IS THERE EMPIRICAL SUPPORT FOR THE 'MODERN' VIEW OF MACROECONOMICS?

Ray C. Fair
Yale University

May 2001

Yale SCHOOL *of* MANAGEMENT

Is There Empirical Support for the 'Modern' View of Macroeconomics?

Ray C. Fair*

May 2001

Abstract

This paper argues that the basic model of the 'modern' view of macroeconomics appears to be a poor approximation of the actual economy.

1 Introduction

At least since Lucas's (1976) critique of macroeconometric models, macroeconomics has been in a state of flux. Beginning in the 1970's, macroeconomic research scattered in a number of directions, and many have puzzled as to whether the field is going anywhere. Recently, however, a particular view of macroeconomics has emerged that some see as a convergence. Taylor (2000, p. 90), for example, states:

> …at the practical level, a common view of macroeconomics is now pervasive in policy-research projects at universities and central banks around the world. This view evolved gradually since the rational-expectations revolution of the 1970's and has solidified during the

*Cowles Foundation, Yale University, New Haven, CT 06520-8281. Voice: 203-432-3715; Fax: 203-432-6167; e-mail: ray.fair@yale.edu; website: http://fairmodel.econ.yale.edu. I am grateful to Andrew Levin and David Reifschneider for helpful discussions about the FRB/US model.

> 1990's. It differs from past views, and it explains the growth and fluctuations of the modern economy; it can thus be said to represent a modern view of macroeconomics.

This view is nicely summarized in Clarida, Galí, and Gertler (1999), and it is used in Clarida, Galí, and Gertler (2000) to examine monetary policy rules. Taylor (2000, p. 91) points out that virtually all the papers in Taylor (1999a) use this view and that the view is widely used for policy evaluation in many central banks. Romer (2000) proposes a way of teaching this view at the introductory level.

The view is based on the following three equations:

- **Interest Rate Rule**: The Fed adjusts the nominal interest rate in response to inflation and the output gap (deviation of output from potential).[1] The nominal interest rate responds positively to inflation and the output gap. The coefficient on inflation is greater than one, and so the real interest rate rises when inflation rises.

- **Price Equation**: Inflation depends on the output gap, cost shocks, and expected future inflation.

- **Aggregate Demand Equation**: Aggregate demand (real) depends on the real interest rate, expected future demand, and exogenous shocks. The real interest rate effect is negative.

This basic model is, of course, a highly simplified view of the way the macro economy works, as everyone would admit. Many details have been left out. If,

[1] In empirical work the lagged interest rate is often included as an explanatory variable in the interest rate rule. This picks up possible interest rate smoothing behavior of the Fed.

however, the model captures the broad features of the economy in a fairly accurate way, the lack of detail is not likely to be serious for many purposes; the details can be filled in when needed. The 'modern' view of macroeconomics is that the broad features of the economy have been adequately captured by this model.

In this model a positive cost shock has a negative effect on aggregate demand. A positive cost shock increases inflation through the price equation, and the Fed raises the nominal interest rate more than the increase in inflation through the interest rate rule. This increase in the real interest rate then has a negative effect on aggregate demand through the aggregate demand equation. The behavior of the Fed is obviously crucial in this story. If the Fed did not increase the nominal interest rate more than the increase in inflation, the effect of the cost shock on aggregate demand would be positive and likely imply an unstable economy. Some have criticized Fed behavior in the 1960s and 1970s as following in effect a rule with a coefficient on inflation less than one—see, for example, Clarida, Galí, and Gertler (1999) and Taylor (1999b).

How can this basic model be tested? Unfortunately, one consequence of the movement away from structural macroeconometric modeling since the Lucas critique is that macroeconomics has moved away from its empirical roots. Models are generally not tested by comparing the predicted value of, say, real GDP with its actual value quarter by quarter or year by year. Calculating measures like root mean squared errors (RMSEs) is no longer common. Instead, models are calibrated, and the moments of the predicted values are compared to the moments of the actual values. The aim of the calibration is usually to match the predicted and actual values of particular moments as closely as possible. It is not the case, for example, that the above aggregate demand equation has been chosen because various versions of it fit the data well in terms of the RMSE criterion and the like. A less data determined route has been taken, having to do with the use and analysis of the equation in calibrated models—see, for example, Clarida, Galí, and Gertler (2000).

This paper argues that the basic model of the modern view is not supported by the data. First, the data support the use of nominal rather than real interest rates in aggregate expenditure equations. This implies that if inflation increases more than the nominal interest rate, this is not necessarily expansionary. Second, there is evidence than wages lag prices, and so a positive cost shock results in an initial fall in real wage rates and thus real labor income. A fall in real labor income has, other things being equal, a negative effect on real household expenditures. In addition, some household income is nonlabor income that does not respond quickly to a change in inflation, and so real nonlabor income is likely to fall initially when inflation increases. Third, if the percentage increase in nominal household wealth from a positive cost shock is less than the percentage increase in the price level, which the evidence suggests is true, there is a fall in real household wealth. A fall in real household wealth has, other things being equal, a negative effect on real household expenditures.

These three features imply that a positive cost shock has a negative effect on aggregate demand even if the nominal interest rate is held constant. Not only does the Fed not have to increase the nominal interest rate more than the increase in inflation for there to be a contraction, it does not have to increase the nominal rate at all! The cost shock itself will contract the economy through the real income and real wealth effects. If these three features are true, the modern-view model is quite misleading, especially for purposes of evaluating monetary policy.

