Understanding the international great moderation*

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Abstract

The majority of OECD countries has experienced a reduction in the volatility of output during the past two and a half decades. This period has also been characterized by a process of capital accounts liberalization among these countries. We study an open economy business cycle model with financial market frictions and show that the international liberalization of capital markets can lead to lower volatility of output and higher co-movement among the liberalizing countries.

1 Introduction

The United States is not the only country to show a reduction in macroeconomic volatility during the past two and a half 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. This period is

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also characterized by a gradual relaxation of restrictions on the international 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). The goal of this paper is to investigate whether these two patterns are related.

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 ability of the business sector to access external financing.

Within this model we show that, if country-specific shocks are not perfectly correlated across countries, financial liberalization reduce the macroeconomic volatility of the liberalizing countries. The estimated version of the model predicts that the full removal of barriers to the international mobility of capital leads to a 25 percent drop in the standard deviation of output growth.

In addition to capturing the decline in macroeconomic volatility, the model also provides a theoretical framework for understanding how credit shocks in one country propagate to other economies (contagion). Another prediction of the model is that liberalization leads to greater cross-country correlation in output which is consistent with the findings of several studies including Artis & Okubo (2008), Kose, Otrok, & Prasad (2008) and Imbs (2006).[2]

[1] This is in contrast to 'commercial liberalization'. Cecchetti et al. (2006) do find that commercial openness is negatively correlated with fluctuations in GDP growth but it is not statistically significant.

[2] The study of Artis & Okubo (2008) uses long time series, from 1870 to 2001. They distinguish three sub-periods: the first globalization wave (1870-1914), the period of the 'bloc economy' (1915-1959) and the second globalization wave (1960-2001). One of the findings is that the second globalization period shows a generally higher level of cross correlations and a lower variance than the other two periods. Kose et al. (2008) find that

The paper is structured as follows. Section 2 presents the empirical findings that motivate the paper. Section 3 presents a simple version of the model without capital accumulation where we can characterize some of the equilibrium properties analytically. Section 4 extends the model by allowing for the accumulation of physical capital. Section 5 estimates the general model using Bayesian methods and conducts the quantitative analysis. Section 6 concludes.

2 Empirical analysis

The main motivation of the paper starts from the observation that, over the past two and a half decades, many developed 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 by different degrees and timing. The goal of this section is to document these two patterns and to show that there is a strong association between them.

2.1 The data

The analysis is conducted using a set of OECD countries during the period 1970-2005.[3] The main variables of interest are an index of macroeconomic volatility over a particular period and an index of capital account openness over the same period. Our benchmark measure of macroeconomic volatility is the simplest and the most widely used that is the standard deviation of *quarterly* real GDP growth computed over the period of interest.

Measuring international financial openness is less straightforward. In the literature usually two types of indicators are used: *de-iure* or *de-facto*. *De-iure* indicators (for example the amount of legal restrictions on capital ac-

during the recent period of globalization (1985-2005), there has been some convergence of business cycle fluctuations among the group of industrial economies as well as among the group of emerging market economies. However, they do not find convergence among these two different groups. Given our focus on OECD countries, the finding of Kose et al. (2008) are consistent with our theory.

[3]In particular we use data from all OECD countries for which we can obtain comparable (across time and across countries) data starting in the 1970s. We obtain these data from the OECD publication Quarterly National Accounts. The countries used in the analysis are those reported in Figures 1 and 2.

count transactions) are conceptually better as they capture the actual restrictions to international capital flows. However, the actual restrictions to international capital flows are difficult to measure and quantify. *De-facto* indicators (which usually capture the volume of foreign assets trading or holding) are conceptually inferior as, for example, a low holding of foreign assets does not necessarily indicate a lack of international financial openness but it might simply reflect a preference for domestic assets. Their advantage is that international assets transactions can be measured and quantified more easily.

In the following analysis we will use both indicators. The *de-iure* indicator of openness is 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 and our *de-iure* index of capital account openness in a given period is simply the average of the Chinn-Ito index over that period.

Our *de-facto* measure of international financial openness is a measure of gross international diversification i.e. the sum of foreign assets and foreign liabilities of a country normalized by its GDP. Data on foreign assets and liabilities are from Lane and Lane & Milesi-Ferretti (2006) and they are also available for the period 1970-2005 at the annual frequency. Therefore, our *de-facto* index of capital account openness in a given period is simply the average of gross international diversification over that period.

Figures 1 and 2 plot the two indexes of international financial openness together with the indexes of volatility for all the countries included in the sample. The first panel in each figure reports the averages (across countries) of the indexes over time. Notice how both measures of international financial openness and volatility display very different trends: volatility tends to fall over time, while international financial openness tends to go up. To make this relation more precise and to control for possible other factor driving it we now turn to a simple panel regression analysis.

