The stock market and the Fed

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This article investigates the reaction of the Federal Reserve to developments in the stock market. The issue is analysed by first constructing an Index of Stock Price Misalignment (ISPM) in which the fundamental value of the stocks is computed on the basis of the discounted cash flow approach and by then including this index, among the regressors, into a forward looking Taylor rule. In accordance with the descriptive evidence, based mainly on the analysis of the Federal Open Market Committee (FOMC) meetings and public statements, our findings show that the Fed tends to lower the Fed funds rate when stock prices fall below their fundamental value, while there is no evidence of monetary stringency during episodes of exuberance in the stock market.

I. Introduction

Central Bankers have always been aware that speculation in the stock market represents a potential threat to macroeconomic stability. At the end of the 1920s, for example, there was a bitter contention, inside the Federal Reserve System, on how to respond to the fast increase in stock prices. The Federal Reserve Bank of New York urged quantitative measures of higher discount rates and open market sales, while the Federal Reserve Board preferred direct pressure on banks making securities loans. As Friedman and Schwartz (1963) put it, the conflict was resolved in 1928 and 1929 by adoption of a monetary policy not restrictive enough to halt the bull market and yet too restrictive to foster vigorous business expansion.

The Fed has faced similar dilemmas also in more recent times. As we will document in the following pages, a careful reading of the transcripts of the Federal Open Market Committee (FOMC) committee and the analysis the public interventions of A. Greenspan, starting with the famous warning of December 1996 against ‘irrational exuberance’ in financial markets show that the Fed has been deeply concerned about developments in the stock market in the last 20 years.

The extent to which the concern expressed by Fed officials has translated into active policy is however open to debate. Miller (2002) document the existence, during the 1990s, of a widespread opinion among financial analysts that the Fed, in case of a decline in stock values, would actively intervene to avoid any disruption in the stock market and claim that this ‘Greenspan put’ was a major cause of the recent stock market bubble. Indeed, there are three episodes in the past two decades – the aftermath of the 1987 crash, the Russian/LTCM (Long-Term Capital Management) crisis of October 1998 and the stock market crisis following the 11 September 2001 terrorist attacks – in which the Fed has clearly used monetary policy to stabilize financial markets through a series of swift liquidity injections. On the other side, the inactivity of the Fed during the development of the stock market bubble has been a puzzle to observers and has been widely criticized.

In this article we try to verify whether the Fed systematically uses monetary policy in response to
developments in the stock market, i.e. whether it also follows a rule in responding to misalignments in stock prices through changes in short-term interest rates. This issue is analysed through both a careful study of the evidence contained in the transcripts of the FOMC committee and the estimation of a Taylor rule in which we include also some measure of nonfundamental movements in stock prices.

The problem of measuring the reaction of the Fed to stock prices has been recently analysed by Bernanke and Gertler (1999) and Rigobon and Sack (2003). Bernanke and Gertler estimate a forward-looking Taylor rule and add to the regressors (expected inflation and the output gap) the contemporaneous change in stock prices. They find that the reaction of monetary policy to changes in stock prices is negative and insignificant and suggest as an interpretation that, in a forward looking rule, the impact of stock prices is already incorporated in the forecasts of output and inflation.

Rigobon and Sack concentrate on the identification problem that arises when one tries to measure the reaction of monetary policy to the stock market. This depends on the fact that the stock market endogenously responds to monetary policy decisions at the same time that policy is reacting to the stock market. The authors criticize the standard procedure used by Bernanke and Gertler, which consists of instrumenting for the change in stock prices with lags of macroeconomic variables and stock returns. They propose a simple two variable Vector Autoregressive (VAR) model and use the heteroskedasticity of stock market returns to identify the reaction of monetary policy to the stock market. Through their model, Rigobon and Sack find that the Fed reacts significantly to stock market movements, with a 5% rise in the S&P 500 index increasing the likelihood of a 25 basis point tightening by about a half.

One common feature of both the Bernanke–Gertler and Rigobon–Sack papers is that the stock market variable included in the Fed’s reaction function is simply the change in stock prices. Indeed, if changes in stock prices reflect changes in underlying economic fundamentals, the Fed would have no reason to be concerned with stock price volatility per se. In this case, asset prices would be of interest only as indicators of the state of the economy. If instead asset prices are driven by nonfundamental factors, such as irrational behaviour of investors (herd behaviour, excessive optimism or short termism) then they can become a source of aggregate instability and the Central Bank may want to react with appropriate monetary policy measures. A correctly specified monetary policy rule implying that the Fed is concerned about the macroeconomic consequences of stock price movements must include some measure of the gap between actual stock prices and fundamental values.

