Monetary policy with asset price shocks and financial globalization

Vincenzo Quadrini
University of Southern California and CEPR

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Abstract

This papers studies how the stabilization role of monetary policy in response to asset price shocks changes with the globalization of financial markets. Changes in asset prices affect production through a credit channel and monetary policy can stabilize the macro-economy with counter-cyclical interventions. The paper shows that, as financial markets become internationally integrated, stabilization policies shift their focus from domestic asset prices to worldwide asset prices.

1 Introduction

Whether monetary authorities should take into account the dynamics of asset prices in the design of their policy interventions is still a debated issue. On the one hand, there is the view that monetary policy need not be, or even should not be, dependent on the price of assets. For examples, Bernanke and Gertler (1999, 2001) show that there is no need to respond to asset prices if the monetary authority controls inflation. Carlstrom and Fuerst (2007) even argue that responding to asset prices may lead to indeterminacy and potentially to greater macroeconomic instability. On the other hand, the 'activist' view suggests that monetary policy should respond to movements in asset prices. An example is Cecchetti, Genberg, Lipsky, and Wadhwani (2000). With the arrival of the most recent crisis where the macroeconomic downturn has been associated with large asset price declines, the activist view of monetary policy has gained momentum.

In this paper I revisit the issue of monetary policy interventions in the context of a simple model where business cycle fluctuations are only driven by shocks that affect the market value of firms (asset prices). I am especially interested in understanding how the stabilization role of monetary policy changes with the globalization of financial markets. During the last three decades most countries have become more integrated in the world financial markets as barriers to the mobility of capital have been lifted. The primary goal of this paper is to understand how the liberalization process has impacted on the effectiveness and, possibly, desirability of monetary policy in response to asset price movements.

The analysis of this paper is in the spirit of Bernanke and Gertler (2001) in the sense that fluctuations in asset prices have real macroeconomic consequences but it reaches a slightly different conclusion in terms of stabilization policies. In particular, a monetary policy that keeps inflation or the nominal interest rate constant does not stabilize macroeconomic fluctuations induced by asset price movements. Instead, macroeconomic stabilization requires the explicit response of monetary policy to asset prices. In this sense, the results of this paper is in line with the 'activist' view described above. This conclusion applies with or without international financial markets integration. However, with integrated financial markets, worldwide asset prices become important for the design of stabilization policies.

The central feature of the model is that asset price movements have real macroeconomic consequences through a credit channel similar to Jermann and Quadrini (2012) and Perri and Quadrini (2011). Because of financial frictions, changes in asset prices affect the availability of credit to firms which in turn affect their production decisions. 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, as long as there is monetary non-neutrality, monetary policy could play an important stabilization role by linking the growth rate of money to asset prices. In particular, it is found that monetary policy should react counter-cyclically to movements in asset prices, that is, it should decrease the growth rate of money and inflation in response to asset price booms. As the economy becomes more financially integrated, domestic asset price movements have a lower macroeconomic impact which requires a weaker monetary policy response. At the same time, the macro-economy becomes more sensitive to asset price movements in the rest of the world. Thus, the focus of monetary policy shifts from domestic asset prices to worldwide prices.

The paper is structured as follows. Section 2 first presents the closed-economy model and characterizes some of the general equilibrium properties. Section 3 shows analytically that asset price shocks are destabilizing under a monetary policy rule that keeps inflation or the nominal interest rate constant and characterizes The stabilization policy numerically. Section 4 extends the model to an open economy and studies the impact of financial globalization. Section 5 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. I will then close the model and define a general equilibrium.

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 $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t c_t$. Investors are the shareholders of firms and the dividends are their only source of income.

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 allow firms to generate profits. It could derive either from a concave production function in a perfectly competitive market or from monopolistic competition. The exact specification of technology and market structure will be provided in the next sub-section 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. If the firm loses the ability to generate revenues, it liquidates its assets and exits. The liquidation value is the capital $\bar{k}$ net of the outstanding liabilities as specified below.

Exiting firms are replaced by the same number of new firms whose ownership is equally shared among investors independently of their ownership of incumbent firms.[1] Firm exit is an idiosyncratic shock that arises with probability $1-q$. The law of large numbers then implies that in each period there is a fraction $1-q$ of firms replaced by new entrants. Idiosyncratic uncertainty is resolved at the beginning of the period.

In addition to the idiosyncratic shock (firm exit), there is an aggregate shock that affects the probability of survival q. More specifically, q 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 shocks to the price of assets. Throughout the paper, I will refer to unexpected changes in q as 'asset price shocks'. This is the only source of *aggregate* uncertainty in the model.

At the beginning of the period a surviving firm starts with nominal debt $\tilde{b}_t$ and cash $\tilde{m}_t$. It chooses the labor input, l_t, it contracts the new debt, $\tilde{b}_{t+1}$, it repays the liabilities carried from the previous period, $\tilde{b}_t$, and it makes cash payments to the shareholders, $P_t d_t$. Here d_t is the real dividend payment and P_t is the nominal price. The firm's budget constraint is

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

where R_t is 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,

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

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 to obtain the following budget constraint

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

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

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

after getting the revenues but before paying the wages. Let $\overline{V}_t(b_{t+1})$ be the real value of the firm at the end of the period. This is defined as

$$\overline{V}_t(b_{t+1}) \equiv \mathbb{E}_t \sum_{j=1}^{\infty} \beta^j \left(\Pi_{\ell=1}^{j-1} q_{t+\ell}\right) \bar{d}_{t+j} \tag{1}$$

where $\bar{d}_{t+j}$ are the expected real payout at the beginning of period $t+j$, before knowing whether the firm is still viable. These expected payments are equal to $\bar{d}_{t+j} = q_{t+j}d_{t+j} + (1-q_{t+j})(\bar{k} - b_{t+j}/P_{t+j})$, where d_{t+j} is the payment conditional on survival and the liquidation value of the firm is the capital $\bar{k}$ minus the real liabilities b_{t+j}/P_{t+j}.

