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"*Equity prices and monetary Policy: An Overview with an Exploratory Model*"

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Equity Prices and Monetary Policy: An Overview with an Exploratory Model

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Abstract

Financial stability, with an emphasis on the relevance of asset prices stability to the stability of the overall economy, has become the subject of wide discussion among monetary authorities. Closely related to these issues are the concerns of central bankers with a bubble economy and its aftermath. After briefly surveying the potential links between financial markets and the real economy and its implications for the design of monetary policy, we illustrate some of the issues in this literature through the analysis of a simple linear rational expectations model. From this exercise we conclude that the benefits of reacting to asset prices depend crucially on the kind of shock hitting the economy. Ideally, reacting to the misalignment of equity prices is desirable. However, the presence of uncertainty in the estimation of the variables to which the policy rule responds may overturn this conclusion.

"The U.S. slipped into recession in mid-1929 because of tight domestic monetary policy aimed at stemming speculation on the U.S. stock market. The Great Depression started in earnest when the stock market crash in the U.S. caused consumers and firms to become nervous and therefore to stop buying irreversible durable goods." (Romer: 1993)

Keywords: Asset Prices, Inflation Targeting, Taylor Rule, Rational Expectations, Uncertainty.

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1 Introduction

With inflation stabilised in almost all industrialised countries - see, for example, Cecchetti and Krause (2001)[1] - central banks have moved their attention to financial markets and its institutions.[2] Several factors can explain why financial markets have become so important for monetary policymakers. First, the extraordinary development of financial markets since the beginning of the 80s which was accompanied by an increasing importance of stock markets as a share of families' wealth in developed countries. To this development have contributed importantly the deregulation and privatisation since the beginning of the 80s (see, for example, Shiller: 2000). Second, the world increasing economic interdependence, due to the globalisation of financial markets, contributed to increasing uncertainty and higher asset markets volatility (see, for example, Krugman: 2000, and, on the latter aspect, Borio, Kennedy and Prouse: 1994). Goodhart (2000), however, associates the increasing volatility of financial markets with financial market deregulation and liberalisation. Last but not least, the recovery in last decades of a trend in economic research that goes back to the 30s, with Irving Fisher's ideas on the Great Depression, that places financial markets at the centre of business cycles explanations and highlights their relevance in the transmission mechanism of monetary policy.

The Japanese recession in the 90s, the US 1991 crisis, the East Asia crisis of 1998, and the discussion about the potentially damaging effects of a possible bubble economy in the USA during the 90s have certainly contributed decisively to the attention devoted to the association of movements in the real economic activity and in financial markets.

Closely related to these developments are the recent concerns of central bankers about what to do in the presence of asset price volatility and, in the more extreme cases, of a bubble economy and in the aftermath of a bubble burst. These events have motivated several comments, among which is the widely cited Alan Greenspan's 1996 speech. There the Chairman of the Federal Reserve mentioned the importance of asset price stability to the stability of the overall economy, and, after mentioning the case of the Japanese economy, questioned when should central bankers be concerned about irrational exuberance in asset prices. Those remarks synthesise two problems often present in monetary policy discussions. First, facing some sort of "irrational exuberance" in the stock market should the central bank intervene? The answer to this question depends in part on the answer to a second question: what are the effects of the developments in the stock

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[1]Cecchetti and Krause (2001) provide evidence of an improvement in macroeconomic performance over 23 countries, in the last two decades, measured as an index of output and inflation volatility.

[2]In Mark Gertler's (Gertler *et al*.: 1998) words, "the issue of financial stability has become one of the most discussed issues among monetary authorities."

market on the real economy?

In section 2 we briefly survey the potential links between financial markets, with a special emphasis on equity prices, and the real economy and its implications to the monetary transmission mechanism. In section 3 we discuss different monetary policy approaches to deal with asset price volatility. In section 4 we employ an exploratory rational expectations model to examine the more specific issues of how equity prices may relate to output and inflation and the appropriate response of monetary policy to equity prices. We discuss how uncertainty in the estimation of misalignments may change the desirability of reacting to equity prices. Section 5 concludes.

2   The channels by which asset prices impinge on the real economy

Traditionally, theories of the monetary transmission mechanism have stressed the direct effects of interest rates and exchange rates on output, and then, indirectly, on inflation. However, an old tradition in macroeconomics that focused on the importance of financial markets in the transmission of the monetary policy has recently been recovered. This renewed interest results basically from the belief of policymakers and theorists in the existence of causal links between movements in financial markets and output fluctuations. From this emerges their relevance for the making of monetary policy. Furthermore, recall that monetary policy is implemented through financial markets.[3] We begin our exposition of these issues start by describing the links between financial markets and the real economy and their implications for the monetary transmission mechanism.[4] We then examine the relevance of equities for real macroeconomic outcomes in contemporary developed economies.

2.1   Financial markets, the real economy and the transmission mechanism

To find a reference to the links between financial markets and the behaviour of economic activity we can go as far back as the 30s, during the Great Depression. At that time several economists, notably Irving Fisher, considered over-indebtedness and the resulting crisis in the financial sys-

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[3]As Blinder (1997) remarks "Monetary policy works through financial markets, so perceptions of likely market reactions must be relevant to policy formulation and actual market reactions must be relevant to the timing and magnitude of monetary policy effects."

[4]Gertler (1988) has a nice description of the role financial markets have had in the explanation of output fluctuations.

tem as the main cause of the contraction in output.[5] Although Keynes stressed the importance of financial markets for real activity, namely in the determination of investment, his followers centred their attention on the role of interest rates in the transmission of monetary policy to the real economy. Thereafter, with a few marginal exceptions, notably Gurley and Shaw (1955), the role of financial markets was for long forgotten in mainstream macroeconomics, either in its neoclassical or in its Keynesian form. As Bernanke (1993) put it, "in the standard model, factors such as the financial conditions of banks and firms play no role in affecting investment or other types of spending."

Behind that view was the paradigm of perfect information and complete markets. In such a world the role of the financial system is almost inexistent, as one of the most influential results in this literature shows: the Miller-Modigliani irrelevance theorem. Modigliani and Miller (1958) showed the irrelevance of the firms' financial structure under the assumption of competitive markets and perfect information.