In this article we try to provide a more adequate specification of the Fed’s reaction function by including, among the regressors, an Index of Stock Price Misalignment (ISPM), i.e. a measure of the deviation of stock prices from fundamental values. Obviously, estimating stock price misalignments is quite difficult and carries some degree of arbitrariness and indeed many economists and central bankers have questioned the ability of central banks to obtain useful estimates of fundamental values. However, we think that the exercise of including estimates of the gap between actual prices and fundamental values in the Fed’s reaction function is a useful exercise for a series of reasons. First, it is evident from the statements of Governor Greenspan that the Fed has clear opinions about stock price misalignments and it is quite plausible that these opinions are supported by empirical evaluations. Second, as we will show in the following pages, there is an interesting literature on the estimation of the fundamental value of stocks and therefore estimates of the degree of misalignment in stock prices can be easily obtained. As Cecchetti et al. (2000) claim, this empirical exercise is not more difficult and arbitrary than estimating the Non-Accelerating Inflation Rate of Unemployment (NAIRU) or preparing inflation forecasts. Third, it is always important to keep in mind that a monetary policy rule is a very synthetic description of a complex decision process and that the measures we provide of the gap may actually capture a series of evaluations made by central bankers in setting monetary policy.

This article is divided into four sections. In Section I we give some anecdotal evidence on the policy followed by the Fed vis-à-vis the stock market. In Section II we describe the methodology used to construct the ISPM. In Section III we describe the properties of this Index. In Section IV we discuss the specification of our augmented Taylor’s rule and, in Section V, we report the main findings of our econometric analysis.

II. The Stock Market and the Fed: Anecdotal Evidence

A careful reading of the events of the period 1980 to 2001 and of the documents available – mainly the transcripts of the FOMC meetings and the public intervention of the Chairman of the Fed, A. Greenspan – shows that the Fed has always been extremely attentive to the developments in the stock
market and that, in some cases, it has used monetary policy to stabilize the financial system. This is quite clear if we consider the two most relevant episodes of the period, i.e. the crash of 19 October 1987, when the Dow Jones index fell by 22.6%, the largest one-day decline in stock prices in US history, and the crisis following the terrorist attack of 11 September 2001. In both these cases large injections of liquidity ($17 billion through open market operations in 1987 and $83 billion through open market operations in 2001 plus $45 billion through the discount window) were able to avoid major disruptions in the financial system.

Financial stability, however, has been an important goal of the Federal Reserve also in less dramatic periods. The FOMC transcripts reveal many instances in which decisions concerning interest rates were influenced by overall conditions in the stock market. In the months following the 1987 crisis the FOMC weighed the possibility of an increase in the fed funds rate but ruled against it because of the uncertainty surrounding the stock market. Three years later, on 12 April 1991, the transcripts of a Conference Call of the FOMC report very clearly that the urgency of an interest rate cut was dictated by the need to avoid a shock in the stock market.

At the meeting of 4 February 1994 when after 5 years of continuous decline in interest rates a strategy of small, gradual increases was established, the need to keep stock prices under control was clearly stated as a major policy goal. Again, the transcripts of the meetings of 18 April 1994 and of 19 December 1995 reveal that interest rate decisions were taken after careful consideration of the situation of the stock and bond market.

Particularly interesting is the debate that took place inside the FOMC at the meeting of 24 September 1996, at a time in which a consensus was forming, inside the Fed, on the existence of a bubble in the price of high technology stocks. The need to act to prevent the consequences of a misalignment in stock prices was clearly stated by Governor Lindsey: ‘Unfortunately, optimism is ripe in the markets. Excessive optimism is also necessary to justify current levels of IPO activity and valuations of highly speculative stocks. (…) But the long-term costs of a bubble to the economy and society are potentially great. They include a reduction in the long-term saving rate, a seemingly random redistribution of wealth, and the diversion of scarce human capital in the acquisition of wealth. As in the United States in the late 1920s and Japan in the late 1980s, the case for a central bank ultimately to burst the bubble becomes overwhelming. I think it is far better that we do so while the bubble still resembles surface froth and before the bubble carries the economy to stratospheric heights.’

Greenspan’s response is a clear statement of the difficulties and the dangers of active intervention: ‘I recognize that there is a stock market bubble problem at this point and I agree with Governor Lindsey that this is a problem we should keep an eye on. We have very great difficulty in monetary policy when we confront stock market bubbles. That is because, to the extent that we are successful in keeping product price inflation down, history tells us that price-earnings ratios under these conditions go through the roof. What is really needed to keep stock market bubbles from occurring is a lot of product price inflation, which historically has tended to undercut stock markets almost everywhere. There is a clear tradeoff, if monetary policy succeeds in one, it fails in the other. Now, unless we have the capability of playing in between and managing to know exactly when to push a little here and to pull a little there, it is not obvious to me that there is simple set of monetary policy solutions that deflate the bubble.’

In the following years Greenspan started voicing concern about the formation of a bubble in the attempt to stabilize the market through moral suasion. In December 1996, A. Greenspan shook the world markets by describing the situation as a consequence of ‘irrational exuberance’ and on 26 February 1997 he stated before to the Senate Banking Committee that ‘these gains have obviously raised questions of sustainability.’ In October 1997 he said to the House of Representatives Committee on the Budget that stock values had reached a

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3 In this instance, A. Greenspan stated very clearly: 24 hours ago, as Tom Melzer knows, I frankly would have preferred not to do anything. But we are potentially in a position, at this stage, where if we do not move, the markets could break. Having stiffed them several times in the last week, it’s the type of situation that raises the degree of risk.

