MONETARY POLICY AND THE U.S. STOCK MARKET

Marc D. Hayford and A. G. Malliaris*
Department of Economics
Loyola University Chicago

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Abstract

Does the Federal Reserve System consider the level of the stock market when setting monetary policy? This paper examines empirically if monetary policy, since the October 19, 1987 stock market crash, has been influenced by the stock market. We conclude that the Fed considers the stock market only to the extent that it influences inflation and the output gap. As a consequence the Federal Reserve policy accommodated the high valuations in the 1990s of the stock market as measured by the S&P500 P/E ratio.

(JEL Classification: E50, G10, Key Words: monetary policy, stock market, Federal funds rate, Taylor's rule, bubbles)

*Corresponding author: A. G. Malliaris, Department of Economics, Loyola University Chicago, 820 North Michigan Avenue, Chicago, Illinois 60611 USA;
email: tmallia@luc.edu Phone: (312) 915-6063; Fax: (312) 915-6063

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1. Introduction

The monetary policy goals of the Federal Reserve System, as often stated in publications and testimony of Fed officials, are “price stability” and “sustainable economic growth”. Recently the Fed officials and academic economists have addressed the question of whether in addition to price level stability, a central bank should also consider the stability of assets prices. As Greenspan, in his December 5, 1996 Lecture to the American Enterprise Institute for Public Policy Research, says "… where do we draw the line on what prices matter? Certainly prices of goods and services now being produced--our basic measure of inflation-- matter. But what about futures prices or more importantly prices of claims on future goods and services, like equities, real estate, or other earning assets? Is stability of these prices essential to the stability of the economy?" Chairman Greenspan, answers his own question in the form of both reflections and additional questions: "But how do we know when *irrational exuberance* has unduly escalated asset values, which then become subject to unexpected and prolonged contractions as they have in Japan over the past decade? And how do we factor that assessment into monetary policy?”

Perhaps partly in response to these statements by Greenspan, the academic literature has addressed both the normative question “should monetary policy react to asset bubbles?” as well as the positive question “does monetary policy react to asset bubbles?”. After a review of the academic literature in section 2, this paper focuses on the positive question of whether monetary policy since 1987 has been influenced by the high valuation of the stock market. Numerous statements made by Chairman Greenspan indicate that he believes that soaring stock prices may create imbalances in the economy that threaten the goals of general price level stability and sustainable economic growth. It is natural to ask: Have these concerns by the Chairman been activated into monetary policy decisions?

2. Review of the Literature

How should monetary policy react to a stock market bubble? Using the language of control theory we can ask the more technical question: should monetary policy target the level of equity prices, measured by an index such as the S&P 500 Index? Most economists consider these **normative** questions as meaningless because there is little agreement on how to recognize a bubble *ex ante*. Defining a bubble as the difference between the actual market price and the fundamental price is a relative statement that becomes operational provided one could compute the fundamental price. If the fundamental price cannot be computed, then one cannot talk about the existence and the magnitude of the bubble. Shiller (1989) and, more recently Sagle (1997), offer an extensive review of the literature on market volatility and discuss both the theoretical and empirical issues associated with bubbles.

At the risk of oversimplification, one finding of this literature is that bubbles are easier to identify *ex post* rather than *ex ante*. For example, it is difficult to find economists who would argue today that the stock market increase in Japan in the late 1980s or the Nasdaq increase in the late 1990s reflected only fundamentals. The fact that in both cases these markets declined significantly is *ex post* evidence of the existence of a bubble, yet there was no consensus among economists prior to its dramatic collapse that a bubble was present in these two markets.

If we cannot ascertain the existence of a bubble, how can we decide what should the reaction of the monetary policy be in regard to it? One way to simplify the analysis is to follow Blanchard (2000) who, for the sake of argument, assumes that the central bank knows that there is a bubble in the stock market. In other words, suppose that the Fed has decided that the price of stocks, measured by some index, exceeds fundamentals and also assume that this bubble will eventually collapse and stock prices will return to fundamentals. How monetary policy ought to respond under these assumptions?

Economists have proposed two answers. One group, represented by Bernanke and Gertler (1999, 2001) argues that monetary policy that targets the rate of inflation is best, independent of whether a bubble exists or not. Put differently, the existence of a bubble should not cause the central bank to change its policy of targeting inflation. Another group represented by Cecchetti (1998) argues that the central bank can improve economic performance by paying attention to asset prices. Next, we present a brief elaboration of these arguments.

Bernanke and Gertler (1999) argue that a central bank dedicated to a policy of flexible inflation targeting should pay little attention to asset inflation because a proper setting of interest rates to achieve the desired inflation target will also stabilize asset prices. The authors (1999, p.18) "view price stability and financial stability as highly complementary and mutually consistent objectives to be pursued within a unified policy framework". Elsewhere they (1999, p.18) state the "[t]rying to stabilize asset prices *per se* is problematic for a variety of reasons, not the least of which is that it is nearly impossible to know for sure whether a given change in asset values results from fundamental factors, nonfundamental factors, or both".

The sufficiency of targeting inflation can be argued as follows. Keeping both current and expected inflation at a constant level is equivalent to maintaining output at its natural level. The existence of a bubble can either cause no change in aggregate demand or cause it to increase because of the wealth effect or some other reason. In either case, the monetary rule of inflation targeting guides the central bank to act appropriately, either by doing nothing in the case the bubble causes no change in aggregate demand or by tightening in the case the bubble increases aggregate demand via the wealth effect.

Blanchard (2000) finds the arguments of Bernanke and Gertler powerful but also argues that their model works provided the bubble affects some components of spending more than others. For example, if the bubble increases consumption, via the wealth effect, that puts pressure on inflation, and Fed tightening guided by inflation targeting can be optimal. What if the bubble causes publicly traded firms whose equity has increased because of the bubble to increase their investment? If investment depends on the bubble, among other economic factors, then with output at its natural level, an increase in investment can occur only by an equivalent decrease in consumption. Thus, while inflation targeting keeps inflation constant, the composition of output tilts more in favor of investment and thus the bubble may cause excessive capital accumulation. When ultimately the bubble bursts this excessive capital accumulation deters firms from investment and postpones economic growth. Thus inflation targeting does not address issues related to the impact of a bubble on the composition of output and the long-run impact of the bubble on capital accumulation and growth.

Others who have also evaluated the model of Bernanke and Gertler (1999) are Bordo and Jeanne (2001) who have argued that asset price reversals can be very costly in terms of declining output, such as the cases of the US in the early 1930s or of Japan during the 1990s. They go further to argue that traditional monetary policy may be unable to correct such asset price disturbances and therefore monetary policy should attempt, primarily, to discourage the emergence and growth of bubbles, rather than act after they burst in an effort to stabilize the economy.

Mishkin (2000) also acknowledges that the most serious economic downturns are often associated with financial instability but does not discuss specifically the impact of a stock market crash on the economy. The implication of Mishkin's argument is that monetary policy should attempt to avoid financial instabilities such as the 1929 US stock market crash or the Japanese stock market decline of the 1990s. However, Cogley (1999) argues that deliberate attempts to puncture asset price bubbles may destabilize the economy and thus monetary policy may generate instabilities that are similar to the ones arising from the burst of a bubble.

