2 Empirical motivation

The main motivation of the paper starts from the observation that, during the last two decades, industrialized countries have gradually liberalized their capital account. During the same period, these countries have also experienced a decline in the volatility of the business cycle. Although the decline started at different times, it is observed for the majority of these countries. The goal of this section is to document these two patterns.

The analysis is conducted using the sample of OECD countries during the period 1970-2004. The main variables of interest are an index of macroeconomic volatility and an index of capital account openness. For the first we use the standard deviation of quarterly GDP growth computed over a particular time window. For example, if we use a four-year window, the volatility of GDP in the first quarter of 1980 is calculated using data from 1978.1 to 1982.1, for a total of 17 quarters.

For the capital account openness we use the index compiled by Chinn & Ito (2005). The index is based on binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions* (AREAER). The dummy variables reflect the four major categories of restrictions: multiple exchange rates, restrictions on current account transactions, restrictions on capital account transactions, and requirements for the surrender of export proceeds. The index is the first standardized principal component of these four variables and it takes higher values for countries that are more open to cross-border capital transactions.

The Chinn and Ito index is available for the period 1970-2005 at the annual frequency. Because GDP data is available at the quarterly frequency, we transform the annual series of capital account openness to a quarterly frequency by assuming that the annual value is also the value for each of the four quarters.

Figure 1 plots the index of volatility and openness averaged across the OECD countries. The volatility index is constructed using a four-year window. The openness index is lagged by 9 quarters. In this way the variable precedes the first observation used to compute the volatility index. The figure clearly shows that the two series move in the opposite directions. The next step is to conduct a more systematic analysis taking advantage of the longitudinal (cross-sectional and time-series) structure of the data.

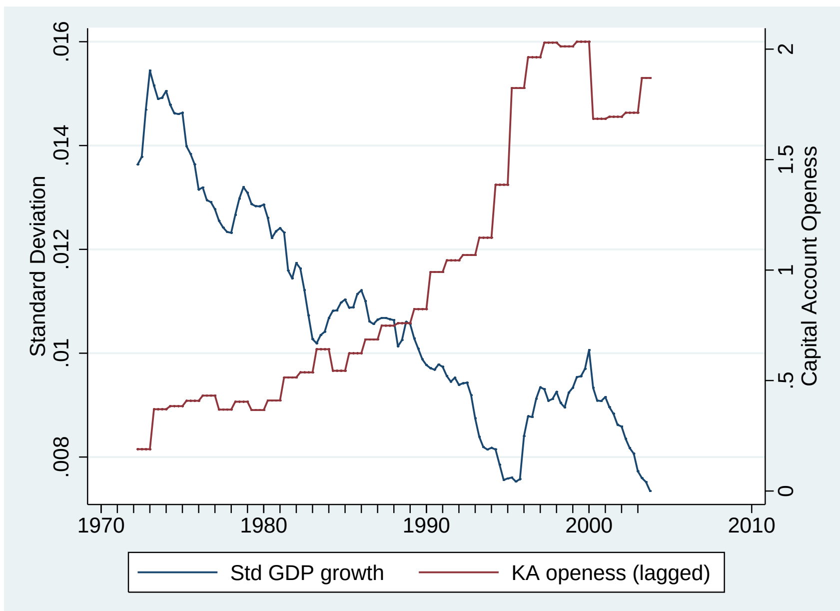

Figure 1: Financial liberalization and macroeconomic volatility. Average of OECD countries.

We estimate a regression equation where the index of volatility of each country is linearly dependent on the capital account openness. To take into account country specific characteristics, we include a country fixed effect. We also include a dummy for each quarterly date to account for possible common trends. The value of the openness index is for the first quarter before the time window used to calculate the volatility index. For example, if we use a four-year window, then the volatility in 1980.1 is calculated using growth rates for the period 1978.1-1982.1. The openness index is for 1977.4.

The estimation results for several time windows are reported in Table 1.

Independently of the time window we use to compute the volatility in GDP growth, the estimated coefficient of capital account openness is negative and statistically significant.

Table 1: Financial liberalization and macroeconomic volatility in the OECD countries. Fixed effect regression of GDP Volatility on Capital Account Openness.

	Time window		
	Two years	*Three years*	*Four years*
Capital account openness	-0.977	-0.959	-1.027
	*(0.142)**	*(0.132)**	*(0.125)**
R^2 (within)	0.122	0.128	0.144
R^2 (between)	0.145	0.143	0.161
R^2 (overall)	0.117	0.118	0.122
Observations	2,671	2,471	2,273

Notes: GDP volatility is the standard deviation of quarterly GDP growth for OECD countries over the particular time window. Capital account openness is the index compiled by Chinn & Ito (2005) from the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions* (AREAER). The value of the index is for the first quarter before the time window used to compute the GDP volatility. The regression also includes a dummy for each quarterly date.

* Significant at 1 percent level.

3 Model

We first describe the closed-economy version of the model which we then extended to a multi-country setup. There are two sectors. The 'business' sector populated by a continuum of risk neutral entrepreneurs and the 'workers' sector populated by a continuum of risk-averse workers. We first describe the business sector.