4 This is clear by A. Greenspan reaction to the request of raising interest rates by ½ percentage points instead of ¼: I think it might be very helpful to have anticipations in the market now that we are going to move rates higher because it will subdue speculation in the stock market; at this particular stage, having expectations hanging in the market that we may move again, and move reasonably soon, could have a very useful effect. (…) If we have the capability of having a sword of Damocles over the market, we can prevent it from running away.

5 At the FOMC meeting of December 19, in evaluating the risks of the proposed cut in the fed fund rate A. Greenspan is reported to have said: I am not worried about product price inflation if for no other reason than I think that the longer term is helpful. […] The real danger is that we are at the edge of a bond and stock bubble […] That is why, if we are perceived to be easing policy, it is conceivable that we could foster further problems in that regard.
level ‘not often observed at this stage of economic expansion [...] It would clearly be unrealistic to look for a continuation of stock market gains of anything like the magnitude of those recorded in the past couple of years’.

However, in spite of the public warnings issued by Greenspan, there is no evidence that, in the period of major acceleration in stock prices, the Fed used monetary policy to counteract the bubble. Between the beginning of 1996 and the mid-1999, except for a slight increase in March 1997, interest rates were never raised. Actually, a series of cuts in interest rates were decided in the second half of 1998, mainly in response to the international financial instability following the Russian default of October and the LTCM crisis. When the Fed undertook a policy of gradual increase in interest rates between the mid-1999 and the mid-2000 it is unlikely that the stock market had much to do with it.

The inaction of the Fed during the acceleration of the tech stock bubble raises the question whether monetary policy has been incoherent with the previous behaviour which we could characterize as strong intervention during a crash and careful consideration, in less dramatic times, of the effects of monetary policy on stock prices. Our reading of the history of those years leads us to believe that there was no incoherence. The Fed has always been aware of the effects that financial instability has on the real economy and has always been ready to act to avoid major disruptions. However, in the presence of a bubble like the one occurred in the second half of the 1990s, it did not feel that it had the powers to fight against the forces of irrational exuberance and, probably, it did not believe it had a mandate to actually engage in a policy that would have the result of the reduction of the wealth of a large part of the population.

This interpretation has been recently confirmed by A. Greenspan himself in a recent speech of 30 August 2002. Reviewing the events of the late 1990s he in fact said: ‘It was far from obvious that bubbles, even if identified early, could be preempted short of the central bank inducing a substantial contraction in economic activity – the very outcome we would be seeking to avoid. Prolonged periods of expansion promote a greater rational willingness to take risks, a pattern very difficult to avert by a modest tightening of monetary policy. In fact our experience over the past 15 years suggests that monetary tightening that deflates stock prices without depressing economic activity has often been associated with subsequent increases in the level of stock prices. (...) It seems reasonable to generalize from our recent experience that no low-risk, low-cost, incremental monetary tightening exists that can reliably deflate a bubble. But is there at least some policy that can at least limit the size of a bubble and, hence, its destructive fallout? From the evidence to date, the answer appears to be no’.

III. Measures of Misalignment in Stock Prices

The accounting literature adopts three main approaches to calculate the fundamental value of a stock: (i) the comparison of balance sheet multiples (EBITDA: Earnings Before Interest, Taxes, Depreciation and Amortization; EBIT: Earnings Before Interest and Tax) for firms in the same sector; (ii) the residual income method; (iii) the Discounted Cash Flow (DCF) method.

The first approach has two types of problems. The first is due to the fact that usually market agents have nonhomogeneous information sets or adopt different trading strategies, and therefore the benchmark used for comparison may be overvalued or undervalued. In this case, in the presence of a stock market bubble, the value of a stock would be assessed with respect to the overvalued or undervalued average of its sector peers. The second problem with this method is that, as far as firms diversify their activities and develop new products or services which cannot be easily classified into traditional taxonomies, industry or sector classifications become always more tricky. Industrial diversification makes it hard to assume that two firms classified into the same industry may have an identical risk profile and that their multiples may be effectively comparable (Kaplan and Ruback, 1995).

The problem with the second approach (residual income method), which is largely used in the literature (Frankel and Lee, 1998; Lee et al., 1999), is that the formula for evaluating the fundamental value of a stock uses a balance sheet measure whose accuracy and capacity of incorporating changes in the stock fundamental value is limited. As shown by Lee et al. (1999), for example, the price to book ratio...

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6 The speech was delivered at a symposium sponsored by the Federal Reserve Bank of Kansas City at Jackson Hole, Wyoming, and the text is available on the Web page of the Kansas Fed.

