

Macroeconomic Volatility after Trade and Capital Account Liberalization

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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. The paper shows that international financial integration, modeled by relaxing a borrowing constraint à 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, the analysis uses 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 (2003).

This paper—a product of the Office of the Chief Economist, Middle East and North Africa Region—is part of a larger effort in the department to understand the impact of trade and capital liberalization on macroeconomic volatility. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted at cpancaro@worldbank.org and cosimo79@yahoo.it.

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Macroeconomic Volatility after Trade and Capital Account Liberalization*

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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 increase 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 regards 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 regards financial integration, advanced economies have 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 (2003).

We specify a two-country, two-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 termed as Home, are subject to a borrowing constraint à la Kiyotaki. Through the introduction of this constraint on international borrowing, we define 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 a rise in the degree of capital openness, increases the capacity of domestic agents to borrow on foreign markets. Since in this model, borrowers in the domestic country are assumed to be relatively impatient, a relaxed borrowing constraint leads to an increase in borrowing, rises 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

The empirical literature that studies the links between trade and capital liberalization and macroeconomic volatility is very extensive and it has definitely not reached a clear consensus.

As regards capital liberalization, Gavin and Hausmann (1996) find that capital flows volatility is a significant source of output volatility in a large sample of developing countries between 1970 and 1992. Bekaert, Harvey and Lundblad (2002) find that capital liberalization causes an increase in consumption volatility in emerging markets. In these works, the incapacity of emerging markets to exploit risk sharing opportunities is explained by the weakness of financial institutions and the limited financial development. Finally, Kose, Prasad and Terrones (2009) show that, despite financial globalization, developing and emerging economies have not reached higher risk sharing outcomes. This is explained by the extremely high volatility of portfolio flows that largely move to emerging countries.

As regards trade liberalization, Karras and Song (1996) provide evidence that an increase in

trade openness produces a higher output volatility in 24 OECD countries. Easterly, Islam and Stiglitz (2001) study the causes of output volatility in a sample of 74 countries over the period 1960-97. Their results show that trade openness is positively and significantly associated with output volatility, mainly in emerging countries. Bejan (2006) shows that trade openness increases output volatility in developing countries. Finally, Haddad, Lim, Saborowski (2009) show that trade liberalization implies an increase in economic volatility whether a country does not exhibit a well diversified exports basket.

There are also several works that study the relationship between trade and capital liberalization and macroeconomic volatility from a theoretical perspective.

As regards capital liberalization, 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 and investment for a small country at an intermediate level of financial development. Evans and Hnatkovska (2007) study the effects of financial integration on macroeconomic volatility and welfare. They examine a two-sector, two-country model with incomplete markets where financial integration is modeled by extending the set of available internationally traded assets. Moving from financial autarky to low financial integration implies an increase in the volatility of consumption and output. However, as the set of traded assets is widened and the economy moves to high financial integration, consumption and output volatility decline. Therefore, their model predicts a nonlinear relationship between the volatility of consumption and output and financial integration. Faia (2010) uses a small open economy model where domestic agents are subject to a constraint on foreign borrowing to show that capital account liberalization causes an increase in consumption volatility and a decline in agents' welfare. Durable goods are the collateral on which borrowing is secured¹.

As regards trade liberalization, several theoretical models show that its effects on output and consumption volatility largely depend on the degree of specialization and on the type of shocks that hit the economy. Krugman (1993) proves that if trade liberalization leads to a higher inter-industry specialization and the shock that hits the economy is industry specific and highly persistent both the volatility of consumption and output increase. On the other side, Razin and Rose (1994) show that if trade liberalization leads to a higher degree of intra-industry trade output volatility decreases².

¹Broner and Ventura (2010), Leblebicioglu (2009), Levchenko (2005) and Pisani (2010) also show that financial liberalization causes an increase in consumption volatility.

²For a comprehensive review of the literature on the sources and the effects of macroeconomic volatility in developing countries look at Loayza, Rancière, Servén and Ventura (2007).

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 of Kose, Prasad, Terrones (2003) 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%³.

Kose, Prasad, Terrones (2003) examine the role of trade and capital account 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 output volatility suggesting that more open economies are more vulnerable to external shocks. However, they also provide evidence that a higher degree of trade integration causes a decline in the volatility of consumption relative to that of output. This ratio is taken as a measure for consumption smoothness. Capital account openness has a positive effect on output (this coefficient is only marginally significant), consumption and relative consumption volatility. Moreover, they provide evidence that there is a non linear relationship between capital account liberalization, consumption and relative consumption volatility. This means that a higher financial openness implies a higher volatility but only up to a certain threshold.