However, developments in the economics of imperfect information in the 70s, notably with Akerlof (1970), challenged the results of the complete markets literature and allowed a new understanding of the functioning of credit markets, namely of the crucial role of banks and other financial intermediaries. The imperfect and asymmetric information that characterise financial markets will determine the borrower-lender relationship and the financial structure of firms. For example, Jensen and Meckling (1976) concluded that with imperfect information and incentive problems external finance is more expensive than internal finance. Thus firms that base their investment projects on external finance will be willing to invest less than firms that do not.

The key role of imperfect information in the relationship between borrowers and lenders is that it makes it costly for banks to obtain information on firms' projects. These capital market imperfections result in an inefficient allocation of funds in credit markets and in a sub-optimal investment level in the economy. That is, if due, for example, to agency costs external finance is more costly than internal finance - that is, we have an external finance premium - then investment demand must depend on the firm's balance sheet position and the Modigliani-Miller theorem does not hold anymore. The higher the agency costs the less efficient will be

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[5]His debt-deflation theory of great depressions, presented in Fisher (1933), works as follows: over-indebtedness of firms, created by "new opportunities to invest at a big prospective profit" and "easy money" , leading to liquidation, results in a contraction of firms' activity and deflation; the decrease in the price level increases the real debt burden of firms and precipitates bankruptcies with the consequent decrease of output and in the price level, trapping the economy in a recession.

the allocation of funds in credit markets and the lower will be the investment in the economy. Therefore, Bernanke and Gertler (1989) argue that the level of investment depends positively on the firms' balance sheet position: a higher net worth or cash flow has a positive effect on investment directly, because it increases the sources of internal finance, and indirectly because it reduces the external costs of financing, by offering more collateral - see also Kiyotaki and Moore (1997). Because agency costs vary counter-cyclically - increasing during recessions and decreasing during expansions - they will have an amplification effect during the cycle. Bernanke *et al.* (1996) call this amplification effect of the cycle the *financial accelerator mechanism.*

All these developments have contributed to put the emphasis on the role of credit market imperfections and financial markets in general when explaining economic fluctuations. Some authors - like Mishkin (1978) and Bernanke (1983) - focused on the importance of financial factors in the Great Depression and both concluded on the significant role of the collapse of the financial system in causing and reinforcing the deep economic crisis of the 30s. Bernanke's paper recovers Irving Fisher's idea that the Great Depression was mainly a financial crisis and provided some evidence of the role of non-monetary factors, in contrast with the, until then prevalent, analysis of Friedman and Schwartz (1963).[6] Bernanke and Gertler (1999) argue that this framework has also been very useful in understanding several other historical and contemporaneous episodes, more notably the behaviour of the Japanese economy in the 90s.

Another very important influence of the developments described above was on the way economists and policymakers see the effects of monetary policy and the role of financial markets in the transmission of monetary policy to the real economy. According to this view, imperfections in capital markets result in a new channel for monetary policy. This "new" channel for monetary policy is usually known as the *credit channel.* According to Bernanke and Gertler (1995) the "credit channel" should be seen as a set of factors that "amplify and propagate conventional interest rate effects," and can be decomposed into a balance sheet and a bank-lending channel.

The balance sheet channel captures the potential impact of monetary policy decisions on firms' balance sheets and therefore on its investment ability (Bernanke and Gertler: 1995). For example, a rise in interest rates that lowers asset prices reduces the market value of borrowers' collateral. This reduction in value may force some firms to reduce investment spending as their ability to borrow declines. From this results an additional impact of monetary policy on

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[6]The strong correlation between money and output, specifically between 1929 and 1933, found in Friedman and Schwartz's work stressed the importance of money in the explanation of cycles and dwarfed the role of other financial factors.

the real economy: because agency costs vary counter-cyclically, an increase in interest rates with the resulting contraction in economic activity helps to deteriorate balance sheets, raising agency costs and therefore constraining firms' investment capacity. This endogenous change in borrowers' balance sheets and its effect on economic activity constitutes the financial accelerator mechanism mentioned above. Bernanke *et al.* (1996) provide empirical evidence supporting the relevance of the balance sheet channel.

The second, the bank lending channel, captures the effect of monetary policy on banks' ability to lend and thus on the funds available for firms' investment. Kashyap and Stein (1994) provide empirical evidence on the importance of the bank-lending channel.

Because nowadays equity has an increasing weight on the balance sheet position of firms and because of high asset price volatility, we will now concentrate on the importance of stock markets to the real economy.

2.2 How equity prices impinge on the real economy

Highlighting the relation between equity prices and the real economy, Bernanke and Gertler (1999) mention that the bust part of the asset price cycle was in many cases associated with contractions in the real economy. Although it is very difficult to obtain accurate estimates of the effects of changes in asset prices on the real economy, there is some historical evidence that large asset prices movements can have important effects on the economy. As argued by Bernanke and Gertler (2001), "asset booms and busts have been important factors in macroeconomic fluctuations in both industrial and developing countries." The same assertion can be found in Cecchetti *et al.* (2000), who stress as examples of this relation the cases of the Great Depression and Japan in the 90s.[7]

We now briefly describe the channels by which equity price movements impinge on the real economy. The three most likely channels are the households' wealth effect, Tobin's q effects and the firms' balance sheet channel.

The relevance of the wealth channel has been increasingly referred to as one of the main vehicles transmitting changes in asset markets to real economic activity. The wealth effect describes the influence of asset prices (mainly stock prices) on households' wealth and then on aggregate consumption. The increasing number of families that own shares in developed countries - more than 50% of the families in the United States own stocks, a percentage that

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[7]As Christina Romer (1993) wrote, "The most likely source of the precipitous drop in American consumption following the stock market crash in 1929 is the crash itself."

is even greater in Australia; and even in a country like Germany, where unions are still very important, more than 20% of the families own stocks - have made the role of this channel increasingly important through its impact on the households' wealth (see, for example, Shiller: 2000). Despite the conclusions concerning the effects of the stock market crash on consumption during the Great Depression (more evidence on the same effect is provided by Temin: 1976), recent empirical studies have not found a strong or reliable relation between stock market and consumption - see, for example, Ludvigson and Steindel (1999) and Campbell (1999).

An additional demand-diminishing effect of a stock market crash is the one described by Christina Romer (1993). According to this author, the extraordinary drop in consumption during the Great Depression is partly explained by the uncertainty about future incomes due to the stock market crash. In Romer (1990), the same author used regression analysis to provide evidence of the role of the stock market crash in explaining the decrease in consumer purchases of durable goods.

