International Risk Sharing in Emerging Economies*

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Abstract

This paper looks into the implications of international risk sharing in emerging economies. From an empirical perspective, I document two new facts. First, the Backus-Smith puzzle is more severe in emerging than in industrial economies. Second, international investment correlations in emerging economies are lower compared to industrial economies. I also confirm two previously documented findings: 1) international consumption correlations in emerging economies are low and often negative, whereas they are positive in industrial economies; and 2) there is excess volatility of consumption relative to income in emerging but not in industrial economies. Altogether, these facts imply lower levels of risk sharing in emerging *vis-à-vis* industrial economies.

From a theoretical standpoint, I develop a multi-country general equilibrium model with asymmetric trade that explains these facts using two key transmission mechanisms: 1) inelastic trade, and 2) stochastic shocks to trend growth. On the one hand, due to inelastic trade, a negative productivity shock at home leads to a depreciation of the terms of trade that further reduces domestic wealth. A strong enough negative wealth effect results in a drop of total demand of the domestic good; thus explaining the perceived lack of international risk sharing. On the other hand, due to stochastic shocks to the rate of productivity growth and a low share of world trade, emerging economies have a lower scope of risk sharing. This further decouples emerging from industrial economies' international co-movements of prices and quantities. I calibrate the model to match within-country and across-countries' business cycle statistics for Mexico *vis-à-vis* US.

Keywords: International Finance, Business Cycles, Open Economy.

JEL codes: E32, F31, F41

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1 Introduction

A large body of literature attempts to explain the puzzles of international macroeconomics from the perspective of industrial economies. However, less is known about the relevance and properties of such puzzles from the perspective of emerging economies. In this paper, I study international consumption risk sharing from the perspective of emerging economies making two contributions: First, I document two new facts and confirm two additional facts of international risk sharing that distinguish emerging from industrial economies. Second, I develop a 3-country general equilibrium economy that is consistent with these facts.

On the empirical side, I document two new facts that distinguish emerging from industrial economies. First, the Backus-Smith puzzle, or the negative correlation between real exchange rate and relative consumption, is more severe in emerging economies with a mean correlation of -0.35 than in industrial economies with a mean correlation of -0.08. Second, international investment correlations are stronger in industrial economies with a mean correlation of 0.58 than in emerging economies with a mean correlation of 0.16. The first fact is in contrast with the prediction of a positive co-movement between relative prices and relative consumption that should result from insurance against country-specific risk through international trade and finance. Along these lines, the spillover of consumption risk sharing to investment decisions should be reflected in higher and not lower international investment correlations. Thus, my empirical findings suggest that international risk sharing is lower in emerging economies than in industrial economies.

In a similar vein, I more widely establish two previously documented empirical facts about risk sharing in emerging economies. First, international consumption correlations are usually low and often negative in emerging economies with a mean correlation of -0.02 whereas they are positive and stronger for industrial economies with a mean correlation of 0.49. Second, consumption volatility exceeds income volatility in emerging economies with a mean relative consumption-to-income volatility of 1.04, while the converse is true for industrial countries with a mean relative volatility 0.77. The first empirical observation has been noted by Obstfeld and Rogoff (1996) henceforth OR 1996, and Kose, Prasad, and Terrones (2007) henceforth KPT 2007. The latter study documents negative international consumption correlations for developing economies with a median of -0.03 and emerging economies with a median of -0.11 as well as a positive correlation for industrial economies with a median of 0.52 during the globalization period of 1987 to 2004. The second empirical observation of excess relative consumption volatility has been documented by Kose, Prasad and Terrones (2003) henceforth KPT 2003, Neumeyer and Perri (2005) henceforth NP

2005, and Aguiar and Gopinath (2007) henceforth AG 2007. In agreement with these studies, my results confirm the presence of lower levels of consumption risk sharing in emerging *vis-à-vis* industrial economies. Further, my dataset is more recent (1980 to 2009) and contains more countries (n=73) than NP 2005, KPT 2007, and AG 2007.

To explain the observed patterns of consumption risk sharing of both emerging and industrial economies I develop a 3-country, two-sector, general equilibrium model of the economy. The model structure merges two related, yet separate, strands of the literature. One strand is the open economy general equilibrium literature (e.g., Backus, Kehoe, and Kydland (1992) henceforth BKK 1992), the other strand is the small open economy literature with partial equilibrium models (e.g., Mendoza (1991)). Specifically, in my model I draw on two key transmission mechanisms. First, I extend the inelastic trade mechanism of Corsetti, Dedola, and Leduc (2008) to a 3-country model with asymmetric trade. Second, I follow AG 2007 and use stochastic shocks to trend growth to model the business cycle channel of emerging economies.

In my model, the world economy is composed of two large (industrial) countries and one small (emerging) country, each with similar levels of home bias. The relative importance in world trade amongst these countries is determined by the size of their trade linkages. Thus, in my model the emerging country contributes only a small fraction to world trade relative to the large economies. The implication of this asymmetric trade is that it constrains the impact of the emerging economy on world prices. Then, given trade asymmetries, the transmission mechanisms work as follows: First, due to inelastic trade, a negative productivity shock at home can generate a depreciation of the terms of trade further reducing the home country's wealth. A strong enough negative wealth effect results in a drop of total demand of the domestic good. Thus, on impact, a negative productivity shock causes a real depreciation that leads to a drop in relative consumption which explains the observed lack of international risk sharing. Second, due to stochastic shocks to the rate of productivity growth and asymmetric trade, shocks to productivity in the emerging economy have negligible impact on international prices. As a result, productivity shocks in the emerging economy are further decoupled from the world economy resulting in lower international correlations of prices and quantities relative to industrial economies.[1]

Last, I examine the fit of the 3-country model by calibrating it to match within-country and across-countries' statistics of consumption risk sharing. Namely, I calibrate the model to match relative volatilities and international prices and quantities'

[1] The empirical relationship between trade intensity and business cycle asymmetries in developing countries has been documented by Calderon, Chong, and Stein (2002).

correlations for Mexico *vis-à-vis* US during the period 1980-2003.

