



ELSEVIER

Journal of Monetary Economics 49 (2002) 75–97

Journal of
MONETARY
ECONOMICS

www.elsevier.com/locate/econbase

Monetary policy and asset prices[☆]

Simon Gilchrist^{a,b}, John V. Leahy^{c,d,*}

^a *Boston University, Boston, MA 02215, USA*

^b *National Bureau of Economic Research, Cambridge, MA 02138, USA*

^c *Department of Economics, Boston University, 270 Bay State Road, Boston, MA 02215, USA*

^d *National Bureau of Economic Research, Cambridge, MA 02138, USA*

Received 18 April 2001; received in revised form 8 August 2001; accepted 9 August 2001

Abstract

The first part of this paper surveys the literature on asset prices and monetary policy. We then consider the appropriate policy response to two types of shocks that are associated with how asset prices affect the economy. The first set of shocks are the ones whose primary impact lies in the future. These shocks affect the economy and asset prices through expectations of future growth. The second set are shocks to net worth which directly impact the ability of firms to borrow and for consumers to lend. © 2002 Elsevier Science B.V. All rights reserved.

JEL classification: E44; E52; E60

Keywords: Monetary policy; Asset prices

1. Introduction

With large movements in asset prices in the United States and Japan apparently coinciding with large swings in growth rates, many commentators have recently called for monetary policy makers to respond to asset price volatility. Policy makers, at least in the United States, appear to have taken notice. The collapse of the equity markets is undoubtedly part of the motivation for the recent reductions in the

[☆]We would like to thank Bill Dupor and an anonymous referee for valuable comments and Chris House for valuable research assistance. We would also like to thank the National Science Foundation for financial support.

*Corresponding author. Department of Economics, Boston University, 270 Bay State Road, Boston, MA 02215, USA, Tel.: +1-617-353-6675; fax: +1-617-353-4449.

E-mail address: jleahy@bu.edu (J.V. Leahy).

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 first part of this paper provides an overview of the literature on asset prices and monetary policy. Three general arguments are considered: asset prices belong in a measure of the price level, asset prices forecast inflation, and there are structural links between asset prices and consumption and investment.

Our summation of the literature is that the first argument is impractical, the second unfounded, and that the third, while important, does not alone provide a basis for basing policy on asset prices. Concerning the first, whether or not the price of future consumption belongs in an appropriately defined price index, assets such as the stock market do not proxy well for these futures prices. As for the second, we show that asset prices have little forecasting power beyond output and consumption. Finally, the third argument is theoretically correct, but because asset price movements tend to be positively correlated with movements in output and inflation, policies based on these variables subsume most of the gains from reacting to asset prices.

After surveying the literature, we perform a number of experiments of our own. We consider two situations in which asset prices are likely to have a big impact on the economy. The first concerns shocks that have their main impact in the future. We have in mind situations like the recent revolution in information technology in which current productivity gains become magnified by dreams of a “new economy” and the resulting potential for future growth. We consider the effects of a “future loaded” technology shock in three different models: a real business cycle model, a new Keynesian model with Calvo-style price rigidity and a model with a financial accelerator. The RBC model provides the fictionless benchmark. The other two reflect different distortions.

Interestingly, simulations of the models behave very differently. In the RBC model, the expected increase in productivity causes consumption to rise and labor to substitute to the future. The initial fall in labor supply causes output to fall and investment is initially crowded out by consumption. In this model, asset prices actually fall in anticipation of the productivity boom. This result appears to be quite robust to changes in the parameter values. When prices and interest rates are sticky, the latter due to the policy of the central bank, a rise in expected inflation causes the real interest rate to fall and output to expand. As a result asset prices rise greatly. If in addition, there is a financial friction so that borrowing depends on the value of collateral, then the initial boom is even larger. These two models tend to push output, inflation and asset prices in the opposite direction of the RBC model.

In the end, however, we do not find that these differences provide an argument including asset prices in monetary policy rules. Instead, choosing an interest rate rule that is reactive to inflation eliminates the differences between the models. The reason is that optimism and the resulting asset boom causes output, inflation and investment to all rise. A policy of increasing the real interest rate brings them all back down together.

The second type of experiment that we consider are shocks to the net worth of entrepreneurs. The motivation for considering these shocks are the problems that

appear to arise between borrowers and lenders after large asset price movements. In New England in the early 1990s and in Japan today weak balance sheets have appeared to hold the economy back. Since variations in net worth directly affect the efficiency of contractual relations between borrowers and lenders and hence the gap between output and its optimal level, monetary policies cannot completely offset the effects of net worth shocks. A policy of price stability eliminates the inefficiencies caused by price inertia, but still leaves much of the effect of the net worth shock on output. Eliminating the effect on output requires deflation. To make matters worse, net worth shocks drive a wedge between consumption and investment. The real interest rate tends to rise, thereby reducing consumption. At the same time the borrowing rate falls due to the fall in the risk premium on loans, thereby increasing investment. So that even if output is stable, the components of output may fluctuate. Theoretically, this provides the best argument for including asset prices in a policy rule, since asset prices provide information concerning the distortion in the financial markets. Interest rates spreads, however, could also perform this task.

Section 2 provides a brief survey of the literature on monetary policy and asset prices. Section 3 discusses “future loaded” technology shocks and shocks to net worth. Section 4 concludes.

2. Why asset prices?

The literature on asset prices and monetary policy tends to focus on three arguments. We treat these in turn.

2.1. *Broader price indexes*

Alchian and Klein (1973) argue that monetary authorities should be concerned about asset prices for their own sake. In their view, price indices, such as the CPI or the GDP deflator, are deficient because they consider only the price of goods consumed today. A complete measure of the cost of living would also include changes in the prices of future goods. If, for example, housing prices rise, but rents remain unchanged, they would argue that the purchasing power of money had fallen even though the CPI would show no effects.

Alchian and Klein’s ideal index would be the minimum cost of purchasing a unit of life-time utility in a complete set of Arrow–Debreu futures markets. In practice, however, such futures markets do not exist, so Alchian and Klein suggest using asset prices in their stead. In a sense, all saving is an attempt to purchase future consumption. Shibuya (1992) shows that under certain conditions the Alchian–Klein measure of inflation can be summarized as a weighted sum of consumer price inflation and asset price inflation.

While the theoretical validity of the Alchian and Klein argument is debatable, two practical issues pretty well doom the approach. First, the link between asset prices such as stock prices and the Arrow–Debreu prices required by the theory is often tenuous. Asset prices change for many reasons, not all related to the cost of future

consumption. For example, when expected profits rise, share prices may rise with no change in interest rates. Each share purchases a greater amount of future consumption. In this case, asset prices confuse changes in the price of future consumption with changes in the quantity of future consumption. This may lead, not only to errors of magnitude, but to errors of sign. For example, applying the Alchian–Klein methodology to the U.S. stock price boom of the 1990s would have led to the conclusion that the cost of living had risen. The high real interest rates of the period, however, indicated that the cost of future consumption was in fact low. Presumably, the stock boom reflected high expected profits, not an increase in the cost of future consumption. Similarly, the recent stock market collapse has been associated with falling interest rates and falling expected returns. Again a stock price based index would show falling prices when the true cost of living is probably rising.

Second, even if an ideal Alchian and Klein index could be constructed, it is not obvious that monetary authorities should prefer it as a measure of price stability to conventional measures such as the CPI. Which the monetary authority should prefer depends on one's theory concerning the welfare costs of inflation. If the cost of inflation is associated with price stickiness, either directly through the cost of changing prices, or indirectly through the cost of misaligned prices, then the correct index is the one most closely associated with rigid prices. Since asset prices tend to be more flexible than goods prices, monetary authorities should presumably focus their attention on stabilizing the CPI.

