The Macroeconomic Effects of Asset Price Shocks in a Globalized Financial Market

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Abstract

This paper studies a model where shocks to asset prices affect the real sector of the economy through a credit channel. As financial markets become internationally integrated, the economy becomes less vulnerable to domestic asset price shocks, but more vulnerable to foreign asset price shocks. To the extent that monetary policy stabilization is feasible and desirable, the globalization of financial markets shifts the focus of monetary policy from domestic asset prices to worldwide asset prices.

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I. Introduction

Movements in asset prices are often associated with movements in the volume of credit and economic activity. While statistical association does not imply causation, an important body of literature has emphasized some of the channels through which asset price movements determine the performance of the real sector of the economy. Of course, the reverse causation—from real macroeconomic performance to the dynamics of asset prices—may also be important. In this paper, however, I will focus on the first channel by studying a model in which autonomous movements in asset prices are transmitted to the real sector of the economy. The primary goal of the paper is to study how the transmission of these shocks changes with the globalization of financial markets.

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). Due to financial frictions, changes in asset prices affect the availability of credit to firms, which in turn affects their production decisions. In the absence of financial frictions, movements in asset prices would not impact employment and production. However, due to market incompleteness, asset price fluctuations have a direct effect on the real sector of the economy. By extending the model to a multi-country set up, I study how the transmission of these shocks changes with the globalization of financial markets. The main finding is that, as financial markets globalize, the real sector of the economy becomes less dependent on domestic asset prices but more dependent on foreign asset prices. This implies that the focus on stabilization policies shifts from domestic asset prices to global asset prices.

In terms of policy implications, the paper examines the potential role of monetary policy. Whether monetary policy should be designed to take into account the dynamics of asset prices 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). This view has gained momentum after the arrival of the recent crisis where the macroeconomic downturn was associated with large asset price declines.

The analysis of this paper shows that a monetary policy rule that keeps inflation or the nominal interest rate constant does not stabilize the macro-economy in response to asset price shocks. Since the macroeconomic movements caused by asset price shocks are not induced by technology or preference changes, they are typically inefficient. It is on this premise that monetary policy stabilization, explicitly targeted to movements in asset prices, could be desirable from a welfare stand point. In this sense, the policy conclusion reached in the paper is more in line with the 'activist' view described above. This conclusion differs from the more passive view because of the use of a model with a more direct link between movements in asset prices and real economic activity. The policy conclusion applies with or without the globalization of financial markets. However, with globalization, worldwide asset prices become more important for the design of stabilization policies.

The paper is structured as follows. Section II. presents the closed-economy model and characterizes some of the general equilibrium properties. Section IV. extends the model to a two-country set up and studies the effects of financial globalization. Section IV. analyzes the monetary policy implications and Section V. concludes.

II. Model

I start describing the closed economy version of the model. After the characterization of the closed economy, it will be easy to extend it to a multi-country set-up.

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.

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. It is further assumed that investors cannot borrow but they could hold non-state contingent bonds. However, as we will see, in the neighborhood of the steady state it is not optimal for them to hold bonds. We can then analyze the model as if there is a representative investor who simply consumes the dividends paid by firms.[1]

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 in labor allow firms to generate profits. The concavity 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 is provided in Appendix A. 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.[2] 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 for all firms. 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

[1] I could study the maximization problem of investors explicitly by assuming that they trade two types of assets: non-negative quantity of nominal bonds (with workers) and shares of firms (among themselves). In this way investors would solve a portfolio choice subject to a no-borrowing constraint. In equilibrium, however, they will never lend since, as we will see, the interest rate is smaller than the inter-temporal discount rate. Therefore, they only hold shares of firms and simply consume the dividends.

[2] 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.

of *aggregate* uncertainty in the model.

At the beginning of the period a surviving firm starts with nominal debt b_t and cash m_t. It chooses the labor input, l_t, pays the wages, $P_t w_t l_t$, contracts the new debt, b_{t+1}, repays the liabilities carried from the previous period, b_t, and pays dividends, $P_t d_t$. Here w_t is the real wage rate, d_t the real dividend and P_t the nominal price. The beginning-of-period budget constraint is

$$b_t + P_t w_t l_t + P_t d_t = m_t + \frac{b_{t+1}}{R_t},$$

where R_t is the gross nominal interest rate. The cash carried to the next period is equal to the firm's revenues, that is,

$$m_{t+1} = P_t F(l_t).$$

As far as the flows of cash is concerned, we have that firms start the period with cash which is used to make payments of wages, $P_t w_t l_t$, dividends, $P_t d_t$, and financial transactions, $b_t - b_{t+1}/R_t$. After that, all cash is held by shoppers (investors and workers) who will then use the cash to buy the goods produced by firms. In this way, the cash returns to firms by the end of the shopping stage. Firms will then carry the cash to the next period.

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

$$\tilde{b}_t + P_t w_t l_t + P_t d_t = \frac{\tilde{b}_{t+1}}{R_t} + \frac{P_t F(l_t)}{R_t}.$$

We can see that the firm's output $F(l_t)$ is discounted by the nominal interest rate R_t. This follows from the cash-in-advance assumption described above where the cash revenues in period t are realized at the end of the period and, therefore, they will be distributed to shareholders at the beginning of period $t+1$. A dollar distributed at the beginning of period $t+1$ is equivalent to $1/R_t$ dollars distributed in period t. Alternatively, I could assume that the cash is distributed at the end of the period but investors need to wait the next period because the distribution arises after the shopping stage.