Figure 1: Volatility and *De-iure* financial openness

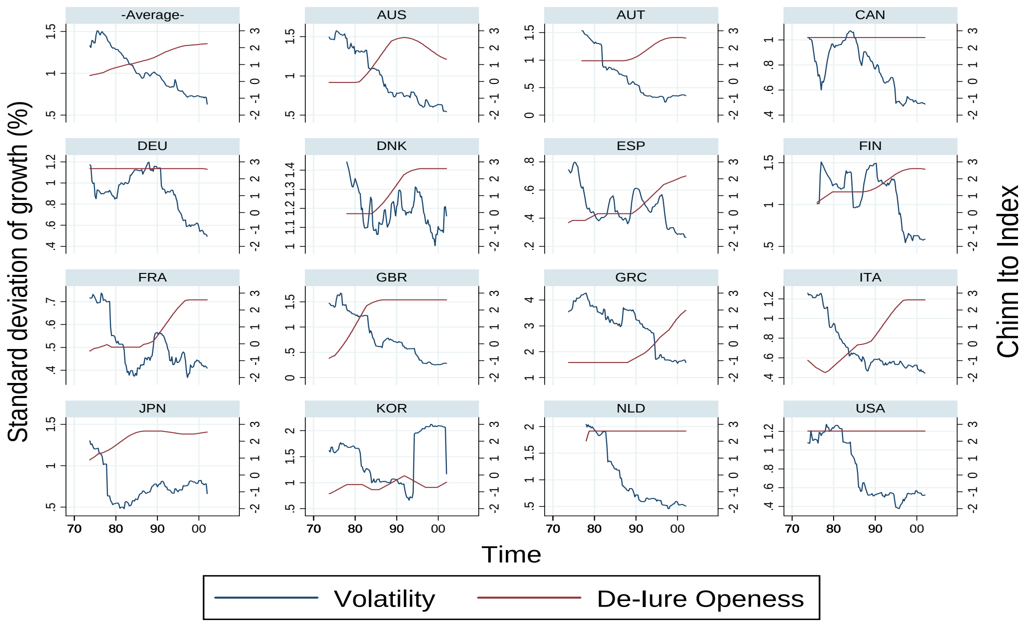
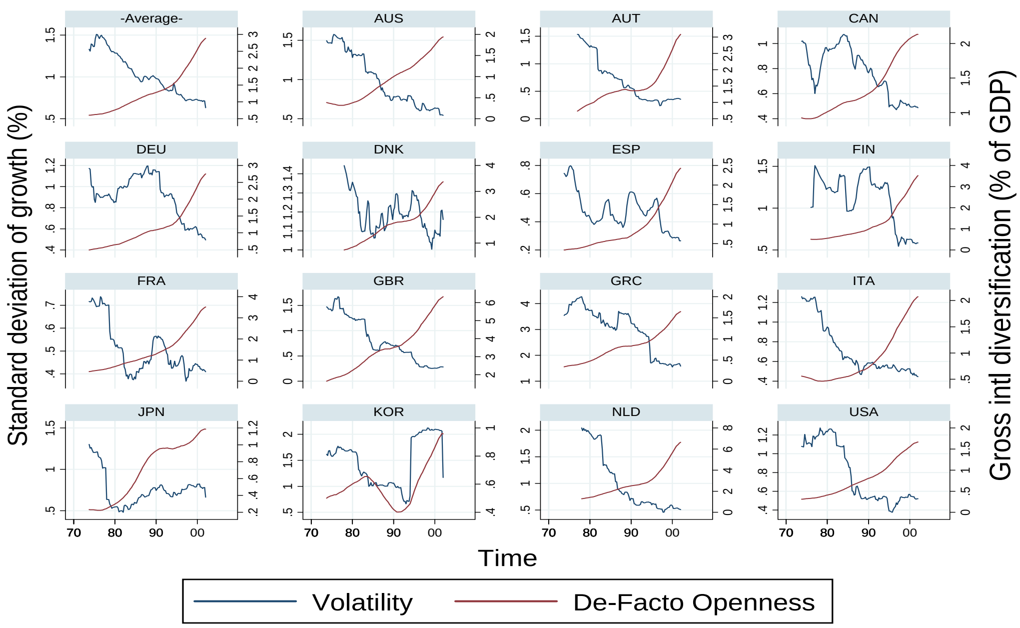


Figure 2: Volatility and *De-facto* financial openness



2.2 Regression results

The first three columns of Table 1 report the coefficient obtained from the regression of volatility on the index of financial openness. The volatility variable is the standard deviation of GDP growth computed on series of overlapping 5 years windows. The index of financial openness is computed as average over the same overlapping windows. Notice how the coefficients are always significant and negative. This is the case also when both indexes of openness are included in the regression, suggesting that the two measures are complementary.

One obvious concern is that this result might be driven by the volatility of large common shocks (like oil shocks) falling at around the same time in which the world has become more financially integrated. In order to control for this possibility, the last three columns report the same coefficients obtained from a regression which includes time and country effects.

Country and time effects fit a common decreasing (over time) path for volatility, allowing each country to start from a different level so they fully control for the effect on volatility induced by common shocks across countries. In some sense these effects control 'too much' because the increase in global financial openness is clearly such a shock; so the coefficients on openness in the last three columns of Table 1 should be interpreted as a lower bound for the conditional correlation between openness and volatility. Still the table shows that both indexes of openness continue to be statistically significant and economically meaningful.

To get a sense of the economic magnitude of this correlation, consider as an example the case of UK in the late 1970s and in the early 2000s. Inspection of Figures 1 and 2 shows that the volatility in these two periods is quite different: 1.5 percent in the first period and 0.4 percent in the second. How much of this volatility difference can be accounted by the difference in international financial openness? UK in the 1970s has a Chinn-Ito index of about -0.5 and international diversification of about 200 percent while in 2000s these indexes climbed up to 2.5 and 600 percent. Using these numbers together with the coefficients in the last 3 columns of Table 2 we conclude that the *de-iure* measure of financial openness can account for about 30 basis points in the decline of volatility while the *de-facto* measure can account for about 50 basis points. Jointly they account for about 70 basis points, which is more than half of the observed decline in volatility.

Table 1: Volatility and international financial openness. Dependent variable is standard deviation of GDP growth computed on 5 years windows.

	(1)	(2)	(3)	(4)	(5)	(6)
KA openness (*De-iure*)	-0.27		-0.24	-0.10		-0.09
	(-24.3)		(-19.5)	(-8.17)		(-7.0)
KA openness (*De-facto*)		-0.20	-0.06		-0.13	-0.11
		(-14.0)	(-4.4)		(-6.95)	(-5.6)
Country & Time effects	N	N	N	Y	Y	Y
Observations	1750	1750	1750	1750	1750	1750
Adj. R^2	0.25	0.10	0.26	0.79	0.78	0.79

Note: All regression include a constant. t-statistics are in parenthesis.

2.3 Robustness checks

One potentially important argument against the existence of a fundamental relation between volatility and international financial openness might arise because of the following argument. Some countries in some periods (for example countries entering the European Community such as Spain or Greece) adopt a package of structural reforms. Suppose that some of these reforms (for example labor market reforms) are responsible for the reduction in volatility. Since usually international financial opening is part of the reform package, one could still observe a strong association between international opening and reduction in volatility, but the association may be the consequence of omitting variables that control for additional reforms.

Controlling for additional reforms can be quite challenging but if one assumes that the reforms affecting volatility also affect average growth, then one can control for them by simply including in the regression the average growth computed over the period of interest. Results for this exercise are reported in Table 2.

The table shows that average growth is negatively related to volatility, suggesting the presence of events or reforms that increase growth and reduce volatility.[4] However, even if we control for this, the coefficients on the openness indexes remain negative and statistically significant, although the

[4]This finding is reminiscent of Ramey & Ramey (1995) who document a strong negative relation between growth and volatility for the set of developed countries.

magnitude is cut by almost a half (compare the last three columns of Table 2 with the equivalent columns of Table 1). One of the explanations for the fall in the size of the coefficients is based on the argument we made above. Another explanation is that financial openness might actually affect growth and so, by including growth directly in the regression, we simply reduce the coefficients because of multicollinearity. But even if we were to make the more conservative assumption that the true relation between international financial openness and volatility is captured by the coefficients in the last 3 columns of Table 2, the relation is still economic relevant. Using again the UK example from the previous section, it is easy to compute that the increase in international financial openness can account for almost one third of the actual decline in the volatility of GDP growth in the UK.

Table 2: Volatility and international financial openness. Dependent variable is standard deviation of GDP growth computed on 5 years windows.

