Monetary Policy and Asset Price Volatility

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During the past twenty years, the world's major central banks have been largely successful at bringing inflation under control. Although it is premature to suggest that inflation is no longer an issue of great concern, it is quite conceivable that the next battles facing central bankers will lie on a different front. One development that has already concentrated the minds of policy-makers is an apparent increase in financial instability, of which one important dimension is increased volatility of asset prices. Borio, Kennedy, and Prowse (1994), among others, document the emergence of major boom-bust cycles in the prices of equity and real estate in a number of industrialized countries during the 1980s. Notable examples include the United States, Japan, the United Kingdom, the Netherlands, Sweden, and Finland.

Associated with the "bust" part of the asset price cycle in many of these cases were significant contractions in real economic activity. For example, many economists attribute at least some part of the 1990 recession (and the slow recovery) in the United States to the preceding decline in commercial real estate prices, which weakened the capital positions of banks and the balance sheets of corporate borrowers (Bernanke and Lown, 1991). More recently, of course, we have seen asset price crashes in East Asia and Latin America, along with continued stagnation of stock and land prices in Japan, all of which have been associated with poor economic performance. With these experiences in mind, some observers have viewed the remarkable rise of the past few years in U.S. stock prices, and to a lesser extent in real estate prices, as an ominous development. Of course, as of this writing, whether the U.S. stock market boom will be sustained or will end in tears is anybody's guess.

In this paper we address the question of how central bankers ought to respond to asset price volatility, in the context of an overall strategy for monetary policy. To be clear, we agree that monetary policy is not by itself a sufficient tool to contain the potentially damaging effects of booms and busts in asset prices. Well-designed and transparent legal and accounting systems, a sound regulatory structure that helps to limit the risk exposure of banks and corporations, and prudent fiscal policies that help instill public confidence in economic fundamentals, are all vital components of an overall strategy to insulate the economy from financial disturbances. However, our reading of history is that asset price crashes have done sustained damage to the economy only in cases when monetary policy remained unresponsive or actively reinforced deflationary pressures. This observation is our justification for focusing on monetary policy here.

The principal argument of the paper is easily stated. Our view is that, in the context of short-term monetary policy management, central banks should view price stability and financial stability as highly complementary and mutually consistent objectives, to be pursued within a unified policy framework. In particular, we believe that the best policy framework for attaining both objectives is a regime of flexible inflation targeting, either of the implicit form now practiced in the United States or of the more explicit and transparent type that has been adopted in many other countries. (We prefer the latter, for reasons explained briefly at the conclusion of the paper.)

The inflation-targeting approach dictates that central banks should adjust monetary policy actively and pre-emptively to offset incipient inflationary or deflationary pressures. Importantly, for present purposes, it also implies that policy should *not* respond to changes in asset prices, except insofar as they signal changes in expected inflation.

Trying to stabilize asset prices *per se* is problematic for a variety of reasons, not the least of which is that it is nearly impossible to know for sure whether a given change in asset values results from fundamental factors, non-fundamental factors, or both. By focusing on the inflationary or deflationary pressures generated by asset price movements, a central bank effectively responds to the toxic side effects of asset booms and busts without getting into the business of deciding what is a fundamental and what is not. It also avoids the historically relevant risk that a bubble, once "pricked," can easily degenerate into a panic. Finally, because inflation targeting both helps to provide stable macroeconomic conditions and also implies that interest rates will tend to rise during (inflationary) asset price booms and fall during (deflationary) asset price busts, this approach may reduce the potential for financial panics to arise in the first place.

The remainder of the paper is organized as follows. We begin with an informal summary of our views on how asset prices interact with the real economy and of the associated implications for monetary policy. To address these issues more formally, the next two sections present some illustrative policy simulations derived from a small-scale macroeconomic model that features an explicit role for financial conditions in determining real activity. We then move from theory to practice as we briefly examine the recent performance of monetary policy in the United States and Japan, both of which have experienced asset price volatility. Finally, we conclude with some discussion of additional issues. The appendix provides more details of the simulation model.

Asset prices, the economy, and monetary policy: an overview

Asset prices, including, in particular, the prices of equities and real estate, are remarkably variable. And although we must not lose sight of the fact that ultimately asset prices are endogenous variables, there are periods when asset values seem all but disconnected from the current state of the economy. As we noted in the introduction, during the past two decades economies across the globe have experienced large boom-and-bust cycles in the prices of various assets, including equities, commercial real estate, residential housing, and others.

Should fluctuations in asset prices be of concern to policy-makers? In the economist's usual benchmark case, a world of efficient capital markets and without regulatory distortions, movements in asset prices simply reflect changes in underlying economic fundamentals. Under these circumstances, central bankers would have no reason to concern themselves with asset price volatility *per se*. Asset prices would be of interest only to the extent that they provide useful information about the state of the economy.

Matters change, however, if two conditions are met. The first is that "non-fundamental" factors sometime underlie asset market volatility. The second is that changes in asset prices unrelated to fundamental factors have potentially significant impacts on the rest of the economy. If these two conditions are satisfied, then asset price volatility becomes, to some degree, an independent source of economic instability, of which policy-makers should take account.

That both of these conditions hold seems plausible to us, though there is room for disagreement on either count. We briefly discuss each in turn.

As potential sources of "non-fundamental" fluctuations in asset prices, at least two possibilities have been suggested: poor regulatory practice and imperfect rationality on the part of investors ("market psychology"). Regarding the former, Borio et al. (1994) present evidence for the view that financial reforms that dramatically increased access to credit by firms and households contributed to asset-price booms in the 1980s in Scandinavia, Japan, the Netherlands, the United Kingdom, and elsewhere. Financial liberalizations in developing countries that have opened the gates for capital inflows from abroad have also been associated in some cases with sharply rising asset values, along with booms in consumption and lending.

But aren't liberalizations a good thing? It depends. As Allen and Gale (1998) and others have emphasized, problems arise when financial liberalizations are not well coordinated with the regulatory safety net (e.g., deposit insurance and lender-of-last-resort commitments). If liberalization gives additional powers to private lenders and borrowers while retaining government guarantees of liabilities, excessive risk-taking and speculation will follow, leading, in many cases, to asset-price booms. Ultimately, however, unsound financial conditions are exposed and lending and asset prices collapse. This scenario seems to characterize reasonably well the banking crises recently experienced in a number of countries, including the United States and Japan, as well as some of the recent crises in East Asia and Latin America.

The other possible source of non-fundamental movements in asset prices that has received much attention is irrational behavior by investors, e.g., herd behavior, excessive optimism, or short-termism. There is, of course, a large amount of literature on bubbles, fads, and the like. This literature has gained a measure of credence because of the great difficulty of explaining the observed level of financial volatility by models based solely on economic fundamentals (see, for example, the recent survey by Campbell, forthcoming). Advocates of bubbles would probably be forced to admit that it is difficult or impossible to identify any particular episode conclusively as a bubble, even after the fact.[1] Nevertheless, episodes of "irrational exuberance" in financial markets are certainly a logical possibility, and one about which at least some central bankers are evidently concerned. With this concern as motivation, we present simulations of the economic effects of bubbles and of alternative policy responses to bubbles later in this paper.

The second necessary condition for asset-price volatility to be of concern to policy-makers is that booms and busts in asset markets have important effects on the real economy. Although the two-way causality between the economy and asset prices makes it difficult to obtain sharp estimates of the real effects of changes in asset prices, the historical experience—from the Great Depression of the 1930s to the most recent epidemic of crises—is supportive of the view that large asset-price fluctuations can have important effects on the economy.

What are the mechanisms? One much-cited possibility is that changes in asset prices affect consumption spending via their effects on household wealth. We are not inclined to place a heavy weight on this channel, however. Empirical studies (e.g., Ludvigson and Steindel, 1999; Parker, forthcoming) have not found a strong or reliable connection between stock market wealth and consumption, for example. This result is, perhaps, not too surprising, as much of the stock owned by households is held in pension accounts, implying that changes in stock values have relatively little direct impact on spendable cash.

Our own view is that the quantitatively most important connections between asset prices and the real economy operate through aspects of what in earlier work we have called the "balance sheet channel."[2] The world in which we live, as opposed to the one envisioned by the benchmark neoclassical model, is one in which credit markets are not frictionless, i.e., problems of information, incentives, and enforcement are pervasive. Because of these problems, credit can be extended more freely and at lower cost to borrowers who already have strong financial positions (hence, Ambrose Bierce's definition of a banker as someone who lends you an umbrella when the sun is shining and wants it back when it starts to rain).

A key implication of the existence of credit-market frictions is that cash flows and the condition of balance sheets are important determinants of agents' ability to borrow and lend. Research suggests that the effects of asset price changes on the economy are transmitted to a very significant extent through their effects on the balance sheets of households, firms, and financial intermediaries (see, for example, Bernanke, Gertler, Gilchrist, forthcoming; Bernanke and Gertler, 1995). For example, firms or households may use assets they hold as collateral when borrowing, in order to ameliorate information and incentive problems that would otherwise interfere with credit extension. Under such circumstances, a decline in asset values (for example, a fall in home equity values) reduces available collateral, leads to an unplanned increase in leverage on the part of borrowers, and impedes potential borrowers' access to credit. Financial intermediaries, which must maintain an adequate ratio of capital to assets, can be deterred from lending, or induced to shift the composition of loans away from bank-dependent sectors such as small business, by declines in the values of the assets they hold.

Deteriorating balance sheets and reduced credit flows operate primarily on spending and aggregate demand in the short run, although in the longer run they may also affect aggregate supply by inhibiting capital formation and reducing working capital. There also are likely to be significant feedback and magnification effects. First, declining sales and employment imply continuing weakening of cash flows and, hence, further declines in spending. Bernanke, Gertler, and Gilchrist (1996) refer to this magnification effect as the "financial accelerator" (see Bernanke and Gertler, 1989, for an early formalization). Second, there may also be feedback to asset prices, as declining spending and income, together with forced asset sales, lead to further decreases in asset values. This "debt-deflation" mechanism, first described by Irving Fisher (1933), has been modeled formally by Bernanke and Gertler (1989), Kiyotaki and Moore (1997), and Bernanke, Gertler, and Gilchrist (forthcoming).

A large amount of literature has studied the macroeconomic implications of credit-market frictions, both theoretically and empirically.[3] We have reviewed that body of research on several occasions and will not attempt to do so here. We note, however, that in general this perspective has proved quite useful for interpreting a number of historical episodes, including the Great Depression (Bernanke, 1983; Bernanke and James, 1991), the deep Scandinavian recession of the 1980s, the "credit crunch" episode of 1990-91 in the United States (Bernanke and Lown, 1991), and the protracted weakness of the Japanese economy in the 1990s. A number of observers (Mishkin, 1997; Aghion, Bacchetta, and Banerjee, 1999; Krugman, 1999) also have used this framework to make sense of the fact that, contrary to conventional wisdom, exchange-rate devaluations have appeared to be contractionary in a number of the developing countries that experienced financial crises in recent years. The explanation is tied to the fact that—beguiled by sometimes large interest differentials between loans made in foreign and domestic currencies—banks and corporations in these countries made liberal use of unhedged, foreign-currency-denominated debt. The large devaluations that subsequently occurred raised the domestic-currency value of these debts, wreaking havoc with bank and corporate balance sheets and inducing financial distress and major dislocations in credit, employment, and supplier relationships.

