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Understanding the International Great Moderation

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Understanding the international great moderation*

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VERY PRELIMINARY AND INCOMPLETE

Abstract

The majority of OECD countries has experienced a reduction in the volatility of output during the last two decades. This period is also characterized by the liberalization of the capital accounts of these countries. This paper examines whether capital markets liberalization can lead to lower macroeconomic volatility. We study a business cycle model with multiple countries and financial market frictions and show that financial liberalization can lead to lower aggregate volatility.

1 Introduction

The United States is not the only country to have experienced a reduction in macroeconomic volatility during the last two decades. As shown in Cecchetti, Flores-Lagunes, & Krause (2006), the decline in the volatility of GDP is also observed for a majority of OECD countries. The last 20 years have also been characterized by a gradual relaxation of restrictions on the international

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mobility of capital among OECD countries. Direct or indirect indicators of financial openness all point to a significant increase in capital mobility. See for example Obstfeld & Taylor (2004).

Are the two patterns related? In particular, did capital liberalization contribute to the lower macroeconomic volatility of the liberalizing countries? Using quarterly data for the OECD countries we show that capital account liberalization is negatively associated with the lower volatility of GDP growth. This finding is consistent with earlier results by Bekaert, Harvey, & Lundblad (2006) based on annual data. They find that financial liberalization and especially equity market liberalization, is mostly associated with lower consumption volatility in advanced economies.[1]

Motivated by these empirical findings, we investigate the theoretical channel through which financial liberalization can lead to greater macroeconomic stability. We construct a multi-country business cycle model with financial market frictions. We consider two types of shocks. In addition to the typical TFP shocks, we allow for shocks that affect the borrowing ability of the business sector.

Within this model we show that, if country-specific shocks are not perfectly correlated across countries, financial liberalization reduces the macroeconomic volatility of the liberalizing countries. The magnitude of the decline depends on the prevalence of the two shocks as driving forces of the business cycle. In particular, the impact of liberalization on the volatility of output is especially large when credit shocks are a major source of business cycle fluctuations. In the limiting case in which countries are small and credit shocks are the only source of macroeconomic volatility, the output of each country becomes constant after liberalization. Another prediction of the model is that liberalization leads to greater cross-country correlation in output with each of the integrating countries. The increase in cross-country co-movement is consistent with the empirical finding of Imbs (2006).

In addition to capturing the decline in macroeconomic volatility and the increase in cross-country correlation, the model also provides a theoretical framework for understanding how credit shocks in one country affect other economies (contagion).

The paper is structured as follows. Section 2 presents the empirical find-

[1] This is in contrast to 'commercial liberalization'. Cecchetti et al. (2006) find that increased commercial openness is negatively, although insignificantly, correlated with fluctuations in GDP growth.

ings that motivate the paper. Section 3 presents the model and characterizes some of the general equilibrium properties. Section 4 conducts the quantitative analysis. Section 5 concludes.

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 a majority of these countries have also experienced a decline in the volatility of the business cycle, although with different degrees and timing. 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 value in each infra-year quarter is equal to the annual value.

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.

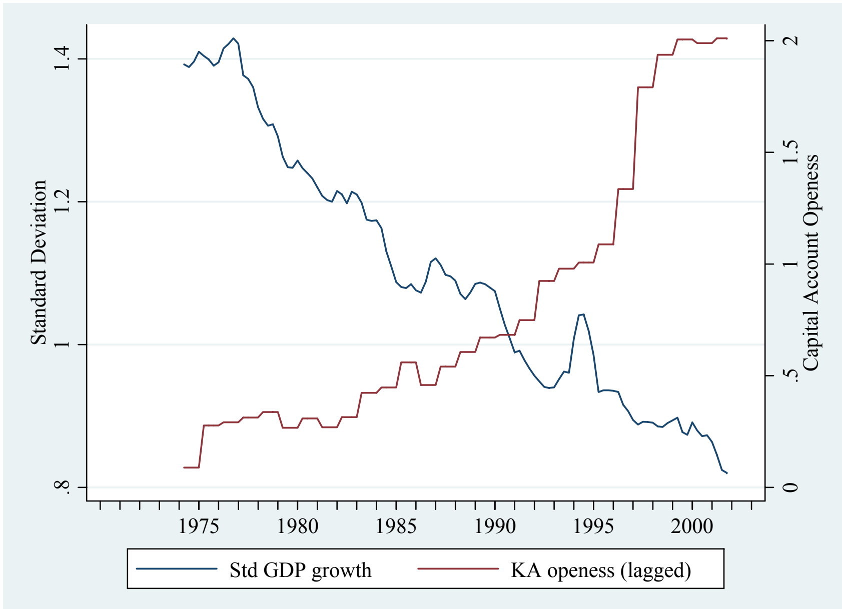

Figure 1: Financial liberalization and macroeconomic volatility. Average of OECD countries.

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 and the openness index is for 1977.4.

The estimation results for several time windows are reported in Table 1. Independently of the number of observations 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		
	Four years	*Six years*	*Eight years*
Capital account openness	-0.1024	-0.0992	-0.1048
	*(0.0129)**	*(0.0119)**	*(0.0114)**
R^2 (within)	0.148	0.157	0.175
R^2 (between)	0.134	0.146	0.158
R^2 (overall)	0.123	0.123	0.125
Observations	2,750	2,542	2,337

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 calendar date.

