

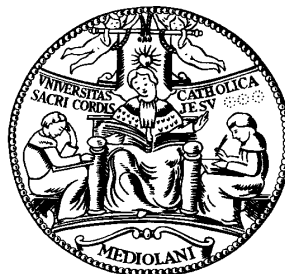
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Zeno Rotondi (*) Giacomo Vaciago (**)

(*) Capitalia, Area Studi, 00187 Roma, e-mail: zeno.rotondi@capitalia.it

(**) Direttore dell'Istituto di Economia e Finanza, Università Cattolica del Sacro Cuore,
Via Necchi 5 – 20123 Milano, e-mail: giacomo.vaciago@unicatt.it

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Istituto di Economia e Finanza
Università Cattolica del S. Cuore
Via Necchi, 5
20123 Milano
tel.: 0039.02.7234.2976
fax: 0039.02.7234.2781
e-mail: ist.ef@unicatt.it

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Abstract

The Reaction of central banks to Stock Markets

Should central banks react to stock market prices? This problem has become fashionable again after the bubble of the 1990s. After examining the theoretical implications of the inclusion of stock prices in the central bank's interest rate rule, we present a new set of estimates showing that the Fed reacted to stock market prices in the period 1988-2000. In particular, we find a significant lagged response for both real-time data and ex post revised data. We discuss also the implications of our findings for the ECB. The ECB appears less convinced on this approach and rightly so: European exchanges follow the leadership of Wall Street.

JEL classification: D84, E44, E52, E58, G12.

Keywords: Central Bank, Interest Rate Rule, Monetary Policy, Stock Market Prices, Irrational Exuberance, Stock Market Bubble, Federal Reserve, Greenspan, European Central Bank.

1. Introduction¹

In the present analysis we try to measure the reaction of central banks to stock price movements. In examining this issue we will restrict our attention to the behaviour of the Federal Reserve during the 1990s, for it represents a prominent case study in this field of research. In fact, during the second half of the 1990s the US central bank has faced stock prices that have been bid up to unusually high levels. In March 2000 the major bull market in equities in the United States was followed by a decline in stock values that destroyed trillions of dollars in wealth and contributed to deepening the recession that began in March 2001.²

After this experience an important debate started on the issue of whether, by precluding any attempt to guide the course of asset prices, the Fed has accommodated the overvaluation in the 1990s. This issue implies the following question: if the Fed had reacted earlier to contain the sharp growth in stock prices, in order to “prick the bubble” at an early stage, might macroeconomic stabilization have been achieved?

In order to evaluate the policy implications of that asset price bubble we need to first understand clearly what has been the reaction of the Fed to stock market movements. The measurement of this type of reaction is not an easy task. The main reason is the existence of a simultaneous response of stock prices to interest rate changes, which introduces an endogeneity problem in the estimation of the policy reaction.

For all the above reasons we will focus on the period 1988:Q1 – 2000:Q1, during which Mr Greenspan was chairman of the Federal Reserve.³ He was definitely the first to use the famous term “irrational exuberance” to express the concern that the unusually high and unsustainable levels reached by stock prices were driven by market psychology.⁴

¹ We wish to thank Ron Smith for helpful discussions, Brian Sack and Robert Shiller for having kindly provided part of the data used in the present analysis. The usual disclaimer applies.

² According to the National Bureau of Economic Research.

³ He originally took office as Chairman in August 11, 1987, and still holds this position.

⁴ The speech on “irrational exuberance” was made by Greenspan on December 5, 1996. Two days after John Campbell and Robert Shiller made a presentation at the Fed, in which they used several measures to argue that the stock market was overvalued. Their presentation was later published in Campbell and Shiller (1998).

In the present analysis we follow the econometric approach of Bernanke and Gertler (1999), but in order to eliminate the simultaneity bias, we include in the interest rate rule only the one-quarter lag of stock market returns.

We consider the Wilshire 5000 index, instead of the Standard & Poor's 500 or the Dow-Jones, which is a broader stock index. This broader stock market index seems more appropriate for taking into account the pass-through of stock market shocks to aggregate demand in the monetary policy rule. Moreover, we include also a new variable, not considered in the previous literature, intended to capture the importance of the relationship between the stock market and the bond market for monetary policy decisions. Finally, another innovation is that we use both ex post revised data and real-time data in order to check for the robustness of our estimates and specifications of the policy rule.

Our main findings show that, contrary to Bernanke and Gertler's empirical analysis, there exists a significant response of monetary policy to the stock market and that this response is lagged. The results based on ex post revised data suggest that an increase – *ceteris paribus* – in the quarterly average of the Wilshire 5000 index by 5% increases the quarterly average of the federal funds rate in the next quarter by about 8 basis points. While the results based on real-time data suggest a slightly greater impact, of about 11 basis points.

The result that the response to stock market volatility is lagged is not surprising given the complexity of disentangling the presence of bubbles from swings in assessments of the underlying fundamentals during booms and busts in stock prices. Indeed, this complexity calls for caution and gradualism in the adjustment of the monetary instrument.

The order of magnitude of the lagged response to an increase in stock prices is close to that found by Sack and Rigobon (2003) by using an alternative econometric approach. In particular, they get a monetary policy response of about 14 basis points. By means of rough calculations, Sack and Rigobon argue that the estimated policy response is approximately of the dimension needed to offset the expected pass-through effect of stock market shocks to aggregate demand.

Finally, in the last part of the present work we discuss the implications of our findings on the Fed for the ECB and the euro-zone stock market. In particular, we examine whether the relevance of the stock market for the conduct of monetary policy is becoming greater and, consequently, if we could

expect in the near future a greater attention and emphasis posed by the ECB on stock market movements.

