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Investment and non-fundamental movements in asset prices: is there a role for monetary policy?

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ABSTRACT

The role of monetary policy during periods of asset price volatility has been the subject of discussion among economists and policymakers at least since the 1920s and the Great Depression that followed. Some economists have been arguing that the performance of inflation-targeting central banks can be improved by reacting to misalignments in asset prices, because these may result in distortions in consumption and investment decisions. Using a sticky price model with endogenous investment driven by non-fundamental movements in asset prices, we discuss the potential benefits, in terms of output and inflation stabilisation, of monetary policy reacting to asset prices over and above the deviation of the inflation forecast from the target. We show that identifying the source of asset price movements is crucial to welfare gains.

1. INTRODUCTION

THE ROLE OF MONETARY POLICY during periods of high asset price volatility has been the subject of discussion among economists and policymakers at least since the 1920s and the Great Depression that followed. Discussion on this topic increased greatly after the collapse of the recent Japanese and US asset price bubbles. In both cases asset price bubbles coincided with investment booms. A recession followed the crash in capital markets and the economy found itself with too much capital. This raised concerns about the proper monetary policy when asset prices deviate from fundamentals.

In the 1990s, the inflation-targeting regime was almost universally accepted as the ideal monetary policy regime, whether there is a bubble in asset prices or not.[2] According to this view, 'monetary policy should not respond to changes in asset prices, except insofar as they signal changes in expected inflation' (Bernanke and Gertler, 1999, p.18). Although this view is almost consensual among economists, it has been the subject of some criticisms, notably by Cecchetti *et al.* (2000). Cecchetti *et al.* (2000) argue that the performance of inflation-targeting central banks, in terms of output and inflation stability, can be improved by reacting to asset-price misalignments over and above the deviation of the inflation forecast from the target. The reason for a better macroeconomic performance is that misalignments in asset prices will result in distortions in investment and consumption decisions, creating potentially disruptive effects on output and inflation.

Other authors have argued that, given the effects that stock prices may have on investment, a flexible inflation-targeting regime may not be the best monetary policy strategy to deal with a bubble economy. Blanchard (2000), for example, argued that the existence of some sort of irrationality in asset prices might result in excessive capital accumulation if monetary policy is not aggressive enough to pin down its distortionary effect on investment. A similar argument was put forward by William Poole at a speech delivered at Bradley University (Poole, 2001), who asserted that 'distorted price signals from the stock market permitted the industry to raise capital easily and cheaply, which certainly contributed to the overexpansion' of the US economy in the 1990s. In the same context, Dupor (2002) argues that asset price inflation should be taken into account by policymakers as an indicator of capital over-accumulation.

In this paper we discuss these arguments by means of a sticky price model with endogenous investment driven by non-fundamental movements in asset prices.[3] We evaluate the potential benefits, in terms of output and inflation stabilisation, of employing a monetary policy rule that reacts to asset prices. We assume that equity prices are contaminated by sentiment — i.e., deviations from rationality — and that this distorts firms' investment decisions: managers cannot disentangle sentiment and information about fundamentals, leading to 'wrong' investment decisions. If there is a bubble in stock prices, this may result in excessive capital accumulation.

In section 2 we discuss, through the presentation of theories and evidence on the relationship between stock prices and investment, whether the existence of some form of irrational exuberance in the stock market may induce firms to invest beyond what fundamentals suggest.

In section 3, we describe a sticky-price model with endogenous investment and adjustment costs where asset prices may be driven by a non-fundamental shock. Section 4 discusses the policy evaluation approach used in this paper, which John Taylor (2000, p.61) has called the 'new normative macroeconomics'. Section 5 analyses the dynamics of the system, looking at the variance of the system under different policy rules and at the impulse response functions when the economy is hit by a technology and a non-fundamental shock. We also look into the issue of asset price versus inflation stabilisation. Section 6 concludes.

2. Stock prices and the real economy: the investment channel

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 monetary policy, has recently been recovered. This renewed interest arises 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.

If movements in stock prices reflected only fundamentals, policymakers would not have to pay attention to price volatility *per se*. However, at least since the seminal work of Shiller (1981), theoretical and empirical work suggests that fashions and fads, and not only fundamentals, affect asset prices. Shiller and others in a series of papers, most of them collected in Shiller (1989), looked for evidence on the relative importance to asset price movements of changes in economic fundamentals and changes in opinion or psychology. Although the answer to this question is still not well established owing to statistical difficulties, it is almost consensual today that stock prices exhibit more volatility than is justified by fundamentals. Given these findings, several authors (e.g., Robert Shiller, Andrei Shleifer, James Poterba, Lawrence Summers, among others) have been proposing behavioural theories, models of contagion of opinion and behaviour, fads and bubbles to provide an explanation for the empirical findings that have raised doubts on the efficient markets hypothesis, and therefore to justify marked and prolonged deviations of asset prices from fundamentals.

Additionally, for policymakers to be concerned about movements in stock prices, the non-fundamental movements will have to affect real economic activity. Bernanke and Gertler (2001, p.253) argued that 'asset booms and busts have been important factors in macroeconomic fluctuations in both industrial and developing countries'. Although there are several channels through which asset prices may impinge on the real economy, in this paper we focus on the effects that go through the investment channel.[4]

The opposite views of Bosworth (1975) and Fischer and Merton (1984) describe the divergence in the literature on the effects of market valuations on investment. On the one hand, Bosworth (1975, p.280) argues that although 'the stock market and investment behaviour are intimately bound together since firms invest to earn profits, and activity in the stock market represents an attempt by investors to evaluate the magnitudes of that stream of profits', managers should ignore the information from the market and base their investment decisions on their own valuation of fundamentals. In that case the stock market would be a sideshow with no effect on investment decisions.

On the other hand, Fischer and Merton (1984) argue that managers should simply consider the stock market valuation and explore investor sentiment. In the authors' opinion, whether or not they coincide with their assessment of fundamentals, firms should react to stock prices changes when taking their investment decisions: firms should follow investor exuberance and invest until the marginal product of capital equals the rate of return the investor expects. In this case, non-fundamental movements in asset prices affect investment and, therefore, the real economy, opening an avenue for the intervention of monetary policy.

Next we describe the main channels through which asset prices may affect investment.

2.1 *Tobin's q, the active informant hypothesis and the balance sheet channel*

Although there is by now enough evidence that stock returns predict investment (Morck *et al.*, 1990) the channels that make that correlation hold are not so evident. The most cited channels between stock prices and investment are the Tobin's *q*, the active informant hypothesis and the balance sheet channel.

The Tobin's *q* theory was first presented in Tobin (1969), where *q* stands for the ratio of the market's valuation of capital to its replacement cost. According to this theory an increase in stock prices increases the value of capital relative to the cost of acquiring new capital and thus increases investment demand by firms. However, several studies (see, for example, Barro, 1990, Blanchard *et al.*, 1993, and Chirinko, 1993) have shown that *q* is not a good predictor of investment, at least when compared to other variables. A first problem in the empirical investment literature is that fundamentals are unobservable by the econometrician and therefore a proxy has to be chosen — sales and cash flow in Morck *et al.* (1990) and profits or its expected present discounted value as in Blanchard *et al.* (1993) — and the results are not independent of the choice.