Firms could divert the cash revenue $P_t F(l_t)$ and default. Since diversion arises at the end of the period, that is, after the shopping stage, the present value of the diverted revenues is $P_t F(l_t)/R_t$ and the real value is $F(l_t)/R_t$. In this way I keep symmetry in the value of diverted and non-diverted cash (they are both discounted by R_t).

To derive the enforcement constraint, let's first define $\overline{V}_t(\tilde{b}_{t+1})$ the *real* value of the firm at the end of the period. This is equal to

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

where $\bar{d}_{t+j}$ is 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 while the payment in the event of exit is the liquidation value of the firm given by the capital $\bar{k}$ minus the real net liabilities $\tilde{b}_{t+j}/P_{t+j}$.

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 determining the market value of active firms.[3]

In case of default, the firm diverts the revenues and renegotiates the debt. Suppose that renegotiation succeeds with probability χ. Therefore, shareholders retain the value $\overline{V}_t(\tilde{b}_{t+1})$ only with probability χ. Enforcement requires that the value of not defaulting is at least as big as the value of defaulting, that is,

$$\overline{V}_t(\tilde{b}_{t+1}) \geq \frac{F(l_t)}{R_t} + \chi \cdot \overline{V}_t(\tilde{b}_{t+1}).$$

After rearranging, the enforcement constraint can be written as

$$\overline{V}_t(\tilde{b}_{t+1}) \geq \phi \cdot \left(\frac{F(l_t)}{R_t}\right), \tag{2}$$

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

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

[3]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).

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 real liabilities $\tilde{b}_{t+1}/P_t$, which requires a reduction in the current payout d_t.

Firm's problem: Because the stock of money grows 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

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

subject to:

$$\frac{\tilde{b}}{P} + wl + d = \frac{(1+g)\tilde{b}'}{RP} + \frac{F(l)}{R}$$

$$\overline{V}(\mathbf{s};\tilde{b}') \geq \phi \cdot \frac{F(l)}{R}$$

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

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

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. Equation (4), together with (3), provides the recursive formulation of the firm's value defined in (1).

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

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

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

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. For the moment I assume that $r < 1/\beta - 1$, that is, the expected real interest rate is smaller than the intertemporal discount 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 B.

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.

In order to provide the economic interpretation of the labor wedge, consider the following thought experiment. Consider an increase in the labor input. This increases the revenue of the firm and, therefore, the value of defaulting. This implies that the enforcement constraint becomes tighter and the firm has to cut real borrowing. Since the cost of borrowing is the expected real interest rate $r = R\mathbb{E}(P/P'(1+g))-1$ which, by assumption, 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 the increased financial cost. Effectively, the labor wedge represents the marginal cost of changing the financial structure which is made necessary by the decision to hire more labor.

The second first order condition, equation (6), shows that μ is decreasing in the (expected) real interest rate on debt $r = R\mathbb{E}(P/P'(1+g)) - 1$. 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 raises because the substitution between debt and equity is more costly. The increase in μ then raises 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.

Closing the model and general equilibrium

There is a continuum of 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 investors. 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. Therefore, the market for equity is segmented with participation limited to investors.

The utility function is specified as $U(c_t, h_t) = \ln(c_t - \alpha h_t^{\gamma}/\gamma)$, where $1/(\gamma - 1)$ is the elasticity of labor supply. This particular specification of the utility function with the disutility 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

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

The total resources are given by the wage income, the payment of the bond, the beginning-of-period money, and the monetary transfers $g_t M_t$ from the monetary authority. The variable g_t denotes the growth rate of money and M_t the aggregate stock of money at the beginning of period t before the monetary transfers. The available funds are used for consumption, the purchase of new bonds and cash carried to the next period.

Households are subject to the cash-in-advance constraint

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

Combining the budget constraint with the cash-in-advance constraint we obtain $m_{t+1} = 0$. Therefore, workers do not carry any cash to the next period and we can set $m_t = m_{t+1} = 0$ in the worker's budget.

Assuming that the cash in advance constraint binds, the first order conditions with respect to labor, h_t, and next period wealth, b_{t+1}, are

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

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

The first condition defines the supply of labor as an increasing function of the wage rate. The second condition defines the nominal interest rate as the ratio of expected marginal utility from consumption corrected by the inflation rate.

I can now define a competitive equilibrium for a given monetary 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, $\tilde{B}$.

Definition 1 (Recursive equilibrium) *For a given monetary policy rule determining the growth rate of money g_t, 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 $l(\mathbf{s};\tilde{b})$, $d(\mathbf{s};\tilde{b})$ and $\tilde{b}(\mathbf{s};\tilde{b})$; (iii) firms' value $V(\mathbf{s};\tilde{b})$; (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 $V(\mathbf{s};\tilde{b})$ 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.*

Notice that in the definition of equilibrium I did not include any aggregate resource condition since this is implicitly satisfied once the budget constraints of firms and workers are satisfied. In fact, if we sum the two budget constraints we obtain $d_t + c_t = F(l_t)$, that is, the consumption of investors and workers must be equal to aggregate production.

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 $\bar{R} > 1$. 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 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 *If revenues are not divertible, changes in q have no effect on employment l.*

If firms cannot divert the cash revenues, that is, $\phi = 0$, the enforcement constraint becomes $\overline{V}_t(b_{t+1}) \geq 0$. In this case the demand for labor from condition (5) becomes $F_l(l) = wR$. Therefore, the labor demand depends only on the wage rate and the nominal interest rate. Because the supply of labor depends only on w (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 revenues are divertible, that is, $\phi > 0$. In this case the demand for labor depends on the tightness of the enforcement constraint. An increase in the value of a firm relaxes the enforcement constraint allowing for more borrowing. The change in the demand for credit then 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.

