

Asset-price driven business cycle and monetary policy

Vincenzo Quadrini
University of Southern California, CEPR and NBER

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VERY PRELIMINARY

Abstract

This paper studies the stabilization role of monetary policy when the business cycle is driven by asset price shocks. Changes in asset prices affect production decisions through a credit channel. Within this framework, monetary policy can stabilize the economy by linking the monetary instrument to asset prices. The paper also studies how the stabilization role of monetary policy changes with the globalization of financial markets.

1 Introduction

A heated debate in monetary policy discussion focuses on whether central banks should take into account the dynamics of asset prices in the design of policy interventions. On the one hand, the ‘activist’ view suggests that monetary policy should respond to movements in asset prices. An example is Cecchetti, Genberg, Lipsky, & Wadhvani (2000). On the other, there is the view that monetary policy need not be, or even should not be, dependent on the price of assets. For examples, Bernanke & Gertler (1999, 2001) show that there is no need to respond to asset prices if the monetary authority controls inflation. Carlstrom & Fuerst (2007) even argue that responding to asset prices may lead to indeterminacy and, potentially, to greater macroeconomic instability. The analysis of this paper is in the spirit of Bernanke & Gertler

(2001) in the sense that fluctuations in asset prices have real macroeconomic consequences but it reaches a different conclusion in terms of stabilization policies. More specifically, a monetary policy that keeps inflation or the nominal interest rate constant does not reduce the macroeconomic fluctuations induced by asset price movements. Instead, macroeconomic stabilization requires the explicit response of monetary policy to asset price changes. In this sense, the results of this paper is in line with the ‘activist’ view described above.

The central feature of the model is that asset price movements have real macroeconomic consequences through a credit channel similar to Jermann & Quadrini (2006). Because of financial frictions, changes in asset prices affect the availability of credit to firms which in turn affect their production decision. In the absence of financial frictions, movements in asset prices would not have any impact on employment and production. However, due to market incompleteness, asset price fluctuations have a direct impact on the real sector of the economy. Then monetary policy could play an important stabilization role by linking the growth rate of money to asset price changes.

During the last two decades, most countries have become more integrated in world financial markets as barriers to the international mobility of capital have been gradually removed. The process of international globalization has important implications for the macroeconomic volatility of a country, and therefore, for the conduct of monetary policy. On the one hand, the lower dependence on the local market for the supply of funds has a stabilization effect against domestic asset price fluctuations. On the other, the economy becomes more vulnerable to external asset price shocks. Consequently, whether globalization leads to lower or higher macroeconomic volatility depends on the cross-country correlation of asset prices. The general implication is that globalization changes the focus of monetary policy from domestic asset prices to foreign asset prices.

The paper is structured as follows. Section 2 presents the model and characterizes some of the general equilibrium properties. Section 3 shows analytically that keeping the inflation rate or the nominal interest rate constant are not the optimal policies. The optimal stabilization policy is characterized numerically in the next Section 4. Section 5 studies the impact of financial globalization and Section 6 concludes.

2 Model

There are two types of agents: a continuum of risk neutral investors and a continuum of risk-averse workers, both of total mass 1. I first describe the environment in which an individual firm operates.

2.1 Financial and production decisions of firms

There is a continuum of firms, in the $[0, 1]$ interval, owned by investors with lifetime utility $E_0 \sum_{t=0}^{\infty} \beta^t c_t$. Investors are the only shareholders of firms and each investor owns a diversified portfolio of firms. The assumption that investors are diversified is not essential here given that they are risk-neutral. It is only made to simplify the presentation of the model. The ownership of firms is the only source of income for investors.

Each firm operates the revenue function $\tilde{F}(k_t, l_t)$, which is concave in the inputs of capital, k_t , and labor, l_t , and displays decreasing returns to scale. Decreasing returns could derive either from a concave production function in a perfectly competitive market or from monopolistic competition. For the decision problem of the firm, however, all it matters is that the revenue function is concave so that there are residuals profits. The exact specification of the technology and the market structure will be provided in the next subsection after the characterization of the firm's problem.

To simplify the analysis I assume that the input of capital is constant and equal to \bar{k} . Then, without loss of generality, I can rewrite the revenue function as $F(l_t)$.

Each firm retains the ability to generate revenues with probability q . In the event of market loss, the firm liquidates its assets and exits. Exiting firms are replaced by the same number of new firms whose ownership is equally shared among investors.¹ The law of large numbers implies that in each period there is a fraction $1 - p$ of firms replaced by new entrants. Uncertainty is resolved at the beginning of the period.

The probability q is stochastic and follows a first order Markov process with transition probability $\Gamma(q, q')$. As we will see, changes in q generate movements in the value of firms, and therefore, they are essentially shocks to the price of assets. Throughout the paper I will refer to them as 'asset price shocks'. This is the only source of aggregate uncertainty in the model.

¹The ownership of the new firms does not depend on the ownership of incumbent firms. This is important for the derivation of the market value of a firm as I emphasize later.

At the beginning of the period a surviving firm starts with nominal debt \tilde{b}_t and cash \tilde{m}_t . At this stage it chooses the labor input, l_t , contracts the new debt, \tilde{b}_{t+1} , makes cash payments to the shareholders, $P_t d_t$, and repays the liabilities carried from the previous period, \tilde{b}_t . The budget constraint is:

$$\tilde{b}_t + P_t d_t = \tilde{m}_t + \frac{\tilde{b}_{t+1}}{R_t}$$

where P_t is the nominal price and R_t the gross nominal interest rate. The cash carried to the next period is equal to the firm's revenues, net of the wage payments, that is,

$$\tilde{m}_{t+1} = P_t [F(l_t) - w_t l_t]$$

where w_t is the real wage rate.