Section 2 discusses the evidence in favor of the use of nominal over real interest rates in expenditure equations. Section 3 discusses the real wealth effect, and Section 4 discusses the real income effect. Section 5 uses a multicountry econometric model (the MC model[2]) to estimate the overall effect of a cost shock on the economy. It will be seen that the properties of this model are quite different from those of the modern-view model.

2 Nominal versus Real Interest Rate Effects

This section uses consumption and investment equations in the MC model to test for nominal versus real interest rate effects. It is important to stress that these are not tests using the aggregate demand equation of the modern-view model. The argument here is that if consumption and investment, the two major components of aggregate demand, are affected by nominal rather than real interest rates, it seems unlikely that the use of the real interest rate in the aggregate demand equation is a good specification.

It should also be stressed that there is theory behind the consumption and investment equations. The Cowles Commission approach to macroeconomic model building, which is followed for the MC model, is to estimate decision equations, or at least approximations to decision equations. Theory is used to determine left

[2]The MC model is described in Fair (1994), and the latest version is on the website listed in the introductory footnote. All the equations in the model, including those used for the results in Table 1 below, are presented on the website.

and right hand side variables, i.e., to guide the specification of the equations to be estimated, and then techniques like two stage least squares are used to estimate the equations. Part of the specification concerns expectation formation, and one option is to assume that expectations are rational (model consistent).

The theory behind the consumption and investment equations in the MC model is that households maximize expected lifetime utility and that firms maximize the present discounted value of expected future profits.

In the MC model there are five expenditures equations for the United States (explaining consumption expenditures for services, nondurables, and durables and investment expenditures for housing and for plant and equipment) and two each for many other countries (explaining total consumption expenditures and total investment expenditures). In most of these equations a nominal interest rate is an explanatory variable, with a negative coefficient estimate.

In the process of arriving at the final specifications of the expenditure equations the following test for real interest rate effects was made. Let at time t i_t denote the nominal interest rate, r_t the real interest rate, and $\dot{p}_t^e$ the expected future rate of inflation, where the horizon for $\dot{p}_t^e$ matches the horizon for i_t. By definition $r_t = i_t - \dot{p}_t^e$. The test is to add a measure of $\dot{p}_t^e$ to each equation with i_t already included and see if it has a coefficient estimate roughly equal to the coefficient estimate of i_t but with the opposite sign.

For countries with quarterly data, four measures were tried: $\dot{p}_t^e = (P_t/P_{t-1})^4 - 1$, $\dot{p}_t^e = P_t/P_{t-4} - 1$, $\dot{p}_t^e = (P_t/P_{t-8})^{.5} - 1$, and $\dot{p}_t^e = (P_{t+1}/P_{t-1})^2 - 1$, where P_t denotes the price level for quarter t. For countries with only annual data, three measures were tried: $\dot{p}_t^e = (P_t/P_{t-1})^4 - 1$, $\dot{p}_t^e = P_t/P_{t-2} - 1$, and

$\dot{p}_t^e = (P_{t+1}/P_{t-1})^2 - 1$, where P_t denotes the price level for year t. The results of the tests are presented in Table 1. Each column in the table reflects a separate regression. For the first column the regression includes only the nominal interest rate. For each of the next four columns (three for the countries with annual data) the regression includes the nominal interest rate along with one of the measures of $\dot{p}_t^e$. For the last column the regression includes the real interest rate using the "best" measure of $\dot{p}_t^e$. The best measure is taken to be the one whose coefficient estimate when the measure is entered separately is closest to the negative of the coefficient estimate of the nominal interest rate.

The other variables in the household expenditure equations include real income and lagged real wealth. In the three consumption equations for the United States age distribution variables are added, and in the durable consumption equation for the United States the lagged stock of durable goods is added. In the housing investment equation for the United States the lagged stock of housing is added. The other variables in the plant and equipment investment equation for the United States include current and lagged values of output and the lagged stock of capital.