Bullard and Schaling (2002) use a simple macroeconomic model to study the implications of targeting inflation, output and equity prices. They show that such a policy that reacts to equity price increases can be counterproductive because it can interfere with the policy maker's ability to minimize inflation and output variability. They also show that under certain conditions, a policy of targeting stock market prices can lead to an indeterminate rational expectations equilibrium and hence a more unpredictable volatility than would be achieved if asset prices were ignored. They conclude that targeting the stock market degrades the effectiveness of monetary policy and can do real damage when such damage is not possible by concentrating on inflation and output targeting. Thus, monetary policy should ignore the stock market.

Goodfriend (2002) reaches a similar conclusion. He argues that the direction and size of the unconditional correlation between asset price movements and real short-term interest rates is not stable. Thus, in principle, the appropriate direction and size of the interest rate response to equity prices would be difficult to discern in practice. Finally, Filardo (2000, 2001) also explores the role of monetary policy in an economy with asset bubbles by developing a small-scale macroeconomic model and running various simulations. He finds that if there is no uncertainty about the role of asset prices in determining output and inflation then monetary policy should respond to asset prices. However, if the monetary authority is sufficiently uncertain about the macroeconomic consequences of stock prices then it is preferable for monetary policy to remain neutral.

In contrast to Bernanke and Getler and the other authors who recommend that monetary policy should not respond to stock market bubbles, Cecchetti (1998) argues that monetary policy should take into account asset prices. The logic behind this argument is the idea that the policymaker must often trade off variability in output for variability in prices because it is generally not possible to stabilize both. More specifically, Cecchetti, Genberg, Lipsky and Wadhwami (2000) argue that central bankers can improve economic performance by paying attention to asset prices. Cecchetti and Krause (2000) examine in detail the connection between the dramatic changes in the financial structure (a concept much more general than stable asset prices) of numerous countries and conclude that these changes contributed to the stability of both economic growth and low inflation.

In a recent paper, Cecchetti, Genberg and Wadhwani (2002) revisit the same question and argue that there are sound theoretical reasons for an inflation targeting monetary policy to improve the economy's performance by reacting to asset price misalignments. They emphasize that policy reactions to stock price bubbles must be qualitatively different from reactions to stock price increases driven by fundamentals, such as increases in productivity and earnings. The concern with stock market bubbles is both their inevitable collapse but also the encouragement of overinvestment and excessive borrowing by households and firms before the bubble collapse. Thus, bubbles can cause, both during their rapid growth and also after their collapse, serious economic imbalances that can cause either inflation or deflation. One reason that Cecchetti and his coauthors support the opposite conclusion than the other authors is because they explore a larger family of policy reaction functions.

What is the tentative answer to the normative question: should monetary policy react to an asset bubble? The answer depends on the timing of the bubble. After the bubble bursts, monetary policy should always act in order to stabilize the economy. Before the collapse of the asset bubble, it is difficult to argue what monetary policy should do because it is not clear how to determine a bubble and estimate its size. If the Fed believes that there is a bubble and its size is rapidly growing, then the Fed should act to reduce it. If the Fed is uncertain about the existence of a bubble, it is hard to argue that it should change its inflation targeting.

Next, we move on from the normative to the **positive** question: what does monetary policy do in response to asset prices. Tarhan (1995) finds evidence that the Fed affects asset prices. Filardo (2000) reviews carefully the literature on including asset prices in inflation measures and finds little evidence that paying attention by the Fed to asset prices would reliably improve economic stability. Fair (2000) uses a macroeconomic model to offer quantitative evidence of the Bordo and Jeanne (2001) claim that the Fed may be unable to correct asset price disturbances. Fair shows that the negative effects from the loss of wealth following a stock market crash dominate the positive effects from the Fed lowering interest rates immediately after such a crash.

Rigobon and Brian (2001) use an identification technique based on the heteroskedasticity of stock market returns to identify the reaction of monetary policy to the stock market. They find that monetary policy reacts significantly to stock market movements, with a 5% rise (fall) in the S&P 500 Index increasing the likelihood of a 25 basis point tightening (easing) by about half. The authors decompose both daily and weekly movements in interest rates and stock prices from approximately 1985 to 1999. Their results suggest that stock market movements have a significant impact on short-term interest rates, driving them in the same direction as the change in stock prices. The authors attribute this response to the anticipated reaction of monetary policy to stock market increases. They acknowledge that this interpretation should be taken a bit cautiously. Hayford and Malliaris (2001) also empirically investigate how the Fed has responded to stock prices using quarterly data and conclude that the Fed was not bubble-neutral.

In contrast to the above literature, this paper takes four approaches to answering the positive question: has monetary policy during the Greenspan Fed been stock market neutral? Our first approach is just to compare, for the period 1987 to 2001, the changes in the Federal funds rate with the behavior of measures of stock market valuation, unemployment, GDP gaps and inflation. The second approach is a review of the minutes of the FOMC meetings. This is the closest we can come to directly asking the FOMC members if the stock market influences their decision with respect to the target for the Federal funds rate and how. Our third approach is to estimate Taylor's Rule (Taylor 1993) augmented with two alternative measures of stock market valuation. Finally we estimate a VAR model to address the question of whether the Fed set the Federal funds rate in response to the stock market.

3. Measures of Stock Market Valuation

In addressing the question of whether monetary policy has responded to the stock market, we use two related measures of stock market overvaluation for the S&P 500: the P/E ratio and the implied equity premium. The P/E is the more commonly used measure. A P/E ratio is above its historic average is often used to signal a potential overvaluation. Shen (2000) finds strong historical evidence that disappointing stock market performance follow high price-earnings ratios.

The calculation of implied equity premium follows from the 'Gordon Equation' (Gordon 1962) for stock market valuation. Stock prices are assumed to be the expected present value of future earnings discounted at the long-term government bond rate plus an equity premium. Assuming that nominal earnings are expected to grow at the current growth rate g, that the nominal long-term government bond rate and the equity premium are constant, then the stock price is given as

$$P_t = \frac{E_t(1+g_t)}{i_t + \rho_t - g_t}$$

where P_t is the stock price, E_t is earnings, and g is the growth rate of earnings. Solving for the implied equity premium results in

$$\rho = (1+g)\frac{E_t}{P_t} - i + g$$

or in real terms

$$\rho = (1 + rg_t)(1 + \pi_t)\frac{E_t}{P_t} - i + rg_t + \pi_t + rg_t \times \pi_t$$

To calculate the implied equity premium (following the World Economic Outlook, April 2000) we use the growth rate of potential real GDP for rg, recent inflation for π, the inverse of the SP 500 price earnings rate for E/P and the ten-year constant maturity Treasury bond rate for i.