3.1 Financial and production decisions of firms

In the business sector there is a mass $m > 1$ of entrepreneurs with utility $E_0 \sum_{t=0}^{\infty} \beta^t c_t$. At each point in time a mass 1 of entrepreneurs are active while the remaining mass $1 - m$ is (temporarily) inactive. Active entrepreneurs run a firm with revenue function $F(z_t, l_t)$, where l_t is the input of labor and z_t is a stochastic variable affecting the productivity of all firm (aggregate productivity). For the moment we assume that labor is the only input of production. Later we will extend the model to allow for capital accumulation. The production function is concave and displays decreasing returns to scale.

Over time there is turnover of entrepreneurs (firms). With probability $1 - q$ active entrepreneurs lose the ability to generate profits and are replaced by inactive entrepreneurs (who become active). One way to interpret this environment is to assume that there is a fixed number of locations or markets. An active entrepreneur has the monopoly of one of these locations. With some probability $1-q$ the monopoly is gained by another entrepreneur. For example because one of the inactive entrepreneurs finds a competitive product that pushes out of the market an existing business. The probability q is stochastic and follows a first order Markov process with transition probability $\Gamma(q, q')$. As we will see shortly, fluctuations in q affect the value of active firms, and therefore, they act as aggregate asset price shocks.

Firms can borrow at the market interest rate. The repayment of the debt is conditional on survival. If the firm survives it repays b_{t+1} otherwise it pays zero.[2] Therefore, given r_t the market interest rate, the gross interest rate charged to the firm is $R_t = (1 + r_t)/Eq_{t+1}$.

Firms start the period with debt b_t and, given the individual and aggregate states, they choose the labor input, l_t, the new debt, b_{t+1}, and make payments to shareholders and workers, d_t and $w_t l_t$ respectively. The budget constraint is:

$$b_t + d_t = F(z_t, l_t) - w_t l_t + \frac{b_{t+1}}{R_t}.$$

Liabilities are constrained by limited enforcement as the firm can divert the revenue $F(z_t, l_t)$ and default. At the beginning of the period the firm hires labor and pays wages and dividends. Therefore, at this stage, the net liabilities are $b_t + d_t + w_t l_t$. After the realization of the revenue at the end of

[2] This can be justified by an enforceability condition. If the firm becomes unproductive, there is nothing that the lender can take from the firm.

the period, the net liabilities are $b_t + d_t + w_t l_t - F(z_t, l_t) = b_{t+1}/R_t$.[3]

Let $V_t(b_{t+1})$ be the real value of the firm for the entrepreneur at the end of the period. This is defined as:

$$V_t(b_t) \equiv E_t \sum_{j=0}^{\infty} \beta^j \left(\Pi_{\ell=1}^{j} q_{t+\ell} \right) d_{t+j}$$

where the term in parenthesis accounts for the fact that the entrepreneur retains the ability to generate dividends only with some probability.

Because the firm can renegotiate the debt after diverting the revenue, the value of defaulting is $F(z_t, l_t) + \kappa$, where κ is the value retained by the firm in the renegotiation stage. This value depends on the bargaining power of the firm and on the cost faced by the lender in liquidating the firm. It captures the degree of enforceability of debt contracts. This expression derives from the solution of the renegotiation game played by the firm and the lender. Its detailed description is provided in the appendix.

Enforcement requires that the value of not defaulting is at least as big as the value of defaulting, that is,

$$\beta E q_{t+1} V_{t+1}(b_{t+1}) \geq F(z_t, l_t) + \kappa.$$

The retention probability q plays a crucial role in the enforcement constraint. In particular, with a persistent fall in q, the market survival is also expected to be smaller in the future. This reduces the hazard rate $\Pi_{\ell=1}^{j-1} q_{t+\ell}$, which in turn reduces the firm's value $\overline{V}_t(b_{t+1})$ and leads to a tighter constraint. In order to satisfy the enforcement constraint the firm has to reduce the debt b_{t+1}. This, in turn, requires a reduction in the current payout d_t, that is, greater entrepreneurial savings. The appendix shows that the debt contract described here implements the optimal long-term contract between the entrepreneur and a financial intermediary.

Firm's problem: The optimization problem of a surviving firm can be written recursively as follows:

$$V(\mathbf{s}; b) = \max_{d,l,b'} \left\{ d + \beta E q' V(\mathbf{s}'; b') \right\} \tag{1}$$

[3] Alternatively we could assume that the dividends are paid at the end of the period. This would not change the key properties of the model but the analytical expressions would be more complex.

subject to:

$$b + d = F(z, l) - wl + \frac{b'}{R}$$

$$\beta E q' V(\mathbf{s}'; b') \geq F(z, l) + \kappa$$

where $\mathbf{s}$ are the aggregate states and prime denotes the next period variable.