4 The model

Our model is a two-country, two-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 determine 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.

³Lane 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 representative agent 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:

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

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

where j is the weight of housing, η is the parameter of labor disutility and β_1, β_2 are the subjective discount factors. We assume that $\beta_1 < \beta_2$. This assumption guarantees that the domestic agent is relatively impatient. The reason and the implications of this assumption are better explained in paragraph 1.4.4.

4.2 The intermediate goods sector

In both countries, the economy encompasses 2 sectors: an intermediate goods producing sector and a final goods producing sector. Each country is completely specialized in the production of a tradable intermediate good. The international trade of the intermediate good is subject to quadratic iceberg costs.

Households supply labor and rent capital to perfectly competitive intermediate 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 intermediate firms using a Cobb-Douglas production function:

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

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

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

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

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

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. q_{1t}^a and q_{2t}^b are the f.o.b. (free on board) prices of the intermediate goods produced in countries 1 and 2 whereas q_{1t}^b and q_{2t}^a are the c.i.f. (cost, insurance, freight) prices of the intermediate goods produced in countries 2 and 1 and imported by countries 1 and 2. Intermediate goods are sold on to final firms in both countries.

4.3 The final goods sector

The final good (G_{it}), which is used both for consumption and investment, is produced by perfectly competitive final firms combining both the domestic and the foreign intermediate inputs via an Armington aggregator:

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

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

where σ measures the elasticity of substitution between domestic and foreign intermediate goods. a_{it} and b_{it} denote the uses of the two intermediate goods, originally produced in countries 1 and 2, in country i . The parameter ω_i defines the degree of home bias in the composition of domestically produced final goods in country i . τ is the trade cost parameter which determines the degree of international trade integration. A lower τ implies a higher degree of international trade integration. Following Ravn and Mazzenga (2004) and Yi and Kose (2006), trade liberalization is modelled introducing quadratic iceberg costs on the international trade of intermediate goods. Trade costs encompass tariffs, non-tariff barriers and costs of international transportation. Quadratic iceberg costs imply that as the quantity of the intermediate goods transported across countries becomes larger, the trade cost increases non linearly. Moreover, they imply that if the Home country exports a_2 units of the intermediate good a to the Foreign country, only $(1 - \tau a_2) a_2$ units arrive and are effectively available to Foreign agents. $\tau (a_2)^2$ is the amount of the intermediate good a lost during the transportation and represent the trade cost. The same holds for the international trade of the intermediate good b from the Foreign country to the Home country. We opt for introducing quadratic iceberg costs instead of the traditional linear iceberg costs because they affects agents' decisions despite the linearization procedure.

The final firm's problem in country 1 is:

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

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

where p_{1t} is the price of the final good produced by country 1. Since the final good in country 1 is the numeraire good, p_{1t} is normalized to 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:

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

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

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

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

In this economy, trade costs introduce a wedge between the domestic and the foreign price of the intermediate goods. Therefore, the price of the same intermediate goods differs across countries. This implies that, in this theoretical framework, 2 different terms of trade can be defined: a terms of trade evaluated at f.o.b. prices and a terms of trade evaluated at c.i.f. prices. As in Ravn and Mazzenga (2004), the Home c.i.f. terms of trade is given by the marginal rate of transformation between domestic and foreign intermediates and it is defined as the ratio between the domestic price of imports, i.e. the c.i.f. price of imports, and the domestic price of exports:

$$TOT_{cif1t} = \frac{q_{1t}^b}{q_{1t}^a} \quad (14)$$

Instead, the Home f.o.b. terms of trade is defined as the ratio between foreign price of imports, i.e. the f.o.b. price of imports, and the domestic price of exports:

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

Since we know that:

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

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

we can notice, as shown in (18) and (19), that the real value of the effective available imports evaluated at the c.i.f. price is higher than the real value of exports evaluated at the f.o.b. price:

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

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

Hence, as Yi and Kose (2006) suggest, we can think of a trading firm, which purchases the intermediate good in the exporting country at the f.o.b price and sells it in the importing countries at the c.i.f. price. The nonlinearity of the trade costs, under perfect competition, generates profits which are distributed to the households in the exporting country who are assumed to own the trading firm.