Although the firm starts with two state variables, \tilde{b}_t and \tilde{m}_t , what matters for the optimization problem are the *net liabilities*, that is, $b_t = \tilde{b}_t - \tilde{m}_t$. Using this new variable, the above two constraints can be combined in the following budget constraint:

$$b_t + P_t d_t = \frac{b_{t+1}}{R_t} + \frac{P_t [F(l_t) - w_t l_t]}{R_t}$$

The liabilities are constrained by limited enforceability as the firm can default and divert the cash revenue $P_t F(l_t)$. Notice that diversion takes place after getting the revenues but before paying the wages. Let $\bar{V}_t(b_{t+1})$ be the real value of the firm at the end of the period. This is defined as:

$$\bar{V}_t(b_{t+1}) \equiv E_t \sum_{j=1}^{\infty} \beta^j \left(\prod_{\ell=1}^{j-1} q_{t+\ell} \right) \bar{d}_{t+j}$$

where \bar{d}_{t+j} are the future payouts, starting from next period.² The term in parenthesis accounts for the fact that the firm survives only with some probability. The assumption that the ownership of new firms does not depend

²Notice that \bar{d}_{t+j} are the expected payments before knowing whether the firm is still viable. They are equal to $\bar{d}_{t+j} = q_{t+j} d_{t+j} + (1 - q_{t+j}) L_{t+j}$, where d_{t+j} is the payment conditional on survival and L_{t+j} is the liquidation value given by the capital \bar{k} minus the real liabilities b_{t+j}/P_{t+j} .

on the ownership of previous firms is essential for this term to affect the value of the firm.³

In case of default, the firm diverts the revenues $P_t F(l_t)$. The current value is $\beta P_t F(l_t)/P_{t+1}$ because cash available at the end of period t is used to purchase consumption only in the next period when the nominal price is P_{t+1} . After diverting the cash flows, the firm renegotiates the debt. Suppose that renegotiation succeeds with probability ψ . Therefore, the shareholders retain its value $\bar{V}_t(b_{t+1})$ only with probability ψ . Enforcement requires that the value of not defaulting is at least as big as the value of defaulting, that is,

$$\bar{V}_t(b_{t+1}) \geq E_t \left(\frac{\beta P_t}{P_{t+1}} \right) F(l_t) + \psi \cdot \bar{V}_t(b_{t+1}).$$

After rearranging, the enforcement constraint can be written as:

$$\bar{V}_t(b_{t+1}) \geq \phi \cdot E_t \left(\frac{\beta P_t}{P_{t+1}} \right) F(l_t)$$

where the $\phi = 1/(1 - \psi)$ captures the degree of limited enforcement.

From the enforcement constraint it is easy to see how the monetary authority can affect credit. By increasing the inflation rate between today and tomorrow, that is, P_{t+1}/P_t , it decreases the real value of diverted cash, and therefore, it decreases the value of defaulting. Lower default values increase the borrowing capability of firms and generate an expansion of credit. Thus, an expansionary monetary policy leads to an expansion of credit and, as we will see, a real macroeconomic boom.

The market retention probability q plays a crucial role in the determination of the firm's value because it affects the effective discount factor. In particular, with a persistent fall in q , the market survival is also expected to be smaller in the future. This reduces the hazard rate $\Pi_{\ell=1}^{j-1} q_{t+\ell}$, which in turn reduces the firm's value $\bar{V}_t(b_{t+1})$ and leads to a tighter constraint. In order to satisfy the enforcement constraint the firm has to reduce the debt b_{t+1} . This, in turn, requires a reduction in the current payout d_t .

³If the ownership of new firms is proportional to the ownership of existing firms, there is no loss of value for the shareholder: the previous firm is simply replaced by the new firm. However, if the ownership of new firms does not depend on the ownership of existing firms, then the exit of a owned firm is a real loss for the shareholders.

Firm's problem: Because money grows over time, all nominal variables are normalized by the beginning-of-period stock of money, M_t . After the normalization, the optimization problem of a surviving firm can be written recursively as follows:

$$V(\mathbf{s}; b) = \max_{d, l, b'} \left\{ d + \bar{V}(\mathbf{s}; b') \right\} \quad (1)$$

subject to:

$$b + Pd = \frac{b'(1+g)}{R} + \frac{P[F(l) - wl]}{R}$$

$$\bar{V}(\mathbf{s}; b') \geq \phi \cdot E \left(\frac{\beta P}{P'(1+g)} \right) F(l)$$

where g is the growth rate of money, \mathbf{s} the aggregate states and prime denotes the next period variable.

The function $V(\mathbf{s}; b)$ is the value of the firm at the beginning of the period, conditional on market retention, and $\bar{V}(\mathbf{s}; b')$ is the value at the end of the period when the default decision is made. This is defined as:

$$\bar{V}(\mathbf{s}; b') = \beta E \left[q' \cdot V(\mathbf{s}'; b') + (1 - q') \cdot \left(\bar{k} - \frac{b'}{P'} \right) \right] \quad (2)$$

The firm retains the ability to generate profits with probability q' and loses it with probability $1 - q'$. In the latter event the remaining activities of the firm, $\bar{k} - b'/P'$, are sold and the revenues are distributed to the shareholders.

The firm takes as given all prices and the first order conditions are:

$$F_l(l) = w \left[\frac{1 + \mu}{1 + \mu(1 - \phi)} \right] \quad (3)$$

$$(1 + \mu)\beta(1 + r) = 1, \quad (4)$$

where μ is the lagrange multiplier for the enforcement constraint and $r = RE(P/P'(1+g)) - 1$ is the expected *real* interest rate. These conditions are derived under the assumption that the solution for the firm's payout is always positive, that is, $d > 0$. As we will see, this condition holds in the neighborhood of the steady state. The detailed derivation is in Appendix A.

We can see from condition (3) that limited enforcement imposes a wedge in the hiring decision. This wedge is strictly increasing in μ and disappears when $\mu = 0$, that is, when the enforcement constraint is not binding. Also notice that the wedge increases with $\phi \geq 1$, that is, with the degree of limited enforcement.

The second condition shows that μ , and therefore, the wedge, are decreasing in the (expected) real interest rate on bonds. This dependence will be key for understanding the properties of the model. As we will see, a negative shock to q , that is, a negative asset price shock, tends to reduce the demand for debt because the enforcement constraint becomes tighter. This reduces the real interest rate. Condition (4) then implies that the reduction in the real interest rate is associated with an increase in μ and, from condition (3), a reduction in the demand for labor.

It is useful here to provide additional insights about the channel through which the real interest rate r affects employment. In each period the firm chooses the internal funds through the payout d . This choice is driven by the return from internal funds that in equilibrium is equalized to the intertemporal discount rate of investors $1/\beta - 1$. The return from internal funds derives from two sources. The first is the reduction in the interest payment due to the substitution of debt with internal funds. This is the interest rate r . The second source is the relaxation of the enforcement constraint which allows for more employment. This is captured by the lagrange multiplier μ . Because in equilibrium the return from internal funds is equalized to $1/\beta - 1$, an increase in the interest rate must be associated with a relaxation of the enforcement constraint. This is clearly shown in the first order condition (4). Then, as the enforcement constraint is relaxed, employment increases (see condition (4)).