2. Monetary policy and asset price volatility

The link between monetary policy and asset price movements has been of perennial interest to policy makers and academic researchers. The literature tends to focus on three main areas of interest: inflation measurement; inflation forecasting; macroeconomic stabilization.⁵ The first area is related to the issue of whether the monetary authorities should be concerned about asset prices in order to construct broader price indexes (Alchian and Klein (1973)). According to this view, price indexes such as the CPI or the GDP deflator are partial measure of the cost of living, as they lack any information about changes in the prices of goods that will be consumed in the future and not just today. A typical example is an increase in the price of houses, which leaves the CPI unaffected. The second area of interest focuses on the issue whether asset prices may play an important role in forecasting inflation.⁶ However, the empirical evidence on this issue is mixed. For instance, according to Stock and Watson (1999), (2001) some asset prices – e.g. stock prices and exchange rates – seem to have predictive power in forecasting inflation, but it is lower than that associated with measures of real economic activity. Moreover, good forecasting performance by one asset price seems to be unrelated to whether it is a useful predictor in a subsequent period.

The third area of research focuses on the view that asset prices may affect real activity. The channels of the transmission mechanism from asset prices to economic activity are mainly three: households' wealth effect on consumption expenditure (Modigliani (1971)); Tobin's Q effect on investment (Tobin (1969)); financial accelerator effect on investment (Bernanke and Gertler (1989)).

⁵ For a review of the literature see for instance Cecchetti, Genberg, Lipsky and Wadhvani (2000) and Gilchrist and Leahy (2002). In our review we do not discuss the line of research that focuses on the impact of monetary policy on asset prices. For the purposes of the present paper it is not needed. A recent review of this issue is provided for example by Rigobon and Sack (2002) and Bernanke and Kuttner (2003).

⁶ See Goodhart and Hufmann (2000) for a recent work that supports the view that movements in asset prices are useful in forecasting inflation.

These three channels are undoubtedly important in affecting both output and inflation, but it is less clear whether they provide a strong argument for basing monetary policy on asset price movements. In fact, it has been argued that the gain of including asset prices in monetary policy rules in practice adds little to stabilizing output and inflation.⁷ This is due to the fact that asset channels are similar to aggregate demand channels, as they tend to increase both output and inflation. Thus inflation targeting yields most of the gains of adopting asset price targeting without the drawbacks of the appearance of interfering in the working of financial markets.

On the other hand, asset prices seem to display exogenous movements unrelated to the underlying state variables. There exist several historical examples that show that extreme movements in asset prices have coincided with prolonged macroeconomic instability.⁸ This raises the question of what can central banks do in order to minimize the likelihood of asset price misalignments. However, even if one accepts the role of asset prices in the propagation of shocks, asset price misalignments are difficult to detect. The problem is that asset prices are too volatile and too unrelated to real activity, as argued for instance by Gertler, Goodfriend, Issing and Spaventa (1998).

The above concern about the ability to detect asset price misalignments by central banks calls for caution and does not imply that we should ignore them. As Cecchetti, Genberg, Lipsky and Wadhwani (2000) observe, the difficulties associated with measuring asset price misalignments are not substantially different from those related to potential GDP or the equilibrium real interest rate. Actually Borio and Lowe (2002) argue that what really matters for monetary policy is not to respond to asset price bubbles *per se*, but rather to reduce the risk of financial distress resulting from the occurrence of financial imbalances. In particular, they show that identifying *ex ante* financial imbalances is difficult but not impossible. By using data from 34 countries they obtained empirical evidence showing that the simultaneous surge in both credit and asset prices provides a relatively reliable warning of financial imbalances ahead.

Moreover, by using the theoretical framework of Bernanke and Gertler (1999), Cecchetti, Genberg, Lipsky and Wadhwani (2000) show that reacting to asset price movements in the “normal” course

⁷ In the literature this point has been particularly stressed by Bernanke and Gertler (1999),(2001) and Gilchrist and Leahy (2002).

⁸ See Cecchetti, Genberg, Lipsky and Wadhwani (2000) for an analysis of the major economic episodes of asset price misalignments.

of monetary policy may reduce the likelihood of bubbles forming or getting out of hand. However, this finding has been questioned. Mishkin (2001, p. 20), for instance, observes that: [they] “*find favorable results in their simulations when the central bank conducts policy to prick asset price bubbles because they assume that the central bank knows the bubble is in progress. This assumption is highly dubious because it is hard to believe that the central bank has this kind of informational advantage over private markets. Indeed, the view that government officials know better than the markets has been proved wrong time and time again*”.⁹

Bernanke (2002) argues that this “leaning-against-the-bubble” strategy, as advocated by Cecchetti, Genberg, Lipsky and Wadwhani among others, implies taking out a little insurance against the formation of an asset-price bubble. However, for the insurance argument to be effective against perceived bubbles, a small increase in the interest rate should imply a corresponding smooth reduction in the likelihood or size of a bubble. Unfortunately the existing empirical and theoretical evidence does not support such a smooth link. He concludes (Bernanke (2002), p. 6): “*All we can conclude with much confidence is that the rate hike will tend to weaken the macroeconomic fundamentals through the usual channels, while the asset bubble, if there is one, may well proceed unchecked*”. This observation has led Bernanke and Gertler among others to support the view that monetary policy should react to asset price movements only to the extent that these affect expected inflation.

3. The inclusion of stock prices in monetary policy rules

3.1 Theoretical framework

In this section we develop a framework for examining the case when stock prices are included in the central bank’s interest rate rule. The model considered is that of Rotemberg and Woodford (1998), (1999) while the analysis developed draws on Clarida, Gali and Gertler (1998), (2000).

⁹ Bernanke and Gertler (2001) also observe that the findings of Cecchetti, Genberg, Lipsky and Wadwhani (2000) are based on the implausible assumption that the policy maker knows with certainty when the exogenous bubble is going to burst.