4.4 *Households' problem*

As in Faia (2010) and Pisani (2010), the representative agent in country 1 maximizes his expected lifetime utility function (1) subject both to a budget constraint (20), a borrowing constraint (21) and a capital law of motion (22), which are defined hereafter:

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

B_t is the free risk non contingent bond traded across countries. In this framework, one country's debt corresponds to the other country's credit. The international trade of the bond is subject to a quadratic bond holding cost that, as shown by Schmitt-Grohé and Uribe (2001), ensures the stationarity of the solution. Q_t is the price of the bond, denominated in units of the intermediate good produced in country 1. Hence, q_{1t}^a converts the bond in units of the final good produced in country 1. $q_{1t}^{\bar{h}_1}$ is the price of the local real estate in terms of final consumption 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:

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

The maximum amount of debt an agent can contract ($-q_{1t}^a B_t$) must be smaller or equal to a fraction (m) of the expected future value of the collateral $\left(E_t \left[q_{1t+1}^{\bar{h}_1} \bar{h}_{1t} \right] \right)$. m is the parameter which determines the degree of capital account liberalization. A higher m implies a higher degree of capital account liberalization. A rise in m causes a relaxing of the borrowing constraint and an increase in the availability of foreign borrowing for domestic agents.

It is relevant to stress that, by assumption, the domestic households' discount factor, β_1 , is lower than the foreign households' discount factor, β_2 . This assumption guarantees that in equilibrium the borrowing constraint is always binding and the Home country has a negative foreign asset position.

The capital stock is accumulated in the standard way:

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

where δ is the depreciation rate and x_{1t} is the amount of the final good allocated to investment in country 1.

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 :

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

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

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

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

Equation (23) is the Euler equation for consumption adjusted to account for 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 χ_t) induces a distortion in the value of consumption across different time periods.

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 marginal utility of real estate hinges on 3 different factors: a) the direct marginal utility of one additional unit of the real estate; b) the expected marginal utility of one additional

unit of consumption in the future, if the agent purchases one additional unit of real estate today, in the future his ability to borrow and hence to consume increases; c) the marginal utility of relaxing the borrowing constraint when an extra unit of real estate becomes available. This last term $\left(i.e.m\chi_t q_{1t+1}^{\bar{h}_1}\right)$ shows that a binding borrowing constraint introduces a distortion in the value of the collateral across different time periods. This distortion can modify 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. χ_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. This latter effect dominates on the former and it is the main driver of a higher volatility of domestic consumption, after a productivity shock, under a more relaxed borrowing constraint.

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) defines the optimal choice of labor supply. It equates the real wage to the marginal rate of substitution between leisure and consumption at time t .

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

4.5 *Market clearings*

Market clearing for intermediate input goods is given by:

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

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

Market clearing for final goods is given by:

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

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

Market clearing for real estate is given by:

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

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

4.6 *Equilibrium*

An equilibrium is a set of prices and quantities that, for all $t > 0$, solves the households' optimization problem given the budget constraint, the borrowing constraint and the capital law of motion, the firms' optimization problem given the production functions and satisfy all market clearings.

5 Calibration

For purposes of calibration and computing statistics, we identify country 1 as an emerging economy and country 2 as an advanced economy⁴. We calibrate the model assuming that one period of time corresponds to one quarter. We set the discount factor of the Foreign agent (β_2) equal to 0.99 such that the annual interest rate is equal to 4%. Instead the discount factor of Home agent (β_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 0.029 and the loan to value ratio (m) equal to 0.4. In this framework, m equal to 0.4 corresponds to a case of intermediate financial integration. This baseline parametrization guarantees that in steady state the debt of the domestic country is equal to 30% of its GDP. The elasticity of substitution between foreign and domestic goods (σ) is equal to 0.9 as in Heathcote and Perri (2002)⁵. The parameters ω_1 and ω_2 , which define the degree of home bias in the composition of domestically produced final goods, are set respectively equal to 0.69 and 0.81 and the trade cost parameter τ is set equal to 0.2 as in Ravn and Mazzenga (2004). In this framework, τ 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 (δ) is 2.5% and the capital share of output (θ) is 36%. We set η , 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.

⁴We report the values of the parameters of the baseline calibration in Table 1 and Table 2 in the appendix.