In solving this problem, the firm takes as given all prices. Remembering that $R = (1 + r)/Eq'$, the first order conditions are:

$$F_l(z, l) = \frac{w}{1 - \mu} \tag{2}$$

$$(1 + \mu)\beta(1 + r) = 1, \tag{3}$$

where μ is the lagrange multiplier for the enforcement constraint. These conditions are derived under the assumption that the solution for the dividend is always positive, that is, $d > 0$. This condition holds in the neighborhood of the steady state. The detailed derivation is in Appendix B. The appendix also shows that the same optimality conditions are derived if entrepreneurs sign optimal long-term contracts with a financial intermediary. This confirms that the financial contract considered here is actually the optimal contract.

We can see from condition (2) 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.

The second condition shows that μ, and therefore, the wedge, are decreasing in the real interest rate. This dependence will be key for understanding the properties of the model. As we will see, a negative shock to q, that is, a negative asset price shock makes the enforcement constraint tighter and this reduces the demand for debt. The reduction in the demand for debt, in turn, reduces the interest rate. Condition (3) then implies that the reduction in the real interest rate is associated with an increase in μ and, from condition (2), a reduction in the demand for labor.

The intuition underlaying the channel through which the interest rate affects employment can be explained as follows. In the margin, the cost of hiring labor has two components. The first is the wage w. The second, captured by μ, derives from the fact that more labor makes the enforcement constraint tighter. Consequently, if the firm wants to hire more labor, it has to pay less dividends to the entrepreneur (lower consumption). But, as long as the entrepreneur discounts the future at a higher rate than the interest rate, retaining funds in the firm is costly. The cost of retaining funds is equal to $1-\beta(1+r)$, that is, the difference between the value of consuming the extra unit today and the discounted value of consuming it tomorrow. More specifically, by retaining an extra unit today, the entrepreneur will consume $1+r$ in the next period which has a current expected value of $\beta(1+r)$. Therefore, when the interest rate increases, the cost of retaining funds in the firm becomes smaller and this reduces the indirect cost of hiring more labor. Fundamentally, a higher interest rate increases the incentive of the entrepreneur to save and this relaxes the enforcement constraint.

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

3.2 Closing the model and general equilibrium

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

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

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

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:

$$x_i = z l_i^\nu$$

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

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

$$F(z, l_i) = Y^{1-\eta} \left(z l_i^{\nu} \right)^{\eta}$$

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

Workers: There is a continuum of homogeneous workers with lifetime utility $E_0 \sum_{t=0}^{\infty} \delta^t U(c_t, h_t)$, where c_t is consumption, h_t is labor and δ is the intertemporal discount factor. I assume $\delta > \beta$, that is, workers have a lower discount rate than entrepreneurs. This is the key condition for the enforcement constraint to bind most of the time. Workers hold a diversified portfolio of bonds issued by firms.[5] This is the only form of savings for workers.

The utility function is specified as $U(c_t, h_t) = (c_t - \alpha h_t^{\gamma}/\gamma)^{1-\sigma}/(1-\sigma)$ where $1/(\gamma - 1)$ is the elasticity of labor supply. This specification allows for the derivation of some results analytically but it is not essential for the main properties of the model.

The budget constraint is:

$$w_t h_t + b_t = c_t + \frac{b_{t+1}}{1 + r_t}$$

and the first order conditions with respect to labor, h_t, and next period bonds, b_{t+1}, are:

$$h_t = \left(\frac{w_t}{\alpha} \right)^{\frac{1}{\gamma - 1}} \tag{4}$$

[4]The paper focuses on the case of monopolistic competition ($\eta < 1$) because this allows us to specify a production function with constant or even increase returns. With perfect competition ($\eta = 1$) the production function must have decreasing returns to scale, implying that productivity decreases when firms employ more labor.

[5]Diversification is important because the repayment of the bonds from each individual firm is conditional on their survival.

$$1 = \delta(1+r_t)E_t\left(\frac{U_c(c_{t+1},h_{t+1})}{U_c(c_t,h_t)}\right) \tag{5}$$

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. The second condition defines the interest rate.

General equilibrium: We can now define a competitive equilibrium. The sufficient set of aggregate states, $\mathbf{s}$, are given by the productivity, z, the survival probability, q, and the aggregate stock of bonds.

Definition 3.1 (Recursive equilibrium) *A recursive competitive equilibrium is defined by 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 (4)-(5); (ii) firms' policies are optimal and $V(\mathbf{s};b)$ satisfies the Bellman's equation (1); (iii) the wage and interest rates are the equilibrium clearing prices in the labor and bond markets; (iv) the law of motion $H(\mathbf{s})$ is consistent with individual decisions, the stochastic process for q and the monetary policy rule.*

3.3 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. Consider first the version of the economy without shocks. In this deterministic economy the default constraint is always binding in the steady state. Next, if the cash revenue cannot be diverted, changes in the survival probability q have no effect on employment.

Proposition 3.1 *The no-default constraint binds in a deterministic steady state.*

In a deterministic steady state, the first order condition for the bond, equation (5), becomes $\delta(1+r) = 1$. Using this condition to eliminate $1+r$ in (3), 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. For the enforcement constraint to be always binding we further need to impose that β is sufficiently smaller than δ.

