

# Macroeconomic Volatility after Trade and Capital Account Liberalization\*

Cosimo Pancaro<sup>†</sup>

European University Institute

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## Abstract

What are the equilibrium effects of trade and capital liberalization on consumption smoothing? This question is addressed by studying the response to productivity shocks in a baseline two country, two goods, incomplete market model, where foreign borrowing is secured by collateral. We show that international financial integration, modeled by relaxing a borrowing constraint a la Kiyotaki in the domestic country, worsens consumption smoothing; international trade integration, modeled by a reduction of non linear iceberg transportation costs, improves it. As a measure of consumption smoothing we use the ratio between the simulated standard deviation of consumption growth and the simulated standard deviation of output growth. These results are qualitatively consistent with the empirical evidence provided by Kose, Prasad and Terrones (2005).

*Keywords:* International business cycles, capital account liberalization, trade liberalization.

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<sup>†</sup>Cosimo Pancaro, Department of Economics, European University Institute, Villa San Paolo, Via della Piazzuola 43, 50133 Florence, Italy. Email: cosimo.pancaro@eui.eu.

# 1 Introduction

The process of globalization involves the integration of goods and financial markets across countries. In the last decades the world economy has continued to become more open to trade and there has been an impressive raise in the volume and in the value of financial flows which has implied an increase in the degree of financial integration. This growing process of integration has opened a debate among economists on the costs and benefits of globalization. As regard trade integration, there is a widespread consensus on its positive effects on economic development. A vast empirical literature proves the existence of a positive relationship between trade liberalization and economic growth. Openness to trade reduces the price of goods and factors, increases their availability and produces incentives for investment and innovation. As regard as financial integration, advanced economies has certainly gained from international financial integration in terms of a more efficient allocation of capital and in terms of better risk sharing opportunities but the evidence for emerging markets is more controversial. There is a diffused perception that developing countries, that opened up to capital flows, have been more vulnerable to crises. Thus understanding the impact of financial and trade liberalization on macroeconomic volatility is a major challenge for the economic literature.

In this paper we address this issue for emerging markets from a theoretical point of view. We show that capital liberalization raises the volatility of consumption and it worsens consumption smoothing, i.e. increases the volatility of consumption relative to that of output. Instead trade liberalization improves consumption smoothing, i.e. reduces the volatility of consumption relative to that of output. These results are qualitatively consistent with the empirical evidence provided by Kose, Prasad and Terrones (2005).

We specify a 2 country, 2 goods, international real business cycle model built upon Heathcote and Perri (2002). In this model a single non-contingent bond is traded and foreign borrowing is secured by a collateral, which is represented by the local real estate. Agents in country 1, which models an emerging economy and is defined as Home, are subject to a borrowing constraint a' la Kiyotaki. Through the introduction of this constraint on international borrowing, we capture the imperfect integration of international financial markets. By introducing in the standard framework quadratic iceberg costs on the international trade of intermediate inputs, we model trade liberalization.

Relaxing the borrowing constraint, which corresponds to an increase in the degree of capital openness, makes the access to funds easier and works as a positive income shock. Since in this model, borrowers in the domestic country are impatient, a positive income shock leads to an increase in borrowing, raises consumption and the demand for the real estate. In turn the price of the real estate goes up and hence its value increases. A higher value of collateral relaxes the borrowing limit, increases the availability of loans and raises further the demand for the real estate. Overall this effect translates into a rise in the volatility of consumption and in the relative volatility of consumption to output, in response to a productivity shock.

On the other hand, trade costs introduce a wedge between the Home and the Foreign price of the domestic input. In presence of trade frictions, a productivity shock causes the Foreign price of the domestic input to decline relatively less than its Home price. Thus the improvement in the Foreign's terms of trade is larger when transport costs are brought to zero, i.e. in the case of free trade. This implies that the response of Foreign employment, investment, output and consumption is larger under free trade. Trade liberalization produces an amplification mechanism which leads to a stronger response of domestic employment, investment, output but not of consumption. Under free trade, the reaction of consumption is weaker because a higher portion of the wealth effect, led by the productivity shock, is transmitted to the foreign country through the larger worsening of the domestic terms of trade. Consequently trade integration induces a decline in the relative volatility of consumption to output.

Since the relative volatility of consumption to output is a measure of the efficacy of consumption smoothing relative to output volatility, the evidence for emerging markets suggests that a deeper financial integration worsens consumption smoothing whereas trade liberalization improves it. Hence the results of this literature, consistent with those from the present model, suggest that financial and trade liberalization should go hand in hand.

The rest of the paper is organized as follows. Section 2 illustrates the related literature, section 3 examines the stylized facts, section 4 describes the model, section 5 shows the baseline values used in the calibration, section 6 explains the results and finally section 7 summarizes the main conclusions of the paper.

## 2 Related Literature

This paper is related to different strands of the empirical and theoretical literature on international economic integration.

There are several empirical papers that study the links between openness and macroeconomic volatility.

Gavin and Hausmann (1996) study the sources of output volatility in developing countries over the period 1970-1992. They find that there is a significant positive association between the volatility of capital flows and output volatility. Bekaert, Harvey and Lundblad (2002) and Kose, Prasad and Terrones (2005) find that an increase in financial openness tends to increase consumption volatility (even relative to that of output) in emerging markets. These studies stress the role of limited international risk sharing for economies whose financial markets are characterized by strong informational asymmetries and poor financial development.

Karras and Song (1996) suggest that trade openness is positively associated with output volatility in 24 OECD countries. Easterly, Islam and Stiglitz (2001) explore the sources of output volatility using data for a sample of 74 countries over the period 1960-97. They find that an increase in the degree of trade openness leads to an increase in the volatility of output, especially in emerging

countries. Bejan (2006) shows that trade openness increases output volatility in developing countries. Kose, Prasad and Terrones (2005) find that an increase in trade openness tends to increase output volatility and to decrease the volatility of consumption relative to that of output.