7 The residual income method consists of revaluating the current book value at the discounted excess return of equity (firm expected return of equity minus the discount rate or the equityholder rate of return). By comparing the two approaches it is evident that they are equivalent would the current book value be equal to the sum of the normal expected DCF (or the cash flow growing exactly at a rate equal to the discount rate).
for the Dow Jones Industrial Average has risen three times between 1981 and 1996, showing a marked uptrend which extends for a period much longer than that of the stock market bubble. This might be the consequence of the fact that accounting methodologies lag behind in adjusting to changes in investors’ market value assessments of firms whose share of intangible assets (i.e. human capital, know-how) is rising over time.8

The DCF approach that we consider here following Kaplan and Ruback (1995) is based on I/B/E/S consensus forecasts of financial analysts and has therefore the advantage of using only current net earnings as an accounting variable. According to this model – and under the assumption that the DCF to the firm is equal to net earnings – the ‘fundamental price-earning’ ratio of the stock may in fact be written as:

\[ \frac{MV}{X} = \sum_{t=0}^{\infty} \frac{(1 + E[g_t])^t}{(1 + r_{\text{CAPM}})^t} \] (1)

where MV is the equity market value, X is the current cash flow to the firm, \( E[g_t] \) is the yearly expected rate of growth of earnings,9 \( r_{\text{CAPM}} = R_f + \beta E[R_m] \) is the discount rate adopted by equity investors or the expected return from an investment of comparable risk, \( R_f \) represents the risk free rate, \( E[R_m] \) the expected stock market premium and \( \beta \) is exposure to systematic nondiversifiable risk.

The use of this approach is also problematic since, as pointed out by Shiller (1981), from a strictly theoretical point of view, the fundamental value of a stock should be calculated using, instead of earnings, dividends which are what shareholders effectively cash. We must consider, however, that forecasts on dividends are not usually available. Moreover, even if we made some assumptions on the formation of expectations, the use of dividends is not satisfactory from an empirical point of view. Claus and Thomas (2001) and Jagannathan et al. (2001), for example, have shown that recent stock market values generate unreasonably low risk premia when the present value of stocks is calculated by discounting future expected dividends.10 The DCF approach instead has the advantage not only of being a very widely used technique, but also has been shown, by Kaplan and Ruback (1995) among others, to be very useful and reliable.11

Before analysing the issues implied by the practical implementation of Equation 2, notice that this equation could also be used to estimate a time-varying risk premium, instead of the fundamental value of stocks. This could be done by solving for the term \( E(R_m) \) after equating MV to the actual price of a stock. Since they derive from the same equation, the two measures are largely equivalent. We choose however to derive the fundamental value of a stock rather than deriving a time-varying risk premium because it gives a more direct evaluation of misalignment in stock prices driven by phenomena like herd behaviour, excessive optimism or panics. These are the phenomena, in fact, that we think might be relevant for monetary policy purposes.

In order to calculate the fundamental price-earning ratio, following Adriani and Becchetti (2004) and Bagella et al. (2006) we consider the following two-stage growth approximation of (1):

\[ \text{MVE} = X + \sum_{t=1}^{5} \frac{X(1 + E[g_t])^t}{(1 + r_{\text{CAPM}})^t} \left( \frac{(1 + E[g_t])^6}{(r_{\text{CAPM(TV)}} - gn)(1 + r_{\text{CAPM}})^6} \right) \] (2)

where MVE is the two-stage growth equity market value, \( E[g_t] \) is the expected yearly rate of growth of earnings according to the consensus of stock analysts. According to this formula the stock is assumed to exhibit excess growth in the first stage of growth and to behave like the rest of the economy in the second stage. The second stage contribution to MVE is calculated as a terminal value in the second addend of (2) where \( r_{\text{CAPM(TV)}} = R_f + E[R_m] \) and gn is the perpetual nominal rate of growth of the economy.

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8 The reason for such discrepancy between book value and market value assessment lies probably on the practice or reporting capital losses at their historical value and capital gains at the market value.

9 Actually, when estimating the model we should use the expected rate of growth of cash flow to the firm instead of the expected rate of growth of earnings. Even though earnings are obviously different from cash flow to the firm, our measure is not biased under the assumption that the expected rate of growth of earnings is not different from the expected rate of growth of cash flow to the firm. The relevance of our approach is also supported by recent empirical evidence on the higher value relevance of earnings with respect to dividends (Naceur and Goaied, 2004).

10 Another argument in favour of the DCF is that the value of a stock is the net present value of cash flow in cases of a takeover which involves 100% of equity capital. Therefore, it is possible that in periods of stock market boom, with waves of mergers and acquisition and shareholders which rationally anticipate stock values for the bidder, fundamental values move towards DCF values.

11 Kaplan and Ruback (1995) show, for example, that in a sample of 51 highly leveraged transactions completed between 1983 and 1989, the valuations of DCF forecasts are within 10%, on average, of the market values of completed transactions.
The analytical definition of the DCF model imposes some crucial choices on at least five parameters: the risk-free rate, the risk premium, the beta, the length of the first stage growth and the rate of growth in the terminal period.

For the risk-free rate, we use the yield on the 3-month US Treasury Bill. For the risk premium, we consider that our measure should be somewhere between the historical difference in the rates of return of stocks and T-bills (around 8%) and the implied premium for US equity markets at the end of the sample period which is extremely low and around 2%. Both of these two extremes might be incorrect estimates of the risk premium. The former because it assumes that the long-term historical premium is equal to the current premium neglecting fundamental institutional and political changes occurring in the last decades. The latter because it assumes that financial markets are correct in evaluating stocks (this is not the case in presence of a bubble or of a nonzero share of noise or liquidity traders trading with arbitrageurs of limited patience).

The third critical factor in the 'two-stage' DCF formula is the terminal value of the stock. We arbitrarily fix at the 6th year the shift from the high growth period to the stable growth period. Sensitivity analysis on this threshold shows nonetheless that this choice is not so crucial for the determination of the value of the stock. The parameter gn is calculated at 3%, consistently with values adopted in the literature.