One potential response, is that movements in flexible asset prices presage movements in sticky goods prices. This, however, is not an issue of the correct price index, but of forecasting future prices. We turn to this issue next.

2.2. *Asset prices as indicators*

Many proponents of broader measures of inflation favor the inclusion of asset prices not because they belong in a measure of the cost of living or the cost of inflation, but because they predict future movements in the CPI. The argument that movements in asset prices are useful in forecasting inflation goes at least back to Fisher (1911) who argued that increases in the money supply were first manifested in rising asset prices and only later in the prices of consumer goods. This view has recently been taken up by the *Economist* magazine and by Goodhart and Hufmann (2000).¹

Do asset prices predict inflation? There seems to be very little evidence that stock prices do. Stock and Watson (1999) consider the ability of 168 economic indicators to forecast U.S. inflation at a 1 year horizon. They conclude that measures of real economic activity perform best. Stock prices and exchange rates perform poorly relative to a traditional Phillips curve. Interest rates appear to contain some information.

One asset price that has received a lot of recent attention is the price of housing. Interest in housing prices has been stimulated by the observation that real estate

¹See, for example, April 18, 1998, p. 16.

Table 1
Significance in forecasting equations

	Inflation	Output
Housing prices	2.69	2.83
S&P 500	−0.27	1.15
Spread	−2.63	−1.38
Housing starts	0.15	2.20
Cash flow	−0.36	−0.9

booms appear to have preceded inflation in Japan and the United Kingdom in the 1980s. Goodhart and Hufmann (2000) find that housing prices enter significantly into CPI equations for 12 countries. Cecchetti et al. (2000) and Filardo (2000), however, find that while housing is correlated with future inflation, the inclusion of housing does not significantly improve the performance of inflation forecasts.²

The first column of Table 1 presents the *t*-stats from regressions of inflation on various asset prices. The regressions are in first differences. Each regression includes a constant, lagged inflation, lagged output, the lagged consumption/output ratio, and the asset variable of interest. To conserve space the table only reports the significance of the asset variable, so each line is associated with a different regression. Coefficients on other variables and their significance is stable across specifications. The asset variables include: housing prices, the S&P 500, and the spread between the prime lending rate and the 1 year treasury bond rate. This spread is meant to capture fluctuations in the risk premium on loans. We also considered cash flow and housing starts, because they are related to the financial and asset variables of interest. Regressions begin in 1975, the first year for which we have the housing price data.

The results are broadly in accord with past findings. The spread variable and housing prices were significantly related to inflation. The S&P was unrelated to inflation.

The second column of Table 1 performs the same experiment this time with output as the dependent variable. In this case both housing prices and housing starts are significant. The S&P, the spread variable, and cash flow are insignificant.

We now take a closer look at housing prices. Fig. 1 shows fitted values from regression of inflation on the price of housing and other controls. The thick solid line represents actual inflation, while the thin line represents predicted inflation and the dashed line represents predicted inflation with the coefficient on housing prices set to zero.³ The conclusion is that, while housing prices may be statistically significant, the

² Cecchetti et al. (2000) argue for including the sale prices of homes in a measure of core inflation. They define core inflation as the common trend in the prices of all goods, services and assets, and then derive the price weights that yield the best estimate of this trend. Stock prices are noisy; they therefore provide little information about the trend and receive small weight. Housing prices, on the other hand, receive significant weight. It is not clear, however, what this common trend is supposed to represent. We see no reason that the trend in consumer prices should be the same as the trend in housing or the stock market.

³ These are from a level regression with a quadratic trend, since the non-stationarity of the first differenced data would make such an exercise meaningless.

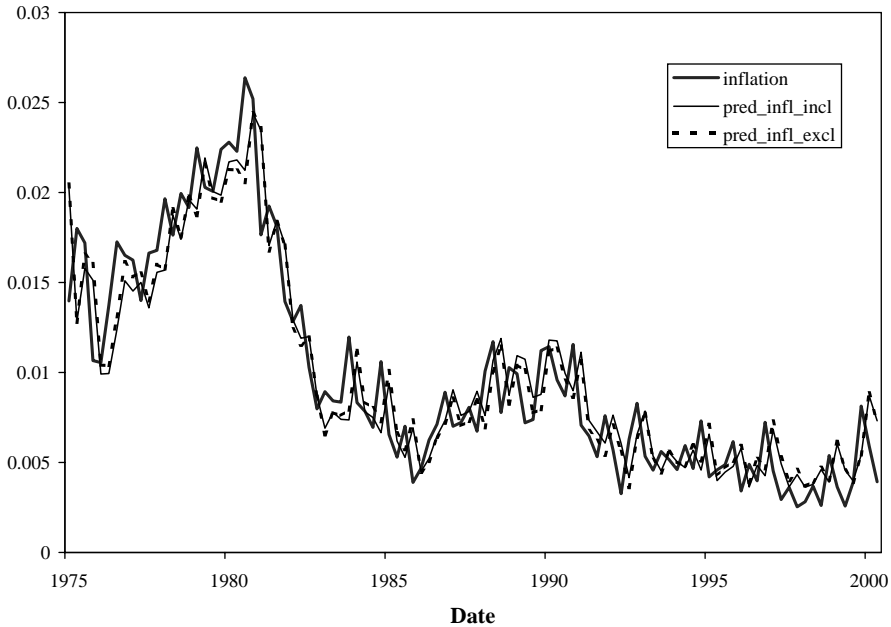


Fig. 1. Fitted and actual inflation.

amount of information that they convey appears limited and the type of information is different from what proponents would hope for. Fig. 2 shows the main reason why housing prices are poor indicators. The figure depicts output and housing prices both detrended by a polynomial trend. We see clearly that housing prices lag output. This should not come as a surprise. Housing economists have long known, that housing prices are a lagging indicator, that shifts in demand tend to show up first in the time to sale and only late are reflected in prices.

We conclude that asset prices do not contain information valuable for forecasting. At this point several words of caution are in order. The failure of asset prices to provide much additional information concerning output and inflation should not be taken to mean that they are unrelated to output and inflation. Most of the asset measures are correlated with output and inflation. They just do not contribute much in addition to lagged output and the consumption/output ratio. Second, as argued by Woodford (1994), an indicator may have value even if it performs poorly in forecasting equations. In fact, poor performance may be expected. If policy makers make use of the information in an indicator and respond to this information, then the indicator is likely to lose some of its forecasting power. For this reason, we should not make recommendations based on regressions alone. It is important to consider structural models of the relationship between asset prices and economic activity.

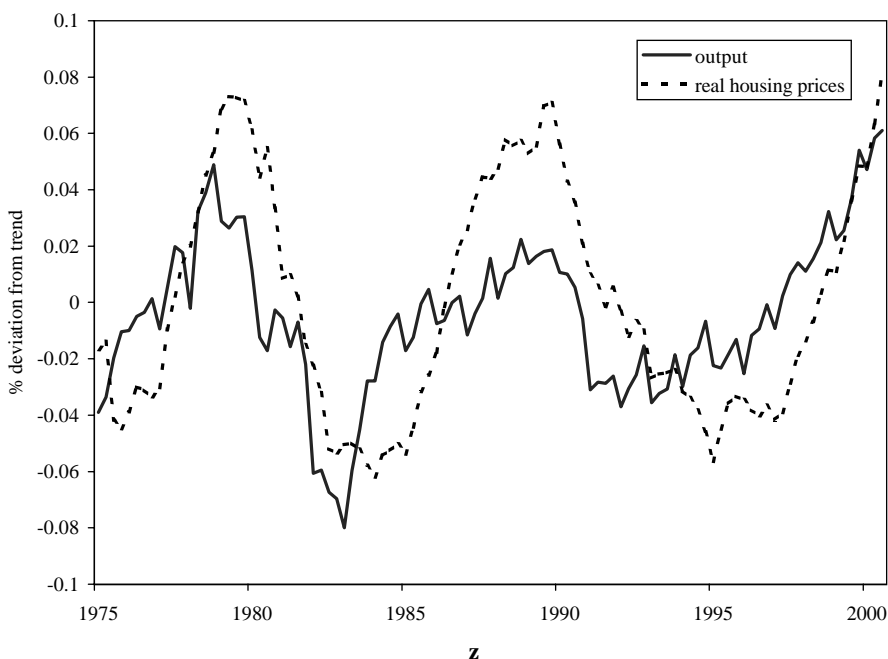


Fig. 2. Output and housing prices.