There are also many papers that address the relationship between openness and macroeconomic volatility from a theoretical point of view.

Aghion, Bacchetta and Banerjee (2004), using a dynamic open economy model, show that capital account liberalization has a negative effect in terms of volatility of output for a small country at intermediate level of financial development. In their analysis, they mainly focus on the volatility of investment and output, and do not discuss the implications for consumption. Evans and Hnatkovska (2007) study the effects of financial integration on macroeconomic volatility and welfare. They examine a two-sector, two-country world economy with production in which both stocks and bonds are traded internationally, but markets are incomplete. The model predicts a non-monotonic relationship between the degree of financial integration and the volatility of several macroeconomic variables. Greater integration is initially associated with more volatile consumption and output, but as integration proceeds further volatility declines. Faia (2008) uses a small open economy model where foreign lending to households is constrained. Borrowing is secured by collateral in the form of durable investment whose accumulation is subject to adjustment costs. In this economy an increase in the degree of capital account liberalization increases consumption volatility as agents are unable to exploit risk-sharing opportunities. In presence of risk averse agents an increase in financial integration reduces welfare<sup>1</sup>.

In the theoretical literature, the impact of trade integration on macroeconomic volatility depends greatly on patterns of trade specialization and the nature of shocks. If trade openness is associated with increased inter-industry specialization across countries and industry-specific shocks are important in driving business cycles, the result could be a rise in output volatility (Krugman (1993)). If these shocks are highly persistent, then they could increase the volatility of consumption as well. However if increased trade is associated with increased intra-industry specialization across countries, which leads to a larger volume of intermediate inputs trade, then the volatility of output could decline (Razin and Rose (1994)). Moreover Kraay and Ventura (2002), in a Ricardian model with complete markets show that a cut in transport costs implies an increase in the volatility of the trade balance.

### 3 Stylized Facts

In this section we first give some statistics about the developments of trade and financial integration in the past years and then we illustrate the empirical results

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<sup>1</sup>Broner and Ventura (2008), Leblebicioglu (2008) and Levchenko (2005) also show that financial liberalization causes an increase in consumption volatility.

of Kose, Prasad, Terrones (2005) which are consistent with the main results of our model.

In the past decades the growth of world trade has been higher than the growth of world output and it has averaged 6% per year. Emerging markets and developing economies have become much more important in world trade. In the last twenty years, the expansion in goods' trade has been stronger for emerging and developing economies than for advanced countries. Their share of world trade has substantially increased up to 40% in 2006. On the other side, the growth pace of cross border asset trade has been more gradual for emerging and developing economies than for advanced countries. If we measure international financial integration as the sum of the stock of external assets and liabilities over gdp, we see that the value of this ratio has increased from 45% in 1970 to 300% in 2004 for advanced economies, while for emerging and developing economies the value of this same ratio has increased from the same starting point to 150%<sup>2</sup>.

Kose, Prasad, Terrones (2005) examine the role of trade and financial openness in driving the patterns of macroeconomic volatility in a large group of countries both industrial and developing economies over the period 1960-1999. Their results suggest that trade openness is positively correlated with volatility suggesting that more open economies are more vulnerable to external shocks. Notwithstanding a higher degree of trade integration implies a higher volatility of both consumption and output, it has a negative effect on the ratio of the volatility of consumption growth to that of output growth volatility. This ratio is taken as a measure for consumption smoothness. Financial openness has a positive effect on output (this coefficients is only marginally significant), consumption and relative consumption volatility. Moreover their results suggest that there is a non linear relationship between capital account liberalization, consumption and relative consumption volatility since the coefficient on the quadratic term has a negative sign. This means that higher financial openness implies a higher volatility but only up to a certain threshold.

## 4 The model

Our model is a 2 country, 2 goods, incomplete market model built upon Heathcote and Perri (2002). In this model a single non-contingent bond is traded and borrowing is secured by a collateral which is represented by the local real estate. Agents in country 1, which models an emerging economy and is defined as Home, are subject to a borrowing constraint a' la Kiyotaki. Through the introduction of this constraint on international borrowing we capture the imperfect integration of international financial markets. By introducing in the standard framework quadratic iceberg costs on the international trade of intermediate inputs we model trade liberalization.

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<sup>2</sup>Lane and Milesi-Ferretti (2001) and Lane Milesi-Ferretti (2008).

## 4.1 Preferences

Both countries are inhabited by a large number of identical, infinitely lived households. The agents in each country are represented by a stand-in agent who derives utility from consumption of the final good ( $c_{it}$ ) and local real estate service ( $\bar{h}_{it}$ ) and derives disutility from supplying labour ( $n_{it}$ ).  $\bar{h}_{it}$  is fixed in supply and does not depreciate over time. The representative agent's life time expected utility at date 0 ( $U_0$ ) is defined as:

$$U_0 = E_0 \left\{ \sum_{t=0}^{\infty} \beta_i^t \left[ \ln c_{it} + j \ln \bar{h}_{it} - \frac{k}{\eta} n_{it}^\eta \right] \right\} \quad (1)$$

$$i = 1, 2; \quad 0 < \beta_1 < \beta_2 < 1; \quad j, k, \eta > 0$$

where  $j$  is the weight of housing,  $\eta$  is the parameter of labor disutility and  $\beta_1, \beta_2$  are the subjective discount factors. We assume that  $\beta_1 < \beta_2$ . This assumption guarantees that the domestic agent is impatient. However the reason and the implications of this assumption are explained better in paragraph 4.5.

## 4.2 The intermediate goods sector

In both countries there are 2 sectors: a traded intermediate goods producing sector and a non traded final goods producing sector. Each country is completely specialized in producing an intermediate good. The international trade of intermediate inputs is subject to quadratic iceberg costs.