* Significant at 1 percent level.

3 The model

It will be convenient to describe first the closed-economy version of the model. Once we understand the working of the model in the autarky regime, it will be trivial to extend it to the environment with international mobility of capital.

There are two sectors. The 'business' sector populated by a continuum of risk neutral entrepreneurs and the 'household-worker' sector populated by a continuum of risk-averse workers. We start with the description of business sector.

3.1 Financial and production decisions of firms

In the business sector there is a unit mass of firms run by entrepreneurs who maximize the utility $E_0 \sum_{t=0}^{\infty} \beta^t c_t$. Firms generate revenues $F(z_t, k_t, l_t)$, where k_t and l_t are the inputs of capital and labor, and z_t is a stochastic variable affecting the productivity of all firms (aggregate productivity). Capital depreciates at rate τ. The production function is concave and displays decreasing returns to scale.

One way to think about the business sector is that there is a fixed number of locations or markets controlled by entrepreneurs. Entrepreneurs can run more than one firm but in order to do so they need to buy the location or market from another entrepreneur. Therefore, the total mass of firms remains always equal to 1.

Firms can borrow at the gross interest rate R_t. They start the period with debt b_t and they choose the production inputs, k_t and l_t, the new debt, b_{t+1}, and make payments to entrepreneurs and workers, d_t and $w_t l_t$ respectively. The budget constraint is:

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

where r_t is the rental rate of capital. We assume that productive capital is accumulated by households-workers who rent it to firms at the market price r_t. The alternative assumption that capital is owned by firms instead of workers would not make any difference.

Let $V_t(b_{t+1})$ be the value of the firm at the end of the period, after the payments of dividends. At this point the firm's liabilities are b_{t+1}. This value is defined as the discounted value of payments d_t, that is,

$$V_t(b_{t+1}) \equiv E_t \sum_{j=1}^{\infty} \beta^j d_{t+j}.$$

Because of the limited enforcement of debt contracts, $V_t(b_{t+1})$ affects the ability of a firm to borrow. We assume that firms can default after diverting the revenue $F(z_t, k_t, l_t)$. At the beginning of the period the firm hires labor and pays wages and dividends. At the same time it contracts the new debt b_{t+1}/R_t. With the new debt contract, the lender provides the funds to rent the capital, $r_t k_t$, the wages, $w_t l_t$, and to pay for the dividends, d_t. The firm agrees to transfer the revenues at the end of the period in partial repayment of the loaned funds. Therefore, the liabilities of the firm at the end of the period are $b_t + r_t k_t + w_t l_t + d_t - F(z_t, k_t, l_t) = b_{t+1}/R_t$.

Default arises after the realization of revenues. By defaulting the entrepreneur retains the revenues, $F(z_t, k_t, l_t)$, as these are liquid funds that can be easily diverted. In addition he/she gets an additional value A_t that derives from the renegotiation of the debt. This value depends on the bargaining power of the firm and on the cost faced by the lender in liquidating the firm. It derives from the solution of the renegotiation game played by the firm and the lender as described in Appendix A.

Enforcement requires that the market value of the firm $V_t(b_{t+1})$ is at least as big as the value of defaulting, that is,

$$V_t(b_{t+1}) \geq A_t + F(z_t, k_t, l_t).$$

The renegotiation value A_t is assumed to be stochastic. Shocks to A_t play a crucial role in the enforcement constraint. In particular, an increase in A_t leads to a tighter constraint. In order to satisfy the enforcement constraint, the firm has to reduce the debt b_{t+1} and/or the input of labor l_t. Essentially, these shocks affect the ability to borrow and, from now on, we will refer to them as 'credit shocks'. Therefore, there are two aggregate shocks in the model: productivity shocks, z_t, and credit shocks, A_t.

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

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

subject to:

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

$$\beta EV(\mathbf{s}'; b') \geq A + F(z, k, l)$$

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

In solving this problem the firm takes as given all prices and the first order conditions are:

$$F_k(z, k, l) = \frac{r}{1-\mu} \tag{2}$$

$$F_l(z, k, l) = \frac{w}{1-\mu} \tag{3}$$

$$(1+\mu)\beta R = 1, \tag{4}$$

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, $d > 0$, which usually holds in the neighborhood of the steady state. The detailed derivation is in Appendix B.

We can see from condition (2) and (3) that limited enforcement imposes a wedge in the demand for capital and labor. This wedge is strictly increasing in μ and disappears when $\mu = 0$, that is, when the enforcement constraint is not binding.

The third 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 positive shock to A, that is, a negative credit shock, makes the enforcement constraint tighter and this reduces the demand for debt. The reduction in the demand for debt, in turn, is likely to reduce the interest rate. Condition (4) then implies that the reduction in the real interest rate is associated with an increase in μ and, from conditions (2) and (3), a reduction in the demands of capital and labor.