I find that a 3-country model with asymmetric trade replicates the international risk sharing facts in terms of relative rankings in international correlations as well as within-country business cycle statistics for both emerging and industrial economies. One caveat of the 3-country model is that it overestimates relative investment volatility in emerging economies by about as twice as that of industrial economies. Although my empirical findings do not support this prediction, it is interesting to note that AG 2007 have documented that investment tends to be more volatile in emerging countries.[2]

The paper is organized as follows. Section 2 discusses the empirical evidence on consumption risk sharing for a cross-section of 73 countries. Section 3 develops the full dynamic model. Section 4 describes the workings of the model, its calibration to data of Mexico *vis-à-vis* US, and the quantitative implications of different versions of the model. Section 5 checks for robustness. Last, section 6 concludes.

2 Empirical Facts

I construct my dataset from a cross-section of 73 countries. I collect national income accounts (NIPA) data from Penn World Tables 7.0, and price data from International Financial Statistics (IFS). The frequency is annual and the period is 1980-2009. I classify the countries in three clusters following KPT 2003. The three subsamples are: 23 emerging economies, 27 developing economies, and 23 industrial economies. The data series are per-capita, constant-dollar, chain-weighted, purchasing-power-parity adjusted (base year 2005). Following KPT 2003 I construct the world country equivalent from a trade-weighted average of G7 economies. The G7 aggregate accounts for about 50% of global nominal GDP; this makes it a sensible candidate for world benchmark.[3]

I measure consumption risk sharing through several empirical relationships predicted by economic theory (Backus and Smith (1993), OR 1996). First, I calculate international consumption correlations of each country relative to the world. Open economy theory suggests that in a world where the law of one price holds domestic and foreign consumption should be positively associated. Second, if the world is more accurately represented by large deviations from purchasing power parity (PPP)

[2] This remains an inconclusive fact as Aguiar and Gopinath (2007) use a smaller cross-country sample (n=23), a shorter time period (1980-2003), and different data frequency (quarterly).

[3] KPT 2007 test the sensitivity of the international correlations to the choice of the world aggregate. Their results are robust to the choice of world aggregate (G7 or a larger sample of industrial countries).

then a standard to measure risk sharing is the international correlation between real exchange and relative consumption. Third, a rough measure of consumption risk sharing can also be obtained by measuring consumption volatility relative to income. The lower the relative consumption volatility, the more the households are insured against consumption risk. Last, I calculate international output and investment correlations as they are informative measures of the quantity puzzles in international economics (BKK 1992, OR 1996). Table 1 summarizes the key moments from a cross-section of 73 countries during the period 1980-2009. The countries are classified into 23 emerging countries, 27 developing countries, and 23 industrial countries.

	Emerging	**Developing**	**Industrial**
$\frac{\sigma_c}{\sigma_y}$	1.04	1.37	0.77
$\frac{\sigma_i}{\sigma_y}$	3.33	4.52	3.70
$\rho(y, y^*)$	0.15	0.03	0.66
$\rho(c, c^*)$	-0.02	-0.07	0.49
$\rho(i, i^*)$	0.16	0.09	0.58
$\rho(rer, \frac{c}{c^*})$	-0.35	-0.14	-0.08
N	23	27	23

Table 1. Within and across-country statistics (means)

I document the following features that distinguish industrial from non-industrial economies, for the latter: 1) consumption is more volatile than income; 2) international consumption correlations are low and negative; 3) international investment correlations are low and positive; 4) the Backus-Smith correlation is more severe compared to industrial countries.

Additionally, I measure relative investment-to-income volatility. This moment is larger in developing countries with a mean of 4.5 than in industrial countries with a mean of 3.7. However for the subsample of emerging economies there is a lower relative investment volatility with a mean of 3.3. In this respect AG 2007 document that relative investment volatility is larger in emerging and developing economies with a mean 3.9 than in industrial economies with a mean of 3.4. As noted earlier, AG 2007 draw on a smaller sample size and a shorter time period than this paper. However, when I put together the subsamples of emerging and developing countries then relative investment volatility has a mean of 4.0 and thus it is larger than its corresponding industrial country sample with a mean of 3.7; thus roughly in agreement with AG 2007. Table 6 Exhibits A (Emerging), B (Developing), and C (Industrial) in Appendix B provide more detail of the statistics on a by-country basis.

The subsample of developing countries in Exhibit B tends to further reinforce the empirical observations found for emerging markets in that developing countries appear to have lower levels of risk sharing as reflected by larger values of relative consumption volatility and lower international consumption correlations. In contrast, as shown in Exhibit C, industrial economies have: 1) positive international consumption correlations; 2) less severe Backus-Smith correlation; iii) higher and positive international output and investment correlations; iv) relative consumption volatility lower than unity.

Further evidence of the lack of consumption risk sharing is given by the pattern of international output-consumption correlations. Theory suggests that consumption risk sharing should be indicated by international consumption correlations being greater than international output correlations. All the sub-samples fail this test. This result is known as the international output-consumption correlations puzzle and it has been extensively documented elsewhere (BKK (1992, 1995), OR 1996, KPT (2003, 2007)). My empirical results, with a larger and more recent sample, confirm this quantity puzzle for the full-sample as well as the subsamples of countries.

3 Model

The canonical framework for emerging economies is the small open economy (SOE) model (Mendoza, 1991) and related small-country outlines of standard open economy models (OR 1996). Two important shortcomings of the standard SOE model are: 1) it reduces trade to the exchange of a risk-free international bond; 2) it is a partial equilibrium approach. For the purpose of this study I address these limitations by fully integrating the SOE within the standard open economy general equilibrium framework.

My model is built upon and extends the multi-country structure as in Corsetti, Dedola and Leduc (2008), henceforth CDL 2008, with the innovation that I explicitly add a third country which represents the emerging economy. To ensure consistency with the small economy paradigm, I incorporate the SOE into the model so that it has minimal impact on the world interest rate and world output. Aside from the previous condition, the SOE is modeled in a standard fashion.