Another channel linking equity prices and real economic activity works through the relative value of firms' capital to its replacement cost, that is, Tobin's q. An increase (decrease) in equity prices increases (decreases) the value of capital relative to its replacement cost and thus stimulates (inhibits) investment demand by firms. A related issue is the effect of overvaluation of stocks on investment decisions by firms. This issue is analysed empirically in Blanchard *et al.* (1993). In their regression analysis using time series for the period 1900-1990, these authors concluded that, although market valuations appear to have a role in the determination of investment decisions, it is a limited one. However, when commenting on the potential effects of the increase in stock prices during the last decade, Blanchard (2000) says that empirical evidence suggests that firms with overvalued stocks may increase investment beyond what is justified by fundamentals, the result being an excess of capital accumulation. This same link between equity prices and the real economy is stressed by William Poole (2001). Poole offers the example of the dotcom industry (and the extraordinary increase in its stocks - between December 1990 and March 2000, the Nasdaq Telecommunications Index increased approximately 1300 percent) where "the distorted price signals from the stock market permitted the industry to raise capital easily and cheaply, which certainly contributed to the overexpansion."

Besides these direct effects of equity price oscillations on goods and services demand, they can also have important effects on economic activity through their indirect effects on the financial structure of firms and on the stability of the financial system. Here is a more promising link between asset prices and the real economy through the above described balance sheet channel (Bernanke *et al.*: 1999). As we saw above, capital markets work imperfectly due to information,

incentive and enforcement problems. In such a world the cost of borrowing depends on the financial position of agents and, therefore, a decrease in asset prices reduces the market value of borrowers' collateral and their ability to borrow and then to invest. These effects can be highly damaging for the economy in the special case when a bubble in asset prices bursts, as the experiences of the Great Depression and in Japan in the 90s seem to suggest. In this context, Kent and Lowe (1997) stress that movements in asset prices, by disturbing the process of financial intermediation, may result in an asymmetric effect: declines in asset prices may have stronger effects on output and inflation. That is, the effects of asset prices movements tend to be more conspicuous when asset prices fall than when they increase; as we will see this effect once proven to exist may have substantial implications in the definition of monetary policy.

3   Monetary policy and asset prices

The already mentioned 1996 speech of the Chairman of the Federal Reserve, Alan Greenspan, where he alluded to the irrational exuberance in the American stock market, is the most cited remark on policymakers' concerns with movements in the stock market. As the quotation of Christina Romer at the beginning of this paper suggests, the issue of the appropriate reaction to movements in the stock markets is discussed and has influenced monetary policy at least since the 20s and the Great Depression that followed.[8] Actually, one of the most famous examples of those actions was the monetary tightening by the Federal Reserve, in 1928, aiming to prevent the development of a bubble in the American stock market.[9]

However, for the reasons mentioned above, the potential effects of stock markets on the real economy are nowadays certainly more acute: increasing integration of national financial markets and a strengthening of links with real economic activity have reinforced the concerns of monetary policymakers with movements in equity prices. Thus, several studies have discussed whether asset prices should be taken into account in the formulation of monetary policy. There is wide agreement, among both economists and central bankers, that that should be case - see, for example, Greenspan (1996), Gertler *et al.* (1998), Bernanke and Gertler (1999), Cecchetti

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[8]This exceptional period of the American economy still motivates a great deal of research. Among the reasons for that interest is certainly the remarkable movements in the stock market: the 20s were a period of euphoria in capital markets only surpassed by the exuberance of the 90s. For a very interesting description of the similarities between these two "eras" see Shiller (2000).

[9]Hamilton (1987), an important paper on monetary policy in this period, concludes that "the major factor influencing monetary policy during 1928-29 was surely the stock market"

et al. (2000), Goodhart and Hofmann (2000), among others.[10] However, there is disagreement on the exact role asset prices should play in the design of monetary policy and how they should be used in practice. Some authors defend that policymakers should target a broader price index that includes asset prices (for a discussion of this view see Goodhart: 1999); others argue that they should only be used in inflation forecasts (Bernanke and Gertler: 1999); and others believe that asset prices should be taken into account in everyday monetary decisions, with policymakers aiming at stabilising their value around fundamentals (Cecchetti *et al.*: 2000). We briefly discuss next the arguments of the first two approaches. Then we concentrate our attention on the last issue of wether or not central banks should react to equity prices.

Alchian and Klein (1973) suggested that the traditional Consumer Price Index (CPI) aimed at measuring household's purchasing power, and the target of monetary policy, should include asset prices. Their argument was based on the idea that the purchasing power of households depends not only on current prices of consumption but also on future prices. Since asset prices can be seen as a measure of future prices they should therefore be included in the construction of price indexes.[11] Charles Goodhart has been one of the supporters of the replacement of traditional price indexes targets, like the Consumer Price Index, with a broader measure of the price level that includes housing and stock prices with an appropriate weight.

The same author also argues for the inclusion of asset prices in the price index to be targeted by the monetary authority based on the idea that asset prices contribute to improve inflation forecasts. Thus, an increase in asset prices could imply an increase in interest rates even when conventionally measured inflation remains unchanged. This practice could then result in a better macroeconomic performance, so the argument goes. However, as we discuss below, the predictive power of asset prices is subject to discussion. Additionally, changes in asset prices can give wrong indications about future inflation given its high volatility and the variety of its possible origins (Filardo: 2000). Cecchetti *et al.* (2000) argue that the problems associated with its implementation make the construction of such an index unpractical. Vickers (1999) shares the same view.

This interest in the role of asset prices to build inflation forecasts was also strengthened by the fact that a great number of developed and developing countries are now inflation targeters that have made inflation forecasts a crucial instrument in policymakers' actions. An example of

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[10] According to a study by the Centre for Central Banking Studies of the Bank of England, mentioned in Cecchetti et al (2000), asset prices influence monetary policy in most of the countries questioned.

[11] Shibuya (1992) shows that their proposed measure of inflation can be written as a weighted sum of a traditional measure of inflation and asset price inflation.

information conveyed by asset prices is the information on inflation expectations.