	(1)	(2)	(3)	(4)	(5)	(6)
KA openness (*De-iure*)	-0.29		-0.26	-0.07		-0.06
	(-24.3)		(-21.0)	(-5.64)		(-5.1)
KA openness (*De-facto*)		-0.21	-0.07		-0.07	-0.05
		(-14.2)	(-4.9)		(-3.83)	(-3.0)
Average growth	-0.26	-0.12	-0.27	-0.58	-0.58	-0.56
	(-6.6)	(-2.7)	(-7.0)	(-18.6)	(-18.6)	(-17.8)
Country & Time effects	N	N	N	Y	Y	Y
Observations	1750	1750	1750	1750	1750	1750
Adj. R^2	0.27	0.10	0.28	0.82	0.82	0.82

Note: All regression include a constant. t-statistics are in parenthesis.

3 The model without capital accumulation

We first describe a simple version of the model without capital accumulation. This allows us to derive some results analytically providing simple intuitions for the quantitative results derived with the more general model.

The basic structure of the economy has some similarities with the model studied in Kiyotaki & Moore (1997) in the sense that there are two sectors populated by agents with different discount factors and different investment opportunities. In the first sector there is a continuum of risk neutral entrepreneurs who discount the future at rate β. In the second sector there is a continuum of risk-averse workers with discount factor $\delta > \beta$. The different discounting implies that entrepreneurs borrow from workers subject to the enforcement constraints we will describe below. Differently from Kiyotaki & Moore (1997), the lenders (*i.e.* workers) are risk averse. An important implication of this assumption is that the interest rate is not constant in equilibrium but fluctuates in response to aggregate shocks. As we will see, fluctuations in the interest rate play a central role in the analysis.

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

3.1 Financial and production decisions of firms

There is a unit mass of entrepreneurs who maximize $E_0 \sum_{t=0}^{\infty} \beta^t c_t$. Firms generate revenues $F(z_t, l_t)$, where l_t is the input of labor and z_t is a stochastic variable affecting the productivity of all firms (aggregate productivity). In this section we assume there is not physical capital.

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 or project 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 start the period with debt b_t. Before producing they choose the labor input, l_t, and raise additional funds to make payments to entrepreneurs, d_t, and workers, $w_t l_t$. After raising these additional funds, the total liabilities are $b_t + d_t + w_t l_t$. At the end of the period, firms receive the revenue $F(z_t, l_t)$, which is used in partial repayment of the debt. Therefore, the net liabilities at the end of the period are $b_t + d_t + w_t l_t - F(z_t, l_t)$. These liabilities will be carried out to the next period with the addition of the interests. Thus, the next period debt will be:

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

where R_t is the gross interest rate. This is the budget constraint for the firm.

It is important to point out that the assumption that wages and dividends are paid at the beginning of the period, as opposed to the end of the period, is not crucial for the results but it simplifies the analytical expressions.

Let $V_t(b_{t+1})$ be the value of the firm's equity at the end of the period when the liabilities are b_{t+1}. This is defined as the discounted value of payments d_t to the entrepreneur, 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. Default arises after the realization of revenues. By defaulting the entrepreneur retains the revenues, $F(z_t, l_t)$, as these are liquid funds that can be easily diverted, and renegotiates the debt.

To determine the renegotiation outcome, we assume that the lender can sell the firm to other entrepreneurs and use the net revenue to partially recover the debt. However, there is some loss of value in selling the firm. In particular, we make the following assumptions: (*i*) There is a stochastic cost κ_t in selling the firm; (*ii*) Only a fraction $1-\chi < 1$ of the equity value of the firm is recovered through the sale. Thus, the net revenue from liquidating the firm is $(1-\chi)V_t(b_{t+1}) - \kappa_t$.

Because of the loss of value in liquidating the firm, it is in the interest of the lender to renegotiate the debt and leave the ownership to the current entrepreneur. The net surplus from reaching an agrement will be $\chi V_t(b_{t+1}) + \kappa_t$. Without loss of generality (see Appendix A) we assume that the entrepreneur has all the bargaining power, and therefore, the value he or she receives in the renegotiation stage is $\chi V_t(b_{t+1}) + \kappa_t$. Thus, the total value from defaulting is $F(z_t, l_t) + \chi V_t(b_{t+1}) + \kappa_t$, that is, the revenues plus the renegotiation value.

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,

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

Rearranging terms, the enforcement constraint can be rewritten as:

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

where $\phi = 1/(1-\chi)$ and $\xi_t = \kappa_t/(1-\chi)$ is a stochastic variable that depends on the cost to sell the firm κ_t. See Appendix A for the detailed description of the renegotiation process and the derivation of the enforcement constraint.

An increase in the liquidation cost of the firm, κ_t, raises the value of ξ_t and leads to a tighter constraint. This requires either a reduction in the next period debt b_{t+1} and/or in the input of labor l_t. These shocks affect the ability to borrow and, from now on, we will refer to them as 'credit shocks'. They can also be interpreted as asset price shocks as they affect the net revenue from selling the firm, $(1-\chi)V_t(b_{t+1}) - \kappa_t$.[5]

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

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

subject to:

$$b + d = F(z, l) - wl + \frac{b'}{R} \tag{2}$$

$$\beta EV(\mathbf{s}'; b') \geq \phi \cdot F(z, l) + \xi \tag{3}$$

where $\mathbf{s}$ are the aggregate states, including the shocks z and ξ, 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:

$$F_l(z, l) = \frac{w}{1 - \phi\mu} \tag{4}$$

$$(1 + \mu)\beta R = 1, \tag{5}$$

where μ is the lagrange multiplier for the enforcement constraint. These conditions are derived under the assumption that the solution for the entrepreneur's consumption 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 (4) that limited enforcement imposes a wedge in the demand for labor. This wedge is strictly increasing in μ and disappears when $\mu = 0$, that is, when the enforcement constraint is not binding.

[5] They can also been interpreted as liquidity shocks as in Kiyotaki & Moore (2008).

Condition (5) 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, an increase in ξ, that is, a negative credit shock, makes the enforcement constraint tighter and reduces the demand for debt. The reduction in the demand for debt reduces the interest rate. From condition (5) we have that the reduction in the interest rate must be associated with an increase in μ, that is, the enforcement constraint is tighter. Condition (4) then shows that the demand for labor declines.

Further intuition about the credit shock: Because the value of default is positively related to the input of labor, the firm can hire more labor only if it pays less dividends, and therefore, it borrows less. Hence, in the margin, the cost of hiring labor results from two sources: the wage w and the cost of retaining earnings (reducing consumption).

What is the cost of retaining earnings? This depends on the difference between the intertemporal discount rate and the interest rate, that is, $1/\beta - R$. If the entrepreneur reduces the debt by one unit, the cost of doing so will be a one unit reduction in current consumption. The gain will be an increase of R in next period consumption which, today, has a present value of βR. Therefore, the cost of reducing debt is $1-\beta R$. According to condition (5), this cost is captured by the Lagrange multiplier for the enforcement constraint μ: higher is μ and higher is the cost of reducing debt.