In the general equilibrium, the change in the firms' policies also affects the wage rate w . We expect a fall in both, the wage rate w and the employment l . To derive the aggregate effects we need to close the model and derive the general equilibrium.

2.2 Closing the model and general equilibrium

I now describe the remaining components of the model and define the general equilibrium. First I specify the market structure and technology leading to the revenue function $F(l)$. I then describe the problem solved by workers.

Production and market structure: The modelling of the market structure and technology is similar to Farmer (1999). Each firm produces an intermediate good x_i that is used in the production of final goods:

$$Y = \left(\int_0^1 x_i^\eta di \right)^{\frac{1}{\eta}}.$$

The inverse demand function for good i is $v_i = Y^{1-\eta} x_i^{\eta-1}$, where v_i is the price of the intermediate good and $1/(1-\eta)$ is the elasticity of demand.

The intermediate good is produced with capital and labor according to:

$$x_i = \left(\bar{k}^\theta l_i^{1-\theta} \right)^\nu$$

where ν determines the returns to scale in the production technology. The general properties of the model do not depend on the value of ν . However, the case $\nu > 1$ is of interest because the model can also generate pro-cyclical endogenous fluctuations in productivity. Increasing returns can be interpreted as capturing, in simple form, the presence of fixed factors and variable capacity utilization.

Given the wage w , the revenues of firm i , $v_i x_i$, can be written as:

$$F(l_i) = Y^{1-\eta} (\bar{k}^\theta l_i^{1-\theta})^{\nu\eta}$$

The decreasing returns property of the revenue function is obtained by imposing $\eta\nu < 1$. In equilibrium, $l_i = L$ for all firms and $Y = (\bar{k}^\theta L^{1-\theta})^\nu$. Therefore, the aggregate production function is homogenous of degree ν . Notice that the model embeds as a special case the environment with perfect competition. This is obtained by setting $\eta = 1$ and $\nu < 1$. In this case the concavity of the revenue function derives from the concavity of the production function.⁴

Workers: There is a continuum of homogeneous workers with lifetime utility $E_0 \sum_{t=0}^{\infty} \delta^t U(c_t, h_t)$, where c_t is consumption, h_t is labor and δ is the intertemporal discount factor. I assume $\delta > \beta$, that is, households have a

⁴The paper will focus on the case of monopolistic competition ($\eta < 1$) because this allows to specify a production function with constant or even increase returns. With perfect competition ($\eta = 1$) the production function must have decreasing returns to scale, implying that productivity decreases during an expansion.

lower discount rate than entrepreneurs. This is the key condition for the enforcement constraint to bind most of the time. Workers hold nominal bonds issued by firms. This is the only form of savings for workers. The utility function is specified as $U(c_t, h_t) = (c_t - \alpha h_t^\gamma / \gamma)^{1-\sigma} / (1-\sigma)$ where $1/(\gamma - 1)$ is the elasticity of labor supply. This specification allows us to derive analytical results but it is not essential for the qualitative properties of the model.

The budget constraint is:

$$P_t w_t h_t + b_t + m_t + g_t M_t = P_t c_t + \frac{b_{t+1}}{R_t} + m_{t+1}$$

The total resources are given by the wage income, the payment of the bond, the beginning-of-period money, and the monetary transfers $g_t M_t$. The variable g_t denotes the growth rate of money and M_t the aggregate stock of money. The resources are used to buy consumption, new bonds and money.

Money is used for transactions with the following cash-in-advance constraint:

$$P_t c_t = m_t + b_t + g_t M_t - \frac{b_{t+1}}{R_t}$$

Also in this case we normalize all nominal variables by the beginning-of-period money. Assuming that the cash in advance constraint binds, the first order conditions with respect to labor, h_t , and next period bonds, b_{t+1} , are:

$$h_t = \left(\frac{w_t}{\alpha R_t} \right)^{\frac{1}{\gamma-1}} \quad (5)$$

$$\frac{1}{R_t} = \delta E_t \left[\frac{U_c(c_{t+1}, h_{t+1})}{U_c(c_t, h_t)} \frac{P_t}{P_{t+1}(1+g_t)} \right] \quad (6)$$

These are standard optimization conditions for the household's problem. The first condition defines the supply of labor as an increasing function of the wage rate. It also depends on the nominal interest rate because wages are paid at the end of the period in cash, and therefore, they can be used to purchase consumption goods only in the next period. The second condition defines the nominal interest rate as the ratio of expected marginal utility from consumption corrected by the inflation rate.

General equilibrium: I can now define a competitive equilibrium for a given monetary policy rule. In reduced form, the monetary policy rule determines the growth rate of money as a function of the aggregate states.

After normalizing all nominal variables by the stock of money, the sufficient set of aggregate states, \mathbf{s} , are given by the survival probability, q , and the (normalized) aggregate net liabilities of firms, B .

Definition 2.1 (Recursive equilibrium) *For a given monetary policy rule, a recursive competitive equilibrium is defined as a set of functions for (i) households' policies $h(\mathbf{s})$, $c(\mathbf{s})$, $b(\mathbf{s})$; (ii) firms' policies $l(\mathbf{s}; b)$, $d(\mathbf{s}; b)$ and $b(\mathbf{s}; b)$; (iii) firms' value $V(\mathbf{s}; b)$; (iv) aggregate prices $w(\mathbf{s})$ and $R(\mathbf{s})$; (v) law of motion for the aggregate states $\mathbf{s}' = H(\mathbf{s})$. Such that: (i) household's policies satisfy the optimality conditions (5)-(6); (ii) firms' policies are optimal and $V(\mathbf{s}; b)$ satisfies the Bellman's equation (1); (iii) the wage and interest rates are the equilibrium clearing prices in the labor and bond markets; (iv) the law of motion $H(\mathbf{s})$ is consistent with individual decisions, the stochastic process for q and the monetary policy rule.*

2.3 Some characterization of the equilibrium

To illustrate the main properties of the model, it will be convenient to look at some special cases in which the equilibrium can be characterized analytically. Suppose that the monetary authority keeps the nominal interest rate constant at $R > 1/\delta$. I can then show that for a deterministic steady state with constant q , the default constraint is always binding. Second, if the cash revenue cannot be diverted, which is equivalent to assuming $\phi = 0$, changes in the survival probability q have no effect on the real sector of the economy.

Proposition 2.1 *The no-default constraint binds in a deterministic steady state.*

In a deterministic steady state, the first order condition for the bond, equation (6), becomes $\delta(1 + r) = 1$, where r is the real interest rate. Using this condition to eliminate $1 + r$ in (4), we get $1 + \mu = \delta/\beta$. Because $\delta > \beta$ by assumption, the lagrange multiplier μ is greater than zero, implying that the enforcement constraint is binding.