A novel feature of my modeling approach is that, in order to effectively incorporate a SOE within a multi-country configuration, I build a model of international trade composed by three (3) countries. Namely, two (industrial) large open economies (LOEs) and one (emerging) small open economy (SOE). The idea behind the 3-country configuration relies in that through asymmetric trade I reduce the impact of SOE shocks on the world interest rate and world output. I achieve this by imposing a low share of SOE's production that can be consumed from abroad via international trade. Further, the 3-country model allows me to study simultaneously the business cycle properties of both large and small economies. Last, another advantage of the 3-country configuration is that, given its structure, the 2-country model becomes a special case of the 3-country setup. I proceed now to discuss the details of the model.

Each LOE produces Tradable (T) and Non-Tradable (NT) goods. For simplicity I assume that the SOE produces tradable goods only. In what follows I denote the (home) emerging economy as E and the (foreign) developed economies as $D1$ and $D2$.

3.1 Production

Each industrial country (LOE) $i = \{D1, D2\}$ produces both tradable (T) and non-tradable (N) *intermediate* goods using the following technologies.

$$(1) \qquad Y_{i,t}^{T} = e^{z_t^T}(K_{i,t}^{T})^{\alpha^T}(Z_{i,t}^{T} \cdot L_{i,t}^{T})^{1-\alpha^T}$$
$$(2) \qquad Y_{i,t}^{N} = e^{z_t^N}(K_{i,t}^{N})^{\alpha^N}(Z_{i,t}^{N} \cdot L_{i,t}^{N})^{1-\alpha^N}$$

The productivity processes are AR(1): $z_t^k = \rho_i^k z_{t-1}^k + \epsilon_{i,t}^k$, with $\epsilon_{i,t}^k \sim N(0, \sigma_{i,k}^2)$ with $k = \{T, N\}$

Each country i production has labor-augmenting technology that follows the process:

$$\ln(Z_{i,t}^k) = \ln(G_t^k) + \ln(Z_{i,t-1}^k) \text{ with } G_t^k = e^{g_t^k}$$

The shock g_t^k follows a standard AR(1) process with a drift:

$$g_t^k = \mu_g + \epsilon_t^k \text{ with } \epsilon_t^k \sim N(0, \sigma_k^2)$$

I stationarize equations (1) and (2) along the balanced growth path using detrended variables $\hat{V}_{i,t}^j = \frac{V_t^j}{Z_{i,t-1}^j}$ to obtain:

$$(1') \qquad \hat{Y}_{i,t}^{T} = e^{z_t^T}(\hat{K}_{i,t}^{T})^{\alpha^T}(e^{g_{i,t}^T} L_{i,t}^{T})^{1-\alpha^T}$$
$$(2') \qquad \hat{Y}_{i,t}^{N} = e^{z_t^N}(\hat{K}_{i,t}^{N})^{\alpha^N}(e^{g_{i,t}^N} L_{i,t}^{N})^{1-\alpha^N}$$

Next is the SOE. The emerging country specializes in the production of a *final* traded good. Production in the emerging economy is given by:

$$(3) \qquad Y_{E,t} = e^{z_t}(K_{E,t-1})^{\alpha^E}(Z_{E,t} \cdot L_t)^{1-\alpha^E}$$

I follow AG 2007 and specify $Z_{E,t}$ as an *stochastic trend* growth process denoted by:

$$\ln(Z_{E,t}) = \ln(G_t) + \ln(Z_{E,t-1}) \text{ with } G_t = e^{g_t}$$

where the shocks z_t and g_t follow standard AR(1) processes:

$$g_t = (1\text{-}\rho_g)\mu_g + \rho_g g_{t-1} + \epsilon_t^g$$

$$z_t = \rho_i z_{t-1} + \epsilon_t^e, \text{ with } \epsilon_t^j \sim N(0, \sigma_i^2) \text{ and } j = \{e, g\}$$

I define the detrended counterpart of the SOE's variables as $\hat{X}_t = \frac{X_t}{Z_{E,t-1}}$.
Thus equation (3) becomes:

$$(3a) \qquad \hat{Y}_{E,t} = e^{z_t}(\hat{K}_{E,t})^{\alpha_E}(e^{g_t}L_t)^{1-\alpha_E}$$

Final producers in each of the economies are competitive. They purchase home (h) and foreign (f) tradable goods at wholesale prices $\bar{P}_{hij,t}$ and $\bar{P}_{fji,t}$, where $i, j = \{D1, D2, E\}$ and $i \neq j$. [4] The final traded goods basket in each economy is given by:

$$(4) \qquad C_{i,t}^T = \left[a_h^{\frac{1}{\omega_h}} \hat{C}_{hi,t}^{\frac{\omega_h - 1}{\omega_h}} + (1 - a_h)^{\frac{1}{\omega_h}} \hat{C}_{fi,t}^{\frac{\omega_h - 1}{\omega_h}} \right]^{\frac{\omega_h}{\omega_h - 1}}$$

Similarly, the bundle of foreign goods $C_{f,t}$ is an aggregate of traded goods originating in the foreign countries:

$$(5) \qquad \hat{C}_{fi,t} = \left[a_f^{\frac{1}{\omega_f}} \hat{C}_{fij,t}^{\frac{\omega_f - 1}{\omega_f}} + (1 - a_f)^{\frac{1}{\omega_f}} \hat{C}_{fik,t}^{\frac{\omega_f - 1}{\omega_f}} \right]^{\frac{\omega_f}{\omega_f - 1}}$$

The parameter $\omega_k > 0$, $k = \{h, f\}$ captures the (constant) trade elasticity of substitution. The parameter $a_h \in (0, 1)$ is the share of each country's domestic good in the consumption basket. Similarly, $a_f \in (0, 1)$ denotes the relative share of foreign goods consumed from the rest of the world. I assume home bias ($a_h > 1/2$) and foreign bias towards a preferred trading partner ($a_f > 1/2$).It is important to note here that given the 3-country model structure, I can configure a 2-country model as a special case by setting the parameter $a_f = 1$.

[4] For simplicity of exposition, in what follows I use stationarized versions of all the equations.