Households supply labor and rent capital to perfectly competitive intermediate-goods producing firms. Neither capital ( $k_{it}$ ) nor labor is internationally mobile. Intermediate firms in country 1 produce one intermediate good called  $a$ , while those in country 2 produce a different intermediate good called  $b$ . These goods are produced by firms according to a Cobb-Douglas production function:

$$F(z_{it}, k_{it}, n_{it}) = z_{it} k_{it}^\theta n_{it}^{1-\theta}; \quad i = 1, 2; \quad 0 < \theta < 1 \quad (2)$$

where  $z_{it}$  is an exogenous technology shock and  $\theta$  is the capital share in output.

We assume that domestic and foreign technologies,  $\mathbf{z}_t = [z_{1t}, z_{2t}]$  have the following process:

$$\mathbf{z}_t = \mathbf{A}\mathbf{z}_{t-1} + \boldsymbol{\varepsilon}_t \quad (3)$$

where  $\mathbf{A}$  is a 2x2 matrix, and  $\boldsymbol{\varepsilon}_t$  is a 2x1 vector of independently distributed random variables with variance covariance matrix  $\Sigma$ .

The problem of the intermediate good firms is given by:

$$\max_{k_{1t}, n_{1t}} \{q_{1t}^a F(z_{1t}, k_{1t}, n_{1t}) - w_{1t} n_{1t} - r_{1t} k_{1t}\} \quad (4)$$

$$\max_{k_{2t}, n_{2t}} \{q_{2t}^b F(z_{2t}, k_{2t}, n_{2t}) - w_{2t}n_{2t} - r_{2t}k_{2t}\} \quad (5)$$

$w_{it}$  and  $r_{it}$  denote the wage rate and the rental rate of capital in country  $i$  in terms of the final good in country 1.  $q_{it}^a, q_{it}^b$ , are the prices of goods  $a$  and  $b$  in country  $i$ , in units of the final good produced in country 1. We call  $q_{1t}^a$  and  $q_{2t}^b$  the f.o.b. (free on board) or factory gate prices of the intermediate goods produced in country 1 and 2 whereas we call  $q_{1t}^b$  and  $q_{2t}^a$  the c.i.f. (cost, insurance, freight) prices of the intermediate goods produced in country 2 and 1 and imported by country 1 and 2. Intermediate goods are sold on to final good producers in both countries.

### 4.3 Trade Costs

Trade liberalization is modeled by introducing trade costs on the exports of the intermediate good to the other country. These costs are a stand-in for tariffs and other non-tariff barriers, as well as transportation costs. Following Kose, Yi (2006), we model the trade costs as quadratic iceberg costs. This formulation of transport costs generalizes the standard linear iceberg specification and takes into account that transportation costs become higher as the amount of traded goods gets larger. Moreover we need to use quadratic costs because our linearization solution procedure eliminates any marginal impact of the usual linear or proportional costs. Specifically, if country 1 exports  $a_2$  units to country 2,  $\tau(a_2)^2$  units are lost in transit, where  $\tau$  is the transport cost parameter. That is, only  $(1 - \tau a_2)a_2$  units are imported by country 2. We think of  $\tau a_2$  as the iceberg trade cost; it is the fraction of the exported goods that are lost in transit. As we will explain in the next paragraphs,  $\tau$  is a key parameter in our analysis since different values of  $\tau$  correspond to different levels of trade integration. A lower  $\tau$  implies a deeper trade integration. Analogous is the case for the trade of good  $b$  from country 2 to country 1. If we think of imaginary transportation firms, we can say that the firms providing the transportation services pay the exporting country the f.o.b. (free on board) price of the good, and then receive the c.i.f. (cost, insurance, freight) price from the importing country. We assume that the households in the exporting country own these firms and hence the firms profits are distributed to the household as dividends.

### 4.4 The final goods sector

The final good, which is the consumption good, is produced by using both the domestic and the foreign intermediate inputs. Final goods firms are perfectly competitive and assemble intermediate goods produced both domestically and abroad via an Armington aggregator. Let  $a_{it}$  and  $b_{it}$  denote the uses of both the two intermediate goods in country  $i$ , originally produced in country 1 and 2, respectively. Final goods are used for consumption and investment. The final goods are produced on the basis of the following constant returns to scale technology:

$$G_{1t} = \left\{ \omega_1 a_{1t}^{\frac{\sigma-1}{\sigma}} + (1 - \omega_1) [(1 - \tau b_{1t}) b_{1t}]^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}} \quad (6)$$

$$G_{2t} = \left\{ (1 - \omega_2) [(1 - \tau a_{2t}) a_{2t}]^{\frac{\sigma-1}{\sigma}} + \omega_2 b_{2t}^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}} \quad (7)$$

where  $\sigma$  measures the elasticity of substitution between domestic and foreign goods. The parameter  $\omega_i > 0.5$  determines the extent to which there is a home bias in the composition of domestically produced final goods in country  $i$ .

The final firm's problem in country 1 is:

$$\max_{a_{1t}, b_{1t}} \{ p_{1t} G_{1t} - q_{1t}^a a_{1t} - q_{1t}^b [(1 - \tau b_{1t}) b_{1t}] \} \quad (8)$$

$$s.t. a_{1t}, b_{1t} > 0$$

where  $p_{1t}$  is the price of the final good produced by country 1. The final good in country 1 is the numeraire good; hence  $p_{1t} = 1$ .

$$G_{1t}^{\frac{1}{\sigma}} \omega_1 \left( \frac{1}{a_{1t}} \right)^{\frac{1}{\sigma}} = q_{1t}^a \quad (9)$$

$$G_{1t}^{\frac{1}{\sigma}} (1 - \omega_1) \left[ \frac{1}{(1 - \tau b_{1t}) b_{1t}} \right]^{\frac{1}{\sigma}} = q_{1t}^b \quad (10)$$