Figure 1

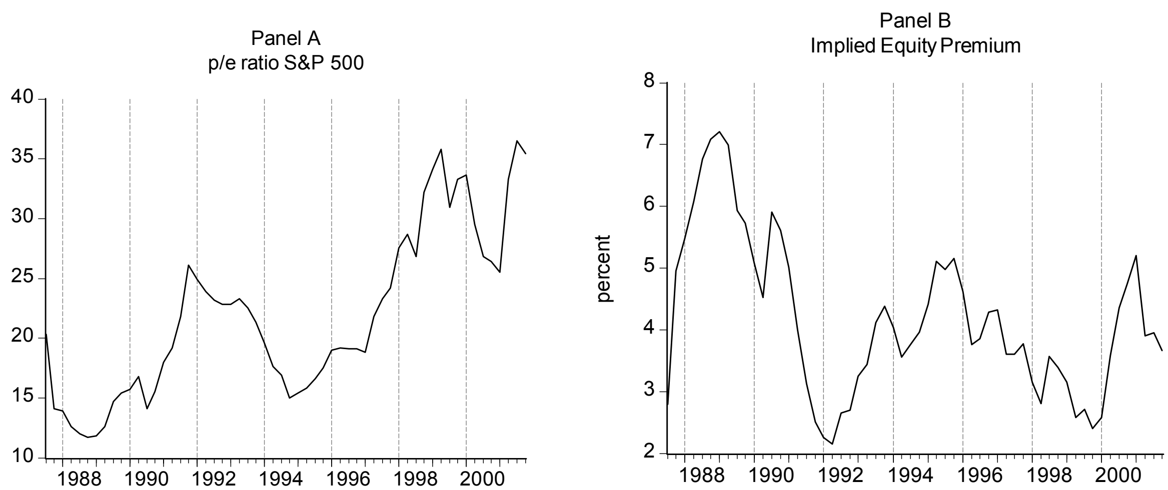


Figure 1 compares the two measures of market valuation from 1987:3 to 2001:4. The mean for the S&P 500 P/E ratio for the period 1948 to 1993 is about 14. Hence by historic standards, a P/E ratio in excess of 14 would indicate a potentially overvalued market. The historic average of the implied equity premium from 1960 to 1993 is 8%. An equity premium below this value could signal overvaluation. Both measures the stock market was overvalued prior to the 1987 crash. Further both measures agree that from 1996 to 2001 the market was overvalued.

4. Stock market valuations, the unemployment rate, inflation, GDP gaps and the Federal funds rate.

In this section we make the prima facie case that the Fed has tended to accommodate stock market overvaluation since 1987. This observation is consistent with the Fed having a primary goal of price stability excluding asset prices. Figure 2 gives the graphs of the major economic indicators from 1987 to 2001.

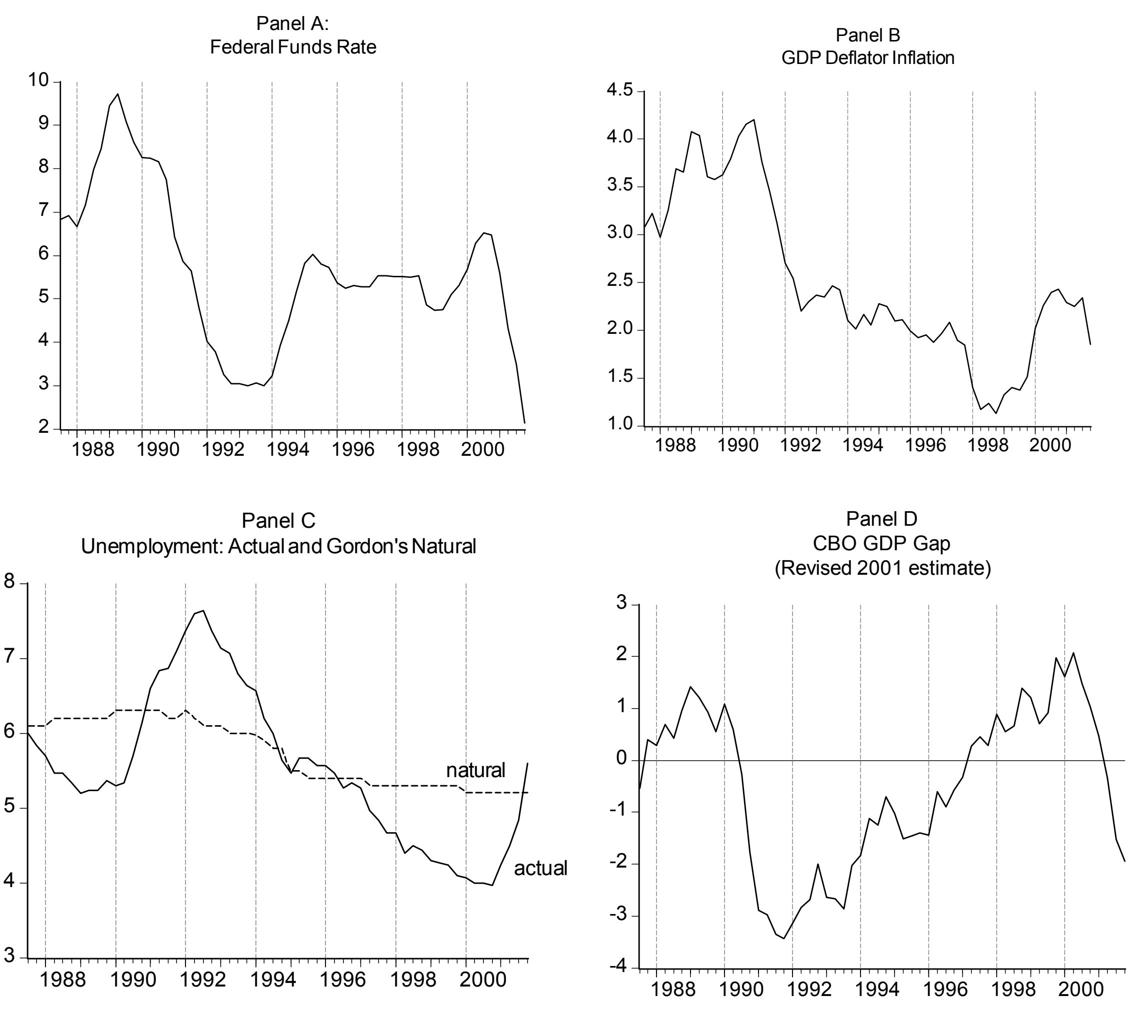
As measured by the nominal Federal funds rate (see panel A), there are three periods of monetary tightening in the sample period. The first is from March 30, 1988 to May 17, 1989. Both measures of stock market valuation presented in figure 1 suggest the stock market was more or less appropriately valued in this period. This suggests the Fed must have tightened for some reason other than the stock market. Panel B shows that GDP deflator/inflation was increasing, panel C that unemployment was below the Gordon (2000) estimates of the natural rate and panel D shows that output was above potential, using the CBO year 2001 estimates of potential GDP in 1988-89. This suggests that the Fed tightened due to concerns about potential accelerating inflation.

The second period of tightening runs from February 4, 1994 to February 1, 1995. The data suggest the Fed may have tighten to deflate a financial bubble since at the beginning of 1994 the P/E ratio was about 20, while inflation had been falling and was at 2%. In addition, the unemployment rate was above estimates of its natural rate and the CBO output gap was negative. The final period of tightening is the period from June 1999 to December 2000. Both measures of stock market valuation suggest the market was overvalued at the beginning of the tightening period. In addition, while inflation was subdued, measures of excess demand, such as the gap between the natural and actual unemployment rate and the GDP gap all indicated substantial excess demand. While the

FOMC may have moved to tighten due to the stock market, it is perhaps more plausible that the Fed was attempting to preempt inflationary pressure.

There are three periods since October 1987 where the Fed has been easing or holding the nominal Federal funds rate constant. The first, from June 6, 1989 to 1993, rates were falling and then were constant for all of 1993. During this period the P/E has an upward trend, starting at 13 and ending at almost 23 and the equity premium is falling. The second period of ease or relatively constant Federal funds rates starts on July 6, 1995 and runs until June 30, 1999 with one increase on March 25, 1997. During this period the P/E ratio rose from 17 to over 30 and the equity premium has a downward trend. Chairman Greenspan's comments suggest that he was concerned about the stock market by the end of December 1996.