Table 1
Nominal Versus Real Interest Rates: Coefficient Estimates

Countries with Quarterly Data

	Variable	Nom. Rate i_t	$\dot{p}_t^e$ a	b	c	d	Real Rate $i_t - \dot{p}_t^e$	Sample Period
1.	US: CS	-.113	-.058	-.025	.027	-.051	-.097[c]	1955.1-2001.1
		(-5.23)	(-2.40)	(-0.88)	(0.80)	(-2.08)	(-3.15)	
2.	US: CN	-.188	-.095	-.090	-.073	-.111	.010[c]	1955.1-2001.1
		(-4.44)	(-3.10)	(-2.75)	(-1.84)	(-3.54)	(0.26)	
3.	US: CD	-.344	-.162	-.469	-.547	-.128	-.099[d]	1954.1-2000.4
		(-1.92)	(-0.98)	(-2.38)	(-1.87)	(-0.74)	(-0.80)	
4.	US: IH	-3.044	.092	-.948	-1.370	.593	-1.165[d]	1954.1-2000.4
		(-5.97)	(0.60)	(-2.48)	(-2.23)	(2.20)	(-4.17)	
5.	US: IK	-.0031	.0023	.0014	.0017	.0017	-.0025[a]	1954.1-2001.1
		(-1.38)	(1.42)	(0.77)	(0.80)	(1.01)	(-1.50)	
6.	CA: C	-.145	.006	.023	.076	.005	-.123[c]	1967.1-1999.4
		(-4.16)	(0.21)	(0.76)	(2.05)	(0.20)	(-3.56)	
7.	CA: I	-.202	.105	.115	.109	.109	-.147[d]	1966.1-1999.4
		(-2.45)	(1.52)	(1.57)	(1.27)	(1.61)	(-2.26)	
8.	JA: C	-.113	-.065	-.049	-.041	-.064	.029[c]	1967.1-1999.4
		(-2.60)	(-3.22)	(-2.19)	(-1.40)	(-2.96)	(0.92)	
9.	JA: I	-.314	-.066	-.233	-.206	-.047	-.022[d]	1966.1-1999.3
		(-2.79)	(-0.94)	(-3.21)	(-2.51)	(-0.57)	(-0.28)	
10.	AU: I	-.586	.402	1.243	1.024	.509	-.593[d]	1970.1-1999.1
		(-1.67)	(2.27)	(2.71)	(2.17)	(1.71)	(-2.20)	
11.	FR: I	-.244	-.064	-.184	-.199	-.182	-.017[a]	1971.1-1999.4
		(-4.15)	(-1.06)	(-2.21)	(-1.82)	(-1.98)	(-0.27)	
12.	GE: C	-.205	-.151	-.006	-.014	-.178	-.067[b]	1971.1-1999.4
		(-3.62)	(-2.68)	(-0.15)	(-0.22)	(-2.71)	(-1.65)	
13.	GE: I	-.503	.204	-.087	-.048	.429	-.564[d]	1971.1-1999.3
		(-1.80)	(1.13)	(-0.45)	(-0.19)	(1.39)	(-2.15)	
14.	IT: C	-.064	-.001	-.089	-.044	-.000	-.017[d]	1971.2-1999.3
		(-1.82)	(-0.03)	(-1.95)	(-0.69)	(-0.01)	(-0.56)	
15.	IT: I	-.181	.098	.058	-.021	.108	-.134[d]	1971.1-1999.4
		(-4.42)	(3.02)	(1.33)	(-0.34)	(2.86)	(-3.38)	
16.	NE: C	-.255	.139	.159	.198	.195	-.219[d]	1978.1-1999.1
		(-2.63)	(2.47)	(1.52)	(1.47)	(2.74)	(-3.09)	
17.	NE: I	-.933	-.258	.067	-.097	.162	-.168[d]	1978.1-1999.2
		(-3.12)	(-1.23)	(0.27)	(-0.29)	(0.85)	(-0.84)	
18.	ST: C	-.239	-.036	.112	.116	-.040	-.122[b]	1983.1-1998.4
		(-2.67)	(-0.87)	(2.29)	(1.16)	(-0.78)	(-2.28)	
19.	UK: C	-.150	-.051	-.015	.000	-.034	.058[c]	1967.1-1999.3
		(-3.84)	(-2.07)	(-0.56)	(0.01)	(-1.32)	(1.75)	
20.	UK: I	-.502	.107	.041	.011	.196	.033[d]	1967.1-1999.3
		(-4.44)	(2.07)	(0.58)	(0.13)	(2.71)	(0.53)	
21.	FI: C	-.045	-.157	-.033	-.071	-.109	-.027[b]	1976.1-1999.4
		(-1.38)	(-2.82)	(-0.56)	(-0.84)	(-1.88)	(-0.82)	
22.	FI: I	-.321	-.123	1.134	1.403	-.009	-.445[c]	1977.1-1999.4
		(-1.60)	(-0.58)	(3.35)	(3.52)	(-0.04)	(-2.79)	

Table 1 (continued)

	Variable	Nom. Rate i_t	$\dot{p}_t^e$ a	b	c	d	Real Rate $i_t - \dot{p}_t^e$	Sample Period
23.	AS: I	-.245	.037	-.095	-.091	.030	-.067[a]	1966.1-1999.4
		(-2.87)	(0.72)	(-1.30)	(-1.07)	(0.43)	(-1.30)	
24.	SO: I	-.672	.029	.122	.321	-.059	-.389[c]	1962.2-1999.4
		(-3.22)	(0.89)	(1.71)	(3.24)	(-0.94)	(-4.15)	
25.	KO: C	-.157	-.024	.039	.093	.063	-.094[c]	1975.1-1999.3
		(-2.18)	(-0.50)	(0.67)	(1.56)	(1.22)	(-1.59)	
				Countries with Annual Data				
26.	BE: I	-2.454		.831	.496	.725	-1.031[b]	1962-1996
		(-4.47)		(1.71)	(1.13)	(1.59)	(-1.96)	
27.	DE: I	-1.310		1.490	1.947	3.861	-3.499[d]	1967-1997
		(-3.13)		(1.02)	(1.80)	(2.66)	(-4.28)	
28.	IR: C	-.406		-.355	-.473	-.400	.416[b]	1968-1997
		(-2.32)		(-1.86)	(-1.99)	(-1.68)	(1.97)	
29.	PO: I	-1.226		.088	.017	.097	.127[d]	1962-1995
		(-3.46)		(0.34)	(0.06)	(0.38)	(0.46)	
30.	SP: I	-.739		-.372	-.497	-.271	.244[d]	1962-1997
		(-2.21)		(-1.31)	(-1.72)	(-0.97)	(0.82)	
31.	NZ: C	-.254		.083	.206	.030	-.169[c]	1962-1997
		(-1.65)		(1.03)	(1.95)	(0.33)	(-1.54)	
32.	NZ: I	-.784		.268	.392	.072	-.362[c]	1962-1997
		(-1.64)		(1.11)	(1.26)	(0.25)	(-1.13)	
33.	VE: I	-.533		-.425	-.547	-.545	.323[b]	1962-1998
		(-2.49)		(-3.76)	(-2.95)	(-3.02)	(2.49)	
34.	CO: C	-.210		-.100	-.064	-.067	-.094[c]	1971-1997
		(-2.96)		(-1.49)	(-0.67)	(-0.74)	(-1.09)	
35.	ID: C	-.583		-.047	.109	-.340	-.300[c]	1962-1997
		(-3.25)		(-0.40)	(0.72)	(-2.43)	(-2.22)	
36.	PH: I	-1.974		-.008	-.074	.430	-.652[d]	1962-1998
		(-4.66)		(-0.04)	(-0.22)	(1.62)	(-2.01)	
37.	CH: I	-.741		1.545	1.775	1.660	-.642[b]	1984-1999
		(-0.55)		(3.07)	(1.73)	(3.95)	(-1.43)	