2.3. Asset prices and economic activity

The final reason to consider asset prices is that they may have a direct effect on the level of economic activity. Three channels dominate the literature: the wealth effect on consumption, Tobin's Q effect on investment, and the financial accelerator effect on investment. We discuss these in turn.

2.3.1. The wealth effect

The logic of budget constraints dictates that there should be some link between consumption and asset prices. All else equal, wealthier agents consume more. The question is when.

Poterba (2000) surveys the effects of stock prices on consumption. Most estimates find that a \$1 increase in financial assets leads to a 3¢ increase in consumption. This is roughly the magnitude predicted by Friedman's permanent income hypothesis.

It is difficult to know what to make of this literature. On the one hand, time series estimates of the effect of asset prices on consumption rarely contain good instruments for asset prices and rarely control for general equilibrium effects such as changes in interest rates which effect both variables. On the other hand, it is not clear that the cross-sectional evidence is much better. How does one identify idiosyncratic shocks to wealth? How informative are the cross-sectional estimates for aggregate dynamics that are effected by all sorts of equilibrium feedback?

2.3.2. Tobin's Q effect

Much of the empirical investment literature of the past two decades can be viewed as an attempt to explain why the link between asset prices and investment does not work the way that Tobin thought it did.

Tobin argued that the ratio of the stock price to the replacement cost of capital, a statistic that has become known as Tobin's Q , should be a good indicator of a firm's invest incentives. If this ratio is greater than one, then capital is more valuable inside the firm which is greater than its cost on the open market, and investment is profitable. Tobin's argument ignored investment adjustment costs and the distinction between the average value of capital as valued by the stock market and the marginal value of capital that matters for investment. Hayashi, however, showed that Tobin's intuition held, so long as the firm's profit function is homogeneous of degree one in capital and adjustment costs are convex and homogeneous of degree of one. In this case, Tobin's Q is a sufficient statistic for investment.

Subsequent research, however, has shown that Tobin's Q performs poorly in investment regressions. Q is hardly a sufficient statistic. Other variables such as output or cash flow and even lagged Q prove useful in forecasting investment. Moreover, the coefficient on Q tends to be small, implying that the adjustment costs are high.⁴

Many explanations have been put forward for this poor performance. Some question the Hayashi assumptions of constant returns to scale and convex adjustment costs. Others argue that if it is cheaper to finance investment with internal funds then investment may be correlated with cash flow. These arguments do not fundamentally undermine Tobin's intuition that increases in the value of the firm should be correlated with increases in the incentive to invest. Rather the link may not be as direct as Tobin believed.

Blanchard et al. (1993), on the other hand, attempt to sever the link. They argue that as a result of fads, bubbles, or the influence of uninformed traders, stock prices may deviate from fundamentals. In such situations, managers may find it in their interests to ignore the signals arising from asset markets and invest on their own superior information. Blanchard et al. find that given proxies for fundamentals market value appears to play a limited role in determining investment. Bond and Cummins (2000) make a similar argument and find that investment responds much more strongly to a measure of q constructed from profit forecasts than q constructed using the stock market. Aside from the conclusion that the authors draw, these results look very similar to earlier studies of Tobin's Q . In the end, it is difficult to know whether managers are ignoring the stock market or the proxies for fundamentals are capturing some flaw in the Hayashi assumptions, such as the gap between marginal and average Q .

⁴The argument is that if adjustment costs were small, investment would respond quickly to deviations of asset prices from the cost of capital.

2.3.3. *The financial accelerator*

Bernanke and Gertler (1989) argue that the net worth of entrepreneurs may play an important role in propagating shocks to the economy. In order to align the incentives of entrepreneurs and those who supply them the capital, it may be important that entrepreneurs put up some of the capital for investment. The greater the share of investment that is self-financed, the more closely are incentives aligned and the greater the willingness of lenders to supply capital. Employing this intuition Bernanke and Gertler construct a model in which successful investment today leads to greater entrepreneurial net worth tomorrow, thereby reducing the cost of capital tomorrow and increasing investment. In this way shocks to returns today are propagated into future periods.

In the Bernanke–Gertler model net worth rises and falls with revenues. Kiyotaki and Moore (1997) provide another mechanism by which aggregate activity may affect net worth and hence investment. They argue that the values of the assets held by entrepreneurs will rise in good times, thereby amplifying the effects on net worth and investment.

2.3.4. *Asset prices and monetary policy*

While the channels by which asset prices affect economic activity are interesting and important, it is not clear that they provide a rationale for basing monetary policy on asset price movements. In the end, asset prices are endogenous variables that reflect the underlying state variables, such as the capital stock, the level of productivity, and the net worth of entrepreneurs. It would appear to make more sense to base policy on these variables directly.

Those that argue that for the inclusion of asset prices in policy rules argue either that there are exogenous movements in prices that are unrelated to other state variables or that it is informationally efficient to use asset prices in place of the underlying state variables. The first assumption is controversial. What are these exogenous movements in asset prices? Do they reflect bubbles or fads? If they are unrelated to other state variables do they affect output and inflation? If they reflect asset market misalignments, how can the bank detect these misalignments when market participants cannot. The second assumption is on firmer theoretical ground. Asset prices aggregate information from diverse sources in a timely matter and are obvious candidates to be proxies of the underlying state of the economy.

Other economists are unconvinced by these arguments, arguing that asset prices are too volatile and too unrelated to economic activity (Goodfriend, in Gertler et al., 2000), that asset price misalignments are too difficult to detect, and that mistakes in responding to asset prices may add variance to output (Cogley, 1999). These concerns, however, would appear to argue for caution in using asset price information, rather than ignoring such information (Brainard, 1967). Moreover, it requires a model in which to judge the usefulness of asset prices (Woodford, 1994).

Bernanke and Gertler (1999, 2001) argue that even if asset prices play a role in the propagation of shocks, the gain to including asset prices in monetary policy rules may be slight. Bernanke and Gertler consider the model of Bernanke et al. (1999), which incorporates a financial accelerator into a fairly standard stochastic general

equilibrium model with Calvo-style price rigidity. They introduce an exogenous bubble component to stock prices which interacts with the financial friction to affect investment. They find that even though stock prices have a direct effect on output, a policy rule that includes output and expected inflation captures most of the gains from including stock prices. They evaluate policies based on their effects on the variance of output and inflation. Since bubbles tend to increase both output and inflation, policies that raise interest rates when output or inflation rise, do a good job by their criterion. These variables can, therefore, stand in for stock prices.

Gertler (Gertler et al., 1998) argues further that price stability and financial stability are complementary, that by stabilizing prices and output, the monetary authority may also stabilize asset prices. Low inflation gives the monetary authority room to react to financial crisis. Reaction in high inflation environment may breed instability. While intriguing, there does not appear to be any theoretical or empirical basis for these observations.

Our summary of the literature is that, whereas there are good theoretical grounds for including asset prices in monetary rules, in practice this adds little to stabilizing output and inflation. The reason is that asset channels are similar to aggregate demand channels; they tend to increase both output and inflation. Inflation targeting, therefore, yields most of the benefits of asset price targeting without the baggage of the appearance of interfering in the workings of financial markets.