The term in parenthesis in equation (1) accounts for the fact that firms survive only with some probability. The assumption that the ownership of new firms does not depend on the ownership of incumbent firms is essential to have this term in the market value of active firms.[2]

In case of default, the firm diverts the revenues $P_tF(l_t)$. The current expected real value is $\mathbb{E}_t[\beta P_t F(l_t)/P_{t+1}]$ because cash available at the end of period t can be used to purchase consumption goods in the next period when the nominal price is P_{t+1}.

After diverting the cash flow, the firm renegotiates the debt. Suppose that renegotiation succeeds with probability χ. Therefore, shareholders retain the value $\overline{V}_t(b_{t+1})$ only with probability χ. Enforcement requires that the value of not defaulting is at least as big as the value of defaulting, that is,

$$\overline{V}_t(b_{t+1}) \geq \mathbb{E}_t \left(\frac{\beta P_t}{P_{t+1}}\right) F(l_t) + \chi \cdot \overline{V}_t(b_{t+1}).$$

After rearranging, the enforcement constraint can be written as

$$\overline{V}_t(b_{t+1}) \geq \phi \cdot \mathbb{E}_t \left(\frac{\beta P_t}{P_{t+1}}\right) F(l_t), \tag{2}$$

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

From the enforcement constraint (2), it is easy to see how the monetary authority can affect credit. By increasing the inflation rate between today

[2]If the ownership of new firms is proportional to the ownership of incumbent firms, there is no loss of value for shareholders: previous firms are simply replaced by new firms. However, if the ownership of new firms does not depend on the ownership of incumbent firms, then the exit of a firm is a real loss for an individual shareholder. A similar idea has been used in Laitner and Stolyarov (2005).

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. With a lower default value, the borrowing capability of the firm increases allowing for a credit expansion. We then have that an expansionary monetary policy induces an expansion of credit and, as we will see, a real macroeconomic boom.

The market retention probability q plays a key 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, which reduces the hazard rate $\Pi_{\ell=1}^{j-1} q_{t+\ell}$. From equation (1) we can see that this reduces the firm's value $\overline{V}_t(b_{t+1})$, which in turn leads to a tighter enforcement constraint. In order to satisfy the enforcement constraint, the firm has to reduce the debt b_{t+1}/P_t, which requires a reduction in the current payout d_t.

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

$$V(\mathbf{s};b) \quad = \quad \max_{d,l,b'} \left\{ d + \overline{V}(\mathbf{s};b') \right\} \tag{3}$$

subject to:

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

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

where g is the growth rate of money, $\mathbf{s}$ the aggregate states, and the prime denotes the next period variable. Although I use the same notation, all nominal variables are now ratios over the aggregate stock of money M.

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

$$\overline{V}(\mathbf{s};b') = \beta\mathbb{E}\left[q' \cdot V(\mathbf{s}';b') + (1-q') \cdot \left(\bar{k} - \frac{b'}{P'}\right)\right]. \tag{4}$$

The firm remains viable in the next period with probability q' and exits with probability $1 - q'$. In the latter event capital is sold and the revenues, net of the liabilities, are distributed to shareholders.

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

$$F_l(l) = w\left(\frac{1+\mu}{1-\mu(\phi-1)}\right), \tag{5}$$

$$(1+\mu)\beta(1+r) = 1, \tag{6}$$

where μ is the lagrange multiplier for the enforcement constraint and $r = R\mathbb{E}\left(\frac{P}{P'(1+g)}\right) - 1$ 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, $d > 0$. The detailed derivation is in Appendix A.

We can see from equation (5) 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 limited enforceability of contracts.

What is the economic interpretation of the labor wedge? An increase in the labor input increases the revenues and, therefore, the value of default. This implies that the enforcement constraint becomes tighter and the firm has to cut borrowing. Since the cost of borrowing is the expected real interest rate $r = R\mathbb{E}(P/P'(1+g)) - 1$, which is smaller than the cost of equity $1/\beta - 1$, the substitution of debt with equity increases the overall financial cost. Thus, the firm requires that the marginal product of labor is higher in order to compensate for the increased financial cost. Essentially, the labor wedge represents the marginal cost of changing the financial structure made necessary by hiring more labor.

The second first order condition, equation (6), shows that μ is decreasing in the (expected) real interest rate on debt $r = R\mathbb{E}(P/P'(1+g)) - 1$. Effectively, the multiplier μ captures the cost differential between equity, $1/\beta - 1$, and debt, r. When the cost differential increases (because the cost of debt r decreases) μ increases because the substitution between debt and equity is more costly. The increase in μ then increases the labor wedge as we can see from equation (5), which in turn reduces the demand for labor. The dependence of μ from the (expected) real interest rate r will be key for understanding the general equilibrium properties of the model.