The supply function is given by a New Keynesian Phillips curve that relates inflation positively to the output gap:

$$\pi_t = \delta E_t \pi_{t+1} + \lambda y_t, \quad (1)$$

where δ is the discount factor considered in the discounted sum of utilities of a representative household, with $0 < \delta < 1$.

We have also an IS equation which relates inversely the output gap to the real interest rate:

$$y_t = -\frac{1}{\sigma} (r_t - \bar{r} - E_t \pi_{t+1}), \quad (2)$$

where σ is the coefficient of relative risk aversion and the nominal short-term interest rate r_t is expressed as a deviation from its trend value \bar{r} .

Monetary policy is formulated in terms of a feedback rule for setting the nominal short-term interest rate of the following form:

$$r_t - \bar{r} = \rho (r_{t-1} - \bar{r}) + (1 - \rho) r_t^*, \quad (3)$$

with $0 < \rho < 1$ and

$$r_t^* = \alpha E_t \pi_{t+1} + \chi y_t + \theta \left[\gamma (\log p_t^S - \log \bar{p}^S) + (1 - \gamma) (\log p_{t-1}^S - \log \bar{p}^S) \right] \quad (4)$$

where p_t^S is the price of a share of aggregate equity and \bar{p}^S is its long-run equilibrium level. According to expression (4), the central bank is concerned about large deviations of both current

and lagged stock prices from the long-run equilibrium level.¹⁰ In the expression (3) the coefficient ρ measures the degree of inertia in the central bank's response to inflation and output.

Now Clarida, Galí and Gertler (1998), (2000) have found that, in the case of $\theta=0$, $\alpha>1$ is required for stability in economies with monetary rules similar to those of (3). In particular, they show that values of $\alpha<1$ may lead to indeterminacy of equilibrium with self-fulfilling (sunspot) fluctuations in output and inflation. Let's see what happens in the case when $\theta>0$, i.e. when stock prices are included in the policy rule.

In the Rotemberg-Woodford framework, under the assumption of absence of arbitrage opportunities and complete financial markets, a financial claim to a random nominal quantity X_T has a nominal value at t of:

$$V(X_{t,T}) = E_t[\beta_{t,T}X_T], \quad (5)$$

where $\beta_{t,t+1}$ is the stochastic discount factor for pricing arbitrary (non-monetary) financial claims.¹¹ Thus, in the case of a riskless one-period bond purchased in period t , the gross nominal interest rate must satisfy:

$$R_t = E_t[\beta_{t,t+1}]^{-1}. \quad (6)$$

From the above equations follows that the logarithm of the price of a share of aggregate equity will be equal to:

$$p_t^S = \frac{1}{R_t}. \quad (7)$$

¹⁰ Our formalization of the interest rate rule is a combination of those presented in the theoretical literature. For example, Bernanke and Gertler (1999) and Cecchetti, Genberg, Lipsky and Wadwhani (2000) consider an interest rate rule with lagged stock prices, while Bullard and Schaling (2002) examine the case with current stock prices.

¹¹ The pricing relation (5) applies, of course, only to financial assets that (unlike money) do not yield additional non-pecuniary benefits. Under the assumption of complete markets the stochastic discount factor is uniquely defined.

Now by taking the logarithm of (7) and rearranging it we get:

$$\log R_t = -\log p_t^s. \quad (8)$$

Moreover Rotemberg and Woodford define the (instantaneous) short-term nominal interest rate as:

$$r_t \equiv \log R_t. \quad (9)$$

By using (8) and (9) and rearranging them, expressions (3) and (4) become

$$r_t - \bar{r} = \rho'(r_{t-1} - \bar{r}) + (1 - \rho)r_t^*, \quad (10)$$

$$r_t^* = \alpha' E_t \pi_{t+1} + \chi' y_t; \quad (11)$$

with

$$\begin{aligned} \rho' &= \frac{\rho - (1 - \rho)\theta(1 - \gamma)}{1 + (1 - \rho)\theta\gamma}; \\ \alpha' &= \frac{\alpha}{1 + (1 - \rho)\theta\gamma}; \\ \chi' &= \frac{\chi}{1 + (1 - \rho)\theta\gamma}. \end{aligned} \quad (12)$$

Now we are ready to examine the case when $\theta > 0$. With the help of expressions (10), (11) and (12) we can prove the following propositions:

Proposition 1 (*Macroeconomic Instability*): *it is possible to have indeterminacy of equilibrium when $\alpha > 1$ and $\theta > 0$, if*

$$\theta > \frac{\alpha - 1}{(1 - \rho)\gamma}. \quad (13)$$

PROOF. This result follows from imposing on (12) the restriction of $\alpha' < 1$.

Proposition 2 (*Monetary Inertia*): *there is a relatively lower degree of monetary inertia when $\theta > 0$.*

PROOF. The result follows from imposing on (12) the restriction of $\rho' < \rho$ and by observing that it is always satisfied for the given assumptions on the parameters.

Propositions 1 and 2 show that the inclusion of stock prices in the policy rule may have important policy implications. On the one hand, if the reaction of monetary policy to stock prices movements is too vigorous it may imply macroeconomic instability, with the risk of leading to an unstable process for inflation and output. On the other hand, the inclusion of stock prices in the central bank's policy should imply a lower degree of partial adjustment to the previous period interest rate, i.e. a lower degree of monetary inertia.