In a model with uncertainty, however, the constraint may not be always binding because firms may reduce their borrowing in anticipation of future shocks. In this case the enforcement constraint is always binding only if β is sufficiently small compared to δ .

Proposition 2.2 *If revenues are not divertible, changes in q have no effect on employment l .*

If firms cannot divert the cash revenues, the enforcement constraint becomes $\bar{V}_t(b_{t+1}) \geq 0$. Therefore, this is equivalent to assuming that $\phi = 0$. In this case the demand for labor from condition (3) becomes $F_l(l) = w$, and therefore, it depends only on the wage rate. Because the supply of labor depends on w and R (see condition (5)), employment and production will not be affected by fluctuations in q , as long as the nominal interest rate does not change, for example when the monetary authority keeps R_t constant. Changes in the value of firms affect the real interest rate and the allocation of consumption between workers and investors but they do not affect employment.

This result no longer holds when $\phi > 0$. In this case the demand for labor depends on the tightness of the enforcement constraint. An increase in the value of firms relaxes the enforcement constraint allowing for more borrowing. The change in the demand for credit impacts on the (expected) real interest rate. Then using conditions (3) and (4) we can see that the change in the real interest rate affects the demand of labor. Given the supply (equation (5)), this leads to a change in employment and output (unless the monetary authority targets a constant employment rate and reacts accordingly).

3 Stabilization policy

After showing that asset price shocks destabilize the real sector of the economy, I ask what the monetary authority can do to counteract these shocks. The next proposition establishes that keeping a constant inflation rate or a constant nominal interest rate are not the optimal stabilization policies.

Proposition 3.1 *Suppose that the goal of the monetary authority is to stabilize output. If $\phi \neq 1$, then targeting the inflation rate or the nominal interest rate is not optimal.*

Proof 3.1 *See appendix B.*

The proposition has a simple intuition. Let's start with the case in which the monetary authority keeps the inflation rate constant. The real and nominal interest rates will change in response to asset price shocks. From conditions (3) and (4) we see that the change in the real and nominal interest

rates will change the demand and supply of labor. This will lead to changes in employment and production. The only exception is when $\phi = 1$. In this case the impact of μ on the demand of labor will be perfectly compensated by the impact of the nominal interest rate on the supply of labor. Therefore, there will be no changes in employment.

A similar argument shows that a constant nominal interest rate is not optimal because it does not guarantee a constant inflation rate. As a result, the expected real interest rate will be affected by asset price movements. Conditions (3) and (4) then imply that employment will not be constant.

So what should be the optimal stabilization policy? This will be characterized numerically in the next section. The numerical results point out that the stabilization policy responds counter-cyclically to movements in asset prices: it contracts the growth rate of money after an asset price boom and expands it after an asset price drop. This also implies that inflation responds counter-cyclically to asset price fluctuations under an optimal stabilization policy.

4 Quantitative analysis

In this section I show the properties of the model numerically. The parametrization is on a quarterly basis and the discount factors are set to generate an average real yearly return on bonds of 1% and on stocks of 7%. In the model the discount factor of workers determines the average return on bonds. Therefore, for the quarterly model I set $\delta = 0.9975$. The real return for stocks is determined by the discount factor of investors, which I set to $\beta = 0.9825$.

The utility function is specified as $U(c, h) = \ln(c - \alpha h^\gamma / \gamma)$. The parameter γ is set to 2, implying an elasticity of labor of 1. This is customary in business cycle studies. The parameter α will be chosen together with other residual parameters as specified below.

For the parametrization of the revenue function I start by setting the returns to scale parameter in the production technology $\nu = 1.5$. Next I choose the demand elasticity parameter η which affects the price markup. In the model, the markup over the average cost is equal to $1/\nu\eta - 1$. The values commonly used in macro studies range between 10 to 20 percent. I use the intermediate value of 15 percent, that is, $\nu\eta = 0.85$. Given $\nu = 1.5$, this requires $\eta = 0.567$. The technology parameter θ and the fixed capital stock are chosen together with other residual parameters as specified below.

The probability of survival follows a first order Markov process with persistence coefficient of 0.9. The average retention probability is set to $\bar{p} = 0.975$. This implies an annual exit rate of about 10 percent, which is the approximate value for the whole US economy as reported by the OECD (2001).⁵ The standard deviation of the white noise component will be specified in the description of the particular simulations.

For all the monetary policy specifications consider in the paper, we assume that the average growth rate of money is equal to 0.0075, which implies an average annual inflation ratio of about 3 percent.

At this point there are four residual parameters that need to be calibrated: the utility parameter α , the technology parameter θ , the fixed stock of capital \bar{k} , and the enforcement parameter ϕ . They are chosen simultaneously to match the following steady state targets: working time (1/3), capital income share (0.4), capital-output ratio (2.65), and leverage ratio (0.4). The values of these four parameters need to be chosen simultaneously because they all contribute to the four targets. The whole set of parameter values are reported in Table 1.

Table 1: Calibration.

<i>Description</i>	<i>Parameter values</i>
Discount factor for workers	$\delta = 0.9975$
Discount factor for investors	$\beta = 0.9825$
Utility parameter	$\alpha = 2.5$
Production technology	$\theta = 0.2, \nu = 1.5,$
Elasticity parameter	$\eta = 0.567$
Market survival	$q = 0.975, \rho = 0.5$
Enforcement parameters	$\phi = 9.5$
Growth rate of money	$g = 0.0075$
Capital stock	$\bar{k} = 3$

⁵When weighted by the size of firms, the exit probability is smaller than 10 percent. However, the exit rate in our model should be interpreted more broadly than firms' exit. It also includes the sales of business activities. When interpreted in this broader sense, the 10 percent annual probability is not unreasonable.

Simulation results The model is solved after log-linearizing the dynamic system around the steady state. The full list of dynamic equations is reported in Appendix C.

Figure 1 plots the impulse responses of several variables to a one percent positive shock to q when the monetary authority keeps the inflation rate constant. The response to a negative shock, not reported, is symmetric to the responses following a positive shock. An asset price boom generates an increase in the real interest rate and a macroeconomic expansion. It is also interesting to notice that, because of the expansion in employment, measured TFP also increases. This is a consequence of the increasing returns to scale.