2.2 Closing the model and general equilibrium

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

Production and market structure: Each firm produces an intermediate good x_i that is used in the production of final goods,

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

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 production. 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 therefore, $Y = (\bar{k}^\theta L^{1-\theta})^\nu$. This implies that 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.

Workers: There is a continuum of homogeneous workers with lifetime utility $\mathbb{E}_0 \sum_{t=0}^\infty \delta^t U(c_t, h_t)$, where c_t is consumption, h_t is labor and δ is the intertemporal discount factor. I assume that $\delta > \beta$, that is, households have a 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 but cannot hold firms' equity.

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 particular specification of the utility function with the dis-utility from working additive to consumption allows me to derive analytical results but it is not essential for the qualitative properties of the model.

The workers' budget constraint is

$$P_t w_t h_t + \tilde{b}_t + m_t + g_t M_t = P_t c_t + \frac{\tilde{b}_{t+1}}{R_t} + m_{t+1}.$$

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 funds on the left-hand-side of the budget constraint are used for consumption, new bonds and cash carried to the next period.

Notice that, in equilibrium, the beginning of period money holding of workers, m_t, is not equal to the aggregate stock of money, M_t. This is because firms also hold some cash at the beginning of the period, denoted by $\tilde{m}_t$. Therefore, $m_t + \tilde{m}_t = M_t$.

Households are subject to the cash-in-advance constraint

$$P_t c_t = m_t + \tilde{b}_t + g_t M_t - \frac{\tilde{b}_{t+1}}{R_t}.$$

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

$$h_t = \left(\frac{w_t}{\alpha R_t}\right)^{\frac{1}{\gamma-1}}, \tag{7}$$

$$\frac{1}{R_t} = \delta \mathbb{E}_t \left[\frac{U_c(c_{t+1}, h_{t+1})}{U_c(c_t, h_t)} \frac{P_t}{P_{t+1}(1+g_t)}\right]. \tag{8}$$

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 (7)-(8); (ii) firms' policies are optimal and $V(\mathbf{s}; b)$ satisfies the Bellman's equation (3)-(4); (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 $\bar{R} > 1/\delta$. 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, 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 (8), becomes $\delta RP/P'(1+g) = 1$. Using this condition to eliminate

$RP/P'(1+g)$ in (6), 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 $\overline{V}_t(b_{t+1}) \geq 0$. In this case the demand for labor from condition (5) 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 (7)), employment and production will not be affected by fluctuations in q, as long as the nominal interest rate does not change. This is the case, for example, when the monetary authority keeps R 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 cash revenues are divertible. 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 $r = R\mathbb{E}P/P'(1+g)-1$. Using conditions (5) and (6) we can see that the change in the real interest rate affects the demand for labor. Given the supply, equation (7), this leads to a change in employment and output (unless the monetary policy targets a constant employment rate and reacts accordingly).

3 Stabilization policies

After showing that asset price shocks could destabilize the real sector of the economy, I ask what the monetary authority can do to counteract these shocks in order to stabilize output. The next proposition establishes that monetary policy rules that maintain constant inflation rates or constant nominal interest rates do not stabilize output.

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 (5) and (6) 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 $\phi = 1$.

A similar argument shows that a constant nominal interest rate R is not optimal. A constant nominal interest rate policy does not guarantee a constant inflation rate. As a result, the expected real interest rate $r = R\mathbb{E}P/P'(1+g)$ will be affected by asset price movements. Conditions (5) and (6) then imply that employment will not be constant.

If constant inflation or nominal interest rate policies are not optimal in the sense of output stabilization, what should be the optimal policy? Here the term optimality is used to the extent that the goal of the monetary authority is to stabilize output. The stabilization policy, characterized numerically, responds counter-cyclically to movements in asset prices: it contracts the growth rate of money after an asset price boom and it expands the growth rate of money after an asset price fall. This also implies that inflation responds counter-cyclically to asset price movements.

3.1 Numerical characterization

The goal of the numerical simulation conducted in this section is not meant to provide a full calibration exercise to study the *quantitative* properties of the model but to show its *qualitative* features.

The parametrization is on a quarterly basis and the discount factors for workers and investors are set to generate an average real yearly return on bond 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. The parameter α will be chosen together with other parameters as specified below.

For the parametrization of the revenue function, I start by setting the return to scale parameter in the production function to $\nu = 1.5$. 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 from 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 survival probability is set to $\bar{q} = 0.975$. 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).[3] The standard deviation of the white noise component will be specified in the description of the particular simulation.

For all monetary policy rules considered in this paper, I assume that the average growth rate of money is equal to $\bar{g} = 0.0075$, which implies an average annual inflation ratio of about 3 percent.

There are four parameters left 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 (2.88), and leverage ratio measured as debt over capital (0.4). The list of parameter values are reported in Table 1.

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 under different monetary policy rules. The response to a negative shock, not reported, is symmetric with inverted sign.

[3]When weighted by the size of firms, the exit probability is smaller than 10 percent. However, the exit rate in the model should be interpreted more broadly than firm exit. It also includes, for example, the sales of business activities. When interpreted this way, the 10 percent annual probability is not implausible.

Table 1: Parametrization.