Beyond providing a mechanism via which non-fundamental movements in asset prices may disrupt the economy, a key implication of the credit-market-frictions perspective is that the magnitude of the effects of asset-price fluctuations on the economy will depend strongly on *initial financial conditions*. By the term, we mean primarily the initial state of household, firm, and intermediary balance sheets.[4] In particular, the theory predicts a highly nonlinear effect of asset prices on spending (Bernanke and Gertler, 1989). Thus, if balance sheets are initially strong, with low leverage and strong cash flows, then even rather large declines in asset prices are unlikely to push households and firms into the region of financial distress, in which normal access to credit is jeopardized, or to lead to severe capital problems for banks. Put another way, the extent to which an asset-price contraction weakens private sector balance sheets depends on the degree and sectoral distribution of initial risk exposure.

The current (1999) U.S. economy is, we conjecture, a case in point. After many years of expansion, strong profits in both the corporate and banking sectors, and enormous increases in the values of equities and other assets, U.S. balance sheets are in excellent condition. A correction in the stock market of, say, 25 percent would, no doubt, slow the economy, but our guess is that the effects would be relatively transitory, particularly if monetary policy responds appropriately. In contrast, a 25 percent decline in Japanese stock prices, given the parlous condition of its financial system and its seeming inability to implement a coherent stabilization policy, would (we expect) create grave and long-lasting problems for that economy.

If we believe that asset price swings can occur for non-fundamental reasons, and that these swings—either through balance-sheet effects or some other channel—have the potential to destabilize the real economy, then what are the implications for monetary policy? As suggested in the introduction, our view is that central banks can and should treat price stability and financial stability as consistent and mutually reinforcing objectives. In practice, we believe, this is best accomplished by adopting a strategy of flexible inflation targeting.[5]

What is flexible inflation targeting? Although specific practices differ, broadly speaking, a regime of inflation targeting has three characteristics. First, as the name suggests, under inflation targeting, monetary policy is committed to achieving a specific level of inflation in the long run, and long-run price stability is designated the "overriding" or "primary" long-run goal of policy. Importantly, inflation targeters are concerned that inflation not be too low as well as that it not be too high; avoidance of deflation is as important (or perhaps even more important) as avoidance of high inflation. Second, within the constraints imposed by the long-run inflation objective, the central bank has some flexibility in the short run to pursue other objectives, including output stabilization—hence, the nomenclature "flexible inflation targeting."[6] Third, inflation targeting is generally characterized by substantial openness and transparency on the part of monetary policy-makers, including, for example, the issuance of regular reports on the inflation situation and open public discussion of policy options and plans.

Our characterization of Federal Reserve policy in recent years is that it meets the first two parts of the definition of inflation targeting (see subsequent section on reaction functions for econometric support of this view) but not the third, i.e., the Fed practices "implicit" rather than "explicit" inflation targeting. Bernanke et al. (1999) argue that the Fed ought to take the next step and adopt explicit inflation targeting. For most of the present paper, however, we make no distinction between implicit and explicit inflation targeting; we return to the issue briefly in the conclusion.

For our purposes here, the main advantage of flexible inflation targeting is that it provides a unified framework both for making monetary policy in normal times, and for preventing and ameliorating the effects of financial crises. In particular, *a key advantage of the inflation-targeting framework is that it induces policy-makers to automatically adjust interest rates in a stabilizing direction in the face of asset-price instability or other financial disturbances*. The logic is straightforward; since asset price increases stimulate aggregate demand and asset price declines reduce it, the strong focus of inflation targeters on stabilizing aggregate demand will result in "leaning against the wind"—raising interest rates as asset prices rise and reducing them when they fall. This automatic response not only stabilizes the economy but it is likely to be stabilizing for financial markets themselves for several reasons. First, macroeconomic stability, particularly the absence of inflation or deflation, is itself calming to financial markets.[7] Second, the central bank's easing in the face of asset price declines should help to insulate balance sheets to some degree, reducing the economy's vulnerability to further adverse shocks. And, finally, if financial-market participants expect the central bank to behave in this countercyclical manner, raising interest rates when asset price increases threaten to overheat the economy and vice versa, it is possible that overreactions in asset prices arising from market psychology and other non-fundamental forces might be moderated.

The logic of inflation targeting also implies that central banks should ignore movements in stock prices that do not appear to be generating inflationary or deflationary pressures. We concede that forecasting the aggregate demand effects of asset-price movements may not always be an easy task. However, it is certainly easier than, first, attempting to distinguish between fundamental and non-fundamental fluctuations in asset prices and, second, attempting to surgically "prick" the bubble without doing collateral damage to financial markets or the economy. We explore the implications of alternative policy responses to asset-price fluctuations in greater detail in the next two sections.

Monetary policy in the presence of asset price bubbles: a quantitative model

To make the previous discussion more concrete, we will present some model-based simulations of the performance of alternative monetary rules in the presence of bubbles in asset prices. To do this, we extend a small-scale macroeconomic model developed by Bernanke, Gertler, and Gilchrist (forthcoming), henceforth BGG. For the most part, the BGG model is a standard dynamic new Keynesian model, modified to allow for financial accelerator effects, as described in the previous section. Our principal extension of the BGG model here is to allow for exogenous bubbles in asset prices.

In this section, we first provide an informal overview of the BGG model and then describe how we modify the model to allow for bubbles in asset prices. The equations of the complete model are given in the Appendix.[8] (Readers who are not interested in any of this background material may wish to skip directly to the simulation results in the next section.)

The BGG model

As noted, the foundation of the BGG model is a standard dynamic new Keynesian framework. The most important sectors are the household sector and the business sector. Households are infinitely lived; they work, consume, and save. Business firms are owned by entrepreneurs who have finite expected life.[9] There is also a government that manages fiscal and monetary policy.

Firms own the stock of physical capital, financing the acquisition of capital through internally generated funds (primarily revenues from production and capital gains on assets) and by borrowing from the public. With their accumulated capital plus hired labor, firms produce output, which may be used for consumption, investment, or government purchases. There is no foreign sector.

Following Taylor (1980), Calvo (1983), and others, BGG assume the existence of staggered nominal price setting. The resulting "stickiness" in prices allows monetary policy to have real effects on the economy. Optimization and forward-looking behavior are assumed throughout; the single exception is the Phillips curve relationship, in which inflation expectations are modeled as being formed by a combination of forward- and backward-looking behavior.[10] This modification increases the persistence of the inflation process, allowing a closer fit to the data.

The BGG model differs from this standard dynamic new Keynesian framework primarily in assuming the existence of credit-market frictions, i.e., problems of information, incentives, and enforcement in credit relationships. The presence of these frictions gives rise to a "financial accelerator" that affects output dynamics. In particular, in the BGG model, credit-market frictions make uncollateralized external finance more expensive than internal finance. This premium for external finance affects the overall cost of capital and, thus, the real investment decisions of firms. The external finance premium depends inversely on the financial condition of potential borrowers. For example, a borrowing firm with more internal equity can offer more collateral to lenders. Thus, procyclical movements in the financial condition of potential borrowers translate into countercyclical movements in the premium for external finance, which, in turn, magnify investment and output fluctuations in the BGG model (the financial accelerator).

Consider, for example, a shock to the economy that improves fundamentals, such as a technological breakthrough. This shock will have direct effects on output, employment, and the like. In the BGG model, however, there are also indirect effects of the shock, arising from the associated increase in asset prices. Higher asset prices improve balance sheets, reducing the external finance premium and further stimulating investment spending. The increase in investment may also lead to further increases in asset prices and cash flows, inducing additional feedback effects on spending. Thus, the financial accelerator enhances the effects of primitive shocks to the economy.

The financial accelerator mechanism also has potentially important implications for the workings of monetary policy. As in conventional frameworks, the existence of nominal rigidities gives the central bank in the BGG model some control over the short-term real interest rate. However, beyond the usual neoclassical channels through which the real interest rate affects spending, in the BGG model there is an additional effect that arises from the impact of interest rates on borrower balance sheets. For example, a reduction in the real interest rate (a policy easing) raises asset prices, improving the financial condition of borrowers and reducing the external finance premium. The reduction in the premium provides additional stimulus for investment. BGG find the extra “kick” provided by this mechanism to be important for explaining the quantitative effects of monetary policy. Note also that, to the extent that financial crises are associated with deteriorating private-sector balance sheets, the BGG framework implies that monetary policy has a direct means of calming such crises.

The BGG model assumes that only fundamentals drive asset prices, so that the financial accelerator serves to amplify only fundamental shocks, such as shocks to productivity or spending. Our extension of the BGG framework in this paper allows for the possibility that non-fundamental factors affect asset prices, which, in turn, affect the real economy via the financial accelerator.

Adding exogenous asset price bubbles

The fundamental value of capital is the present value of the dividends the capital is expected to generate. Formally, define the fundamental value of depreciable capital in period Q_t as:

$$\begin{aligned} Q_t &= E_t \sum_{i=0}^{\infty} [(1-\delta)^i D_{t+1+i} / \prod_{j=0}^{i} R^q_{t+1+j}] \\ &= E_t \{[D_{t+1} + (1-\delta) Q_{t+1}] / R^q_{t+1}\} \end{aligned} \tag{2.1}$$

where E_t indicates the expectation as of period δ is the physical depreciation rate of capital, D_{t+i} are dividends, and R^q_{t+i} is the relevant stochastic gross discount rate at t for dividends received in period $t+1$.

As noted, our principal modification of the BGG model is to allow for the possibility that observed equity prices differ persistently from fundamental values, e.g., because of "bubbles" or "fads."[11] We use the term "bubble" here loosely to denote temporary deviations of asset prices from fundamental values, due, for example, to liquidity trading or to waves of optimism or pessimism.[12]

The key new assumption is that the market price of capital, S_t, may differ from capital's fundamental value, Q_t. A bubble exists whenever $S_t - Q_t \neq 0$. We assume that if a bubble exists at date *t*, it persists with probability and p grows as follows[13] :

$$S_{t+1} - Q_{t+1} = \frac{a}{p} (S_t - Q_t) R^q_{t+1} \tag{2.2}$$

with $p<a<1$. If the bubble crashes, with probability 1-p, then

$$S_{t+1} - Q_{t+1} = 0 \tag{2.3}$$

Note that, because $a/p>1$, the bubble will grow until such time as it bursts. For simplicity, we assume that if a bubble crashes it is not expected to re-emerge. These assumptions imply that the expected part of the bubble follows the process

$$E_t\left(\frac{S_{t+1} - Q_{t+1}}{R^q_{t+1}}\right) = a(S_t - Q_t) \tag{2.4}$$

Because the parameter a is restricted to be less than unity, the discounted value of the bubble converges to zero over time, with the rate governed by the value of a.[14] That is, bubbles are not expected to last forever.

Using (2.1) and (2.4) we can derive an expression for the evolution of the stock price, inclusive of the bubble:

$$S_t = E_t\{[D_{t+1} + (1-\delta)S_{t+1}]/R^s_{t+1}\} \tag{2.5}$$

where the return on stocks, R^s_{t+1}, is related to the fundamental return on capital, R^q_{t+1}, by

$$R^s_{t+1} = R^q_{t+1}[b + (1-b)\frac{Q_t}{S_t}] \tag{2.6}$$

and $b \equiv a(1-\delta)$.

Equation (2.6) shows that, in the presence of bubbles, the expected return on stocks will differ from the return implied by fundamentals. If there is a positive bubble, $S_t/Q_t > 1$, the expected return on stocks will be below the fundamental return, and vice versa if there is a negative bubble, $S_t/Q_t < 1$. However, if the bubble persists (does not "pop") a series of supranormal returns will be observed. This process seems to us to provide a reasonable description of speculative swings in the stock market.

The bubble affects real activity in the extended model in two ways.