Figure 2 plots the impulse responses to an asset price boom when the monetary authority follows a constant nominal interest rate rule. In this case the linearized system has two stationary solutions, one of which displaying a mild stationary cycle. The responses associated with both solutions are plotted in the figure. The main difference is in the responses of firm's liabilities. In the first solution the firm expands its liabilities. In the second solution the real value of liabilities contracts sharply. In the first period this is helped by a monetary expansion which deflates the real value of the outstanding debt. This further increases the value of the firm and allows for more employment without violating the enforceability constraint. But in both solutions we see that an asset price boom generates an increase in the real interest rate and a macroeconomic expansion.⁶

Figure 3 plots the impulse responses to an asset price boom when the monetary authority follows a stabilization policy that keeps employment constant. In this case there is only one stationary solution. A key property of this policy is that the monetary authority responds to the increase in asset prices with a reduction in the growth rate of money.

To understand this property we need to reconsider the enforcement constraint. Because $\bar{V}(b_{t+1}) = V(b_t) - d_t$, the constraint can be rewritten as:

$$V(b_t) - d_t = \left(\frac{\beta P_t}{P_{t+1}} \right) F(h_t)$$

The key to a stabilization policy is that this constraint remains satisfied without any change in h_t . Because $V(b_t)$ increases, there are three ways to

⁶If the monetary authority commits to keep constant the 'expected' inflation rate, instead of the 'actual' ex-post inflation rate, then there would be two stationary solutions. The dynamic responses would be similar to the ones obtained under a constant interest rate policy (see Figure 2).

re-establish the equality without changing h_t : (i) by increasing d_t ; (ii) by reducing the current price level so that the real value of b_t increases and the real value of the firm falls; (iii) by reducing the inflation rate so that the value of defaulting increases.

If the main adjustment takes place through d_t , the consumption of workers must decrease (given that output does not change). But this would necessarily change the real interest rate. By condition (4), a change in the real interest rate changes the demand for labor and would be inconsistent with a constant h_t . Therefore, the adjustment must take place through the second and third channels, that is, by reducing the current and future growth rates of money. The reduction in the current growth rate increases the real value of the outstanding debt and reduces the left-hand-side of the enforcement constraint. The reduction in future growth rates decreases the expected inflation rate and increases the value of defaulting, that is, the right-hand-side of the enforcement constraint. In substance, the reduction in the current and future growth rates of money has a contractionary effect on credit. This is necessary to offset the increase in the availability of credit that follows the increase in the value of firms.

The monetary contraction also leads to some changes in the nominal and real interest rates. While the fall in the nominal interest rate increases the labor supply, the fall in the real interest rate reduces the demand for labor. The changes in supply and demand compensate each other without affecting employment (although the wage rate falls).

5 Financial globalization

During the last two decades, financial markets have experienced dramatic changes due to a gradual process of international liberalization. The goal of this section is to explore the implications of this process for the business cycle properties of the economy and the stabilization role of monetary policy.

Financial globalization has two major implications. On the one hand, firms are less dependent on the domestic market for raising funds. Therefore, for an individual country, globalization increases the elasticity of the supply of funds to the *real* interest rate. On the other, globalization makes the country more vulnerable to external asset price shocks.

To show how these two effects impact on the business cycle properties of the economy, I need to provide some specification for the foreign supply of

funds. To keep the analysis simple, I assume that the net supply of foreign funds is only a function of the expected domestic real interest rate, r , and the expected foreign real interest rate, r^f , that is:

$$B^f = \varphi(r, r^f)$$

with $\varphi(r, r^f) = 0$ when $r = r^f$. The derivatives of this function satisfy $\partial\varphi(r, r^f)/\partial r > 0$ and $\partial\varphi(r, r^f)/\partial r^f < 0$. In other words, foreign capital is attracted by higher domestic interest rates but discouraged by higher interest rates abroad. The effect of globalization is to increase the absolute value of these derivatives. In the limiting case of perfect integration they would converge to infinity and in equilibrium $r = r^f$.⁷

It is now easy to see what happens as the economy globalizes. The easier way to show this is to compare the polar cases of autarky and full integration. In the first case the flow of foreign funds are always zero. This is the closed economy version studied in the previous sections. In the case of full integration the domestic interest rate cannot be different from the foreign interest rate. In the analysis that follows I assume that the economy is small, and therefore, the foreign interest rate is taken as given.

Domestic asset price shocks The following proposition characterizes the response of the economy to a domestic asset price shock in a regime with perfect mobility of capital.

Proposition 5.1 *Suppose that $\partial\varphi(r, r^f)/\partial r = \infty$, that is, there is perfect capital mobility. Furthermore, suppose that the monetary authority keeps the nominal interest rate constant. If the economy is small, a domestic asset price shock has no effect on employment and output.*

We can see from condition (4) that, if the expected real interest rate is constant, then μ is also constant. Condition (3) then says that the demand for labor depends only on the wage rate. On the other hand, the supply of labor depends also on the nominal interest rate (see condition (5)). However, because the monetary authority keeps the nominal interest rate constant, the

⁷Because this is a monetary economy, nominal exchange rates could also play a role because they affect the ex-post return from foreign investments. However, with the PPP assumption, differentials in inflation rates are fully captured by movements in nominal exchange rates.

supply of labor does not change. Therefore, employment will not be affected by fluctuations in asset prices.

A corollary to this finding is that, with perfect capital mobility, the optimal stabilization policy keeps the nominal interest rate constant. Because the real interest rate is constant, the constancy of the nominal interest rate is equivalent to maintaining a fixed inflation rate. Therefore, a constant inflation rate is also the optimal policy. This is in contrast to the optimal policy without mobility of capital. As stated in Proposition 3.1, the control of the nominal interest rate or the inflation rate does not stabilize the economy if capital is not internationally mobile.

The main differences between the closed and open economy can be described as follows. In both cases an asset price boom changes the borrowing capacity of firms, and therefore, the demand of funds. In a closed economy the change in the demand of funds must be compensated by a change in the supply from domestic workers. However, this requires a change in the real interest rate. The change in the interest rate then affects the employment decision of firms with real macroeconomic effects. When the economy is open, instead, the change in the demand of funds can be compensated by foreign supply without the need of a real interest rate change. Because the interest rate does not change, firms do not change their employment decisions.

External asset price shocks We can now study the impact of ‘external’ asset price shocks. Given the reduced form approach to the flow of foreign financial assets, we have to make some assumptions on how external asset price shocks affect the foreign interest rate. We have seen that in the domestic economy, at least when the monetary authority controls the nominal interest rate or the inflation rate, an asset price shock affects the domestic real interest rate. It is then natural to assume that external asset price shocks affect the foreign real interest rate. We then have the following proposition.