- Each column is a separate regression. Estimation method is 2SLS. t-statistics in parentheses.
- Quarterly countries: P_t = price level for quarter t
  $^a\,\dot{p}_t^e = (P_t/P_{t-1})^4 - 1$, $^b\,\dot{p}_t^e = P_t/P_{t-4} - 1$,
  $^c\,\dot{p}_t^e = (P_t/P_{t-8})^{.5} - 1$, $^d\,\dot{p}_t^e = (P_{t+1}/P_{t-1})^2 - 1$
- Annual countries: P_t = price level for year t
  $^b\,\dot{p}_t^e = (P_t/P_{t-1})^4 - 1$, $^c\,\dot{p}_t^e = P_t/P_{t-2} - 1$, $^d\,\dot{p}_t^e = (P_{t+1}/P_{t-1})^2 - 1$
- Countries: US = United States, CA = Canada, JA = Japan, AU = Austria, FR = France, GE = Germany, IT = Italy, NE = Netherlands, ST = Switzerland, UK = United Kingdom, FI = Finland, AS = Australia, SO = South Africa, KO = Korea, BE = Belgium, DE = Denmark, IR = Ireland, SP = Spain, NZ = New Zealand, VE = Venezuela, CO = Colombia, ID = India, PH = Philippines, CH = China
- Variables: CS = Consumption of Services, CN = Consumption of Non Durables, CD = Consumption of Durables, IH = Housing Investment, IK = Plant and Equipment Investment, C = Total Consumption, I = Total Investment

Output is the main explanatory variable in the investment equations for the other countries. Each equation includes the lagged dependent variable to pick up adjustment and expectational effects. The U.S. household expenditure equations and the consumption equations of the other countries are in per capita terms. All the equations are in log form except for the U.S. durable consumption and housing investment equations. For these latter two equations the interest rates and expected inflation measures are multiplied by an exogenous scale variable before being included in the equation.

The equations are estimated by two stage least squares (2SLS), where the first stage regressors are the main predetermined variables for the given country. Under standard assumptions the 2SLS estimates are consistent. Also, the predicted values from the first stage regressions can be interpreted as predictions of the agents in the economy. For example, both i_t and $\dot{p}_t^e$ are treated as endogenous in the 2SLS estimation, and the agents can be assumed to have used the first stage regressions for i_t and $\dot{p}_t^e$ for their predictions. These predictions use the information in the predetermined variables in the model. This interpretation is important when considering the use of P_{t+1} in one of the measures of $\dot{p}_t^e$. Agents in effect are assumed to form predictions of P_{t+1} by running first stage regressions.

In most cases a long term interest rate is used, although for a few countries only a short term interest rate is available. The long term interest rate used for the United States is a mortgage rate for the household expenditure equations and the AAA bond rate for the plant and equipment investment equation. A short term rate is used for the U.S. consumption of services equation.

To save space in Table 1, the coefficient estimate of i_t is not presented when the coefficient estimate of $\dot{p}_t^e$ is. In most cases the inclusion of $\dot{p}_t^e$ does not change the coefficient estimate of i_t much. The most important comparison in Table 1 is between the first and last columns, which is a direct comparison of the use of a nominal versus a real interest rate.

The nominal interest rate clearly dominates the real interest rate for the four U.S. household expenditure equations (rows 1–4). In only 3 of the 16 cases is the coefficient estimate of $\dot{p}_t^e$ even of the right (positive) sign, and in all four rows the t-statistic for the nominal rate is larger in absolute value than the t-statistic for the real rate. What this shows is that when i_t is forced to have $\dot{p}_t^e$ subtracted from it, its explanatory power in the equation diminishes.