Proposition 3.2 *If the firm revenue cannot be diverted, changes in q have no effect on employment l.*

If firms cannot divert the cash revenues, the enforcement constraint becomes $\beta E q' V(\mathbf{s}_{t+1}, b_{t+1}) \geq \kappa$. In this case the demand for labor from condition (2) becomes $F_l(z, l) = w$, and therefore, it depends only on the wage rate. Because the supply of labor depends on w (see condition (4)), employment and production will not be affected by fluctuations in q, as long as the interest rate does not change. 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 the revenue is 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. Then using conditions (2) and (3) we can see that the demand for labor changes. Given the supply (equation (4)), this leads to a change in employment and output.

4 Open economy

We now consider a symmetric, two-country economy where each country has the same characteristics as those described in the previous section. The shocks z and q are country specific and they follow a joint first order autoregressive process. Let $A_t \equiv \{z_t, q_t, \tilde{z}_t, \tilde{q}_t\}$ be the vector of shocks in both countries. The tilde denotes the foreign country. The transition density function is denoted by $\Gamma(A_t, A_{t+1})$.

To capture differences in the degree of capital markets integration, we assume that positive holdings of foreign assets is costly. Denote by N_t the aggregate foreign position of the domestic country. The cost per unit of foreign holdings is $\varphi(N_t) = \phi N_t$. The assumption that the cost depends on the aggregate position of a country instead of the position of each individual worker makes the problem easier but it is not essential. The parameter ϕ captures the degree of international capital market integration. When $\phi = 0$ we have perfect integration. Because in equilibrium it is irrelevant whether the cost is incurred by the domestic and/or foreign country, to simplify the analysis we assume that the cost is incurred only by the domestic country.

Denote by n_t the foreign position of an individual worker and b_t the domestic holding. The worker's budget constraint can be written as:

$$w_t h_t + b_t + n_t \left(1 - \varphi(N_t)\right) = c_t + \frac{b_{t+1}}{1 + r_t} + \frac{n_{t+1}}{1 + \tilde{r}_t}$$

Compared to the closed economy, workers have an additional choice variable, that is, the foreign lending n_t (or borrowing if negative). The first order conditions are:

$$h_t = \left(\frac{w_t}{\alpha}\right)^{\frac{1}{\gamma - 1}} \tag{6}$$

$$1 = \delta(1 + r_t) E_t \left(\frac{U_c(c_{t+1}, h_{t+1})}{U_c(c_t, h_t)}\right) \tag{7}$$

$$1 = \delta(1 + \tilde{r}_t)\Big(1 - \varphi(N_{t+1})\Big) E_t \left(\frac{U_c(c_{t+1}, h_{t+1})}{U_c(c_t, h_t)}\right) \tag{8}$$

Combining the last two conditions we get:

$$1 + r_t = (1 + \tilde{r}_t)(1 - \varphi(N_t)).$$

Therefore, the interest rate is always lower in the country with a positive foreign asset position.

We can now define the equilibrium for this two-country economy. The aggregate states, denoted by $\mathbf{s}$, are given by the vector of shocks A, the bond issued by firms in both countries, B and $\widetilde{B}$, and the foreign position of the domestic country N (or alternatively of the foreign country $\widetilde{N}$).

Definition 4.1 (Recursive equilibrium) *A recursive competitive equilibrium is defined by the following set of functions for the domestic and foreign countries: (i) households' policies $h(\mathbf{s})$, $c(\mathbf{s})$, $b(\mathbf{s})$, $n(\mathbf{s})$, $\tilde{h}(\mathbf{s})$, $\tilde{c}(\mathbf{s})$, $\tilde{b}(\mathbf{s})$, $\tilde{n}(\mathbf{s})$; (ii) firms' policies $l(\mathbf{s}; b)$, $d(\mathbf{s}; b)$, $b(\mathbf{s}; b)$, $\tilde{l}(\mathbf{s}; b)$, $\tilde{d}(\mathbf{s}; b)$, $\tilde{b}(\mathbf{s}; b)$; (iii) firms' value $V(\mathbf{s}; b)$, $\widetilde{V}(\mathbf{s}; b)$; (iv) aggregate prices $w(\mathbf{s})$, $r(\mathbf{s})$, $\tilde{w}(\mathbf{s})$, $\tilde{r}(\mathbf{s})$; (v) aggregates of domestic and foreign holdings of workers, N, B^w, $\widetilde{N}$, $\widetilde{B}^w$, and firms,*

B^f, $\widetilde{B}^f$; (vi) law of motion for the aggregate states $\mathbf{s}' = H(\mathbf{s})$. Such that: (i) household's policies satisfy the optimality conditions (6)-(8); (ii) firms' policies are optimal and satisfy the Bellman's equation (1); (iii) the wages clear the labor market of each country and the interest rates clear the bond markets; (iv) the law of motion $H(\mathbf{s})$ is consistent with individual decisions and the stochastic process for A.

The only difference with respect to the equilibrium in the closed economy is that now there is a market for foreign bonds. The clearing condition is $N + \widetilde{N} = 0$. This is in addition to the clearing conditions for the domestic markets, that is, $B^h = B^f$ and $\widetilde{B}^h = \widetilde{B}^f$.