Figure #2



The third period of monetary ease begins January 2001. Since the stock market begins its fall in March 2000 the timing suggests the Fed was responding to the economic slowdown evident in the decrease in the output gap and the rise in the unemployment rate. Of course, the economic slowdown may have been due in part to the fall in the stock market. In summary, the first two periods of monetary ease arguably helped to facilitate an increase in stock market valuation and provide a prima facie case that in these periods the Fed has accommodated the potential overvaluation of the stock market. The third period of monetary ease follows a decline in the stock market but presumably was reacting to the slowdown in the real economy. Of the three periods of rising Federal funds rates, only the 1994 monetary tightening is a possible candidate for an increase in the Federal funds rate being a direct response to an overvalued stock market.

5. Evidence from FOMC minutes

The minutes of the FOMC meetings are available six weeks after each meeting. The minutes clearly show that sometimes the Fed does consider the stock market when determining the stance of monetary policy. For example, the minutes of the FOMC meeting on November 3, 1987, the first meeting after the October 1987 stock market crash, document the fact that the Fed increased bank reserves in response to the decline in the stock market. The concern of the members of the FOMC was the fragility of financial markets in the wake of the crash and the potential negative wealth effect on aggregate demand. From 1988 to September 1993 the minutes show little discussion of the stock market other than to mention what happened to stock prices in the inter-meeting periods. For 1993 to January 2002, Table 1 provides a rough summary of mentions of the stock market in the FOMC minutes from 1993 to January 2002. The second column of Table 1 gives the number of meetings at which FOMC members expressed concern the potential overvaluation of the stock market. For example in 1996 in 4 out of 8 meetings members expressed such a concern which consistent with Chairman Greenspan giving his 'irrational exuberance' speech in December 1996. The third column gives the number of meetings where the FOMC minutes mention the stock market in context of its' wealth effect on consumption and/or its effect on the cost of capital. From 1998 to 2000 the stock market wealth effect was mentioned in the minutes of every meeting. The last column in table 1 gives the number of meetings where the minutes mention concern about the reaction of the stock market to monetary policy.

A careful reading of the minutes suggests that the central goal of monetary policy is price stability and sustainable economic growth. Further the minutes suggest that the stock market is considered to the extent that members of the FOMC feel the behavior of the stock market may influence aggregate demand and hence output and inflation. Consistent with a recent speech by Federal Reserve Board Governor Gramlich (2001), there is no evidence from the minutes that the FOMC has an implicit target for the stock market independent of the FOMC goals for inflation and growth. However the FOMC minutes suggest that monetary policy may respond to the stock market indirectly through the wealth effect of the stock market on aggregate demand.

Table 1: Summary of discussion of stock market in FOMC meeting

Year	Concern about value of stock market or possible correction	Concern or discussion of effect of stock market on aggregate demand	Concern or discussion of stock market as a constraint on monetary policy
1993	1	1	1
1994		6	
1995		7	

1996	4	5	
1997	2	4	
1998	1	8	1
1999	2	8	
2000	2	8	
2001		8	

6. The Taylor Rule Evidence

To estimate whether has monetary policy systematically responded to the stock market, we augment Taylor's (1993) monetary policy rule with a target for the stock market:

(1) $$i_t = \pi_t + r^* + \alpha_1(\pi_t - \pi^*) + \alpha_2 y_t + \alpha_3(\rho_t - \rho^*)$$

where i_t denotes the current nominal Federal funds rate, π is the average inflation rate, π^* is the target inflation rate, r^* is the long run equilibrium real Federal funds rate, y is the output gap, and ρ_t is a measure of stock market valuation and ρ^* is its target value. The Taylor monetary policy rule implies that the Fed sets the Federal funds rate to hit a target inflation rate and a target for real GDP that equals potential GDP. Monetary policy is "stable", i.e. offsets increases in inflation by increasing the real Federal funds rate if $\alpha_1 > 0$. If monetary policy is also set to systematically influence the stock market, the Fed would attempt set ρ_t equal to ρ^*. If ρ_t is the price earnings ratio and it is above its target value, a monetary policy aimed at reducing the estimated bubble would involve increasing the Federal funds rate, so $\alpha_3 > 0$. However, if monetary policy is contributing to a stock market bubble then, $\alpha_3 < 0$. If instead ρ_t is implied equity premium (to be defined below) and it is below its target value, a monetary policy aimed at reducing the estimated bubble would involve decreasing the Federal funds rate, so $\alpha_3 < 0$. However, if monetary policy is accommodating a stock market bubble, then $\alpha_3 > 0$.

Following Taylor (1993) we use quarterly data to estimate equation (1). To measure excess demand, Taylor uses the Hodrick- Prescott filter and revised data for real GDP to calculate the GDP gap as the percent deviation of real GDP from the Hodrick- Prescott measure of potential GDP. Orphanides (2000) argues that using real time estimates of potential GDP that were available at the time the FOMC met is more appropriate and that doing so reduces the explanatory power of Taylor's rule. Evans (1998) argues that using the gap between unemployment and an estimate of the natural rate of unemployment comes closer to real time data than using revised values of real GDP. A detailed evaluation of Taylor's rule is presented in Benhabib, Schmitt-Grohe and Uribe (1998), Kozicki (1999) and Hetzel (2000). In this paper we use two alternative measures of excess demand: the CBO's estimate of the real GDP gap and the deviation of NAIRU from the actual unemployment rate. Inflation is measured as the growth rate of the GDP deflator from the same quarter of the previous year.

Table 2: Variable Definitions and sample statistics

Fedfunds = Federal funds rate
Inflation = Growth in the GDP deflator, year over year
CBOGAP = CBO estimate of GDP gap, using data available in year 2000
UNEMGAP = Gordon's (2000) estimate of NAIRU minus actual unemployment rate.
P/E = S&P 500 price earnings ratio
PREMIUM = implied equity premium on the S&P 500

Sample period: 1987:3 to 2001:4

	mean	Std. Dev	Max	Min
Fedfunds	5.64	1.76	9.73	2.13
Inflation	2.51	0.85	4.20	1.13
CBOGAP	-0.50	1.55	2.07	-3.43
UNEMPGAP	0.21	0.77	1.23	-1.53
P/E	20.83	6.92	36.50	11.70
PREMIUM	4.17	1.27	7.20	2.15

Estimating equation (1), both with and without the measures of stock market valuation, results in serially correlated errors. This does not seem to bother Taylor (1999). Other researchers (e.g. Evans (1998), Judd and Rudebusch (1998) and Bernanke and Gertler (1999)) use a "dynamic" specification of Taylor's rule to obtain serially uncorrelated errors. Below we report estimates of Taylor's rule with both 'static' and 'dynamic' specifications.

7. Static Specifications

The econometric specification of equation (1), is as follows

(2) $i_t^* = c_1 + c_2\pi_t + c_3 y_t + c_4\rho_t$

where

$c_1 = r^* - \alpha_1\pi^* - \alpha_3\rho^*$

$c_2 = 1 + \alpha_1 > 1$ if monetary policy is stable

$c_3 = \alpha_2$

$c_4 = \alpha_3$

Table 3 reports estimates of equation (2) for two measures of excess demand and the two measures of stock market valuation. All coefficients are statistically significant at the usual significance levels. Model 1 and Model 2 reported in columns 2 and 3 of Table 3 report the estimates of equation (2) using CBOGAP and UNEMGAP as alternative measures of excess demand without including a measure of stock market valuation. The estimated parameters for inflation and excess demand are consistent with those reported by Taylor (1999). Monetary policy is found to be stable during this period, with the Federal funds rate estimated to increase by 1.5 percentage points for every 1 percentage point increase in inflation, if the CBOGAP is the measure of excess demand. If

UNEMGAP is used, the Federal funds rate is less responsive to inflation but monetary policy is still estimated to be stable over the period.