⁵In 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.

As regards the stochastic productivity process, we use the estimates of Heathcote and Perri (2002) for the Foreign country: the standard deviation of the productivity shock is set equal to 0.0073, the diagonal element of the autocorrelation matrix $\mathbf{A}$, which defines the degree of persistence of the shock, is set equal to 0.97. The off-diagonal element of $\mathbf{A}$ 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 economy in line with the literature for emerging countries. The latter is set equal to 0.010 because we assume that the spillover of a shock in 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 (2003). In particular we show how, after a positive productivity shock to the domestic country, the volatility of consumption and the volatility of consumption over output predicted by the model change when the degree of trade integration (*i.e.* τ) 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 first focus on the mechanisms which drive these results and then we perform a robustness analysis.

6.1 Impulse response functions

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 hence in domestic investment, employment and output. This implies a higher level of consumption and a stronger demand of real estate. Real estate prices raise as well. The terms of trade of the Home country worsens because of the fall in the price of domestic intermediate good. The rise in the terms of trade 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 worsens⁶.

⁶Figure 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

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 move 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 works as positive income shock. Given the same amount of collateral, he borrows more because he can accede to more resources and he consumes more because he prefers current to future consumption. Moreover, the larger availability of foreign borrowing allows both a higher consumption and a higher demand for real estate. This implies a raise in the real estate prices and therefore in the value of the collateral. Overall, a higher capital account openness increases consumption volatility and the volatility of consumption relative to that of output. The standard deviation of consumption goes from 0.92 in financial autarky to 1.04 in a financially integrated market. The relative volatility of consumption to output goes from 0.4181 in financial autarky to 0.4601 in a financially integrated market ⁷. Figure 3 shows the sensitivity of the consumption volatility over that of output to a variation of the degree of financial integration. Deeper international financial integration worsens consumption smoothing.

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 ($\tau = 0.50$) 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 improvement 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

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.

⁷The 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.

larger transmission of the wealth effect to the foreign country. Overall, trade liberalization leads to a higher volatility of output and to a lower volatility of consumption. The ratio between the standard deviation of consumption and the standard deviation of output goes from 0.4676 under trade frictions to 0.4167 with free trade. Figure 4 shows the sensitivity of the consumption volatility over that of output to a variation of the degree of trade integration. Deeper international trade integration improves consumption smoothing.

6.3 *Sensitivity analysis*

Hereafter, we analyze the sensitivity of the main results to the variation of the elasticity of substitution between domestic and foreign goods (σ). As in Heathcote and Perri (2002), we try both $\sigma = 1.5$ and $\sigma = 0.5$. As we can see from tables 7 and 9 in the appendix, in front of a productivity shock to the Home country, 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 high elasticity case than in the 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 high elasticity case than in the low elasticity case. With a higher elasticity of substitution between domestic and foreign goods, prices are less reactive to the domestic productivity shock, this implies a lower volatility of the main variables of interest. 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 (η). We first set $\eta = 1.5$ which implies a higher Frisch elasticity of labor supply equal to 2. Then we set $\eta = 2.5$ which implies a lower Frisch elasticity of labor supply equal to 0.6. For a same productivity shock, the effects of trade and capital account liberalization on the volatility of consumption relative to that of output are slightly stronger for a less 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 to 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 trade costs.

In front of a productivity shock, an exogenous relaxing of the borrowing constraint implies that

domestic agents, who 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 leads to 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 implies an improvement of consumption smoothing.

The results of the model, which are qualitatively consistent with the empirical evidence provided by Kose, Prasad and Terrones (2003), suggest that in emerging markets there is a complementarity between trade and capital liberalization.

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8 Appendix

Table 1: Benchmark Parameters Value.

Discount factor in country 1	β_1	0.95
Discount factor in country 2	β_1	0.99
Depreciation rate	δ	0.025
Bond holding cost	ψ	0.003
Home bias in country 1	ω_1	0.69
Home bias in country 2	ω_2	0.81
Elasticity of substitution between domestic and foreign good	σ	0.9
Capital share of output	θ	0.36
Transportation costs parameter	τ	0.2
LTVR	m	0.4
Weight of housing	j	0.029
Constant	κ	1
Parameter of labor disutility	η	2