In what follows, we test the robustness of this conclusion in two ways. First, we consider technology shocks that are phased in over time. Our motivation for considering these shocks is the literature on stock market volatility. Much of this volatility appears to come from expectations of the future. We therefore consider shocks whose main effects are in the future. Second, we consider shocks to net worth directly. Many of the problems caused by fluctuations in asset prices appear to be related with firms ability to borrow and banks ability to lend. By shocking this mechanism directly we hope to get the clearest picture of the effects of financial frictions.

3. Two experiments

3.1. Expectations

Large movements in asset prices tend to be associated with optimism and pessimism about the future. In the 1970s, the stock market languished. This was a decade of pessimism, recession, slow productivity growth, and rising oil prices. The growth of the 1950s and 1960s appeared to be at an end. The United States was politically and economically weak, and would be for the foreseeable future. The market began to recover only when the political and economic outlook improved in the 1980s. In the 1980s the Japanese market soared. This was the decade of Japanese ascendance. Japanese management and production techniques were the envy of the world. It appeared only a matter of time before Japanese productivity and knowhow caught up and surpassed that of the United States. The boom in the U.S. during the

1990s corresponded to a decade of American ascendance. The cold war was won, and a new era of productivity growth appeared at hand. In each case, large swings in the markets coincided with large swings in perceptions of the future.

Several researchers have proposed swings in expectations as explanations for Shiller's (1981) excess volatility puzzle. Barsky and DeLong (1993) propose that dividend growth has a unit root. Small increases in the dividend growth rate therefore lead to large increases in share prices because they effect expectations of dividends in the far future. While one can argue with the premise that dividend growth is non-stationary, the related idea that agents extrapolate short-run trends has intuitive appeal. Zeira (1999) writes a model in which there is uncertainty concerning how long a boom will last. Each period the boom continues stock prices rise. As soon as the boom ends there is a big collapse as the potential for future gains disappears. The end of the boom is similar to a decline in the expected growth rate. Again changes in expectations amplify the effect of a shift today, and large movements in asset prices are the result.

In order to understand the effects of expectations, we perform a number of experiments with shocks whose main impact comes in the future. We consider three types of models, which we discuss briefly here. The details are provided in an appendix. The first is a fairly standard real business cycle model. The only non-standard feature is a convex cost of adjusting the capital stock. We add this cost for comparability with the two models which follow. These costs prove useful in eliminating wild movements in investment that may arise when we introduce price rigidities. The second model is a new Keynesian sticky price model. It is identical to the real business cycle model, except that monopolistically competitive producers set prices using time dependent rules. The timing of price adjustments follows Calvo (1983). Firms receive opportunities to adjust their prices each period with a fixed probability. Adjustment opportunities are independent across firms. Monetary policy is introduced into the model as an interest rate rule.

The third model adds a financial propagation mechanism on top of the new Keynesian sticky price model as in Bernanke et al. (1999). The capital stock is owned by entrepreneurs who finance their purchases of capital through internal funds and through borrowing from consumers. The return on investment is observable to lenders only at a cost. This gives rise to a moral hazard problem. The optimal contract, following Townsend (1979), is for the lender to fix the interest rate in terms of observables and to monitor only in the case that the borrower fails to pay. The interest rate involves a markup over the risk free rate in order to compensate the lender for the possibility of default. The key comparative static concerns this risk premium which falls as the investor brings more of his own money to the project. Hence positive shocks to the economy tend to increase entrepreneurial net worth, thereby lowering the risk premium on loans and further increasing investment and output. This is the financial accelerator.

We calibrate the models as in Bernanke et al. (1999). Labor share, the depreciation rate and the discount factor are set at 0.65, 0.025 and 0.99 respectively. In the models with sticky prices, the steady-state markup is set at 10% while the degree of price rigidity is chosen so that the average price duration is four quarters. The labor

elasticity is set to 3. We view these parameters as standard in the literature. We choose the adjustment cost for investment to roughly match the size of investment movements relative to output in response to a monetary policy shock. For this parameter, and the labor elasticity, we have done extensive sensitivity analysis which we discuss below.⁵

The first shock that we consider is a technology shock that is phased in gradually over time. Specifically, the log of technology a follows:

$$a_t = z_t - w_t, \quad (1)$$

where

$$z_t = z_{t-1} + \varepsilon_t$$

and

$$w_t = 0.95w_{t-1} + \varepsilon_t.$$

z is a random walk and w is an AR(1). The shock ε_t enters both z and w so innovations in the two are positively correlated. The result is a shock that has no initial impact, but eventually grows to a 1% permanent technology shock. This path is perfectly anticipated by agents.

Fig. 3A presents the impulse responses of various variables to the increase in technology under weak inflation targeting. The dotted curves represent the responses in the RBC model. Output essentially follows the path of the shock. This is to be expected. The shock is phased in gradually so the amplification and propagation mechanisms of the RBC model which are normally weak will be even weaker. Note that there is a slight drop in output initially. This results from intertemporal substitution in labor. Since productivity will be high in the future, there is an incentive to wait and work when labor is more productive. Consumption (not shown) rises due to the wealth effect of the shock. The decline in labor reduces the marginal product of capital, which along with a slight rise in the real interest rate causes the price of equity (marginal q) to fall. As a result investment falls, which makes room for the increase in consumption.

The middle curve is associated with the new Keynesian model with the following rule for nominal interest rates:

$$i_t = \rho i_{t-1} + (1 - \rho)\gamma E_t \pi_t, \quad (2)$$

where $\rho = 0.9$ and $\gamma = 1.1$. This rule exhibits a mild reaction to current inflation (weak inflation targeting) and some of the inertia in interest rates that we see in the data.⁶ Note that now output rises in response to the shock. The reason for this expansion is that expected inflation rises. With the nominal interest rate essentially fixed in the short run due to the policy rule, the real interest rate must fall, which

⁵There is also a set of parameters governing the financial contracting structure. We choose the death rate of entrepreneurs, the variance of project outcomes and the size of monitoring costs so that the steady-state premium on external funds is 2% on an annual basis, the business failure rate is 3% on an annual basis, and leverage is 50%. See Bernanke et al. (1999) for details.

⁶Bernanke et al. (1999) use this rule in their simulations because it seems to describe the recent behavior of the Federal Reserve reasonably well.

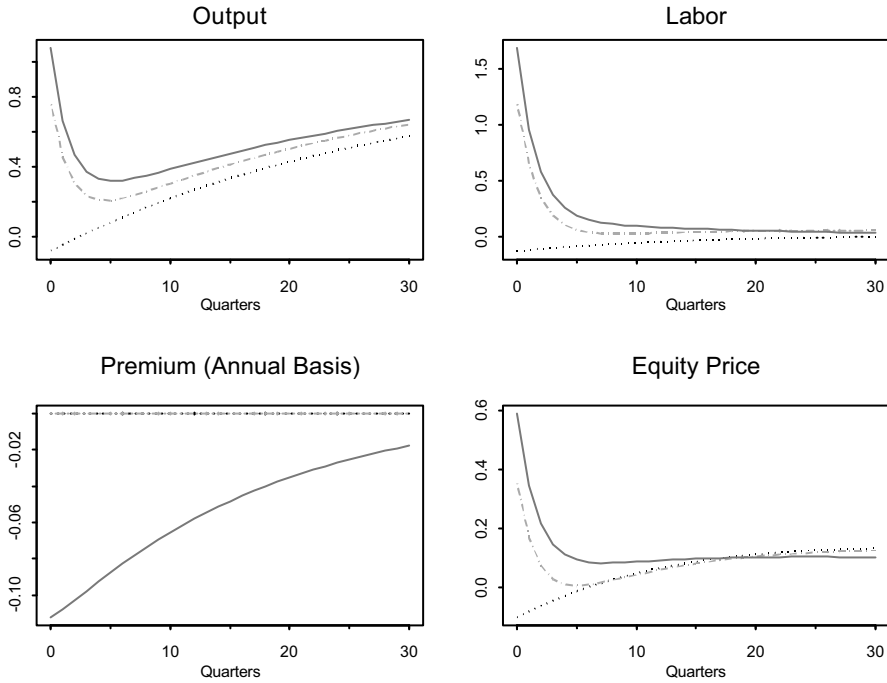


Fig. 3A. Increase in technology, weak inflation targeting.

requires an increase in the capital stock and hence investment. Consistent with the rise in output and investment, labor supply and equity prices also rise.