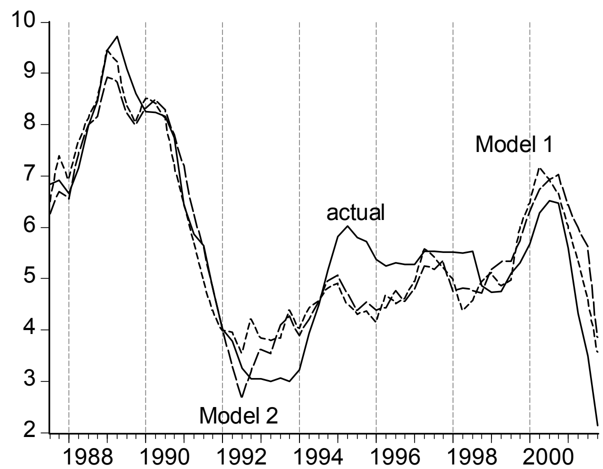
Table 3: Static Taylor rules, OLS estimation
Dependent Variable: Federal funds rate (mean = 5.64, standard deviation = 1.77)
Sample: 1987:3 to 2001:4 (t-statistics in parenthesis)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant: c_1	2.20 (7.37)	1.91 (6.11)	4.60 (7.48)	1.80 (5.22)	5.34 (9.91)	1.52 (4.29)
Inflation: c_2	1.52 (13.42)	1.36 (11.63)	1.16 (8.96)	1.29 (8.17)	0.84 (7.47)	1.13 (7.14)
Measure of excess demand: c_3						
CBOGAP	0.74 (11.89)	-	0.75 (13.72)	0.67 (9.81)	-	-
UNEMGAP	-	1.47 (11.22)	-	-	1.56 (16.25)	1.32 (9.21)
Measure of stock market valuation: c_4						
P/E	-	-	-0.07 (-4.30)	-	-0.10 (-7.03)	-
PREMIUM		-	-	0.23 (2.09)	-	0.24 (2.14)
$\overline{R}^2$	0.83	0.82	0.87	0.84	0.90	0.82
DW	0.35	0.24	0.47	0.36	0.39	0.25

Figure 3 shows the actual Federal funds rate and the predicted Federal funds rate from Model 1 and Model 2. Using UNEMGAP as the measure of excess demand gives a slightly better fit to the actual Federal funds rate. Models 3 to 6 in Table 3 (columns 4 to 7) report estimates of equation (2) using the two measures of stock market valuation and the two measures of excess demand. Consistently there is negative coefficient on the price earnings ratio (P/E)and a positive coefficient on the implied equity premium (PREMIUM). Estimated models 3 and 5 imply that an increase in the P/E ratio of 6.9 (an approximately 1 standard deviation increase), results in a decrease in the Fed funds rate by 48 to 69 basis points. Models 4 and 6 indicate that a decrease in the implied equity premium by 1.3 (an approximately 1 standard deviation decrease) results in a decrease in the Fed funds rate by about 30 basis points. The effects seem to us to be large for the P/E ratio. One interpretation of these results is that during the sample period, controlling for inflation and the GDP gap, the Fed was lowering the Federal funds rate as the market became more overvalued.

The inclusion of measures of stock market valuation in the static Taylor rule in most cases reduced the magnitude of inflation coefficient (c_2). Model 5, which uses UNEMPGAP as the measure of excess demand and P/E for the measure of stock market overvaluation, results in unstable monetary policy that is $c_2 < 1$. Obviously, both P/E and

Figure 3:
Static Taylor Rules: Model 1 versus Model 2



PREMIUM depend on interest rates themselves, so perhaps the regression results reflect some simultaneity bias.

To address the problem of potential simultaneity bias, we estimated equation (2) using instrumental variables (IV). As instruments for the measures of stock market overvaluation we used zero to two lags of the growth rate of real GDP from the previous year. We use these instruments on two grounds: (a) the lag between changes in the Federal funds rate and output growth is “long and variable” and typically stated by the Fed to be 12 to 18 months. In addition, over the sample period 1987 to 2001 the correlation between current real GDP growth and the level of the Federal funds rate is –0.04. This suggests that the growth rate of current and past real GDP is uncorrelated with the current level of the Federal funds rate. (b) Stock prices as market participants discounted forecasts of future earnings will be correlated to current real GDP growth if market participants are forecasting the future based on what they observe in the present. Empirically, current real GDP growth is correlated with the measures of market overvaluation, 0.23, and –0.16 for P/E and PREMIUM respectively. On theoretical grounds we would expect earnings to be correlated with GDP growth.

Table 4 shows the IV estimates of equation (2) with the two measures of excess demand and the two measures of market overvaluation. Compared with the OLS estimates the inflation coefficients are larger and still imply a stable monetary policy for 3 of 4 regressions. The coefficient estimates on the measures of excess demand show little change. The dramatic differences are with the coefficient estimates on the measures of stock market overvaluation. Using current and lagged output growth as instruments, results in statistically insignificant estimates in 3 of 4 regressions. In addition the magnitude of the coefficients are much smaller than the OLS estimates for regressions using the CBOGAP as the measure of excess demand. Only model 5 gives results consistent with and increase in the P/E resulting in a decrease in the Federal funds rate.

To sum up the results of Table 3 and 4, adding a measure of stock market valuation to the “static” Taylor rule results in a negative correlation, although statistically weak for the instrumental variables regressions, between the Federal funds rate and measures of stock market overvaluation after controlling for inflation and measures of excess aggregate demand. Taken seriously, this result indicates that the Greenspan monetary regime, rather than deflating apparent speculative bubbles, has *at most* accommodated them. This is consistent with the prima facie evidence presented in section 3 above.

At this point some readers might be concerned about the low Durban Watson statistic with its implication that the errors in the above regression equations are serially correlated. Following other researchers (e.g. Judd and Rudebusch (1998)) we address this issue by estimating a "dynamic Taylor rule".

Table 4: Static Taylor rules, IV estimation
Dependent Variable: Federal funds rate (mean = 5.64, standard deviation = 1.77)
Sample: 1987:3 to 2001:4 (t-statistics in parenthesis)

	Model 3	Model 4	Model 5	Model 6
Constant: c_1	2.21 (2.21)	2.06 (4.55)	4.86 (5.94)	1.57 (3.54)
Inflation: c_2	1.52 (8.28)	1.44 (6.17)	0.92 (6.24)	1.16 (5.15)
Measure of excess demand: c_3				
CBOGAP	0.74 (11.81)	0.72 (8.41)	-	-
UNEMGAP	-	-	1.55 (15.71)	1.34 (7.69)
Measure of stock market valuation: c_4				
P/E	-0.00 (-0.02)	-	-0.08 (-3.77)	-
PREMIUM	-	0.08 (0.40)	-	0.21 (1.02)
$\overline{R}^2$	0.83	0.84	0.90	0.83
DW	0.34	0.35	0.37	0.25

Instruments: Inflation, CBOGAP (models 3 and 4) UNEMGAP (models 5 and 6) Growth rate of real GDP from year ago (lags 0 to 2).