Another problem is the choice of the variable to represent market valuation, that is, Tobin's *q* or the stock price. The use of *q* can easily result in measurement error problems, given the problems involved in the computation of *q*, namely, the construction of capital at replacement cost. More recently, Bond *et al.* (2000) and Bond and Cummins (2001) mention noise in equity prices as an explanation for the empirical failure of the model. In his study on the effects of stock prices on investment, Barro (1990) concludes that stock prices outperform a standard *q*-variable in explaining investment and that stock prices are an important determinant of US investment, especially for long-term samples, even when he controls for cash flow variables.

Morck *et al.* (1990), when revising the different channels from stock prices to investment, emphasise the one that stresses the fact that managers, when making investment decisions, have in the stock market a source of information that may or may not correctly describe future fundamentals. According to this view, the active informant hypothesis, stock prices predict investment because they convey relevant information to managers when deciding on investment. It is arguable that the market does inform firms' managers, which have to take investment decisions about, for example, the future state of the economy, namely future aggregate or individual demand. However, information contained in stock prices may accurately, or inaccurately, predict fundamentals. It can inaccurately predict fundamentals because of their inherent unpredictability 'or because stock prices are contaminated by sentiment that managers cannot separate from information about fundamentals' (Morck *et al.*, 1990, p.164). In that case, sentiment — that is, the component of stock prices that is not explained by fundamentals — may distort investment decisions through the false signals it transmits to the managers. According to these authors' terminology, in that case, the stock market will be a 'faulty active informant'.

Morck *et al.* (1990) regress investment growth on stock returns and the growth in fundamental variables in order to see how important the stock market is, after controlling for fundamentals — the growth rates of sales and cash flow. As they put it, they try to answer the following question: 'If managers knew future fundamentals, would orthogonal movements in share price still help predict their investment decisions?' (Morck *et al.*, 1990, p.169). Although they concluded that they could never reject the null hypothesis that investor sentiment does not affect investment through the stock market, their results suggest that it is not the most important factor in explaining investment. For firm-level data they conclude that investor sentiment has a very small explanatory power for investment and that the 'market may not be a complete sideshow, but nor is it very central' (Morck *et al.*, 1990, p.199). The same results were achieved from aggregate data.

Another important paper on the effects of stock prices on investment is Blanchard *et al.* (1993). These authors analyse whether investment moves more with the stock market or with fundamentals, using time series for the period 1900-1990. For fundamentals they employ two proxies: first, the expected present discounted value of the profit rate, conditional on information available as of the time of investment; second, the profit rate. When controlling for fundamentals, and especially when they use profits as a proxy, they conclude that market valuation has a limited effect in explaining investment behaviour over the period of analysis and that 'time series evidence strongly rejects the hypothesis that managers simply follow the market valuation' (Blanchard *et al.*, 1993, p.127). However, they conclude that stock prices matter: 'an increase of 1 percent in the market valuation not matched by an increase in fundamentals leads to an increase in investment of 0.45 percent' (Blanchard *et al.*, 1993, p.124).

Another important channel by which stock prices influence investment is the balance sheet channel (see, for example, Bernanke *et al.*, 1999, and Kiyotaki and Moore, 1995). In this case, the link between stock prices and investment works through their indirect effects on the financial structure of firms. Capital markets are characterised by imperfect information and incentive and enforcement problems. In such a world, the cost of borrowing depends on the financial position of agents and, therefore, an increase (decrease) in asset prices increases (decreases) the market value of borrowers' collateral and their ability to borrow and invest. These effects may 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 of Japan in the 1990s seem to suggest.

Bernanke and Gertler (1999) analyse the benefits of monetary policy reacting to asset prices in a small-scale dynamic New Keynesian model, extended to allow for financial accelerator effects — as developed in Bernanke *et al.* (1999) — and for exogenous bubbles in asset prices, which affect investment, and therefore the real economy, via the financial accelerator. In this model firms' capital is financed through internally generated funds and by borrowing. As described above, because there are credit-market frictions, stock price movements, through their impact on firms' net worth, affect the collateral firms can offer to banks and thus their costs of financing, and this affects investment. Therefore in this model, links between changes in asset prices and the real economy work through the financial accelerator mechanism. Gilchrist and Leahy (2002) use the framework of Bernanke *et al.* (1999) to analyse the effect of a non-fundamental shock to the net worth of firms and of a technological shock.

Dupor (2002) develops a sticky price-imperfect competition model with endogenous capital accumulation and investment adjustment costs. Dupor concludes that optimal monetary policy should react to non-fundamental movements in asset prices. In Dupor's model a non-fundamental increase in equity prices leads to inefficient physical investment.

2.2 Periods of marked deviations from fundamentals

The study of the relationship between stock prices and investment is of great interest during periods of marked deviations of stock prices from fundamentals. Gilchrist and Leahy (2002, p.84) mention that 'large movements in asset prices tend to be associated with waves of optimism and pessimism about the future'. If there is some irrational exuberance in the stock market driving prices up because investors believe in a New Era economy, as described in Shiller (2000), then firms may be 'forced' to follow that enthusiasm and invest beyond what would be suggested by fundamentals.

The 1920s and the Great Depression that followed, and the crash of 1987, have been studied as periods during which asset prices deviated markedly from fundamentals. The examination of both periods by Barro (1990) led him to conclude that managers do not follow the market valuation closely in their investment decisions. Firms invested less during the 1920s than implied by market valuation; and after the 1929 crash, investment fell more than the fall in the stock market would suggest. In the case of the 1987 crash, the author concludes that, when investing, firms must have considered information other than market valuation was 'surprisingly strong', what provides evidence that firms ignore stock prices in their investment decisions. Blanchard *et al.* (1993) reached the same conclusion.

Two other periods of marked deviations from the fundamentals are the second half of the 1980s in Japan and the 1990s in the American economy. The Japanese stock price index Nikkei 225 climbed from 11,543 in January 1985 to 38,916 — an increase of 237 per cent or an average annual growth rate of 27.5 per cent; the S&P 500 stock price index for the American economy climbed from 459 in January 1995 to 1521 in September 2000 — an increase of 231 per cent or an average annual growth rate of 23.5 per cent. During these periods, fixed capital investment increased at an average annual real growth rate of nine per cent.[5] Looking at the Japanese economy in the 1980s, Chirinko and Schaller (2001), using different types of evidence conclude that there was a bubble in the equity markets and that it affected business fixed investment. The authors first confirm that the stock market boom of the late 1980s coincided with high levels of business fixed investment and that, at the peak in 1989, the funds raised from securities issues covered almost 90 per cent of the expenditures on business fixed investment by the principal Japanese enterprises, when usually it covers only 30 per cent. Using a non-structural forecasting equation and controlling for other macroeconomic factors that might have affected investment, the authors concluded that 'the investment/capital ratio was about 20 per cent higher than predicted by these factors in the late 1980's, but lower than predicted following the crash' (Chirinko and Schaller, 2001, p.678). This evidence is reinforced by the use of orthogonality tests and parametric estimates; from these they concluded that the bubble 'boosted fixed investment by approximately 6-9 percent in the years 1987-89' (Chirinko and Schaller, 2001, p.679). The boom in stock prices and in fixed investment in the American economy in the 1990s is certainly worthy of further research.

The overall conclusion from these empirical studies is that market valuation, when proxying fundamentals by cash flow and profits, has a role, although a limited one, in the determination of investment decisions. That is, the stock market is not a sideshow; it affects real economic activity, through its effect on investment. Therefore, in the next section, we describe a model with endogenous investment where the asset price is affected by a non-fundamental shock that will allow us to discuss the potential benefits from monetary policy reacting to asset prices, in terms of inflation and output stabilisation.