First, there is a wealth effect on consumption. Following estimates of the wealth effect presented in Ludvigson and Steindel (1999), we parameterize the model so that these effects are relatively modest (about four cents of consumption spending for each extra dollar of stock market wealth). Second, because the quality of firms' balance sheets depends on the market values of their assets rather than the fundamental values, a bubble in asset prices affects firms' financial positions and, thus, the premium for external finance.

Although bubbles in the stock market affect balance sheets and, thus, the cost of capital, we continue to assume that—conditional on the cost of capital—firms make investments based on fundamental considerations, such as net present value, rather than on valuations of capital including the bubble. This assumption rules out the arbitrage of building new capital and selling it at the market price *cum* bubble (or, equivalently, issuing new shares to finance new capital). This assumption is theoretically justifiable, for example, by the lemons premium associated with new equity issues, and also seems empirically realistic; see, e.g., Bond and Cummins (1999).

In summary, the main change effected by our extension of the BGG framework is to allow non-fundamental movements in asset prices to influence real activity. Although the source of the shock may differ, however, the main link between changes in asset prices and the real economy remains the financial accelerator, as in the BGG model.

The impact of asset-price fluctuations under alternative monetary policy rules

In this section, we use the extended BGG model to simulate the effects of asset-price bubbles and related shocks, such as innovations to the risk spread, on the economy. Our goal is to explore what types of policy rules are best at moderating the disruptive effects of asset-market disturbances. To foreshadow the results, we find that a policy rule that is actively focused on stabilizing inflation seems to work well, and that this result is reasonably robust across different scenarios.

As a baseline, we assume that the central bank follows a simple forward-looking policy rule of the form

$$r_t^n = \bar{r}^n + \beta E_t \pi_{t+1} \tag{3.1}$$

where r_t^n is the nominal instrument interest rate controlled by the central bank, $\bar{r}^n$ is the steady-state value of the nominal interest rate, and $E_t \pi_{t+1}$ is the rate of inflation expected in the next model "period." We will always assume $\beta > 1$, so that the central bank responds to a 1 percentage point increase in expected inflation by raising the nominal interest rate by more than 1 percentage point. This ensures that the real interest rate increases in the face of rising expected inflation, so that policy is stabilizing.

The policy rule given by equation (3.1) differs from the conventional Taylor Rule in at least two ways.[15] First, policy is assumed to respond to anticipations of inflation rather than past values of inflation. Clarida, Gali, and Gertler (1998, forthcoming) show that forward-looking reaction functions are empirically descriptive of the behavior of the major central banks since 1979. See also the estimates presented in the next section of this paper. The second difference from the standard Taylor Rule is that equation (3.1) omits the usual output gap term. We do this primarily for simplicity and to reduce the number of dimensions along which the simulations must be varied. There are a number of rationales for this omission that are worth brief mention, however. First, for shocks that primarily affect aggregate demand, such as shocks to asset prices, rules of the form (3.1) and rules that include an output gap term will be essentially equivalent in their effects. Second, as we will see in the next section, empirical estimates of the responsiveness of central banks to the output gap conditional on expected inflation are often rather small. Finally, assuming for simulation purposes that the central bank can actually observe the output gap with precision probably overstates the case in reality. By leaving out this term we avoid the issue of how accurately the central bank can estimate the gap.

Although we do not include the output gap in the policy rule (3.1), because of our focus on asset price fluctuations, we do consider a variant of (3.1) that allows the central bank to respond to changes in stock prices. Specifically, as an alternative to (3.1), we assume that the instrument rate responds to the once-lagged log level of the stock price, relative to its steady-state value:

$$r_t^n = \bar{r}^n + \beta E_t \pi_{t+1} + \xi \log(\frac{S_{t-1}}{S}) \tag{3.2}$$

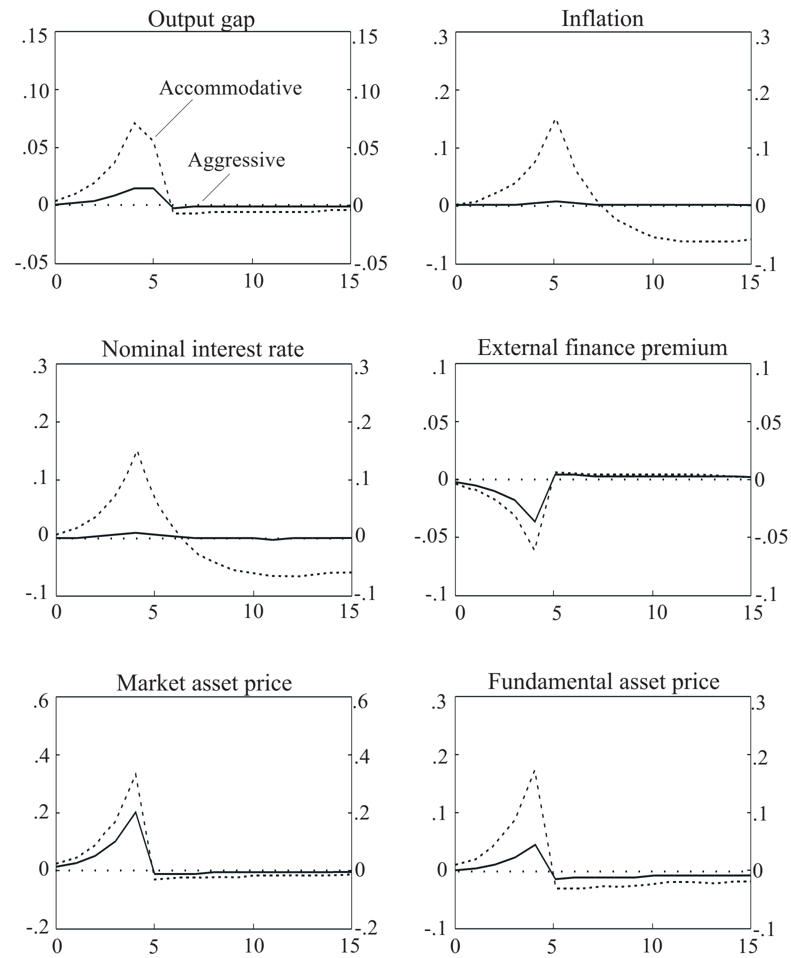
Alternative interpretations of policy rules like (3.2) are discussed in the next section.

We conducted a variety of simulation experiments, of which we here report an illustrative sampling. We begin with simulations of the effects of a stock-market bubble that begins with an exogenous 1 percentage point increase in stock prices (above fundamentals). We parameterize equation (2.4), which governs the bubble process, so that the non-fundamental component of the stock price roughly doubles each period, as long as the bubble persists.[16] The bubble is assumed to last for five periods and then burst.[17] Just before the collapse, the non-fundamental component is worth about 16 percent of the initial steady state fundamental value.

Asset bubbles with policy responding only to inflation. Chart 1 illustrates the simulated responses of the economy[18] to the bubble under two policy rules of the form (3.1): an "inflation accommodating" policy for which $\beta = 1.01$ and a more aggressive "inflation targeting" policy for which $\beta = 2.0$.[19]

As Chart 1 shows, under the accommodating policy, the bubble stimulates aggregate demand, leading the economy to "overheat." Inflation and output rise sharply. The rise in stock prices stimulates spending and output both through the balance sheet effects described earlier (notice the decline in the external finance premium in the figure, which stimulates borrowing) and through wealth effects on consumption (which are the relatively less important quantitatively). When the bubble bursts, there is a corresponding collapse in firms' net worth. The resulting deterioration in credit markets is reflected in a sharp increase in the external finance premium (the spread between firms' borrowing rates and the safe rate) and a rapid fall in output. The

Chart 1
Effects of an Asset Bubble When Monetary Policy Responds Only to Expected Inflation



Note: The panels of the chart show simulated responses of selected variables to a positive innovation to the bubble process in period zero equal to 1 percent of the steady-state fundamental price. The ex ante probability that the bubble will burst in any period is 0.5. We assume a realization in which the bubble bursts in period 5. The solid lines show responses under an aggressive monetary policy, $r_t^n = 2.0 E_t \pi_{t+1}$. The dashed lines show responses under an accommodative policy, $r_t^n = 1.01 E_t \pi_{t+1}$.

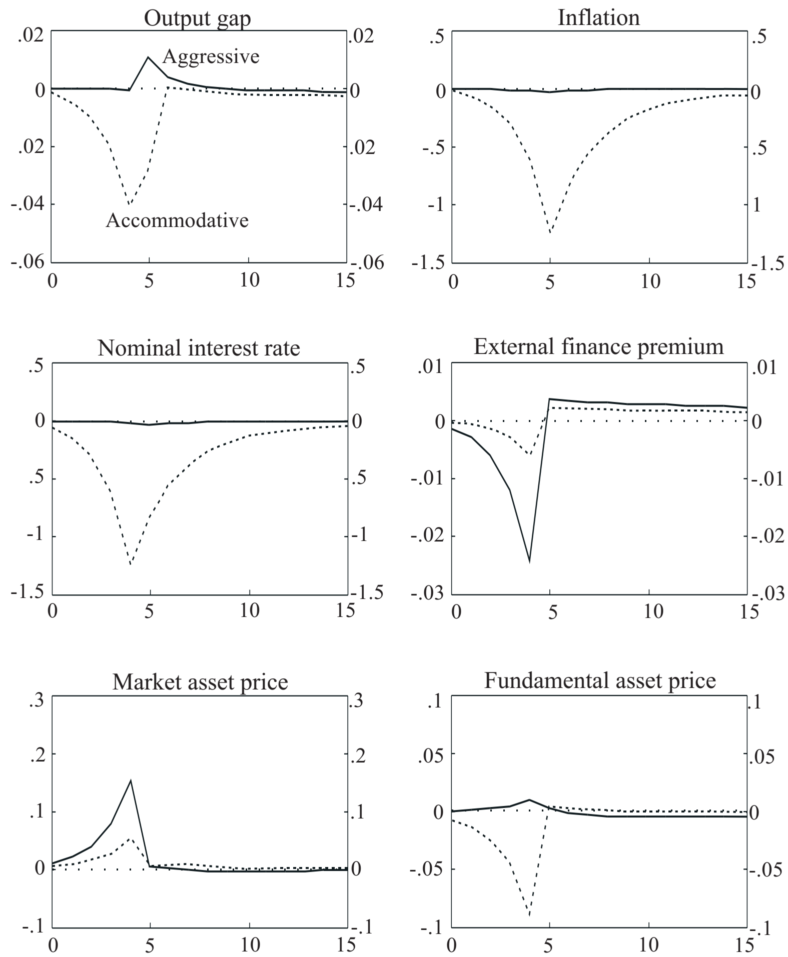
decline in output after the bursting of the bubble is greater than the initial expansion, although the "integral" of output over the episode is positive. In the absence of further shocks, output does not continue to spiral downward but stabilizes at a level just below the initial level of output. Below we consider scenarios in which the collapse of a bubble is followed by a financial panic (a negative bubble), which causes the economy to deteriorate further.

In contrast to the accommodative policy, Chart 1 shows that the more aggressive "inflation targeting" policy greatly moderates the effects of the bubble. Although policy is assumed not to respond directly to the stock market per se, under the more aggressive rule, interest rates are known by the public to be highly responsive to the incipient inflationary pressures created by the bubble. The expectation that interest rates will rise if output and inflation rise is sufficient both to dampen the response of overall asset prices to the bubble and to stabilize output and inflation—even though, *ex post*, interest rates are not required to move by as much as in the accommodative policy.