4.1 Quantitative analysis

In this section we show the properties of the model numerically. The model is parameterized on a quarterly basis and the discount factors are set to generate an average real yearly return on bonds of 3% and on stocks of 7%. In the model the discount factor of workers determines the average return on bonds. Therefore, we set it to the quarterly value of $\delta = 0.9925$. The real return for stocks is determined by the discount factor of entrepreneurs, which we set to the quarterly value of $\beta = 0.9825$.

The utility function is specified as $U(c,h) = \ln(c - \alpha h^\gamma/\gamma)$. The parameter γ is set to 2, implying an elasticity of labor of 1. This is customary in business cycle studies. The parameter α is chosen so that in the steady state working hours are 1/3.

For the parametrization of the revenue function we start with a return to scale parameter in the production technology of $\nu = 1.5$. Next we choose the demand elasticity parameter η which affects the price markup. In the model, the markup over the average cost is equal to $1/\nu\eta - 1$. The values commonly used in macro studies range between 10 to 20 percent. We use the intermediate value of 15 percent, that is, $\nu\eta = 0.85$. Given $\nu = 1.5$, this requires $\eta = 0.567$.

The technology shock is assumed to be independent of the probability of survival. They follow the first order Markov processes:

$$
\begin{aligned}
z_{t+1} &= (1-\rho_z)\bar{z} + \rho_z z_t + \chi_z \upsilon_{t+1} + (1-\chi_z)\tilde{\upsilon}_{t+1} \\
\tilde{z}_{t+1} &= (1-\rho_z)\bar{z} + \rho_z \tilde{z}_t + \chi_z \tilde{\upsilon}_{t+1} + (1-\chi_z)\upsilon_{t+1}
\end{aligned}
$$

$$
\begin{aligned}
q_{t+1} &= (1-\rho_q)\bar{q} + \rho_q q_t + \chi_q \epsilon_{t+1} + (1-\chi_q)\tilde{\epsilon}_{t+1} \\
\tilde{q}_{t+1} &= (1-\rho_q)\bar{q} + \rho_q \tilde{q}_t + \chi_q \tilde{\epsilon}_{t+1} + (1-\chi_q)\epsilon_{t+1}
\end{aligned}
$$

where υ, ϵ, $\tilde{\upsilon}$, $\tilde{\epsilon}$ are white noise disturbances and the parameters ρ_z, ρ_q, χ_z, χ_q determine the serial and cross-country correlations.

We begin by assigning $\rho_z = \rho_q = 0.9$ and $\chi_z = \chi_q = 1$. Therefore, shocks are highly correlated across time but they are independent across countries. The average productivity $\bar{z}$ is set to 1 and the average retention 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). The standard deviation of the white noise components are set to $\sigma_z = \sigma_q = 0.00655$.

The last parameter to be pinned down is the enforcement parameter κ. This is chosen to have an annual debt-to-output ratio of 0.8. The whole set of parameter values are reported in Table 2.

Table 2: Calibration.

Description	*Parameter values*
Discount factor for workers	$\delta = 0.9925$
Discount factor for investors	$\beta = 0.9825$
Utility parameter	$\alpha = 2.25$, $\gamma = 2$
Production technology	$\nu = 1.5$,
Elasticity parameter	$\eta = 0.567$
Enforcement parameter	$\kappa = 1.5$
Productivity	$\bar{z} = 1$, $\rho_z = 0.9$, $\sigma_z = 0.0065$, $\chi_z = 1$
Market survival	$\bar{q} = 0.975$, $\rho_q = 0.9$, $\sigma_q = 0.065$, $\chi_q = 1$

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 D.

Figure 2 plots the impulse responses of credit, measured TFP and output to a one percent positive shock to z (left panel) and to q (right panel) when

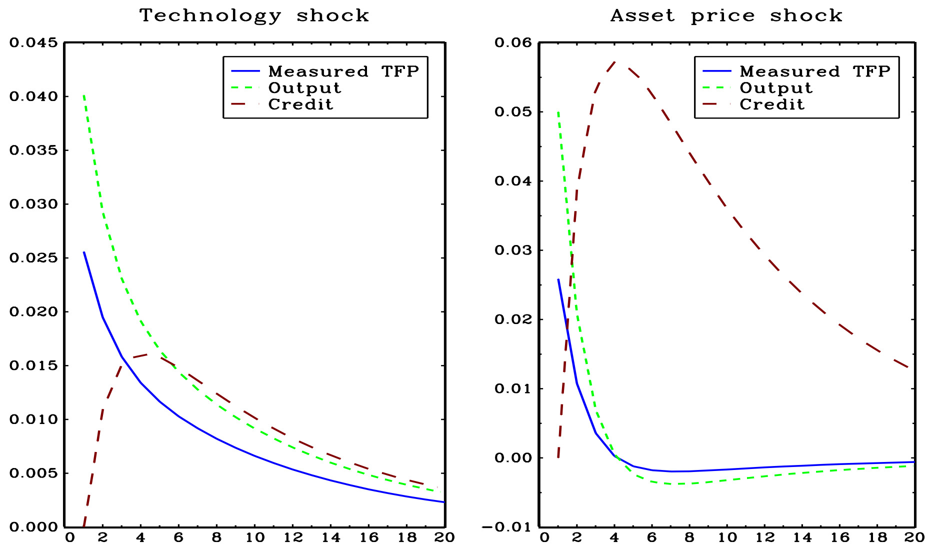

Figure 2: Impulse responses to a 1% productivity increase (left panel) and to a 1% asset price boom (right panel).

the economies are closed. The responses to negative shocks are not reported because they are symmetric to the responses following a positive shock. Both shocks generate a credit and macroeconomic expansion. Measured TFP also increases because, with increasing returns to scale, productivity increases with employment.