3. A MODEL WITH INVESTMENT AND A NON-FUNDAMENTAL SHOCK

Because of its high volatility and weight in aggregate demand, investment is seen, at least since John Maynard Keynes, as a major determinant of the business cycle. Therefore, with central banks aiming at stabilising inflation and output, and given the evidence presented above, we ask if there is something monetary policy can do to improve things in periods of enthusiasm or optimism about the future, with stock prices booming and firms induced to invest beyond what fundamentals would imply or, on the other hand, during a wave of pessimism, a crash in stock prices and delays in the implementation of investment projects. That is, does the distortionary effect of a bubble on investment provide an argument for a reaction of monetary policy to asset prices, in order to stabilise output and inflation?

In our analysis, we use the dynamic New Keynesian framework with endogenous investment and adjustment costs developed by Casares and McCallum (2000). The model assumes monopolistic competition and nominal price rigidities to allow for non-neutral effects of monetary policy. To the basic model we add an *ad hoc* term in the investment equation, that, as explained below, should be seen as a shock to fundamentals which distorts firms' investment decisions. This model allows us to discuss the benefits of a monetary policy rule that reacts to asset prices, in terms of a welfare function to be defined below, when misalignments in asset prices induce distortions in investment and consumption decisions.

The system is described by the following equations, which are log-linearised around the steady state.[6]

$$y_t = w_1 c_t + w_2 x_t \tag{1}$$

$$c_t = E_t c_{t+1} - \rho^{-1}(i_t - \pi_t) + \beta v_t \tag{2}$$

$$x_t = \frac{1}{1+\delta} E_t x_{t+1} + \Omega\left[\Theta E_t f_{2t+1} - (i_t - E_t \pi_{t+1}) + \psi_t\right] + \frac{\delta}{1+\delta} k_t \tag{3}$$

$$q_t = \eta(x_t - k_t) \tag{4}$$

$$k_{t+1} = (1-\delta)\, k_t + \delta x_t \tag{5}$$

$$f_{2t} = f_2\left(n^{ss}, k^{ss}\right)(y_t - k_t) \tag{6}$$

$$a_t = \rho_a a_{t-1} + \varepsilon_{at} \tag{7}$$

$$\bar{y}_t = (1-\alpha)\, a_t + \alpha k_t \tag{8}$$

$$\tilde{y}_t = y_t - \bar{y}_t \tag{9}$$

$$\pi_t = \phi_0 E_t \pi_{t+1} + (1-\phi_0)\pi_{t-1} + \phi_1 \tilde{y}_t + \varepsilon_{\pi t} \tag{10}$$

All variables represent percent deviations around the steady state. Equation (1) is the overall resource constraint, with w_1 and w_2 giving the steady-state shares of consumption, c_t, and investment, x_t, respectively, in total output. Equation (2) is the Euler equation for consumption, which depends positively on its own next period's expected value and negatively on the real interest rate, $r_t = i_t - E_t\pi_{t+1}$. Additionally, consumption depends on a preference shock, v_t, that is assumed to follow an AR(1) process.

Equation (3) is, in the words of Casares and McCallum (2000, p.13), an 'expectational investment equation' as investment, x_t, depends on its own expected next period's value. Investment also depends on the difference between the expected return on physical capital, $E_t f_{2t+1}$, and the return on the financial asset, r_t, which the authors above refer to as the real asset premium. The coefficient of this term, Ω, should be read as the semi-elasticity of investment relative to the real asset's premium and depends on the adopted adjustment cost specification and parameterisation. The inclusion of costs in installing capital — besides its theoretical justification — results from the fact that, in its absence capital, the marginal product of capital, and the marginal product of labour are more volatile than observed in the data. Among the different adjustment cost specifications considered in Casares and McCallum (2000) we chose that which makes, as shown in Hayashi (1982), the average value of Tobin's *q* equal to its marginal value: that is, the total adjustment cost depends not only on the amount of new capital invested but also on the stock of capital, implying constant returns to scale for the production function net of adjustment costs. This specification is of interest to us because, in this case, the marginal value of Tobin's q, which is a sufficient statistic to determine the level of investment by firms, is equal to the market value of capital, q_t, which is defined below.

Additionally we include an *ad hoc* term, ψ_t, that should be seen as a non-fundamental shock. The introduction of this non-fundamental shock represents a deviation from rationality and implies that firms will sometimes misestimate the gap between the expected return on capital and the real interest rate, leading to a distortion in investment decisions. The non-fundamental shock will therefore affect investment and asset prices. This is similar to Dupor (2002), where there is a deviation from rational expectations in that firms can misestimate the future return to current capital accumulation; when firms overestimate them, investment increases and asset prices run-up. Bernanke and Gertler (1999) allow for bubbles in stock prices, but their effects on the real economy are transmitted through the balance sheet channel and a wealth effect: investment decisions by firms are based on fundamentals. Thus, in Bernanke and Gertler (1999) non-fundamental movements in asset prices do not affect investment directly, with firms' investment decisions being based on fundamental *q*.

In our model, the non-fundamental shock, when positive, will result in an overestimation of the gap between the expected return on physical capital and the interest rate and will, therefore, stimulate investment beyond what fundamentals suggest. We thus assume that the stock market will be, in this case, a 'faulty active informant' in Morck *et al*'s. (1990, p.165) terminology — that is, the information about fundamentals in stock prices may be inaccurate and may therefore distort investment decisions through false signals to managers.

Alternatively, the non-fundamental shock may be interpreted as a misalignment in the value of capital, which affects investment through a q effect and thus the real economy. We assume that the non-fundamental shock follows an autoregressive process, $\quad_{t} = \rho^{f}\psi_{t-1} + \varepsilon_{t}^{f}$.

The market value of capital, q_t, is derived from the optimality condition for investment decisions and implies that, in equilibrium, the cost of acquiring one additional unit of capital is equal to the expected present value of next period's net return and is given by equation (4).

Equation (5) is the log-linearised form of capital accumulation. Equation (6) is the log-linear approximation to the marginal product of capital for a Cobb-Douglas production form. Equation (7) describes the process followed by the labour-augmenting technology. Equation (8) gives natural output, $\bar{y}$, that is, the output that would prevail if there was no deviation from full price flexibility. Equation (9) defines the output gap, $\tilde{y}$, as the deviation of output from its natural level.

Equation (10) depicts the price-adjustment process — the Phillips curve — in the economy. This specification differs from the New Phillips curve as it includes a backward-looking term for inflation that is believed to match the data more closely. An equation like the hybrid Phillips curve was derived by, e.g., Galí and Gertler (1999). The backward-looking term reflects the existence of a fraction of firms that employ a 'rule of thumb' procedure to set their prices. This price adjustment specification is also similar to the one adopted by Fuhrer and Moore (1995) and produces both price and inflation inertia. These authors found that this hybrid Phillips curve fits the USA data well. A similar conclusion was obtained by Roberts (2001) and Rudebusch (2002).

The value of the parameters used in our simulation exercise are summarised in Table 1. They are as in Casares and McCallum (2000), except for the value of 0.13 for the hybrid Phillips curve coefficient on the output gap. This is a higher value than the one used in Casares and McCallum (2000), 0.03, and follows the value estimated in Rudebusch (2002) that is thought to be a more reasonable value.