Essentially, the difference between the intertemporal discount rate, $1/\beta$, and the interest rate, R, is the 'equity premium', that is, the difference between the expected return on equity—which in this framework with risk-neutral entrepreneurs is always equal to the intertemporal discount rate—and the interest rate. A negative credit shock, that is, an increase in ξ, raised the equity premium (through the decline in the interest rate) and increases the cost of hiring labor.

Another way to look at the mechanism 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, $\beta R > 1$, the entrepreneur retains all the earnings and the enforcement constraint will not be binding. The entrepreneurs 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, by changing the equity premium (given the constancy of β), 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 is more elastic, and therefore, a credit shock will impact less on the interest rate. Smaller changes in the equity premium then imply smaller changes in the demand of labor and in the aggregate production.[6] In the general equilibrium, of course, prices would also change. In particular, movements in the demand of labor would also affect the wage rate w. To derive the aggregate effects we need to close the model and characterize the general equilibrium.

3.2 Closing the model and general equilibrium

In this section we describe the remaining components 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 labor according to:

$$x_i = z l_i^{\nu}$$

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. Increasing returns is a parsimonious way of capturing the presence of fixed factors and variable capacity utilization.

[6] In the limiting case of a small open economy, the interest rate is constant and credit shock will not affect the demand of labor.

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 the case of 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. Workers have a lower discount rate than entrepreneurs, that is, $\delta > \beta$. This is the key condition for the enforcement constraint to bind most of the times. Workers hold bonds issued by firms. The budget constraint is:

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

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

$$U_h(c_t, h_t) + w_t U_c(c_t, h_t) = 0, \tag{6}$$

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

These are standard optimizing conditions for the typical consumer'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 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, ξ, 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 $h(\mathbf{s})$, $c(\mathbf{s})$, $b(\mathbf{s})$; (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 (6)-(7); (ii) firms' policies are optimal and $V(\mathbf{s}; b)$ satisfies the Bellman's equation (1); (iii) the wage and the interest rate are the equilibrium clearing prices in the markets for labor and bonds; (iv) the law of motion $H(\mathbf{s})$ is consistent with individual decisions and the stochastic processes for z and ξ.*

3.3 Some characterization of the equilibrium

To illustrate the main properties of the model, we look at some special cases in which the equilibrium can be characterized analytically. Consider first the economy without shocks. We have the following proposition.

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

In a steady state, the first order condition for the bond, equation (7), becomes $\delta R = 1$. Using this condition to eliminate R in (5), 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. Entrepreneurs want to borrow as much as possible because the cost of borrowing—the interest rate—is smaller than their discount rate (the equity premium is positive).

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, so that the interest rate is always smaller than the discount rate of entrepreneurs.

Let's consider now the case with shocks and the utility function takes the special 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, $h_t = (\alpha\gamma/w_t)^{\frac{1}{1-\gamma}}$. If the firm's revenues cannot be diverted, that is, $\phi = 0$, the enforcement constraint becomes $V_t(b_{t+1}) \geq \xi_t$ and credit shocks do not affect labor and production. This is stated formally in the next proposition.

Proposition 3.2 *Suppose that there are not wealth effects on the supply of labor. If the firm revenues cannot be diverted ($\phi = 0$), changes in ξ have no effects on employment and output.*

If firms cannot divert the cash revenues, the demand for labor defined by condition (4) becomes $F_l(z, l) = w$, and therefore, it depends only on the wage rate. Changes in ξ affect the interest rate and the allocation of consumption between workers and entrepreneurs but, without wealth effects in the supply of labor, they do not affect employment and output.

This result no longer holds when the revenue can be diverted. In this case the demand for labor depends on the tightness of the enforcement constraint. An increase in ξ tightens the enforcement constraint restricting the amount of borrowing. The change in the demand for credit impacts on the interest rate. Then using conditions (4) and (5) we can see that the demand for labor changes and this leads to a change in employment and output.

3.4 The economy with mobility of capital

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

To capture different degrees 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 ψN_t. The assumption that the cost depends on the aggregate position of a country instead of individual positions avoids some technical complications. The parameter ψ captures the degree of international capital market integration. When $\psi = 0$ 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 it is the domestic country that incurs the cost. 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 market for international lending.[7]

Denote by n_t the foreign position of an individual worker and b_t the

[7]This does not imply that entrepreneurs cannot own foreign firms. Cross-country ownership of firms is not determined in the model. However, this is not a problem because equilibrium output and employment are independent of the business ownership.

domestic holding. The worker's budget constraint can be written as:

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

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 (6) and (7), we also have the optimality condition for the choice of foreign bonds, which reads:

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

Combining (7) with (8) we get:

$$R_t = \widetilde{R}_t (1 - \psi \cdot N_t),$$

which implies that 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, ξ, $\tilde{z}$, $\tilde{\xi}$, 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 a set of functions for: (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' values $V(\mathbf{s}; b)$ and $\widetilde{V}(\mathbf{s}; b)$; (iv) aggregate prices $w(\mathbf{s})$, $R(\mathbf{s})$, $\tilde{w}(\mathbf{s})$, $\widetilde{R}(\mathbf{s})$; (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) 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 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, ξ, $\tilde{z}$, $\tilde{\xi}$.*

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 $\widetilde{B}^w = \widetilde{B}^f$.

3.5 A numerical example

Before considering the general model with capital accumulation, we show some of the properties numerically. The goal of this section is not to provide a rigorous quantitative analysis but simply to illustrate some of the properties of the model numerically.

We assign the following parameter values. The discount factors are set to $\delta = 0.9925$ and $\beta = 0.9825$. The utility function takes the form $U(c,h) = \ln(c - \alpha h^{\gamma})$ and the value of α is chosen to have $h = 1/3$ in the steady state.

For the parametrization of the revenue function, we set $\nu = 1.5$ and $\eta = 0.606$, implying a mark-up over the average cost of $1/\nu\eta - 1 = 0.1$.

Productivity and credit shocks are independent across countries and they follow the first order Markov processes:

$$\begin{aligned} \log(z_{t+1}) &= \rho_z \log(z_t) + \epsilon_{t+1}, \\ \log(\xi_{t+1}) &= \rho_\xi \log(\xi_t) + \varepsilon_{t+1}, \end{aligned}$$

with $\epsilon \sim N(0, \sigma_z)$ and $\varepsilon \sim N(0, \sigma_\xi)$.

Finally, the enforcement parameter is set to $\phi = 5.5$, which implies a steady state ratio of debt over output of 3.75.

Figure 3 plots the impulse responses of credit, measured TFP and output after an unexpected increase in z (left panel) and a decline in ξ (right panel) in the autarky equilibrium. Both shocks generate a credit and macroeconomic expansion. Measured TFP also increases because, with increasing returns to scale, productivity increases with employment.[8]

We now show how the responses will change after capital markets integration. The top panels of Figure 4 plot the responses of output in both countries when the technology shock arises only in country 1. The open economy version of the model is obtained by setting the cost of foreign holdings close to zero, that is, $\psi \simeq 0$.[9]

When the economies are closed, only the output of country 1 is affected (see left panel). However, with mobility of capital, the output of both coun-

[8] To measure TFP we follow the standard Solow residuals procedure, which is based on the assumption of a constant returns production function. Because the actual production function displays increasing returns, the procedure leads to a mis-measurement of TFP. This is why measured TFP increases after a credit shock even if z stays constant.