Neither rate is significant for the U.S. plant and equipment investment equation (row 5), and so there is essentially no comparative information here. From the beginning of the estimation of plant and equipment investment equations, it has been hard to find significant interest rate effects, and this is still true today. Although this is embarrassing for introductory teaching purposes, since the usual stress is on the interest rate affecting firms' investment decisions, the U.S. evidence suggests that the main effects of interest rates are through the household expenditure equations. In the MC model I have retained the nominal rate in the equation even though it only has a t-statistic of -1.41, primarily to avoid embarrassment when dealing with introductory students.

Rows 6 through 25 pertain to the other countries for which there are quarterly data. In terms of size of the t-statistics (in absolute value), the nominal rate is better than the real rate in all but 5 of the 20 rows. (The 5 rows are 10, 13, 16, 22, and 24.) For rows 26 through 37, which pertain to countries with only annual data, the nominal rate is better in all but 2 of the 12 rows. (The 2 rows are 27 and 37.) Of the 32 rows that pertain to the other countries, 10 have the wrong (negative) sign for all the measures of $\dot{p}_t^e$ tried (rows 8, 9, 11, 12, 14, 21, 28, 30, 33, 34). Both the U.S. results and the overall results for the other countries are thus strongly supportive of the use of nominal rather than real interest rates in consumption and investment equations.

3 Real Wealth Effects

Although household wealth is not a variable in the modern-view model, it is a channel through which a change in the real interest rate may affect aggregate demand. This channel exists if the real interest rate affects household wealth and household wealth in turn affects household expenditures. In many structural macroeconometric models household wealth is an explanatory variable in household expenditure equations. In the MC model, for example, household wealth appears in the four U.S. household expenditure equations discussed in the previous section.

U.S. household wealth changes when the saving of the U.S. household sector changes and when there is a change in the value of corporate equities held. Most of the variation of wealth is from the variation in equity values (stock prices), not from variation in saving. The key question in the present context is thus how real interest rates affect stock prices. If the price of a stock is assumed to be the present discounted value of expected future earnings, one needs to estimate how stock prices change when expected future discount rates and earnings change.

In the MC model the capital gains (+) or losses (+) on the equity holdings of

U.S. households (denoted CG_t) is constructed from data from the U.S. Flow of Funds accounts. CG_t is highly correlated with the change in the S&P 500 stock price index. When CG_t/GDP_{t-1} is regressed on $(SP_t - SP_{t-1})/GDP_{t-1}$, where SP_t is the value of the S&P 500 index at the end of quarter t and GDP_{t-1} is the value of nominal GDP in quarter $t-1$, the results are:

$$\frac{CG_t}{GDP_{t-1}} = \underset{(6.19)}{.0534} + \underset{(27.96)}{9.18} \frac{SP_t - SP_{t-1}}{GDP_{t-1}}, \; R^2 = .805, \; 1954.1 - 2001.1 \qquad (1)$$

GDP_{t-1} is used for scale purposes to lessen the chances of heteroscedasticity.) The fit of this equation is very high, reflecting the high correlation of CG_t and the change in the S&P 500 index.

In the MC model the variable CG_t is taken to be a function of the change in the nominal AAA bond rate (ΔRB_t) and the change in after tax corporate profits ($\Delta\Pi_t$). The change in the bond rate is meant to proxy for changes in expected future discount rates, and the change in after tax profits is meant to proxy for changes in expected future earnings. The estimated equation is:

$$\frac{CG_t}{GDP_{t-1}} = \underset{(4.75)}{.101} - \underset{(-2.08)}{.148} \Delta RB_t + \underset{(1.62)}{15.06} \frac{\Delta\Pi_t}{GDP_{t-1}}, \; R^2 = .035, \; 1954.1 - 2001.1 \quad (2)$$

If $SP_t - SP_{t-1}$ is used in place of CG_t, the results are:

$$\frac{SP_t - SP_{t-1}}{GDP_{t-1}} = \underset{(2.43)}{.00506} - \underset{(-2.44)}{.0172} \Delta RB_t + \underset{(1.90)}{1.733} \frac{\Delta\Pi_t}{GDP_{t-1}}, \; R^2 = .024, \; 1954.1 - 2001.1 \quad (3)$$

These equations were estimated by 2SLS, with the first stage regressors being the main predetermined variables for the United States. The signs of the coefficient estimates in the two equations are as expected, although very little variance of the variables has been explained, with R^2's of only .035 and .024. Because equation (2) is part of the MC model, there is a link in the model from changes in interest rates and after tax profits to changes in CG_t and thus to changes in household wealth.

4 Real Income Effects

In the late 1970s there began a movement, led by Robert J. Gordon, away from the estimation of structural price and wage equations to the estimation of reduced form price equations (i.e., price equations that do not include wage rates as explanatory variables).[3] This line of research evolved to the estimation of "NAIRU" equations, where the inflation rate depends on the expected future inflation rate, the deviation of the unemployment rate from its natural rate (the NAIRU value), and cost shocks. The expected future inflation rate is usually taken to depend on past inflation rates, where the coefficients on the past rates sum to one. An output gap measure may be substituted for the deviation of the unemployment rate from its natural rate. Equations of this type represent the modern view.

A problem with this approach is that it ignores real wage effects. To see the consequences of this, it will be useful to compare the price equation of the modern view with the structural price and wage equations in the MC model. In the price equation in the MC model for a given country the price level depends on the nominal wage rate, a cost shock variable (the price of imports), a demand variable

[3] See, for example, Gordon (1980) and Gordon and King (1982).