8. Dynamic Taylor rule Specifications

Following Judd and Rudebusch (1998) and including a target for the stock market, write the target for the nominal Federal funds rate as:

(3) $i_t^* = \pi_t + r^* + \alpha_1(\pi_t - \pi^*) + \alpha_2 y_t + \alpha_3(\rho_t - \rho^*)$

with the actual changes in the fed funds rate following:

(4) $\Delta i_t = \gamma_1(i_t^* - i_{t-1}) + \gamma_2 \Delta i_{t-1}$

where γ_1 measures the speed of adjustment of the actual fed funds rate to the target. Instantaneous adjustment would imply that γ_1 is infinite. Combining equation (3) and (4) results in:

$$\Delta i_t = \gamma_1\left[\pi_t + r^* + \alpha_1(\pi_t - \pi^*) + \alpha_2 y_t + \alpha_3(\rho_t - \rho^*) - i_{t-1}\right] + \gamma_2 \Delta i_{t-1}$$

Resulting in the regression equation:

(5) $\Delta i_t = c_1 + c_2 \Delta i_{t-1} + c_3\left[c_4 \pi_t + c_5 y_t + c_6 \rho_t - i_{t-1}\right]$

where:

$c_1 = \gamma_1\left[r^* - \alpha_1 \pi^* - \alpha_3 \rho^*\right]$

$c_2 = \gamma_2$

$c_3 = \gamma_1$ adjustment parameter

$c_4 = 1 + \alpha_1 > 1$ if monetary policy is stable.

$c_5 = \alpha_2$

$c_6 = \alpha_3$

Table 4 reports estimates of equation (5) for the two measures of excess demand and the two measures of stock market overvaluation. For these models the Q-statistics suggest that regression errors are serially uncorrelated.

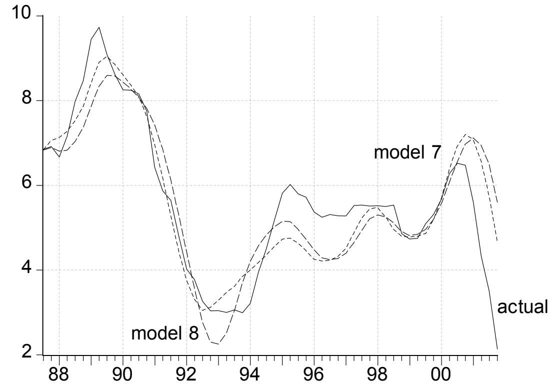
Table 5: Dynamic Taylor rules, OLS estimates
Dependent Variable: Δ Federal funds rate (mean =-0.08, standard deviation = 0.51)Sample: 1987:3 to 2001:4 (t-statistics in parenthesis)

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Constant: c_1	0.56 (3.14)	0.46 (2.51)	2.03 (5.68)	0.55 (2.86)	2.34 (5.85)	0.46 (2.28)
Δ Fedfunds$_{-1}$: c_2	0.63 (6.33)	0.72 (7.23)	0.35 (3.37)	0.62 (5.85)	0.39 (3.76)	0.72 (6.66)
Adjust. Param. c_3	0.23 (4.46)	0.22 (3.61)	0.29 (6.11)	0.24 (4.33)	0.33 (5.98)	0.22 (3.53)
Inflation: c_4	1.43 (6.68)	1.24 (5.08)	0.75 (3.27)	1.40 (4.52)	0.51 (2.37)	1.24 (3.54)
Measure of excess demand: c_5						
CBOGAP	0.78 (5.87)	-	0.90 (8.73)	0.78 (5.38)	-	-
UNEMGAP	-	1.37 (4.78)	-	-	1.71 (9.66)	1.36 (4.36)
Measure of stock market valuation: c_6						
P/E	-	-	-0.14 (-4.12)	-	-0.15 (-4.91)	-
PREMIUM	-	-	-	0.02 (0.10)	-	0.01 (0.02)
$\overline{R}^2$	0.60	0.55	0.71	0.59	0.69	0.54
DW	1.65	1.65	1.70	1.65	1.43	1.65
Q-statistic 4 lags (Prob)	7.23 (0.12)	5.67 (0.23)	2.33 (0.68)	7.11 (0.13)	5.48 (0.24)	5.65 (0.23)

Model 7 and Model 8 reported in columns 2 and 3 of Table 5 report the estimate of equation (5) using CBOGAP and UNEMGAP as alternative measures of excess demand without including a measure of stock market valuation..

The results for Model 7 are similar to the static Model 1 in terms of the size of the parameters on inflation and the CBOGAP. Using UNEMPGAP as the measure of excess demand results in a smaller response of the Federal funds rate to inflation although monetary policy is still stableFigure 4 shows the actual Federal funds rate and the predicted Federal funds rate from Model 7 and 8. The picture is very similar to that of figure 3 with the dynamic models, which assume the Fed adjusts the Federal funds rate gradually to the desired targeted value, predicting as one would expect, a smoother path for the Federal funds rate. Models 9 to 12 (columns 4 to 7 of Table 5) estimate equation (5) with the two alternative measures of excess demand and the two alternative measures of stock market overvaluation. For models 9 and 11 monetary policy is unstable (i.e. $c_4 < 1$). This result is a bit troublesome since there seems to be consensus in the literature that the Greenspan years have been characterized by stable monetary policy. Our regression results show that the use of UNEMGAP, which is probably a more accurate measure of the real time perception of excess demand (see Evans (1999)) rather than CBOGAP, reduces the responsiveness of the Federal funds rate to inflation. Adding measures of stock market valuation lowers the response even more. This might be the consequence of simultaneity bias. The response of the Federal funds rate to changes in CBOGAP and the UNEMGAP are of similar magnitude and expected sign as in the estimates of the static Taylor rules and suggests that the FOMC increases the Federal funds rate in respond to increases in excess aggregate demand. As with the static regressions, the coefficients on P/E are consistently negative and on PREMIUM consistently positive. The magnitude of the coefficient on P/E is 1.5 to 2 times larger than in the static regressions. The coefficients on PREMIUM are lower in the dynamic regressions compared with the static regressions and are essentially equal to zero.

Figure 4
Dynamic Taylor Rules: CBOGAP versus UNRATEGAP



Next we re-estimated equation (5) using current and past real GDP as instruments for the measures of stock market overvaluation to attempt to account for the possibility of the measures of overvaluation being endogenous in equation (5). The results are reported in Table 6. The estimated response of the Federal funds rate to inflation and measures of excess demand are the same for IV and OLS estimates.

In models 9 and 11, the estimated coefficients on P/E ratio are similar in sign and magnitude to the OLS results reported in Table 5. The coefficients are also statistically significant at standard levels and larger than the estimates in the static Taylor rule regressions. The IV coefficient estimates on PREMIUM are the same sign and larger but still statistically insignificant.

To summarize, the estimated dynamic regressions reported in Table 5 and 6 are consistent with the results of the static regressions reported in Table 3 and 4. Adding the P/E ratio as a measure of stock market valuation to either static or dynamic Taylor rule results in a negative correlation between the Federal funds rate and stock market overvaluation after controlling for inflation and measures of excess aggregate demand for all estimated equations except one. In fact, as Figure 5 shows, including the P/E ratio in the dynamic Taylor rule results in a slightly better fit of the actual Federal funds rate.