3.2 Previous empirical evidence on the Fed

According to the empirical evidence deriving from the dominant literature on interest rate rules, which uses Generalized Method of Moments (GMM) estimates with a defined set of lagged instruments, the Federal Reserve does not react to changes in stock market prices when adjusting its instrument. In particular, Bernanke and Gertler (1999) estimate a forward-looking policy rule where the federal funds rate reacts to expected inflation and output gap as well as to the current and lagged change in stock prices.¹² The stock market index used in their empirical analysis is the Dow-Jones. They find an insignificant reaction of monetary policy to stock market volatility. A possible interpretation of this finding could be related to the forward-looking nature of the policy rule, as the information content of stock prices movements could already be included into the forecasts of

¹² They consider monthly data and report the p -value for the hypothesis that the sum of the six coefficients of the lags 0-5 of the log-differenced change in stock prices is equal to zero.

output and inflation. Thus, Bernanke and Gertler provide an indirect confirmation of the intuition that the gain of including asset prices in monetary policy rules in practice adds little to stabilizing output and inflation.

However, Sack and Rigobon (2001) argue that Bernanke and Gertler's results may be affected by the presence of a simultaneity bias due to the endogenous reaction of stock market prices to the interest rate. In figure 1 it is possible to compare the six-month rolling correlation between daily changes in the three-month T-Bill and daily log-differenced percentage changes in the Wilshire 5000 index, with the six-month rolling standard deviation of the Wilshire 5000 index.¹³ As it is possible to observe from the figure the correlation is typically negative, due to the negative endogenous reaction of stock prices to the interest rate. It is also interesting to notice that during periods in which the volatility of stock markets is high, the correlation often becomes positive. This suggests that shifts in the volatility of shocks do affect the correlation between interest rates and stock prices. Thus, if we run a regression between changes in interest rates and stock prices without taking into account these shifts in the variance of the shocks, it is not surprising we get disturbances that do not allow to identify the slope of the policy reaction function of monetary policy. This fact is depicted in figure 2.

In order to solve the endogeneity problem, Sack and Rigobon propose an approach for estimating the reaction of monetary policy to the stock market based on the heteroskedasticity found in interest rates and stock market returns. Following this approach they find that the Federal Reserve does in fact react to changes in stock market valuations when adjusting the federal funds rate. In particular they estimate that an increase in the S&P 500 index by 5% increases the federal funds rate expected for the next FOMC meeting by about 14 basis points. Moreover, they argue that this finding is consistent with the view that the central bank reacts to stock prices volatility only to the extent warranted by its impact on the macroeconomy.¹⁴

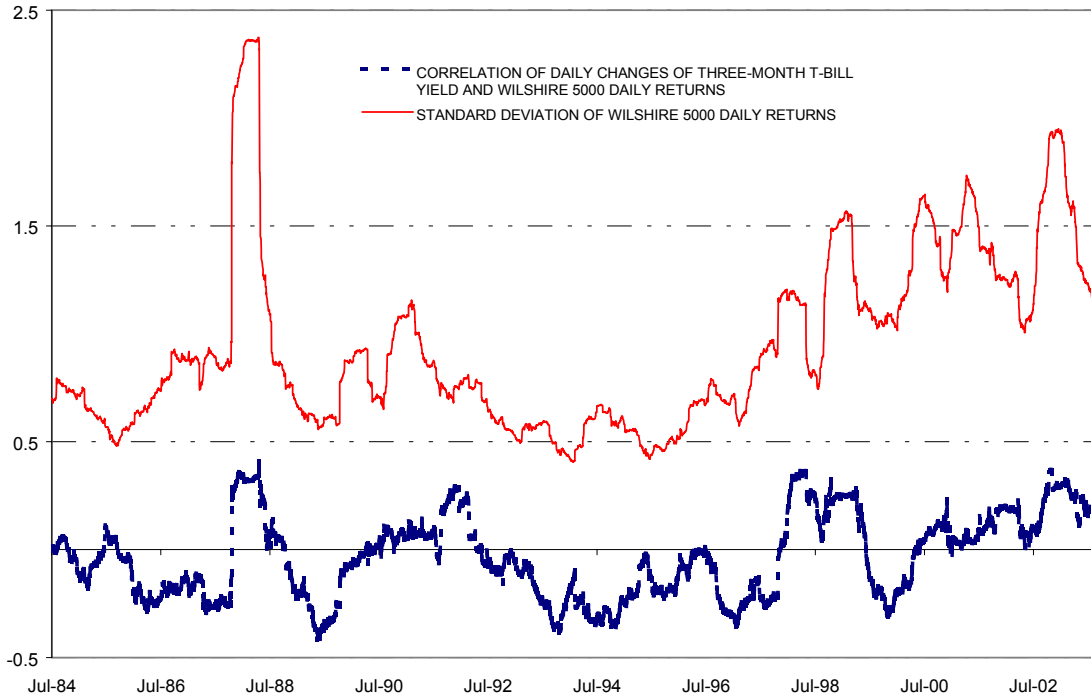
D'Amico and Farka (2003) have confirmed the findings of Sack and Rigobon, by using an identification scheme which uses weaker assumptions to address the endogeneity problem.

¹³ The source of the data is the following: for the three-month T-Bill is FRED II, of the Federal Reserve Bank of St. Louis; for the Wilshire 5000 index is DataStream – Thomson Financial.