3.2 Households

3.2.1 LOE

The representative household $i = \{D1, D2\}$ chooses a composite bundle of consumption $C_{i,t}$ and labor $L_{i,t}$ to maximize the expected stream of lifetime utility. The household's problem is

$$\underset{C_{i,t}}{Max} E_t \sum_{t=0}^{\infty} \theta_{i,t} U(\hat{C}_{i,t}, L_{i,t})$$

I use standard CES preferences $U(\hat{C}_{i,t}, L_{i,t}) = \frac{[\hat{C}_{i,t}^{\nu}(1-L_{i,t})^{1-\nu}]^{1-\sigma}}{1-\sigma}$ with $\sigma \geq 0$ the risk aversion parameter. As in Schmitt-Grohe and Uribe (2003), the term θ_t denotes the endogenous discount factor which I assume it to be a function of per capita consumption as in CDL 2008:

$$\theta_{i,t+1} = \theta_{i,t} \beta(\hat{C}_{i,t}, L_{i,t})$$

$$\beta(\hat{C}_{i,t}, L_{i,t}) = [1 + \psi \hat{C}_{i,t}^{\nu}(1 - L_{i,t})^{1-\nu}]^{-1}$$

where $\psi > 0$ is calibrated so that the steady state annual real interest rate is 4%.

Aggregate household consumption $\hat{C}_{i,t}$ is a basket of traded (T) and non-traded (N) goods

$$\hat{C}_{i,t} \equiv \left[a_T^{\frac{1}{\epsilon}} (\hat{C}_{i,t}^{T})^{\frac{\epsilon-1}{\epsilon}} + (1 - a_T)^{\frac{1}{\epsilon}} (\hat{C}_{i,t}^{N})^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} \tag{6}$$

where a_T denotes the share of traded goods and $\epsilon > 0$ is the elasticity of substitution between traded and non-traded goods.[5]

3.2.2 SOE

The SOE household chooses a bundle of consumption goods $\hat{C}_{E,t}$ and labor supply L_t to maximize the expected future value of lifetime utility. The SOE household solves

$$\underset{\hat{C}_t, L_t}{Max} E_t \sum_{t=0}^{\infty} \theta_{E,t} U(\hat{C}_{E,t}, L_t)$$

[5] For expositional convenience from here onwards I omit the time subscript wherever possible.

$$\text{with } U(\hat{C}_{E,t}, L_t) = \frac{[\hat{C}^{\nu}_{E,t}(1-L_t)^{1-\nu}]^{1-\sigma}}{1-\sigma}, \nu \in (0,1)$$

Without loss of generality, I assume that aggregate household consumption in the SOE consists only of traded goods. Therefore the consumption bundle of the household $\hat{C}_{E,t}$ is equivalent to $\hat{C}^T_{E,t}$ as in (4).

3.3 Prices and demand functions

3.3.1 LOE

The price index of the domestic final good in each developed economy $i = \{D1, D2\}$ is given by:

$$(8) \qquad P_{i,t} = \left[a_T(P^T_{i,t})^{1-\epsilon} + (1-a_T)(P^N_{i,t})^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$$

Likewise, the price index of tradables in country (i) is given by:

$$(9) \qquad P^T_{i,t} = \left[a_h P^{1-\omega_h}_{hi,t} + (1-a_h)P^{1-\omega_h}_{fi,t}\right]^{\frac{1}{1-\omega_h}}$$

Last, the price of foreign goods is:

$$(10) \qquad P_{fi,t} = \left[a_f P^{1-\omega_f}_{fij,t} + (1-a_f)P^{1-\omega_f}_{fik,t}\right]^{\frac{1}{1-\omega_f}}$$

where $j, k = \{D1, D2, E\}$ and $i \neq j \neq k$,

I follow CDL 2008 by distinguishing between consumer's prices (P) and (wholesale) producer's prices $(\bar{P})$ under the assumption of distribution services. In other words, the consumer price P is different from the intermediate firm's (producer) price $\bar{P}$ due to the additional cost of non-traded inputs associated to distribution of final (consumer) goods

$$P = \bar{P} + \eta P^N$$

where η denotes the share of non-traded input in the traded consumption good $(C_{hi}$ or $C_{fi})$.

3.3.2 SOE

Since the SOE only produces and consumes traded goods, its final goods price index $P_{E,t}$ is equivalent to $P^T_{E,t}$ as in equation (9). Without loss of generality I impose an additional simplifying assumption and allow the SOE to trade with one

LOE ($D1$) only (i.e., the major trading partner of the emerging economy). The latter assumption effectively simplifies the model by eliminating one quantity index (Eq. 5) and one price index (Eq. 10) from the SOE configuration.

Given price indices, quantities, and elasticities, the demand functions for each country i are:

1) demand of domestic goods

$$\hat{C}_{hi,t} = \left(\frac{P_{hi,t}}{P^T_{i,t}}\right)^{-\omega_h} \hat{C}^T_{i,t}$$

2) demand for traded goods

$$\hat{C}^T_{i,t} = \left(\frac{P^T_{i,t}}{P_{i,t}}\right)^{-\epsilon} \hat{C}_{i,t}$$

3.4 Aggregate resource constraints and capital accumulation

All countries in the model economy can borrow and lend through an international non-contingent bond B_{it} given in units of the aggregate consumption good. Debt is repaid after each period.

The aggregate resource constraint of each large economy $i = \{D1, D2\}$ is given by:

$$(11) \qquad P_{i,t}\hat{C}_{i,t} + \bar{P}_{hi,t}\hat{I}_{i,t} + P_{i,t}\hat{B}_{i,t} \leq P_{i,t}\hat{Y}_{i,t} + e^{g^i_t} Q_t \hat{B}_{i,t+1}$$