We now compare how the economies respond to shocks when they are fully integrated. Figure 3 plots the responses of output to a technology shock in country 1. The graphs reports the responses of output in both countries even if the shock affects only the technology of country 1. When the economies are closed, only the output of country 1 is affected (see left panel). With mobility of capital the output of both countries react to the technology shock in country 1 (see right panel). The response in country 2 derives from the increase in the interest rate induced by the technology shock in country 1. This follows from the increase in the demand of credit in country 1. However, the response of output in country 2 is relatively small.

Figure 4 plots the impulse responses to an asset price boom (higher q). Under the autarky regime, only the output of country 1 is affected by the shock. With mobility, instead, the outputs of both countries react to the asset

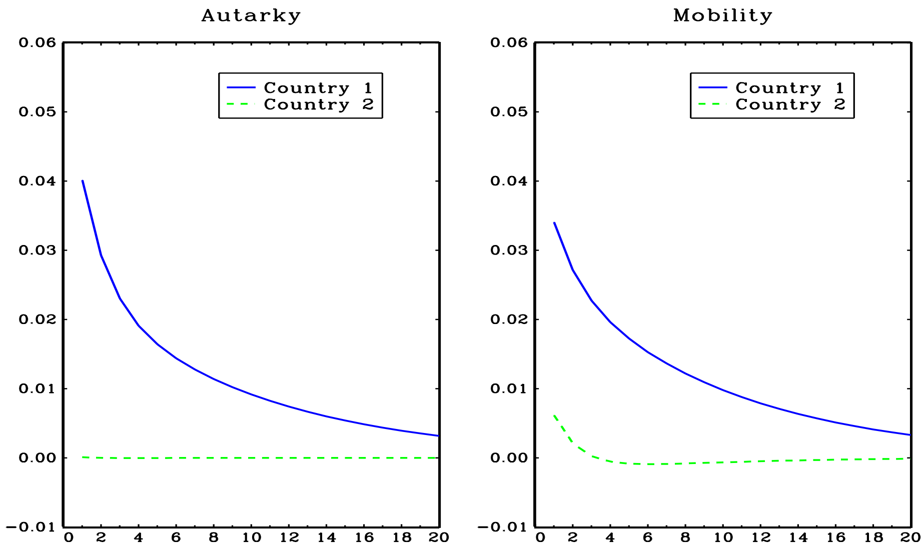

Figure 3: Impulse responses of output to a 1% technology shock in country 1 under the autarky regime (left panel) and under the regime with capital mobility (right panel).

price boom of country 1. It is interesting to observe that, even if the shock is in country 1, the output of country 2 increases by the same magnitude as the output of country 1. Also notice that the output of country 1 increases much less than in the case of autarky. Therefore, mobility has two effects. On the one hand, it mitigates the transmission of a domestic shock. On the other, the country becomes more vulnerable to external shocks. However, as long as shocks are not perfectly correlated across countries, the impact of liberalization is to reduce the macroeconomic volatility of each country.

To further illustrate this point, Table 3 reports typical business cycle statistics when the main driving force of the business cycle are either asset price shocks or technology shocks. Consistent with the impulse responses, liberalization reduces macroeconomic volatility with both, asset price and technology shocks. However, while with productivity shocks the stabilization is very small, with asset price shocks the aggregate volatility falls by a large factor.

To show the importance of the assumption that shocks are independent across countries, the bottom panel of Table **??** reports the same statistics

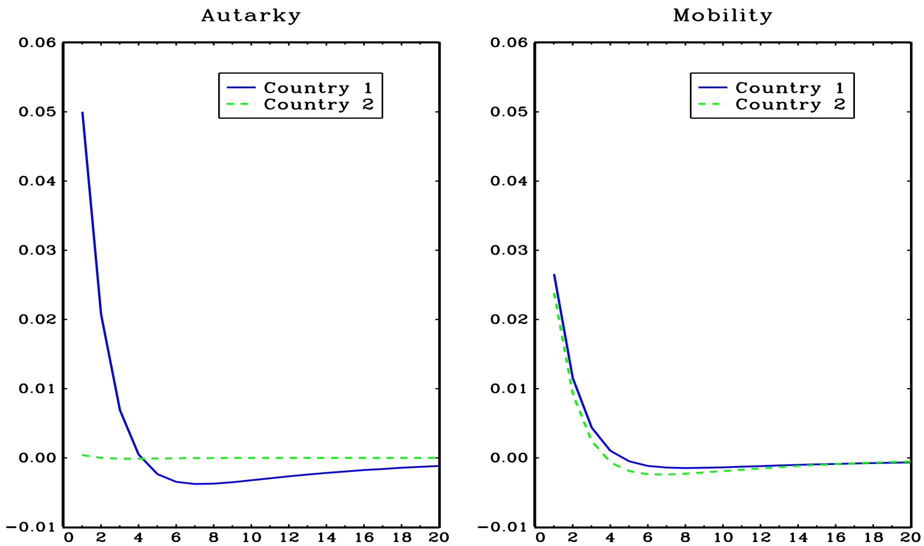

Figure 4: Impulse responses of output to a 1% increase in the q of country 1 under the autarky regime (left panel) and under the regime with capital mobility (right panel).