Table 1: Parameters' values

ρ	α	δ	ϕ_0	ϕ_1	ρ_a	ρ_v	Ω	Θ	w_1	w_2	η
5	0.36	0.025	0.5	0.13	0.95	0.3	2.5	0.03	0.78	0.22	2.55

In the next section we describe in some detail the method of analysis we use to evaluate the benefits of monetary policy reacting to the non-fundamental shock in the context of the model we have just described.

4. Policy evaluation approach

In this model, monetary policy is implemented through simple monetary policy rules for the nominal interest rate, the central bank's instrument. To study the potential benefits from monetary policy moderating the impact of misalignments in asset prices, we evaluate the effects of letting the policy instrument react to asset prices over and above the reaction to deviations of expected inflation from the target. Our policy evaluation approach is based on the computation of an expected loss, described below, for alternative policy rules with respect to the entire probability distribution of economic shocks, not just the most unfavourable outcomes. We then can compare the ability of different policy rules to stabilise inflation, output and the other variables of the system, when the economy is hit by asset-market disturbances.[7] The stability of the variables is evaluated in terms of their unconditional variance, as explained below.

4.1 Policy rules

All monetary policy rules considered in our analysis are interest rate rules, and all are simple rules, in that they make the interest rate dependent on the values taken by a small number of key variables. The exclusive use of interest rate rules for policy rests on the evidence that virtually all industrialized countries' central banks use some short-term (nominal) interest rate as their policy instrument (Walsh, 1998). Simple rules have been widely discussed among academics and in wider discussions about monetary policy. Of course, because simple rules do not use all the information available they will not in general be optimal.

There is a debate as to their descriptive realism. On the one hand, Taylor (1993) has argued that a simple rule — the Taylor rule — was a good description of the Federal Reserve's interest rate policy, and Clarida *et al.* (1998) have argued that the Bundesbank can be represented as having set German interest rates in response to a few key variables. On the other hand, Ryan and Thompson (2000) remark that no central bank actually uses a simple rule. It is important to note that in the whole analysis it is assumed that policymakers can adhere to the policy rules that have been chosen. Questions of time-inconsistency do not arise here.

Next, we describe briefly each of the interest rate rules used in this paper. The symbols used in the following equations are defined as follows: i_t is the nominal interest rate; π_t is the inflation rate; q_t is the fundamental value of capital; ψ_t is the non-fundamental shock in the investment equation. All are measured as log-deviations from steady state values.

A narrow definition of inflation targeting is as a regime in which the interest rate is set so as to achieve the target value for the forecast of the inflation rate, at an appropriate horizon. Rudebusch and Svensson (1999, p.203) define inflation targeting as a 'framework for policy decisions that involves comparing an inflation forecast to the announced target, thus providing an "inflation-forecast" targeting policy, where the forecast serves as an intermediate target'. They view inflation targeting as a regime in which central bankers can be modelled as setting interest rates using all available information so as to optimise a welfare function that penalises deviations from the inflation target.

A slightly looser definition of inflation targeting, following Batini and Nelson (2000), McCallum and Nelson (1999) and others, is as a regime in which the policy instrument reacts to deviations of expected inflation from target, for a given horizon. On this looser definition, a policy would approximate more closely that under the narrower definition (strict inflation targeting) the greater the strength of the response of the interest rate to the deviation from target. It is argued that such forecast-based forward-looking rules approximate well the behaviour of inflation-targeting central banks (see, for example, Svensson, 1997).[8] In our analysis we will take this wider view of inflation targeting and represent inflation targeting as the use of a rule that sets the policy instrument (the nominal interest rate) as a function of the deviations of the inflation forecast, for a defined horizon, from the target. The policy rule is:

$$i_t = \gamma E_t \pi_{t+1} \tag{11}$$

where i is the policy instrument and γ is the feedback parameter; $E_t \pi_{t+1}$ is expected inflation in the next period, conditional on the information at time *t*. In our analysis, and given the lag structure of our model, we assume that central banks set nominal interest rates in response to deviations of the inflation forecast one period ahead from the target. This rule will be referred to as IFT.

Most of the research on central banks' reaction to asset prices conclude that they change interest rates when forecast inflation deviates from the target and that monetary policy does not react to asset price movements (see, for example, Kozicki, 1999). However, Dupor and Conley (2004) estimate an interest rule which includes a stock market measure and find that the Federal Reserve responds to the stock market. Gilchrist and Leahy (2002, p.75) say that 'the collapse of the equity markets is undoubtedly part of the motivation for the recent reductions in the federal funds rate, just as a concern over "irrational exuberance" which provided some motivation for the relatively tight policy of the preceding few years'. The behaviour of the system under this policy rule will allow us to assess the arguments of the defenders of a reaction to asset prices when there is some form of irrationality driving their value.

Dupor (2002) found it optimal to react to the asset price because it provides an indicator of capital accumulation, which cannot be identified through consumer price inflation. We then consider the case in which the monetary policy rule reacts not only to deviations of inflation from the target but also to the current asset price:

$$i_t = \gamma_1 E_t \pi_{t+1} + \gamma_2 q_t \tag{12}$$

Hereafter this rule will be referred to as *IFT+q*. In choosing the optimised coefficients for the classes of policy rules described above, we consider that the policymaker tries to minimise the unconditional variances of inflation, output and of the policy instrument. We also experimented with 'Taylor rules' instead of these 'inflation-forecast targeting' rules. The Taylor rules performed worse than the IFT rules. To save space, the results are not reported here. The loss function used in the comparisons is described in the next section.

4.2 The Central Bank's loss function

In considering what concerns the welfare function, we should also mention that although the focus of analysis is the question of whether or not monetary policy should react to asset prices over and above deviations of inflation from the target, we are not addressing the question of whether or not monetary policy should target asset prices in the sense that they belong in the objective function. The dominant view is that monetary policy should concentrate on goods and services inflation and should not aim at asset price stability. Therefore, the discussion of whether or not central bankers should stabilise asset prices around fundamentals, should be understood as a means to stabilise output and inflation. Or, as Cecchetti *et al.* (2002, p.2) put it, '... we are concerned with how an inflation targeting bank can most effectively fulfil its objectives'. 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. Therefore, the welfare function that we consider has the following form:

$$E[L_t] = V(\pi_t) + V(y_t) + 0.5V(i_t - i_{t-1}) \tag{13}$$

The inclusion of output and inflation in the central bank's loss function reflects the wide agreement that they represent the most important concerns of policymakers — even inflation targeters such as the Bank of England claim that they are not 'inflation nutters', in Mervyn King's words. The inclusion of an interest rate smoothing term in the expected loss reduces volatility of the policy instrument and is justified, among other reasons, because policymakers are very concerned about financial stability (Mishkin, 1999). A similar loss can be derived from a microfounded general equilibrium model without endogenous investment, as shown in Rotemberg and Woodford (1997), as a second-order approximation to the utility function of the representative agent.[9]

In the baseline simulations the same weight is given to the unconditional variance of output and inflation, and half of this weight is given to the unconditional variance of the policy instrument, following Rudebusch and Svensson (1999).

Gilchrist and Leahy (2002) use a different approach to evaluate the performance of policy rules. They first simulate a real business cycle (RBC) version of their model and then simulate New Keynesian and financial accelerator versions under inflation-targeting rules. They assess the optimality of the rules by how close the variables' paths are to their paths in the RBC version.