The solid curve is associated with the financial accelerator. This experiment uses the same interest rate rule (2) as the new Keynesian model. The financial accelerator increases the size of the initial boom by about 40%. The expected productivity boom, increases the value of capital and hence the net worth of entrepreneurs. This causes the risk premium on loans to fall, and gives the economy an extra kick.

What is interesting about these experiments is the fundamentally different ways in which the models respond to the same shock. Price inertia and the financial accelerator do not merely amplify the RBC dynamics, they alter the timing of the boom and the direction of the initial response of output, labor, investment and equity prices to the shock.

What sort of policy response is warranted? The RBC model lacks distortions and therefore gives the efficient response of the economy to the shock. The goal of policy should be to mimic this response as closely as possible.⁷ It turns out that this can be

⁷We are focusing here on the optimal policy with commitment. The policy maker faces a time consistency problem in both the new Keynesian model and the financial accelerator model. In the new Keynesian model there is an incentive to inflate in order to reduce the markup of price over marginal cost. In the financial accelerator model there is an incentive to inflate to reduce the real interest rate faced by borrowers, thereby relaxing the borrowing constraint.

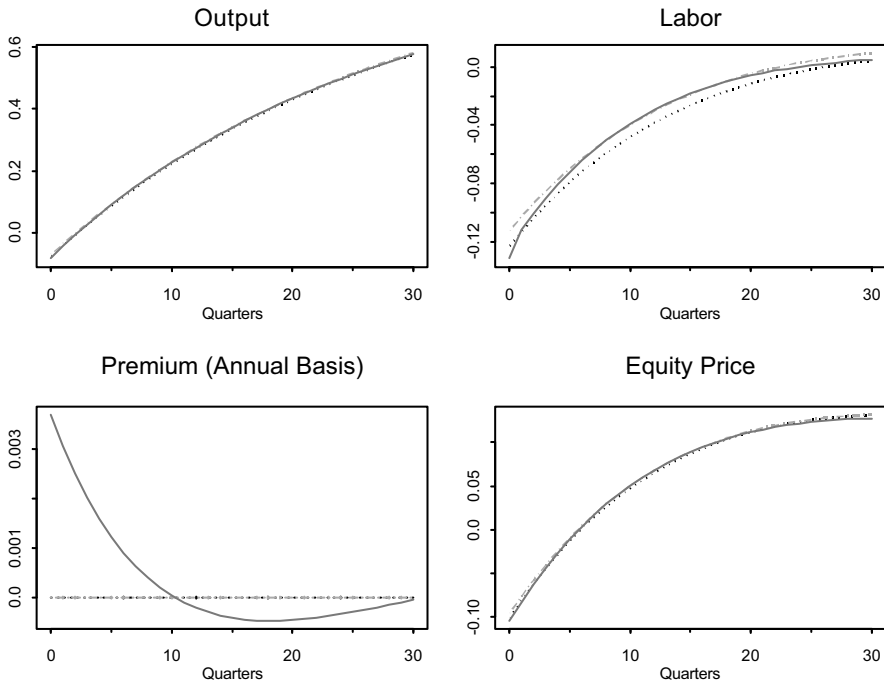


Fig. 3B. Increase in technology, strong inflation targeting.

done merely by increasing the weight on expected inflation in the policy rule. Fig. 3B shows the effects of the following rule:

$$i_t = \bar{r} + 2E_t\pi_{t+1}. \quad (3)$$

Now the dynamics of the three models are nearly indistinguishable. The paths of output, labor and equity prices lie virtually on top of each other. The risk premium in the model with the financial accelerator hardly moves. Making the interest rate sensitive to the output gap or to stock prices does little to improve the situation further.

What is encouraging about this result is that (3) is the same rule considered by Bernanke and Gertler when they consider more conventional technology shocks. If different types of shocks, or as in this case a different shaped shock, had required different types of rules, then even if strong inflation targeting was effective against each type of shock individually, a more general rule be required to combat the different shocks simultaneously. The central bank, after all, can only choose one coefficient on expected inflation. This, however, does not appear to be a problem in this case. Similar policies work against different types of technology shocks and in different types of models.

Fig. 4 illustrates one interesting aspect of these experiments. Note that the realized paths of the nominal interest rate under the two rules, (2) and (3), is very similar,

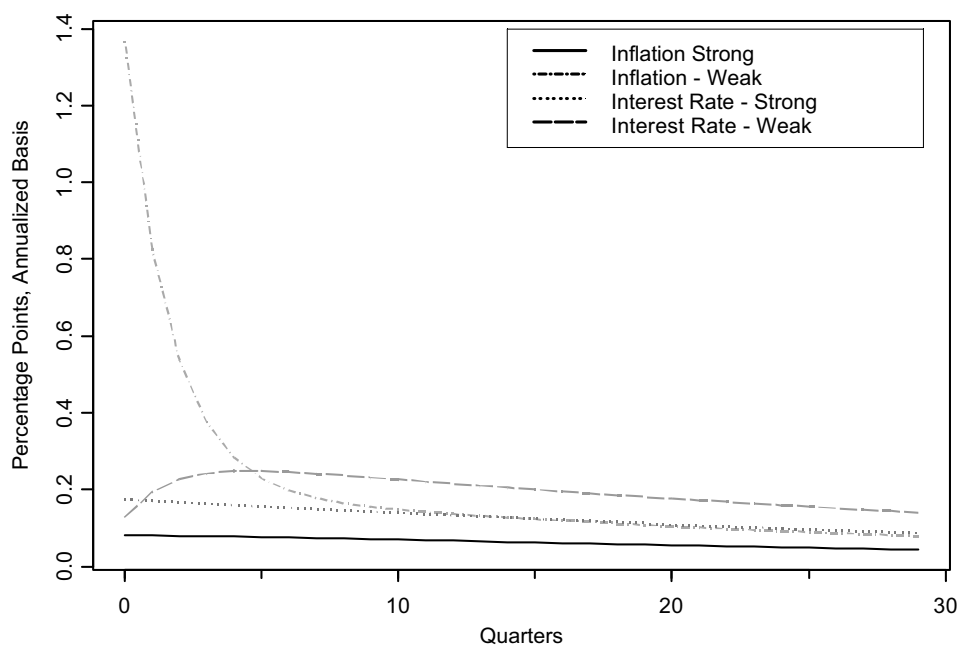


Fig. 4. Nominal interest and inflation response to technology increase.

whereas the realized path for inflation is very different. In fact the movement in nominal interest rates is generally greater under the weak inflation targeting rule (2) than it is under strong inflation targeting (3). The difference in the response to these policies is driven largely by expectations engendered by the policy rule. This illustrates the importance of credibility.