Description	*Parameter values*
Discount factor for investors	$\beta = 0.9825$
Discount factor for workers	$\delta = 0.9975$
Utility parameters for workers	$\alpha = 2.25,\ \ \gamma = 2,\ \ \sigma = 1$
Production technology	$\theta = 0.2,\ \ \nu = 1.5,\ \ \bar{k} = 5$
Elasticity parameter	$\eta = 0.567$
Market survival	$\bar{q} = 0.975$, $\rho = 0.9$
Growth rate of money	$\bar{g} = 0.0075$
Enforcement parameters	$\phi = 9.5$

I consider three monetary policy regimes. In the first regime, the monetary authority adjusts the growth rate of money to keep the inflation rate constant at $\bar{g} = 0.75\%$ per quarter.

In the second regime, the monetary authority keeps the nominal interest rate constant at $\bar{R} = (1 + \bar{g})/\delta$. With a constant nominal interest rate, however, the nominal price level is not necessarily unique. Thus, I have to make some assumption about the determination of the nominal price level. To this end, I assume that the actual price tomorrow is equal to the price expected today, that is, $P_{t+1} = \mathbb{E}_t P_{t+1}$. Under this particular assumption, the impulse responses under the inflation rule are equivalent to the responses under the nominal interest rate rule.

In the third policy regime, the monetary authority adjusts its policy instrument to keep production constant. Since in this economy production is fully determined by the input of labor, effectively, this 'stabilization' policy keeps employment constant. An important question, of course, is whether the full stabilization policy is optimal from a welfare point of view. This question is not addressed in this paper. However, two remarks are in order. First, if the monetary authority has a strong motive to stabilize macroeconomic activity—at least in response to non-technological shocks—then the stabilization rule may be optimal for the monetary authority. The second remark is that, since the asset price shock does not affect the technological capacity of the economy and, in absence of financial frictions, it would be completely neutral, then it is plausible that the stabilization rule is welfare improving compared to the inflation or interest rate rules.[4]

As we can seen from Figure 1, a positive asset price shock under the inflation or interest rate rules, generates an increase in the (expected) real interest rate and a macroeconomic expansion. It is also interesting to notice that, because of the expansion in employment, measured TFP increases. Measured TFP is the Solow residuals constructed using a (misspecified) production function with constant returns to scale. This is the standard approach used in the literature. Thus, the increase in measured TFP follows from the fact that the actual production function displays increasing returns to scale. With a different parametrization of the production technology that displays decreasing returns, the qualitative dynamics of the impulse responses would be similar, except for measured TFP.

When the monetary authority follows a stabilization rule that keeps employment constant, the growth rate of money declines in response to the increase in asset prices. To understand this property we need to reconsider the enforcement constraint. Since $\overline{V}_t(b_{t+1}) = V(b_t) - d_t$, the enforcement constraint (2) can be rewritten as

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

The key to a stabilization policy is to insure that this constraint remains satisfied with equality without a change in l_t (employment). Because $V(b_t)$ increases in response to a higher value of q_t (assuming that the process for q_t is persistent), there are three ways in which the equality can be reinstate without changing l_t: (i) by increasing d_t; (ii) by reducing the current price level P_t so that the real value of debt, b_t/P_t, increases and the real value of the firm $V(b_t)$ falls;[5] (iii) by reducing the next period nominal price level P_{t+1} so that the value of defaulting increases.

If the main adjustment takes place through an increase in d_t, which must be associated with higher borrowing from workers, the consumption of workers would decrease (given that output does not change). But this would

[4]The steady state equilibrium is also inefficient and monetary policy could affect the steady state. In the above argument I am abstracting from the possibility that the monetary authority could eliminate the inefficiencies that characterize the steady state equilibrium. Instead, monetary policy focuses only on deviations from the steady state.

[5]This also reduces the value of defaulting (the right-hand-side of the above equation). However, this can be compensated by an increase in the next period price P_{t+1}.

necessarily change the expected real interest rate $r_t = R_t \mathbb{E}_t P_t / P_{t+1}$. By condition (6), a change in the real interest rate affects the demand for labor and would be inconsistent with a constant l_t. Therefore, the adjustment must take place through the second and third channels, that is, by reducing the current and future inflation rates which requires a reduction in the growth rate of money. The reduction in the current inflation rate increases the real value of the outstanding debt and reduces the left-hand-side of the enforcement constraint. The reduction in future inflation rates increases the value of default, 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 generated by 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 and employment stays constant (but the wage rate falls).[6]

4 Financial globalization

After showing the properties of the model when financial markets are not integrated, I now extend the model to allow for the mobility of capital. Financial globalization has two major implications. On the one hand, borrowers (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 and on the stabilization policy, I first take a reduced form approach where I specify the net supply of foreign funds as an exogenous function of the domestic and foreign interest rates. By further assuming that the country is a small open economy, I can take the foreign interest rate as exogenous. After studying the impact of globalization in reduced form, I

[6] In practice, the monetary authority may not be able to perfectly stabilize employment if this requires a negative nominal interest rate as it happens in the simulation reported in Figure 1. In this case the monetary authority will only be able to make the drop in employment smaller.

extend the model to a two-country environment where the net foreign supply of funds and the foreign interest rate are derived endogenously. This will confirm the intuitions obtained with the reduced form approach.

4.1 Reduced form approach

Suppose that the country of interest is a small open economy and the net foreign supply of funds is given by the function

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

where $r = R\mathbb{E}P/P'(1+g)$ is the expected domestic real interest rate and r^* is the expected foreign real interest rate. Under the assumption that the economy is small, the foreign interest rate can be taken as exogenous.