Asset bubbles with a policy response to stock prices. Chart 2 shows simulation results analogous to those in Chart 1, except that now the central bank is allowed to respond directly to stock prices as well as to expected inflation. We set the parameter in equation (3.2) equal to 0.1, implying that (for constant expected inflation) a 10 percentage-point rise in the stock market leads to a 1 percentage-point rise in the instrument rate. Of course, the full response of the short-term rate to a stock market appreciation is greater than that, because policy also responds to the change in expected inflation induced by a bubble.[20]

Chart 2 shows that the effect of allowing policy to respond to stock prices depends greatly on whether policy is assumed to be accommodating or aggressive with respect to expected inflation. Under the accommodating policy ($\beta = 1.01$), allowing a response to stock prices produces a perverse outcome. The expectation by the public that rates will rise in the wake of the bubble pushes down the fundamental component of stock prices, even though overall stock prices (inclusive of the bubble component) rise. Somewhat counter-intuitively, the rise in rates and the decline in fundamental values actually more than offset

Chart 2
Effects of an Asset Bubble When Monetary Policy Responds to Stock Prices As Well As to Expected Inflation



Note: The panels of the chart show simulated responses of selected variables to a positive innovation to the bubble process, under the same assumptions as in Chart 1. Monetary policy responds to the lagged log stock price as well as to expected inflation. The solid lines show responses under an aggressive monetary policy, $r_t^n = 2.0E_t\pi_{t+1} + 0.1s_{t-1}$. The dashed lines show responses under an accommodative policy, $r_t^n = 1.01E_t\pi_{t+1} + 0.1s_{t-1}$.

Table 1
Variability of Output Gap and Inflation Under Different Policy Rules

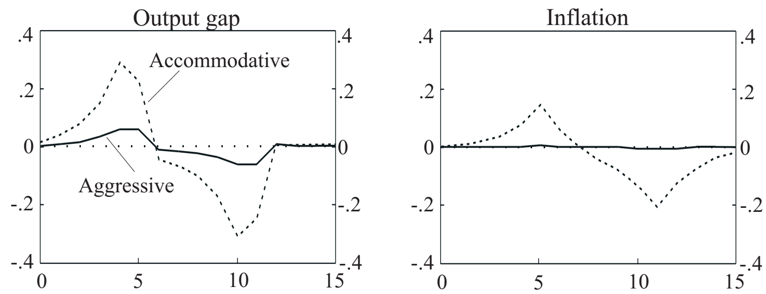
	Bubble shock		Technology shock	
Policy rule	Output gap	Inflation	Output gap	Inflation
$r_t^n = 1.01 E_t \pi_{t+1}$	2.221	9.676	1.409	17.975
$r_t^n = 2.0 E_t \pi_{t+1}$	1.471	.119	.103	.231
$r_t^n = 1.01 E_t \pi_{t+1} + 0.1 s_{t-1}$	5.908	120.032	.987	39.855
$r_t^n = 2.0 E_t \pi_{t+1} + 0.1 s_{t-1}$	1.518	1.556	.132	.767

Note: Shown are the unconditional variances of the output gap and inflation under different policy rules, for bubble shocks, and technology shocks. A new bubble starts every period, and its size is randomly drawn from a standard normal distribution. The probability that a bubble will last one, two, or three periods is, respectively, 0.5/0.875, 0.25/0.875, and 0.25/0.875, reflecting the relative probabilities of each duration when p = 0.5. Technology shocks are permanent and are randomly drawn from a standard normal distribution.

the stimulative effects of the bubble, leading output and inflation to decline—an example of the possible "collateral" damage to the economy that may occur when the central bank responds to stock prices. The result that the economy actually contracts, though a robust one in our simulations, may rely too heavily on sophisticated forward-looking behavior on the part of private-sector investors to be entirely plausible as a realistic description of the actual economy. However, the general point here is, we think, a valid one—namely, that a monetary policy regime that focuses on asset prices rather than on macroeconomic fundamentals may well be actively destabilizing. The problem is that the central bank is targeting the wrong indicator.

Under the aggressive policy ($\beta = 2.0$), in contrast, allowing policy to respond to the stock price does little to alter the dynamic responses of the economy. Evidently, the active component of the monetary rule, which strongly adjusts the real rate to offset movements in expected inflation, compensates for perverse effects generated by the response of policy to stock prices.

Chart 3
Effects of an Asset Boom
Followed by an Asset Bust



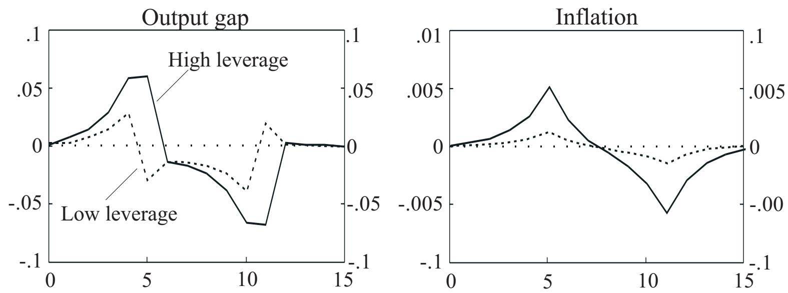
Note: Same exercise as in Chart 1, except that the positive bubble shock is followed by a symmetric negative bubble shock that lasts from periods 6 through 10. Monetary policy responds only to expected inflation.

To recapitulate, the lesson that we take from Chart 2 is that it can be quite dangerous for policy simultaneously to respond to stock prices and to accommodate inflation. However, when policy acts aggressively to stabilize expected inflation, whether policy also responds independently to stock prices is not of great consequence.

As an alternative metric for evaluating policy responses to bubbles, we also computed the unconditional variances of output and inflation under the four different policy scenarios (accommodative versus non-accommodative on inflation, responding to stock prices versus not responding). We considered bubbles lasting one, two, and three periods, weighting them in the population according to their relative likelihood of being realized (conditional on a bubble starting). The left panel of Table 1 reports the results. The table shows that a policy of focusing aggressively on inflation and ignoring stock prices does best by a significant margin, achieving the lowest unconditional variance of both output and inflation.[21]

Asset bubble then asset bust. So far in the simulations we have assumed that, after the collapse of the bubble, asset prices are again governed solely by fundamentals. With this assumption we tend to

Chart 4
The Effects of Leverage on Responses to an Asset-Price Boom and Bust



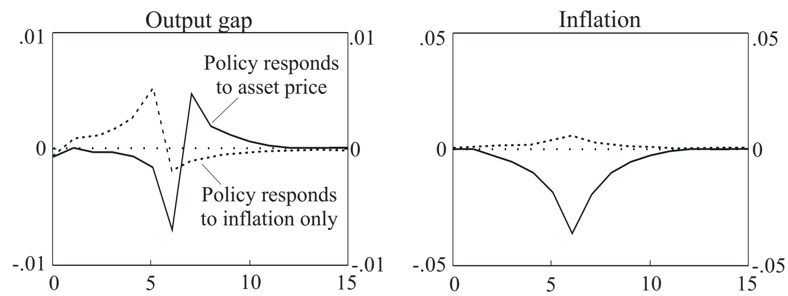
Note: Same exercise as in Chart 3, comparison of high steady-state leverage (ratio of net worth to capital of 0.5, as in baseline simulations) and low steady-state leverage (net worth-capital ratio of 0.75). Monetary policy is assumed to target expected inflation aggressively.

find that a stock-price crash wipes out the output gains from the bubble but not much more. There is only a slight overreaction in the decline in output.[22]

An alternative scenario, which may be of the greatest concern to policy-makers, is that the collapse of a bubble might damage investor confidence sufficiently to set off a panic in financial markets. We model this possibility in a simple way by assuming that the crash of the bubble sets off a negative bubble in stock prices (an undervaluation) that is exactly symmetric with the positive bubble that preceded it. This panic is unanticipated by investors before it happens. If we maintain the assumption that the initial positive bubble lasts five periods before popping, then this alternative scenario implies a ten-period "boom-bust" scenario.

Chart 3 shows simulation results under the accommodative ($\beta = 1.01$) and aggressive ($\beta = 2.0$) policy rules, and assuming no direct response of policy to stock price movements ($\xi = 0$). The positive bubble followed by the negative bubble sets off an oscillation in both financial markets and the general economy. However, the magnitude of the oscillation depends critically on the type of monetary policy

Chart 5
Responses to Stock-Price Increases Based on a Mixture of Fundamental and Non-Fundamental Forces



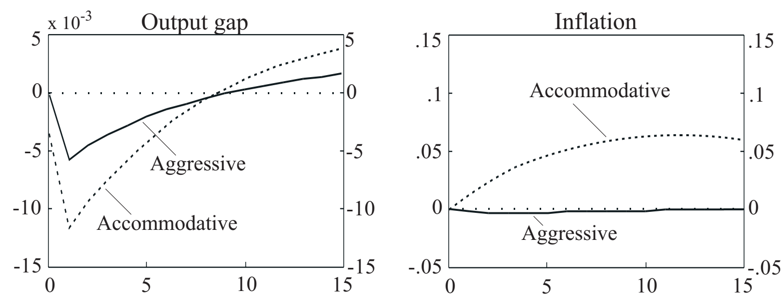
Note: The chart shows the simulated responses of selected variables to a permanent 1 percent increase in productivity followed by a five-period positive bubble. Monetary policy is aggressive in targeting inflation. The solid line shows responses when policy responds to the lagged stock prices as well as expected inflation, the dashed line shows responses when policy responds to expected inflation only.

employed. Under the accommodative policy the cycle is large, whereas the more aggressive policy significantly dampens the oscillation. By strongly targeting expected inflation, monetary policy stabilizes aggregate demand and, thus, greatly reduces the economic effects of the volatility in stock prices.

Note that in the experiment we assume that the negative asset bubble arises after the initial crash, regardless of the policy environment. However, if there is some connection between market psychology and fundamentals (e.g., markets overreact to movements in fundamentals), and if financial market participants perceive policy has been effective in stabilizing fundamentals, then perhaps the panic might not arise in the first place. Put differently, an added benefit of the aggressive policy, not accounted for in our simulations, might be to reduce the overall likelihood of the follow-on panic.

Implications of reduced leverage. As we mentioned earlier, in a model with a financial accelerator, the impact of the bubble on real activity also depends on initial financial conditions, such as the degree

Chart 6
The Effects of a Rise in the External Finance Premium



Note: Shown are responses to an exogenous 50-basis-point rise in the premium for external finance, with autoregressive coefficient 0.9. Monetary policy responds only to expected inflation. The dashed lines show variable responses under accommodative monetary policy, the solid lines show responses under aggressive monetary policy.

of leverage among borrowers. Chart 4 explores the impact of a lower steady-state leverage ratio, 25 percent instead of 50 percent as in the baseline scenario. The chart shows that a reduction in leverage significantly moderates the cycle. Besides its reaffirmation of the superiority of inflation-focused monetary policy, this simulation also suggests a rationale for regulatory and tax policies that discourage excessive leverage.

Asset-price fluctuations arising from a mixture of fundamental and non-fundamental sources. We saw in Chart 2 that allowing monetary policy to respond to asset prices can be destabilizing, particularly if policy is accommodative of inflation. The costs of targeting asset prices are probably greater in practice than suggested by the bubble scenario of Chart 2, because it is quite difficult or impossible for the central bank to discern whether changes in asset prices reflect fundamental forces, non-fundamental forces, or a combination of both. To the extent that asset price movements reflect fundamental forces, they should be accommodated rather than resisted. Attempts to "stabilize" asset prices in that case are directly counterproductive.