III. Financial globalization

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 these two implications, I extend the model to an open economy set up with two countries: 'home' and 'foreign'. Each country has the same characteristics as described in the previous section. The stochastic variable q, however, is country-specific. Thus, there are two aggregate asset price shocks, home and foreign. The two shocks follow independent Markov processes. Later I will also consider differences in the relative sizes of the two countries.

To capture different degrees of capital markets integration, I assume that the holding of foreign bonds is costly. The presence of this cost insures that the foreign asset position of a country is stationary. 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, is not essential but simplifies the analysis.

Whether international lending and/or borrowing is done by firms or workers is irrelevant. Therefore, I assume that only workers participate in international financial market.[4] 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 foreign lending (or borrowing) is denominated in the currency of the home country.

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

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 with integrated financial markets is

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

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

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

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 currency). Since 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,

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

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

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 $\Psi_t = \mathrm{Cov} \left(\frac{U_c^*(c_{t+1}, h_{t+1}^*) P_t^*}{U_c(c_t^*, h_t^*) P_{t+1}^*(1 + g_t^*)} , \frac{e_{t+1}}{e_t} \right)$.

Equation (11) is the 'uncovered interest rate parity with risk averse agents and foreign transaction costs. If we abstract from uncertainty, use the law of one price $e_t = P_t^*/P_t$ and impose the equilibrium condition $N_{t+1} = -N_{t+1}^*$, the equation can be rewritten as

$$r_t = (1 + r_t^*) \left(\frac{1 - \psi \cdot N_{t+1}}{1 + \psi \cdot N_{t+1}} \right) - 1. \tag{12}$$

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 similar to the definition provided in the previous section for 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 holdings), $\tilde{B}$ and $\tilde{B}^*$, and the foreign asset position of the home country N (or alternatively of the foreign country $N^* = -N$). The only difference 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 conditions in local financial markets, that is, the bonds issued by local firms must be purchased by local workers.

Some characterization of the equilibrium

I can now establish formally the two major implications of financial globalization: higher elasticity of a country supply of funds to the *real* interest rate and greater exposure to foreign asset price shocks. I further show that the importance of these two effects decreases with the relative size of the country in the world economy.

Proposition 3 *Suppose that the monetary authorities of both countries keep the nominal interest rate constant and there is perfect mobility of capital, $\psi = 0$. Then the impact of a one-time asset price shock in the home country on home output is smaller than in the autarky regime. However, it also affects the output of the foreign country.*

Proof 1 *See appendix C.*

This result has a simple intuition. An asset price shock to the home country changes the demand of credit and this requires a change in the interest rate to clear the financial market. In an integrated economy the supply of credit comes from both the home and foreign countries and the real interest rate is equalized across countries. This implies that, if the shock arises only in the home country, the real interest rate responds less compared to the regime without mobility of capital. We can then see from equations (5) and (6) that the macroeconomic impact of the shock is smaller in the home country. At the same time, however, the real interest rate also changes in the foreign country (because of the cross-country interest rate equalization). Thus, through equations (5) and (6), the foreign country is also affected by the home country shock.

The next proposition shows that the size of a country also matters.

Proposition 4 *Suppose that the monetary authorities of both countries keep the nominal interest rate constant and there is perfect capital mobility, $\phi = 0$. Furthermore, assume that the size of the home country is negligible (small open economy) compared to the foreign country (large economy). Then an asset price shock in the home country has no effect on home and foreign output. However, a foreign asset price shock affects the output of both countries.*

Proof 2 *See appendix D.*

Also this result has a simple intuition. A small open economy takes the real interest rate as given and home shocks cannot affect the real interest rate. If the real interest rate is constant (and the monetary authority keeps the nominal interest rate constant), equations (5) and (6) show that the demand for labor does not change. The foreign country is, effectively, the world economy. Therefore, an asset price shock in the foreign country affects the world interest rate and, therefore, through equations (5) and (6), the output of the small open economy.

In summary, as financial markets become more integrated, domestic asset prices become less important for the macroeconomic performance of one country but each country becomes more vulnerable to foreign asset price fluctuations. To the extent that the monetary authority finds feasible and desirable to pursue a stabilization policy, the focus of monetary policy would shift from domestic asset prices to foreign asset prices.

IV. The role of monetary policy

So far I have only shown the impact of asset price shocks under inactive monetary policy, that is, under the assumption that the monetary authorities keep the nominal interest rate constant. The analysis conducted so far have shown that asset price shocks destabilize the real sector of the economy. A natural question is then whether monetary policy should be used to counter balance the destabilizing effects of these shocks on production.

In general, there is no guarantee that, in terms of welfare, the objective of monetary policy is to stabilize output. This observation is especially important when fluctuations in economic activities are driven by shocks to productivity and/or preferences. However, when macroeconomic fluctuations are driven by asset price shocks, some output stabilization could be welfare improving. This is because asset price shocks generate both a change in economic activity and a redistribution of consumption between the two groups of agents, investors and workers. Assuming that the steady state equilibrium is optimal from the point of view of the policy maker, deviations from the steady state induced by asset price shocks are then necessarily sub-optimal. Therefore, provided that the policy maker has the capability to keep the allocation closer to the steady state, it should be optimal to do so.[5]

In the context of the model presented here, the above argument is valid under two important modeling assumptions. The first is that fluctuations in economic activity are only driven by asset price shocks. In response to other shocks, of course, output stabilization may not be desirable. This point is well understood in the literature and it does not require further exploration. The goal of the current paper is only to study the response to particular type of shocks, specifically, shocks that affect the availability of credit for borrowers. In reality, it is difficult to separate these shocks from more fundamental shocks. But to the extent that this is possible, the analysis of this paper provides some insights about possible monetary actions.[6]

The second important assumption is that nominal prices are perfectly flexible and there are not inefficiencies associated with nominal price movements. Of course, if changes in

[5]The steady state equilibrium is not efficient because markets are not complete. I am abstracting from the possibility that the monetary authority could eliminate the inefficiencies associated to the steady state equilibrium. I only focus on deviations from the steady state.