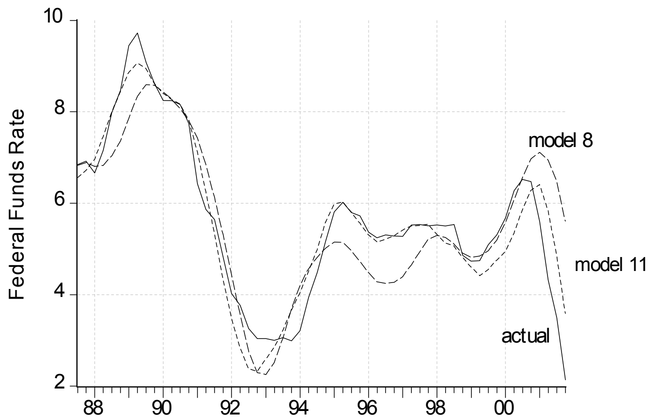
Table 6: Dynamic Taylor rules, IV estimation
Dependent Variable: ΔFederal funds rate (mean =-0.01, standard deviation = 0.45)
Sample: 1987:3 to 2001:4 (t-statistics in parenthesis)

	Model 9	Model 10	Model 11	Model 12
Constant: c_1	1.97 (3.97)	0.52 (2.35)	3.28 (4.04)	0.46 (1.92)
ΔFedfunds$_{-1}$: c_2	0.36 (2.94)	0.61 (5.01)	0.23 (1.40)	0.71 (5.71)
Adjust. Param. c_3	0.29 (5.90)	0.25 (4.17)	0.38 (5.43)	0.22 (3.41)
Inflation: c_4	0.78 (2.91)	1.31 (2.89)	0.29 (1.17)	1.22 (2.31)
Measure of excess demand: c_5				
CBOGAP	0.89 (8.47)	0.75 (4.63)	-	-
UNEMGAP		-	1.80 (10.23)	1.36 (3.67)
Measure of stock market valuation: c_6				
PE	-0.13 (-3.09)	-	-0.19 (-4.63)	-
PREMIUM	-	0.12 (0.30)	-	0.02 (0.03)
$\overline{R}^2$	0.71	0.63	0.66	0.54
DW	1.71	1.63	1.09	1.64
Q-statistic 4 lags (Prob)	2.33 (0.68)	6.66 (0.16)	13.17 (0.01)	5.61 (0.23)

Instruments: ΔFedfunds$_{-1}$, Fedfunds$_{-1}$, Inflation, CBOGAP (models 9 and 10) UNEMGAP (models 11 and 12) Growth rate of real GDP from year ago (lags 0 to 2) .

These results do not support the hypothesis that the Greenspan Fed has been systematically trying to deflate apparent speculative bubbles in the stock market. Rather a case can be made, as is done with the prima facie evidence presented in section 3 above, that the FOMC has, at least, accommodated the apparent stock market bubble in the mid and late 1990s.

Figure 5:
Dynamic Taylor Ruole
measure of excess demand = UNRATEGAP



9. VAR Specification

As a final approach to the question of whether monetary policy has been systematically influenced by valuation of the stock market, we estimate the following VAR model:

$$
(5)\qquad \begin{bmatrix} 1 & 0 & 0 & 0 \\ -a_{21} & 1 & 0 & 0 \\ -a_{31} & -a_{32} & 1 & 0 \\ -a_{41} & -a_{42} & -a_{43} & 1 \end{bmatrix} A(L) \begin{bmatrix} \pi_t \\ y_t \\ i_t \\ S_t \end{bmatrix} X_t = \begin{bmatrix} b_{11} & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 \\ 0 & 0 & b_{33} & 0 \\ 0 & 0 & 0 & b_{44} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{AS} \\ \varepsilon_t^{IS} \\ \varepsilon_t^{MP} \\ \varepsilon_t^{SM} \end{bmatrix}
$$

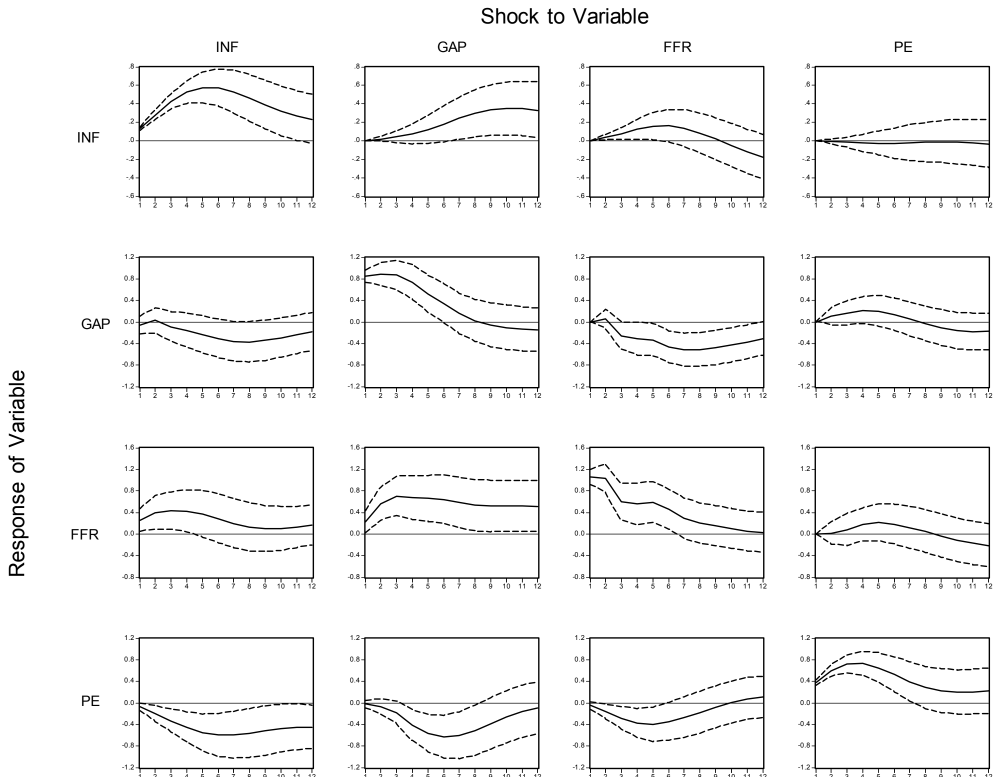
where the vector $[\pi_{,}, y_t, i_t, pe_t]'$, consists of inflation, a measure of the output gap, the Federal funds rate and the P/E ratio respectively. The $[\varepsilon_t^{AS}, \varepsilon_t^{AD}, \varepsilon_t^{MP}, \varepsilon_t^{SM}]'$ is a vector of structural disturbances which we interpret as shocks to the aggregate curve, the aggregate curve, monetary policy, and to the stock market respectively. A(L) is a matrix polynomial in the lag operator L. The recursive structure of equation (5) can be given the following structural interpretation. In the first equation, the only contemporaneous variables that inflation depends on are contemporaneous shocks to inflation. This can be interpreted as a horizontal aggregate supply curve in inflation-output gap space as in Taylor's (2001). The second equation can be interpreted as an aggregate demand curve that depends contemporaneously on inflation. This allows shocks to inflation to have contemporaneous effects on output. The third equation represents monetary policy with the Federal funds rate depending contemporaneously on inflation and the output gap. This is Taylor's rule for monetary policy and assumes that the stock market only influences monetary policy contemporaneously through the effects it has on the inflation and output gap. The fourth equation represents the stock market, where the P/E ratio depends on contemporaneous shocks to inflation, the output gap and the fed funds rate which is appealing since stock market participants presumably look at all available and relevant information when determining the appropriate price of stocks.

The VAR is estimated with the following data with four lags of each variable (i.e. A(L) is of order 4) and a constant in each equation. The data definitions are same as in section 7. To summarize the VAR results, Figure 7 shows the graphs of the impulse response functions for the Greenspan sample period 1987:3 to 2001:1. For comparison with the Greenspan period, Figure 6 gives the results for the sample period 1960:1 to 1987:2.