Finally, the literature generally proposes three alternatives for the choice of beta: the estimation of time-varying firm specific or industry specific betas and a fixed unit beta. We adopt the first option (estimation of time-varying beta in a 5-year window of monthly beta) which is consistent with the criterion adopted by most financial analysts.

IV. The ISPM

Using the approach described in (1) and (2) we constructed the aggregate DCF fundamental of the S&P index computed as an unweighted average of the 309 stocks which remained in the S&P500 index during the overall observation period (January 1980–December 2001).

Figure 1 shows our ISPM computed as the ratio between the observed S&P500 index and the aggregate DCF fundamental calculated by setting the risk premium at 8% and the nominal growth rate of Gross Domestic Product (GDP) in the terminal period at 3%.

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12 We use 1-year and 2-year ahead average I/B/E/S earnings forecasts for the first 2 years and the long-term average earnings forecasts from the third to the 6th year. The use of the median estimate alternatively to the mean estimate does not change significantly our results as already found by Frankel and Lee (1998). The recent evidence of Mohanty and Aw (2006) on the consistency of I/B/E/S analysts earning forecasts with the rational expectations hypothesis supports the validity of our choice.

13 Damodaran (1996), for example, estimates that the risk premium for the period 1926 to 99 is 9.41 or 8.14% if we take, respectively, arithmetic averages or geometric averages of the stocks-T bill spread. The 8% risk premium is broadly consistent with estimates from Kaplan and Ruback (1995) indicating a value of 7.78% and Ibbotson and Associates (1996) reporting a similar value for the arithmetic average of historical risk premium.

14 To calculate the current implied premium we use the Gordon and Shapiro (1956) formula in which value is equal to expected dividends next year/(required return on stocks − expected growth rate) where the required return on stocks is the sum of the riskfree rate and the risk premium. In the light of this formula, the extremely low implicit risk premium in the sample period may be interpreted as the availability to pay higher prices for a given expected growth rate even in presence of a low dividend payout.

15 The fact that the implied risk premium is lower today than in periods (such as the 1960s) with similar growth and inflation rates may depend for instance on political factors such as the end of the ‘cold war’ which may make investors’ expectations more optimistic over long time horizons therefore reducing the risk of holding the stock.

16 If we just adopt the implied risk premium without weighting it for the historical risk premium, we would implicitly assume that no fundamental value exists or that the fundamental is just what investors believe in that period. In this way changes in the implied risk premium constantly update the fundamental value and the latter becomes just what investors are willing to pay for the stock. In the light of these considerations it is clear that the ratio between the observed and fundamental stock market value ISPM which we will use in our empirical analysis is a proxy of the deviation between the current and the historical risk premium.

17 We must in fact consider that the positive impact on value of an additional year of high growth must be traded off with a heavier discount of the terminal value, which represents a significant part of the final value. Information on this sensitivity analysis is available from the authors upon request.

18 In the terminal value it is obviously assumed that the stock cannot grow more and cannot be riskier than the rest of the economy.
As we can see the observed/fundamental S&P500 ratio is stationary around mean one, is normally distributed, and exhibits a few sharp changes corresponding to:

(a) the continuation of the effects of the 1979 oil shock (January–June 1980);
(b) the crisis of the International Bank which manifests the weakness of the US banking systems and preludes to the crisis of the S&L. At the same time there is an important change in the Fed’s operating procedures (February 1982–August 1982);
(c) the stock market crash of 19 October 1987, when the Dow Jones Index dropped by 22% in one day;
(d) the effects of the international currency crisis leading to the devaluation of the Italian lira and of the British pound (March 1992–October 1992);
(e) the Russian financial crisis (August 1998–October 1998);
(f) the end of the long boom in stock prices linked to the boom of the new economy.

Specification of the model and econometric issues

We follow Clarida et al. (2000) by estimating an augmented forward looking Taylor rule where the Fed is assumed to react systematically to future values of the output gap, the deviation of expected inflation from its target value and our ISPM. This rule can be expressed as

\[ r_t^* = r^* + \beta (E[\pi_{t+k}|\Omega_t] - \pi^*) + \gamma (E(y_{t+q}|\Omega_t) + \delta (P_t - E[P_{t+1}|\Omega_t]) + \varepsilon_t \]

where \( r^* \) is the target rate for the Federal funds’ rate in period \( t \), \( \pi_{t+k} \) denotes the percent change in the price level between periods \( t \) and \( t+k \), \( \pi^* \) is the target rate of inflation, \( y_{t+q} \) is the average output gap between \( t \) and \( t+q \), defined as the percent deviation between actual GDP and the corresponding target, \( P_t \) is the observed stock market index and \( P_{t+k} \) the fundamental ‘average’ stock market price between \( t \) and \( t+k \); \( E \) is the expectation operator and \( \Omega_t \) is the information set at the time the Federal Funds rate is set.