[6]The desirability of stabilization policies suggests that a Taylor rule that assigns high weight to output could be desirable. With multiple shocks that are not easily identifiable, however, this simple rule may not improve welfare because output stabilization is not necessarily desirable in response to other shocks (for example, in response to TFP shocks). Then, expanding the Taylor rule with a term for asset prices could bring monetary policy closer to the optimal policy.

aggregate prices are associated with micro inefficiencies as in the case of models with nominal adjustment costs, the policy maker trades off output fluctuations with price fluctuations. This, however, is unlikely to change the key results insight of the paper in the sense that some output stabilization could still be desirable although to a lesser degree.

Keeping in mind the above considerations regarding the desirability of output stabilization, I start the analysis of monetary policy by showing that monetary policy rules that keep the inflation rate or the nominal interest rate constant do not stabilize output.

Proposition 5 *If $\phi > 0$, targeting the inflation rate or the nominal interest rate does not stabilize output.*

Proof 3 *See appendix E.*

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 of labor. This will lead to changes in employment and production.

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. This result applies to both closed and (large) open economies.

If constant inflation or nominal interest rate rules do not stabilize output, what does the stabilization policy looks like? Unfortunately, an analytical characterization of the perfect stabilization policy is not available. Therefore, I characterize its properties numerically.

Numerical characterization

The goal of this section is to illustrate the qualitative properties of the model by simulation. Although the assignment of parameter values is based on specific calibration targets, we should keep in mind that the ultimate goal is not to asses the model quantitatively.

The parametrization is on a quarterly basis and the discount factors for workers and investors are set to generate average yearly real returns 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 parametrization 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.

Appendix A shows that the revenue function can be derived in an environment in which each firm produces a differentiated good and there is monopolistic competition. In particular, the revenue function takes the form $F(l) = Y^{1-\eta}(\bar{k}^\theta l^{1-\theta})^{\nu\eta}$. The concavity is obtained by setting $\nu\eta < 1$, where the parameter ν denotes the return to scale in production and η determines the elasticity of demand. The parameter θ determines the relative importance of capital and labor in production. The first two parameters are set to $\nu = 1.5$ and $\eta = 0.567$, while θ and the fixed capital $\bar{k}$ are chosen together with other residual parameters as explained below.[7] I would like to emphasize that the only purpose for having increasing returns in production is to have pro-cyclical TFP in response to asset price shocks. With a constant return to scale the shape of the impulse responses shown below will be similar but the response of TFP would be flat.

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).[8] 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

[7]With the chosen parameters the curvature of the revenue function is $\nu\eta = 0.85$. These parameters imply an average price mark-up over the average cost equal to $1/\nu\eta - 1 = 0.15$.

[8]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 could also include the sales of business activities. In the context of the model, exit can be interpreted as acquisition of business activities if the price paid to the shareholders of the acquired firm is equal to its book value of assets. Notice that there is no loss of assets when the firm is liquidated. Only the future revenues are lost. When interpreted this way, the 10 percent annual probability is not implausible.

rate of money is equal to $\bar{g} = 0.0075$, which implies an average annual inflation ratio of about 3 percent.

At this point there are four parameters left: 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 (2.86), and leverage ratio measured as debt over capital (0.4). The list of parameter values are reported in Table 1.

Table 1: Parametrization.

Description	*Parameter values*
Discount factor for investors	$\beta = 0.9825$
Discount factor for workers	$\delta = 0.9975$
Utility parameters for workers	$\alpha = 2.25,\ \ \gamma = 2,$
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	$\phi = 9.3$

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

Figure 1 plots the impulse responses of several variables in the autarky regime to a one percent positive shock to q under different monetary policy rules. Remember that q follows an autoregressive process with persistence parameter of 0.9. Therefore, after the initial increase, q slowly returns to the steady state.

[**Place Figure 1 here**]

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 determined. Thus, to eliminate the indeterminacy I assume that the price level tomorrow is equal to the price level expected today, that is, $P_{t+1} = \mathbb{E}_t P_{t+1}$. Under this assumption, the impulse responses under the inflation rule are similar to the responses under the nominal interest rate rule. In the third policy regime, the monetary authority adjusts its policy instrument—the growth rate of money—to keep output constant. Since in this economy production is fully determined by the input of labor, the output 'stabilization' rule keeps employment constant.

As we can seen from Figure 1, a positive asset price shock under the interest rate (or inflation) rule generates an increase in the (expected) real interest rate and a macroeconomic expansion. This is because the shock increases the demand of credit which must be followed by the increase in the real interest rate to clear the financial market. The increase in the real interest rate implies that the premium required by investors to self-finance hiring $(1/\beta - 1 - r)$ decreases and firms hire more labor. This is formally captured by conditions (5) and (6).