The supply of foreign funds satisfies $\varphi(r, r) = 0$, $\partial\varphi(r, r^*)/\partial r > 0$ and $\partial\varphi(r, r^*)/\partial r^* < 0$. These properties imply that capital inflows increase with higher domestic interest rates and lower interest rates abroad. The effect of globalization is to increase the absolute value of these derivatives. In the limiting case of perfect integration the elasticity will converge to infinity and in equilibrium $r = r^*$.[7]

It is now easy to see what happens as the economy globalizes. The easier way to show this is to consider the polar cases of autarky and full integration. In the first case the flow of foreign funds are always zero, that is, $\varphi(r, r^*) = 0$. 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, that is, $r = r^*$.

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

Proposition 4.1 (Domestic shock) *Suppose that $\partial\varphi(r, r^*)/\partial r = \infty$ (perfect capital mobility in a small open economy). Furthermore, suppose that the monetary authority keeps the nominal interest rate constant. Then a domestic asset price shock has not effect on employment and output.*

[7]Because 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.

We can see from condition (6) that, if the expected real interest rate is constant, then μ is also constant. Condition (5) 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 (7)). However, because the monetary authority keeps the nominal interest rate constant, the supply of labor does not change. Therefore, employment will not be affected by fluctuations in asset prices.

A corollary to this finding is that, the Friedman rule of a constant nominal interest rate is the optimal stabilization policy when capital is perfectly mobile. Because the real interest rate is constant, the constancy of the nominal interest rate is equivalent to maintaining a fixed inflation rate. 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 is not optimal if capital is not internationally mobile.

The main difference between the closed and open economies leading to this result 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 stays constant, firms do not change their employment decisions.

The model also provides some predictions about the impact of asset price movements on the international flow of funds. More specifically, asset price booms lead to capital inflows while asset price crashes lead to capital outflows. This channel is in contrast to an alternative channel where it is financial flows that cause asset price movements.

What would be the impact of a 'foreign' asset price shock? Given the reduced form approach to capital inflows, I have to make some assumptions on how external asset prices affect the foreign real interest rate r^*. We have seen that in the domestic economy, at least when the monetary authority stabilizes the nominal interest rate or the inflation rate, an asset price shock affects the domestic real interest rate r. It is then natural to assume that external asset price shocks affect the foreign real interest rate r^*. We then have the following proposition.

Proposition 4.2 *Suppose that $\partial\varphi(r, r^*)/\partial r = \infty$ (perfect capital mobility in a small open economy). Furthermore, suppose that the monetary authority keeps the nominal interest rate constant. Then an external asset price shock affects employment and output by changing the domestic real interest rate.*

With perfect mobility of capital, the domestic interest rate adjusts immediately to the foreign interest rate. Then, the change in domestic real interest rate affects employment and output as we have seen in the previous sections.

A corollary to Propositions 4.1 and 4.2 is that, as the economy becomes more globalized, the optimal stabilization policy should be less concerned about domestic asset price shocks and more concerned about external asset price shocks.

Corollary 4.1 *Suppose that the goal of the monetary authority is to stabilize output. Without capital mobility, that is, $\partial\varphi(r, r^*)/\partial r = \partial\varphi(r, r^*)/\partial r^* = 0$, the optimal stabilization policy responds only to domestic asset price movements. With perfect mobility of capital, that is, $\partial\varphi(r, r^*)/\partial r = \infty$ and $\partial\varphi(r, r^*)/\partial r^* = -\infty$, 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 globalizes, it is also possible that domestic asset prices become more synchronized with foreign prices. Therefore, linking monetary policy to fluctuations in domestic asset prices could be a good approximation for targeting foreign asset prices.

4.2 Two-country model

I now consider the open economy version of the model with two countries: 'home' and 'foreign'. Each country has the same characteristics as those described in the previous sections. The stochastic variable q is country-specific. Thus, there are two aggregate asset price shocks, home and foreign. They follow independent Markov processes.

To capture different degrees of capital markets integration, I assume that the holding of foreign bonds is costly. This cost is also helpful in making the model stationary in terms of foreign asset positions. Denote by N_t the aggregate net foreign asset position of the domestic country. The cost per unit of foreign holdings is ψN_t. The parameter ψ captures the degree of international capital market integration. When $\psi = 0$ we have perfect mobility of capital. The assumption that the cost depends on the aggregate position of a country, instead of individual positions, simplifies the analysis.

Whether international borrowing and/or lending is done by firms or workers is irrelevant. Therefore, I assume that only workers participate in the international financial market.[8] Workers in the home country lend or borrow from foreign workers with one period non-contingent debt contracts. To simplify the analysis, I also assume that these contracts are denominated in the currency of the home country.