[9] We do not set ψ exactly equal to zero because the dynamic system would become unstable. With a positive but small value of ψ, the real variables behave almost identically to the case in which $\psi = 0$ but with stationary b's.

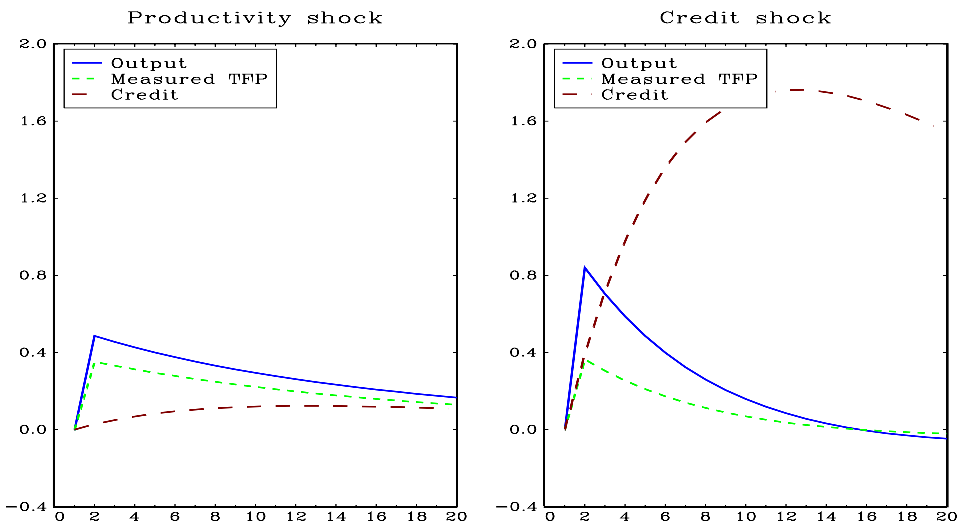


Figure 3: Autarky equilibrium: Impulse responses to an increase in z (left panel) and to a decrease in ξ (right panel).

tries react to the technology shock in country 1 (see right panel). The response in country 2 derives from the increase in the interest rate in response to the technology shock in country 1. The increase in the interest rate derives from the increase in the demand of credit in country 1. However, the response of output in country 2 is relatively small.

The bottom panels of Figure 4 plot the impulse responses to a positive credit market shock (lower ξ) in 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 decrease in ξ in country 1. Even if the shock is in country 1, the output of country 2 increases by a similar 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 forces of the business cycle are either credit shocks or technology shocks. Consistent with the impulse responses shown above, liberalization reduces the macroeconomic volatility in both cases.

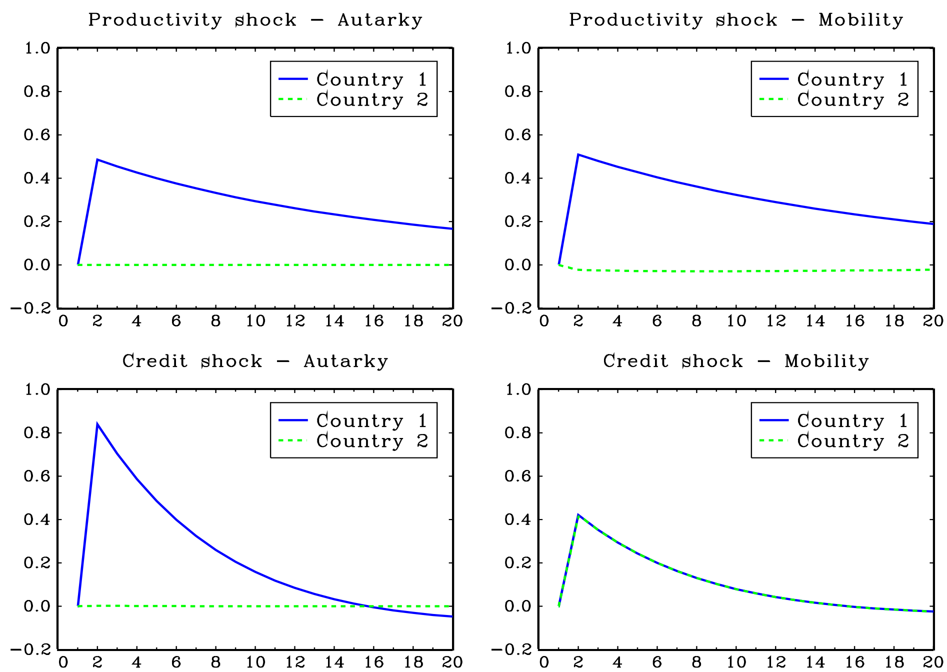


Figure 4: Impulse responses of output to an increase in z (top panels) and a decrease in ξ (bottom panels) with and without capital mobility. The shocks are only in country 1.

However, the stabilization effect is much bigger when credit shocks are the main driving force of the business cycle. With productivity shocks the stabilization effect is almost negligible.

To show the importance of the assumption that shocks are independent across countries, the bottom panel of Table 3 reports the same statistics after assuming that shocks are partially correlated across countries. We assume a correlation of 0.5. As can be seen from the table, the reduction in volatility induced by capital markets liberalization is smaller when shocks are correlated across countries. However, for the case of credit shocks, the reduction is still sizable.

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).

	Productivity shocks			**Credit shocks**		
	Autarky	*Mobility*	*Ratio*	*Autarky*	*Mobility*	*Ratio*
(a) Shocks are independent across countries						
St.Dev. Output	1.43	1.56	1.09	1.50	1.06	0.71
St.Dev. Productivity	1.07	1.13	1.05	0.65	0.46	0.71
Corr. Output	0.00	-.16		0.00	1.00	
Corr. Productivity	0.00	-.10		0.00	1.00	
(a) Shocks are correlated across countries						
St.Dev. Output	1.43	1.50	1.05	1.51	1.31	0.86
St.Dev. Productivity	1.07	1.10	1.03	0.65	0.57	0.86
Corr. Output	0.50	0.36		0.50	1.00	
Corr. Productivity	0.50	0.42		0.50	1.00	

4 General model with capital accumulation

Production sector: There are two production inputs, physical capital k_t and labor l_t. The production function of an individual firm takes the form $x_t = z_t(k_t^\theta l_t^{1-\theta})^\nu$. Beyond the addition of capital as an input of production, the market structure and revenue function are the same as in Section 3.2. In particular,

$$F(z_t, k_t, l_t) = Y_t^{1-\eta}\left(z_t(k_t^\theta l_t^{1-\theta})^\nu\right)^\eta,$$

where Y_t is aggregate production, z_t aggregate productivity, k_t and l_t the individual production inputs.