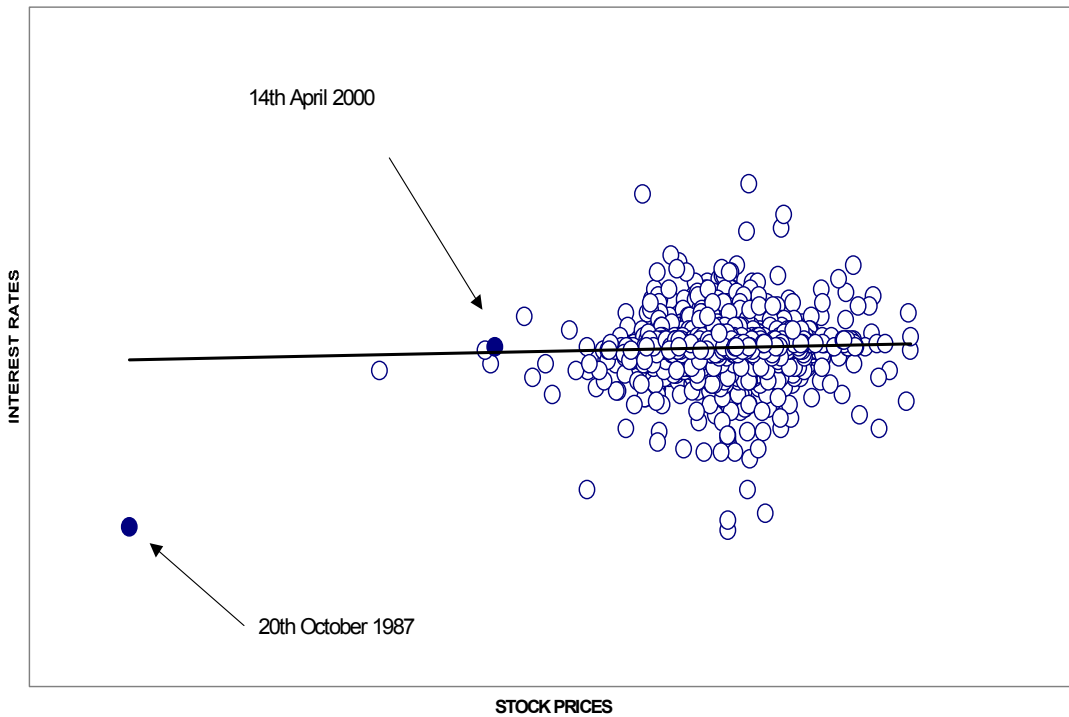
¹⁴ Simple calculations made by Sack and Rigobon suggest that the estimated policy response is approximately of the dimension needed to offset the expected pass-through of stock market shocks to aggregate demand.

Another important issue relative to the reaction of monetary policy to the stock market is whether the Fed has contributed to the stock market overvaluation. Miller, Weller and Zhang (2001) show that one-sided intervention policy by the Fed may lead investors into wrongly believing that they are insured against downside risk in the stock market. According to this view of a “Greenspan put” the bubble involves, like in Shiller (2000), market psychology, but its origin is more related to an exaggerated faith in the stabilizing power of Mr Greenspan rather than to “irrational exuberance”. Hayford and Malliaris (2001) and Valckx (2003) have provided empirical evidence that supports the view that the Fed had accommodated the overvaluation of the 1990s. They obtain this finding by inserting deviations of price earnings ratio and price dividend ratio from fundamental values in a backward-looking interest rate rule.

**Figure 1 - Comovements in equity prices and interest rates
(six-month rolling correlations and standard deviations)**



**Figure 2 - Joint determination of interest rates and stock prices
(July 1984 - September 2003)**



4. New empirical evidence

4.1 Data description

We extend the extant empirical literature in several directions. We use instead of the Standard & Poor's 500 or the Dow-Jones the Wilshire 5000 index, which is a broader stock index. This broader stock market index seems more appropriate for taking into account the pass-through of stock market shocks to aggregate demand in the monetary policy rule.

We include also a new variable, not considered in the previous empirical analyses, intended to capture the importance of the relationship between the stock market and the bond market for monetary policy decisions. The most widespread version of this relationship is commonly referred to as the "Fed model", by the non-academic investing community.¹⁵ This model, so named for allegedly being found in the Monetary Policy Report to the Congress, has never received any official endorsement. Nevertheless it has become a very popular yardstick for judging whether the U.S. stock market is fairly valued. According to this model, by comparing the stock market's earnings yield (the earnings yield or E/P is the inverse of the well known price-to-earnings ratio or P/E) with current nominal interest rates it is possible to make an assessment on stock prices. The comparison is usually made by using the ten-year Treasuries yield and, in its simplest form, asserts that stocks are undervalued when E/P exceeds the long-term yield, overvalued when E/P is lower than the long-term yield, and fairly valued when the two are equal.

There is a broad consensus among practitioners that the comparison underlying the alleged "Fed model" is valid. The main argument used for supporting this relationship is based on the well-known Gordon's dividend discount model, which expresses the expected nominal return on an individual stock as the dividend yield plus the expected growth of dividends. In particular, if the current price of stock is the discounted present value of future cash flows to investors from the company, then it is possible to argue that when interest rates decrease the present value today of future cash flows rises as well as the fair price-to-earnings ratio.

It is possible to argue that this line of reasoning is flawed as it is based on the restrictive assumption that when interest rates fall all else remains equal, and in particular that expected cash flows remain

¹⁵ See for example Yardeni (2003).

the same. Actually, if nominal interest rates fall as a consequence of lower inflation expectations, then future nominal cash flows from equities also fall. And the latter effect may offset the effect of a rising discount factor.

Nevertheless, the Federal Reserve seems to take into account the evolution of this spread in their assessment of stock market movements. Evidence of this behavior by the Fed is provided, for instance, by the following excerpt from the Fed's July 1997 Monetary Policy Report to the Congress: *"The run-up in the stock prices in the spring was bolstered by unexpectedly strong corporate profits for the first quarter. Still, the ratio of prices in the S&P 500 to consensus estimates of earnings over the coming twelve months has risen further from levels that were already unusually high. Changes in this ratio have often been inversely related to changes in long term Treasury yields, but this year's stock price gains were not matched by a significant net decline in interest rates. As a result, the yield on ten-year Treasury notes now exceeds the ratio of twelve-month-ahead earning to prices by the largest amount since 1991, when earnings were depressed by the economic slowdown. One important factor behind the increase in stock prices this year appears to be a further rise in analysts' reported expectations of earnings growth over the next three to five years. The average of these expectations has risen fairly steadily since the steep recession of the early 1995 and currently stands at a level not seen since the steep recession of the early 1980s, when earnings were expected to bounce back from levels that were quite low."*