Table 2: Productivity Process

Autocorrelation matrix	0.970	0.025
	0.010	0.970
Std. dev. of innovations to productivity	$\sigma_{e_1} = 0.0073$	$\sigma_{e_2} = 0.015$
Correlations of innovations to productivity	$\text{corr}(\epsilon_1, \epsilon_2) = 0.290$	

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

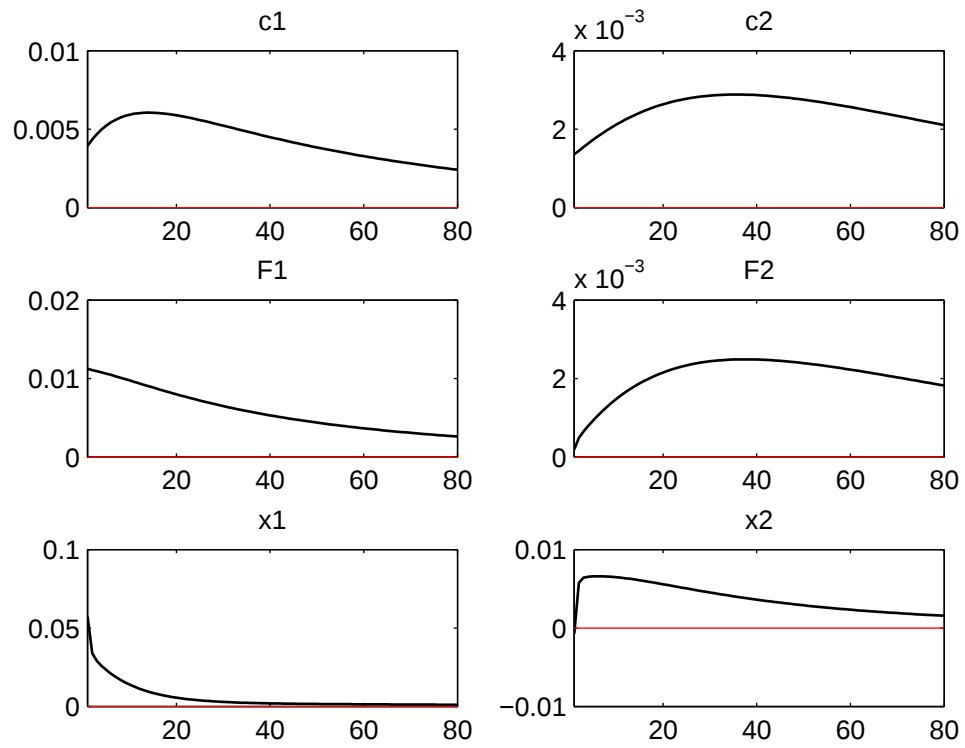


Figure 2: Impulse responses for 1% productivity shock. Terms of trade, debt, export, import, price of collateral.