To understand this result, we have to consider the incentive to consume (or save) for the entrepreneur, that is, paying dividends. This is determined by the difference between $1/\beta$ and R. Closer is the interest rate to the intertemporal discount rate and lower is the incentive to consume. Essentially, the term $1-\beta R$ represents the value of retaining earnings, which is captured by the lagrange multiplier μ. Because of the enforcement problem, if the firm wants to increase the input of labor, it has to pay less dividends. Therefore, in the margin, the cost of hiring labor results from two sources: the wage w and the cost of retaining earnings captured by μ. When the interest rate increases, the second component of the cost declines, and therefore, the firm demands more labor.

Another way to state this is that higher interest rates mitigate the enforcement problem because entrepreneurs have a higher incentive to save. This is because high interest rates increase the cost of borrowing, and therefore, they reduce the incentive to borrow to pay dividends. In the case in which the intertemporal discount rate is smaller than the interest rate, that is, $\beta R < 1$, entrepreneurs retain all the earnings and the enforcement constraint will not be binding as they would like to lend, not borrow. This implies that $\mu = 0$ and the marginal cost of labor will only be w.

To summarize, a credit shock affects the interest rate and, through the change in the savings of entrepreneurs, it affects production. This mechanism is key for understanding the effect of liberalization. We can anticipate that with higher mobility of capital the supply of funds will be more elastic, and therefore, a credit shock will impact less on the interest rate. Smaller changes in the interest rates then imply smaller changes in the demand of labor and in aggregate production.

In the general equilibrium, of course, the prices are also going to change. In particular, the change in the demands of capital and labor also affects the rental rate of capital r and the wage rate w. 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 from which the revenue function is derived. We then describe the problem solved by households-workers.

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

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

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

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

$$x_i = e^z (k_i^\theta l_i^{1-\theta})^\nu$$

where ν determines the returns to scale in production. The case with $\nu > 1$ is of interest because the model can also generate pro-cyclical endogenous fluctuations in productivity. It is important to emphasize that increasing returns capture, in simple form and in the short term, 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:

$$F(z, k_i, l_i) = Y^{1-\eta} \left[e^z (k_i^\theta l_i^{1-\theta})^\nu \right]^\eta$$

The decreasing returns property of the revenue function is obtained by imposing $\eta\nu < 1$. In equilibrium, $l_i = L$ for all firms and $Y = e^z [K^\theta L^{1-\theta}]^\nu$.

Therefore, the aggregate production function is homogenous of degree ν. Notice that the model embeds as a special case the environment with perfect competition. This is obtained by setting $\eta = 1$ and $\nu < 1$. In this case the concavity of the revenue function derives from the concavity of the production function.

Households-Workers: There is a continuum of homogeneous households-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. We assume that $\delta > \beta$, 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 physical capital and bonds issued by firms. The budget constraint is:

$$w_t h_t + (1 - \tau + r_t)k_t + b_t = c_t + k_{t+1} + \frac{b_{t+1}}{R_t}$$

and the first order conditions for labor, h_t, next period capital, k_{t+1}, and bonds, b_{t+1}, are:

$$U_h(c_t, h_t) + w_t U_c(c_t, h_t) = 0, \tag{5}$$

$$\delta E_t \left\{ \frac{(1 - \tau + r_{t+1}) U_c(c_{t+1}, h_{t+1})}{U_c(c_t, h_t)} \right\} = 1, \tag{6}$$

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

These are standard optimization conditions for the standard consumer's problem. The first condition defines the supply of labor as an increasing function of the wage rate. The second and third conditions define the rental rate of capital and the interest rate on bonds.

General equilibrium: We can now define a competitive equilibrium. The sufficient set of aggregate states, $\mathbf{s}$, are given by the productivity shock, z, the credit shock, A, the aggregate stock of capital, K, and the aggregate stock of bonds, B.

Definition 3.1 (Recursive equilibrium) *A recursive competitive equilibrium is defined by a set of functions for (i) workers' policies* $h(\mathbf{s})$, $c(\mathbf{s})$, $k(\mathbf{s})$,

$b(\mathbf{s})$; (ii) firms' policies $k(\mathbf{s})$, $l(\mathbf{s};b)$, $d(\mathbf{s};b)$ and $b(\mathbf{s};b)$; (iii) firms' value $V(\mathbf{s};b)$; (iv) aggregate prices $r(\mathbf{s})$, $w(\mathbf{s})$ and $R(\mathbf{s})$; (v) law of motion for the aggregate states $\mathbf{s}' = H(\mathbf{s})$. Such that: (i) household's policies satisfy the optimality conditions (5)-(7); (ii) firms' policies are optimal and $V(\mathbf{s};b)$ satisfies the Bellman's equation (1); (iii) the rental rate, the wage and the interest rate are the equilibrium clearing prices in the markets for capital, labor and bonds; (iv) the law of motion $H(\mathbf{s})$ is consistent with individual decisions and the stochastic processes for z and A.

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.

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 (7), becomes $\delta R = 1$. Using this condition to eliminate R in (4), we get $1 + \mu = \delta/\beta$. Because $\delta > \beta$ by assumption, the lagrange multiplier μ is greater than zero, implying that the enforcement constraint is binding.

In a model with uncertainty, however, the constraint may not be always binding. For this to be the case, we further need to impose that β is sufficiently smaller than δ.