Hence it is of some interest to evaluate the information content of the spread $(E/P-r^{10y})_t$ for monetary policy decisions. Following the widespread practice of the investment community and for simplicity, the spread $(E/P-r^{10y})_t$ will be termed by us the "Fed model" spread. As discussed above, this does not mean that we believe that it is a valid stock valuation model. The earnings-to-price ratio used in the present analysis is taken from Shiller (2000), while the ten-year Treasury yields are taken from FRED II, of the Federal Reserve Bank of St. Louis.¹⁶

In our empirical analysis we follow the econometric approach of Bernanke and Gertler, but we include in the interest rate rule only the one-quarter lag of the log-differenced percentage change in stock prices. This choice rules out by definition the simultaneity bias. Moreover, we use both ex

¹⁶ The data used in Shiller (2000) is updated in <http://www.econ.yale.edu/~shiller/data.htm>. We thank Robert Shiller for the kind permission to use his data.

post revised data and real-time data in order to check for the robustness of our estimates and specifications of the policy rule. As argued in Orphanides (2001, p. 964) “*often, however, the analysis underlying these policy rules is based on unrealistic assumptions about timeliness of data availability and ignores the difficulties associated with the accuracy of initial data and subsequent revisions*”. The quarterly data for output gap, inflation and the fed funds interest rate used here are the same data used by English, Nelson and Sack (2002), (2003).¹⁷

4.2 Measuring the response to stock market movements

First we have estimated by means of GMM, for the period from 1988:1 to 2000:1, the following baseline interest rate rule without stock prices:

$$r_t = c_1 r_{t-1} + (1 - c_1 - c_5) \cdot [c_2 + c_3 E_t \pi_{t+1} + c_4 E_t y_t] + c_5 r_{t-2}. \quad (14)$$

The specification used is the same as that of Clarida, Galí and Gertler (1999) for the case of the Federal Reserve. The second-order partial adjustment mechanism modeled in the specification is intended to capture the degree of monetary inertia by the Fed. Recently Rudebusch (2002), by focusing on the apparent contradiction between interest-rate smoothing and low predictability of policy rates, has asserted that policy inertia is an illusion. In particular he argues that the lagged interest rate may not enter the actual policy rule at all, as the empirical evidence on interest-rate smoothing might be related rather to the presence of serially correlated errors in the Fed's policy rule.¹⁸

We have used a correction for heteroskedasticity and autocorrelation of unknown form with a Newey-West fixed bandwidth, and chosen Bartlett weights to ensure positive definiteness of the

¹⁷ We thank Brian Sack for having kindly provided all the data. The sample period of the ex post revised data is 1987:1 – 2001:4, while that of the real-time data is 1987:1 – 1995:4.

¹⁸ This issue is quite controversial. See also English, Nelson and Sack (2003) and Söderlind, Söderström, and Vredin (2003) for further analyses on the issue of the potential illusion of monetary policy inertia.

estimated variance-covariance matrix.¹⁹ The instrument set includes four lags of output gap, inflation and the fed funds rate.²⁰

As a second step we have estimated the following reaction function, including the one-quarter lagged log-differenced percentage change of stock prices:

$$r_t = c_1 r_{t-1} + (1 - c_1 - c_5) \cdot [c_2 + c_3 E_t \pi_{t+1} + c_4 E_t y_t + c_6 \Delta \log p_{t-1}^s] + c_5 r_{t-2}. \quad (15)$$

Here, the instrument set used for the GMM estimation includes one lag of the “Fed model” spread, four lags of output gap, inflation, the fed funds rate, the log-differenced percentage change of the Wilshire 5000 index, and the annual growth rate of the Nasdaq and the Standard & Poor’s indexes. In table 1 are reported the estimated coefficients with the associated robust standard errors for specifications (14) and (15), for both ex post revised data and real-time data. For the case of real-time data we have reported in table 1 Nonlinear Least Squares (NLS) estimates of the specified policy rule.

As it is possible to observe, contrary to Bernanke and Gertler, we obtain a highly significant estimated lagged response of the fed funds rate to stock returns, with the correct sign if we think of the Fed as being tempted to try to stabilize stock prices. For the case of ex post revised data our findings suggest that an increase (decrease) – *ceteris paribus* – in the quarterly average of the Wilshire 5000 index by 5% increases (decreases) the quarterly average of the federal funds rate in the next quarter by about 8 basis points. In the case of real-time data we get a slightly greater response: 11 basis points. In both cases the order of magnitude of this lagged response is of similar dimension to that found by Sack and Rigobon (2001), as they get a monetary policy response of about 14 basis points.

Table 1 – GMM and NLS estimation of postulated policy rules

¹⁹ The optimal weighting matrix is obtained from first-step Two-Stage Least Squares (2SLS) parameter estimates.

	Ex post revised data	Real-time data	Ex post revised data	Real-time data
c_1	1.34 (0.06)	1.00 (0.15)	1.40 (0.03)	0.99 (0.12)
c_2	3.08 (0.77)	1.98 (0.72)	2.76 (0.27)	1.29 (0.53)
c_3	1.16 (0.30)	1.08 (0.26)	1.15 (0.10)	1.28 (0.18)
c_4	0.75 (0.14)	0.66 (0.10)	0.68 (0.05)	0.60 (0.09)
c_5	-0.51 (0.07)	-0.33 (0.13)	-0.58 (0.03)	-0.37 (0.09)
c_6			0.09 (0.01)	0.06 (0.02)
Adj. R-Squared	0.97	0.98	0.97	0.99
S.D. dep.var.	1.79	2.19	1.79	2.19
S.E. regress.	0.32	0.30	0.31	0.27
J-Statistic	4.21		10.63	

Notes: robust standard errors in parentheses.