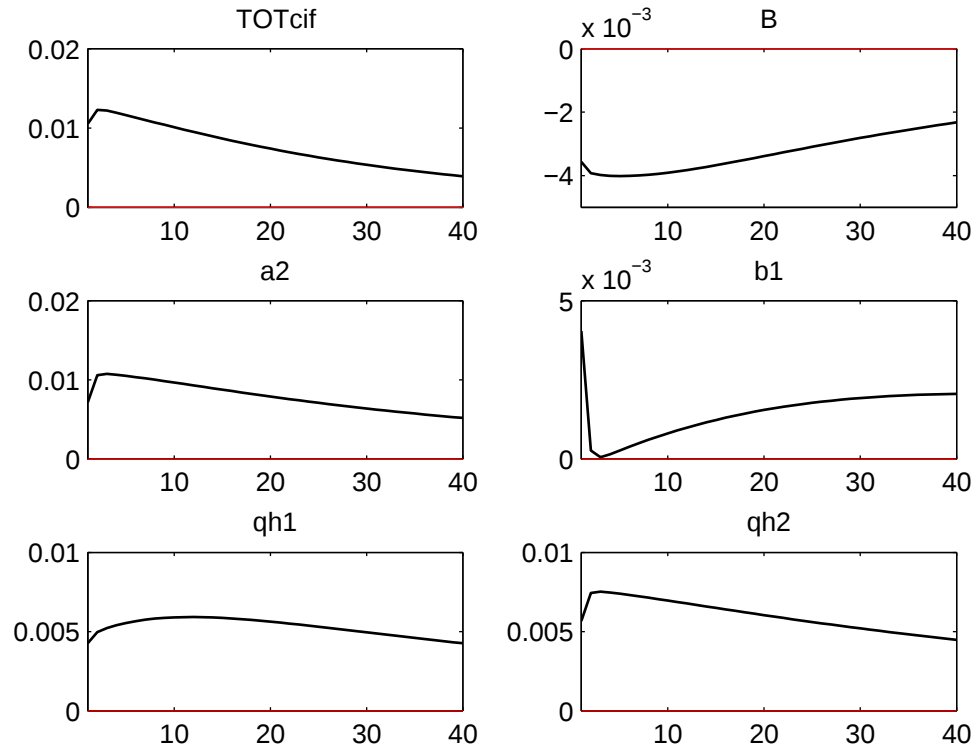


Table 3: Volatility of the main variables for $m=0.4$ and for $\tau = 0.2$.

Consumption	0.98
Output	2.23
Investment	9.36
Labor supply	0.36
Terms of Trade c.i.f.	2.32
Exports	2.02
Imports	1.23

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

Consumption	0.9325
Investment	0.8769
Labor Supply	0.8665
Terms of Trade c.i.f.	0.9016
Exports	0.9688
Imports	0.4280

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	0.4601
Consumption	0.92	1.04
Output	2.20	2.26
Investment	7.68	11.69
Labor supply	0.36	0.38
Terms of Trade c.i.f.	2.42	2.24
Exports	2.19	1.97
Imports	1.07	1.62

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

	$\tau = 0.50$	$\tau = 0$
Relative consumption to output	0.4676	0.4167
Consumption	1.01	0.95
Output	2.16	2.28
Investment	8.70	9.78
Labor supply	0.27	0.43
Terms of Trade c.i.f.	2.37	2.31
Exports	1.71	2.21
Imports	1.04	1.34

Figure 3: Sensitivity of consumption volatility over output volatility to a variation of the degree of capital liberalization.