Table 2
Federal Reserve Reaction Functions

	β	γ	ρ_1	ρ_2	ξ	π^*
Baseline[1]	1.60 (.15)	.14 (.04)	1.27 (.02)	-.34 (.02)	–	2.88
Adding stock returns[2]	1.71 (.23)	.20 (.07)	1.27 (.02)	-.33 (.02)	-.082[3] (.37)	2.79
Sample period: 79:10 - 97:12						

Note: The dependent variable is the federal funds rate. The output gap is measured as the residuals from a regression of industrial production on time and time squared for the period 1960:1-1998:12. Estimates are by G.M. with correction for MA(12) autocorrelation. The optimal weighting matrix is obtained from first-step 2SLS parameter estimates. χ^2 Tests for overidentifying restrictions are easily passed ($p > 0.95$) in all specifications.

[1] The instrument set includes a constant, plus lags 1-6, 9, and 12 of log-differenced commodity prices (Dow-Jones), log-differenced CPI, log-differenced output gap, and the federal funds rate.
[2] The instrument set is the same as above plus lags 1-6 of the log-differenced change in stock prices.
[3] Sum of the coefficients on lags 0-5 inclusive of the log-differenced change in stock prices. The reported standard error is for the sum of the coefficients. The p-value for the hypothesis that all six coefficients are equal to zero is 0.021.

To illustrate these issues, we consider a scenario in which improvements in productivity generate a rise in market fundamentals, as well as increasing potential output. However, a euphoric response to the fundamental boom also sets off a bubble. Specifically, we suppose that there is a 1 percent permanent increase in productivity that is followed one period later by the inception of a stock-price bubble, which we again assume lasts for five periods. Chart 5 shows the results, comparing an aggressive inflation stabilization policy with one that also allows for responses to stock prices. As the chart shows, in this scenario, tightening policy in response to the increase in asset prices prevents output from rising by the amount of the increase in potential output. In other words, responding to the rise in asset prices has the undesirable effect of temporarily stifling the beneficial impact of the technology boom.

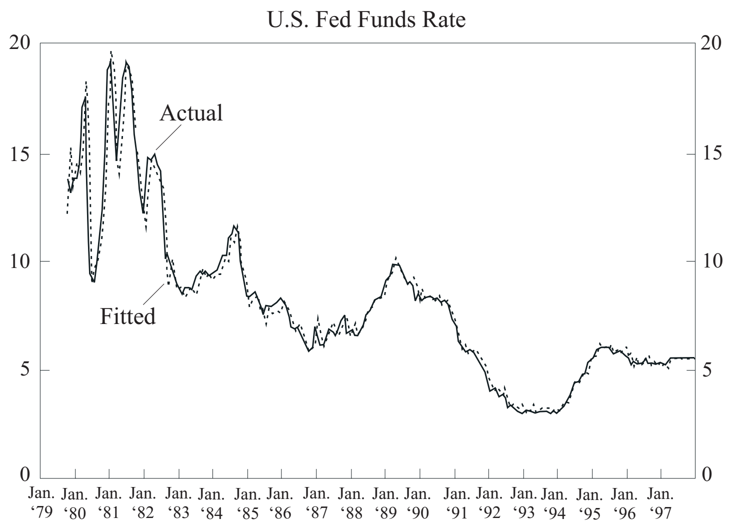
Table 3
Bank of Japan Reaction Functions

	β	γ	ρ_1	ξ	π^*
Baseline[1]	2.21 (.23)	.20 (.05)	.95 (.006)	–	1.73
Adding stock returns[2]	2.25 (.29)	.21 (.05)	.95 (.006)	-.006[3] (.099)	1.88
Sample period: 79:04 - 97:12					
Baseline[1]	2.00 (.22)	.33 (.11)	.95 (.006)	–	2.12
Adding stock returns[2]	1.85 (.21)	.39 (.11)	.96 (.004)	-0.286[3] (.111)	1.59
Sample period: 79:04 - 89:06					
Baseline[1]	1.12 (.15)	.30 (.02)	.94 (.004)	–	-3.39
Adding stock returns[2]	1.24 (.13)	.30 (.02)	.95 (.003)	.188[3] (.035)	-1.56
Sample period: 89:07 - 97:12					

Note: The dependent variable is the call rate. The output gap is measured as the residuals (forecast errors, after 1989:6) from a regression of industrial production on time and time squared for the period 1968:1-1989:6. Estimates are by GMM with correction for MA(12) autocorrelation. The optimal weighting matrix is obtained from first-step 2SLS parameter estimates. χ^2 tests for overidentifying restrictions are easily passed ($p > 0.95$) in all specifications.

[1] The instrument set includes a constant, plus lags 1-6, 9, and 12 of log-differenced commodity prices (IMF), log-differenced CPI, log-differenced output gap, and log-differenced real yen-dollar exchange rate, and the call rate.
[2] The instrument set is the same as above plus lags 1-6 of the log-differenced change in stock prices.
[3] Sum of the coefficients on lags 0-5 inclusive of the log-differenced change in stock prices. The reported standard error is for the sum of the coefficients. The p-value for the hypothesis that all six coefficients are equal to zero is 0.020 for the full sample, 0.000 for both the 79:04 - 89:06 and 89:07 - 97:12 subsamples.

Chart 7
Actual and Fitted Values of the U.S. Federal Funds Rate

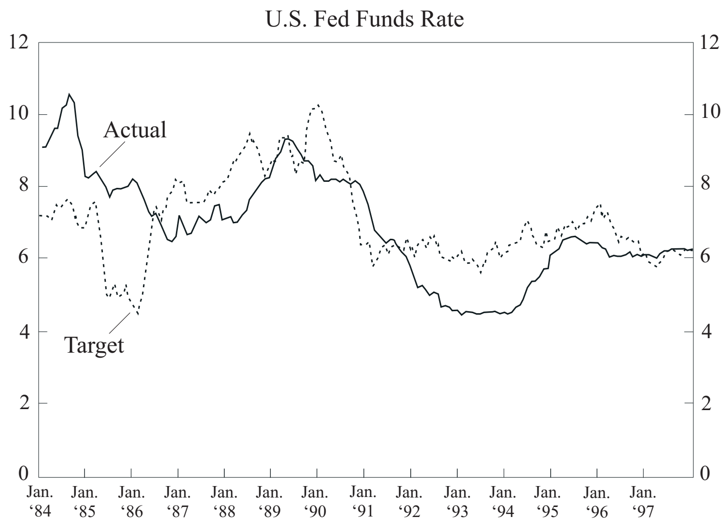


Note: The chart shows actual and fitted values of the U.S. federal funds rate, with fitted values derived from a model that accommodates lagged adjustment of the actual rate to the target rate.

We explore the issue a bit further by calculating the unconditional variability of the output gap (output minus potential output) under the four different policy scenarios, assuming in this case that only a productivity shock has buffeted the economy.[23] The right panel of Table 1 reports the results. As with the case of bubble shocks, the results indicate that the policy that responds aggressively to inflation and does not target stock prices works best.

A shock to the external finance premium. The last scenario we consider is a disruption of financial markets that temporarily tightens credit conditions. A real-world example is the default on Russian bonds in the fall of 1998 that induced significant capital losses for key bank creditors and drove up premiums on long-term corporate bonds.[24] The analogue in our model is a shock that drives up the pre-

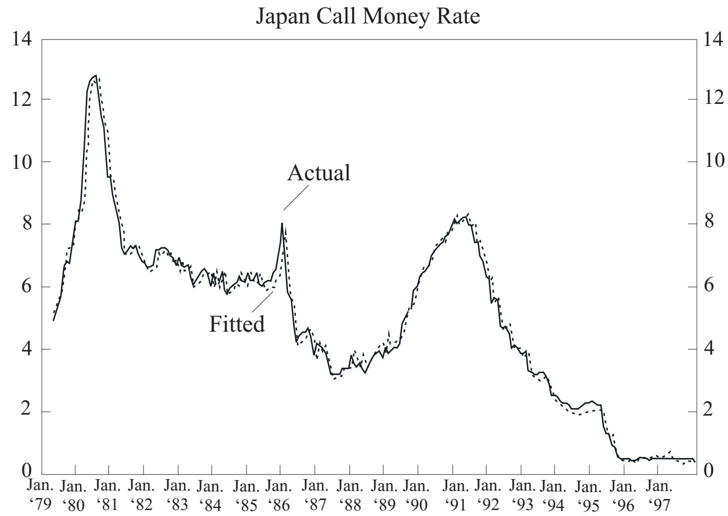
Chart 8
Actual and Target Values of the U.S. Federal Funds Rate



Note: The chart shows actual and fitted values of the U.S. federal funds rate. Estimated target values make no allowance for the lagged adjustment of the interest rate.

mium for external finance, holding constant firm balance-sheet positions. Formally this can be modeled as a decline in the efficiency of the financial intermediation process (see Bernanke, Gertler, and Gilchrist, forthcoming). Chart 6 shows the responses of output and inflation to an exogenous 50-basis-point rise in the external finance premium, under both the aggressive and accommodative policy rules (it is assumed here that policy does not respond to asset prices). The chart shows clearly that the aggressive policy response works best. We believe that this experiment helps to provide a rationale for the Fed's intervention in the fall of 1998. Basically, because the rise in the spread observed at that time had a potentially deflationary effect on the economy, it was appropriate to ease policy in response.

Chart 9
Actual and Fitted Values of the Japanese Call Money Rate



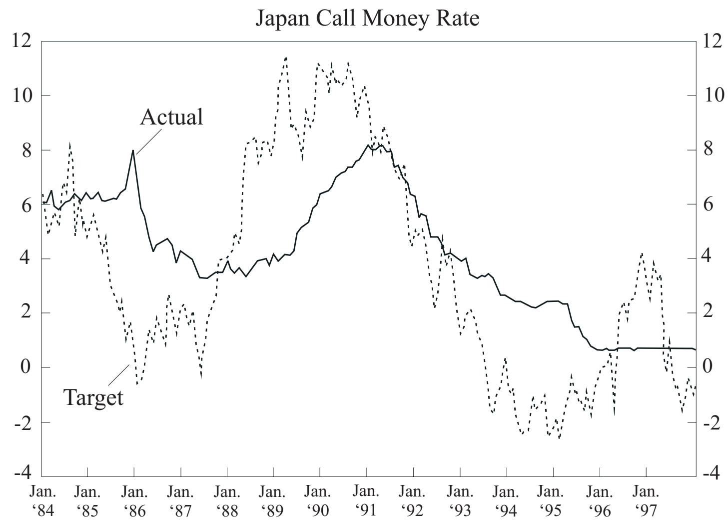
Note: Comparison of the actual and fitted values of the Japanese call money rate, analogous to Chart 7.

Estimated reaction functions for the Federal Reserve and the Bank of Japan

The previous section considered the stabilizing properties of various hypothetical interest rate rules for central banks. These experiments raise the question of what rules (reaction functions) best describe the actual practice of contemporary central banks. In practice, do central banks react to forecasts of inflation and the output gap in a stabilizing manner? And do they react to stock prices, over and above the reaction to stock prices implied by the pursuit of output and inflation stabilization?

In this section we apply the methods of Clarida, Gertler, and Gali (1998, forthcoming), henceforth CGG, to estimate forward-looking reaction functions for the Federal Reserve and the Bank of Japan for the period since 1979. To preview the results, we find that the Fed has

Chart 10
Actual and Target Values of the Japanese Call Money Rate



Note: Comparison of the actual and estimated target values of the Japanese call money rate, analogous to Chart 8.

largely followed our advice over the past two decades, reacting in a strongly stabilizing manner to changes in the inflation forecast and the expected output gap but, for the most part, not reacting to changes in stock prices (except to the extent that they contain information about inflation and output). The record of the Bank of Japan is less satisfactory by our estimates. We find that easy monetary policy in Japan actively fueled the increase in stock prices during the 1987-89 period. After the stock market crashed in 1990, Japanese monetary policy appeared to make some attempt to support stock prices but failed to react sufficiently aggressively to the declining rate of inflation. Consequently, Japanese monetary policy was too tight from late 1992 at least until the beginning of 1996. To some extent, it should be noted, these problems reflected the very slow rate of adjustment of nominal interest rates in the face of changing macroeconomic conditions.