The final firm's problem in country 2 is:

$$\max_{a_{2t}, b_{2t}} \{ p_{2t} G_{2t} - q_{2t}^a [(1 - \tau a_{2t}) a_{2t}] - q_{2t}^b b_{2t} \} \quad (11)$$

$$s.t. a_{2t}, b_{2t} > 0$$

$$p_{2t} G_{2t}^{\frac{1}{\sigma}} (1 - \omega_2) \left[ \frac{1}{(1 - \tau a_{2t}) a_{2t}} \right]^{\frac{1}{\sigma}} = q_{2t}^a \quad (12)$$

$$p_{2t} G_{2t}^{\frac{1}{\sigma}} \omega_2 \left( \frac{1}{b_{2t}} \right)^{\frac{1}{\sigma}} = q_{2t}^b \quad (13)$$

In this economy prices differ across markets because of transportation costs. Price differences are reflected in the differences between terms of trade evaluated at f.o.b. prices and at c.i.f. prices. In our model, the c.i.f. definition of the terms of trade will be linked directly to the marginal rate of transformation, but the f.o.b. terms of trade will differ from the c.i.f. terms of trade due to costs of transportation. As in Ravn and Mazzenga (2004), we can use the first order conditions from (8) and (11) to calculate the relative price of domestic imports to domestic exports. This relative price is the Home c.i.f. terms of trade:

$$TOTci f_{1t} = \frac{q_{1t}^b}{q_{1t}^a} \quad (14)$$

Instead the relative price of the goods purchased abroad to the domestic price of exports gives the Home f.o.b. terms of trade:

$$TOTfob_{1t} = \frac{q_{2t}^b}{q_{1t}^a} \quad (15)$$

Then we know that:

$$q_{1t}^a = (1 - 2\tau a_{2t}) q_{2t}^a \quad (16)$$

$$q_{2t}^b = (1 - 2\tau b_{1t}) q_{1t}^b \quad (17)$$

Hence, we can see that the c.i.f. price multiplied by imports exceeds the f.o.b. price multiplied by exports:

$$R_{1t} = q_{2t}^a [(1 - \tau a_{2t}) a_{2t}] - q_{1t}^a a_{2t} > 0 \quad (18)$$

$$R_{2t} = q_{1t}^b [(1 - \tau b_{1t}) b_{1t}] - q_{2t}^b b_{1t} > 0 \quad (19)$$

Specifically we can think of an imaginary transportation firm that purchases the intermediate good in the exporting country paying the f.o.b. price and sells the same intermediate good in the importing country obtaining the c.i.f. price. As we can see from (18) and (19), the non linearity of trade costs imply that under perfect competition there are positive profits ( $R_{it}$ ) which are distributed to the households in the exporting country that by assumption own these firms.

#### 4.5 *Households' problems*

The representative agent in country 1 maximizes (1) subject both to a budget constraint and a borrowing constraint which are defined hereafter:

$$p_{1t}(c_{1t} + x_{1t}) + q_{1t}^a(Q_t B_t - B_{t-1}) + q_{1t}^{\bar{h}_1}(\bar{h}_{1t} - \bar{h}_{1t-1}) = w_{1t}n_{1t} + r_{1t}k_{1t} + R_{1t} \quad (20)$$

In this model, there is only a single free-risk non contingent bond ( $B_t$ ) which is traded across countries. Thus one country's debt corresponds to the other country's credit ( $B_t < 0$  is a debt). The price of the bond, denominated in units of the intermediate good produced in country 1, is  $Q_t$ . Hence to convert the bond in units of the final good produced in country 1, we need to multiply it by  $q_{1t}^a$ .  $q_{1t}^{\bar{h}_1}$  is the price of the local real estate in terms of final consumption in country 1 and  $x_{1t}$  is the amount of the final good devoted to investment in country 1. Households in country 1, the emerging market, face a constraint on foreign borrowing since, as in Kiyotaki and Moore (1997), lenders can not force borrowers to pay back their debts unless they are secured by a collateral. The borrowing constraint is:

$$-q_{1t}^a B_t \leq mE_t \left[ q_{1t+1}^{\bar{h}_1} \bar{h}_{1t} \right] \quad (21)$$

The maximum amount that an agent can borrow  $\left(mE_t \left[ q_{1t+1}^{\bar{h}_1} \bar{h}_{1t} \right] \right)$  is given by the expected value of the local real estate, where  $m$  is the fraction of the future value of the collateral that is guaranteed to be repaid.  $m$  reflects the degree of international financial market integration. A higher value of  $m$  corresponds to a higher degree of capital account liberalization, i.e. for a given value of the collateral the agents can borrow more. A rise in  $m$  allows to relax the borrowing limit and to increase the availability of foreign borrowing. Under the assumption that the domestic households' discount factor  $\beta_1$  is lower than  $\beta_2$ , we guarantee that the borrowing constraint is always binding.

The capital stock is accumulated in the standard way:

$$k_{1t+1} = (1 - \delta) k_{1t} + x_{1t} \quad (22)$$

where  $\delta$  is the depreciation rate.

Combining the first order conditions with respect to  $B_t$ ,  $h_{1t}$ ,  $k_{1t+1}$ ,  $n_{1t}$  with the first order condition with respect to  $c_{1t}$ , we obtain :

$$\frac{q_{1t}^a Q_t}{c_{1t}} = E_t \beta_1 \left[ \frac{q_{1t+1}^a}{c_{1t+1}} \right] + \chi_t q_{1t}^a \quad (23)$$

$$\frac{q_{1t}^{\bar{h}_1}}{c_{1t}} = j \frac{1}{h_{1t}} + E_t \left[ \beta_1 \frac{q_{1t+1}^{\bar{h}_1}}{c_{1t+1}} + m \chi_t q_{1t+1}^{\bar{h}_1} \right] \quad (24)$$

$$\frac{1}{c_{1t}} = \beta_1 E_t \left[ \frac{r_{1t+1} + (1 - \delta)}{c_{1t+1}} \right] \quad (25)$$

$$k n_{1t}^{\eta-1} = \frac{w_{1t}}{c_{1t}} \quad (26)$$

Equation (23) is the Euler equation for consumption modified to take into account the marginal value of additional borrowing  $\chi_t q_{1t}^a$ . The tighter the borrowing constraint (i.e. the smaller is the value of  $m$ ), the higher is the marginal value of getting an extra unit of borrowing. A binding borrowing constraint (i.e. a positive  $\chi_t$ ) induces an intratemporal distortion in the value of consumption between two different dates.