Discussion of the pre-Greenspan sample period 1960:1 to 1987:2:

Figure 6, row 1 shows the responses of inflation to shocks to inflation, output gap, Federal funds rate and the P/E ratio. Inflation responds positively to a gap shock. The inflation response to a federal funds shock shows what is called the "price puzzle" in the SVAR literature, namely that a positive shock to the Federal funds rates results in an increase in inflation.

Figure 6: Impluse Response Functions for Equation (5): Sample 1960:1 to 1987:2, Recursive indentification



This apparent anomalous result may the outcome of the fed increasing the Federal funds rate in anticipation of higher inflation. Shocks to the P/E ratio have little effect on inflation. Row 2 shows the response the output gap to shocks to inflation, fed funds rate and the P/E ratio. The results are consistent with economic theory. An inflation shock causes a decline in the output gap as does a shock to the Federal funds rate. The gap increases when there is a shock to the PE ratio, which is consistent with a wealth effect running from the stock market to consumption to output. Row 4 gives the responses of the PE ratio to shocks to inflation, gap and fed funds rate. Positive shocks to inflation result in a decline in the PE ratio. The same is true of gap shocks that are somewhat surprising. However perhaps a positive gap shock, given that it is temporary, increases current earnings more than stock prices. A positive shock to the Federal funds rate results in a decrease in the P/E ratio. In summary, from 1960 to 1987 the response of the P/E ratio to inflation gap and Federal funds rate shocks is consistent with what one would expect from economic theory.

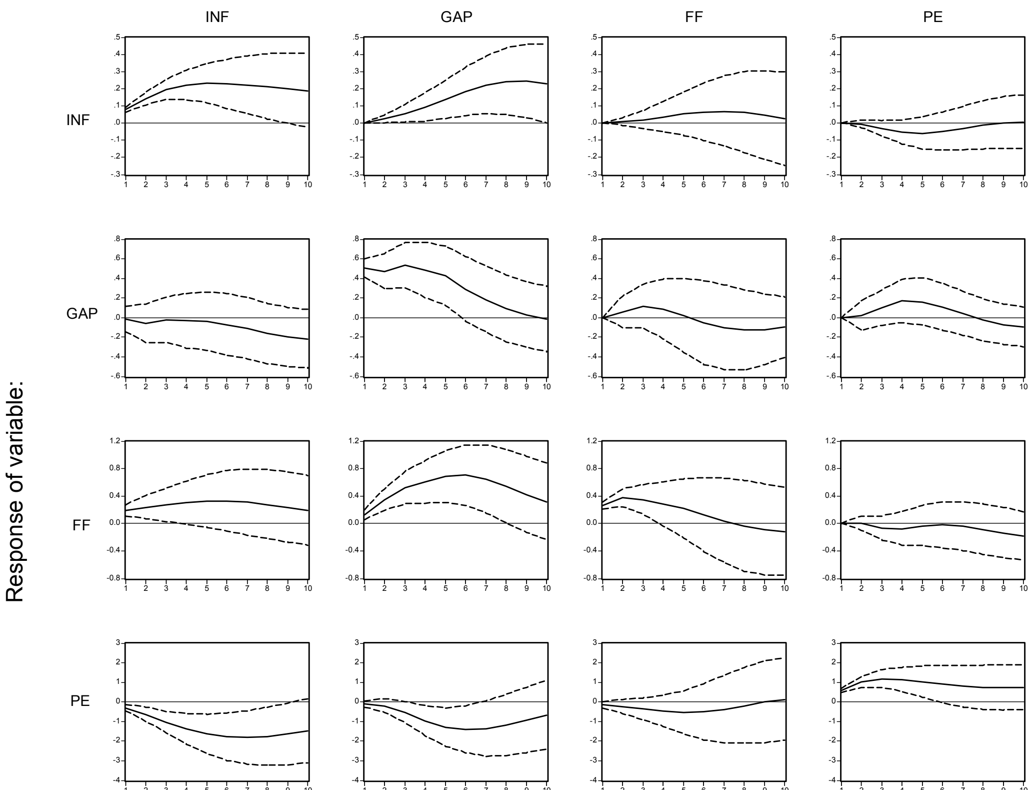
Row 3 shows that the Federal funds rate responds positively to inflation and gap shocks which is consistent with Taylor's monetary policy rule. The Federal funds rate also responds positively to shocks to the P/E ratio although the effects are insignificantly different from zero. These results suggest that in the sample period 1960 to 1987, monetary policy, as measured by the Federal funds rate was responding to positively inflation and output gap shocks and also positively to P/E shocks although the estimated effect is statistically insignificant.

Discussion of the Greenspan sample period 1987:3 to 2001:1:

Figure 7, row 1 shows that the response of inflation to a gap shock is similar to figure 6. However shocks to the fed funds rate now have little effect on inflation (so there is no price puzzle) and shocks to the P/E result in decreases in inflation. This is consistent with the 'new economy' interpretation that increases in the P/E ratio in the late 1990s corresponded to positive productivity shocks. Row 2, figure 7 shows that for the Greenspan sample period the output gap seems to be responding mainly to shocks to the output gap, with shocks to inflation, fed funds and P/E having little impact on the output gap. Row 4 gives the response of P/E to inflation and gap shocks is similar to the results presented in figure 6. In the 1987-2002 sample period, however, fed funds shocks have little effect on the P/E ratio. Row 3, figure 7 presents the responses of monetary policy to shocks. Both inflation and output gap shocks result in an increase in the fed funds rate.

Interestingly and in contrast to the figure 6, the fed funds rate responds negatively, but not statistically significant, to a positive shock to the P/E. This result suggests that monetary policy was not systematically responding to changes in stock market valuation and thus essentially tacitly accommodated the apparent stock bubble in the late 1990s.

Figure 7: Impluse Response funcstions for equation (5), Sample 1987:3 to 2001:4, Recursive Idenification
Shock to variable:



10. Conclusions

The review of the literature does not offer a conclusive answer of whether and how should the Fed respond to asset bubbles. In contrast to the inconclusiveness of the normative question "should monetary policy respond to stock market overvaluation?", the positive question "has monetary policy responded to stock market overvaluation?"

can be answered by examining the data. This paper examines empirically if monetary policy, under Greenspan, has been influenced by the high valuation of the stock market using different methodologies. The results suggest that rather than the Greenspan FOMC using the Federal funds rate policy to offset increases in the value of the stock market above estimates of fundamentals, federal funds policy has, perhaps inadvertently, on average, accommodated the apparent stock market overvaluation. Chairman Greenspan's 'jaw boning' of the stock market in the late 1990s, may have been an attempt to find another policy instrument to influence the stock market in the direction of estimates of fundamentals. The evidence from the FOMC minutes, consistent with Taylor's rule, suggests the Federal funds rate target has largely been set in response to inflation and measures of excess demand and, at least, has not been *increased solely* to offset a potential stock market overvaluation. The augmented Taylor rule indicates that the Fed funds rates might have been slightly higher had the Fed completely ignored the overvaluation of the market as measured by the S&P500 Index. This evidence suggests that the Fed has not taken the risk to increase fed funds aggressively in order to reduce speculation, at least during the 1995-1999 period, being aware of the potential overreaction of the stock market. The data suggest that the Greenspan Fed has had no intentions, beyond the rhetoric of "irrational exuberance" to actually orchestrate a rapid correction of the stock market's overvaluation because of the destabilizing effects of declining asset prices on the economy.

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