Goodhart and Hofmann (2000) analysed the explanatory power of asset prices through the estimation of equations for CPI inflation for seventeen countries and concluded that equity prices are a "relatively limited predictor of future inflation." However, they concluded that house prices could help forecast inflation. Filardo (2000) also concludes on the benefits of considering housing price inflation in the prediction of future consumer price inflation, although "the marginal improvement in forecasting accuracy is fairly small." Cecchetti *et al.* (2000) stress the fact that the role of asset prices in inflation forecasts depend crucially on the importance of the different channels by which asset prices impinge on the real economy. For instance, the exchange rate will certainly have a more important role as an input of inflation forecasts in small-open economies - as it happens at the Bank of England - than in a large closed-economy like the United States (Cecchetti *et al.*: 2000). Poole (2001) argues that, in the special case of stock markets, its information is more useful as a supplement of information from other sources.

In the next section we focus at length on the last and more controversial issue of whether, in order to improve macroeconomic performance, monetary policy should react directly to asset prices. We discuss different points of view on this issue and we illustrate some of them by means of an exploratory model.

4   Should Monetary Policy React to Equity Prices?

Given that there are reasons to suspect that monetary policy can have important effects on financial markets and that asset price volatility may be damaging, one may ask whether monetary policy should react to asset prices. However, the arguments mentioned in the previous section are not the only arguments sustaining the desirability of reacting to asset prices. Another argument, following Poole's (1970) analysis, is that monetary policy should "lean against the wind" of significant asset price movements if these disturbances originate in the asset markets themselves (Cecchetti *et al.*: 2000). In this section we illustrate and discuss this argument by means of a simplified macro-model. The full model comprises a system of equations describing the key aspects of the macroeconomy, a loss function reflecting the preferences of the central bank, and a monetary policy rule. Smets (1997) has used a model that is similar in some regards.

Our stylized system of macroeconomic equations is the following:

$$y_t = \alpha_1.E_t y_{t+1} + \alpha_2.A_{t-1} - \alpha_3.r_{t-1} + \varepsilon_t^d \tag{1}$$

$$\pi_t = \beta_1.\pi_{t-1} + (1-\beta_1).E_t \pi_{t+1} + \beta_2.y_t - \varepsilon_t^s \tag{2}$$

$$A_t \;=\; \gamma_1 . \left(y_t + \varepsilon^{sp} + \varepsilon_t^{stu} + \varepsilon_{t-1}^{sta} \right) + \gamma_2 . E_t A_{t+1} - r_t + \varepsilon_t^e \tag{3}$$

$$F_t \;=\; \gamma_1 . \left(y_t + \varepsilon^{sp} + \varepsilon_t^{stu} + \varepsilon_{t-1}^{sta} \right) + \gamma_2 . E_t F_{t+1} - r_t \tag{4}$$

$$\varepsilon_t^s \;=\; \varepsilon_t^{sp} + \varepsilon_t^{stu} + \varepsilon_{t-1}^{sta} \tag{5}$$

$$\varepsilon_t^{sp} \;=\; \rho . \varepsilon_{t-1}^{sp} + \varepsilon_{t-1}^{spa} + \varepsilon_t^{spu} \tag{6}$$

The variables are intended to represent percent deviations around the steady state. Equation (1) depicts a simplified aggregate demand equation that includes a leading term for output capturing the effects of expected income on today's spending $(E_t y_{t+1})$.[12] Output also depends negatively on the real interest rate (r) with one lag. Aggregate demand incorporates a wealth effect, either through consumption or investment, resulting from asset price movements as described in section 2.2, through the inclusion of the lagged term A_{t-1}.

Equation (2) is a Phillips curve including expected and lagged inflation on the right-hand side as in the New Keynesian form.[13] Additionally, inflation depends on the output gap with a lag.

Equation (3) is based on a standard dividend model of asset pricing: it gives equity prices as a function of next period dividends (assumed to depend on current output and productivity shocks), other expected future dividends (incorporated in the expected equity price, $E_t A_{t+1}$), and the interest rate. The coefficient on $E_t A_{t+1}$ is the inverse of the gross risk-adjusted rate of interest, assumed to be approximately 3% following Bernanke *et al.* (1999). We add a disturbance (ε^e) that may, for instance, represent an equity premium shock as mentioned in Cecchetti *et al.* (2000). We will interpret this as a non-fundamental shock. An equity premium shock could be justified by a change in the risk level of equity holdings or in shareholders' preferences. In our model these changes do not occur, and thus equity shocks will be seen as the source of misalignments. Equation (4) gives the fundamental value of equities. It is the same as equation (3), except for the omission of the non-fundamental equity premium shock.

Notice that, although there are misalignments, there are not "bubbles" (in the usual mathematical sense) in our model. Thus, the model will not address the issue of whether central banks should react to asset prices in order to prevent the development of bubbles. A model that pretends to study that issue must treat bubbles as endogenous in some way, so that the central banks' actions may influence their evolution. However, that raises difficult technical problems.

Equation (5) defines the supply shock as the sum of a persistent component (ε^{sp}), an unan-

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[12]This term was first derived by McCallum and Nelson (1999) from a fully optimising general equilibrium model.

[13]The lagged term for inflation reflects inflation persistence, which may result from elements of backward-lookingness in the wage-setting process (see, for example, Fuher and Moore: 1995).

ticipated temporary supply shock (ε^{stu}), and an anticipated temporary supply shock (ε^{sta}). Equation (6) gives the behaviour of the persistent supply shock. This is assumed to have two components: one that is anticipated one period before it occurs (ε^{spa}), and one that is unanticipated (ε^{spu}). The autoregressive coefficient should equal unity, if what we wanted was a permanent shock. However, that would imply the system to be non-stationary. As we will be interested in computing variances (in order to compare different policy rules), we reduced the autoregressive coefficient to 0.9. Demand and equity shocks, though not shown, are assumed to have the same structure as the supply shock.

To this system of equations we add another equation describing the behaviour of the central bank. We will employ two types of rules:

$$r_t = \lambda_1.y_t + \lambda_2.\pi_t + \lambda_3.A_t^* \tag{7}$$

$$r_t = \delta_1.E_t.\pi_{t+1} + \delta_2.A_t^* \tag{8}$$

Equation (7) is a common monetary policy rule that expresses the real interest rate in terms of current output and inflation deviations - the well-known Taylor Rule, after Taylor (1993) - with the possible addition of a reaction to asset prices: either to equity prices themselves ($A_t^* = A_t$) or to the misalignment in asset prices ($A_t^* = A_t - F_t$). Later we will discuss the implications of reacting to one or the other. Equation (8) is an inflation-forecast targeting rule, where the interest rate responds to movements in the expected inflation one period-ahead - therefore providing a good description of inflation targeters' behaviour, as argued in Alexandre et al. (2001) -, and possibly also to asset prices.[14]

We assume that the central bank does not observe the shocks that buffet the economy.