Let's consider now a special case of the model in which the capital stock is constant, that is, $k = \bar{k}$. Furthermore, let's assume that the utility function takes the form $U(c_t, h_t) = (c_t - \alpha h_t^{\gamma})^{1-\sigma}/(1-\sigma)$. This particular specification eliminates wealth effects on leisure so that the supply of labor depends only on the wage rate, that is, $h_t = (\alpha\gamma/w_t)^{\frac{1}{1-\gamma}}$. Then, if the firm's revenues cannot be diverted, that is, the enforcement constraint is $V_t(b_{t+1}) \geq A_t$, credit shocks do not affect labor and production. This is stated formally in the next proposition.

wealth

Proposition 3.2 *Suppose that $k = \bar{k}$ and there are not wealth effects on the supply of labor. If the firm revenue cannot be diverted, changes in A have no effect on employment and output.*

If firms cannot divert the cash revenues, the enforcement constraint becomes $\beta EV(\mathbf{s}_{t+1}, b_{t+1}) \geq A$. The demand of labor defined by condition (2) becomes $F_l(z, k, l) = w$, and therefore, it depends only on the wage rate. Because the supply of labor depends only on w, employment and production will not be affected by fluctuations in A. Changes in A affect the interest rate and the allocation of consumption between workers and entrepreneurs but they do not affect employment. The constancy of the capital then implies that output will also stay constant.

This result no longer holds when the revenue can be diverted in case of default. In this case the demand for labor depends on the tightness of the enforcement constraint. An increase in A tightens the enforcement constraint restricting the amount of borrowing. The change in the demand for credit impacts on the interest rate. Then using conditions (2) and (4) we can see that the demand for labor changes. Given the supply of labor, this leads to a change in employment and output.

Of course, when capital is not constant, the shock is also transmitted through the accumulation of physical capital. But the key mechanism remains the one emphasized in the model without capital accumulation.

3.4 Allowing for the mobility of capital

We now consider the open economy version of the model with two countries. Each country has the same characteristics as those described in the previous section. The shocks z and A are country specific and they follow a joint Markov process.

Physical capital cannot be moved internationally and the international flows of funds take place through foreign bonds. To capture differences in the degree of capital markets integration, we assume that positive holdings of foreign bonds is costly. Denote by N_t the aggregate net foreign asset 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 individual positions avoids some technical complications. 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. Also, whether the international borrowing and/or lending is done by firms or workers is irrelevant. We then assume that only households-workers participate in the international market.

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:

$$w_t h_t + (1 - \tau + r_t)k_t + b_t + n_t\left(1 - \varphi(N_t)\right) = c_t + k_{t+1} + \frac{b_{t+1}}{R_t} + \frac{n_{t+1}}{\widetilde{R}_t}$$

Compared to the closed economy, workers have an additional choice variable, that is, the foreign lending n_t (or borrowing if negative). Therefore, in addition to the first order conditions (5)-(7), we also have the optimality condition for the choice of foreign bonds, which reads:

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

Combining (7) with (8) we get:

$$R_t = \widetilde{R}_t(1 - \phi \cdot N_t).$$

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 shocks in both countries, z, A, $\tilde{z}$, $\tilde{A}$, the bond issued by the firms of both countries, B and $\widetilde{B}$, and the foreign position of the domestic country N (or alternatively of the foreign country $\widetilde{N} = -N$).

Definition 3.2 (Recursive equilibrium) *A recursive competitive equilibrium is defined by the following set of functions for the domestic and foreign countries: (i) households' policies $h(\mathbf{s})$, $c(\mathbf{s})$, $k(\mathbf{s})$, $b(\mathbf{s})$, $n(\mathbf{s})$, $\tilde{h}(\mathbf{s})$, $\tilde{c}(\mathbf{s})$, $\tilde{k}(\mathbf{s})$, $\tilde{b}(\mathbf{s})$, $\tilde{n}(\mathbf{s})$; (ii) firms' policies $k(\mathbf{s}; b)$, $l(\mathbf{s}; b)$, $d(\mathbf{s}; b)$, $b(\mathbf{s}; b)$, $\tilde{k}(\mathbf{s}; b)$, $\tilde{l}(\mathbf{s}; b)$, $\tilde{d}(\mathbf{s}; b)$, $\tilde{b}(\mathbf{s}; b)$; (iii) firms' values $V(\mathbf{s}; b)$ and $\widetilde{V}(\mathbf{s}; b)$; (iv) aggregate prices $r(\mathbf{s})$, $w(\mathbf{s})$, $R(\mathbf{s})$, $\tilde{r}(\mathbf{s})$, $\tilde{w}(\mathbf{s})$, $\widetilde{R}(\mathbf{s})$; (v) aggregates of domestic and foreign bonds held by workers, N, B^w, $\widetilde{N}$, $\widetilde{B}^w$, and firms, B^f, $\widetilde{B}^f$; (vi) aggregates of productive capital held by workers, K^w, $\widetilde{K}^w$, and firms, K^f, $\widetilde{K}^f$; law of motion for the aggregate states $\mathbf{s}' = H(\mathbf{s})$. Such that: (i) household's policies satisfy the optimality conditions (5)-(8); (ii) firms' policies are optimal and satisfy the Bellman's equation (1); (iii) the rental rates clear the markets for capital; the wages clear the labor markets; 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 z, A, $\tilde{z}$, $\widetilde{A}$.*

The only difference with respect to the equilibrium in the closed economy is that there is the additional 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, $B^w = B^f$ and $\widetilde{B}^w = \widetilde{B}^f$.