Likewise, the budget constraint of the emerging economy is:

$$(12) \qquad P_{E,t}\hat{C}_{E,t} + \bar{P}_{hE,t}\hat{I}_{E,t} + P_{E,t}\hat{B}_{E,t} \leq P_{E,t}\hat{Y}_{E,t} + e^{g_t} Q_{E,t} \hat{B}_{E,t+1}$$

where Q_t is LOE's i price of debt B_{it} due in $t+1$ and $Q_{E,t}$ is the price of debt in the SOE at $t+1$ and is defined as in AG 2007

$$Q_{E,t} = [1/Q_t + \psi_E(e^{\hat{B}_{Et} - \bar{B}_E} - 1)]^{-1}$$

For each economy, capital accumulation follows a standard law of motion. For the LOEs we have:

$$(13) \qquad e^{g^i_t}\hat{K}_{j,t} = \hat{I}_{j,t} + (1-\delta)\hat{K}_{j,t-1}, \; j = \{T, N\}$$

and for the SOE:

$$(14) \qquad e^{g_t}\hat{K}_{E,t} = \hat{I}_{E,t} + (1-\delta)\hat{K}_{E,t-1}$$

3.5 Competitive Equilibrium

The competitive equilibrium of the model is obtained by solving the decentralized economy problem for each country's (LOE and SOE) representative household:

$$\underset{\hat{C}_{i,t},L_t}{Max} E_t \sum_{t=0}^{\infty} \beta U(\hat{C}_{i,t}, L_t)$$

subject to the aggregate resource constraints (11, 12), capital accumulation (13, 14), and the technology shock matrix $\Lambda_{t+1} = \Omega\Lambda_t + \epsilon_t$, where $\Lambda = [z_{i,t}^T, z_{i,t}^N, Z_{E,t}, z_t]$, $i, j = \{D1, D2\}$, $i \neq j$.

Given the state of the world $s = \{\hat{B}_{i,t}, \hat{B}_{E,t}, \hat{K}_{i,t}, \hat{K}_{E,t}; \Lambda_t\}$, the recursive general equilibrium is defined as:

i) A set of household and production decision rules:

$$\left\{\hat{C}_{hi,t}(s), \hat{C}_{fi,t}(s), \hat{C}_{i,t}^N(s), \hat{C}_{hE,t}(s), \hat{C}_{fE,t}(s), \hat{I}_{i,t}(s), \hat{I}_{E,t}(s), L_t(s), \hat{B}_{i,t+1}, \hat{B}_{E,t+1}\right\}$$

ii) A set of price functions:

$$\{P_{hi,t}(s), P_{fi,t}(s), P_i^N(s), Q_{i,t}(s), Q_{E,t}(s)\}$$

Such that:

a) Given the prices (ii) and technologies (1)-(3), the allocations (i) solve the household and production problems.

b) the goods markets clears:

$$\hat{Y}_{i,t}^N = \hat{C}_{i,t}^N + \eta(\hat{C}_{hi,t} + \hat{C}_{fi,t}),$$

$$\hat{Y}_{i,t}^T = \hat{I}_{i,t} + \hat{C}_{hi,t} + \hat{C}_{hj,t} + \hat{C}_{hE,t}$$

$$\hat{Y}_{E,t} = \hat{I}_{E,t} + \hat{C}_{hE,t} + \hat{C}_{hD1,t}$$

c) the factors' market clears:

$$\hat{K}_{i,t} = \hat{K}_{i,t}^T + \hat{K}_{i,t}^N,$$

d) the international bonds market clears:

$$\hat{B}_{D1,t+1} + (1 - a_f)\hat{B}_{D2,t+1} + a_f\hat{B}_{E,t+1} = 0$$

The dynamic equilibrium holds in all states, given the realizations of aggregate shocks at time t.

4 Model Analysis, Calibration, and Results

This section describes the workings of the model based on a basic endowment economy version of the model under different market structures. Next I describe the calibration of model parameters to data of Mexico *vis-à-vis* US. The section concludes with a discussion of the results implied by different versions of the model that illustrate the quantitative implications of the transmission mechanisms.

4.1 Core Model Analysis

I take CDL 2008 theory of the international transmission of productivity shocks and extend it to a multi-country model that embeds a small open economy (SOE) within the world economy. CDL 2008 posit a solution to the international risk sharing puzzle through a negative trade channel driven by a low value of the trade price elasticity of demand. The basic intuition is that with inelastic trade a terms of trade depreciation that lowers domestic wealth relative to the rest of the world can cause a drop in total demand for domestic goods.

To illustrate the key transmission mechanisms in the multi-country model I study a more simple version of the model. The world is represented by an endowment economy with 3-countries and 3-traded goods under incomplete markets and home bias in consumption. Specifically, I use a 3-country model with 2 LOEs and one SOE. The 3-country framework allows me to set the relative size of trade linkages in a way that the SOE contributes a small fraction to world trade. As it will be shown below, the implication of the 3-country framework is that the LOEs are dominant in setting world prices relative to the SOE.

There are 3 countries denoted by $\{e, u, r\}$ where e is the SOE, u is the US, and r is the rest of the world (RoW). Households in each country have standard CES preferences given by $U = \frac{C^{1-\sigma}}{1-\sigma}$. For simplicity I further assume that u trades both with e and r, but the latter two do not trade with each other (e.g., due to geographical distance constraints).

Thus, the consumption basket of each country $k = \{e, r\}$ is given by an aggregate of home k and foreign goods u:

$$C_k = [a_h^{\frac{1}{\omega}} C_{k,k}^{\frac{\omega-1}{\omega}} + (1 - a_h)^{\frac{1}{\omega}} C_{u,k}^{\frac{\omega-1}{\omega}}]^{\frac{\omega}{\omega-1}}$$

where $\omega > 0$ is the elasticity of substitution between home and foreign goods and $a_h > \frac{1}{2}$ denotes the home bias motive.

The associated price index is $P_k = [a_h P_{k,k}^{1-\omega} + (1 - a_h) P_{u,k}^{1-\omega}]^{\frac{1}{1-\omega}}$ with $P_{k,k}(P_{u,k})$ the domestic (foreign) price.

The demand function for the domestic good is given by the expression

$$C_{k,k} = a_h(\frac{P_{k,k}}{P_k})^{-\omega} C_k$$

where ω is the price elasticity of demand as well as the trade elasticity of substitution.