Defining \( rr_t^* = rr_t - E[\pi_{t+k}|\Omega_t] \) and \( rr_t^* = r_t^* - \pi^* \), Equation 3 can be expressed in the terms of the real rate \( rr_t^* \), so that

\[ rr_t^* = rr_t + (\beta - 1)(E[\pi_{t+k}|\Omega_t] - \pi^*) + \gamma (E(y_{t+q}|\Omega_t) + \delta (P_t - E[P_{t+1}|\Omega_t]) + \varepsilon_t \]

Let us now assume that the long run rate is constant and independent of nonmonetary factors.
and that the Fed Funds rate adjusts only partially to the target rate \( r_t^* \), i.e.

\[
r_t = \rho r_{t-1} + (1 - \rho) r_t^*
\]

(5)

In this case the forward-looking Taylor rule can be rewritten as

\[
r_t = \rho r_{t-1} + (1 - \rho)[rr^* - (\beta - 1)\pi^*] + (1 - \rho)\beta E(\pi_{t, q} | \Omega_t) + (1 - \rho)\gamma E(y_{t, q} | \Omega_t) + (1 - \rho)\delta(P_t - E(P_{t, s} | \Omega_t)) + \varepsilon_t
\]

(6)

As in Clarida et al. (2000) we replace the expectations of variables in Equation 6 with actual realized values of the variables, and then we use an instrumental variable technique, i.e. the Generalized Method of Moments (GMM), with an optimal weighting matrix that accounts for possible serial correlation. If we assume rational expectations, errors will not be correlated with the instruments and we can obtain consistent estimates of the parameters of the monetary policy rule. Following again Clarida et al. (2000) we assume that both inflation and the nominal interest rate are stationary. Also our ISPM is assumed to be stationary.

An important issue in the estimation is whether the use of instrumental variables is sufficient to solve the difficult identification problem that arises in this context due to the fact that stock prices are generally influenced by movements in the fed fund rate and therefore cannot be regarded as exogenous. There is not an easy way to this problem. In a recent paper, Rigobon and Sack (2003) have proposed an identification method based on the heteroskedasticity of stock market returns,\(^{19}\) which however is used in a VAR context with daily observations, and cannot be easily applied to our standard Taylor rule estimation. We choose therefore to deal with the exogeneity problem through a careful choice of instruments, trying to select variables that belong to the policymakers’ information set but that, at the same time, are uncorrelated with the current interest rate shock.

We use quarterly data for the period January 1980 to April 2001. The target horizon we assume for inflation, the output gap and the ISPM is 1, (i.e. \( k = q = s = 1 \)). The interest rate we use is the average Federal Funds rate (FEDF) in the first of each quarter, expressed in annual rates. In the baseline estimate we use, as a measure of inflation, the annualized rate of change of the GDP deflator (INFDEF), but we also use an alternative measure, i.e. a rate of inflation obtained using the Consumer Price Index (INFCPI). The output gap (GDPGAP) is given by the difference between the log of real GDP and the log of potential GDP constructed by the Central Budget Office (CBO). In the estimates provided to check the robustness of our results we also use the gap between the log of real GDP and its quadratic trend (GDPGAP1) and the difference between the log of the unemployment rate (UGAP) and its quadratic trend. The variable representing the difference between stock market prices and stock market fundamentals is given by the ISPM described above, expressed in percentage terms.\(^{20}\)

In order to test whether the Fed shows an asymmetric behaviour \( \text{vis-à-vis} \) episodes of undervaluation and over-valuation of stock prices, we also use other variables derived from our ISPM. ISPMNEG and ISPMPOS are two variables containing, respectively, the negative and positive values of our index. The variables ISPM30PC and ISPM40PC contain values of the ISPM below, respectively, the 30th and the 40th percentiles, while the variables ISPM70PC and ISPM60PC contain values of the ISPM above, respectively, the 70th and the 60th percentiles.

Following Clarida et al. (2000), Equation 6 is estimated by assuming that the Federal Reserve forms its rational expectations on the output gap, inflation and the ISPM by using a set of indicators which include lagged values of the regressors, the difference between long-term and short-term interest rates (DTASSI), the rate of growth of M2 (M2GROWTH) and the rate of change of oil prices, based on the producer price index of all commodities (COMINF).\(^{21}\) Although the contemporaneous value of the ISPM is probably used by the Fed in making decisions about the fed funds rate, we do not include it among instruments as it is probably correlated to the current interest rate shock.

The evidence

In Tables 1 and 2 we report different specifications of our augmented Taylor rule. Each group of equations contains four equations that differ depending on the different variables used for the

\(^{19}\) The method is based on the observation that in period of high (low) variance of stock market prices interest rates are usually positively (negatively) correlated with asset prices.

\(^{20}\) In practice, the variable is the difference between the S&P500 index and the DCF fundamental, divided by the DCF fundamental.