Equation (24) defines the optimal intertemporal choice of real estate. It equates the marginal utility of consumption, weighted by the price of the real estate, to the marginal utility of the real estate. The latter depends on three different components: a) the direct utility gain from an additional unit of the real estate; b) the expected utility from expanding future consumption, if an agent today shifts one unit of consumption to the purchase of real estate, she increases her collateral and thus her capacity of borrowing and hence her future consumption; c) the marginal utility of relaxing the borrowing constraint as an additional unit of collateral becomes available. This last term (i.e.  $m \chi_t q_{1t+1}^{\bar{h}_1}$ ) makes clear that a binding borrowing constraint causes an intertemporal distortion in the value of the collateral which can shift the allocation of resources between consumption and real estate. A relaxed borrowing constraint (i.e. a

higher value of  $m$ ) has two contrasting effects. It makes access to credit easier producing a positive income shock and hence reducing the demand for the collateral. But it also reduces the shadow value of the collateral (i.e.  $\chi_t$  goes down) causing an increase in the marginal utility of an extra unit of the collateral today and hence producing a higher demand of the real estate.

Equation (25) defines the optimal intertemporal allocation of capital. It equates the marginal cost of foregoing one unit of consumption today to the marginal benefit of an extra unit of investment.

Equation (26) is the first order condition with respect to labor supply, it says that the wage is equal to the marginal rate of substitution between leisure and consumption at time  $t$ . It gives the optimal choice of labor supply.

The representative agent in country 2 solves a similar maximization problem but she is not subject to any borrowing constraint.

#### 4.6 *Market clearings*

Market clearing for intermediate input goods requires that:

$$a_{1t} + a_{2t} = e^{z_{1t}} k_{1t}^\theta n_{1t}^{1-\theta} \quad (27)$$

$$b_{1t} + b_{2t} = e^{z_{2t}} k_{2t}^\theta n_{2t}^{1-\theta} \quad (28)$$

Market clearing for final goods requires that:

$$c_{1t} + x_{1t} = \left[ \omega_1 a_{1t}^{\frac{\sigma-1}{\sigma}} + (1 - \omega_1) [(1 - \tau b_{1t}) b_{1t}]^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \quad (29)$$

$$c_{2t} + x_{2t} = \left[ (1 - \omega_2) [(1 - \tau a_{2t}) a_{2t}]^{\frac{\sigma-1}{\sigma}} + \omega_2 b_{2t}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \quad (30)$$

Market clearing for real estate requires that:

$$\bar{h}_{1t} = \bar{h}_{1t-1} = \bar{h}_1 \quad (31)$$

$$\bar{h}_{2t} = \bar{h}_{2t-1} = \bar{h}_2 \quad (32)$$

#### 4.7 *Equilibrium*

An equilibrium is a set of prices for all  $t > 0$  such that when intermediate and final good firms as well as households take these prices as given, households solve (1) subject to the budget constraint (20), to the borrowing constraint (21) and to the capital accumulation equation (22) and firms solve their static problems (4), (5) and (8), (11) subject to the production functions (2) and (6), (7); furthermore, all markets clear.

## 5 Calibration

For purposes of calibration and computing statistics we identify country 1 as an emerging economy and country 2 as an advanced economy<sup>3</sup>. We calibrate the model assuming that one period of time corresponds to one quarter. We set the discount factor of the Foreign agent ( $\beta_2$ ) equal to 0.99 such that the annual interest rate is equal to 4%. Instead the discount factor of Home agent ( $\beta_1$ ) is set equal to 0.95 such that the borrowing constraint is always binding. The weight of housing in the utility function ( $j$ ) is set equal to 0.019 and the loan to value ratio ( $m$ ) equal to 0.4. In our framework  $m$  equal to 0.4 corresponds to a case of intermediate financial integration. This baseline parametrization guarantees that in steady state the foreign debt of the domestic country is equal to 20% of its GDP. The elasticity of substitution between foreign and domestic goods ( $\sigma$ ) is equal to 0.9 as in Heathcote and Perri (2002)<sup>4</sup>. The parameters  $\omega_1$  and  $\omega_2$ , which determine the extent to which there is a home bias in the composition of domestically produced final goods, are set respectively equal to 0.69 and 0.81 and the transportation costs parameter  $\tau$  is set equal to 0.2 as in Ravn and Mazzenga (2004). In our framework  $\tau$  equal to 0.2 corresponds to a case of intermediate trade integration. Under this parametrization the Home import share is equal to 30% of the Home GDP whereas the Foreign import share is equal to 20% of the Foreign GDP. The quarterly rate of depreciation of the capital stock ( $\delta$ ) is 2.5% and the capital share of output ( $\theta$ ) is 36%. We set  $\eta$  the parameter of labor disutility equal to 2 such that the Frisch elasticity of labor supply is equal to 1 as in Gali, Gertler and López-Salido (2007). Most micro studies suggest a low estimate of the Frisch elasticity, between 0 and 0.5. But Browning et al. (1999) note that these microeconomic estimates are often incompatible with real business cycle models that use values in the range of 3 or higher.

Concerning the stochastic productivity process, for the Foreign country we use the estimation results of Heathcote and Perri (2002): the standard deviation of the productivity shock is set equal to 0.0073, the diagonal element of the transition matrix  $A$ , which defines the degree of persistence of the shock, is set equal to 0.97. The off-diagonal element of the same matrix, which determines the degree of the spillover of the foreign shock to the domestic country, is set equal to 0.025. For the Home country, we use the same calibration but for the standard deviation of the productivity shock and for the degree of spillover of the shock to the other country. The former is set equal to 0.015 which is about twice the value of the corresponding standard deviation in the advanced

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<sup>3</sup>We report the values of the parameters of the baseline calibration in table 1 and 2 in the appendix.