Denote by n_t the net foreign asset position denominated in domestic currency of an individual worker in the home country and b_t the domestic holding of bonds (also denominated in domestic currency). The worker's budget constraint can be written as

$$P_t w_t h_t + \tilde{b}_t + n_t(1 - \psi N_t) + g_t M_t = P_t c_t + \frac{\tilde{b}_{t+1}}{R_t} + \frac{n_{t+1}}{\tilde{R}_t} + m_{t+1},$$

where $\tilde{R}_t$ is the interest rate on foreign borrowing denominated in domestic currency (the currency of the home country). The budget constraint for workers in the foreign country is

$$P_t^* w_t^* h_t^* + \tilde{b}_t^* + e_t n_t^*(1 - \psi N_t^*) + g_t^* M_t^* = P_t^* c_t^* + \frac{\tilde{b}_{t+1}^*}{R_t^*} + \frac{e_t n_{t+1}^*}{\tilde{R}_t} + m_{t+1}^*,$$

where R_t^* is the interest rate in the foreign country (on bonds denominated in the currency of the foreign country) and e_t is the nominal exchange rate (units of foreign currency for one unit of home country currency). Since

[8] This does not imply that entrepreneurs cannot own foreign firms. Given the risk neutrality of investors, cross-country ownership of firms is not determined in the model and equilibrium output and employment are independent of the business ownership.

domestic goods are perfectly substitutable to foreign goods, the law of one price must hold, that is, $e_t = P_t^*/P_t$.

Compared to the closed economy, workers in the home country also choose n_{t+1} and workers in the foreign country also choose n_{t+1}^*. Therefore, in addition to the first order conditions (7) and (8), the optimality conditions for the choices of n_{t+1} and n_{t+1}^* are, respectively,

$$\frac{1}{\tilde{R}_t} = \delta(1-\psi N_{t+1})\mathbb{E}_t\left[\frac{U_c(c_{t+1},h_{t+1})}{U_c(c_t,h_t)}\frac{P_t}{P_{t+1}(1+g_t)}\right], \tag{9}$$

$$\frac{1}{\tilde{R}_t} = \delta(1-\psi N_{t+1}^*)\mathbb{E}_t\left[\frac{U_c^*(c_{t+1},h_{t+1}^*)}{U_c(c_t^*,h_t^*)}\frac{e_{t+1}P_t^*}{e_tP_{t+1}^*(1+g_t^*)}\right]. \tag{10}$$

We can now combine equation (8) for both countries with equations (9) and (10) to obtain

$$\frac{1}{R_t} = \frac{1}{R_t^*}\mathbb{E}_t\left(\frac{e_{t+1}}{e_t}\right)\left(\frac{1+\psi\cdot N_{t+1}}{1-\psi\cdot N_{t+1}}\right) + \Psi_t, \tag{11}$$

where $\Psi_t = \mathrm{Cov}\left(\frac{U_c^*(c_{t+1},h_{t+1}^*)P_t^*}{U_c(c_t^*,h_t^*)P_{t+1}^*(1+g_t^*)}, \frac{e_{t+1}}{e_t}\right)$. I also made use of the equilibrium condition $N_{t+1} = -N_{t+1}^*$.

This equation is the 'uncovered interest rate parity' with risk averse agents and foreign transaction costs. If we abstract from uncertainty and use the law of one price $e_t = P_t^*/P_t$, the equation can be rewritten as

$$r_t = (1+r_t^*)\left(\frac{1-\psi\cdot N_{t+1}}{1+\psi\cdot N_{t+1}}\right) - 1.$$

Thus, the real interest rate is lower in countries with positive net foreign asset positions. With perfect mobility of capital, $\psi = 0$, the real interest rates are equalized across countries.

The definition of a recursive competitive equilibrium is very similar to the definition in the autarky regime. The aggregate states, denoted by $\mathbf{s}$, are given by the stochastic variables q and q^*, the bonds issued by firms in both countries (net of money holding), B and B^*, and the foreign asset position of the home country N (or alternatively of the foreign country $N^* = -N$). The only difference compared to the autarky equilibrium is that now there is also the clearing condition in international borrowing and lending between workers, that is, $N' + N^{*'} = 0$. This is in addition to the clearing condition in the local markets for bonds, that is, the bonds issued by local firms must be purchased by local workers.

4.3 Numerical simulation

As for the analysis conducted in Section 3.1, the goal of the numerical simulation is not meant to be a full calibration exercise aimed at studying the *quantitative* properties of the model but rather to show its *qualitative* features. The parameter values are the same as those used in Section 3.1. The new parameter ψ, capturing the cost of holding foreign assets, is set to 0.01. The stochastic variables q and q^* are assumed to follow independent processes.

Figure 2 plots three impulse responses in the home country to positive asset price shocks when the monetary authorities of both countries follow an inflation or interest rate rule. The first line is the impulse response to a shock that arises only in the home country. The second is the impulse response to a shock that arises only in the foreign country. The third is the impulse response to contemporaneous shocks in both countries. This third case is equivalent to the response to a domestic shock in the autarky equilibrium as shown in Section 3.1.

The response of employment and output to a domestic asset price shock is smaller when the home country is financially integrated (the response in autarky would be equivalent to the response to both shocks). At the same time, however, when financial markets are integrated, the home country is affected by a shock that arises in the foreign country (the foreign shock would be irrelevant for the home country in the autarky regime). Therefore, while financial integration allows countries to smooth domestic shocks, it also makes countries more vulnerable to foreign shocks, which validates the analysis conducted in the previous section with a reduced form approach. As financial markets become more globalized, the focus of monetary policy shifts from domestic asset prices to foreign asset prices.

5 Conclusion

This paper has studied a monetary economy where the driving force of the business cycle is a shock 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. A stabilization policy would react counter-cyclically to asset price movements:

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 fall.