Define terms of trade as the relative price of imports over exports:

$$\tau_{k,u} = \frac{P_{u,k}}{Pk,k}$$

The consumption basket of country u is similar:

$$C_u = [a_h^{\frac{1}{\omega}} C_{u,u}^{\frac{\omega-1}{\omega}} + (1-a_h)^{\frac{1}{\omega}} C_{w,u}^{\frac{\omega-1}{\omega}}]^{\frac{\omega}{\omega-1}}$$

where $C_{w,u}$, the consumption basket of foreign goods has two varieties:

$$C_{w,u} = [a_e^{\frac{1}{\omega}} C_{e,u}^{\frac{\omega-1}{\omega}} + (1-a_e)^{\frac{1}{\omega}} C_{r,u}^{\frac{\omega-1}{\omega}}]^{\frac{\omega}{\omega-1}}$$

The parameter $a_e \ \epsilon \ [0,1]$ denotes the size of trade linkage of country u with country e and $(1-a_e)$ is the relative size of trade between u and r. Thus, a low value of a_e makes e small relative to r in terms of shares of world trade. In the limit, as $a_e \to 0$ the 3-country model turns into the standard 2-country open economy model. Because of symmetry, the expressions for prices and demand functions for country u have the same structure as the ones for country k.

4.1.1 Endowment shocks and prices under complete markets

It is straightforward to show that under complete markets the core model implies the risk sharing condition between two countries $\left(\frac{C}{C^*}\right)^{\sigma} = \frac{P^*}{P}$, where $*$ denotes the foreign country.

The market clearing conditions for the world economy are given by

$$Y_k = C_{k,k} + C_{k,u} \ , \ k = \{e, r\}$$

$$Y_u = C_{u,u} + (1-a_e)C_{u,r} + a_e C_{u,e}$$

Using the model setup introduced earlier and noting that $a_e << 1$, solve for the effect of endowment shocks in country e (i.e, SOE) relative to country u to obtain:

$$\frac{Ye}{Yu} \approxeq \tau_{e,u}^{\omega} \frac{a_e(1-a_{h)}+a_h\left[\frac{a_h\tau_{e,u}^{\omega-1}+(1-a_h)}{a_h+(1-a_h)\tau^{1-\omega}}\right]^{\frac{\sigma\omega-1}{\sigma(1-\omega)}}}{a_h+(1-a_h)\left[\frac{a_h\tau^{1-\omega}+(1-a_h)}{a_h+(1-a_h)\tau^{1-\omega}}\right]^{\frac{\sigma\omega-1}{\sigma(1-\omega)}}}$$

where $\tau = \frac{P_{u,r}}{P_{u,u}}$ denotes the world terms of trade. In log-linear terms, the above expression reduces to:

$$\hat{\tau}_{e,u} = \frac{\hat{Y}_e-\hat{Y}_u}{\omega+a_h^2(\sigma\omega-1)} + \frac{(\sigma\omega-1)(1-a_h)(3a_h-1)}{\omega+a_h^2(\sigma\omega-1)}\hat{\tau}$$

The equation above indicates that, holding world prices constant, positive endowment shocks in country e are associated with a terms of trade depreciation in country e *vis-à-vis* country u. It follows that under complete markets (and standard parameterizations) the transmission channel is *positive*.

4.1.2 Implications under incomplete markets

For the sake of exposition, in the following analysis I assume financial autarky. Begin by using the market clearing condition for SOE tradable output and the budget constraint $P_kC_k = P_{k,k}Y_k$, with $k = \{e, u, r)$ to obtain:

$$\frac{Y_e}{Y_u} = \frac{a_e\tau_{e,u}^{\omega}\left[a_h+(1-a_h)\tau_{e,u}^{1-\omega}\right]}{a_h\tau_{e,u}^{1-\omega}+(1-a_h)\tau_{e,r}^{1-\omega}}$$

where $\tau_{e,r}$ are country e's terms of trade *vis-à-vis* country r which after log-linearization become:

$$\hat{\tau}_{e,u} = \frac{(\hat{Y}_e-\hat{Y}_u)+(1-a_h)(1-\omega)\hat{\tau}_{e,r}}{[1-2a_h(1-\omega)]}$$

The above equation indicates that the relationship between country e's terms of trade and home endowment shocks can have either sign. In particular, holding world prices constant, a positive supply shock in country e can result in a terms of trade appreciation when:

$$\omega < \frac{2a_h-1}{2a_h}$$

In terms of the real exchange rate of country e *vis-à-vis* country u, it is straightforward to show:

$$\widehat{rer}_e = \frac{(2a_h-1)(\hat{Y}_e-\hat{Y}_h)+\omega(1-a_h)\hat{\tau}_{e,r}}{1-2a_h(1-\omega)}$$

Thus, under financial autarky and home bias in consumption, a trade elasticity $\omega < \frac{1}{2}$ results in a terms of trade and real exchange rate *appreciation* in response to a positive endowment shock. This is the *negative* channel for the transmission of supply shocks.

What is the implication of *inelastic* trade on relative consumption? To answer this question use the balanced trade condition $P_{u,e}C_{u,e} = P_{e,u}C_{e,u}$ and find (after log-linearization):

$$\widehat{rer}_e = \frac{1}{2a_H\omega-1}\left[(2a_H - 1)(\hat{c}_e - \hat{c}_u) - (1 - a_h)(1 - \omega)\hat{\tau}_{e,r}\right]$$

The equation above indicates once again that the Backus-Smith correlation can take either sign. In particular, holding world prices constant, when $\frac{2a_H-1}{2a_H\omega-1} < 0$, that is, a trade elasticity $\omega < \frac{1}{2a_H} < 1$ leads to a *negative* correlation between the real exchange rate and relative consumption.

To complete the exposition, I use stochastic shocks to trend growth in the emerging economy (i.e. country e) as in AG 2007. The trend shocks are of the form:

$$Z_{e,t} = e^{g_t} Z_{e,t-1}$$

where g_t is a standard AR(1) process.

As previously discussed, in the 3-country model asymmetric trade ($a_e << 1$) makes country e to have negligible impact on world prices. Thus, in the 3-country model trend shocks in conjunction with a small share of world trade in the SOE work as a modeling device to: 1) match relative consumption volatility in the SOE, and 2) match rankings in international correlations of prices and quantities of the SOE *vis-à-vis* LOEs.

4.2 Calibration

Table 2 summarizes the parameter values of the multi-country model. Most parameter values are drawn from CDL 2008. The capital share (SOE) and the elasticity of the discount factor (SOE) are drawn from AG 2007.