Proposition 5.2 *Suppose that $\partial\varphi(r, r^f)/\partial r = \infty$, that is, there is perfect capital mobility. Furthermore, suppose that the monetary authority keeps the nominal interest rate constant. If the economy is small, an external asset price shock affects employment and output through the impact on the foreign and domestic real interest rates.*

The idea is simple. External asset price shocks affect the foreign real interest rate. But with perfect capital mobility the domestic interest rate

adjusts immediately to the foreign interest rate. The change in the domestic real interest rate then affects employment and output as we have seen in the previous section.

A corollary to Propositions 5.1 and 5.2 is that, as the economy becomes more globalized, the optimal stabilization policy should be less concerned about domestic asset price shocks but more concerned about external asset price shocks. Formally,

Corollary 5.1 *Suppose that the goal of the monetary authority is to stabilize employment. Without mobility of capital ($\partial\varphi(r, r^f)/\partial r = \partial\varphi(r, r^f)/\partial r^f = 0$), the optimal stabilization policy responds only to domestic asset price movements. With perfect mobility of capital ($\partial\varphi(r, r^f)/\partial r = \infty$ and $\partial\varphi(r, r^f)/\partial Er^f = -\infty$), the optimal stabilization policy responds only to foreign asset price movements.*

Extrapolating from this result, we can infer what happens in intermediate cases with imperfect capital mobility, that is, cases in which the partial derivatives of the function φ are different from zero but finite. In this case the stabilization policy responds to both domestic and foreign asset price movements. As the economy becomes more globalized, and therefore, the partial derivatives become bigger, the focus gradually shifts from domestic to foreign asset prices. Of course, as the economy becomes more globalized it is also possible that domestic asset prices become more synchronized with foreign prices. Therefore, linking monetary policy to fluctuations in domestic asset prices is a good approximation for targeting foreign asset prices.

Does globalization requires a more pro-active monetary policy? On the one hand, there is less need for a pro-active monetary policy that responds to ‘domestic’ asset price movements. On the other, monetary policy should play a more active role with respect to foreign asset price movements. It will also depend on how monetary policy abroad reacts to local asset price movements.

6 Conclusion

This paper has studied a monetary economy whether the main driving force for the business cycle are shocks to asset prices. Asset price movements affect the real sector of the economy through a credit channel: booms enhance the borrowing capacity of firms and in the general equilibrium they lead to higher

employment and production. The opposite arises after an asset price fall. The optimal stabilization policy would react counter-cyclically to asset price movements, that is, it responds by contracting the growth rate of money after an asset price boom and by expanding the growth rate of money after an asset price drop.

The paper has also studied the implications of financial globalization for the properties of the business cycle and for the optimal stabilization policy. It is shown that globalization reduces the macroeconomic impact of ‘domestic’ asset price shocks but increases the impact of shocks to ‘foreign’ assets. Therefore, as the economy becomes more globalized, the target of monetary policy for stabilization purposes shifts from domestic asset prices to foreign asset prices.

Appendix

A First order conditions

Consider the optimization problem (1) and let λ and μ be the Lagrange multipliers associate with the two constraints. Taking derivatives we get:

$$\begin{aligned}d : & \quad 1 - \lambda P = 0 \\l : & \quad \frac{\lambda P [F_l(l) - w]}{R} - \mu \phi E \left(\frac{\beta P}{P'(1+g)} \right) F_l(l) = 0 \\b' : & \quad (1 + \mu) \bar{V}_b(\mathbf{s}; b') + \frac{\lambda(1+g)}{R} = 0\end{aligned}$$

Given the definition of $\bar{V}(\mathbf{s}; b')$ provided in (2), the derivative of this function is:

$$\bar{V}_b(\mathbf{s}; b') = \beta E \left[q' V_b(\mathbf{s}'; b') + (1 - q') \frac{1}{P'} \right]$$

The envelope condition is:

$$V_b(\mathbf{s}; b) = -\lambda$$

Using the first condition to eliminate λ and substituting the envelope condition we get (3) and (4).

B Proof of proposition 3.1

Consider first the case in which the monetary authority keeps the nominal interest rate constant. Given the constancy of R , the supply of labor depends only on the wage rate (see condition (5)). Because the demand of labor depends on w and μ (see condition (3)), to show that employment cannot be constant is sufficient to show that μ changes in response to q shocks. This is proved by contradiction. Suppose that μ stays constant. Then condition (4) implies that the inflation rate must be constant and condition (6) implies that workers' consumption does not change. Because output does not change, then $d_t = F(l_t) - c_t$ must also be constant. Now let's look at

the enforcement constraint. Remembering that $\bar{V}(b_{t+1}) = V(b_t) - d_t$, the enforcement constraint can be written as:

$$V(b_t) \geq d_t + \phi E \left(\frac{\beta P_t}{P_{t+1}(1 + g_t)} \right) F(l_t)$$

Before the shock the enforcement constraint is satisfied with the equality sign given the assumption $\delta > \beta$, and therefore, $\mu_t > 0$. Because $V(b_t)$ changes in response to q_t while all terms on the right-hand-side do not change, the enforcement constraint is either violated (if $V(b_t)$ falls) or becomes not binding (if $V(b_t)$ increases). In both cases we get a contradiction to the assumption that μ_t stays constant.

Let's consider now the case in which the monetary authority keeps the inflation rate constant. Combining the demand and supply of labor (conditions (3) and (5)), the equilibrium in the labor market is $F_l(l_t) = \alpha l_t^{\gamma-1} R_t (1 + \mu_t) / [1 + \mu_t(1 - \phi)]$. Using condition (4) to eliminate $R_t(1 + \mu_t)$ we get:

$$F_l(l_t) = \left[\frac{\alpha l_t^{\gamma-1} E \beta P_t / [P_{t+1}(1 + g_t)]}{1 + \mu_t(1 - \phi)} \right]$$

Because the inflation rate is kept constant under the particular monetary policy rule, the only way for employment to stay constant is to have μ_t constant. However, we can prove that this violates the enforcement constraint as we did above for the case of a constant interest rate rule. The only exception is when $\phi = 1$. In this case, a constant inflation rate keeps employment constant as can be seen from the equation above. *Q.E.D.*