It is interesting to observe that in the GMM estimation the test for the validity of the instruments does not reject the null hypothesis also when the one-quarter lagged “Fed model” spread is included in the set of instruments. As discussed for example in Favero (2001), within the GMM framework it is easy to check the importance of omitted variable in the policy rule, as in such case the orthogonality condition should be violated and the J-statistic should reject the null of validity of instruments. According to our empirical evidence the “Fed model” spread affects the central bank’s behavior, being probably used in the assessment of stock market movements, but not as an independent argument of the monetary policy rule.

5. Implications for the Euro-zone

²⁰ The J-statistic reported in the tables is the statistic for the validity of instruments and is distributed as χ^2 .

In its first few years of existence the new ECB has already had the time to study both the Euro-zone transmission mechanism of monetary policy and the appropriate framework for the central bank's reaction to a list of variables that can help to define expected inflation. The role of the stock market is obviously acknowledged, although among many other variables (in the so called "second pillar"), and with the clear recognition that the stock market is less important in the European context (compared to the US) both in terms of consumers' financial wealth and the financing of corporate investment.

After the bubble and in line with the literature on the Fed that we have already examined, the ECB has also reconsidered the topic, with the following results.²¹

First, it is stressed that the *stock market* is also becoming more important in the Euro-zone, although the tradition in Europe was for a more central role of the *banking system* (both for its deposits in the households' wealth and for its loans in financing the corporate sector).

Second, the existence of a two-way relationship between the stock market and monetary policy is duly acknowledged. Stock prices are influenced by monetary policy in three ways: through expected inflation, through changes in interest rates and through changes in expected real growth. On the other hand, the central bank will be advised to consider the trend of stock prices both in order to appreciate the market expectations on growth and inflation and to measure the asset prices impact on the economy.

But stock markets are not and should not be judged - this is the ECB's explicit view - an appropriate target variable for monetary policy, neither in exceptional cases, since "bubbles" cannot be easily detected, nor in normal times; for several reasons. The ECB argues that monetary policy "influences" stock prices but does not "control" them, neither in the long nor in the short term. Besides, it is highly unlikely that the central bank could know, better than the market itself, what the equilibrium market price should be. Finally, the usual *moral hazard* argument is raised: if the central bank interest for the stock market were intended as a kind of guarantee for investors' protection, then the propensity to assume risks would dangerously increase.

²¹ See Cassola and Marana (2002) and ECB (2002).

Given all this, and notwithstanding so many doubts, the ECB stresses the role for the stock market as an “indicator”, among other variables, both to define the expected trends of the economy (*second pillar*) and to interpret the real meaning of monetary aggregates (*first pillar*).

While we agree with most of this analysis, we think that three other factors should also be remembered to appreciate the minor role that stock prices can play in the ECB’s reaction function.

First, let’s remember that there are several stock exchanges in the Euro-zone: therefore which one should be taken into account by the ECB? Furthermore, the most important exchange in Europe, London, is actually outside the Euro-zone. So how can anyone imagine the ECB (or any other central bank) including a “foreign” stock exchange in its reaction function?

Second, and more importantly, all European exchanges are consistently influenced by the developments of Wall Street: both in terms of bubbles and normal changes, we can observe a close correlation which is not only evident in terms of long term trends (not so strange in a global economy...) but also for daily variations. The ECB maintains some degree of monetary sovereignty (for instance in terms of short-term interest rates) and in fact its target for monetary stability still makes sense, but the Euro-zone stock markets depend more on Wall Street’s developments than on ECB’s monetary policy.

Finally, and partly connected to what has already been said, in the Euro-zone the relevance of asset prices for monetary policy, and for monetary stability, can be more usefully referred to as house prices, and real estate in general than to stock prices. Both because of the role of these assets in the households’ portfolio, and therefore for wealth effects on consumption, and because the consideration of these prices provides a better measure of expected inflation, in general.

6. Conclusions

In our analysis we have first examined the results of previous research on the controversy on central bank’s optimal reaction to stock market prices. Should monetary policy ignore the stock market; or try only to prevent abnormal movements (bubbles); or just react in a stabilizing way like it does for all prices? All three different positions have their *pros* and *cons*, with a more recent prevailing view

that the central banks should consider – but not in a rigid way – stock prices in its monetary reaction function.

We present new estimates of the Fed's interest rate feedback rule for the period 1988-2000 and we find convincing evidence that in fact the Greenspan's Fed did include the stock market in its policy decision process. It was a lagged reaction, as we would expect from a stabilizing *leaning-against-the-wind* (if not *against-the-bubble*) approach.

The problems faced by the ECB are somewhat different for at least two reasons. First of all because the stock market is relatively less important in the Euro-zone transmission mechanism (bank credit and real estate can be more important). But above all, in the case of the Euro-zone we have stock markets which depend more on Wall Street's developments than on ECB's policy! It is therefore not surprising to find the ECB more cautious than the Fed on the necessary reaction to stock market developments.