4 Quantitative analysis

The main goal of the paper is to quantify the contribution of capital markets liberalization to the volatility of output. The common view is that the mobility of capital in international markets were substantially restricted before the 1980s and significantly liberalized after that. Therefore, we assume that the pre-1980 period is well approximated by the autarky regime. The subsequent period, especially after the 1990s, is well approximated by a regime with almost perfect mobility of capital.

Based on this interpretation, we estimate the autarky model using data for the period 1952 to 1983. In the autarky regime, we can look at each individual country abstracting from the others. We therefore concentrate on the first country which represents the US economy. The structural estimation of the model uses a likelihood based Bayesian approach.

After the estimation of the autarky model for the period 1952-1983, we study how the business cycle properties of the model change after the liberalization of capital markets. This is a counterfactual experiment that answers the following question: If the US economy gets fully integrated with a country that has the same size and characteristics, what would be the implications for the US business cycle?

4.1 Estimation

The period in the model is a quarter. Because we have two shocks, z and A, we can use two data series to estimate the model in the autarky regime. We use Gross Domestic Product and Domestic Investment.

For the parameters that can be pinned down using steady state targets, we simply use the standard calibration approach. This is equivalent to choosing prior densities concentrated around the calibration values. For the remaining parameters, that is, those that cannot be pinned down using steady state targets, we choose priors that impose as little restrictions as possible. In particular, we chose uniform distributions with boundaries dictated by technical considerations (for example, we set the lower bound of the uniform distribution to zero if the parameter cannot take negative values).

Calibrated parameters In the model the discount factor of workers determines the average return on bonds. We set it to the quarterly value of $\delta = 0.9925$ which implies a yearly return of 3%. The real return for stocks is determined by the discount factor of entrepreneurs, which we set to the quarterly value of $\beta = 0.9825$. This implies a yearly return of 7%.

The utility function takes the form $U(c, h) = \ln(c) + \alpha\ln(1 - h)$. The value of α is set to 0.37 so that, in the steady state, workers spend 1/3 of their time working.

The markup over the average cost is equal to $1/\nu\eta - 1$. We set it to 10 percent, that is, $\nu\eta = 0.9$, which is the value usually used in macro studies. This determines only the product of ν and η. The individual values of these two parameters will be determined by including ν among the set of estimated parameters. Next we set θ so that the share of wages in output is 60 percent. In the model, the share of wages is equal to $\eta\nu(1-\theta)(2-\delta/\beta)$, which requires $\theta = 0.326$. The depreciation rate is set to $\tau = 0.015$.

Productivity and credit shocks are assumed to be independent. The productivity shock follows the first order autoregressive process:

$$z_{t+1} = \rho_z z_t + \epsilon_{t+1}$$

where the disturbances ϵ_t are iid.

The credit shock follows a second order autoregressive process. Define $A_t = \bar{A}e^{x_t}$. The variable x_t follows the process:

$$x_{t+1} = \rho_x x_t + \varepsilon_{t+1}$$

with

$$\varepsilon_{t+1} = \rho_x \varepsilon_t + \varsigma_{t+1}$$

where the disturbances ς_t are iid. For the credit shocks we assume a second order autoregressive process to allow for greater persistence. The mean value $\bar{A}$ is chosen to have a ratio of debt over physical capital of 0.4.

Estimated parameters At this point we are left with five parameters—ν, ρ_z, σ_z, ρ_x, σ_x—which we estimate using Bayesian methods. All prior densities for these parameters are chosen to be uniform. The boundaries for the return to scale ν are 1 and 2. High values of ν will make the system unstable but the upper bound of 2 will insure stability. The parameters ρ_z and ρ_x can take any value between -0.999 and 0.999. Finally, for the standard deviations σ_z and σ_x the lower bound is set to 0.00001 and the upper bound to 0.5. The range of admissible values for the standard deviations is sufficiently large that in essence, it does not impose any restriction. The whole set of parameter values are reported in Table 2. For the estimated parameters, we also report the prior densities.

Table 2: List of parameters.

Calibrated parameters		
Discount factor, δ	0.9925	
Discount factor, β	0.9825	
Utility parameter, α	0.3700	
Production technology, θ	0.3265	
Depreciation rate, τ	0.0150	
Price mark-up, $\nu\eta$	0.9000	
Enforcement parameter, $\bar{A}$	4.3000	
Estimated parameters	*Prior*	*Mode*
Return to scale, ν	U[1,2]	1.9008
Productivity persistence, ρ_z	U[-0.999,0.999]	0.8648
Productivity volatility, σ_z	U[0.00001,0.5]	0.0025
Credit persistence, ρ_x	U[-0.999,0.999]	0.9167
Credit volatility, σ_x	U[0.00001,0.5]	0.0154

4.2 Impulse responses to shocks

We will now show some properties of the parameterized model. The parameters are set to their mode values, that is, the values that maximize the posterior likelihood.