C Dynamic system

The equilibrium is characterized by the following system of equations:

$$\begin{aligned} \alpha R_t h_t^{\gamma-1} &= w_t \\ \delta R_t E \left[\frac{U'_{t+1} P_t}{U'_t P_{t+1} (1 + g_t)} \right] &= 1 \\ 1 + g_t + b_t &= P_t c_t + \frac{b_{t+1}(1 + g_t)}{R_t} + \frac{P_t [F(h_t) - w_t h_t]}{R_t} \\ b_t + P_t d_t &= \frac{b_{t+1}(1 + g_t)}{R_t} + \frac{P_t [F(h_t) - w_t h_t]}{R_t} \end{aligned}$$

$$\begin{aligned}
P_t F(h_t) &= 1 + g_t \\
F'(h_t) &= w_t \left[\frac{1 + \mu_t}{1 + \mu_t(1 - \phi)} \right] \\
(1 + \mu_t) R_t E \left(\frac{\beta P_t}{P_{t+1}(1 + g_t)} \right) &= 1 \\
V_t &= d_t + \phi E \left(\frac{\beta P_t}{P_{t+1}(1 + g_t)} \right) F(h_t) \\
V_t &= d_t + E \left[q_{t+1} V_{t+1} + (1 - q_{t+1}) \left(\bar{k} - \frac{b_{t+1}}{P_{t+1}} \right) \right]
\end{aligned}$$

There are 9 dynamic equations. Together with an exogenous rule for the monetary policy, the total number of dynamic equations are 10. After linearizing the system, we can solve for b_{t+1} , μ_t , w_t , h_t , c_t , d_t , P_t , V_t , g_t and R_t as linear functions of the states, q_t and b_t .

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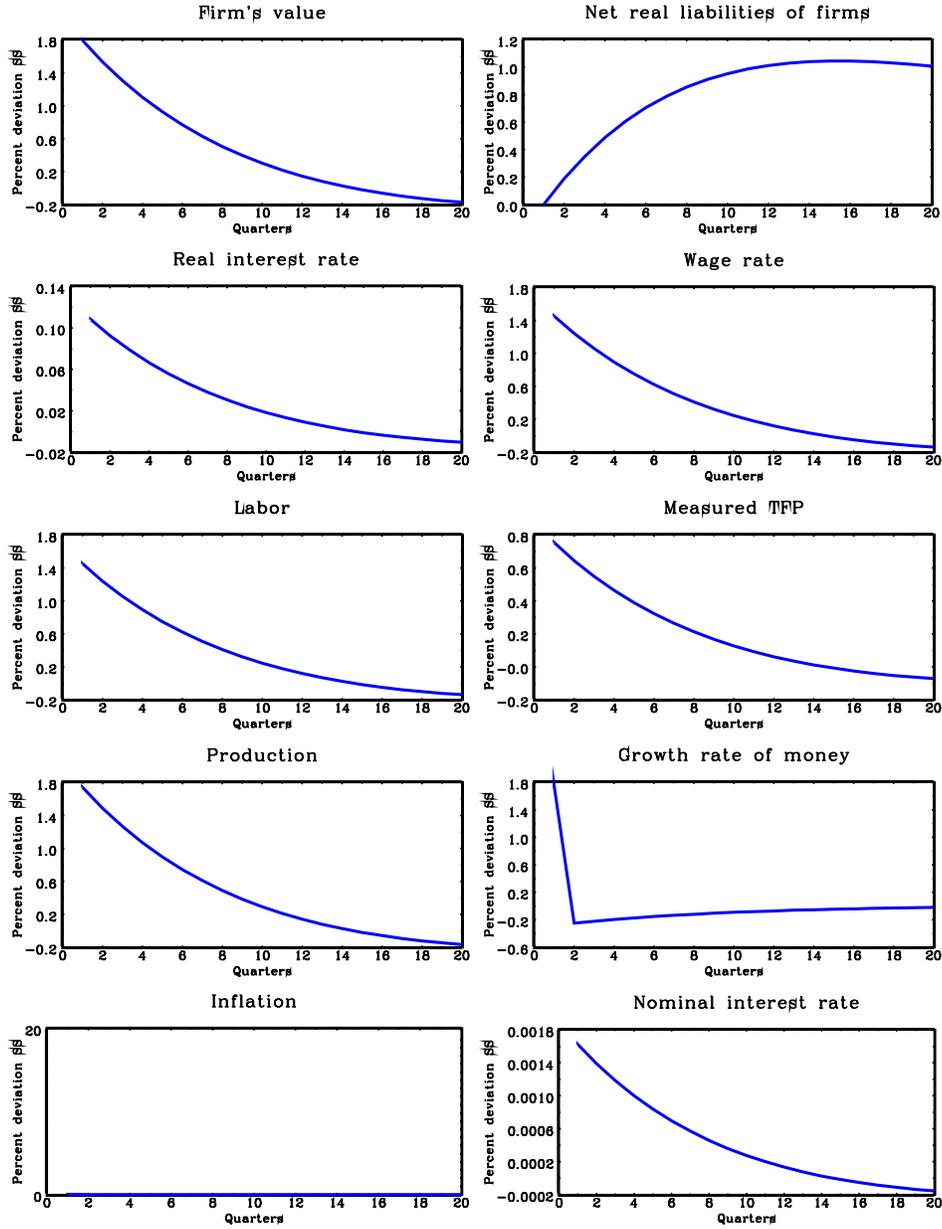


Figure 1: Impulse responses to an asset price boom (1% increase in q) under a constant inflation rule.