5. Reacting to movements in asset prices

According to Bernanke and Gertler (1999), a flexible inflation-targeting regime is the most adequate strategy to deal with non-fundamental movements in asset prices. Thus, in their view central banks should adjust the interest rate 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. The main argument of the supporters of an inflation-targeting regime to deal with non-fundamental movements in asset prices is that price and financial stability are consistent and mutually reinforcing objectives; that is, when policymakers pursue the former objective they are indirectly contributing to the second. This monetary policy strategy would not only stabilise inflation but also financial markets.

Besides their beliefs on the benefits of price stability to financial stability, defenders of an inflation-targeting regime point out several reasons for not reacting to asset prices. The first one, and their main argument against reacting to asset prices, is the inability of central banks to identify in a timely manner deviations of asset prices from their fundamental value (see, for example, Gertler *et al.*, 1998). However, advocates of a more activist reaction of monetary policy to asset prices, while agreeing that there are difficulties in estimating misalignments in asset prices, argue that it is not harder than estimating the output gap or the NAIRU, also crucial for monetary policymaking. Cecchetti *et al.* (2002) argue that, in the case of the output gap, estimates of the same uncertain variables (productivity growth and equity risk premium) are needed as in the estimation of misalignments in asset prices. These authors therefore conclude that 'counter-arguments claiming that it is difficult to interpret asset prices are correct, but they apply to other aspects of inflation targeting as well, so they do not eliminate the case for taking account of asset price misalignments in the conduct of monetary policy' (Cecchetti *et al.*, 2002, p.20). However, Alexandre and Bação (2005) show that when there is noise in the variables to which the monetary policy instrument responds and this noise is positively correlated across variables, benefits from reacting to misalignments in asset prices may disappear.

Another reason for the defenders of an inflation-targeting monetary policy strategy to oppose a reaction to asset prices is based on the argument that financial markets are very sensitive to monetary policy decisions and that the psychology of investors is unpredictable (see, for example, Bernanke and Gertler, 1999). Among the most cited examples of the potentially devastating effects of a monetary policy response to asset prices are the monetary policy of the Federal Reserve during 1928-30 (see, for example, Hamilton, 1987, and

Cogley, 1999) and that of the Bank of Japan in 1989 (see, for example, Posen (ed), 2000).

Another view on what monetary policy should do in the presence of misalignments in asset prices is the one put forward in Cecchetti *et al.* (2000) and Cecchetti *et al.* (2002). According to this view, central banks seeking to smooth output and inflation fluctuations can achieve a better macroeconomic performance by reacting to asset prices. These authors emphasise that they are not recommending that central banks target asset prices but only to react to asset prices such that 'inflation-targeting central banks can most effectively fulfil its objectives' (Cecchetti *et al.*, 2002, p.2). The reason for a better outcome from reacting to asset prices, in terms of output and inflation stability, is that misalignments in asset prices will result in distortions in investment and consumption, creating potentially disruptive effects for output and inflation.

According to this more activist view, central bankers should change interest rates when asset prices deviate from their estimated warranted levels — increasing interest rates when they rise above it and decreasing interest rates when they are below it — in order to offset their potentially destabilising effects on output and inflation. Cecchetti *et al.* (2000), also argue that leaning against the wind (after Poole's 1970 paper) in this way will reduce the probability of bubbles developing and thus reduce the risk of boom-bust investment cycles. To sum up, the main argument of the defenders of a reaction to asset prices by inflation-targeting central banks is based on the belief that financial imbalances may develop without showing up in the price indexes.

Blanchard (2000) also argues against the view of Bernanke and Gertler (1999). According to this author, although an inflation-targeting regime stabilises inflation (and the output gap) it may result in an excess of capital accumulation. Assuming that investment is under the influence of both the real interest rate and the bubble, while consumption is less sensitive to the bubble — in our example, consumption is not affected directly by the non-fundamental shock — and that the central bank increases the interest rate, aiming at stabilizing inflation, the result will be a higher decrease in consumption compared to investment, representing a change in the composition of output. In the end the economy would have too much capital and too little consumption. Similarly, in Dupor (2002) asset price inflation is relevant for monetary policy not because it signals price inflation but because it can be an indicator of distortions in the capital market. In sum, according to Blanchard (2000) and Dupor (2002), when there is some sort of irrationality in asset prices, the use of an inflation-targeting strategy will result in excessive capital accumulation; the reason is that in this case monetary policy will not be aggressive enough to offset the distortionary effect on investment of the asset-price misalignment.

Therefore, in the next section we look at the benefits, in terms of output and inflation stabilisation, of monetary policy reacting to asset prices when they are driven by some form of irrationality that can result in too much investment.

5.1 The variances under different policy rules

The model described above give rise to a system of difference equations in which past and expected values of variables are included. The system is first written in the Blanchard-Kahn form (Blanchard and Kahn, 1980) and then solved using the procedure described in Soderlind (1999), applying a Schur decomposition to the coefficient matrix.[10]

The stability of the variables is evaluated in terms of their unconditional variances that are computed in the way we now describe. The reduced-form solution of the model is of the form

$$X_{t+1} = BX_t + C\varepsilon_{t+1} \tag{14}$$

and the variance-covariance matrix of X, denoted by V, is the solution of[11]

$$V = BVB' + CV(\varepsilon)C' \tag{15}$$

The variance-covariance matrix of the shocks $V(\varepsilon)$, as explained below, is the identity matrix. We should stress that the results are only valid for economies close to their steady state, i.e., that are not experiencing major changes or transitions.

Because of the uncertainty on the sources of the volatility observed in stock prices, we start by conducting sensitivity analysis on the parameters of the non-fundamental component.

5.1.1 Non-fundamental shock persistence: sensitivity analysis

There is a significant component of the volatility of stock prices that is due to fluctuations in the non-fundamental component (Balke and Wohar, 2002). The part of the volatility in stock prices that results from the volatility in the non-fundamental component will depend both on the degree of persistence and on the variance of the shock. We therefore do a sensitivity analysis for both parameters of the non-fundamental process.

We start by considering an identity matrix for the variance-covariance matrix of the shocks considered in the model and compute the optimised coefficients and the loss for different degrees of persistence of the non-fundamental shock in the investment equation. The results for the inflation-targeting rule, reacting and not reacting to asset prices, are presented in Table 2.

As expected, the social welfare loss decreases with the degree of persistence of the non-fundamental shock. When we compare the results of reacting and not reacting to asset prices, we conclude that there is always a welfare benefit from reacting to asset prices and that it increases with the degree of persistence of the shock.

Table 2: Degree of persistence in the non-fundamental shock

	0.3	0.5	0.7	0.9
IFT	$\gamma = 1.6$	$\gamma = 1.69$	$\gamma = 1.95$	$\gamma = 2.54$
Loss	6.15	6.48	7.17	8.51
IFT+q	$\gamma_1 = 1.86$; $\gamma_2 = 0.41$	$\gamma_1 = 2.2$; $\gamma_2 = 0.82$	$\gamma_1 = 2.74$; $\gamma_2 = 1.49$	$\gamma_1 = 2.58$; $\gamma_2 = 1.248$
Loss	6.01	6.17	6.27	6.27

We have also conducted sensitivity analysis for the variance of the non-fundamental shock. Since what is of interest in our study is the variance of the non-fundamental shock relative to the variance of other shocks, we performed our sensitivity analysis for the cases where the variance of the non-fundamental shock is two times and five times the variance of the other shocks, additionally to the case presented above in which the variances of all the shocks in the model are equal to one. We conclude that, for both classes of policy rules, there are significant benefits, in terms of loss, from reacting to asset prices, with the bulk of it coming from a much more stable output gap. The lower volatility in the output gap results from conspicuously higher investment stability, whilst consumption appears to be only slightly more volatile. Inflation does not seem to be significantly affected by the variance of the shock. The policy instrument becomes much more volatile as the variance of the non-fundamental shock increases and, for all the cases analysed, a reaction to asset prices makes it much more stable.