\(^{21}\) Clarida et al. (2000) use a measure of commodity price inflation instead of this variable. We found our specification to perform better over our sample.
Table 1. Augmented Taylor’s rule estimates with selected intervention thresholds for stock price misalignment

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<td>(2.60)</td>
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<td>(2.60)</td>
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Notes: The table presents estimates of coefficients of Equation 6 considering the following set of variables: FEDF average Federal Funds rate in the first quarter of each month, expressed in annual rates; INFDEF: annualized rate of change of the GDP deflator; INFCPI: Consumer Price Index rate of inflation; GDPGAP: difference between the log of real GDP and the log of potential GDP constructed by the CBO; GDPGAP1: gap between the log of real GDP and its quadratic trend; UGAP: difference between the log of the unemployment rate and its quadratic trend. ISPM: difference between stock market prices and stock market fundamentals calculated according to (1) and (2). The estimates in the first group include as regressors the lagged dependent variable (FEDF), a measure of output gap (GDPGAP, GDPGAP 1 or UGAP), of inflation gap (INFCPI or INFDEF). The estimates in the second, third and fourth groups contain also a measure of stock price misalignment (ISPM). More specifically $\rho$ measures the reaction to the lagged dependent variable, $\gamma$ to output gap, $\beta$ to inflation gap, $\delta$ to the Index of Stock Price Misalignment, $\delta_{\text{neg}}$ to the positive values of the ISPM (indicating underevaluation of the stock market), $\delta_{\text{pos}}$ to the negative values of the ISPM (indicating overvaluation of the stock market). With regard to inflation and output gap estimates 1a–4a include GDPGAP and INFDEF, 1b–4b GDPGAP and INFCPI, 1c–4c, GDPGAP1 and INFDEF, 1d–4d UGAP and INFDEF. All the coefficient values (except for $\rho$) are obtained by dividing the estimated coefficients by $1 - \rho$. Instrument list: four lags of the regressors plus four lags of: DTASSI, difference between long-term and short-term interest rates; M2GROWTH, rate of growth of M2, COMINF, rate of change of oil prices, based on the producer price index of all commodities. All estimates pass the Sargan test for overidentifying restrictions that can be applied in a GMM estimate when the number of instruments is higher than the number of regressors. GMM estimates, quarterly data from January 1980 to April 2001, $t$-values in parenthesis.
Table 2. Augmented Taylor’s rule estimates with selected intervention thresholds for stock price misalignment

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<td>0.862</td>
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<td>0.945</td>
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<td>0.887</td>
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<td>1.193</td>
<td>1.551</td>
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<td>0.902</td>
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Notes: The table presents estimates coefficients of Equation 6 considering the following set of variables: FEDF, average Federal Funds rate in the first quarter of each month, expressed in annual rates; INFDEF: annualized rate of change of the GDP deflator; INFCPI: Consumer Price Index rate of inflation. GDPGAP: difference between the log of real GDP and the log of potential GDP constructed by the CBO; GDPGAP1: gap between the log of real GDP and its quadratic trend; UGAP: difference between the log of the unemployment rate and its quadratic trend. ISPM: difference between stock market prices and stock market fundamentals calculated according to (1) and (2). All the estimates include as regressors the lagged dependent variable (FEDF) a measure of output gap (GDPGAP, GDPGAP1 or UGAP), of inflation gap (INFCPI or INFDEF) and of stock price misalignment (ISPM). More specifically $\rho$ measures the reaction to the lagged dependent variable, $\gamma$ to output gap, $\beta$ to inflation gap, $\delta_{40pc}$ to values smaller than the 40th percentile of the ISPM, $\delta_{60ps}$ to values higher than the 60th percentile of the ISPM, $\delta_{30pc}$ to values smaller than the 30th percentile of the ISPM, and $\delta_{70ps}$ to values higher than the 70th percentile of the ISPM. With regard to inflation and output gap estimates 1a–4a include GDPGAP and INFDEF, 1b–4b GDPGAP and INFDEF, 1c–4c, GDPGAP1 and INFDEF, 1d–4d UGAP and INFDEF. All the coefficient values (except for $\rho$) are obtained by dividing the estimated coefficients by $1 - \rho$. Instrument list: four lags of the regressors plus four lags of: DTASSI, difference between long-term and short-term interest rates; M2GROWTH, rate of growth of M2, COMINF, rate of change of oil prices, based on the producer price index of all commodities. All estimates pass the Sargan test for overidentifying restrictions that can be applied in a GMM estimate when the number of instruments is higher than the number of regressors. GMM estimates, quarterly data from January 1980 to April 2001, $t$-values in parenthesis.
output gap or inflation. In the first equation of each group (Equations 1a–4a) we include the GDPGAP, i.e. the output gap calculated on using the potential output series provided by the CBO, and the INFDEF, the rate of inflation based on the GDP implicit price deflator. In the second equation of each group (Equations 1b–4b) we use again GDPGAP but we measure inflation by using the Consumer Price Index (CPI). In the third (Equations 1c–4c) and fourth (Equations 1d–4d) equation of each group we use again the INFDEF but we introduce different variables for the output gap, i.e. an output gap calculated on the basis of a quadratic trend (GDPGAP1) and the unemployment gap (UGAP).

The coefficients reported in Tables 1 and 2 are the estimated parameters divided by 1, where $\rho$ is the coefficient of the dependent variable lagged one period. The coefficients $\beta$, $\gamma$ and $\delta$, therefore, measure the response of the fed funds rate to inflation, the output gap and the ISPM. We denote by $\delta_{\text{pos}}$ and $\delta_{\text{neg}}$ the coefficients associated to the variables ISPNEG and ISPPOS, and by $\delta_{\text{30pc}}, \delta_{\text{40pc}}, \delta_{\text{60pc}}$ and $\delta_{\text{70pc}}$ the coefficients associated to the variables ISPNEG, ISPPOS. Also these coefficients are computed as the ratio of the estimated parameters and $1 - \rho$.