(the unemployment rate or an output gap measure), the lagged price level, and a time trend. The nominal wage rate depends on the price level, the lagged price level, the lagged nominal wage rate, a demand variable, and a time trend. (The price equation is identified because the lagged nominal wage rate is excluded from it, and the wage equation is identified because the price of imports is excluded from it.) A constraint is imposed on the coefficients of the wage equation so that in the derived equation for the real wage rate the real wage rate does not depend on either the lagged value of the price level or the lagged value of the nominal wage rate separately, but only on the lagged value of the real wage rate (otherwise the dynamics are not sensible). This constraint is supported by the data.

An important feature of these two equations is that a cost shock directly affects the price level, with the price level then affecting the nominal wage rate. In the short run a positive cost shock leads to a larger increase the price level than in the nominal wage rate, and so there is a fall in the real wage rate.

Another difference between the price and wage equations of the MC model and the price equation of the modern view concerns long run dynamics. Two dynamic restrictions are imposed by the modern-view (NAIRU) specification: 1) the coefficients on past inflation rates sum to one and 2) the current and past price levels (in logs) appear only in first differenced form (i.e., as inflation rates). These two restrictions were tested for the United States in Fair (2000a) and rejected. The results suggest that price equations should be specified in terms of price levels with no restrictions on the coefficients of the past price levels. The long run properties of the NAIRU specification are thus subject to some doubt.

There are thus two criticisms that can be made of the price equation of the modern view. One is that the equation is not structural and so cannot handle possible changes in the real wage rate. The other is that the equation imposes dynamic restrictions that are not supported by the data. For present purposes the first criticism is more important. Although in the long run the dynamic restrictions make an enormous difference, in the short run (even a short run as long as three years) they do not—see, for example, Table 6 in Fair (2000a).

5 Estimated Effects of a Positive Cost Shock

A useful way of examining the difference between the modern-view model and the MC model is to consider the effects of a positive cost shock with no change in the nominal interest rate. As indicated in Section 1, in the modern-view model a positive cost shock with the interest rate rule dropped is expansionary because there is a fall in the real interest rate.

To examine the effects of a cost shock in the MC model, the following experiment was run. The period used is 1994:1–1998:4, 20 quarters. The first step was to add the estimated (historical) errors to the model and take them to be exogenous. This means that when the model is solved using the actual values of all the exogenous variables, a perfect tracking solution results. The base path for the experiment is thus just the historical path. Then the constant term in the U.S. price equation was increased by .005 (.50 percentage points) from its estimated value. Also, the estimated interest rate rule for the Fed was dropped, and the nominal short term interest rate was taken to be exogenous for the United States. The model was then solved. The difference between the predicted value of each variable and each period from this solution and its base (actual) value is the estimated effect of the price-equation shock. There is no effect for any period on the U.S. short term nominal interest rate because the U.S. interest rate rule was dropped. There is also no effect on U.S. long term nominal interest rates because they depend only on current and past U.S. short term nominal interest rates.

Selected results from this experiment are presented in Table 2. Row 1 shows that real GDP falls: the price shock is contractionary. Row 2 shows the effects of the change in the constant term in the price equation on the price level. The price level is .52 percent higher than its base value in the first quarter, 1.01 percent higher in the second quarter, and so on through the twentieth quarter, where it is 4.51 percent higher. (The shock to the price equation accumulates over time because of the lagged dependent variable in the equation.) Row 3 versus row 2 shows that the nominal wage rate rises less than the price level, and so there is a fall in the real wage rate. Row 4 shows that real disposable income falls. (Although not shown, nominal disposable income increases.) Real disposable income falls because of the fall in the real wage rate and because some nonlabor nominal income, such as interest income, rises less in percentage terms than the price level.

The change in nominal profits is higher (row 5), and this in turn leads to an increase in capital gains (CG) for the household sector (row 6). (This is equation (2) in Section 3 at work.) For example, the increase in capital gains in the first quarter is \$42.8 billion. (CG is not affected by any nominal interest rate changes because there are none.) The increase in CG leads to an increase in nominal household wealth (not shown), but row 7 shows that real household wealth is lower. This

Table 2
Effects of a Positive Shock to the U.S. Price Equation
Nominal Interest Rate Unchanged from Base Values
Changes from Base Values

		Quarters Ahead							
	Variable	1	2	3	4	8	12	16	20
1.	Real GDP	-.04	-.13	-.26	-.42	-1.15	-1.68	-2.05	-2.32
2.	Price level	.52	1.01	1.44	1.83	3.01	3.75	4.23	4.51
3.	Wage rate	.42	.80	1.15	1.46	2.40	2.99	3.37	3.59
4.	Real DPI	-.22	-.43	-.64	-.86	-1.68	-2.29	-2.77	-3.08
5.	$\Delta\Pi$	2.8	1.7	1.3	1.0	1.0	.8	.7	1.0
6.	CG	42.8	24.5	21.1	15.6	24.2	24.8	19.2	58.1
7.	Real Wealth	-.13	-.32	-.52	-.71	-1.41	-1.82	-2.01	-2.10
8.	CS	-.03	-.08	-.15	-.24	-.75	-1.35	-1.91	-2.39
9.	CN	-.03	-.08	-.16	-.27	-.79	-1.27	-1.62	-1.86
10.	CD	-.17	-.48	-.89	-1.35	-3.55	-5.30	-6.23	-6.45
11.	IH	-.23	-.56	-.98	-1.42	-3.12	-3.61	-3.47	-2.98
12.	IK	-.05	-.20	-.44	-.77	-2.69	-4.21	-5.20	-5.84
13.	yen/$ rate	-.03	-.07	-.14	-.22	-.64	-1.12	-1.59	-1.98
14.	DM/$ rate	-.05	-.14	-.25	-.39	-1.08	-1.76	-2.31	-2.67
15.	Price of imports	.13	.18	.25	.32	.80	1.21	1.51	1.29
16.	Price of exports	.47	.89	1.27	1.62	2.68	3.38	3.85	4.12
17.	Real imports	.02	.04	.04	-.01	-.71	-1.78	-2.79	-3.47
18.	Real exports	-.04	-.08	-.14	-.20	-.43	-.64	-.91	-.98
19.	Cur. Act.	.05	.11	.16	.22	.39	.61	.78	.98