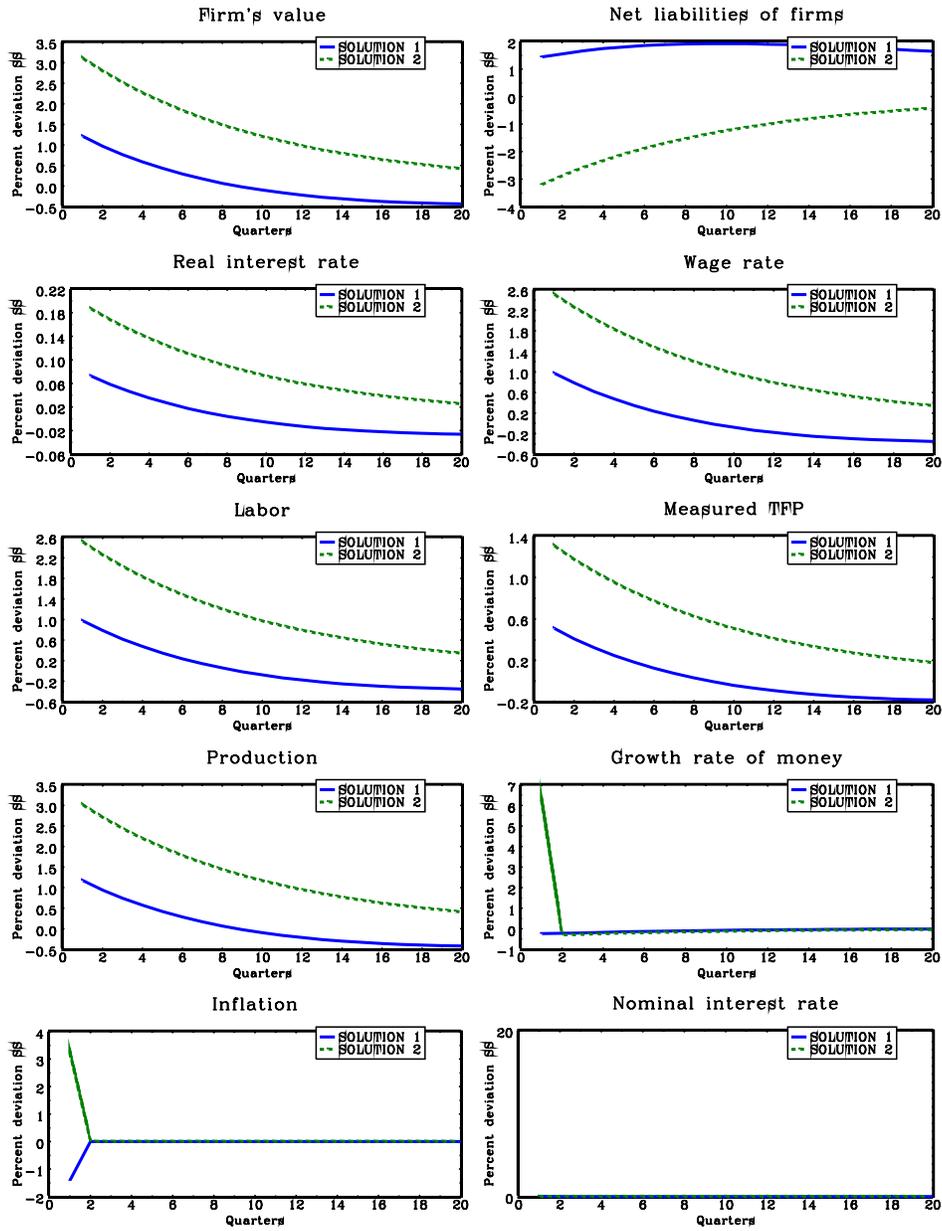


Figure 2: Impulse responses to an asset price boom (1% increase in q) under a constant interest rate rule.

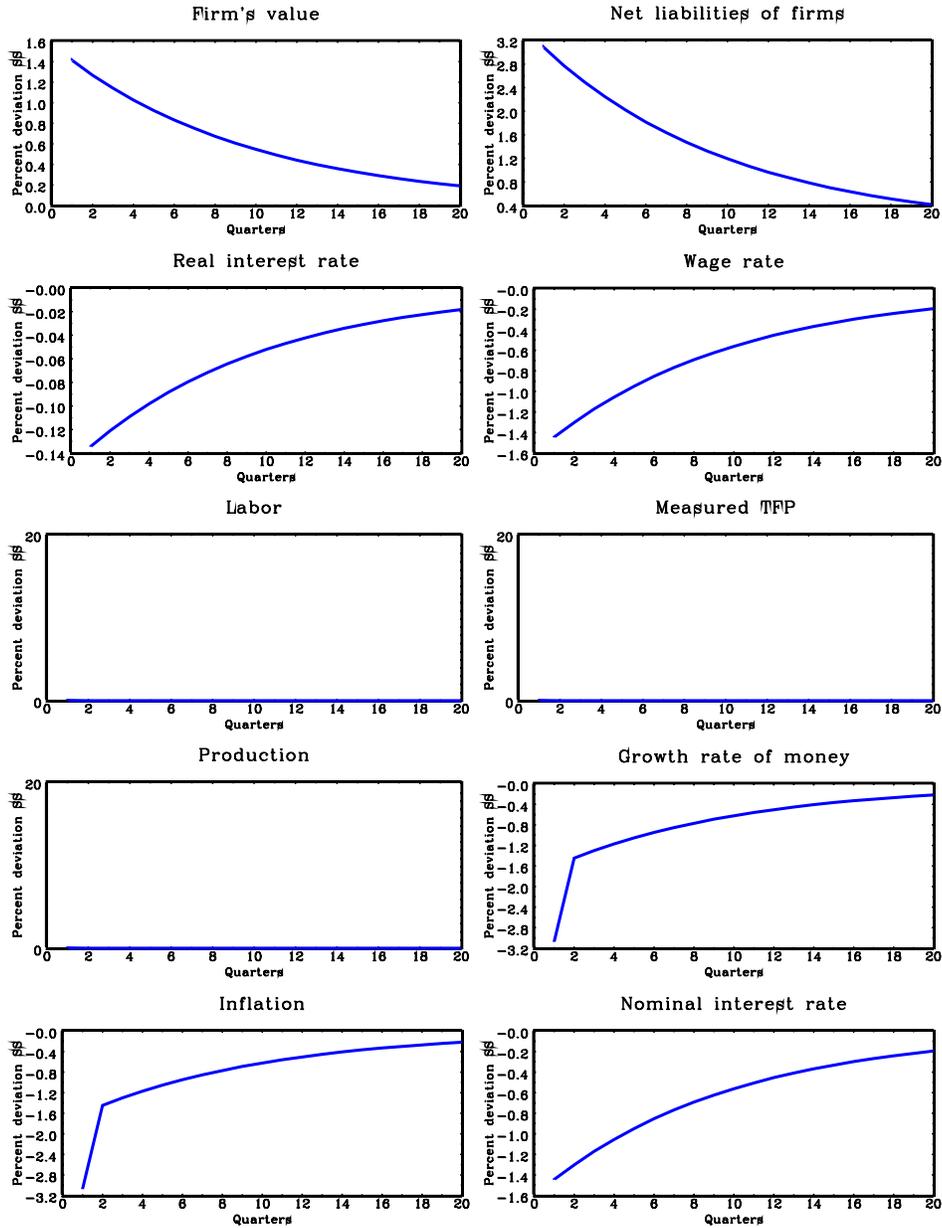


Figure 3: Impulse responses to an asset price boom (1% increase in q) under an output stabilization policy rule.