Because of the expansion of employment, measured TFP increases. Measured TFP is the Solow residual 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 look at the enforcement constraint. Since $\overline{V}_t(\tilde{b}_{t+1}) = V(\tilde{b}_t) - d_t$, the enforcement constraint (2) can be rewritten as

$$V(\tilde{b}_t) - d_t = \phi \cdot \left(\frac{F(l_t)}{R_t} \right).$$

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 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 net liabilities, $\tilde{b}_t/P_t$, increases, reducing the real value of the firm $V(\tilde{b}_t)$; (iii) by reducing the nominal interest rate R_t so that the value of defaulting increases, making the enforcement constraint tighter.

If the main adjustment takes place through an increase in d_t, which must be associated with higher borrowing, the consumption of workers must decrease (given that output does not change). But this would necessarily change the expected real interest rate $r_t = R_t \mathbb{E}_t P_t/P_{t+1}$ since this is determined by the marginal utilities of workers. By conditions (5) and (6), a change in r_t 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, an increase in the nominal price P_t and/or a reduction in the nominal interest rate R_t.

As stated above, the reduction in the current price level, P_t, increases the real value of the outstanding debt and reduces the left-hand-side of the enforcement constraint. At the same time, the reduction in future inflation rates reduces the current and future nominal interest rates. This increases the value of default, that is, the right-hand-side of the enforcement constraint, contrasting the initial increase in the availability of credit.[9] 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 higher value of firms.[10]

The fact that the stabilization policy is implemented with a reduction in the nominal price level may cast some doubts on the actual feasibility of this policy. In particular, if prices are not perfectly flexible in the short-term, a disinflation policy may be costly or even impossible to implement. However, we should also consider that in reality, a significant portion of nominal liabilities are in the form of long-term debt while in the model, for simplicity, there are only short-term liabilities. With long-term debt, a similar effect can be achieved by reducing future nominal prices. Therefore, the disinflation could be gradual.

[9] The reduction in current and future nominal interest rates also increases the value of the firm $V(\tilde{b}_t)$ on the right-hand-side of the enforcement constraint because the current value of revenues is discounted by the nominal interest rate. However, for the particular calibration used here, the impact on the right-hand-side of the enforcement constraint dominates the impact on the right-hand-side.

[10] In practice, the monetary authority may not be able to perfectly stabilize employment if this requires a negative nominal interest rate (interest lower bound). This is the case, for instance, in the simulation reported in Figure 1. In this case the monetary authority will only be able to make the drop in employment smaller.

Another criticism is that, when the monetary authority uses inflation policies more proactively, making inflation more volatile, the use of short-term debt becomes more common. Although this is possible, it is also likely that prices are adjusted more frequently when inflation is more volatile. Therefore, if on the one hand it is more difficult to affect the real value of labilities with inflation because there is more short-term debt, on the other it becomes easier and less inefficient to use inflation because of the higher flexibility of prices.

Figure 2 plots the impulse responses under a constant interest rule for different values of some parameters. In particular, the figure plots the impulse responses when there are not increasing returns to scale ($\nu = 1$), when the average exit rate is only 5% ($\bar{q} = 0.9875$), and when the enforcement parameter allows for an average leverage of 60% ($\phi = 5.5$). As can be seen, the impulse responses change quantitatively but not qualitatively. The only significant exception is the response of measured TFP which remains flat when there are constant returns to scale.

[**Place Figure 2 here**]

Simulation results with globalization: I now consider the open economy version of the model with two symmetric countries. The only additional parameter is ψ, that is, the cost of holding foreign assets. This parameter is set to 0.001 which is a very small number. As a result, the impulse responses are only marginally affected by this cost. Still, from a computational stand point, the small cost is necessary so that all the roots of the linearized system are inside the unit circle. The stochastic variables q and q^* are assumed to follow independent Markov processes. Therefore, when I compute the impulse response to a change in q only, q^* stays constant.

Figure 3 plots three impulse responses in the home country to a positive asset price shock when the monetary authorities of both countries follow a constant 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. The third case is equivalent to the response to a domestic shock in the autarky regime as shown in the previous Figure

1.

[Place Figure 3 here]

The responses of employment and output to a domestic asset price shock are 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 is consistent with Proposition 3.

This result has important implications for stabilization policies in general and monetary policy in particular: As financial markets become more globalized, the focus of monetary policy shifts from domestic asset prices to foreign asset prices. For small open economies, the focus will be entirely on foreign asset prices.

V. Conclusion

In this paper I have studied an economy where the driving forces of 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 a negative asset price shock.

The primary goal of the paper is to investigate how the globalization of financial markets affects the propagation of asset price shocks to the real sector of the economy. It is shown that, as financial markets become internationally integrated, countries become less vulnerable to their own (domestic) asset price shocks but more vulnerable to foreign asset price shocks.

The last section of the paper studies the potential role of monetary policy. Monetary policy can be used to smooth out the macroeconomic impact of asset prices shocks. Although the paper does not characterize the full optimal monetary policy, the structure of the model suggests that it is desirable to use the monetary tools to counteract the macroeconomic changes induced by asset price shocks. As the economy becomes more globalized, however, the fucus of monetary policy shifts from domestic asset prices to foreign asset prices. Another implication of globalization is the possibility that monetary policy could be used strategically by individual countries to gain at the expenses of other countries. The study of international monetary policy competition in the presence of asset price shocks could be an interesting line of research that could contribute to the existing literature on the international coordination of monetary policies.[11]

[11]Some of the contributions to this literature include Rogoff (1985), Corsetti and Pesenti (2001), Cooley and Quadrini (2003), Dedola, Karadi, and Lombardo (2013).