CGG's approach, which we follow here, is to estimate forward-looking reaction functions of the form

$$r_t^* = \bar{r} + \beta E_t(\pi_{t+12} - \pi^*) + \gamma E_t(y_t - y_t^*) + \xi E_t z_t \quad (4.1)$$

where r_t^* is the targeted value of the nominal instrument rate (the federal funds rate for the United States, the call rate for Japan); $\bar{r}$ is the long-run equilibrium nominal rate; $E_t(\pi_{t+12} - \pi^*)$ is the expected deviation of inflation from its target rate over the next twelve months; $E_t(y_t - y_t^*)$ is the contemporaneous value of the output gap, conditional on information available to the central bank at time t; and z_t represents other variables that may affect the target interest rate. We expect the parameters β and γ to be positive. CGG point out that stabilization of inflation further requires $\beta > 1$, i.e., for the real interest rate to rise when expected inflation rises, the nominal interest rate must be raised by more than the increase in expected inflation. In practice, values of β for central banks with significant emphasis on inflation stabilization are estimated to be closer to 2.0. Values less than 1.3 or so indicate a weak commitment to inflation stabilization (at these values of β the real interest rate moves relatively little in response to changes in expected inflation).

Because of unmodeled motives for interest-rate smoothing, adjustment of the actual nominal interest rate toward its target may be gradual. CGG allow for this by assuming a partial adjustment mechanism, e.g.,

$$r_t = (1 - \rho) r_t^* + \rho r_{t-1} + \upsilon_t \quad (4.2)$$

where r_t is the actual nominal interest rate and $\rho \in [0,1)$ captures the degree of interest-rate smoothing. Below, we follow CGG in assuming a first-order partial adjustment mechanism, as in equation (4.2), for Japan and a second-order partial adjustment mechanism for the United States.

To estimate the reaction function implied by equations (4.1) and

(4.2), CGG replace the expectations of variables in equation (4.1) with actual realized values of the variables, then apply an instrumental variables methodology, using as instruments only variables known at time *t*-1 or earlier. Under the assumption of rational expectations, expectational errors will be uncorrelated with the instruments, so that the IV procedure produces consistent estimates of the reaction function parameters.[25]

Estimation results are shown in Table 2 for the Federal Reserve and Table 3 for the Bank of Japan. Following CGG, we begin the U.S. sample period in 1979:10, the date of the Volcker regime shift, and the Japanese sample period in 1979:04, a period CGG refer to as one of "significant financial deregulation." The end date in each case is 1997:12 (our data end in 1998:12 but we must allow for the fact that one year of future price change is included on the right-hand side).[26] We also look at two sub-samples for Japan, the periods before and after 1989:6. It was at the end of 1989 that increases in Bank of Japan interest rates were followed by the collapse of stock prices and land values.

For each country and sample period, the tables report two specifications. As in CGG, the baseline specification shows the response of the target for the instrument interest rate to the expected output gap and expected inflation. The second, alternative specification adds to the reaction function the current value and five lags of the log-difference of an index of the stock market (the S&P 500 for the United States and the TOPIX index for Japan). To help control for simultaneity bias, we instrument for the contemporaneous log-difference in the stock market index. In particular, we add lags 1 through 6 of the log-difference of the stock market index to our list of instruments (see endnote 20). Note, therefore, that in these estimates, the responses of policy to stock market returns arising from the predictive power of stock returns for output and inflation are fully accounted for. Any estimated response of policy to stock returns must therefore be over and above the part due to the predictive power of stock returns.

There are two ways to think about the addition of stock market returns to the reaction function. The first is to interpret it literally as saying that monetary policy is reacting directly to stock prices, as well as to the output gap and expected inflation. The second is to treat the addition of stock returns as a general specification test that reveals whether monetary policy is pursuing other objectives besides stabilization of output and expected inflation. To the extent that policy has other objectives, and there is information about these objectives in the stock market, then we would expect to see stock returns enter the central bank's reaction function with a statistically significant coefficient.

For the United States, the estimates of the baseline reaction function (first line of Table 2) indicate that during the full sample period the Fed responded reasonably strongly to changes in forecasted inflation ($\beta = 1.60$). It also reacted in a stabilizing manner to forecasts of the output gap ($\gamma = 0.14$). Both parameter estimates are highly statistically significant. The CGG procedure also permits estimation of the implied target rate of inflation (see their paper). For the United States, the estimated target inflation rate for the full period is 2.88 percent per year. Chart 7 shows that the actual and fitted values of the federal funds rate are very close for the full sample period.[27]

In the results reported in the second line of Table 2, we allow for the possibility that the Fed responded to stock market returns (or to information contained in stock market returns) independently of their implication for forecasts of inflation and the output gap. The estimated response of the funds rate to stock returns, -0.08, is relatively small, the "wrong" sign (if we think of the Fed as being tempted to try to stabilize stock prices), and statistically insignificant. Other parameter estimates are largely unchanged from the baseline specification. The force of these estimates is that, consistent with the advice we give in this paper, the Fed has focused its attention on expected inflation and the output gap and has neither actively sought to stabilize stock prices nor reacted to information in stock returns other than that useful for forecasting the output gap and inflation.

To help put the Fed's behavior into its historical context, Chart 8 shows the actual value and the estimated target value of the federal funds rate for the period January 1984 to the present. The target value differs from the fitted value in that the latter incorporates the interest-rate smoothing parameters and the former implicitly sets these to zero, i.e., the target value is the interest rate given by equation (4.1). For this figure, the target value at each date is calculated assuming that the Fed had perfect knowledge of the current output gap and inflation over the next year. We do this in order to concentrate on intentional deviations of policy from the average reaction function, as opposed to deviations driven primarily by forecast errors. Because the target value abstracts from the interest-rate smoothing motive, there is a tendency for the actual rate to lag somewhat behind the target. Nevertheless, Chart 8 suggests that the Fed's actual choice of short-term rates followed target rates reasonably closely.

There are, however, three periods of deviation of the actual fed funds rate from the target rate in Chart 8 that deserve comment. First, as was much remarked at the time, the Fed did not ease policy in 1985-86, even though a sharp decline in oil prices reduced inflation during those years.[28] The view expressed by some contemporary observers was that the Fed made a conscious decision in 1986 to enjoy the beneficial supply shock in the form of a lower inflation rate rather than real economic expansion. However, it is also likely that much of the decline in inflation in 1986 was unanticipated, contrary to the perfect foresight assumption made in constructing the figure. If true, this would account for much of the deviation of actual rates from target in 1985.

Second, the Fed kept rates somewhat below target in the aftermath of the 1987 stock market crash. Again, forecasting errors may account for this deviation. The Fed was concerned at the time that the depressing effects of the crash would be larger than, in fact, they turned out to be.

Finally, and most interesting to us, the Fed kept the funds rate significantly below target from late 1991 until the beginning of 1995. This was a period of slow recovery from the 1990-91 recession, which Fed officials argued was caused by financial "headwinds," such as excessive corporate leverage and bank capital problems. We interpret the 1991-95 easing as being consistent with our advice, in that the Fed was concerned about financial conditions not for themselves but primarily for their implications for the macroeconomy.[29] In the event, though, it appears that the Fed eased by more than necessary in this period.[30, 31]

We turn now to the case of Japan. For the entire sample period, estimates of the Bank of Japan's reaction function (Table 3) look qualitatively similar to those found for the Fed. For the whole 1979-1997 period, we estimate that the Bank of Japan responded actively to both expected inflation ($\beta = 2.21$) and to the output gap ($\gamma = 0.20$). The equation also fits the data quite well (Chart 9).[32] However, inspection of the data suggests two very different economic and policy regimes during this period: the so-called "bubble economy" of the 1980s, during which the economy and asset prices boomed, and the period since 1990 during which asset prices have collapsed and the economy has been extremely weak. Accordingly, and keeping in mind the problems inherent in estimation based on small samples, we re-estimated the Bank of Japan's reaction function for the period before and after 1989:06. The date was chosen to separate the periods before and after the accession of Governor Mieno, who instigated a significant policy tightening at the end of 1989.

Table 3 shows that, for the first half of the sample period, the Bank of Japan remained committed to stabilization of inflation ($\beta = 2.00$ in the baseline specification, $\beta = 1.85$ in the specification including stock returns). However, the specification including stock returns also shows that, wittingly or unwittingly, the Bank of Japan was also strongly reinforcing the asset price explosion. The estimated reaction of the Japanese call rate to stock returns during the past six months is –0.286 in the first half of the sample, with a standard error of 0.111. This says that each 10 percent increase in stock prices was associated with a 286-basis-point *decline* in the call rate—a number too large to be taken seriously, but an indication that policy was destabilizing toward the stock market prior to 1989. As noted, we do not necessarily interpret these results as saying that the Bank was actively attempting to raise stock prices. But it does seem that the Bank was pursuing objectives other than output and inflation stabilization (exchange rates?) which led it to ease excessively, and the stock market reflected that ease.[33]

For the second half of the sample, the results are much different. As the bottom third of Table 3 indicates, after 1989 the Bank of Japan greatly weakened its commitment to inflation stabilization ($\beta = 1.12$ in the baseline stabilization). We interpret the low estimated value of β, together with the negative estimated values of the inflation target, as indicating that the Bank was not actively resisting the powerful deflationary forces of this period. However, our estimates suggest that the Bank may have been attempting to stabilize the stock market, or some other factor proxied by the stock market; the estimated reaction of the call rate to stock market returns switches from the large negative value in the earlier subsample to a large and highly significant positive value ($\xi = 0.188$). From the perspective of the arguments advanced in this paper, the Bank of Japan would have done better to focus instead on stabilizing the inflation rate (in this case, preventing the plunge into deflation) than in responding to other factors.

Again, a picture helps to provide historical context. In analogy to Chart 8, Chart 10 shows the actual call money rate and the estimated target rate in Japan after 1984. In this case, unlike in Chart 8, we calculate the target rate using the reaction function estimated for the pre-1989:07 sample, without stock returns. This reaction function seems the right one to use as a benchmark because it implies strongly stabilizing monetary policy, as suggested by the simulations in the previous section. Thus, the target rate for the post-1989 period in Chart 10 indicates what policy would have been if the earlier policies had been continued, with no attention paid to stock returns (except as forecasters of the output gap and inflation).

The results are, again, quite interesting. The target rate in Japan changed sharply during several episodes, and—possibly as a result of an excessive attachment to interest-rate smoothing—the actual call rate lagged far behind. Chart 10 suggests that policy was, on the whole, rather tight in Japan during the 1985-87 period, despite the easing that followed the Plaza Agreement of September 1985. From 1987-89, however, Japan faced strong inflationary pressures (including rocketing asset prices and rapid real growth), to which the Bank of Japan responded extremely slowly.[34] No doubt, it is this period that is responsible for our estimated result that monetary policy actively destabilized the stock market in the pre-1990 period.

Rates began to rise sharply following the appointment of Governor

Mieno in December 1989, and continued to rise until the spring of 1991. The rate increase was undertaken with the intention of curbing the stock market and—like many other attempts to prick market bubbles, including the U.S. boom in 1929—the attempt was too successful for the good of the economy. Asset prices collapsed; and because Japan's financial arrangements were particularly sensitive to asset values (we would argue), the real economy collapsed as well.