Preferences and Technology		
Risk aversion	σ	2
Consumption share	ν	0.34
Capital share in tradables	α^T	0.39
Capital share in non-tradables	α^N	0.34
Capital share (SOE)	α^E	0.32
Elasticity of substitution		
Home and Foreign traded goods	ω	0.92
Between Foreign traded goods	ω_f	0.92
Traded and non-traded goods	ω_t	0.74
Share of Home-traded goods (3-c)	a_h	0.72
Share of Home-traded goods (2-c)	a_h	0.86
Share of SOE-traded goods	a_e	0.05
Share of traded goods	a_T	0.55
Elasticity of discount factor (LOE)	ψ	0.08
Elasticity of discount factor (SOE)	ψ^e	0.01
Distribution margin	η	1.09
Depreciation rate	δ	0.10

Table 2. Parameter Values

I use two versions of the multi-country model: 1) a 2-country (2-c) model; and 2) the benchmark 3-country (3-c) model. The 3-country model includes 2 LOEs and one SOE while the 2-country model contains 1 LOE and 1 SOE. To calibrate the models I choose Mexico as the SOE and US as the (main) LOE. For the second LOE in the 3-country version of the model I use a rest of the world aggregate (RoW). The RoW is a trade-weighted aggregate of G7 countries (excluding US) plus China.

The productivity processes follow standard the AR(1) specification

$$\mathbf{\Lambda}_{t+1} = \lambda \mathbf{\Lambda}_t + \mathbf{u}$$

For the persistence parameters of the SOE I use AG 2007 estimates for the transitory and permanent components of the Solow residual for Mexico, $\rho_e^T = 0.95$ and $\rho_e^P = 0.01$ respectively.[6] For the LOEs shock processes I use CDL 2008 sectoral (T, NT) estimates for US and their trade-weighted RoW aggregate.[7] The persistence

[6]Mexico's time series data spans from 1980-2003 (AG(2007) data appendix).

[7]CDL (2008) impose cross-country symmetry in calculating their estimates. The RoW they use is a traded weighted country aggregate of: Austria, Belgium/Luxemburg, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Spain, Sweden, U.K.

parameters are $\rho^T = 0.82$ and $\rho^N = 0.96$ respectively. For the full cross-country variance-covariance matrix of shocks refer to Appendix A.

Finally, the key parameters that I calibrate are the trade elasticity of substitution ω, the share of SOE-traded goods (trade linkage parameter) a_e in the 3-country version of the model and the share of home traded goods a_h in the 2-country version of the model. First, in the benchmark 3-country model I set $\omega = 0.92$ to match the ratio of consumption volatility to income volatility for Mexico *vis-à-vis* US. Next I set the trade linkage parameter $a_e = 0.05$ consistent with the criterion of choosing Mexico as a the SOE. Last, I set $a_h = 0.86$ in the 2-country version of the model to match the ratio of consumption volatility to income volatility.[8]

4.3 Results and Discussion

I study the quantitative implications under different configurations of the multi-country model. Namely, the benchmark 3-country bond economy and the 2-country version; the latter under two incomplete market structures: 1) financial autarky and 2) bond economy. Table 3 summarizes the relevant within- and across-country data moments and the simulated moments for the different model specifications. I discuss each set of results in what follows.

First is the benchmark 3-country bond economy (3BE). Here I calibrate the trade elasticity of substitution to 0.92 in order to match relative consumption volatility in Mexico. Column 4 in Table 3 shows the implications of the calibrated model. In terms of within-country volatilities, the 3BE model has a good fit with the data matching relative consumption volatilities in both the SOE and the LOEs. In terms of relative investment volatilities the model is also close to the data; although it tends to overestimate the effect on the SOE with a value of 5.47 compared to the data of 4.08, while it underestimates this moment on the LOEs with a value of 2.8 each compared to the data of 4 each. Although the relative volatility of the real exchange rate is underestimated, it is of a similar order of magnitude as in the data. Importantly, the 3BE model captures the ranking of the relative real exchange volatility being larger in the LOE than in the SOE. Moving on to international correlations, the 3BE model does a good job at capturing the patterns of international correlations (i.e., signs and rankings) both in the SOE and the LOEs. Specifically, the 3BE model predicts the Backus-Smith correlation to be more severe in the SOE with a value of -0.95 than in the LOE with a value of -0.59; the international consumption correlation is negative in the SOE with a value of -0.12 while it is positive in the LOE with a value of 0.06;

[8] I calibrate a_h in the 2-country bond economy model without trend shocks, see next section for more details.

last, the international output-consumption anomaly ($\rho(y, y^*) > \rho(c, c^*)$) is larger in LOE than in SOE which is consistent with the data.

Next I examine the 2-country bond economy (2BE). Note that the 2BE is just a nested version of the benchmark 3BE model with trade share of the third country equal to zero ($a_e = 0$). Here I use exactly the same parameterization as in the 3BE model with the exception that to proxy for country size I set the home bias parameter to $a_h = 0.86$, slightly larger than in other related studies (Stockman and Tesar (1995), CDL 2008). Since I solve for symmetric equilibrium, this means that both US and Mexico consume 86% of their own domestic production. In general the implications of the 2BE model suggest a poorer fit with the data. The 2BE model underestimates relative consumption volatility in Mexico to about 1/5 that of the data, relative investment volatility in both SOE and LOE is underestimated to about 1/2 that of the data, and the relative real exchange volatility is underestimated by a half. In terms of international moments the 2BE model predicts a negative international consumption correlation in the SOE with a value of -0.23, and it has a good fit with the Backus-Smith correlation with a value of -0.61. However international output and investment correlations are essentially zero. Another caveat of the 2BE model is that it captures a smaller set of international moments (i.e., SOE international correlations).