In sum, we conclude that changes in the variance of the non-fundamental shock appear to result only in differences in the magnitude of the variance of the system, with the quality of the results being unchanged.[12] Therefore, in the analysis that follows we will concentrate on the case of very high persistence, 0.9, in the non-fundamental shock; that is, a case in which the gap between the expected return on capital and the real interest rate that determines investment deviate for a long period from the fundamentals, and we will assume throughout our analysis a variance-covariance matrix of shocks equal to the identity matrix.

5.1.2 The benefits of reacting to asset prices

The optimised coefficients for the different classes of policy rules are given in Table 3.

Table 3: Optimal parameters in policy rules

	$E_t\pi_{t+1}$	q
IFT	2.54	------
IFT+q	2.58	1.25

Using these coefficients we compute the loss and the variance of the system's variables under the different policy rules and assess their results, namely, the benefits of reacting to asset prices. Table 4 contains the results.

Table 4: Measures of macroeconomic performance under alternative policy rules

	IFT	*IFT+q*
$V(r)$	9.91	6.74
$V(k)$	46.57	40.92
$V(f_2)$	18.93	16.45
$V(\bar{y})$	12.81	11.94
$V(y)$	16.87	13.76
$V(\tilde{y})$	3.82	1.98
$V(c)$	12.85	12.87
$V(\pi)$	2.79	2.88
$V(i)$	209.56	157.6
$V(i_t - i_{t-1})$	3.79	2.81
$V(q)$	11.27	5.76
Loss	8.51	6.27

From the analysis of Table 4 above we conclude that there are gains in terms of welfare from reacting to asset prices. The benefits from reacting to asset prices result from a more stable output gap, which is the consequence of more stable investment: the variance of investment is reduced by approximately 25.5 per cent. A reaction to asset prices results in very small changes in the variance of inflation and consumption.

The results presented above seem therefore to give support to the arguments of Blanchard (2000) and other defenders of the 'bubble view', who criticise the view that a flexible inflation-targeting regime is the most appropriate monetary policy strategy to deal with an asset price run-up, whether or not it is driven by non-fundamental movements. According to Dupor (2002, p.2) reacting to asset prices is optimal because it ‘may provide an indicator of capital overaccumulation, which cannot be gleaned from examining consumer or price inflation’.

5.2 Impulse response functions

As we saw above, Cecchetti *et al.* (2000) and Smets (1997) contend that monetary policy should lean against the wind of significant asset price movements if these disturbances originate in asset markets themselves. That is, according to these authors, the benefits of monetary policy reacting to asset prices depend crucially on the cause behind its movement and, therefore, identifying the source of asset price movements, namely, whether they are caused by changes in fundamentals or by changes unrelated to fundamentals, is required to determining the appropriate monetary policy response. When asset price movements are driven by non-fundamental factors and affect the real economy — as in our model — they can be the cause of instability and should, therefore, be taken into account by policymakers.

In Alexandre and Bação (2002) we also conclude that the desirability of reacting to asset prices depends on the type of shock hitting the economy. Bernanke and Gertler (1999) point out the difficulties in identifying the source in asset price misalignments as one of the main arguments against reacting to asset prices. Therefore we analyse the behaviour of the system under the non-fundamental shock and under a shock in the labour-augmenting technology. This analysis will also allow a better description of the dynamics of the system. In the Appendix we present the graphs of the impulse response functions for different shocks under different policy rules. We also compute the sum of squared deviations.

5.2.1 Non-fundamental shock

The effects of reacting to the non-fundamental shock that deserve to be stressed are the following. A non-fundamental shock to investment results in an increase in investment and in a decrease in consumption for both policy rules (see Figs. 1 and 2). When the economy is under the influence of a non-fundamental shock that results in an increase in investment, for the reasons described above, and monetary policy is targeting inflation, investment will still go up and consumption, that is assumed not to depend directly on the fad, will decrease following the increase in the interest rate. This will result in too much capital in the economy. These results support the findings in Dupor (2002), and the arguments of Blanchard (2000), that pursuing an inflation-targeting strategy when there is some form of irrationality affecting the value of asset prices, will result in too much investment at the cost of lower consumption with what it implies in terms of a misallocation of the resources of the economy. Following the argument of Olivier Blanchard, among others, of reacting to deviations of the expected inflation from the target and, additionally, to deviations from fundamentals, results in a smaller departure of investment from its equilibrium value (its initial deviation from equilibrium is reduced by almost 30 per cent when compared to the inflation-targeting case) while consumption becomes even more depressed. The higher decrease in consumption when the policy instrument reacts to the asset price results from a higher real interest rate than in the previous case (see Fig. 3).

However, the output gap and inflation become more stable when the policy instrument reacts to asset prices additionally to the deviations of expected inflation from the target (see Figs. 4 and 5). Computing the squared deviations from equilibrium for both variables and for both policy rules we get the values in Table 5.

Table 6: Sum of squared deviations following a non-fundamental shock

	Inflation	*Output gap*
IFT	1.033	0.319
IFT+q	0.0869	0.0001

In Table 5 the stabilising effects in terms of output gap and inflation from reacting to asset prices are evident. Gilchrist and Leahy (2002) analyse the effect of a shock to net worth and conclude it creates a dilemma for the central banker. In this case, there is a trade-off in their model between stabilising inflation and output.

5.2.2 Technology shock

Now we look at the results for the output gap and inflation of reacting to asset prices additionally to reacting to deviations of expected inflation from the target, when the economy is hit by a labour-augmenting technology shock. In this case we conclude that reacting to asset prices when the source of the misalignment is a technology shock makes inflation and the output gap more unstable. Computing the squared deviations from equilibrium for both variables and for both policy rules we get the values in Table 6.

Table 6: Sum of squared deviations following a technology shock

	Inflation	*Output gap*
IFT	0.0095	0.0002
IFT+q	0.284	0.02367

The values in Table 6 show the destabilising effects in terms of output gap and inflation from reacting to the asset price when the economy is hit by a technology shock. The reaction of the policy instrument to the asset price motivates a higher real interest rate (see Fig. 8), relative to the situation in which the policy instrument only reacts to deviations of the expected inflation from the target, leading to a larger decrease in the output gap and inflation (see Figs. 6 and 7). The fall in the output gap, despite the increase in consumption and investment, results from a greater increase in natural output than in actual output, as a consequence of the technology shock. Gilchrist and

Leahy (2002) also conclude that when the economy is hit by a technology shock there is no need for monetary policy to react to asset prices.

We conclude, as in Alexandre and Bação (2002), that the origin of the shock matters for the decision of whether reacting to asset prices and that, as Cecchetti *et al.* (2000) argue, monetary policy should lean against the wind of significant asset price movements if these disturbances originate in the asset markets themselves.

5.3 Asset price and inflation stabilisation

As discussed above, one of the main arguments of Bernanke and Gertler (1999) against monetary policy reacting to asset prices is that price and financial stability are consistent and mutually reinforcing objectives. Therefore, according to these authors, an inflation-targeting strategy would not only stabilise inflation but also financial markets.