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

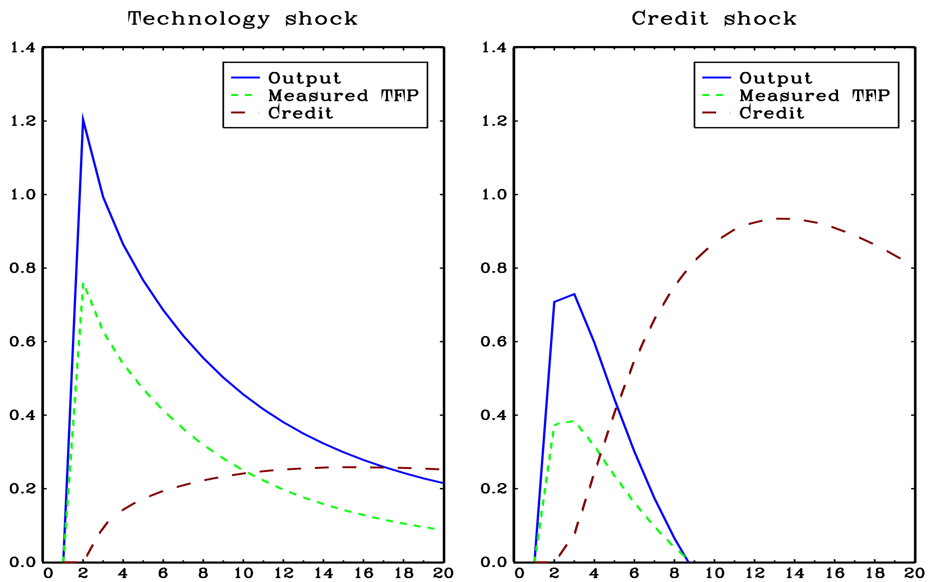

Figure 2: Autarky equilibrium: Impulse responses to a one standard deviation increase in z (left panel) and a standard deviation decrease in x (right panel).

Figure 2 plots the impulse responses of credit (bonds), measured TFP and output to a one standard deviation shock to z (left panel) and to x (right panel) in the autarky equilibrium. Both shocks generate a credit and macroeconomic expansion. Measured TFP also increases after a credit shock because of increasing returns ($\nu = 2$).

We now show the responses after capital markets liberalization. Figure 3 plots the responses of output in both countries when the technology shock increases only in country 1. When the economies are closed, only the output of country 1 is affected (see left panel). However, with high mobility of capital, the output of both countries react to the technology shock in country 1 (see right panel). The lower increase in the output of country 1 is explained by the fact that, with capital mobility, the interest rate in country 1 increases less. The response in country 2 derives from the increase in the interest rate compared to the autarky equilibrium. In the autarky regime, in fact, the interest rate in country 2 remains constant after a technology shock in country 1.

Figure 4 plots the impulse responses to a positive credit shock (lower x) in

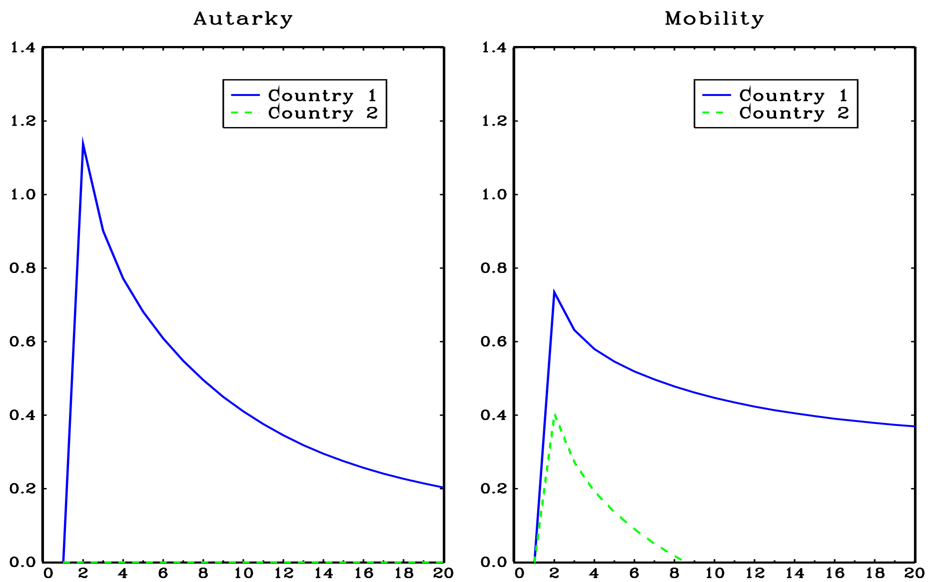

Figure 3: Impulse responses of output to a one standard deviation increase in z in country 1 under the autarky regime (left panel) and under the regime with capital mobility (right panel).

country 1. Under the autarky regime, only the output of country 1 is affected by the shock. With mobility, the outputs of both countries react to the credit shock. Even if the shock is only in country 1, the output of country 2 increases by almost the same magnitude as the output of country 1. The reason the increase is not exactly the same is because the cost on foreign holdings is small but not zero.[2] 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 all countries.

To show this point, Table 3 reports the standard deviations of several variables under the autarky regime and under the regime with capital mobility. The numbers reported in the table are averages of the standard deviations from the posterior distribution. To compute these averages, we make 10,000

[2]When $\phi = 0$, the dynamic system would not be stable. Therefore, we have chosen a value of ϕ that is small but different from zero.