There is no consensus on most values of the parameters, notably on the degree of inflation persistence. In Table 1 we show the parameter values used in our simulations and their sources. Two parameters, α_1 and β_1, are worth of some words. Although adjustment costs that result in output inertia are observable in the data, we set $\alpha_1 = 1$, following the theoretical derivation of McCallum and Nelson (1999). The inflation persistence coefficient, β_1, is another parameter involving high uncertainty (see, for example, Rudebusch: 2000). However, we set $\beta_1 = 0.9$, implying very high inflation persistence.

The values for the parameters in the policy rule will be determined by optimisation of a loss function, with policymakers minimising the variance of output, inflation and the policy

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[14]In Alexandre et al (2001) there is a more detailed description of the significance and relevance of each of these policy rules.

instrument:

$$Loss\ Function = V\left(\pi_t\right) + \omega_1.V\left(y_t\right) + \omega_2.V\left(r_t - r_{t-1}\right)$$

The inclusion of output and inflation in the loss function reflects the wide agreement that they represent the most important concerns of policymakers. As several authors argue - see, for example, Rudebusch and Svensson (1999) and Batini and Haldane (1999) - the inclusion of output and inflation in the loss function is common practice among central bankers, even among inflation targeters. The inclusion of an interest rate smoothing term in the expected loss reduces volatility of the policy instrument and, in the opinion of Mishkin (1999) and others, reflects real concerns of policymakers, since they are very concerned about financial stability.

In our exercise, the same weight is given to the variances of output and inflation, with $\omega_1 = 1$, and only half of this weight is given to the interest rate volatility term, $\omega_2 = 0.5$, following Rudebusch and Svensson (1999) and Rudebusch (2000). The variance-covariance matrix of the errors is assumed to be the identity matrix.

Table 1: Parameters' values and sources

Parameter	Value	Source
α_1	1.00	see Alexandre *et al.* (2001)
α_2	0.04	see Bernanke *et al.* (1999)
α_3	0.60	see Alexandre *et al.* (2001)
β_1	0.90	see Alexandre *et al.* (2001)
β_2	0.40	see Alexandre *et al.* (2001)
γ_1	0.05	see Bernanke *et al.* (1999)
γ_2	0.97	see Bernanke *et al.* (1999)
ρ^{sp}	0.90	persistent shock

To solve this linear rational expectations model, we employed the Schur decomposition as described in Soderlind (1999), after writing the model in the Blanchard-Kahn form (see Blanchard and Kahn, 1980).

4.1 The Effects of Shocks

There is a widespread view in the literature that the benefits of reacting (or not) to asset price movements depend crucially on the cause behind its movement. Identifying the source of asset price movements, namely if they are caused by changes in fundamentals or by changes unrelated to fundamentals, and its implications for future inflation, is required for determining the appropriate monetary policy response, as argued by Smets (1997) and Cecchetti *et al.* (2000),

among others. However, we should stress that this question only makes sense in a world of imperfect capital markets: in a world of efficient capital markets movements in asset prices reflect economic fundamentals and in such a situation the only benefit of looking at asset prices would be the information conveyed about the state of the economy.[15]

Therefore, when asset price movements are driven by non-fundamental factors and affect the real economy they can then be the cause of economic instability and should, therefore, be taken into account by policymakers. For example, an increase in equity prices caused by the "irrational exuberance" of markets and not sustained by improvements in productivity growth that result in higher profits, is likely to result in inflationary pressures and therefore ask for monetary policy action. The most remarkable instance of non-fundamental movements in asset prices is the case of a bubble in the stock market, that can be defined as "an unsustainable increase in prices brought on by investors' buying behaviour rather than by genuine, fundamental information about value" (Shiller: 2000).

Using our exploratory model we evaluate the effects of different shocks on the economy and the potential benefits of reacting to asset prices. In this exercise we try to discern the relevance for monetary policy of movements in asset prices driven by fundamental and non-fundamental shocks.

We begin with the Taylor Rule. The optimised values for the coefficients in the Taylor rule are $\lambda_1 = 0.17$ and $\lambda_2 = 1.71$ (assuming that there is no reaction to asset prices: $\lambda_3 = 0$).

We first display, using the structure in equations (5) and (6) for all categories of shocks (demand, supply, and equity), the effect of a unit shock on the variables of our system. In this context, supply shocks that affect asset prices should be seen as changes in fundamentals, whereas the equity shock, ε_t^{etu}, should be interpreted as a non-fundamental movement in asset prices.

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[15]For instance, consider the case of exchange rate movements in Australia where the appreciation of the dollar, in the beginning of the 90s, was the result of an improvement in the terms of trade: in this case, as noticed by Smets (1997), there was no need for a monetary easing because the positive effect of the increase in the terms of trade on inflation was counteracted by the appreciation of the currency.

Origin	with $\lambda_3 = 0$					with $\lambda_3 = 0.03$				
	y_t	π_t	A_t	F_t	r_t	y_t	π_t	A_t	F_t	r_t
ε_t^{dpu}	1.020	0.454	-7.620	-7.620	0.949	1.118	0.503	-7.450	-7.450	0.825
ε_t^{dpa}	0.470	0.233	-7.792	-7.792	0.477	0.574	0.284	-7.631	-7.613	0.355
ε_t^{dtu}	0.597	0.245	-0.607	-0.607	0.520	0.601	0.247	-0.599	-0.599	0.506
ε_t^{dta}	0.326	0.158	-0.964	-0.964	0.326	0.335	0.163	-0.948	-0.948	0.306
ε_t^{spu}	2.087	-0.192	2.535	2.535	0.030	2.053	-0.209	2.476	2.476	0.070
ε_t^{spa}	1.295	0.514	1.126	1.126	1.098	1.270	0.502	1.084	1.084	1.105
ε_t^{stu}	0.923	-0.654	1.522	1.522	-0.958	0.910	-0.660	1.500	1.500	-0.925
ε_t^{sta}	0.629	0.192	0.956	0.956	0.435	0.617	0.186	0.934	0.934	0.451
ε_t^{epu}	0.148	0.073	5.420	-2.454	0.150	0.081	0.040	5.303	-2.571	0.241
ε_t^{epa}	0.150	0.074	4.954	-2.684	0.153	0.082	0.040	4.836	-2.802	0.228
ε_t^{etu}	0.013	0.006	0.961	-0.039	0.013	0.007	0.003	0.951	-0.049	0.035
ε_t^{eta}	0.019	0.010	0.888	-0.082	0.020	0.011	0.005	0.872	-0.098	0.037