when shocks are partially correlated. The correlation is 0.5. As can be seen the reduction in volatility induced by capital markets liberalization is smaller but, for the case of asset price shocks, still sizable.

5 Capital accumulation

[TO BE DONE]

6 Conclusion

This paper has studied an economy where one of the main driving forces of the business cycle are shocks to the value of firms (asset prices). Asset price movements affect the real sector of the economy through the 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. Within this framework we have shown that

Table 3: Business cycle statistics from model simulated data. Top panel: Shocks are independent across countries. Bottom panel: Shocks are partially correlated across countries (corr=0.5).

	Asset price shocks			**Productivity shocks**		
	Autarky	*Mobility*	*Ratio*	*Autarky*	*Mobility*	*Ratio*
(a) Independent shocks						
St.Dev. Productivity	0.54	0.38	0.70	0.87	0.84	0.96
St.Dev. Output	1.05	0.74	0.70	1.28	1.23	0.96
Corr. Productivity	0.00	1.00		0.00	0.09	
Corr. Output	0.00	1.00		0.00	0.11	
(b) Correlated shocks						
St.Dev. Productivity	0.54	0.47	0.87	0.87	0.85	0.98
St.Dev. Output	1.05	0.92	0.88	1.28	1.25	0.98
Corr. Productivity	0.00	1.00		0.00	0.55	
Corr. Output	0.00	1.00		0.00	0.56	

capital market liberalization leads to lower macroeconomic volatility. This is consistent with the empirical evidence shown in the paper. Capital market liberalization also leads to greater co-movement in macroeconomic variables across countries consistent with the findings of Imbs (2006).

We have also studied the case in which the main driving force of the business cycle are productivity shocks. In this case liberalization leads to only a small reduction in macroeconomic volatility.

Appendix

A Debt renegotiation

Suppose that, in case of renegotiation, the lender can expropriate the firm and sell it at the price $\beta E q_{t+1} V_{t+1}(b_{t+1})$. The assumption is that the firm can be sold to other entrepreneurs at this price. However, this involves a cost τ. This cost then becomes the net surplus from reaching an agreement. This is because this cost will not be paid if an agreement is reached. More specifically, if the firm is liquidated, the value that the lender gets is $betaEq_{t+1}V_{t+1}(b_{t+1}) - \kappa$. However, the borrower looses $betaEq_{t+1}V_{t+1}(b_{t+1})$. Therefore, the net surplus is τ.

Bargaining takes place over the net surplus τ. Denoting by ξ the bargaining power of the entrepreneur, the value that the entrepreneur receives in the renegotiation stage is $\xi\tau$. This is in addition to the diverted revenue. Therefore, the total value from defaulting is $F(z_t, l_t) + \xi\tau$. Defining $\kappa = \xi\tau$, we get the expression written in the main body of the paper.

B First order conditions

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

$$\begin{aligned} d: &\quad 1 - \lambda = 0 \\ l: &\quad \lambda[F_l(l) - w] - \mu F_l(l) = 0 \\ b': &\quad (1+\mu)Eq'V_{b'}(\mathbf{s}'; b') + \frac{\lambda}{R} = 0 \end{aligned}$$

The envelope condition is:

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

Using the first condition to eliminate λ and substituting the envelope condition we get (2) and (3).

C Optimal contract

Suppose that an entrepreneur signs an optimal long-term contract with a financial intermediary. The contract defines the sequence of labor inputs,

l_t, payments to the entrepreneur, d_t, and payments to the intermediary, $F(z_t, l_t) - w_t l_t - d_t$. These sequences are conditional on the survival of the firm and on the history of aggregate states. Define v_t the expected utility of the contract for the entrepreneur. We can write the optimization problem recursively as follows:

$$W(\mathbf{s}; v) \quad = \quad \max_{d \geq 0, l, v(\mathbf{s}')} \left\{ F(z,l) - wl - d + \left(\frac{1}{1+r}\right) Eq'W(\mathbf{s}'; v') \right\}$$

subject to:

$$d + \beta E q' v(s') \geq v$$

$$\beta E q' v(\mathbf{s}') \geq F(z,l) + \kappa$$

The problem maximizes the value of the contract for the intermediary given a utility v promised to the entrepreneur. Notice that the next period utility is conditional on the realization of the aggregate states. We have implicitly assumed that the continuation utility is zero when the firm becomes unproductive. It is easy to show that this is the optimal policy. The problem is subject to the promised-keeping constraint and enforcement constraint.