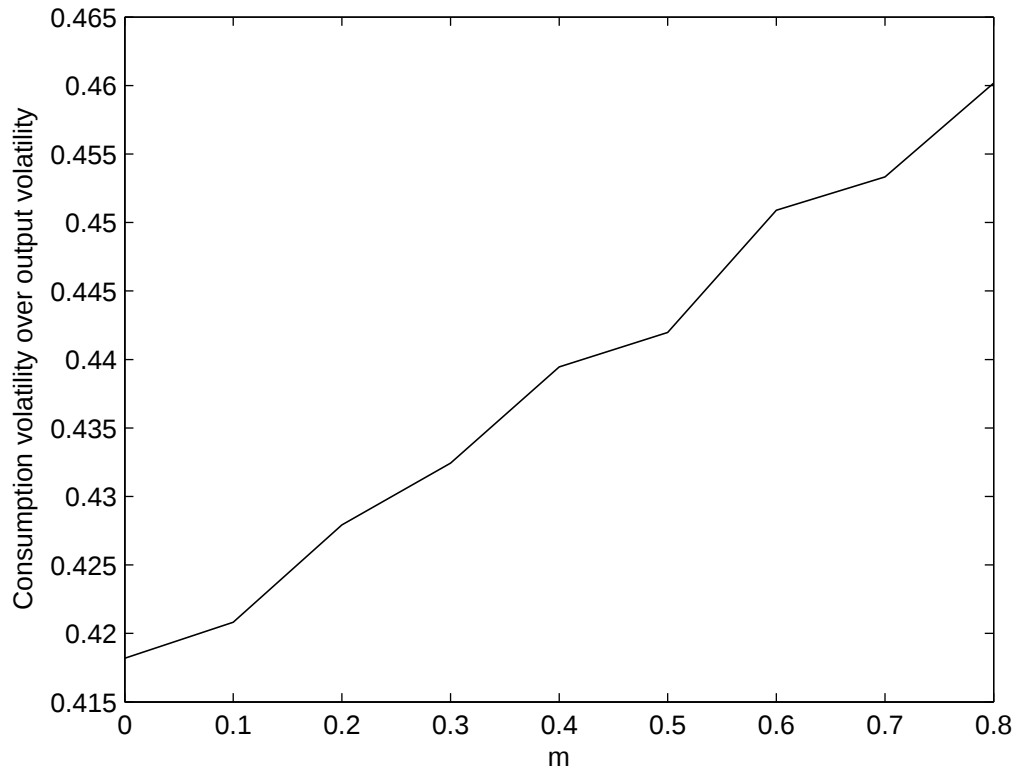
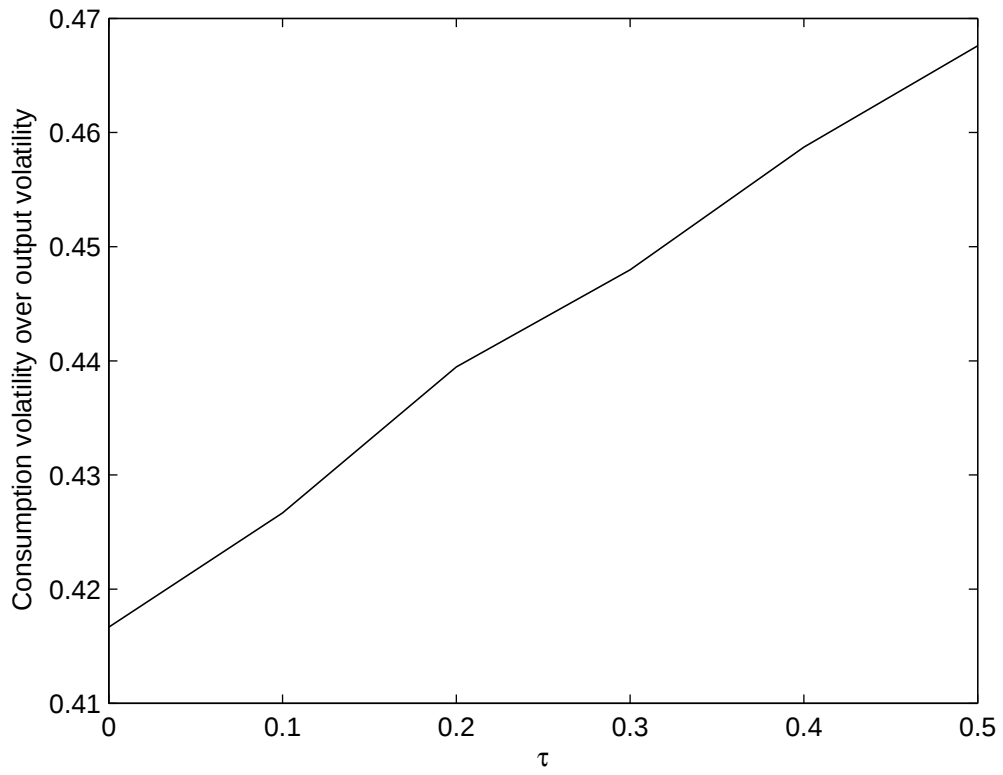


Figure 4: Sensitivity of consumption volatility over output volatility to a variation of the degree of trade liberalization.



Sensitivity Analysis, $\sigma = 1.5$ ⁸.

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

	m=0	m=0.8
Relative consumption to output	0.50	0.5252
Consumption	1.17	1.25

Table 8: Trade liberalization for m=0.4

	$\tau = 0.50$	$\tau = 0$
Relative consumption to output	0.5191	0.5105

⁸All the other parameters are kept at their benchmark values.

Sensitivity Analysis, $\sigma = 0.5$ ⁹.

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

	m=0	m=0.8
Relative consumption to output	0.3350	0.3853
Consumption	0.67	0.79

Table 10: Trade liberalization for m=0.4

	$\tau = 0.50$	$\tau = 0$
Relative consumption to output	0.4270	0.3317

⁹All the other parameters are kept at their benchmark values.

Sensitivity Analysis, $\eta = 1.5$ ¹⁰.

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

	m=0	m=0.8
Relative consumption to output	0.4173	0.4576
Consumption	0.96	1.08

Table 12: Trade liberalization for m=0.4.

	$\tau = 0.50$	$\tau = 0$
Relative consumption to output	0.4598	0.4226

¹⁰All the other parameters are kept at their benchmark values.

Sensitivity Analysis, $\eta = 2.5$ ¹¹.

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

	m=0	m=0.8
Relative consumption to output	0.4186	0.4590
Consumption	0.90	1.02

Table 14: Trade liberalization for m=0.4.

	$\tau = 0.50$	$\tau = 0$
Relative consumption to output	0.4695	0.4208

¹¹All the other parameters are kept at their benchmark values.