We assume that physical capital is accumulated by households-workers who rent it to firms at the market rate r_t. The alternative assumption that capital is owned by firms instead of workers would not make a difference. The only reason to make this assumption is to keep the problem of the firm as close as possible to the problem studied in the previous sections. The budget constraint for the firm is:

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

and the enforcement constraint

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

Therefore, besides adding the input of capital k_t as an additional choice variable, the problem of the firm remains the same as in Problem (1). The first order condition for the choice of k is:

$$F_k(z, k, l) = \frac{r}{1 - \mu\phi}. \tag{9}$$

The optimality conditions for the choices of labor, l_t, and debt, b_{t+1}, remain (4) and (5).

Households/Workers: Physical capital is accumulated by households/workers which is then rented to firms at the rental rate r_t. The budget constraint for households/workers is:

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

where τ is the rate of depreciation for physical capital.

We now have an additional first order condition determining the optimal choice of physical capital, which is given by:

$$\delta E_t \left\{ \frac{(1 - \tau + r_{t+1})U_c(c_{t+1}, h_{t+1})}{U_c(c_t, h_t)} \right\} = 1. \tag{10}$$

The optimality conditions for the choices of labor h_t, domestic bonds b_{t+1} and foreign holdings n_{t+1}, are still given by (6), (7) and (8).

5 Estimation and simulation

The main goal of the paper is to quantify the contribution of capital markets liberalization for the volatility of output. Following is the description of the quantitative exercise.

The common view is that the mobility of capital in international markets was very low before the 1980s and significantly liberalized after that. This has been documented by Obstfeld & Taylor (2004) among others. Consistent with this interpretation, we assume that the pre-1980 period is well approximated by the autarky regime. We then use data for the period 1947 to 1983 to parameterize the model in the autarky regime. Of course, saying that the pre-1980 period is well approximated by the autarky regime does not mean that countries did not have foreign asset positions. What we want to capture is that the foreign positions were not very responsive to changing market conditions.

In principle we could also estimate the model in the regime with capital mobility. However, this poses a significant challenge because it will require a choice of which countries to include in the estimation. In the autarky regime, instead, we can look at each country abstracting from the others. We concentrate on the first country which is representative of the US economy.

After the estimation of the autarky model for the period 1947-1983, we study how the business cycle properties of the model would change after the liberalization of capital markets. This is a counterfactual experiment that answers the following question: Suppose that the US economy gets fully integrated with a country that has the same size and characteristics. What would be the implications for the business cycle of the US and of the other country? Because this is a counterfactual experiment, the it is not meant to replicate the data observed starting from the early 1980s. This is because the international liberalization of capital markets is not the only change that have taken place during this period. Nevertheless, the exercise provides some insights on the direction in which certain properties of the data should have changed in the most recent period as a result of the financial globalization.

5.1 Estimation

We distinguish two sets of parameters. The first set includes parameters that can be pinned down using steady state targets. For this first group of parameters we use the standard calibration technique.

The second set includes parameters that cannot be fixed using steady state targets. These parameters are structurally estimated using Bayesian methods as described in An & Schorfheide (2007). Because we have two shocks, z and ξ, we can use at most two data series to estimate the autarky version of the model. We use Gross Domestic Product and Domestic Investment.

Notice that the preliminary calibration of the first set of parameters conducted before the structural estimation is equivalent to estimating all parameters with the choice of prior densities for the first group concentrated around the calibration values.

Calibrated parameters: 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 about 3%. The real return for stocks is determined by the discount factor for entrepreneurs, which we set to the quarterly value of $\beta = 0.9825$. This implies a yearly return of about 7%.

The utility function takes the log form $U(c, h) = \ln(c) + \alpha \ln(1-h)$, which $\alpha = 0.365$. This implies a steady state value of hours equal to 1/3.

The parameter ϕ affects the enforcement of contracts. Higher is the value of ϕ and lower is the leverage. We choose ϕ to have a steady state ratio of debt over physical capital of 0.4. The required value is $\phi = 5.2$.[10]

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. Because the individual determination of ν and η cannot be done using steady state targets, we include ν in the set of estimated parameters. Essentially, we will use the cyclical predictions of the model to parameterize the return to scale parameter together with the other estimated parameters as described below. Once we have ν, the condition $\nu\eta = 0.9$ will determine the demand parameter η.

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 $\eta\nu(1-\theta)[1 + \phi(1 - \delta/\beta)]$. Given $\eta\nu = 0.9$, $\phi = 5.2$, $\delta = 9925$ and $\beta = 0.9825$, the required value of θ is 0.296. The final parameter that is calibrated is the depreciation rate for physical capital. This is set to the typical value of $\tau = 0.02$.

Estimated parameters The parameters that remain to be pinned down are those determining the stochastic properties of the two shocks, z and ξ, and the return to scale ν.

The productivity and credit shocks are independent from each other and they both follow a first order autoregressive process, that is:

$$\begin{aligned} \log(z_{t+1}) &= \rho_z \log(z_t) + \epsilon_{t+1}, \\ \log(\xi_{t+1}) &= \rho_\xi \log(\xi_t) + \varepsilon_{t+1}, \end{aligned}$$

[10] Notice that the leverage also depends on other parameters. Therefore, the required value of ϕ is chosen through an iterative procedure: We choose ϕ, pin down all the other parameters, solve for the steady state and verify that the leverage ratio is 0.4.

where $\epsilon \sim N(0, \sigma_z)$ and $\varepsilon \sim N(0, \sigma_\xi)$.

Given the processes for the two shocks we have four unknown parameters: ρ_z, σ_z, ρ_ξ, σ_ξ. Therefore, together with ν, we estimate five parameters.

In any Bayesian estimation a central step is the choice of the priors densities. In making this choice we want to impose as little restrictions as possible. This is accomplished by choosing uniform densities with boundaries dictated by technical restrictions. For the parameters ρ_z and ρ_ξ the boundaries are -0.99 and 0.99. These boundaries will keep the dynamic system stationary. For σ_z and σ_ξ the boundaries of the uniform are 0.00001 and 0.5. The range is sufficiently wide that, in essence, there are no restrictions imposed in the estimation. Finally, the boundaries for the return to scale parameter ν are 1 and 2. The lower bound corresponds to the case of constant returns. The upper bound of 2 is imposed to keep the system stable. In fact, for values of ν above a certain threshold, the dynamic system becomes unstable. Given the values of the parameters calibrated above, the upper bound of 2 guarantees that the autarky equilibrium is stable.

The whole set of parameter values are reported in Table 4. For the estimated parameters, we report the mode and the threshold values for the 5 and 95 percentiles of the posterior distributions. The table also reports the prior densities.

Table 4: List of parameters.

