variable, and the row 2 and row 3 results are for the reaction function with the deficit variable.

The calculation of the row 1 results is easy to describe. The actual residuals of the equations were first added to all the equations in the model and were taken to be exogenous.<sup>4</sup> This means that when the model is solved using the actual values of the exogenous variables, a perfect tracking solution is obtained. In other words, the "base" values of the endogenous variables for the experiment are merely the actual values. The government spending variable was then changed and the model was solved. The difference between the predicted value of a variable from this solution and its actual value is the estimate of the response of the variable to the policy change.

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<sup>4</sup>The actual residuals are the residuals that were computed at the time of estimation except for the residuals for the interest rate reaction function. For this equation the residual for a given period is the difference between the actual value of the left hand side variable and the predicted value computed from the right hand side variables exclusive of the deficit variable. This allows a perfect tracking solution to be obtained even though the deficit variable is excluded from the equation. See Fair (1984), Chapter 9, for a general discussion of the use of perfect tracking solutions in the estimation of policy effects.

TABLE 2. Estimated effects of an increase in real government spending

	1970				1971				1972			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Real GNP												
1	1.08	1.27	1.25	1.17	1.04	.91	.79	.68	.60	.54	.50	.47
2	1.06	1.16	1.03	.80	.50	.19	-.12	-.40	-.60	-.74	-.82	-.85
3	1.07	1.22	1.16	1.01	.82	.62	.42	.25	.12	.04	-.01	-.02
GNP Deflator												
1	.01	.10	.19	.25	.34	.41	.44	.48	.50	.52	.51	.53
2	.01	.09	.17	.22	.27	.30	.28	.26	.20	.15	.07	.01
3	.01	.10	.18	.23	.31	.37	.37	.39	.38	.37	.33	.32
Unemployment Rate												
1	-.06	-.10	-.11	-.10	-.09	-.08	-.07	-.06	-.05	-.04	-.04	-.04
2	-.06	-.10	-.10	-.08	-.05	-.02	.01	.03	.05	.06	.07	.07
3	-.06	-.10	-.11	-.09	-.07	-.05	-.04	-.02	-.01	-.00	-.00	-.00
Bill Rate												
1	.10	.13	.15	.16	.16	.16	.16	.16	.16	.16	.15	.15
2	.15	.23	.28	.32	.35	.37	.39	.40	.36	.34	.32	.30
3	.13	.17	.20	.23	.24	.25	.25	.25	.23	.22	.21	.20
Bond Rate												
1	.03	.04	.05	.07	.08	.10	.11	.12	.12	.13	.14	.14
2	.04	.07	.10	.13	.17	.20	.23	.26	.27	.29	.30	.30
3	.03	.05	.07	.10	.12	.14	.16	.17	.18	.19	.20	.20
Deficit as a percent of GNP												
1	.17	.16	.17	.18	.19	.21	.22	.23	.23	.24	.25	.25
2	.18	.17	.19	.22	.25	.28	.31	.34	.36	.38	.39	.40
3	.17	.17	.18	.20	.22	.24	.25	.27	.28	.29	.30	.31
Money Supply												
1	-.15	-.15	-.14	-.15	-.16	-.17	-.20	-.22	-.25	-.28	-.31	-.33
2	-.21	-.33	-.49	-.68	-.90	-1.14	-1.40	-1.66	-1.88	-2.05	-2.21	-2.33
3	-.17	-.23	-.29	-.37	-.46	-.57	-.69	-.80	-.89	-.97	-1.03	-1.08

Notes: 1 = equation 5 in Table 1 used with coefficient of  $D_{t+4}$  set to 0.

2 = equation 5 in Table 1 used as is.

3 = equation 5 in Table 1 used with coefficient of  $D_{t+4}$  set to 10.9558, which is half of the estimated value.

The change in real government spending was 1.0 percent of real GNP.

Let  $y_{it}^a$  be the value of endogenous variable  $i$  for quarter  $t$  before the change and let  $y_{it}^b$  be the predicted value after the change. For real GNP, the GNP deflator, and the money supply the values in the table are  $(y_{it}^b/y_{it}^a - 1) \cdot 100$ . For the other variables the values are  $y_{it}^b - y_{it}^a$ , where the units are in percentage points.

The calculation of the row 2 and row 3 results is more involved. The first problem that must be faced is what to assume about the expectation formation of the Fed. The assumption behind the estimation work in Section II is that the Fed uses all the information in the  $Z_t$  variables in forming its expectation of  $D_{t+4}$ . It does not have to be assumed that the Fed uses my model in forming its expectations, only that the  $Z_t$  variables are among the variables that it uses. When the estimated reaction function is added to the model (with the expected future deficit variable among the explanatory variables), a more specific assumption about expectation formation is needed. Two assumptions have been made for the work here. The first is that the Fed uses my model in forming its expectations, and the second is that the Fed's expectations of the exogenous variables in the model are equal to the actual values. These two assumptions imply that the Fed's expectation of  $D_{t+4}$  is equal to the model's prediction of it. In this sense the Fed's expectations are rational.

The solution of the model is more difficult when future variables like  $D_{t+4}$  are among the explanatory variables. What this means is that future predicted values of the endogenous variables affect current predicted values, and so the standard way of solving models period by period cannot be used. One must instead iterate over solution paths of the endogenous variables. The exact method for doing this is presented in Fair and Taylor (1983), and this is the method that has been used for the row 2 and row 3 results. Unlike the estimation method in Fair and Taylor (1983), which, as mentioned in Section II, is expensive, the solution method is not very expensive.