<sup>4</sup>In the literature there is a large range of estimates for the trade elasticity of substitution. For instance, Taylor [1993] estimates the value for the U.S. to be 0.39, while Whalley [1985], in the study used by Backus et al. [1995], reports a value of 1.5. For European countries most empirical studies suggest a value below 1. For instance, Anderton et al. [2004] report values between 0.5 and 0.81 for the Euro area. Recently, however models with low trade elasticities as Corsetti, Dedola and Leduc (2008) received considerable attention because they seem able to replicate better international business cycles statistics.

economy in line with the literature for emerging countries. The latter is set equal to 0.010, because we assume that the spillover of an emerging market to an advanced economy is relatively less strong.

## 6 Results

Hereafter we first analyze the impulse response functions of some main variables to a 1% productivity shock in the Home country under the baseline parametrization. Then we discuss how the model presented in the previous sections, is able to reproduce some key stylized facts proved by Kose, Prasad, Terrones (2005). In particular we show how, in presence of a positive productivity shock, the main business cycle properties of the model change when the degree of trade integration (i.e.  $\tau$ ) and capital account liberalization (i.e.  $m$ ) are modified. We prove that capital liberalization increases the volatility of consumption and the volatility of consumption relative to that of output whereas trade liberalization leads to a decline in the value of this ratio. We focus mainly on the mechanisms which drive these results. Subsequently we perform a robustness analysis.

### 6.1 *Impulse responses*

A positive productivity shock in the Home country leads to an increase in the marginal return to labor and capital, to a rise in wage and interest rate and hence in domestic investment, employment and output. This implies a higher level of consumption and a stronger demand of real estate. Real estate prices go up as well. The terms of trade of the Home country rises because of the fall in the price of domestic intermediate good. This allows the transmission of the wealth effect to the Foreign country. Thus, it turns out that in the other country investment, employment, output, consumption, real estate demand and real estate prices increase as well. The financial position of the Home country, which is already negative in steady state because of the assumption that domestic agents are relatively impatient, further worsens<sup>5</sup>.

### 6.2 *Business cycle statistics: some key stylized facts*

Hereafter we discuss how the standard deviation of consumption, of output and their ratio change when we pass from financial autarky ( $m = 0$ ) to a high degree of financial integration ( $m = 0.8$ ) keeping the degree of trade integration constant equal to its baseline value ( $\tau = 0.2$ ).

Financial liberalization works through 2 main channels. For an impatient borrower, a relaxed borrowing constraint is like a positive income shock. Given

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<sup>5</sup>Figure 1 and Figure 2 show the impulse response functions of the selected variables. In table 3 and 4, we show the main simulated statistics for the baseline parametrization ( $m = 0.4$ ,  $\tau = 0.2$ ). Volatility is measured by the theoretical standard deviation. Contemporaneous comovement is measured by the theoretical correlation. The simulated moments are obtained shocking productivity in both countries. All series have been logged (except net exports) and Hodrick-Prescott filtered with a smoothing parameter of 1600.

the same amount of collateral, he borrows more because he has access to more resources and he consumes more because he prefers current to future consumption. Moreover, the rise in foreign lending allows not only a higher consumption but also a higher demand for real estate. This implies a raise in the real estate prices and therefore in the value of the collateral. This rises the borrowing capability at the extensive margin. Such valuation effects work in the same direction as the income effect. Overall a higher capital account openness increases consumption volatility and the volatility of consumption relative to that of output. The standard deviation of consumption passes from 0.92% under autarky to 1.03% in a financially integrated market. The relative volatility of consumption to output is equal to 41.81% under financial autarky but goes to 45.57% in a financially liberalized market <sup>6</sup>.

Then we keep the level of financial integration constant equal to its baseline value ( $m = 0.4$ ) and we change the extent of trade integration passing from low integration ( $\tau = 0.35$ ) to free trade ( $\tau = 0$ ). As we mentioned above, a positive productivity shock in the Home country leads to an increase in the domestic output and to a decline in its price. The terms of trade of the other country improves, raising employment, investment, output and consumption in the Foreign country. The fall in the terms of trade of the Foreign country is larger under free trade than under low trade integration. The different behavior of the Foreign terms of trade depends on the different dynamics of the intermediate goods prices at different degree of trade openness. Trade costs introduce a wedge between the Home and the Foreign price of the same intermediate good traded across countries. Only under free trade the two prices are equated. Thus only under free trade the decline in the domestic price of the intermediate good traded to the other country is fully transmitted into its foreign price. Therefore free trade strengthens the response of the Foreign variables to a domestic productivity shock and through them produces an amplification mechanism which reinforces the reaction of all the domestic variables but consumption. Under free trade, the response of domestic consumption to the productivity shock is weaker because of the larger transmission of the wealth effect to the foreign country. Overall trade liberalization leads to a higher volatility of output. The volatility of consumption declines. Consumption smoothing improves since the ratio between the standard deviation of consumption and the standard deviation of output goes from 44.74% under trade frictions to 41.40% with free trade.

### 6.3 *Sensitivity analysis*

In what follows, we analyze the sensitivity of the main results to the variation of the elasticity of substitution between domestic and foreign goods ( $\sigma$ ). As in

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<sup>6</sup>The statistics for capital liberalization are reported in table 5. The statistics for trade liberalization are reported in table 6. Volatility is measured by the theoretical standard deviation. Contemporaneous comovement is measured by the theoretical correlation. The simulated moments are obtained shocking productivity in both countries. All series have been logged (except net exports) and Hodrick-Prescott filtered with a smoothing parameter of 1600.