Calibrated parameters				
Discount factor for households/workers, δ	0.9925			
Discount factor for entrepreneurs, β	0.9825			
Utility parameter, α	0.3650			
Production technology, θ	0.2960			
Depreciation rate, τ	0.0200			
Demand elasticity, ν	0.5215			
Enforcement parameter, ϕ	5.2000			
Estimated parameters	*Prior*	*Mode*	*Percentile*	
			5%	*95%*
Returns to scale, ν	U[1,2]	1.7258	1.6778	1.7590
Productivity persistence, ρ_z	U[-0.99,0.99]	0.9403	0.9102	0.9688
Productivity volatility, σ_z	U[0.00001,0.5]	0.0025	0.0019	0.0036
Credit persistence, ρ_ξ	U[-0.99,0.99]	0.9900	0.9900	0.9900
Credit volatility, σ_ξ	U[0.00001,0.1]	0.0314	0.0284	0.0349

5.2 Simulations

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.

Table 5 reports the standard deviations of several variables under the autarky regime and under the regime with capital mobility. The numbers are averages of the standard deviations from the posterior distribution. To compute these averages, we make 100,000 draws of parameters from the posterior distribution using the Random-Walk Metropolis algorithm and compute the standard deviation of the relevant macroeconomic variables for each draw.

Table 5: Standard deviation of growth for major macroeconomic variables under different international capital markets regimes.

	Autarky	**Mobility**	$\frac{\textbf{Mobility}}{\textbf{Autarky}}$
Output	1.37	1.02	0.75
Measured TFP	0.77	0.58	0.76
Labor	1.02	0.75	0.74
Investment	5.54	4.62	0.83

Notes: The statistics are generated by averaging the standard deviations associated with 100,000 draws of parameters from the posterior distribution.

Capital markets liberalization leads to a sizable reduction in the volatility of the major macroeconomic variables. The reduction in the volatility of domestic output, measured TFP and labor is about 25 percent. The volatility of domestic investment also falls but by a smaller amount, about 17 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 liberalization. The statistics are reported in Table 6. As for the standard deviations, the statistics are computed by averaging the numbers obtained for each of the 100,000 draws from the posterior distribution of the estimated parameters.

Both shocks contribute significantly to the volatility of the major macroeconomic variables. In the autarky regime, credit shocks contributes more than 50% to the volatility of domestic output, measured TFP and labor. The volatility of investment, instead, is mostly driven by productivity shocks.

Table 6: Decomposition of variance for the growth rates of major macroeconomic variables under different international capital markets regimes.

	Autarky		**Mobility**			
	z shock	*ξ shock*	*z shock*	*$\tilde{z}$ shock*	*ξ shock*	*$\tilde{\xi}$ shock*
Output	0.32	0.68	0.24	0.10	0.49	0.17
Measured TFP	0.45	0.55	0.40	0.07	0.39	0.14
Labor	0.16	0.83	0.06	0.12	0.61	0.21
Investment	0.88	0.12	0.84	0.05	0.10	0.01

Notes: The statistics are generated by averaging the variance decomposition associated with 100,000 draws of parameters from the posterior distribution.

The contribution of credit shocks is only 12 percent. Once the economy becomes integrated in the world financial markets, the contribution of domestic shocks, z and ξ, decline. However, the economy is also affected by foreign shocks, $\tilde{x}$ and $\tilde{z}$. Foreign shocks account for more than 20 percent of the volatility of domestic output, measure TFP and labor. The contribution to domestic investment is smaller, about 6 percent.

The result that credit shocks contribute significantly to business cycle fluctuations is consistent with the findings of Christiano, Motto, & Rostagno (2008). They estimate a model with multiple shocks, including a shock to the financial sector, and find that the financial shock accounts for a significant portion of the business cycle fluctuations.[11]

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 correlated, the net effect is a significant reduction in aggregate volatility. In the case of integration between two countries of the same size and characteristics, the reduction in the volatility of output is about 25 percent.

[11]The model and the financial shock used in Christiano et al. (2008) are different from our. However, in spite of the differences, the macroeconomic effects of the financial shock are similar to the macroeconomic effects of our credit shock.

5.3 Sensitivity

To investigate the sensitivity of the results to the choice of some of the parameter specifications, we re-estimate and simulate the model after choosing alternative values for these parameters. First we change the enforcement parameter ϕ by targeting a different leverage. In the baseline model we imposed the steady state leverage to be $b/k = 0.4$. Now we increase it to 0.5. The other parameters are also changed to obtain the same calibration targets as in the baseline model.

The top section of Table 7 reports the standard deviations for the major macroeconomic variables and the top section of Table 8 reports the numbers for the decomposition of variance. As can be seen from the tables, the results are very similar to the baseline model.

Table 7: Standard deviation of growth for major macroeconomic variables under different international capital markets regimes.

	Autarky	**Mobility**	$\frac{\textbf{Mobility}}{\textbf{Autarky}}$
A) Leverage is $b/k = 0.5$			
Output	1.42	1.07	0.75
measured TFP	0.82	0.62	0.76
Labor	1.02	0.76	0.74
Investment	5.57	4.75	0.85
B) Concavity of revenues is $\nu\eta = 0.95$			
Output	1.80	1.44	0.97
Measured TFP	1.11	0.89	0.72
Labor	1.14	0.90	0.68
Investment	6.94	6.90	0.86

Notes: The statistics are generated by averaging the standard deviations associated with 100,000 draws of parameters from the posterior distribution.

Next we consider a different concavity of the revenue function which is given by $\nu\eta$. In the baseline model we set $\nu\eta = 0.9$. Now we consider a value of 0.95. Therefore, the price mark-up will change from 10 to 5 percent. In making this change we must also change the parameter ϕ to keep the leverage to the baseline target of $b/k = 0.4$. Again, we re-estimate and simulate the model. The results are reported in the bottom sections of Tables 7 and 8.

Table 8: Decomposition of variance for the growth rates of major macroeconomic variables under different international capital markets regimes.

	Autarky		**Mobility**			
	z shock	*ξ shock*	*z shock*	*$\tilde{z}$ shock*	*ξ shock*	*$\tilde{\xi}$ shock*
A) Higher leverage: $b/k = 0.5$						
Output	0.36	0.64	0.28	0.10	0.48	0.14
Measured TFP	0.48	0.52	0.43	0.08	0.38	0.11
Labor	0.22	0.78	0.10	0.12	0.60	0.18
Investment	0.92	0.08	0.88	0.04	0.07	0.01
B) Lower concavity of revenues: $\nu\eta = 0.95$						
Output	0.70	0.30	0.53	0.17	0.26	0.04
Measured TFP	0.78	0.22	0.66	0.12	0.19	0.03
Labor	0.60	0.40	0.33	0.24	0.38	0.05
Investment	0.25	0.75	0.56	0.06	0.19	0.19

Notes: The statistics are generated by averaging the variance decomposition associated with 100,000 draws of parameters from the posterior distribution.