Our next experiment was to consider the possibility of unfulfilled expectations. Part of the problem associated with the stock booms in Japan and the United States is that the expectations upon which they were based failed to materialize. When this bad news finally arrived, prices plummeted, and the effects have been felt throughout the economy. In order to capture this boom and bust cycle, we amend the first experiment. We again suppose that the technology shock is phased in over time, so that the perceived gains are mostly in the future. Now, however, at some point in time productivity growth simply stops and the future gains disappear. In other works agents (and the central bank) expect a_t from Eq. (1), but the actual path is follows a_t over the first four quarters and then levels off at a_4 . This process is similar to that considered by Zeira (1999) and has the potential to create large boom–bust cycles. The economy booms on the expectation of future productivity growth, and collapses when this growth fails to occur.

Fig. 5 shows that this is in fact what happens. The solid and dashed lines presents the dynamics of the financial accelerator and new Keynesian models, respectively, using the policy rule (2). These show a very large boom and bust cycle. The other two

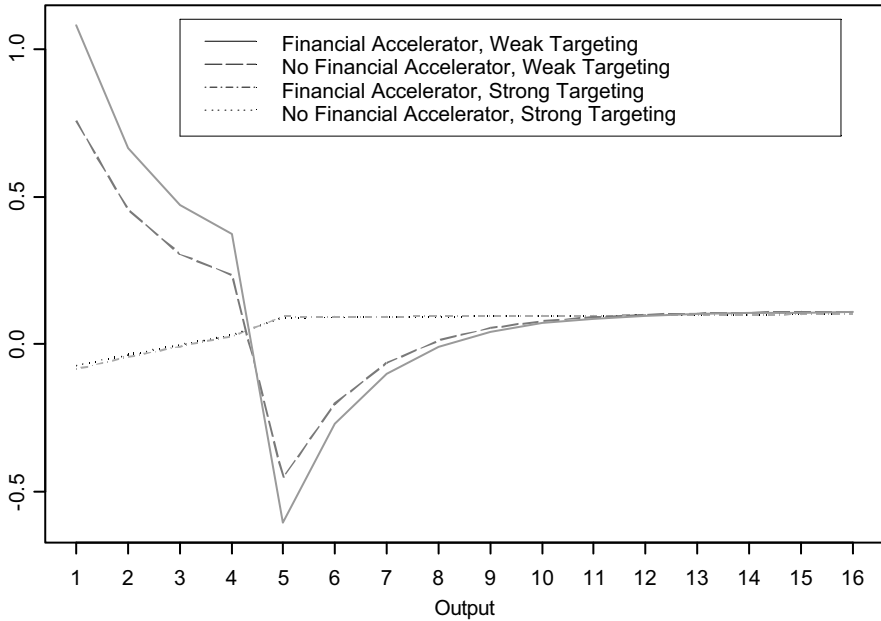


Fig. 5. Technology induced crash: weak vs strong inflation targets.

curves show the effect of strong inflation targeting in the two models. These essentially follow the path of the RBC model. The boom and bust cycles are gone.

One might also ask what policy makers should do if they believe that private sector beliefs concerning the future are unfounded. This situation would correspond to the recent situation which saw the Chairman of the Federal Reserve caution markets about “irrational exuberance”. Suppose therefore that the public expected a_t from Eq. (1), but that the Fed believed productivity growth would level off somewhat earlier as in the second experiment above. Should the Fed be worried? The answer, if the Fed is following strong inflation targeting, is no. It already has the economy essentially on track.

We conclude from these experiments that expectations of the future have the potential to yield wild swings in output relative to the efficient outcome, but that the central bank can virtually eliminate these swings by adjusting the nominal interest rate in response to expected inflation. The reason, for the success of inflation targeting is essentially the same as in the model of Bernanke and Gertler (1999). The asset booms that result from expectations of future riches increase both consumption and investment. Output rises and real interest rates fall. The central bank simply has to raise the interest rate to rectify the situation. Whether the bank raises the interest rate because inflation has risen or output has risen or asset prices have risen really does not matter. One policy instrument is sufficient. In the next section we will consider a situation in which adjustments in the real interest rate are not sufficient to stabilize the economy.

3.2. Net worth shocks

The second class of shocks that we consider are shocks to net worth. Recall that in the model with the financial accelerator, the borrowing rate is negatively related to the collateral of entrepreneurs. If entrepreneurs are putting a lot of their own money into their projects, their incentives are more closely aligned with lenders. Net worth shocks are interesting for two reasons. First, from a practical perspective, many of the problems associated with asset price movements seem to concern the ability of banks to lend and firms to borrow. Second, from a theoretical perspective, the risk premium on loans is one of the main distortions in the model. We want to understand how policy interacts with this distortion.

Figs. 6A and 6B show the responses of a number of variables to a one time 1% shock to net worth in the model with the financial accelerator. Since this shock has no effect in the real business cycle model, the efficient response is for no variable to respond to the shock. The solid lines show the response when the interest rate rule is of form (2) and the financial acceleration is present. Recall that this is a fairly weak short run policy response to inflation. As expected, both output and inflation rise in response to the shock. Net worth responds by more than the shock, since the boom in output raises asset prices and hence the value of collateral. The increase in net

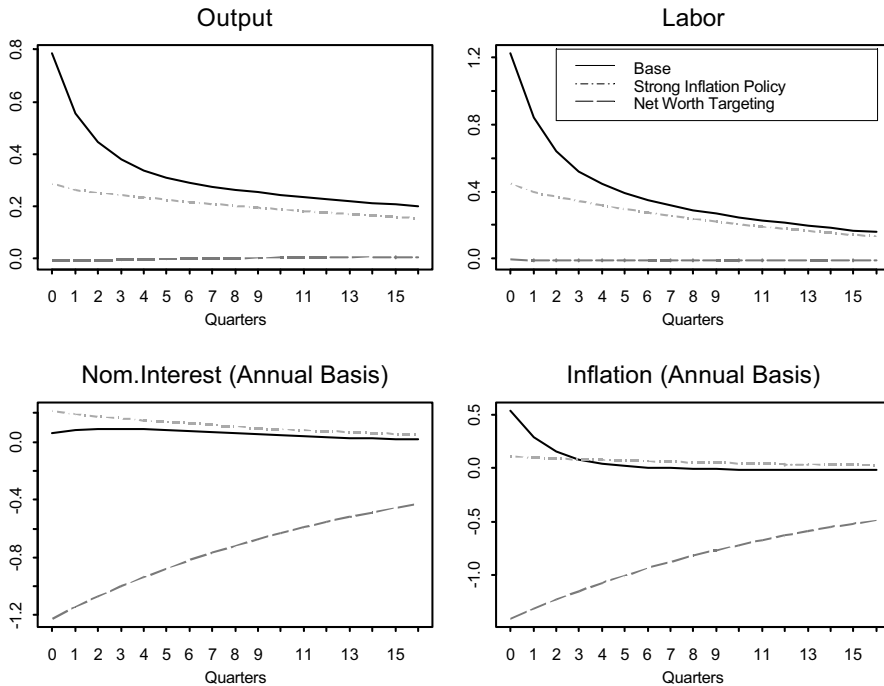


Fig. 6A. Increase in net worth, alternative policy rules.