Heathcote and Perri (2002), we try both  $\sigma = 1.5$  and  $\sigma = 0.5$ . In front of a productivity shock, as we can see from tables 7 and 9 in the appendix, the effects of capital account liberalization on the volatility of consumption and on the volatility of consumption relative to that of output are weaker in the relatively high elasticity case than in the relatively low elasticity case. As we can see from tables 8 and 10 in the appendix, also the effect of trade liberalization on the volatility of consumption relative to that of output is lower in the relatively high elasticity case than in the relatively low elasticity case. The substitution effect becomes stronger for higher values of the trade elasticity. The economy becomes more stable in the sense that both prices and quantities react less to the shock. However, qualitatively the results do not change.

Then we discuss how the main results change when we modify the value of the parameter of labor disutility ( $\eta$ ). We first set  $\eta = 1.5$  which implies a relatively higher Frisch elasticity of labor supply equal to 2. Then we set  $\eta = 2.5$  which implies a relatively lower Frisch elasticity of labor supply equal to 0.6. For a same productivity shock the volatilities of output and consumption are higher for a more elastic labor supply. When labor is relatively more inelastic, it becomes more costly for the agents to adjust labor efforts to insure themselves against productivity shocks. Therefore, they might not be able dampen fluctuations through labor movements. However the main results do not seem to be very sensitive to this parameter, as we can see from tables 11, 12, 13 and 14 in the appendix.

## 7 Conclusions

In this paper we use a 2 country, 2 goods, international real business cycle incomplete market model built upon Heathcote and Perri (2002) to study the relationship between trade integration, capital account liberalization and macroeconomic volatility in emerging markets. Capital liberalization is modeled through the relaxing of a foreign borrowing constraint à la Kiyotaki in the Home country whereas trade integration is modeled by a cut in quadratic iceberg transport costs.

In front of a productivity shock, an exogenous relaxing of the borrowing constraint works as positive income shock. Domestic agents, which are relatively impatient, borrow, consume more and increase their demand of collateral. The availability of borrowing for domestic agents increases further because of the rise in the value of the real estate. Overall capital account liberalization causes a higher consumption volatility and a higher relative volatility of consumption to output. This means a worsening of consumption smoothing.

Trade frictions introduce a wedge between the domestic and the foreign price of the traded intermediate goods. Thus the improvement in the Foreign terms of trade, in presence of a productivity shock, is larger under free trade. This produces a free trade mechanism which amplifies the response of the Foreign variables and also of domestic employment, investment and output. On the other hand, under free trade, the consumption reaction to the shock is weaker

because of the larger portion of the wealth effect transmitted to the foreign country through the movements in the terms of trade. Overall trade liberalization leads to a decline in the relative volatility of consumption to output, which means an improvement of consumption smoothing.

The results of the model, which are qualitatively consistent with the empirical evidence provided by Kose, Prasad and Terrones (2005), suggest that in emerging markets there is a complementarity between trade and capital liberalization.

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# Appendix

Table 1: **Benchmark Parameters Value.**

Discount factor in country 1	$\beta_1$	0.95
Discount factor in country 2	$\beta_1$	0.99
Depreciation rate	$\delta$	0.025
Home bias in country 1	$\omega_1$	0.69
Home bias in country 2	$\omega_2$	0.81
Elasticity of substitution between domestic and foreign good	$\sigma$	0.9
Capital share of output	$\theta$	0.36
Transportation costs parameter	$\tau$	0.2
LTVR	$m$	0.4
Weight of housing	$j$	0.019
Constant	$\kappa$	1
Parameter of labor disutility	$\eta$	2

Table 2: **Productivity Process**

Productivity transition matrix	0.970	0.025
	0.010	0.970
Std. dev. of innovations to productivity	$\sigma_{\epsilon_1} = 0.0073$	$\sigma_{\epsilon_2} = 0.015$
Correlations of innovations to productivity	$\text{corr}(\epsilon_1, \epsilon_2) = 0.290$	

Figure 1: Impulse responses for 1% productivity shock. Consumption, output, investment.

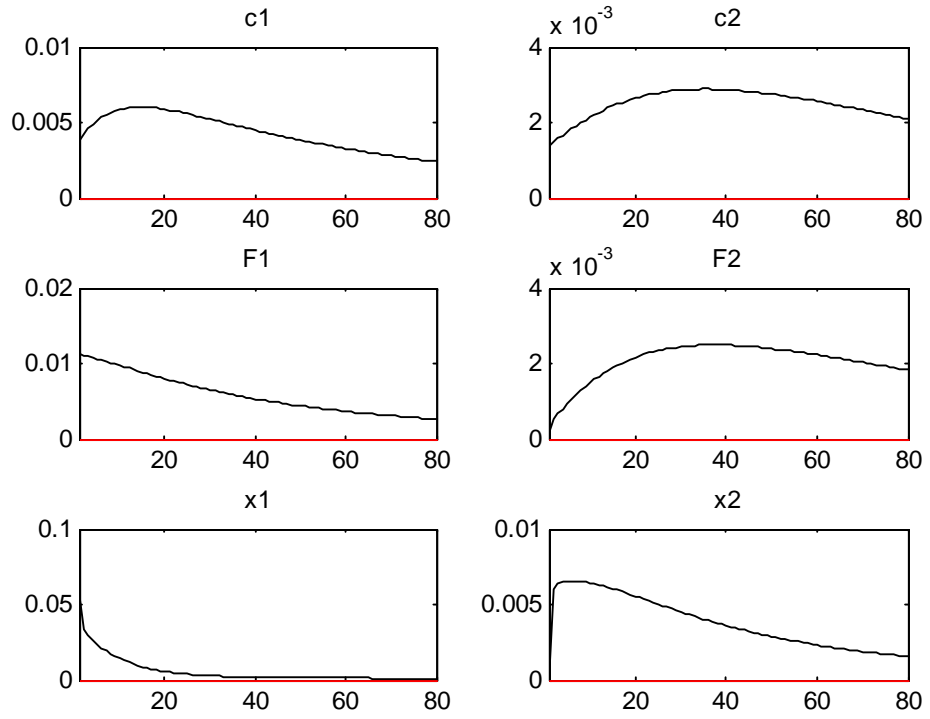


Figure 2: Impulse responses for 1% productivity shock. Terms of trade, external financial position, export, import, price of collateral.