Qualitatively, the properties of the model do not change, although there are some quantitative changes. The most important quantitative change is that the volatility of investment changes very little before and after capital markets liberalization. However, the volatility of domestic output, measure TFP and labor do change significantly following the international capital markets liberalization.

6 Conclusion

The majority of OECD countries has experienced a decline in the volatility of GDP during the past two and a half decades. This change is concomitant to a process of capital account liberalization also experienced by these countries. We have shown that, among the OECD countries, the standard deviation of GDP growth is negatively correlated with indicators of capital account liberalization. Motivated by these findings, we asked whether international capital markets liberalization can lead a country to display lower macroeconomic volatility.

To address this question we have considered an economic environment in which shocks to credit is one of the driving forces of the business cycle, together with a standard productivity shock. Credit shocks 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 contraction of credit.

Within this framework we have shown that international financial liberalization leads to lower output volatility. This is consistent with the empirical evidence shown in the first part of the paper. Of course, the international liberalization of capital markets is not the only structural change that have taken place during the past two and a half decades. For example, some authors have emphasized innovations in domestic financial markets. See Campbell & Hercowitz (2005), Guerrieri & Lorenzoni (2008) and Jermann & Quadrini (2006). This is in addition to other structural changes that have taken place during the same period. Therefore, the contribution of financial globalization should be considered complementary to other possible explanations of the great moderation proposed in the literature.

Capital market liberalization also leads to greater output co-movement among the integrating countries as independent shocks in one country affect, positively, the output of other countries. Therefore, the paper also provides a theory of cross-country contagion of credit shocks which is made possible by the international liberalization of capital markets. The model prediction of higher cross-country co-movement following liberalization, at least among advanced economies, is consistent with the findings of recent empirical studies, such as, Artis & Okubo (2008), Kose et al. (2008) and Imbs (2006).

Appendix

A Debt renegotiation

Suppose that, in case of renegotiation, the lender can confiscate the firm and sell the equity to other entrepreneurs at a cost κ_t. However, the price obtained through the sale is only a fraction $1 - \chi < 1$ of the original value of equity, that is, $(1 - \chi)V_t(b_{t+1})$.

If the parties reach an agrement, the lender receives a payment T_t from the entrepreneur and leaves the debt b_{t+1} for the next period. The value received by the entrepreneur from the renegotiation is $V_t(b_{t+1}) - T_t$. Without renegotiation agrement the entrepreneur gets zero. For the lender, the value received under renegotiation is T_t. Without renegotiation it will be the liquidation value $(1 - \chi)V_t(b_{t+1}) - \kappa_t$. Notice that, independently of whether the lender reaches an agrement or not, it will receive b_{t+1} in the next period.

The bargaining problem is:

$$\max_{T_t} \Big[V_t(b_{t+1}) - T_t\Big]^{\varsigma} \Big[T_t - (1 - \chi)V_t(b_{t+1}) + \kappa_t\Big]^{1-\varsigma},$$

where ς is the bargaining power of the entrepreneur.

The first order conditions are:

$$-\varsigma\Big[T_t - (1 - \chi)V_t(b_{t+1}) + \kappa_t\Big] + (1 - \varsigma)[V_t(b_{t+1}) - T_t\Big] = 0$$

Solving the first order condition for the transfer we get:

$$T_t = \Big[1 - \varsigma + \varsigma(1 - \chi)\Big]V_t(b_{t+1}) - \varsigma\kappa_t$$

Therefore, the renegotiation value received by the entrepreneur is:

$$V_t(b_{t+1}) - T_t = \chi\varsigma V_t(b_{t+1}) + \varsigma\kappa_t.$$

This is in addition to the diverted revenue that the entrepreneur receives independently of the renegotiation outcome. Therefore, the total value from defaulting is $F(z_t, l_t) + \chi\varsigma V_t(b_{t+1}) + \varsigma\kappa_t$. This cannot be smaller than the value of not defaulting, that is,

$$V_t(b_{t+1}) \geq F(z_t, l_t) + \chi\varsigma V_t(b_{t+1}) + \varsigma\kappa_t$$

Collecting terms and re-arranging we get:

$$V_t(b_{t+1}) \geq \phi \cdot F(z_t, l_t) + \xi_t$$

where $\phi = 1/(1-\chi\varsigma)$ and $\xi_t = \varsigma\kappa_t/(1-\chi\varsigma)$. In the main body of the paper we have considered the special case in which the entrepreneur has the whole bargaining power, that is, $\varsigma = 1$. This is without loss of generality: as long as $\varsigma > 0$, the enforcement constraint takes exactly the same form.

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:

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

The envelope condition is:

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

The above conditions can be re-arranged as in (4) and (5).

C Dynamic system

We have to solve for the variables k_{t+1}, b_{t+1}, n_{t+1}, μ_t, r_t, w_t, h_t, c_t, d_t, V_t, R_t in country 1 and for the corresponding variables in country 2 as a function of the states, z_t, ξ_t, k_t, b_t, n_t, in country 1 and for the corresponding states in country 2. Therefore, we have 22 unknowns. To solve for these functions we linearize a system of 22 equations. The 22 equations are as follows. First we have 10 equations from country 1:

$$\begin{aligned} &U_c(c_t,h_t)w_t + U_h(c_t,h_t) = 0 \\ &U_c(c_t,h_t) - \delta R_t E U_c(c_{t+1},h_{t+1}) = 0 \\ &U_c(c_t,h_t) - \delta E U_c(c_{t+1},h_{t+1})(1-\tau+r_t) = 0 \end{aligned}$$

$$
\begin{aligned}
& w_t h_t + (1-\tau+r_t)k_t + b_t + n_t(1-\psi n_t) - c_t - k_{t+1} - \frac{b_{t+1}}{R_t} - \frac{n_{t+1}}{\tilde{R}_t} = 0 \\
& F_k(z_t, k_t, h_t) - \frac{r_t}{1-\phi\mu_t} = 0 \\
& F_l(z_t, k_t, h_t) - \frac{w_t}{1-\phi\mu_t} = 0 \\
& (1+\mu_t)\beta R_t - 1 = 0 \\
& b_t + d_t - \frac{b_{t+1}}{R_t} - F(z_t, k_t, h_t) + r_t k_t + w_t h_t = 0 \\
& \beta E V_{t+1} - \phi F(z_t, k_t, h_t) - \xi_t = 0 \\
& d_t + \beta E V_{t+1} - V_t = 0.
\end{aligned}
$$

We also have 10 corresponding equations from country 2, bringing the total number of equations to 20. The last two equations, closing the system, are the conditions for the equilibrium in the international market,

$$
\begin{aligned}
& R_t - (1-\psi n_{t+1})\widetilde{R}_t = 0 \\
& n_t + \tilde{n}_t = 0.
\end{aligned}
$$

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