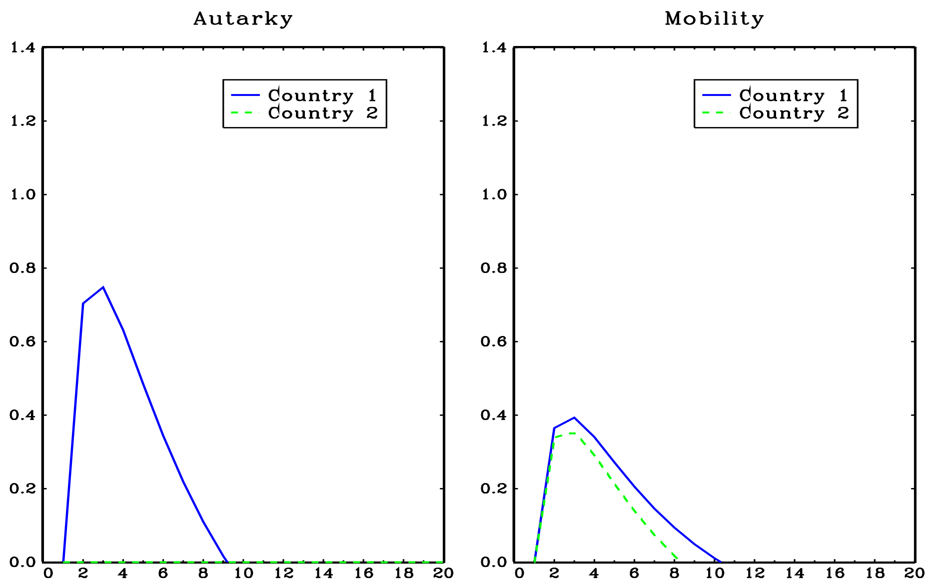

Figure 4: Impulse responses of output to a one standard decrease in x in country 1 under the autarky regime (left panel) and under the regime with capital mobility (right panel).

draws of parameters from the posterior distribution using the Random-Walk Metropolis algorithm. For each draw of parameters we compute the standard deviations for the relevant macroeconomic variables. The numbers reported in the table are the averages of the standard deviations computed for each of the 10,000 draws.

As can be seen from the table, there is a sizable reduction in volatility among the main macroeconomic variables when we compare the autarky regime with the liberalized regime. International financial liberalization can reduce the volatility of GDP by 30 percent; the volatility of measured TFP by 28 percent; the volatility of labor by 32 percent; the volatility of investment by 14 percent.

These results are derived from a model with two independent shocks in each country. To show the contribution of each individual shock, we conduct a decomposition of variance, before and after capital markets integration. The statistics are reported in Table 4. As for the standard deviations reported in the previous table, the numbers are computed by averaging the statistics obtained for each of the 10,000 draws from the posterior distribu-

Table 3: Business cycle statistics for different international capital markets regimes.

	Autarky		**Mobility**	**Mobiility/Autarky**
	Data	*Model*	*Model*	*Model*
Output	1.14	1.49	1.04	0.70
TFP		0.90	0.65	0.72
Labor		1.00	0.68	0.68
Investment	4.51	4.63	4.00	0.86

Notes: The numbers are standard deviations of growth rates. Artificial data is generated by averaging the standard deviations associated with 10,000 draws of parameters from the posterior distribution.

tion of parameters.

Table 4: Decomposition of variance for different international capital markets regimes.

	Autarky		**Mobility**			
	x shock	*z shock*	*x shock*	*z shock*	*$\tilde{x}$ shock*	*$\tilde{z}$ shock*
Output	0.30	0.70	0.15	0.51	0.14	0.19
TFP	0.23	0.77	0.11	0.65	0.10	0.14
Labor	0.38	0.62	0.21	0.33	0.19	0.26
Investment	0.52	0.48	0.14	0.67	0.12	0.07

Notes: The numbers are generated by averaging the variance decomposition associated with 10,000 draws of parameters from the posterior distribution.

Both shocks contribute significantly to the volatility of the major macroeconomic variables. In the autarky regime, credit shocks contributes by 30% to the volatility of GDP and by almost 50 percent to the volatility of investments. Once the economy becomes integrated in the world financial markets, the contribution of 'domestic' shocks, x and z, decline, especially for the credit shocks. Now, however, the economy is also affected by foreign shocks, $\tilde{x}$ and $\tilde{z}$. Foreign shocks account for one third of the volatility of GDP and 45 percent of the volatility of labor. The contributions to the volatility of measured TFP and investment are 24 and 19 percent respectively.

To summarize, financial liberalization reduces the dependence of the business cycle from domestic shocks but increases the dependence from foreign shocks. As long as domestic and foreign shocks are not correlate, the net effect is a significant reduction in aggregate volatility. In the case of integration with a country of the same size and characteristics, the reduction in volatility in the volatility of output is about 30 percent.

5 Conclusion

We have studied an economic environment in which shocks to credit is one of the driving forces of the business cycle. These shocks 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 a contraction of credit. Within this framework we have shown that 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 output co-movement among the integrating countries. This is 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 also leads to a reduction in macroeconomic volatility but the magnitude of the decline is smaller.