As discussed in Cecchetti *et al.* (2000), a persistent unanticipated supply shock results in a higher asset price and a lower inflation. The same is true in the case of a temporary unanticipated supply shock. However, in the first case the change in asset prices is larger, and the change in inflation is smaller. A persistent anticipated supply shock also leads to an increase in asset prices, but inflation also rises. Again, the same is true in the case of a temporary anticipated supply shock, but the immediate impact is larger in the event of a persistent anticipated supply shock.

Now let us compare the results obtained above, when the policy rule does not react to asset prices, to the ones obtained when the policy rule does react to the actual asset prices. We assume $\lambda_3 = 0.03$ and $A_t^* = A_t$.

The effect on the levels of inflation and the output gap of reacting to the level of asset prices depends on the type of shock. The implication is that the desirability of reacting to asset prices will hinge on the type of shocks that are more likely to affect the economy. If demand shocks are predominant, then reacting to the asset prices themselves is destabilising, in terms of both inflation and output. Actually, it would be preferable to react with a negative coefficient. In our model, the optimised values of the policy rule would be $\lambda_1 = 0.20$, $\lambda_2 = 1.47$, $\lambda_3 = -0.05$. Obviously, this implies increasing the variance of equity prices, and thus increasing the possibility of financial crises through the mechanisms discussed in section 2.

If equity premium shocks are predominant, then reacting to equity prices would be stabilising. However, in this model this type of shock has little impact on the variables. This impact would be larger if the value of α_2 (the wealth effect) were bigger. Values of α_2 above 0.14 would make the optimised λ_3 positive. As for supply shocks, reacting to equity prices stabilises both inflation and output in the case of anticipated shocks, and stabilises only output in the case of unanticipated shocks.

Additional research showed that exactly the same patterns would emerge in the case of an inflation-forecast targeting rule as in equation (8). Under this rule, the optimised δ_2 would be positive for values of α_2 larger than 0.07.

The conclusion, as in Cecchetti *et al.* (2000), is that reacting to asset prices themselves is not a good idea. The desirability of reacting to equity prices depends on the type of shocks that disturb the economy. Reacting to equity prices is undoubtedly stabilising if those shocks represent non-fundamental movements in equity prices. Thus, reacting to misalignments would have the benefit of not destabilising (nor would it stabilise) output and inflation in the event of a supply or demand shock. When these shocks occur there is no misalignment and therefore no adjustment of the interest rate. On the other hand, reacting to misalignments would stabilise inflation and output in the event of an equity premium shock. If a positive equity premium shock occurs, equity prices will rise above fundamentals, thus causing a misalignment which would call for a (stabilising) increase of the interest rate.

4.2   Should the Central Bank Aim at Financial Stability? The Welfare Function

Notwithstanding different points of view about the uncertainty surrounding the determination of asset prices equilibrium and other issues raised by reacting to asset prices, described below, there exists some consensus that monetary policy should not aim at asset price stability. According to that dominant view, monetary policy should concentrate on goods and services inflation. This view implies that asset prices should not be included in the central banker's loss function, that is, policymakers should not be concerned with volatility in asset prices in itself. Therefore, the argument set forth by Cecchetti *et al.* (2000) - see section 3 - that central bankers should stabilise asset prices around fundamentals should be understood as a means to stabilise output and inflation. Even authors like Ben Bernanke and Mark Gertler to whom financial stability is a crucial condition for macroeconomic stability - as we saw above - agree that monetary policy should not aim directly at financial stability. We should stress that reacting to asset prices in

order to stabilise the economy and aiming to stabilise the financial markets are two different things.

The variance of inflation, output, the interest rate, equity prices and fundamentals under the different policy rules were computed as in Alexandre *et al.* (2001) and are presented in Table 3. The coefficients used by each rule are shown in Table 4.

Table 3: Variances under different policy rules

Rule	Variance					Loss Function
	y_t	π_t	A_t	F_t	r_t	
TR	66.11	6.04	1098.64	872.93	15.08	76.37
TR+A	65.61	5.54	1108.98	875.82	15.27	75.12
TR+mis.	65.99	5.90	1094.22	874.07	15.10	75.97
IFT	67.51	2.87	1105.87	882.57	14.99	73.16
IFT+A	67.57	2.79	1108.33	883.25	14.00	73.11
IFT+mis.	67.46	2.85	1103.16	883.10	14.98	73.05

Table 4: Optimised coefficients

Rule	Coefficients				
	y_t	π_t	$E_t\pi_{t+1}$	A_t	$A_t - F_t$
TR	0.17	1.71	-	-	-
TR+A	0.20	1.47	-	-0.05	-
TR+mis.	0.17	1.66	-	-	0.04
IFT	-	-	3.07	-	-
IFT+A	-	-	2.84	-0.02	-
IFT+mis.	-	-	2.95	-	0.04

From Table 3 we draw two results. First, inflation-forecast targeting rules perform better than Taylor rules in terms of the overall loss. The improvement comes from a reduction in inflation volatility which compensates for an increase in output volatility. The variance of equity prices tends to be higher under inflation-forecast targeting rules, though only slightly. On the contrary, the variance of the interest rate is slightly lower under inflation-forecast targeting rules. This means that the increase in the volatility of asset prices under an IFT rule comes from the increase in the uncertainty surrounding dividends, i.e. output. Second, changes in variances resulting from reacting to equity prices are relatively small. A more important change occurs, in this model, when we move from a Taylor rule to an inflation-forecast targeting rule.