Appendix

A 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.

B 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:

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

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

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

The envelope condition is:

$$
V_{\tilde{b}}(\mathbf{s};\tilde{b}) \;=\; -\frac{\lambda}{P}
$$

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

C Proof of proposition 3

Since the real interest rate is equalized across countries (see condition (12)), equation (6) implies that the multipliers μ and μ^* will also be equalized across countries. Because the monetary authorities keep the nominal interest rate constant, equation (6) implies that the change in the demand of labor will also be equalized in the two countries. Remembering that the supply of labor depends only on the wage rate (see equation (7)) employment will be equal across countries.

Aggregating the enforcement constraints of domestic and foreign firms taking into account that $l^*=l$ and $R^*=R$ we obtain

$$
\frac{\overline{V}(\mathbf{s};\tilde{b}')+\overline{V}^*(\mathbf{s};\tilde{b}')}{2}\geq\phi\frac{F(l)}{R} \tag{13}
$$

Abstracting from general equilibrium effects, the shock in the home country affects $\overline{V}(\mathbf{s};\tilde{b}')$ but not $\overline{V}^*(\mathbf{s};\tilde{b}')$. Therefore, the impact on the worldwide enforcement constraint, which affects the worldwide demand of credit, is smaller. In autarky, instead, we have

$$eq: EC - Closed\overline{V}(\mathbf{s};\tilde{b}') \geq \phi \frac{F(l)}{R} \tag{14}$$

Therefore, the change in q (keeping q^* constant) will have a stronger affect when the economy is closed. Effectively, the shock affects only the demand of credit of domestic firms but not of foreign firms. Since in an open economy the supply of credit comes from both domestic and foreign workers, the impact on the real interest rate will be smaller. We then see from equations (5) and (6) that the change in labor l will be smaller.

D Proof of proposition 4

The real interest rate is fixed in a small open economy. Since the monetary authority keeps the nominal interest rate constant, equations (5) and (5) show that the demand of labor cannot change in response to a shock in the home country (since this is a small open economy). A shock to the foreign country, instead, acts as a global shock since the foreign country is, in terms of size, the world economy. The shock will induce a worldwide change in the real interest rate and, therefore, in employment as shown in equations (5) and (5).

E Proof of proposition 5

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 a shock (change in q). 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:

$$V(\tilde{b}_t) \geq d_t + \phi\left(\frac{F(l_t)}{R_t}\right)$$

Before the shock, the enforcement constraint is satisfied with the equality sign given the assumption $\delta > \beta$, and therefore, $\mu_t > 0$. Because $V(\tilde{b}_t)$ changes in response to q_t while all terms on the right-hand-side do not change, the enforcement constraint is either violated (if $V(\tilde{b}_t)$ falls) or becomes not binding (if $V(\tilde{b}_t)$ 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 $F_l(l_t) = \alpha l_t^{\gamma-1} R_t/(1-\phi\mu_t)$. Using equation (6) to eliminate R_t we get:

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

Because the inflation rate is kept constant under the particular monetary policy rule, the only way for employment l_t 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. *Q.E.D.*

F Dynamic system

The autarky equilibrium is characterized by the system of equations:

$$\alpha h_t^{\gamma-1} = w_t \tag{15}$$

$$\delta R_t \mathbb{E}_t \left\{ \frac{U_t' P_t (1+g_t)}{U_{t+1}' P_{t+1}} \right\} = 1 \tag{16}$$

$$1 + g_t + \tilde{b}_t + P_t w_t h_t = P_t c_t + \frac{\tilde{b}_{t+1}(1+g_t)}{R_t} + \frac{P_t F(h_t)}{R_t} \tag{17}$$

$$\tilde{b}_t + P_t w_t h_t + P_t d_t = \frac{\tilde{b}_{t+1}(1+g_t)}{R_t} + \frac{P_t F(h_t)}{R_t} \tag{18}$$

$$P_t F(h_t) = 1 + g_t \tag{19}$$

$$F'(h_t) = w_t \left(\frac{R_t}{1-\phi\mu_t} \right) \tag{20}$$

$$(1+\mu_t) R_t \mathbb{E}_t \left\{ \frac{\beta P_t}{P_{t+1}(1+g_t)} \right\} = 1 \tag{21}$$

$$V_t = d_t + \phi \left(\frac{F(h_t)}{R_t} \right) \tag{22}$$

$$V_t = d_t + \mathbb{E}_t \left\{ q_{t+1} V_{t+1} + (1 - q_{t+1}) \left(\bar{k} - \frac{\tilde{b}_{t+1}}{P_{t+1}} \right) \right\} \tag{23}$$

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 $\tilde{b}_{t+1}$, 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 $\tilde{b}_t$.