Our estimates of the Bank of Japan's reaction function for the second half of the sample suggest two countervailing forces. On one hand, there was now some attempt to stabilize the stock market, or some factor proxied by the stock market, by cutting rates as the market fell. On the other hand, the Bank of Japan's commitment to stabilizing inflation (here, resisting deflation) seems to have become much weaker. The net effect was policy that was significantly too tight, at least until the beginning of 1996.[35]

We do not want to overstate the conclusions that can be drawn from this short comparison of U.S. and Japanese monetary policy since the mid-1980s. The comparative experience is at least suggestive, however, that focusing on the traditional goals of monetary policy—the output gap and expected inflation—is the more effective means of avoiding extended swings in asset prices and the resulting damage to the economy.

Conclusion

In order to explore the issue of how monetary policy should respond to variability in asset prices, we incorporated non-fundamental movements in asset prices into a dynamic macroeconomic framework. To a first approximation at least, we believe that our framework captures the main concerns that policy-makers have about possible bubbles in asset prices. In particular, in our model, a large positive bubble exposes the economy to the risk of a sharp market correction, with adverse effects on aggregate demand and economic activity. In the absence of an appropriate policy response, the resulting economic contraction could be quite large. A severe market drop in our model also weakens balance sheets, induces financial distress, leads to further declines in asset prices, and widens spreads in bond markets. Although our framework omits some of the microeconomic details of episodes of stress (e.g., non-price credit rationing, reduced liquidity of financial markets), and, hence, is silent about certain types of lender-of-last-resort interventions that the central bank might undertake, we believe that these omissions are unlikely to affect our central conclusions about aggregate stabilization policy.[36]

The principal conclusion of this paper has been stated several times. In brief, it is that flexible inflation-targeting provides an effective, unified framework for achieving both general macroeconomic stability and financial stability. Given a strong commitment to stabilizing expected inflation, it is neither necessary nor desirable for monetary policy to respond to changes in asset prices, except to the extent that they help to forecast inflationary or deflationary pressures.

A couple of additional issues deserve very brief comment. First, our implicit focus in this paper has been on large industrial economies such as the United States and Japan. However, many of the recent financial crises around the world have occurred in small open economies, with international capital flows and attacks on the currency playing major roles. What lessons does our analysis bear for these countries?

More work would need to be done to extend our model to the open-economy case, and to include other sources of financial crisis, such as speculative attacks on the currency and bank runs. Such an extension would be worthwhile, we believe, because it seems to us that balance-sheet effects of the type captured in the BGG model have played an important role in propagating the effects of financial crises through the real economy. Although we have not yet done such an extension, one likely conclusion from such an exercise seems obvious enough and important enough to be worth stating now, that is: The logic of our approach suggests strongly that fixed exchange rates, as maintained by many of the countries recently hit by financial crises, are highly undesirable in a financially fragile environment.

The key problem with an exchange-rate peg is that its defense generally requires movements in interest rates that are *perverse*, relative to the objective of containing a financial crisis. In particular, the large increases in interest rates necessary to avert devaluation during a currency crisis exacerbate financial crises both directly, by depressing asset prices, reducing corporate profits, and putting pressure on banks, and also indirectly, by slowing current and expected rates of economic activity. In addition, fixed-exchange-rate regimes severely limit the short-run discretion of the central bank, either to assist the financial system (for example, through lender-of-last-resort activities) or to correct short-term imbalances in the economy.

Indeed, the record of fixed-exchange regimes in regard to the incidence and severity of financial crises is notoriously bad.[37] During the Great Depression currency crises (possible, of course, only if the exchange rate is fixed), banking panics, and stock market crashes frequently occurred together. Indeed, to the best of our knowledge, every one of the dozens of major banking panics of that era occurred in a country that was attempting to defend a fixed rate (its gold parity). For the postwar period, in a study spanning the 1970s through the 1990s, Kaminsky and Reinhart (1999) document that banking and currency crises frequently occurred together and appeared to be mutually reinforcing. The strong observed association between fixed exchange rates and financial crises appears to be weakened only under two conditions: First, if international capital flows are highly regulated and restricted, as was the case, for example, during the Bretton Woods era; or second, if the international monetary system is cooperatively managed by the major central banks, as was arguably the case during the classical gold standard of the late nineteenth century (Eichengreen, 1992). Neither of these conditions prevails today.

So, what should small open economies do? Our analysis suggests that, *if possible*, they adopt flexible inflation targeting as part of a broad reform package that includes improved financial regulation and fiscal reform.[38] (Brazil has recently proposed a plan along these lines.) The last part of the recommendation bears emphasis: Change in the monetary regime alone, without support from the regulatory and fiscal arms of government, is not likely to be sufficient. Moreover, we recognize that successful implementation of inflation targeting requires both ample political support from the government and a certain amount of institutional development, e.g., the existence of adequate price indexes (see Eichengreen et al, 1999). With these caveats, we recommend that small open economies head in an inflation-targeting direction. Note that, along with providing enhanced macroeconomic and financial stability, a commitment to an inflation-targeting approach by a small open economy could well deliver greater long-run stability of the nominal exchange rate than a regime that attempts to fix the exchange rate but suffers frequent forced devaluations.

A second broad issue not yet addressed here concerns the difference between implicit inflation targeting, of the type practiced by the Greenspan Fed, and explicit inflation targeting, which involves considerable additional transparency and communication with the public. It is evident from recent U.S. experience that implicit inflation targeting can give good results, and, indeed, our simulations help to show why a strong focus on stabilizing expected inflation promotes overall macroeconomic and financial stability. We, nevertheless, believe that the United States would benefit from a move to explicit inflation targeting, for at least two reasons (see Bernanke et al, 1999, for further discussion). First, making inflation targeting explicit would serve the important goal of ensuring continuity in monetary policy, or at least of increasing the likelihood that future policy would take the same general approach as recent policy has taken. In particular, if the inflation-targeting regime were made explicit, the transition from the current chairman to the next one would create less anxiety in financial markets and for the economy than otherwise. Second, transparency enhances the stabilizing properties of forward-looking policies. In particular, in the simulations reported in this paper we implicitly assumed transparency of policy, in that private-sector actors were assumed to know the policy rule. The results might be very different if, for example, we assumed that private agents thought the central bank was following the accommodative rule when, in fact, it was following the more aggressive inflation-targeting policy. Likewise, much of the stabilizing effect of our recommended policy arises because investors expect the central bank to raise interest rates when rising asset prices threaten to overheat the economy, and vice versa if declining asset prices threaten to induce an economic contraction. From the standpoint of maintaining both macroeconomic and financial stability in the future, the desirability of increased transparency in U.S. monetary policy-making is a topic deserving of close attention in the Fed's planning.

Appendix
Equations of the Simulation Model

The model used for simulations in the third section of this paper is given and briefly described below. To conserve space, we do not review the individual and firm optimization problems that underlie the behavioral equations and, instead, refer the reader to Bernanke, Gertler, and Gilchrist (forthcoming) for details. What we present here is the log-linearized versions of the model equations that were used in the simulations. Except for the addition of an exogenous bubble in the asset price, the model is essentially the same as in BGG. The only other significant differences are that we use Gali and Gertler's (forthcoming) variant of the new Keynesian Phillips curve and that we calibrate the wealth effects on consumption to match the evidence presented by Ludvigson and Steindel (1999).

Throughout, we follow the convention of writing steady-state levels of the variables in upper case and log-deviations from the steady state in lower case. Greek letters and lower-case Roman letters without subscripts denote fixed parameters, and subscripts denote time periods. The expectation given information known as of period s of the value of variable x in period r is written $E_s x_r$.

Aggregate demand

(A.1) $$y_t = \frac{C}{Y} c_t + \frac{C^e}{Y} c_t^e + \frac{I}{Y} i_t + \frac{G}{Y} g_t$$

(A.2) $$c_t = -\sigma r_t + E_t c_{t+1}$$

(A.3) $$c_t^e = s_t + k_{t+1}$$

(A.4) $$E_t q_{t+1} = \varphi (i_{t+1} - k_{t+1})$$

Equation (A.1) is the log-linearized version of the national income identity. We distinguish between consumption of households, C, and consumption of entrepreneurs/firm-owners, C^e; otherwise, the notation is standard. (A.2) is the usual Euler condition for household consumption. (A.3) embodies the assumption that changes in entrepreneurial consumption are proportional to changes in stock values; in the simulations we normalize entrepreneurs' net worth so that the elasticity of entrepreneurial consumption to stock market wealth is about 0.04, as suggested by estimates in Ludvigson and Steindel (1999). (A.4) relates investment to the fundamental value of capital, embodying a one-period delay for planning new investment.

Returns to stocks and capital

(A.5) $$s_t - q_t = \frac{(1-\delta)}{bR^q} E_t(s_{t+1} - q_{t+1})$$

(A.6) $$r_t^q = (1-\vartheta)(mc_t + y_t - k_t) + \vartheta q_t - q_{t-1}$$

(A.7) $$r_t^s = (1-\vartheta)(mc_t + y_t - k_t) + \vartheta s_t - s_{t-1}$$

(A.8) $$E_t r_{t+1}^s = E_t r_{t+1}^q - (1-b)(s_t - q_t)$$

(A.9) $$E_t r_{t+1}^s = r_t - \psi(n_t - s_t - k_{t+1})$$

Equation (A.5) describes the expected evolution of the bubble, cf. (2.4) and recall $a \equiv b/(1-\delta)$. Note that the realized value of the bubble, conditional on not bursting, is defined by

$$s_{t+1} - q_{t+1} = \frac{R^q}{p(1-\delta)}(s_t - q_t).$$

Equation (A.6) defines the fundamental return to capital as the sum of the current return to capital and the increase in fundamental value, where *mc* is the marginal cost of production (equal to the inverse of the markup) and

$$\vartheta = (1-\delta)/(\tfrac{\alpha Y}{K} + 1 - \delta)$$

where α is capital's share. (A.7) defines the returns to stocks analogously. (A.8) shows that the relationship between the stock return and the fundamental return depends on the presence of the bubble; cf. (2.6). Equation (A.9) links the spread between safe returns and stock returns to firm leverage, where n is the log-deviation of firms' internal equity from its steady-state value.

Aggregate supply

(A.10) $$y_t = z_t + \alpha k_t + (1-\alpha) l_t$$

(A.11) $$y_t - l_t + mc_t - c_t = (\chi - 1) l_t$$

(A.12) $$E_{t-1}\pi_t = \kappa\, mc_t + \theta_f E_t \pi_{t+1} + \theta_b \pi_{t-1}$$

Equation (A.10) is a Cobb-Douglas production function, where z is the log-deviation of total factor productivity from its steady-state value and l is labor input. (A.11) is the first-order condition for households' labor-leisure decision, where χ is a parameter of the utility function (we assume log utility so that the coefficient on consumption in (A.11) is one). (A.12) describes the evolution of inflation when prices are changed stochastically as in Calvo (1983) and a subset of firms use rule-of-thumb pricing as in Gali and Gertler (forthcoming). If $\theta_f = 1$ and $\theta_b = 0$ then (A.12) is the fully rational, forward-looking version of the Phillips curve with exogenously sticky prices. Allowing $\theta_b > 1$ introduces a backward-looking element and, hence additional inertia into the inflation process.

Evolution of state variables and shock processes

(A.13) $$k_{t+1} = \delta i_t + (1-\delta)k_t$$

(A.14) $$n_t = R^q[\frac{K}{N}(r_t^s - E_{t-1}r_t^s) + \frac{(1-\tau R^K)}{\tau} y_t + n_{t-1}]$$

(A.15) $$g_t = \rho_g g_{t-1} + \varepsilon_t^g$$

(A.16) $$z_t = \rho_z z_{t-1} + \varepsilon_t^z$$

Equations (A.13) and (A.14) describe the evolution of the two state variables of the model, capital and internal equity, respectively. τ is the probability that a given firm survives into the next period. Equations (A.15) and (A.16) state that government spending and total factor productivity follow first-order autoregressive processes.