4.3 Uncertainty in the Estimation of Misalignments

An issue closely related to this discussion is the estimation of asset price misalignments from its fundamentals; a question that is not very well understood as emphasized in Gertler *et al.* (1998). Actually, the difficulties raised by this task have been one of the main arguments against the reaction to asset prices, notably Bernanke and Gertler (1999). However, supporters of a more active monetary policy, like Cecchetti *et al.* (2000), argue that the difficulty in estimating asset prices misalignments cannot be used as an argument against reacting to asset prices, as policymakers always need to estimate misalignments, for example, when we estimate the output gap or forecast inflation. If it were a valid argument, then we could not use it to estimate the output gap or to forecast inflation. On the other side, Bernanke and Gertler (2001) argue that, although there are difficulties in estimating the output gap, the standard deviations in the estimation of stock prices fundamentals are certainly far higher. Although the difficulties in estimating asset prices misalignments are widely acknowledged, there are several examples of overvaluation in stock markets that seemed to have generated a general consensus, at least *a posteriori*: this is the case of Japan in the end of the eighties and the case of equity prices in the U.S.A. and in most European countries in the 90s, among others (see, for example, Shiller: 2000).

Initially, we propose to introduce uncertainty in our model by means of adding a random noise to the "observed" misalignment. That is, policy-makers will react to $A_t^* = A_t - F_t + \epsilon_t$, where ϵ_t is NID, with variance given by $n.V(A_t - F_t)$. The parameter n is what we will call the "noise-to-signal ratio."

In the case of the Taylor rule (TR+mis. in Table 4), a noise-to-signal ratio of about 1/3 would be required for the uncertainty in the misalignment to make it preferable not to react to misalignments (i.e. employ TR instead). In the case of the inflation-forecast targeting rule (IFT+mis. in Table 4), a noise-to-signal ratio slightly under 1/4 (around 0.23) would be sufficient for rule IFT in Table 4 to be preferable.

Now suppose that there is also noise in the values of y_t, π_t and $E_t\pi_{t+1}$ observed by the monetary authority. Assume again that the errors enter additively and are NID with variance given by $n.V(y_t)$, $n.V(\pi_t)$, and $n.V(E_t\pi_{t+1})$, respectively. Thus, we are assuming that the "noise-to-signal ratio" is the same for all variables. In the case of the Taylor rule, additional experiments showed that an increase of 0.1 in the noise-to-signal ratio leads to a reduction in the benefit of reacting to misalignments approximately equal to 0.005. Given that the benefit (difference between the loss function of TR and the loss function of TR+mis. - see Table 3)

was around 0.4 with a zero noise-to-signal ratio, it will be preferable not to react to asset prices when the noise-to-signal ratio is around 8, which appears to be implausible. As for the inflation-forecast targeting rule, as the noise-to-signal ration increases, the benefit of reacting to misalignments actually increases. This might be signalling that the IFT rule is less "robust" to errors than the IFT+mis. rule.

The analysis in the previous paragraph was conducted under the assumption of zero-correlation between the measurement errors. However, it has been argued (e.g. Cecchetti *et al.*: 2000 - recall the first paragraph in this subsection) that if we there are errors in the estimation of misalignments, then there will also be errors in the estimation of the other policy variables. The implication is that the estimation errors are likely to be correlated. Table 5 shows for different levels of positive correlation between the errors in the estimation of y_t, π_t and $A_t - F_t$ the corresponding level of noise-to-signal ratio that makes the policy-maker indifferent between rules TR and TR+mis. and between rules IFT and IFT+mis..

Table 5: Critical noise-to-signal ratio

	Correlation	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
n	Taylor R.	0.305	0.155	0.104	0.078	0.063	0.052	0.045	0.039	0.035	0.032
	Inf. For. R.	0.386	0.139	0.085	0.061	0.048	0.039	0.033	0.029	0.025	0.023

Apparently, a large noise-to-signal ratio is not required to erase the benefits of reacting to misalignments, if there is some degree of positive correlation between the estimation errors. Also, when an inflation-forecast targeting rule is employed and the correlation is more than 0.1, a lower noise-to-signal ratio wipes out the benefits of reacting to misalignments.

We must stress that these results do not bear on the issue of whether reacting to equity prices contributes to prevent the emergence of bubbles and, since bubbles that do not come into being do not burst, thereby reduces macroeconomic instability. What our results show is that it is possible that the argument that estimation errors cannot be waged against monetary policy "leaning against the wind" may not be acceptable.

4.4 No bubble busting, please!

Bernanke and Gertler (1999), in their very influential paper, defend that, because price and financial stability are highly complementary and consistent objectives, when policymakers pursue the former objective they are indirectly contributing to the second. According to this authors,

therefore, a flexible inflation targeting regime[16] is the most adequate monetary strategy to deal with non-fundamental movements in asset prices. That is, according to this monetary strategy central banks should adjust their policy instrument whenever expected inflation deviates from the target and monetary policy should, therefore, respond to movements in asset prices only insofar as they affect expected inflation.

According to these authors reacting directly to asset prices raises several difficulties and, therefore, there are good reasons for policymakers to concentrate exclusively on price stability, that is, on both inflationary and deflationary forces. Besides the difficulties associated with reacting to asset prices mentioned above, they argue that a flexible inflation targeting strategy is the best monetary policy strategy to deal with volatility in asset prices because it favours macroeconomic stability and, thus, reduces the potential for financial panics. Why are price stability and financial stability consistent and mutually reinforcing objectives and why is a flexible inflation targeting strategy the most adequate framework to achieve both objectives?

Supporters of an inflation targeting regime claim that this monetary policy framework helps to stabilise not only inflation but the whole macroeconomic environment. This monetary strategy would not only stabilise prices but also financial markets. In the opinion of Bernanke and Gertler (1999) there are several reasons for this potential double beneficial effect. First, a low inflation environment is in itself beneficial for financial markets stability. Second, "the central bank's easing in the face of asset prices decline should help to insulate balance sheets to some degree, reducing the economy's vulnerability to further adverse shocks" (Bernanke and Gertler: 1999). Third, "if financial market participants expect the central bank to behave in this countercyclical manner, rising interest rates when asset prices 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" (Bernanke and Gertler: 1999). Additionally, an inflation target strategy implies that only movements in asset prices that produce inflationary effects motivate a reaction by the policy instrument. To illustrate the harmony between financial and price stability, Gertler, in Gertler *et al.* (1998), refers to the October 1987 U.S. crash in the stock market: in that situation, a stable macroeconomic environment allowed the Federal Reserve to avert a more dramatic financial crisis through monetary easing.