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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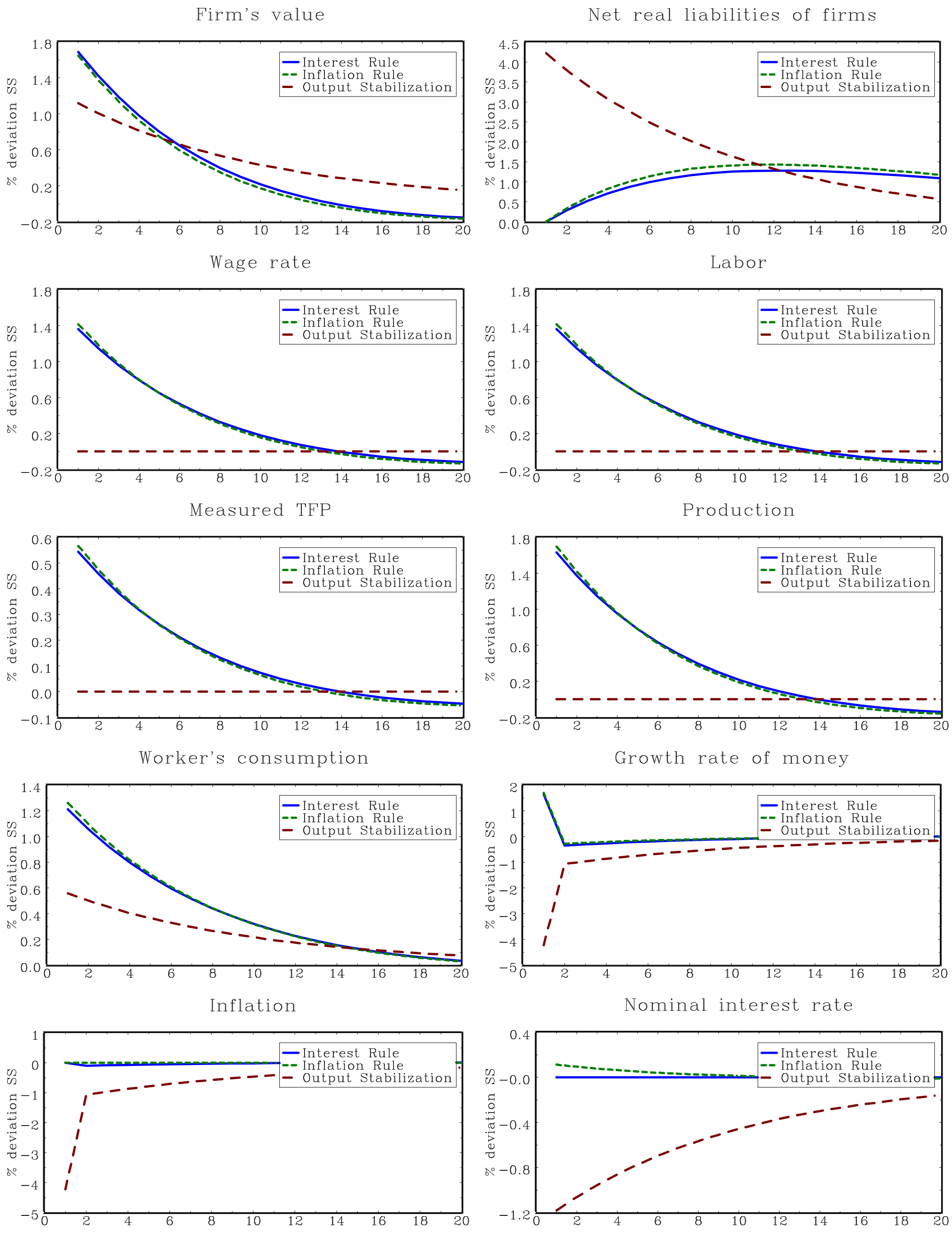

Figure 1: Impulse response to an asset price boom (1% increase in q) in the autarky regime.