Monetary policy rule and interest-rate determination

(A.17) $$r_t^n = \bar{r}^n + \beta E_t \pi_{t+1}$$

(A.18) $$r_t = r_t^n - E_t \pi_{t+1}$$

(A.17) is one example of an interest-rate rule for monetary policy; cf. equation (3.1). (A.18) defines the real interest rate.

Key parameter values include $\frac{G}{Y} = 0.2, \frac{N}{K} = 0.5, \frac{C^e}{Y} = 0.04, \sigma = 1.0,$ $\delta = 0.025$ per quarter, , $a = 0.98,\ \beta = 0.99,\ b = 0.98(1-0.025),\ \alpha = 0.33,$ $\psi = 0.05, \varphi = 0.25, \kappa = 0.086, \theta_f = 0.5, \theta_b = 0.5, \tau = 0.95, \chi = 1.33$**.**

Any parameters not reported are as in BGG.

Endnotes

[1] As we show in the context of our simulation model below, even when a bubble is present, the market price can still be expressed as a discounted stream of cash flows, though with a discount rate that differs from the fundamental rate. In particular, periods in which the market price is above the fundamental are also periods in which the implied discount rate is below the true fundamental rate, and vice versa. Because the "fundamental discount rate" is not directly observable, it is, in general, impossible to know whether there is a non-fundamental component to the current stock price.

[2] To be clear, for the analysis that follows it is only necessary that non-fundamental movements in asset prices affect aggregate demand. In other work we have found that, to explain the observed volatility of output, it is necessary to have a balance-sheet channel supplementing the traditional wealth effect.

[3] For relevant surveys see Bernanke and Gertler (1995), Hubbard (1997), Gilchrist and Himmelberg (1998), and Bernanke, Gertler and Gilchrist (forthcoming).

[4] We implicitly include in this definition any institutional and regulatory structure that may affect private sector risk exposure. For example, both U.S. and Japanese banks hold real estate (or make loans with real estate as collateral), but by law only Japanese banks are allowed to hold equities. This apparently incidental difference has strong implications for the likely effects of a stock-price collapse on bank capital and bank lending in the two countries, as indeed we have seen in Japan in the past few years.

[5] Inflation targeting has been adopted in recent years by a substantial number of industrialized and developing countries, including (among many others) the United Kingdom, Sweden, Canada, New Zealand, Chile, and most recently Brazil. An extensive literature has developed on the early experience with this approach; see, for example, Goodhart and Viñals (1994), Haldane (1995), Leiderman and Svensson (1995), Bernanke and Mishkin (1997), and Bernanke et al. (1999) for comparative analyses.

[6] Inflation targeting has been castigated in some quarters as a policy of "inflation nutters," to use Mervyn King's descriptive phrase. This criticism is simply incorrect, however. As Lars Svensson (1997, 1999) has shown, inflation targeting is completely consistent with a conventional quadratic central-bank loss function that places arbitrary weights on the output gap and inflation; in other words, inflation targeting in no way precludes significant attention to conventional stabilization objectives.

So what then is new? One important advantage is that an inflation-targeting framework makes explicit (for both policy-makers and the public) the simple fact that monetary-policy actions that expand output and employment, but which also leave the inflation rate higher than it was initially, do not necessarily increase social welfare on net. Instead, account must also be taken of the future losses in output and employment that will be necessary to bring inflation back to its initial level; or, alternatively, of the various distortions and reductions in long-term economic growth associated with a permanent increase in inflation. By enforcing the requirement that any sequence of policy actions be consistent with the long-run inflation target (a sort of nominal anchor requirement), the inflation-targeting framework eliminates the upward inflation ratchet that proved so costly in many countries in the 1960s, 1970s, and early 1980s.

[7] Note that even theories that stress the self-fulfilling nature of crisis expectations (e.g. Obstfeld, 1994), usually imply that such expectations can only arise if fundamentals are relatively weak.

[8] Interested readers are referred to Bernanke, Gertler, and Gilchrist (forthcoming) for additional detail.

[9] Finite lives are a metaphor for the entry and exit of firms and the associated turnover in credit markets. The assumption of finite lives also prevents the business sector from ever reaching a steady state in which it is entirely self-financing.

[10] Specifically, we use a variant of Calvo's (1983) staggered price setting model developed by Gali and Gertler (forthcoming) that allows a subset of firms to use rule-of-thumb pricing behavior. The resulting aggregate supply equation is similar in spirit to the "sticky inflation" model of Fuhrer and Moore (1995).

[11] We also make some smaller changes that are important for the simulations we want to do, such as calibrating a realistic effect of changes in asset prices on consumption.

[12] We do not attempt to rationalize why investors do not arbitrage the difference between the market and fundamental returns. To our knowledge, any theory of bubbles based on market psychology relies on some arbitrary assumption along these lines. This point also applies to the so-called rational bubbles of Blanchard and Watson (1982). We do not use Blanchard-Watson rational bubbles in this paper because their non-stationarity creates technical problems in our framework.

[13] By treating the probability that the bubble bursts as exogenous, we rule out the possibility that monetary policy can surgically prick the bubble. Although it is certainly possible to endogenize this probability, so little is known about the effects of policy actions on market psychology that any modification along these lines would necessarily be ad hoc. Note that it is nevertheless the case in our framework that asset prices will be highly sensitive to monetary policy, since policy can affect the fundamental component. Thus, the empirical observation that asset prices react strongly to monetary policy actions is not direct evidence against the exogeneity assumption made here.

[14] Note that $a = 1$ corresponds to the so-called rational bubble described in Blanchard and Watson (1982). Hence, our bubble specification can be made arbitrarily close to a rational bubble by the assumption that a is close to one.

[15] Note also that the rule given by (3.1) abstracts from an interest-rate smoothing motive, which appears to be important empirically; again see Clarida, Gali, and Gertler (1998) and the estimates in the next section. Ignoring this aspect of policy makes the simulation results presented below look somewhat less realistic (because policy reacts "too quickly" to changes in the economy) but does not affect the qualitative nature of the results.

[16] We assume p = 0.5 and $a = 0.98$.

[17] To be clear, agents in the model know only the ex ante stochastic process for the bubble and not the time that it will burst.

[18] All simulations are reported as deviations from the steady state.

[19] We consider the accommodating policy not because it is a realistic alternative, but rather to underscore the point that the impact of a bubble is highly sensitive to the response of monetary policy.

[20] Note that we assume that policy responds to the (observable) level of stock prices, not the (unobservable) level of the bubble, which seems realistic. That distinction is not important in the present exercise but will become important in scenarios in which the central bank is uncertain about the source of the appreciation in stock prices.

[21] Under the usual assumption that social welfare depends on the output gap and inflation, we can, therefore, unambiguously conclude that the inflation-targeting rule maximizes welfare.

[22] The model does not include raw-material or finished-goods inventories. Inclusion of inventory stocks in the model would likely increase the downward reaction by adding an endogenous inventory cycle.

[23] That is, for simplicity here we do not include a confounding bubble shock. The welfare comparisons would not be affected by including a bubble shock.

[24] For evidence that general credit conditions tightened at this time, see Gertler and Lown (1999).

[25] More specifically, CGG apply a GMM estimator with a correction for the moving average error induced by overlapping forecasts (see their endnote 11 for details). Our estimation procedure follows the CGG method very closely, with minor differences described below. In particular, we follow CGG in using as instruments a constant, and lags 1-6, 9, and 12 of log-differenced commodity price index, the log-differenced CPI, the log-differenced output gap, and the instrument interest rate. For Japan, lags 1-6, 9, and 12 of the real yen-dollar exchange rate are also included as instruments. For the commodity price index, we use slightly different series from CGG, specifically, an IMF series for Japan and the Dow-Jones commodity price index for the United States. In auxiliary regressions, discussed below, we also use lags 1 to 6 of the log-difference of the stock price index (TOPIX in Japan and the S&P 500 for the United States).

Following CGG, we construct the output gap for the United States as the residuals of a regression of industrial production on a constant, time, and time squared, for the sample period 1960:1 through 1998:12. Because we believe that Japan has been well below potential output since about 1990, the output gap variable we construct for Japan is based on a quadratic trend for industrial production based on data beginning in 1968:1 and ending in 1989:6. Through 1989:6 the Japanese output gap is measured as the residual from this regression, subsequently it is equated to actual output less the extrapolated quadratic trend value of output.

We thank Richard Clarida for providing the estimation programs.

[26] Estimates (not shown) from samples ending in 1994:12, the end date used by CGG, closely replicated their results.

[27] The fitted values assume that expected inflation and the expected output gap are the realized values. They are thus comparable to the target values reported in Figure 8; see below.

[28] Kozicki (1999) observes, however, that this gap is greatly reduced if a core inflation

measure is used in the estimation of the Fed's reaction function.

[29] Kozicki (1999) makes a similar observation and provides support for her contention with the following revealing quote from Chairman Greenspan:

"In the spring of 1989, we began to ease monetary conditions as we observed the consequence of balance-sheet strains resulting from increased debt, along with significant weakness in the collateral underlying that debt. Households and businesses began much more reluctant to borrow and spend and lenders to extend credit – a phenomenon often referred to as the 'credit crunch.' In an endeavor to defuse these financial strains we moved short-term rates lower in a long series of steps that ended in the late summer of 1992, and we held them at unusually low levels through the end of 1993 – both absolutely and, importantly, relative to inflation." (Testimony of June 22, 1994).

[30] An alternative interpretation, which is consistent with our general approach, is that financial conditions in certain key sectors and regions were sufficiently bad—e.g., bank capital positions well below regulatory minima—that the impact of small interest-rate changes on the economy was reduced. A reduction in the policy multiplier would justify more aggressive Fed policies during this period.

[31] Our sample period does not include the episode of Fall 1998, when the Fed reacted to increased quality spreads in the bond market by easing. Again, this action seems justifiable to us, in that the widening spreads could well have been interpreted as predicting a slowdown in the general economy.

[32] The fitted values again assume perfect foresight by the central bank for inflation and the output gap.

[33] Note that it would not be correct to argue that stock prices matter because of their predictive power for the output gap and inflation. We include stock returns in the information sets for forecasting these variables, thereby controlling for the predictive power of stock returns.

[34] Figure 10 suggests that the Bank of Japan should have raised its key interest rate as high as 8 to 10 percent during 1987-89, which some commentators at the conference thought would not have been politically feasible given that contemporaneous inflation (possibly as a result of exchange rate appreciation) remained low. Our specific measure of the target rate is sensitive to our estimates of the size of the output gap in Japan at the time and is not to be treated as precise. What is striking about the period is not that the BOJ failed to tighten radically, but that it failed to tighten at all. In any case, for the record, we consider the failure to respond to deflationary pressures during 1992-96 (see below) to be the most serious shortcoming of Japanese monetary policy during this period.

[35] As can be seen in Figure 10, the target call rate went negative in 1993, out of the feasible range of the actual rate. Still, it was not until 1995 that the actual call rate went below 2.0 percent.

[36] Further, to the extent that (say) collapse of the banking system would be deflationary, perhaps in a highly discontinuous way, it seems to us that lender-of-last-resort interventions are consistent with the philosophy of flexible inflation targeting.

[37] For an even broader indictment of fixed-exchange-rate regimes see Obstfeld and Rogoff (1995).

[38] Dollarization or a currency union represent an alternative approach for small open economies that also avoids the instabilities of fixed exchange rates. These approaches have their own problems, however.

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