However, this reasoning is not without problems. Implicitly the support for an asymmetric

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[16]Bernanke *et al.* (1999) define inflation targeting as a monetary policy framework in which authorities recognise price stability as the overriding goal of its actions and announce an inflation target in accordance. These authors also emphasise as distinguishing features of this regime the efforts to communicate with the public and central bank's accountability for achieving these objectives.

reaction of policy makers can be conveyed with all the potential for moral hazard behaviour on the part of investors: investors may buy more assets on the expectation that central banks will cut the interest rates to prevent the market from falling.[17] Miller *et al.* (1999) suggest that this was actually the behaviour of the Federal Reserve during the 90s and that it contributed to the stock market climb. However, Alan Greenspan denies the asymmetric character of the Fed monetary policy: equity prices move asymmetrically not the Fed. They go down very sharply, asking for very strong monetary policy reactions in order to prevent a financial crisis; but they generally go up very smoothly and slowly.

By the same token, Blinder (1997) alerts to the dangers of central bankers following the "financial market's lead" that would result from the short term horizon of financial markets and the consequent overreaction of these markets: because financial markets are very sensitive to expectations about what central banks will do, central banks may end doing what markets want. As Issing refers, in Gertler *et al.* (1998), this can raise the risk of circularity or the "dog chasing its tail phenomenon."[18]

Another potential problem with this approach, as we have seen, is the key aspect of the premise of the crucial role of price stability to financial stability in the conclusions of Bernanke and Gertler (1999). If macroeconomic stability is probably the best way to achieve financial stability, as is argued by several authors (see, for example, Gertler *et al.*: 1998), it also true that price stability has been mentioned as one of the factors behind stock markets' irrational exuberance (Blinder: 1999). Shiller (2000) includes low inflation as one of the precipitating factors of the market climb since 1982 and Kent and Lowe (1997) remark that "While low and stable inflation should reduce the likelihood of an asset-price bubble occurring, it does not guarantee that bubbles will not occur; the Japanese experience in the late 80s is an obvious example." These authors also warn that asset-price bubbles in a low-inflation environment may be more damaging for the economy: since in a low-inflation environment falls in nominal asset prices are more likely, financial institutions run a greater risk of not being able to collect the full collateral value on bad loans.

In short, the main conclusion of Bernanke and Gertler (1999) is "no bubble busting, please." Simultaneously, in the presence of an asset price crash they advocate a strong intervention by the

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[17]In Gertler *et al.* (1998), Issing argues that a tendency for central bankers to react asymmetrically - because increases in equity are welcome and declines are seen as distressing for real economic activity - can damage central banks' credibility.

[18]The circularity results from the central bank using private sector forecasts which themselves are based on expected monetary policy. In this case, the anchor that stabilises expectations is missing.

central bank in order to prevent a financial crisis that can be highly disruptive for the economic system. Their rationale comes from the sense of potential non-linearities and asymmetries in asset price effects on the real economy: declines in asset prices may have stronger effects on output and inflation, suggesting that monetary policy should react more aggressively to declines then to increases in asset prices (Crockett: 1998). From their simulation exercise, Bernanke and Gertler (1999) conclude that in the presence of an asset price shock a more aggressive reaction of the policy instrument results in better macroeconomic performance and they also acknowledge that monetary policy may have an important role in face of asset price volatility: their view of history is that asset price crashes have damaged the economy only when monetary policy did not react or instead favoured deflationary pressures - in this context they add the important role of an efficient regulatory financial system and even adequate fiscal policies to increase the public confidence.[19]

Shiller (2000), for example, although suggesting that a small increase in interest rates accompanied by a public statement that it intends to reduce speculation may be beneficial, mentions the cases of the U.S.A. in the 30s and Japan in 1989 as examples of the potentially devastating effects of a monetary policy response. The action of the Federal Reserve during 1928-30 is also used in Cogley (1999) to contend that the impossibility of identifying bubbles timely makes any attempt to stem speculation destabilising. According to Bernanke and Gertler (1999), another reason for not reacting to asset prices is the unpredictable psychology of investors. Yet, in this context, Goodfriend, in Gertler *et al.* (1998), questions why equity markets continue to be so nervous at the prospect of an increase in interest rates.

5   Conclusion

Improvements in macroeconomic performance, in terms of inflation and output stabilisation, over the last decade combined with increasing volatility in asset prices have shifted the attention of central bankers and theorists to developments in financial markets. Among asset prices much attention has been devoted to equity prices.

Our discussion seems to suggest that the disagreement between opposers and supporters of reacting to asset prices is more apparent than real. Both sides agree on the dangers of a stock

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[19]Bernanke and Gertler (1999) do not hesitate to praise the 1987 reaction of the Federal Reserve to the Stock market crash. Similarly, Goodfriend, in Gertler *et al.* (1998), refuses any systematic reaction to asset prices, for all the reasons mentioned above, but strongly supports action by central bankers in order to restore financial stability following a crash in the stock market.

market crash to the stability of the real economy. The difference between the two views is, in our opinion, one of degree: Bernanke and Gertler (1999) are more cautious about reacting to asset price increases given the dangers of generating a financial panic; Cecchetti *et al.* (2000) and Kent and Lowe (1997) are more venturous. Blanchard (2000), commenting on Bernanke and Gertler (1999), considers that not reacting to asset prices is a very "attractive" answer: "It is surely an attractive answer from the point of view of the central bank: having to respond to bubbles is likely to be unpopular with financial investors."

We conclude that the desirability of reacting to equity prices depends on the type of shocks disturbing the economy. Although reacting to equity prices would be stabilising if equity premium shocks are predominant, that would not be the proper policy reaction in the case of demand and supply shocks. Another conclusion is that inflation-forecast targeting rules perform better than Taylor rules in terms of the central bank loss function and that the benefits of reacting to asset prices are marginal.

In deciding the appropriate answer of monetary policy to asset prices two important issues arise: the uncertainty in the estimation of asset prices misalignments and estimation of the wealth effect. Assuming a commonly mentioned value for the wealth effect, our analysis lead to the conclusion that a small degree of positive correlation between estimation errors is sufficient to make reaction to equity prices undesirable at low "noise-to-signal" ratios.

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