The primary goal of the paper is to study how the stabilization role of monetary policy changes as financial markets become more integrated. It is shown that globalization reduces the macroeconomic impact of 'domestic' asset price shocks but increases the impact of 'global' asset price shocks. Therefore, as the economy becomes more globalized, the target of monetary policy for stabilization purposes shifts from domestic asset prices to global asset prices.

Appendix

A First order conditions

Consider the optimization problem (3) and let λ and μ be the Lagrange multipliers associate with the two constraints. Taking derivatives we get:

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

Given the definition of $\overline{V}(\mathbf{s};b')$ provided in (4), the derivative is:

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

The envelope condition is:

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

Using the first condition to eliminate λ and substituting the envelope condition we get (5) and (6).

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 equation (7)). Because the demand of labor depends on w and μ (see condition (5)), 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 (6) implies that the inflation rate must be constant and condition (8) 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 $\overline{V}(b_{t+1}) = V(b_t) - d_t$, the enforcement constraint can be written as:

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

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 (equations (5) and (7)), 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 equation (6) to eliminate $R_t(1+\mu_t)$ we get:

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

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 autarky equilibrium is characterized by the system of equations:

$$\alpha R_t h_t^{\gamma-1} = w_t \tag{12}$$

$$\delta R_t \mathbb{E}_t \left[\frac{U_t' P_t}{U_{t+1}' P_{t+1}} (1+g_t) \right] = 1 \tag{13}$$

$$1 + g_t + b_t = P_t c_t + \frac{b_{t+1}(1+g_t)}{R_t} + \frac{P_t[F(h_t) - w_t h_t]}{R_t} \tag{14}$$

$$b_t + P_t d_t = \frac{b_{t+1}(1+g_t)}{R_t} + \frac{P_t[F(h_t) - w_t h_t]}{R_t} \tag{15}$$

$$P_t F(h_t) = 1 + g_t \tag{16}$$

$$F'(h_t) = w_t \left[\frac{1+\mu_t}{1+\mu_t(1-\phi)} \right] \tag{17}$$

$$(1+\mu_t)R_t\mathbb{E}_t\left(\frac{\beta P_t}{P_{t+1}(1+g_t)}\right)=1 \tag{18}$$

$$V_t=d_t+\phi\mathbb{E}_t\left(\frac{\beta P_t}{P_{t+1}(1+g_t)}\right)F(h_t) \tag{19}$$

$$V_t=d_t+\mathbb{E}_t\left[q_{t+1}V_{t+1}+(1-q_{t+1})\left(\bar{k}-\frac{b_{t+1}}{P_{t+1}}\right)\right] \tag{20}$$

There are 9 equations. Together with a rule for monetary policy, the total number of equations is 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.

In the two-country model we have 21 equations: the 10 equations characterizing the autarky equilibrium (properly updated) for each of the two countries, plus the uncovered interest parity, equation (11). The number of variables are also 21: the 10 variables listed in the autarky equilibrium for each of the two countries, plus the net foreign asset position N_t.

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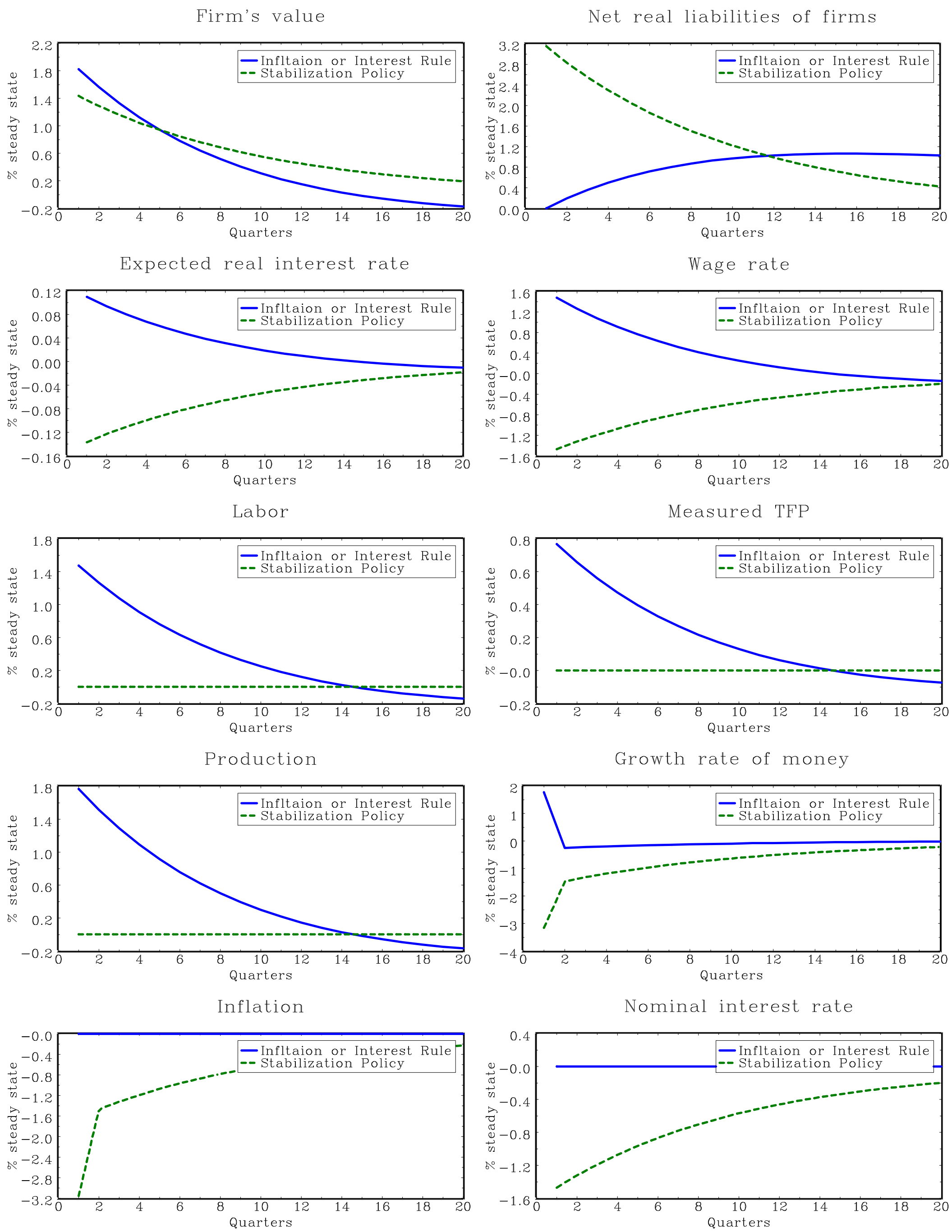