Let λ and μ be the Lagrange multipliers associate with the promised-keeping and enforcement constraints. Assuming that the non-negativity constraint for d is not binding, the first order conditions are:

$$\begin{aligned} d: & \quad -1 + \lambda = 0 \\ l: & \quad F_l(z,l) - w - \mu F_l(z,l) = 0 \\ v(\mathbf{s}'): & \quad \left(\frac{1}{1+r}\right) q' W_{v(\mathbf{s}')}(\mathbf{s}'; v(\mathbf{s}')) + (\lambda + \mu)\beta q' = 0 \end{aligned}$$

The envelope condition is:

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

Using the first condition to eliminate λ and substituting the envelope condition we get:

$$F_l(z,l) = \frac{w}{1-\mu},$$

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

which are the same conditions obtained in (2) and (3).

D Dynamic system

The equilibrium is characterized by the following system of equations:

$$
\begin{aligned}
&U_c(c_t, h_t)w_t + U_h(c_t, h_t) = 0\\
&U_c(c_t, h_t) - \delta(1 + r_t)EU_c(c_{t+1}, h_{t+1}) = 0\\
&w_t h_t + b_t + n_t\Big[1 - \phi(n_t)\Big] - c_t - \frac{b_{t+1}}{1 + r_t} - \frac{n_{t+1}}{1 + \tilde{r}_t} = 0\\
&F_h(z_t, h_t) - \frac{w_t}{1 - \mu_t} = 0\\
&(1 + \mu_t)\beta(1 + r_t) - 1 = 0\\
&b_t + d_t - \frac{b_{t+1}}{R_t} - F(z_t, h_t) + w_t h_t = 0\\
&\beta E q_{t+1} V_{t+1} - F(z_t, h_t) - \kappa = 0\\
&d_t + \beta E q_{t+1} V_{t+1} - V_t = 0\\
&1 + r_t - (1 + \tilde{r}_t)\Big[1 - \phi(n_{t+1})\Big] = 0\\
&U_c(\tilde{c}_t, \tilde{h}_t)\tilde{w}_t + U_h(\tilde{c}_t, \tilde{h}_t) = 0\\
&U_c(\tilde{c}_t, \tilde{h}_t) - \delta(1 + \tilde{r}_t)EU_c(\tilde{c}_{t+1}, \tilde{h}_{t+1}) = 0\\
&\tilde{w}_t \tilde{h}_t + \tilde{b}_t - \tilde{c}_t - \frac{\tilde{b}_{t+1}}{1 + \tilde{r}_t} = 0\\
&F_h(\tilde{z}_t, \tilde{h}_t) - \frac{\tilde{w}_t}{1 - \tilde{\mu}_t} = 0\\
&(1 + \tilde{\mu}_t)\beta(1 + \tilde{r}_t) - 1 = 0\\
&\tilde{b}_t + \tilde{d}_t - \frac{\tilde{b}_{t+1}}{\tilde{R}_t} - F(\tilde{z}_t, \tilde{h}_t) + \tilde{w}_t \tilde{h}_t = 0\\
&\beta E \tilde{q}_{t+1} \widetilde{V}_{t+1} - F(\tilde{z}_t, \tilde{h}_t) - \kappa = 0\\
&\tilde{d}_t + \beta E \tilde{q}_{t+1} \widetilde{V}_{t+1} - \widetilde{V}_t = 0\\
&n_t + \tilde{n}_t = 0
\end{aligned}
$$

These are 18 dynamic equations. After linearizing the system, we can solve for the variables b_{t+1}, n_{t+1}, μ_t, w_t, h_t, c_t, d_t, V_t, r_t, $\tilde{b}_{t+1}$, $\tilde{n}_{t+1}$, $\tilde{\mu}_t$, $\tilde{w}_t$, $\tilde{h}_t$, $\tilde{c}_t$, $\tilde{d}_t$, $\widetilde{V}_t$, $\tilde{r}_t$ as linear functions of the states, A_t, b_t, n_t, $\tilde{A}_t$, $\tilde{b}_t$, $\tilde{n}_t$.

References

Bekaert, G., harvey, C. R., & Lundblad, C. (2006). Growth volatility and financial liberalization. *Journal of International Money and Finance*, *25*(3), 370–403.

Cecchetti, S., Flores-Lagunes, A., & Krause, S. (2006). Assessing the sources of changes in the volatility of real growth. NBER Working Paper No. 11946.

Chinn, M. & Ito, H. (2005). What matters for financial development? capital controls, institutions, and interactions. NBER Working Paper No. 11370.

Farmer, R. (1999). *Macroeconomics of Self-fulfilling Prophecies*. MIT Press, Cambridge, Massachusetts.

Imbs, J. (2006). The real effects of financial integration. *Journal of International Economics*, *68*(2), 296–324.

Obstfeld, M. & Taylor, A. M. (2004). *Global Capital Markets: Integration, Crisis, and Growth*. Cambridge University Press, New York.

OECD (2001). Productivity and firm dynamics: evidence from microdata. *Economic Outlook*, *69*(1), 209–223.