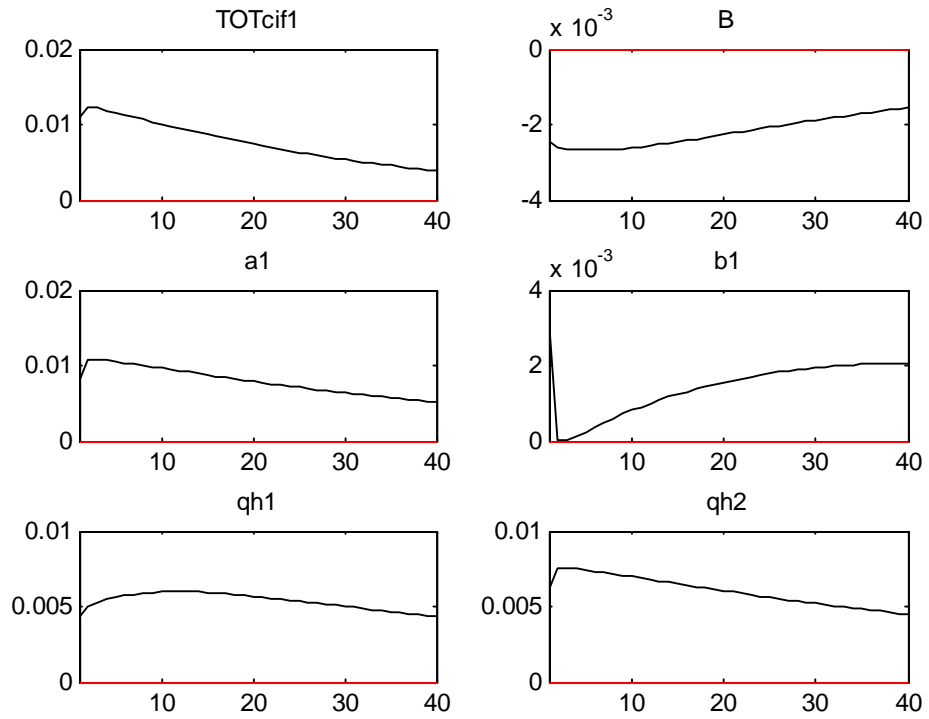


Table 3: **Volatility of the main variables for  $m=0.4$  and for  $\tau = 0.2$ .**

Consumption	0.0096
Output	0.0222
Investment	0.0883
Labor supply	0.0036
Terms of Trade c.i.f.	0.0234
Exports	0.0205
Imports	0.0116

Table 4: **Contemporaneous comovement of the main variables with output for  $m=0.4$  and for  $\tau = 0.2$ .**

Consumption	0.9278
Investment	0.8972
Labor Supply	0.8752
Terms of Trade c.i.f.	0.9057
Exports	0.9836
Imports	0.03887

Table 5: **Capital account liberalization for  $\tau = 0.2$ . Volatility of the main variables.**

	m=0	m=0.8
Relative consumption to output	0.4181	0.4557
Consumption	0.0092	0.0103
Output	0.0220	0.0225
Investment	0.0768	0.1133
Labor supply	0.0036	0.0038
Terms of Trade c.i.f.	0.0242	0.0226
Exports	0.0219	0.0198
Imports	0.0107	0.0156

Table 6: **Trade liberalization for  $m=0.4$ . Volatility of the main variables.**

	$\tau = 0.35$	$\tau = 0$
Relative consumption to output	0.4474	0.4140
Consumption	0.0098	0.0094
Output	0.0219	0.0227
Investment	0.0864	0.0922
Labor supply	0.0031	0.0043
Terms of Trade c.i.f.	0.0236	0.0234
Exports	0.0190	0.0225
Imports	0.0106	0.0128

**Sensitivity Analysis,  $\sigma = 1.5^7$ .**

**Table 7: Capital account liberalization for  $\tau = 0.2$**

	m=0	m=0.8
Relative consumption to output	0.50	0.5252
Consumption	0.0117	0.0125

**Table 8: Trade liberalization for m=0.4**

	$\tau = 0.35$	$\tau = 0$
Relative consumption to output	0.5206	0.5021

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<sup>7</sup>All the other parameters are kept at their benchmark values.

**Sensitivity Analysis,  $\sigma = 0.5$ <sup>8</sup>.**

Table 9: **Capital account liberalization for  $\tau = 0.2$**

	m=0	m=0.8
Relative consumption to output	0.3350	0.3804
Consumption	0.0067	0.0078

Table 10: **Trade liberalization for m=0.4**

	$\tau = 0.35$	$\tau = 0$
Relative consumption to output	0.3814	0.3047

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<sup>8</sup>All the other parameters are kept at their benchmark values.

**Sensitivity Analysis,  $\eta=1.5$ <sup>9</sup>.**

Table 11: **Capital account liberalization for  $\tau = 0.2$ .**

	m=0	m=0.8
Relative consumption to output	0.4173	0.4553
Consumption	0.0096	0.0107

Table 12: **Trade liberalization for m=0.4.**

	$\tau = 0.35$	$\tau = 0$
Relative consumption to output	0.4449	0.4159

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<sup>9</sup>All the other parameters are kept at their benchmark values.

**Sensitivity Analysis,  $\eta = 2.5^{10}$ .**

**Table 13: Capital account liberalization for  $\tau = 0.2$ .**

	m=0	m=0.8
Relative consumption to output	0.4186	0.4590
Consumption	0.0090	0.0101

**Table 14: Trade liberalization for m=0.4.**

	$\tau = 0.35$	$\tau = 0$
Relative consumption to output	0.4485	0.4117

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<sup>10</sup> All the other parameters are kept at their benchmark values.