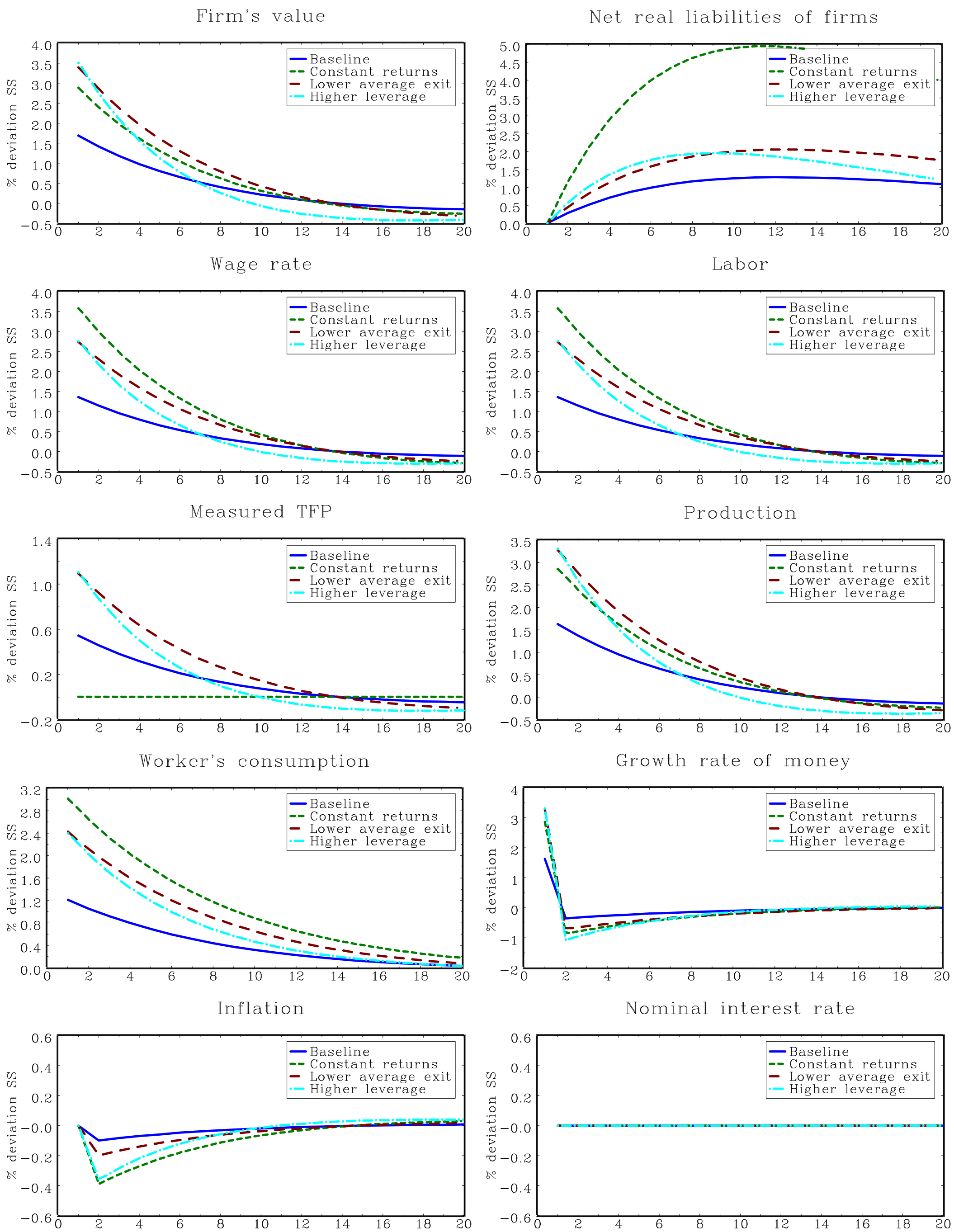

Figure 2: Impulse response to an asset price boom (1% increase in q) in the autarky regime under a constant interest rate rule for alternative values of ν, $\bar{q}$ and ϕ.

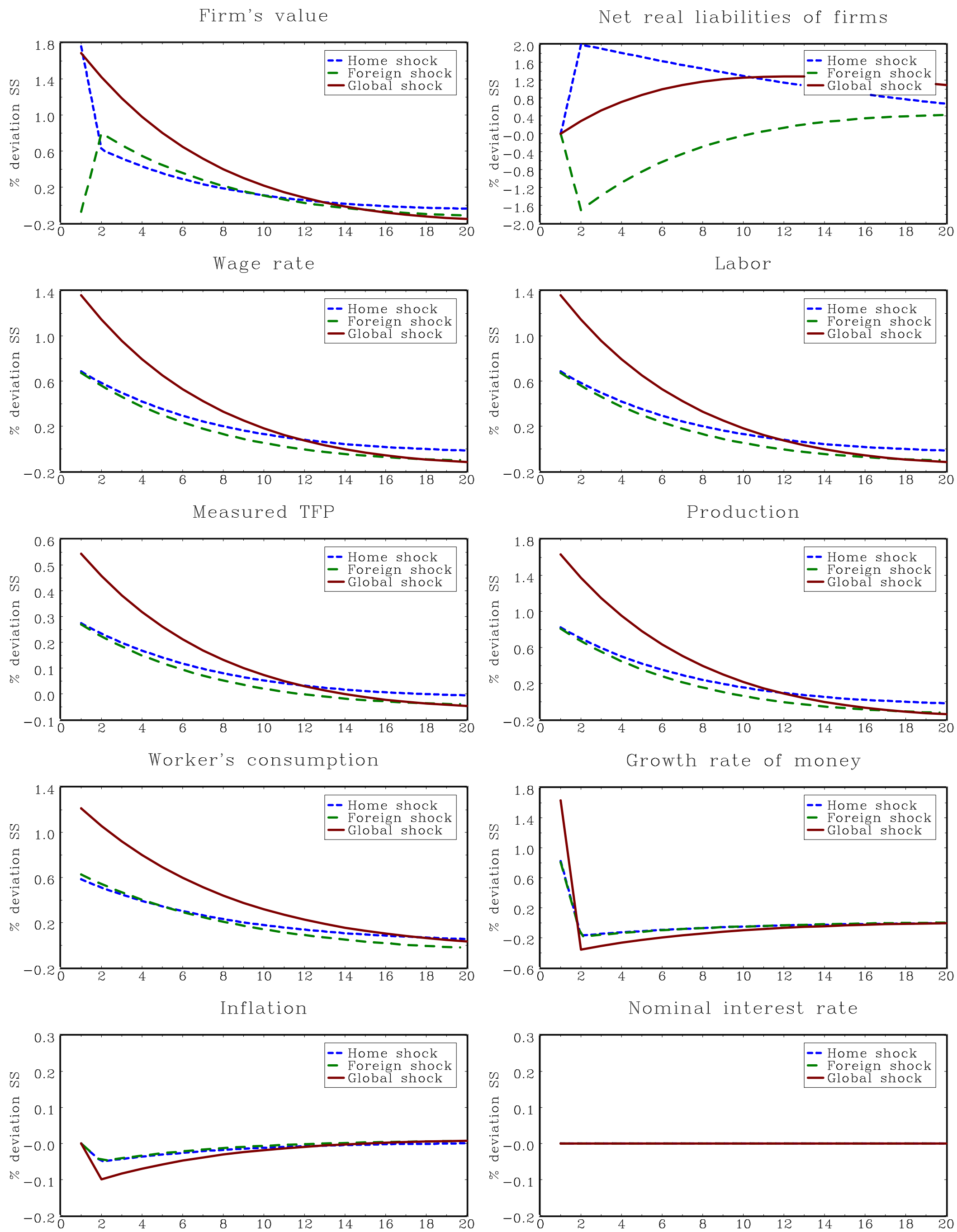

Figure 3: Impulse response to an asset price boom (1% increase in q) under a constant interest rate rule in the regime with financial integration.