Figure 1: Impulse response to an asset price boom (1% increase in q).

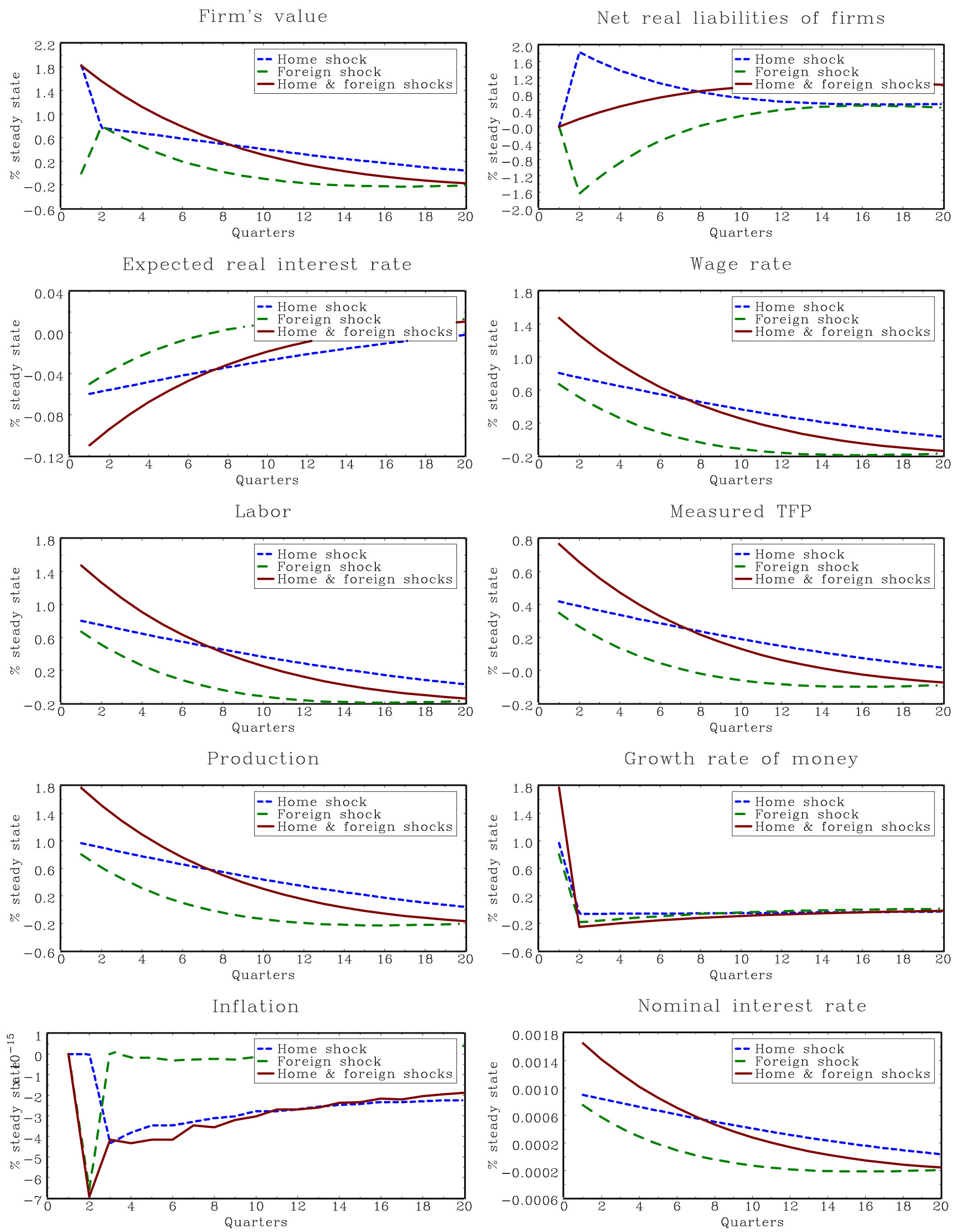

Figure 2: Impulse response to an asset price boom (1% increase in q) under an inflation or interest rate rule.