Cecchetti *et al.* (2000) and Mundell (2000) argue that central bankers pursuing price stability will more easily reach that target by reacting to asset prices. Figs. 4 and 9 depict the reaction of both inflation and the asset price to a non-fundamental shock when the policy instrument reacts and when it does not react to the asset price in addition to deviations of the expected inflation from the target. From this analysis we can conclude that reacting to asset prices when a non-fundamental shock affects the economy makes inflation and the asset price more stable.

Table 7: Sum of squared deviations following a non-fundamental shock

	Inflation	*Asset price*
IFT	1.033	2.487
IFT+q	0.087	1.854

The same result can be observed using the sum of squares for inflation and q for both policy rules in Table 7.

Our results seem to support the argument set forth in Cecchetti *et al.* (2000) as both the asset price and inflation seem to be more stable when the policy instrument reacts to asset prices in addition to deviations of expected inflation from the target. However, that result contrasts with the result in Dupor (2002), in the context of a fully optimal policy rule, that asset price stabilisation is achieved at a higher cost in terms of inflation.

6. Conclusion

Although high investment rates are of great importance for long term growth if, when taking investment decisions, firms are responding to distorted signals from the stock market, the economy may end up with too much capital. The recent asset price bubbles in the stock and housing markets in the Japanese and in the US economies (and their bursting) have raised a wide discussion on what monetary policy can and cannot do to avoid the deranging effects of financial crises on the real economy.

In this paper we have simulated the effects of different policy rules in a sticky price model with endogenous investment and adjustment costs, in order to illustrate the potential benefits of monetary policy reacting to asset prices, when they are under the influence of some form of irrationality which is transmitted to investment. Through our simulations we describe some of the issues present in the discussion of monetary policy and asset prices, in particular, we have tried to assess how a reaction of the central bank's interest rate instrument to asset prices helps to stabilise output and inflation. We measure the benefits of that reaction by comparing it to the results achieved by an inflation forecast targeting rule that we argue to be a good description an inflation-targeting monetary policy regime.

We have seen that there are gains in terms of welfare from reacting to asset prices. Benefits from reacting to asset prices come from a more stable output gap, which is the consequence of more stable investment. Therefore, in the context of our model, we have shown that an inflation-targeting regime may result in a misallocation of the resources of the economy, with too much investment at the cost of lower consumption, when some form of irrationality affects the value of asset prices.

We have also shown that the origin of the shock matters for the decision of whether reacting to asset prices and that, as Cecchetti *et al.* (2000) argue, monetary policy should lean against the wind of significant asset price movements if these disturbances originate in the asset markets themselves. Therefore more efforts in the identification of the fundamental value of asset prices are needed, in order to make it possible to have good estimations of misalignments, and to improve implementation of monetary policy.

Additionally, asset prices and inflation seem to be more stable if the policy instrument reacts to asset prices in addition to deviations of expected inflation from the target, when the economy is hit by a non-fundamental shock. This seems to support the argument set forth in Cecchetti *et al.* (2000) that central bankers that pursue price stability will more easily reach their target by reacting to asset prices.

However, our discussion did not deal with several important issues that have been discussed in the literature. One such issue is that of whether the central bank should react asymmetrically to asset price movements. An asymmetric reaction may create problems of 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. Another issue that certainly deserves more attention in future research is the relation between monetary policy and the behaviour of asset prices, something that is not very well understood and that causes difficulties to interventions by the central bank: a small interest rate increase may not be sufficient to stabilise asset prices; and a large increase can cause an unnecessary recession.

In conclusion, the main efforts in the future will have to concentrate, first, in the identification of the fundamental value of asset prices, in order to make it possible to have good estimations of misalignments and, second, on the effects of monetary policy on asset prices, such that central banks can know by how much they should move the policy instruments to kill off deviations from fundamentals. Finally, for all this to result in more stable output and inflation, policymakers will need to have a better understanding of the way asset prices affect the real economy, namely, they need to have more accurate estimates of the impact of changes in asset prices on consumption and investment.