References

- Alchian, A., Klein, B., 1973. On a Correct Measure of Inflation. *Journal of Money, Credit, and Banking*, 5:173-191.
- Bernanke, B., October 15, 2002. Asset-Price “Bubbles” and Monetary Policy. Speech made before the New York Chapter of the National Association for Business Economics, New York.
- Bernanke, B., Gertler M., 1989. Agency Costs, Net Worth, and Business Fluctuations. *American Economic Review*, 79:14-31.
- Bernanke, B., Gertler M., 1999. Monetary Policy and Asset Market Volatility. *Federal Reserve Bank of Kansas City Economic Review*, 84:17-52.
- Bernanke, B., Gertler M., 2001. Should Central Banks Respond to Movements in Asset Prices? *American Economic Review Papers and Proceedings*, 91:253-257.
- Bernanke, B., K., Kuttner, 2003. What Explains the Stock Market’s Reaction to Federal Reserve Policy? Federal Reserve Bank of New York Staff Reports, No. 174.
- Borio, C., Lowe P., 2002. Asset prices, Financial and Monetary Stability: Exploring the Nexus. Bank of International Settlements Working Paper, No. 114.
- Bullard, J., Schaling, E., 2002. Why the Fed Should Ignore the Stock Market. *Federal Reserve Bank of St. Louis Review*, 84:35-41.
- Campbell, J., Shiller R., 1998. Valuation Ratios and the Long-Run Stock market Outlook. *Journal of Portfolio Management*, 24:11-26.
- Cassola, N., Marana, C., 2002. Monetary Policy and the Stock Market in the Euro Area. European Central bank Working Paper, No. 119.
- Cecchetti, S., Genberg, H., Lipsky, J., Wadhvani, S., 2000. *Asset Prices and Central bank Policy*. Center for Economic Policy Research, London.

- Clarida, R., Gali J., Gertler M., 1998. Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory. National Bureau of Economic Research Working Paper, No. 6442.
- Clarida, R., Gali J., Gertler M., 2000. Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory. *Quarterly Journal of Economics*, 115:147-180.
- D'Amico, S., Farka, M., 2003. The Fed and the Stock Market: A Proxy and Instrumental Variable Identification. Columbia University, Mimeo.
- English, W., Nelson W., Sack B., 2002. Interpreting the Significance of the Lagged Interest Rate in Estimated Monetary Policy Rules. Federal Reserve Finance and Economics Discussion Series, No. 22.
- English, W., Nelson W., Sack B., 2003. Interpreting the Significance of the Lagged Interest Rate in Estimated Monetary Policy Rules. *Contributions to Macroeconomics*, 3:1-16.
- European Central Bank, 2002. The Stock Market and Monetary Policy. Monthly Bulletin, February, 39-52.
- Favero, C., 2001. *Applied Macroeconometrics*. Oxford University Press, Oxford.
- Gertler, M., Goodfriend, M., Issing, O., Spaventa, L., 1998. *asset Prices and Monetary Policy: Four Views*. Center for Economic Policy Research, London.
- Gilchrist, S., Leahy, J., 2002. Monetary Policy and Asset Prices. *Journal of Monetary Economics*, 49:75-97.
- Goodhart, C., Hofmann, B., 2000. Do Asset Prices help Predict Consumer Price Inflation. *Manchester School Journal Supplement*, 68:122-40.
- Greenspan, A., December 5, 1996. The Challenge of Central Banking in a Democratic Society. Speech made at the Annual Dinner and Francis Boyer Lecture of The American Enterprise Institute of Public Policy Research, Washington D.C..
- Hayford, M., Malliaris, A., 2001. Is the Federal Reserve Stock Market Bubble-Neutral? In: Kaufman, G. (Ed.), *Asset Price Bubbles: Implications for Monetary and Regulatory*

- Policies*, Research in Financial Service: Private and Public Policy, vol. 13, 229-243. Elsevier Science, Amsterdam.
- Miller, M., Weller, P., Zhang, L., 2001. Moral Hazard and the US Stock Market: The Idea of a “Greenspan Put”. Center for Economic Policy Research Discussion paper, No. 3041.
- Mishkin, F., 2001. The transmission Mechanism and the Role of Asset Prices in Monetary Policy. In: *Aspects of the Transmission of Monetary Policy, Focus on Austria*, 58-71. Osterreichische Nationalbank, Vienna.
- Modigliani, F., 1971. Monetary Policy and Consumption. In: *Consumer Spending and Monetary Policy: The Linkages*, 9-84. Federal Reserve Bank of Boston, Boston.
- Orphanides, A., 2001. Monetary Policy Rules Based on Real-Time Data. *American Economic Review*, 91:964-985.
- Rotemberg, J., Woodford, M., 1998. An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy: Expanded Version. National Bureau of Economic Research Working Paper No. T0233.
- Rotemberg, J., Woodford, M., 1999. Interest Rate Rules in an Estimated Sticky Price Model. In: Taylor, J. (Ed.), *Monetary Policy Rules*, 294-330. University of Chicago Press, Chicago.
- Rudebusch, G., 2002. Term Structure Evidence on Interest Rate Smoothing and Monetary Policy Inertia. *Journal of Monetary Economics*, 49:1161-1187.
- Sack, B., Rigobon R., 2003. Measuring the Reaction of Monetary Policy to the Stock Market. *Quarterly Journal of Economics*, 118:639-669 .
- Sack, B., Rigobon R., 2002. The Impact of Monetary Policy on Asset prices. National Bureau of Economic Research Working Paper No. 8794.
- Shiller, R., 2000. *Irrational Exuberance*. Princeton University Press, Princeton.
- Sölderlind, P., Söderström, U., Vredin, A., 2003. Taylor Rules and the Predictability of Interest Rates. Swedish Riskbank Working Paper, No. 147.
- Stock, J., Watson, M., 1999. Forecasting Inflation. *Journal of Monetary Economics*, 44:293-335.

- Stock, J., Watson, M., 2001. Forecasting Output and Inflation: The Role of Asset Prices. National Bureau of Economic Research Working Paper No. 8180.
- Tobin, J., 1969. A General Equilibrium Approach to Monetary Theory. *Journal of Money, Credit, and Banking*, 1:15-29.
- Yardeni, E., 2003. Stock Valuation models. Prudential Financial Research Topical Study, No. 58.
- Valckx, N., 2003. Price Dividend Models, Expectations Formation, and Monetary Policy. Hamburg Institute of international Economics, Hamburgisches Welt-Wirtschafts-Archiv Discussion paper, No. 217.

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