The same fiscal policy experiment was performed for the row 2 and row 3 results as was performed for the row 1 results. The only difference



is that  $D_{t+4}$  is included in the interest rate reaction function. Perfect tracking solutions for the experiments were obtained by adding the estimated residuals to the equations and then taking them to be exogenous.<sup>5</sup>

One feature of the model should be explained before the results are described. The long term bond rate and the mortgage rate are linked to the short term interest rate through standard term structure equations. Each long term rate is a function of current and past short term rates. Another possible way that expected future deficits could affect the economy would be through the term structure equations. In other words,  $D_{t+i}^e$  might be an explanatory variable in the term structure equations. No attempt was made to test for this here, and so the long term rates merely follow the short term rate for the present results.

I have experimented with a version of my model in which there are rational expectations in the bond and stock markets. This work is described in Fair (1979) and in Chapter 11 in Fair (1984). This version has not been used for the present results. The results in Chapter 11 show that the timing of fiscal-policy effects is significantly changed by the addition of rational expectations in the bond and stock markets, but that the total effects over, say, 12 quarters are only slightly changed.

The following is a brief discussion of the policy effects in the three versions of the model. Chapter 9 in Fair (1984) contains a much more extensive discussion of the policy properties of the regular version of the model (i.e., the version without the deficit variable in the interest

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<sup>5</sup>For the row 2 experiment the residuals used for the interest rate reaction function are simply the residuals computed at the time of estimation. This is not true for the row 3 experiment, since the coefficient used for  $D_{t+4}$  is not the estimated coefficient. See footnote 4.

rate reaction function).

The results in Table 2 are simple to explain. Consider first the row 1 versus row 2 results. When the federal government increases its spending, this increases the model's predictions (and thus the Fed's expectations) of the government's future deficits. For the row 1 results this has no effect on the Fed's behavior, but for the row 2 results it leads the Fed to raise the short term interest rate more than it otherwise would. This results in an increase in the bond rate and (not shown in Table 2) in the mortgage rate. The higher interest rates for the row 2 results are contractionary, and so the GNP changes are smaller in row 2 than in row 1. The differences are in fact quite large. After three quarters the interest-rate changes in row 2 are about twice the size of those in row 1. After eight quarters real GNP is .79 percent above the base value in row 1, but .12 percent below the base value in row 2. After 12 quarters the values are .47 above in row 1 and .85 below in row 2. After 12 quarters the GNP deflator is .53 percent higher in row 1, but only .01 percent higher in row 2. The money supply falls much more in row 2 than in row 1, which is due to the higher interest rates and lower income in row 2 than in row 1.

The deficit is higher in row 2 than in row 1. There are two main reasons for this. The first is that tax collections are lower for the row 2 experiment because the economy is less expansionary. The second is that government interest payments are higher for the row 2 experiment because interest rates are higher.

The row 3 results are for a coefficient of  $D_{t+4}^e$  that is half the size of the estimated coefficient. As expected, the row 3 results are in between the row 1 and row 2 results. They are closer to the row 1 results

than to the row 2 results, and in this sense the policy responses are non-linear functions of the coefficient of  $D_{t+4}^e$ . This nonlinearity is not surprising since interest rates have a positive effect on the deficit and the deficit has (with a lead) a positive effect on interest rates.

In summary, the results in Table 2 show that fiscal-policy effects are quite sensitive to the Fed's response to expected future deficits. If the Fed does respond to expected future deficits, fiscal policy is less effective than otherwise.

#### IV. Conclusion

The evidence in Section II suggests that Fed behavior may be influenced by expected future deficits. The results in Section III show that fiscal-policy effects are sensitive to this aspect of Fed behavior. It should be stressed, however, that these results are based on some strong assumptions and are highly tentative. The estimation results in Section II will need to be confirmed using future data before much confidence can be placed on them. The policy results in Section III are based on the assumption that the Fed uses my model in forming its expectations of future deficits, which may not be a good approximation. The overall results of this paper are thus only suggestive as to what might be the case.

Two final points should be made. The first concerns whether one thinks of the interest rate reaction as being derived from the solution of an optimal control problem by the Fed. If the Fed were using my model for this purpose, it is unlikely that the interest rate reaction function with the deficit variable added would be a good approximation to the optimal decision equation. It would require an unusual loss function, given the model, for the deficit variable to be a variable in the decision equation,

although one might argue that the deficit variable is proxying for other variables. At any rate, if one feels that the estimated interest rate reaction function is not a good approximation of the optimal decision equation, one must assume either that the Fed does not optimize and only follows suboptimal rules or that the Fed uses a different model from mine in solving its control problem. The second assumption is not an attractive one to make for purposes of this paper because it has been assumed in Section III that the Fed uses my model in forming its expectations of future deficits. The second assumption would thus imply that the Fed uses my model for its expected future deficit calculations and uses some other model for its optimal control calculations. This would only be a good approximation if my model and the other model had similar properties regarding deficit predictions.

The second point concerns one other way in which deficits affect fiscal-policy responses. If the Fed responds to a fiscal-policy expansion by raising interest rates (which the interest rate reaction function predicts is true even without the deficit variable included), there will be an increase in interest payments by the federal government. The larger is the size of the government debt, which is a function of the size of past deficits, the greater will be the increase in interest payments. Government interest payments are part of household nonlabor income, and in my model nonlabor income has a positive effect on consumption. Therefore, the greater is the government debt, the larger will be the effects from a given fiscal-policy change if the Fed changes interest rates in response to the fiscal-policy action. There is, of course, some simultaneity here in that the Fed will offset some of this increased response by larger changes in interest rates. This means that in a model like mine interest

rates respond more to a given fiscal-policy change the larger have been past deficits. This is true even if the interest rate reaction function does not include a deficit variable.

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