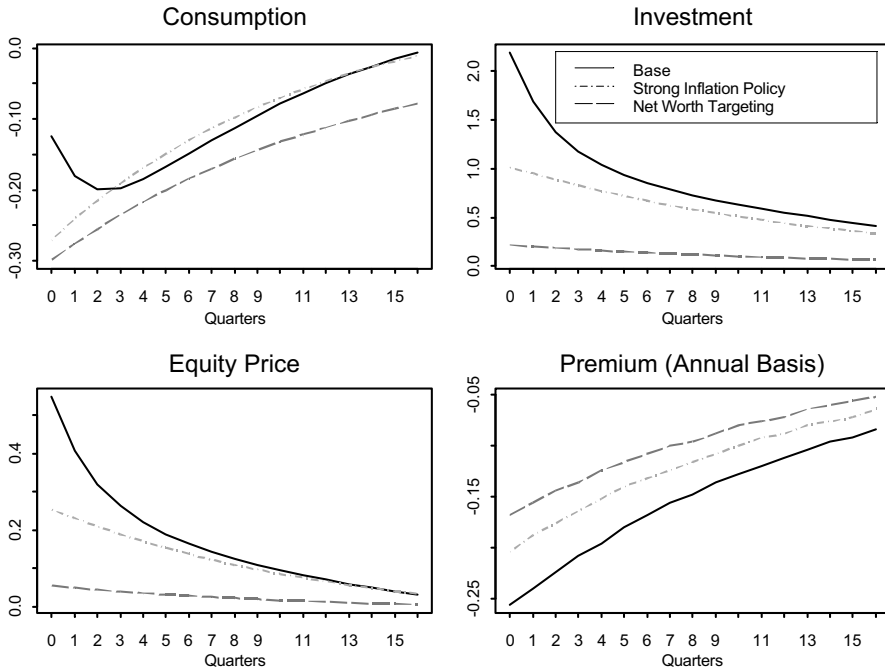


Fig. 6B. Increase in net worth, alternative policy rules.

worth results in a reduced risk premium and an investment boom. Consumption falls as the real interest rate rises.

The dot–dashed lines show the effects of strong inflation targeting of form (3). The effect of the shock on inflation are virtually eliminated by this policy. The large initial increase in output is eliminated. Further out, output is reduced only slightly. Some of this reduction in output comes from a fall in investment, some from a further reduction in consumption. Much of this shift is brought about by a rise in the real rate of interest. There is only a small increase in the risk premium. Since there is already very little inflation under (3), changes in the coefficient on inflation have very little effect on the path for interest rates or for the evolution of the other variables in the model.

The dashed lines are associated with the following policy

$$i_t = \bar{r} + 2E_t\pi_{t+1} + 0.37n_t,$$

where n denotes net worth. Note that this policy is very successful in eliminating fluctuations in output. The rise in the real interest rate almost balances the fall in the risk premium, so investment responds modestly to the shock. Unfortunately, consumption falls even further than under earlier experiments, and inflation is pushed significantly below zero.

We want to emphasize two aspects of these experiments. First, these net worth shocks are examples of what Clarida et al. (1999) call “cost push” shocks.⁸ They lead to variations in the efficiency of the flexible price equilibrium. This gives rise to an output-inflation trade-off. Whereas, in our earlier experiments with technology shocks, it was possible to bring the economy to the efficient output path by stabilizing prices (i.e., strong inflation targeting). In the present case, monetary policy cannot stabilize both output and inflation.

The second point is that even in the case that policy successfully stabilizes output, it does not stabilize the components of output. The reason is that the net worth shock works by reducing the risk premium and hence the interest rate faced by borrowers. In order to stabilize the economy the central bank raises the interest rate. This reduces investment, but it also causes consumption to fall. If the bank were to raise interest rates so far as to eliminate the effects of the net worth shock on investment, it would need to cause a large recession.

In this group of experiments inflation targeting does not take the economy to its efficient path, but then there is no interest rate policy that would achieve the efficient path. All that the central bank can do is set the nominal interest rate, so as to target a path for real interest rates. The problem is that it needs to raise the rates faced by investors, without raising the rate faced by consumers. This is not a feasible policy. Reacting to asset prices, net worth, or the risk premium does not solve the dilemma. The best that the central bank can do is achieve some balance between the fluctuations in the variables that consumers care about, namely consumption, labor supply and inflation. How one weighs these things depends on ones view of the relative costs of fluctuations in these variables.

One could imagine a role for net worth or asset prices in achieving the desired balance among costs. After all net worth is directly related to the financial distortion. One could, however, just as easily imagine designing policy around the spread between the lending rate and the risk free rate or directly around the variables that the bank wishes to target such as inflation, consumption and investment. In the model the approaches will be interchangeable since all these variables are related by precise mathematical formulas. In practice, the best choice will depend on the ability of policy makers to quantify the linkages between observable variables and the distortions in the economy. The tighter the link the more desirable the variable as an input into policy. The jury is still out as to whether asset price perform this function well.

3.3. Discussion

We first discuss the sensitivity of our model to our choice of parameter values. We then discuss extensions of the model.

⁸This is an unfortunate term, chosen because the policy dilemma created by these shocks is similar to that which many economists perceive to arise from supply shocks. See also the discussion in Woodford (1999).

To test the robustness of our finding that a prospective boom causes a fall in output, investment and asset prices, we performed a variety of sensitivity tests regarding choice of parameter values. Of possible controversy are the parameters governing the labor supply elasticity and investment adjustment costs. These may affect the intertemporal allocation of labor and investment.

We find that our results are robust to reasonable variations in the parameters. For the RBC model or the model with strong inflation targeting, changes in either adjustment costs or labor–supply elasticities have minimal effects. With higher adjustment costs, investment and output still fall below the initial steady state with news of the permanent increase in technology, and then rise slowly over time to their new steady-state values. The initial contraction in output is lower when adjustment costs are higher, as the economy seeks to reduce investment fluctuations in the face of high adjustment costs. The attenuation of the investment response, however, implies a larger price response: a doubling the adjustment costs roughly implies a doubling of the size of the initial drop in Tobin's Q (and hence asset prices) from -10% to -20% and a halving of the output response -8% to -4% . Varying the labor supply elasticity, has little effect. This is to be expected since permanent increases in technology, especially when anticipated but delayed, produce very little response of labor in a model without permanent wealth effects on labor supply.

In the experiment with weak inflation targeting, varying either adjustment costs or the labor supply elasticity will affect the size of the boom in a predictable fashion. Increasing either the labor–supply elasticity or reducing the adjustment costs causes a much larger initial boom in investment and output. As a result, the distortions created by weak inflation targeting are greater when labor and investment are more responsive to underlying disturbances.

What then would cause the stock market to boom in response to good news about the future? One possibility is that it does not. Instead, good news about the future is correlated with good news today, and the market is responding to the current situation. Another possibility, suggested by our simulations, is that loose monetary policy, particularly interest rate smoothing, is at fault. In this view, the stock market boom of the 1990 would have been avoided if the Federal Reserve had followed the correct policy and tightened more vigorously. We can also think of extensions to the model which might contribute to a market boom. If, for example, the anticipated technology improvements were embodied in capital, then there might be an added incentive to firms to invest since productivity gains could not be realized without investment. This incentive to invest may be even greater if the rate of technology improvement itself depended on the rate of investment. In either case an investment boom would be associated with an increase in asset prices.

One direction for future research is the incorporation of equity markets into the analysis of the financial accelerator. In our model investment was financed by debt, whereas much investment in the recent boom was financed by venture capital. One possibility is that a bubble in equity market may make such financing cheaper and thereby increase investment. This is basically Tobin's channel. Another possibility is that entrepreneurs and venture capitalists are both looking to sell to the equity markets. In this story, a market bubble aligns their incentives in much the same way

that an increase in net worth aligns the incentives in our second experiment.⁹ Yet a third possibility is that rising asset markets give entrepreneurs additional resources to engage in empire building along the lines of Jensen's free cash flow theory. All of these channels affect the efficiency of the economy. In all of these cases, policy will face a dilemma, it can raise interest rate to attack the distortion caused by rising asset prices, but this will distort other margins such as the intertemporal allocation of consumption. In the end the considerations are similar to those in our second experiment.

4. Conclusion

The original contribution of this paper is to consider two experiments: shocks whose initial impact is on expectations and shocks to net worth. Although asset prices and the economy as a whole can exhibit large fluctuations in response to these shocks. We do not find a strong case for including asset prices in monetary policy rules.