As in Nelson (2000) we do not try to follow the approach followed by Clarida et al. (2000) who give a structural interpretation of the intercept term of the estimated policy rules by deriving the implied inflation target from the estimated constant term. The reason is that data we use in this study are not real time data, i.e. are not the data available to policy makers at the time of their decisions. The use of these data implies some measurement error that Orphanides (2001) has shown consists mainly in an overestimation of the level of potential output. Since these errors are likely to affect mainly the constant term, we prefer not to give a structural interpretation of the intercept term, but rather to concentrate on the estimated response of policy rates to inflation and the output gap and the ISPM.

In the first four equations of Table 1 we report the baseline estimates of the Taylor rule. As in Clarida et al. (2000), the estimates indicate that the coefficient of the inflation variable is well above one, suggesting that the Fed has controlled inflation through more than proportional increases in the fed funds rate. As expected, the coefficients of the output variables are less than one.

In columns 2a–2d we add our ISPM. In two cases we find that the ISPM has a positive sign and is significant, but in two specifications of the augmented Taylor rule it turns out to be insignificant. Although there is some indication of some correlation between the fed funds rate and our index, these results are not robust enough to support the hypothesis of a systematic uniform reaction of the Fed to deviations of stock prices from fundamentals.

In columns 3a–3d and 4a–4d we report a set of regressions where we have added, to the standard Taylor rule specification, two variables indicating an asymmetric response of the Fed to misalignment in stock values. In the first set of equations we have included the variable ISPNEG which includes only negative values of the ISPM and in the second set of equations we have included the variable ISPPOS, which includes positive values of the ISPM. In all cases we find that the variable ISPNEG has a positive sign and is highly significant indicating that the Fed reacts to falls in stock prices below their fundamental values by lowering the fed funds rate. When we include the variable ISPPOS, which gives us a measure of overvaluation in the stock market, we find that the coefficients associated to the variables are negative in three cases out of four and significant in only one case. We interpret these results as a clear indication that the Fed does not react, generally, to stock price misalignments above their fundamental values.

In Table 2 we check the robustness of these results by including in the regressions values of the ISPM respectively below the 40th and the 30th percentiles, and above the 60th and the 70th percentiles. The results we obtain in these regressions confirm the hypothesis that the Fed has an asymmetric response to stock market misalignments. In the equations the variables indicating undervaluation of stock prices are significant and enter with the positive sign while the variables indicating overvaluation are in all cases, except for one, insignificant. These results confirm, in our view, the insights obtained by the anecdotal evidence reported in the previous paragraphs. This evidence indicates that the Fed tends to react to excessive undervaluation of stock prices by lowering the fed funds rate in order to minimize the risk of financial markets instability, but it does not tend to use monetary policy to avoid the formation of stock market bubbles.

V. Conclusions

The increasing awareness of the links between the stock exchange and real economy has led many practitioners, academicians and commentators to argue that the under/overvaluation of the stock market, with its effects on consumers’ confidence and inflation is a concern for the Federal Reserve in addition to inflation and output stabilization. So far,
this proposition has been tested empirically simply by augmenting a Taylor rule with changes in stock prices.

In this article we argue that this variable is not a good proxy, if we want to analyse the Fed’s reaction to the stock market. We propose an interpretation of the Fed’s monetary policy for the period 1980 to 2001, by estimating an augmented Taylor rule where the Fed is assumed to react not only to inflation and deviations of output from the long run trend, but also to deviations of stock market prices from their long run value as indicated by an ISPM constructed on the basis of the S&P500 Index. The Index is computed on the basis of a DCF method applied to the I/B/E/S forecasts.

The econometric results are coherent with the anecdotal evidence we obtain by analysing FOMC transcripts and official interventions. We find that the Federal Reserve not only is concerned by developments in the stock markets, but also reacts systematically to deviations of stock prices from fundamental values. This reaction, however, is not symmetric, since only measures of undervaluation of stock prices appear to be a robust variable of the Fed’s monetary policy rule. Due to the negative effects that stock market crashes can have on the real economy, in the last 20 years the Fed has systematically reacted to periods of crisis in the stock market by keeping interest rates lower.

Consistently with recent statements of A. Greenspan, the evidence collected in this article shows that the Fed has not reacted to stock market overvaluations with a tighter monetary policy, largely convinced that monetary policy actions capable of preventing the formation of a bubble could also have extremely negative consequences for the real economy. This finding raises interesting questions, which however have not been addressed in this article, over the appropriate response of monetary policy to asset price fluctuations, especially when they are not justified by movements in the underlying fundamental. We indeed believe that our finding should lead to a deeper investigation and understanding of the relationships between business cycle predictors, stock market misalignment and the business cycle itself which may be particularly useful in measuring and evaluating the complex interaction between financial markets and the economy.

Acknowledgement
The authors thank R. Chirinko, A. Santomero, C. Favero, I. Hasan, G. Marini, F. Natalucci. The usual disclaimer applies.

References