Appendix

A Debt renegotiation

Suppose that, in case of renegotiation, the lender can confiscate the firm at a cost κ and sell it to other entrepreneurs. The market value of the firm is $\beta EV_{t+1}(b_{t+1})$. The net surplus from reaching an agreement is the confiscation cost κ. This is because κ is paid only if the parties do not reach an agrement. More specifically, if the firm is liquidated, the value that the lender gets is $\beta EV_{t+1}(b_{t+1}) - \kappa$ but the entrepreneur looses $\beta EV_{t+1}(b_{t+1})$. Therefore, the net surplus is κ.

Bargaining is over the net surplus κ. Denoting by ξ the bargaining power of the entrepreneur, the value that the entrepreneur receives in the renegotiation stage is $\xi\kappa$. This is in addition to the diverted revenue. Therefore, the total value from defaulting is $F(z_t, k_t, l_t) + \xi\kappa$. Defining $A = \xi\kappa$, 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:

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

The envelope condition is:

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

The above conditions can be re-arranged as in (2)-(4).

C Dynamic system

The equilibrium is characterized by the following system of equations:

$$U_c(c_t, h_t)w_t + U_h(c_t, h_t) = 0$$

$$U_c(c_t,h_t) - \delta E(1-\tau+r_t)U_c(c_{t+1},h_{t+1}) = 0$$
$$U_c(c_t,h_t) - \delta R_t E U_c(c_{t+1},h_{t+1}) = 0$$
$$w_t h_t + (1-\tau+r_t)k_t + b_t + n_t\Big[1-\phi(N_t)\Big] - c_t - k_{t+1} - \frac{b_{t+1}}{R_t} - \frac{n_{t+1}}{\widetilde{R}_t} = 0$$
$$F_h(z_t,k_t,h_t) - \frac{w_t}{1-\mu_t} = 0$$
$$F_k(z_t,k_t,h_t) - \frac{r_t}{1-\mu_t} = 0$$
$$(1+\mu_t)\beta R_t - 1 = 0$$
$$b_t + d_t - \frac{b_{t+1}}{R_t} - F(z_t,h_t) + r_t k_t + w_t h_t = 0$$
$$\beta E V_{t+1} - A_t - F(z_t,k_t,h_t) = 0$$
$$d_t + \beta E V_{t+1} - V_t = 0$$
$$R_t - \widetilde{R}_t\Big[1-\phi(n_{t+1})\Big] = 0$$
$$U_c(\tilde{c}_t,\tilde{h}_t)\tilde{w}_t + U_h(\tilde{c}_t,\tilde{h}_t) = 0$$
$$U_c(\tilde{c}_t,\tilde{h}_t) - \delta E(1-\tau+\tilde{r}_t)U_c(\tilde{c}_{t+1},\tilde{h}_{t+1}) = 0$$
$$U_c(\tilde{c}_t,\tilde{h}_t) - \delta \widetilde{R}_t E U_c(\tilde{c}_{t+1},\tilde{h}_{t+1}) = 0$$
$$\tilde{w}_t\tilde{h}_t + (1-\tau+\tilde{r}_t)\tilde{k}_t + \tilde{b}_t + \tilde{n}_t - \tilde{c}_t - \tilde{k}_{t+1} - \frac{\tilde{b}_{t+1}}{\widetilde{R}_t} - \frac{\tilde{n}_{t+1}}{R_t} = 0$$
$$F_h(\tilde{z}_t,\tilde{k}_t,\tilde{h}_t) - \frac{\tilde{w}_t}{1-\tilde{\mu}_t} = 0$$
$$F_k(\tilde{z}_t,\tilde{k}_t,\tilde{h}_t) - \frac{\tilde{r}_t}{1-\tilde{\mu}_t} = 0$$
$$(1+\tilde{\mu}_t)\beta\widetilde{R}_t - 1 = 0$$
$$\tilde{b}_t + \tilde{d}_t - \frac{\tilde{b}_{t+1}}{\widetilde{R}_t} - F(\tilde{z}_t,\tilde{k}_t,\tilde{h}_t) + \tilde{r}_t\tilde{k}_t + \tilde{w}_t\tilde{h}_t = 0$$
$$\beta E\widetilde{V}_{t+1} - \widetilde{A}_t - F(\tilde{z}_t,\tilde{k}_t,\tilde{h}_t) = 0$$
$$\tilde{d}_t + \beta E\widetilde{V}_{t+1} - \widetilde{V}_t = 0$$
$$n_t + \tilde{n}_t = 0$$

There are 22 dynamic equations. After linearizing the system, we can solve for the variables k_{t+1}, b_{t+1}, n_{t+1}, μ_t, w_t, h_t, c_t, d_t, V_t, R_t, r_t, $\tilde{k}_{t+1}$, $\tilde{b}_{t+1}$, $\tilde{n}_{t+1}$, $\tilde{\mu}_t$, $\tilde{w}_t$, $\tilde{h}_t$, $\tilde{c}_t$, $\tilde{d}_t$, $\widetilde{V}_t$, $\widetilde{R}_t$, $\tilde{r}_t$ as linear functions of the states, z_t, A_t, k_t, b_t, n_t, $\tilde{z}$, $\widetilde{A}_t$, $\tilde{k}_t$, $\tilde{b}_t$, $\tilde{n}_t$.

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