- All variables but the last two are for the United States.
- Notation: DPI = Disposable Personal Income,
  $\Delta\Pi$ = Change in After Tax Corporate Profits,
  CG = Capital Gains or Losses on Stocks Held by the Household Sector,
  CS = Consumption of Services, CN = Consumption of Non Durables,
  CD = Consumption of Durables, IH = Housing Investment,
  IK = Plant and Equipment Investment,
  Cur. Act. = U.S. Nominal Current Account as a percent of Nominal GDP.
- Changes are in percentage points except for $\Delta\Pi$ and CG, which are in billions of dollars.
- Prediction period is 1994.1–1998.4.

means that the percentage increase in nominal household wealth is smaller than the percentage increase in the price level. Put another way, equation (2) in Section 3 does not lead to a large enough increase in CG to have real household wealth rise.

The fall in real income and real wealth leads to a fall in the four categories of household expenditures (rows 8–11). Plant and equipment investment is lower (row 12), which is a response to the lower values of output.

Rows 13 and 14 present the Japanese and German nominal exchange rates relative to the U.S. dollar. (An increase in a rate is a depreciation of the currency.) The two currencies appreciate relative to the dollar. This is because the U.S. price level rises relative to the Japanese and German price levels, which leads, other things being equal, to an appreciation of the yen and deutsche mark through the estimated equations for two exchange rates.

Row 15 shows that the U.S. import price level rises, which is due to the depreciation of the dollar, and row 16 shows that the U.S. export price level rises, which is due to the increase in the overall U.S. price level.

The real value of imports responds negatively to the import price level relative to the domestic price level and positively to real income. The price shock results in a decrease in the import price level relative to the domestic price level, and row 17 shows that this effect dominates for the first three quarters in that the real value of imports is higher. After that, however, the fall in real income dominates, and the real value of imports is lower. The real value of U.S. exports is lower (row 18), which is due to a higher relative U.S. export price level. (The export price level increases more than the dollar depreciates, and so U.S. export prices in other countries' currencies increase.) Even though the real value of U.S. exports is lower, there is an improvement in the nominal U.S. current account (row 19). This improvement is initially due to the higher U.S. export price level (a J curve type of effect) and later to the fact that the real value of U.S. imports falls more than does the real value of U.S. exports. In other words, the contractionary U.S. economy helps improve the U.S. current account because of the fall in imports.

The MC model and the modern-view model thus have opposite implications regarding the effect of a price shock on aggregate demand if the nominal interest rate is unchanged. A positive price shock with nominal interest rates unchanged is expansionary in the modern-view model and contractionary the MC model.

6 Rational Expectations

Most of the modern-view literature assumes that expectations are rational, whereas expectations are not rational in the version of the MC model used for the experiment in the previous section. The rational expectations (RE) assumption has been tested for many of the equations of the MC model,[4] and very little support has been found. Nevertheless, RE versions of the MC model have been analyzed using the extended path solution method in Fair and Taylor (1983, 1990), and for many experiments these versions have similar properties to those of non RE versions. The RE assumption mostly changes the timing of the effects. If, for example, it is assumed in the MC model that U.S. households have rational expectations

[4]See Fair (1993) for a discussion of the testing procedure, and Fair (1994) and the website for results of the tests.

regarding future real income, it is still the case that a positive price shock has a negative effect on current household expenditures. The effect is in fact larger under the RE assumption, since real income is lower in the future as well as the present and households know this and thus cut back expenditures more now. None of the main points about the MC model's properties in Section 5 hinge on whether or not expectations are rational.

7 The FRB/US Model

The FRB/US model—Federal Reserve Board (2000)—is sometimes cited as a macroeconometric model that is consistent with the modern view (see, for example, Taylor (2000), p. 91). This model has strong real interest rate effects. In fact, if government spending is increased in the FRB/US model with the nominal interest rate held constant, real output eventually expands so much that the model will no longer solve.[5] The increase in government spending raises inflation, which with nominal interest rates held constant lowers real interest rates, which leads to an unlimited expansion. The model is not stable unless there is a nominal interest rate rule that leads to an increase in the real interest rate when inflation increases.