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APPENDIX

Figure 1: Non-fundamental shock - effect on investment

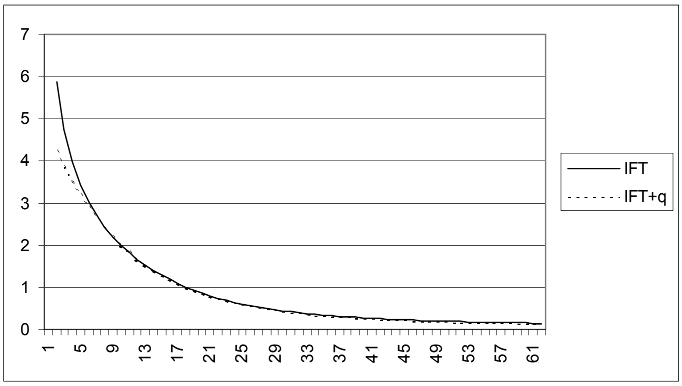


Figure 2: Non-fundamental shock - effect on consumption

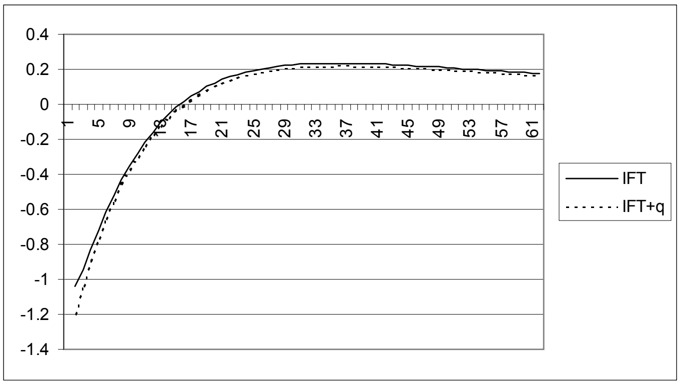


Figure 3: Non-fundamental shock - effect on the real interest rate

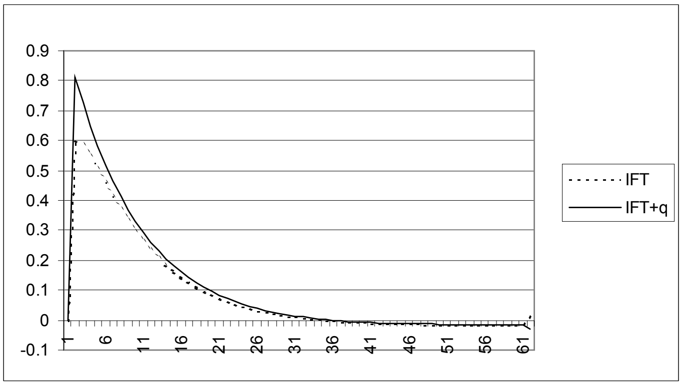


Figure 4: Non-fundamental shock - effect on inflation

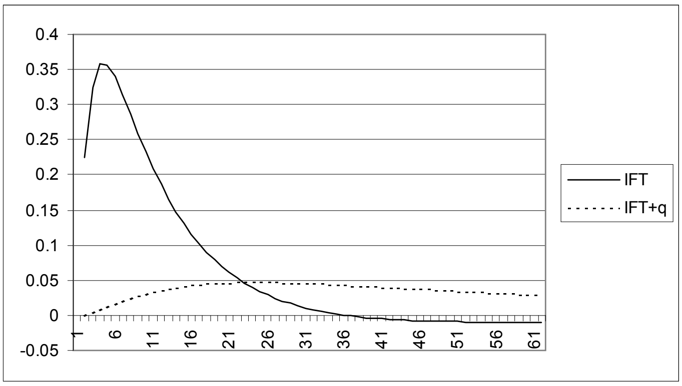


Figure 5: Non-fundamental shock - effect on the output gap

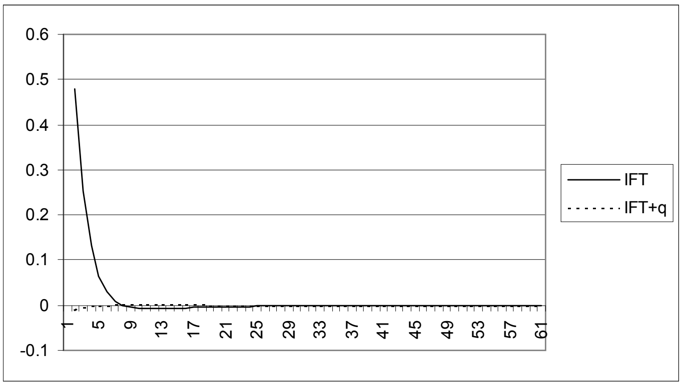


Figure 6: Technology shock - effect on inflation

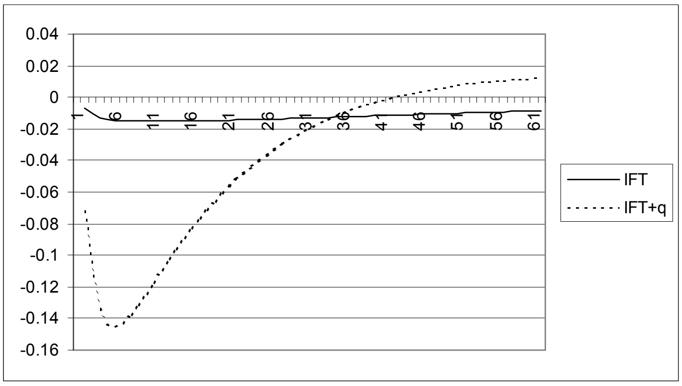


Figure 7: Technology shock - effect on the output gap

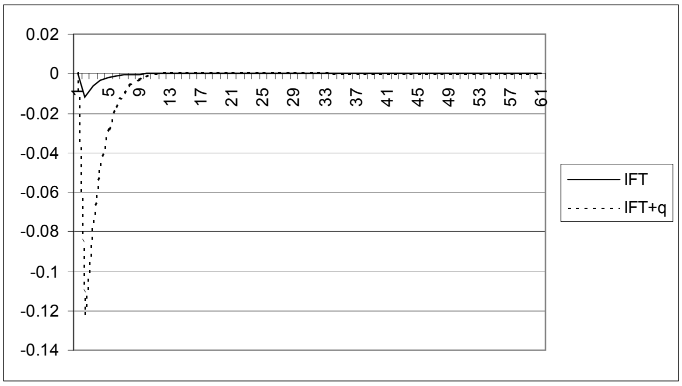


Figure 8: Technology shock - effect on the real interest rate

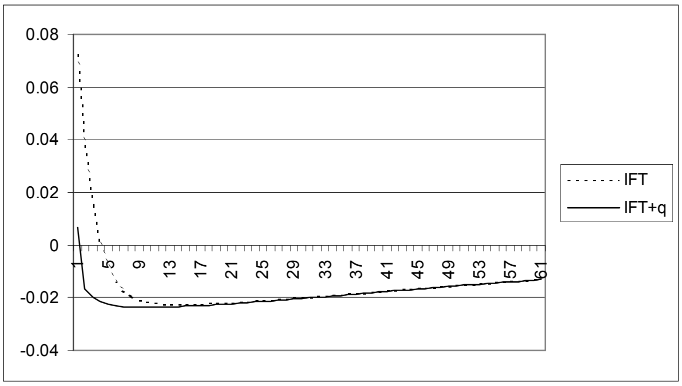
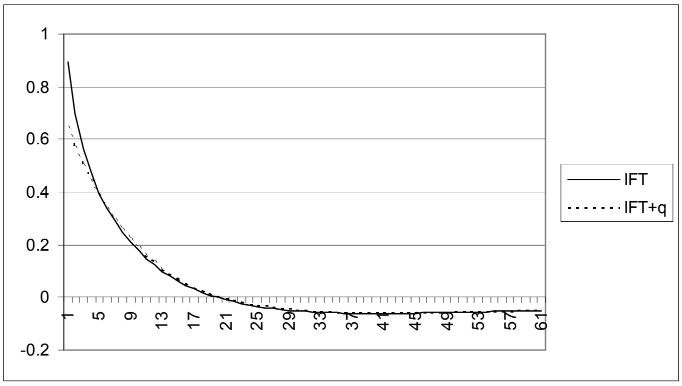


Figure 9: Non-fundamental shock - effect on the asset price



ENDNOTES

1. Alexandre: University of Minho and NIPE; Escola de Economia e Gestão, Universidade do Minho, Braga, Portugal; email: falex@eeg.uminho.pt. Bação: University of Coimbra and GEMF, Coimbra, Portugal; email: pmab@fe.uc.pt. The authors are grateful to John Driffill, Charles Nolan, Andrew Scott, participants at a Birkbeck College Seminar and at the 9th International Conference of Computational Economics, Seattle, an anonymous referee and the editors for helpful comments on earlier versions of this paper. The usual disclaimer applies. The authors also acknowledge financial support from the Portuguese Foundation for Science and Technology under research grant POCI/EGE/56054/2004 (partially funded by FEDER).

2. For a description of this monetary policy regime see, among others, Bernanke *et al.* (1999).

3. Note that the 'non-fundamental shocks' we shall refer to are not related to sunspot equilibria, which arise in models with indeterminate solutions. Our shocks refer to unwarranted deviations from the model's solution. Gilchrist et al. (2004) propose a behavioural model to justify such deviations. We thank an anonymous referee for bringing this to our attention.

4. See, for example, Alexandre and Bação (2002) for a discussion of the wealth effect channel of asset prices.

5. Data from Datastream.

6. A complete explanation of the derivation of these equations is provided in Casares and McCallum (2000).

7. Comparisons of the performance of different policy rules in the context of an otherwise unchanged model always bring to mind the 'Lucas critique'. The fact that in our equations, parameters should be seen as structural and that the IS and the Phillips curve equations are forward looking, should make the Lucas critique ineffective. However, some authors (see, for example, Sims, 2001, and Estrella and Fuhrer, 1998) have been suggesting that, even in that case, a model may still be affected by policy changes. As an example, it is possible that different monetary policy regimes might imply differences in wage setting. This is something that certainly deserves more attention in the future.

8. For a more detailed discussion on this issue see Alexandre *et al.* (2002).

9. Smets and Wouters (2004) provide a very interesting welfare analysis of the impact of non-fundamental shocks. They do not, however, study the benefits of including asset prices in the policy reaction function, which is the focus of this article.

10. We ran all the programs in Gauss and used the implementation of the Schur decomposition made available by Soderlind at http://www.hhs.se//personal/psoderlind.

11. See Hamilton (1994, p.265).

12. These results are available from the authors upon request.

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