Appendix A. The Bernanke–Gertler–Gilchrist model

This appendix presents the model of Bernanke et al. (1999) in log–linear form. This model nests the real business cycle and sticky-price models as described below. For details see Bernanke et al. (1999).

Let capital letters denote steady-state values and small letters log deviations from steady state.

$$y_t = \frac{C}{Y}c_t + \frac{I}{Y}i_t + \dots\phi_t^y, \quad (4)$$

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

$$c_t = -r_{t+1} + E_t\{c_{t+1}\}, \quad (6)$$

$$r_{t+1}^k = (1 - v)(y_{t+1} - k_{t+1} - x_{t+1}) + vq_{t+1} - q_t, \quad (7)$$

$$E_t\{r_{t+1}^k\} - r_{t+1} = -v[n_{t+1} - (q_t + k_{t+1})], \quad (8)$$

$$q_t = \eta^{-1}(i_t - k_t), \quad (9)$$

$$y_t = a_t + (1 - \alpha)k_t + \alpha h_t, \quad (10)$$

$$y_t - h_t - x_t - c_t = \frac{1}{\varepsilon}h_t, \quad (11)$$

$$\pi_t = -\lambda x_t + \beta E_t\{\pi_{t+1}\}, \quad (12)$$

$$n_{t+1} = \left(\frac{\gamma RK}{N}\right)(r_t^k - r_t) + \gamma R(r_t + n_t) + \dots\phi_t^n. \quad (13)$$

⁹Vincenzo Quadrini is currently working on a paper that develops this idea.

Eq. (4) is the aggregate resource constraint which relates output y to consumption c and investment i . The term ϕ^y represents the costs of monitoring loans in default. This term has little effect on the dynamics of the model. Eq. (5) says that capital k depreciates geometrically at a rate δ . Eq. (6) is the consumption Euler equation that relates current and expected consumption and the real rate of interest r . Eq. (7) states that the gross return on capital r^k is equal to the marginal revenue product of capital plus the capital gain. Here x is the markup of retail goods over wholesale goods (note capital and labor are used in the production of wholesale goods), and q the price of a marginal unit of capital. v is equal to $(1 - \delta)/[(1 - \delta) + \alpha YX/K]$. Eq. (8) relates the external finance premium $E_t\{r^k\} - r$ to entrepreneurial net worth n and the capital stock. Eq. (9) is the first order condition for investment. Increases in η correspond to increases in the cost of adjustment. The production function (10) is Cobb–Douglas. h represents labor and α is labor's share. Eq. (11) is the labor market equilibrium. The left-hand side is labor demand: the marginal product of labor weighted by the marginal utility of consumption. The right-hand side is supply: ε is the elasticity of labor supply. Calvo price setting gives rise to the “new Keynesian Phillips curve” (12). Here β is the discount rate, π is the rate of inflation, and $\lambda = (1 - \theta\beta)(1 - \theta)/\theta$ where $1 - \theta$ is the probability that a firm adjusts its price. Eq. (13) gives the evolution of the net worth of entrepreneurs. The first term gives the net return to entrepreneurs from their equity stake. The second term is the return on prior net worth. The term ϕ_t^n is involved and small under reasonable parameterizations. The model is closed by assuming a monetary policy rule, a technology process, and the Fisher equation. The time period is quarter. The parameters are $\alpha = 0.65$, $\beta = 0.99$, $\delta = 0.025$, $\varepsilon = 3$, $\eta = 0.25$, $\theta = 0.75$, $X = 1.1$, $R = 1/\beta$, $\gamma = 0.979$.

In the sticky price version of the model $n = \phi_t^y = 0$ and $r^k = r$. This eliminates Eqs. (13) and (8). In the real business cycle model we also have $mc = \pi = 0$. This eliminates Eqs. (12) and the monetary policy rule.

References

- Alchian, A., Klein, B., 1973. On a correct measure of inflation. *Journal of Money, Credit and Banking* 5, 173–191.
- Barsky, R., DeLong, B., 1993. Why does the stock market fluctuate? *Quarterly Journal of Economics* 108, 291–312.
- Bernanke, B., Gertler, M., 1989. Agency costs, net worth, and business fluctuations. *American Economic Review* 79, 14–31.
- Bernanke, B., Gertler, M., 1999. Monetary policy and asset market volatility. *Federal Reserve Bank of Kansas City Economic Review* 84, 17–52.
- Bernanke, B., Gertler, M., 2001. Should central banks respond to movements in asset prices? *American Economic Review Papers and Proceedings* 91, 253–257.
- Bernanke, B., Gertler, M., Gilchrist, S., 1999. The financial accelerator in a quantitative business cycle framework. In: Taylor, J., Woodford, M. (Eds.), *Handbook of Macroeconomics*. North-Holland, Amsterdam.
- Blanchard, O., Rhee, C., Summers, L., 1993. The stock market, profit, and investment. *Quarterly Journal of Economics* 108, 115–136.

- Bond, S., Cummins, J., 2000. Noisy share prices and the Q Model of investment. Working paper, New York University.
- Brainard, W., 1967. Uncertainty and the effectiveness of policy. *American Economic Review* 57, 411–425.
- Calvo, G., 1983. Staggered prices in a utility maximizing framework. *Journal of Monetary Economics* 12, 383–398.
- Clarida, R., Gali, J., Gertler, R. 1999. The science of monetary policy: a new Keynesian perspective. *Journal of Economic Literature* 37, 1661–1707.
- Cecchetti, S., Chu, R., Steindel, C., 2000. The Unreliability of Inflation 'Indications', Current Issues in Economics and Finance. Federal Reserve Bank of New York, New York.
- Cecchetti, S., Genberg, H., Lipsky, J., Wadhvani, S., 2000. Asset Prices and Central Bank Policy. Center for Economic Policy Research, London.
- Cogley, T., 1999. Should the fed take deliberate steps to deflate asset price bubbles? *Federal Reserve Bank of San Francisco Economic Review* 1, 42–52.
- Filardo, A., 2000. Monetary policy and asset prices. *Federal Reserve Bank of Kansas City Economic Review* 85, 11–37.
- Fisher, I., 1911. *The Purchasing Power of Money*. The Macmillan Company, New York.
- Gertler, M., Goodfriend, M., Issing, O., Spaventa, L., 1998. Asset Prices and Monetary Policy: Four Views. Center for Economic Policy Research, London.
- Goodhart, C., Hufmann, B., 2000. Do asset prices help predict consumer price inflation. Working paper, London School of Economics.
- Kiyotaki, N., Moore, J., 1997. Credit cycles. *Journal of Political Economy* 105, 211–248.
- Poterba, J., 2000. Stock market wealth and consumption. *Journal of Economic Perspectives* 14, 99–118.
- Shibuya, H., 1992. Dynamic equilibrium price index: asset price and inflation. *Monetary and Economic Studies* 10, 95–109.
- Shiller, R., 1981. Do stock prices move too much to be justified by subsequent changes in dividends? *American Economic Review* 71, 421–436.
- Stock, J., Watson, M., 1999. Forecasting inflation. *Journal of Monetary Economics* 44, 293–335.
- Townsend, R., 1979. Optimal contracts and competitive markets with costly state verification. *Journal of Economic Theory* 21, 265–293.
- Woodford, M., 1994. Nonstandard indicators for monetary policy: can their usefulness be judged from forecasting regressions? In: Gregory Mankiw, N. (Ed.), *Monetary Policy*. University of Chicago Press, Chicago.
- Woodford, M., 1999. Inflation stabilization and welfare. Working paper, Princeton University.
- Zeira, J., 1999. Informational overshooting, booms, and crashes. *Journal of Monetary Economics* 43, 237–257.