It may seem puzzling that two macroeconometric models could have such different properties. Given the empirical results in Sections 2 and 3, how can it be that the FRB/US model finds such strong real interest rate effects? The answer is that many restrictions have been imposed on the model that have the effect of imposing large real interest rate effects. In most of the expenditure equations real

[5]Private correspondence with Andrew Levin and David Reifschneider.

interest rate effects are imposed rather than estimated. Direct tests of nominal versus real interest rates like the one used in Section 2 are not done, and so there is no way of knowing what the data actually support in the FRB/US expenditure equations.

Large stock market effects are also imposed in the FRB/US model. Contrary to the estimate of equation (2) in Section 3, which shows fairly small effects of nominal interest rates and nominal earnings on stock prices, the FRB/US model has extremely large effects. A one percentage point decrease in the real interest rate leads to a 20 percent increase in the value of corporate equity (Reifschneider, Tetlow, and Williams (1999), p. 5). At the end of 1999 the value of corporate equity was about $20 trillion (using data from the U.S. Flow of Funds accounts), and 20 percent of this is $4 trillion. There is thus a huge increase in nominal household wealth for even a one percentage point decrease in the real interest rate. A positive price shock with the nominal interest rate held constant, which lowers the real interest rate, thus results in a large increase in both nominal and real wealth in the model. The increase in real wealth then leads through the wealth effect in the household expenditure equations to a large increase in real expenditures. This channel is an important contributor to the model not being stable when there is an increase in inflation greater than the nominal interest rate. Again, this stock price effect is imposed rather than estimated, and so it is not necessarily the case that the data are consistent with this restriction. The empirical work in Section 3 does not find large increases in stock prices in response to changes in interest rates and earnings, certainly nothing close to what is imposed in the FRB/US model.

There is thus no puzzle about the vastly different properties of the two models.

It is simply that important real interest rate restrictions have been imposed in the FRB/US model and not in the MC model. One of the main points of this paper is that the data do not appear to support these restrictions.

8 Conclusion

Advocates of the modern view place a high weight on the fact, as Clarida, Galí, and Gertler (2000) point out, the equations are "grounded in dynamic general equilibrium theory" (p. 1665). But as important as many think this is, it should not come at a cost of deriving a model that is a poor approximation of the economy. The results in this paper suggest that a positive price shock with the nominal interest rate held constant is contractionary, contrary to the properties of the modern-view model. This feature has important implications for monetary policy. If a positive price shock is contractionary with the nominal interest rate held constant, the coefficient on inflation in the nominal interest rate rule need not be greater than one for the economy to be stable. The results of estimating interest rate rules in Fair (2001) suggest that the coefficient may in fact be less than one, but this is not something to get alarmed about. Nothing critical hinges on whether the coefficient on inflation is greater than or less than one.

References

[1] Clarida, Richard, Jordi Galí, and Mark Gertler, 1999, "The Science of Monetary Policy: A New Keynesian Perspective," *The Journal of Economic Literature*, 37, 1661-1707.

[2] ________, 2000, “Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory,” *The Quarterly Journal of Economics*, 115, 147-180.

[3] Fair, Ray C., 1993, “Testing the Rational Expectations Hypothesis in Macroeconometric Models,” *Oxford Economic Papers*, 45, 169-190.

[4] ________, 1994, *Testing Macroeconometric Models*, Cambridge, MA: Harvard University Press.

[5] ________, 2000a, “Testing the NAIRU Model for the United States,” *The Review of Economics and Statistics*, 82, 64-71.

[6] ________, 2001, “Actual Federal Reserve Policy Behavior and Interest Rate Rules,” *FRBNY Economic Policy Review*.

[7] ________, and John B. Taylor, 1983, “Solution and Maximum Likelihood Estimation of Dynamic Rational Expectations Models,” *Econometrica*, 51, 1169-1185.

[8] ________, 1990, “Full Information Estimation and Stochastic Simulation of Models with Rational Expectations,” *Journal of Applied Econometrics*, 5, 381-392.

[9] Federal Reserve Board, 2000, “FRB/US Equation Documentation for the VAR-Based Expectations Version of the Model,” May.

[10] Gordon, Robert J., “Comments on George L. Perry, ‘Inflation in Theory and Practice,”’ *Brookings Papers on Economic Activity* (1980), 249-257.

[11] ________, and Stephen R. King, “The Output Cost of Disinflation in Traditional and Vector Autoregressive Models,” *Brookings Papers on Economic Activity* (1982), 205-242.

[12] Lucas, Robert E., Jr., 1976, “Econometric Policy Evaluation: A Critique,” in K. Brunner and A.H. Meltzer, eds., *The Phillips Curve and Labor Markets*, Amsterdam: North-Holland.

[13] Reifschneider, David, Robert Tetlow, and John Williams, 1999, “Aggregate Disturbances, Monetary Policy, and the Macroeconomy: The FRB/US Perspective,” *Federal Reserve Bulletin*, January, 1-19.

[14] Romer, David, 2000, "Keynesian Macroeconomics without the LM Curve," *The Journal of Economic Perspectives*, 14, 149-169.

[15] Taylor, John B., ed., 1999a, *Monetary Policy Rules*, Chicago: The University of Chicago Press.

[16] ________, 1999b, "A Historical Analysis of Monetary Policy Rules," in Taylor (1999a), 319-341.

[17] ________, 2000, "Teaching Modern Macroeconomics at the Principles Level," *The American Economic Review*, 90, 90-94.