Last, I discuss the 2-country financial autarky (FA) model. Relative to 2BE, the FA model captures better the patterns in international consumption correlations. Its shortcoming lies in that it underestimates the Backus-Smith condition to less than 1/10 of the data. However, the main failure of the FA model is in matching within-country moments. Although the model correctly predicts volatility of consumption in excess of income volatility and a good fit with relative investment volatility for the SOE, it does it at the expense of underestimating relative consumption volatility in the LOE by about 1/7 of the data and overestimating relative investment volatility in the LOE (4 times larger) and an excessively large relative real exchange volatility (10 times larger than in the data).

Overall these results indicate that the benchmark 3BE model not only has a better fit than its 2-country counterparts but further, its richer underlying structure allows it to match a larger set of risk sharing patterns in both SOE and LOEs.

In the following subsection I proceed to discuss alternative model specifications that illustrate the transmission mechanisms that explain the patterns of international risk sharing in emerging economies.

	Data	2-country Financial Autarky	2-country Bond Economy	3-country Bond Economy
		Standard deviations		
$\sigma_{c_{MEX}}/\sigma_{y_{MEX}}$	0.96	1.19	0.22	0.95
$\sigma_{c_{US}}/\sigma_{y_{US}}$	0.73	0.11	0.48	0.68
$\sigma_{c_{ROW}}/\sigma_{y_{ROW}}$	0.90			0.72
$\sigma_{i_{MEX}}/\sigma_{y_{MEX}}$	4.08	3.51	2.25	5.47
$\sigma_{i_{US}}/\sigma_{y_{US}}$	4.00	15.87	2.08	2.80
$\sigma_{i_{ROW}}/\sigma_{y_{ROW}}$	4.11			2.84
$\sigma_{RER_{MEX}}/\sigma_{y_{MEX}}$	4.17	39.85	1.85	1.41
$\sigma_{RER_{US}}/\sigma_{y_{US}}$	7.72			4.58
		International correlations		
$\rho(RER_{MEX}, \frac{C_{MEX}}{C_{US}})$	-0.63	-0.05	-0.61	-0.95
$\rho(RER_{US}, \frac{C_{US}}{C_{ROW}})$	-0.09			-0.59
$\rho(C_{MEX}, C_{US})$	-0.13	-0.28	-0.23	-0.12
$\rho(Y_{MEX}, Y_{US})$	0.14	0.12	-0.00	0.04
$\rho(C_{US}, C_{ROW})$	0.43			0.06
$\rho(Y_{US}, Y_{ROW})$	0.50			0.43
$\rho(I_{MEX}, I_{US})$	0.29	0.31	0.01	0.07
$\rho(I_{US}, I_{ROW})$	0.29			0.43

Table 3. Data *vis-à-vis* Simulated Moments: 2-country vs. 3-country

4.3.1 Transmission mechanisms

What drives consumption risk sharing in emerging economies? To answer this question I proceed to examine each transmission mechanism separately. Table 4 shows the quantitative implications for the 2BE and 3BE models under different configurations. 1) BM is the benchmark model with both *inelastic* trade ($\omega = 0.92$) *and* stochastic shocks to trend; 2) the model labeled ω_{high} is the benchmark with *elastic* trade ($\omega = 4$); and last, 3) the model labeled NTS is the benchmark without shocks to trend growth.

I begin the analysis with the 2-country bond economy (2BE). As shown in column 3 of table 4, two key implications of allowing for elastic trade (ω_{high}) are: 1) the signs of the key international correlations switch from negative to positive; and 2) relative consumption volatility drops *vis-à-vis* the benchmark (BM). The first observation follows the previous analysis early in this section; with elastic trade the transmission mechanism is positive. The second observation is linked to the impact of trend shocks as follows. In column 4 (NTS), I switch off shocks to trend in the SOE. The most notable implication of the NTS model is that relative consumption volatility has an upward jump. This is because, *with inelastic trade,* shutting down trend shocks results in a large drop of (absolute) income volatility in the SOE. Why does the benchmark 2BE model have a lower relative consumption volatility? Closer examination of the full set of simulation results indicates that in fact trend shocks do increase (absolute) *consumption* volatility *vis-à-vis* the NTS model;[9] however, the increase in (absolute) *income* volatility is larger *vis-à-vis* the NTS model. Why? Recall that due to inelastic trade, consumption risk sharing is reduced; thus, trend shocks in the SOE are not sufficiently absorbed by world price adjustments resulting in a lower decrease in (absolute) *income* volatility in the benchmark model. The results of the NTS specification are not surprising insofar as relative consumption volatility is also a measure of consumption risk sharing. What is interesting however is that, within a multi-country framework with inelastic trade, trend shocks actually *dampen* relative consumption volatility.[10] Given this property, I calibrate the 2BE model based on the NTS specification by setting the home bias parameter $a_h = 0.86$ to match the data of relative consumption volatility for Mexico.[11] The results in column 4 show that the NTS specification matches well the Backus-Smith correlation and the sign of the international consumption correlation. However this specification predicts counter factually negative output and investment correlations. Lastly, in terms of within-country moments, it underestimates relative investment volatility in the SOE to be less than 1/3 of its data counterpart and over predicts relative real exchange rate volatility by over 3 times of its data counterpart.

I now proceed to examine the quantitative implications of the 3-country bond economy (3BE). In column 6, the ω_{high} specification with *elastic* trade ($\omega = 4$) fails to match the patterns of risk sharing in the following dimensions: 1) the Backus-Smith correlation is positive in the LOE; and 2) the international consumption correlation is counter factually greater than the international output correlation in the LOE. These two correlations predict, counter factually, increased risk sharing between the two LOEs. In contrast, the international consumption correlation and the Backus-Smith correlation remain negative in the SOE. This, however, is not a fault of the trade transmission channel. To understand why this is the case it helps to compare

[9]The full simulation results with absolute volatilities are not reported here for brevity but are available from the author upon request.

[10]In contrast, within the canonical SOE (partial equilibrium) framework, trend shocks amplify relative consumption volatility.

[11]A larger value of home bias indicates a more closed-economy.

columns 3 and 6 in table 4, the 2BE and 3BE models with high trade elasticity respectively. The key difference between these two models consists in the absence of the NT sector in the SOE within the 3BE model. In column 3, SOE households in the 2BE model have an additional scope of reducing consumption risk through the NT sector, whereas SOE households in the 3BE model do not. Column 7 shows the results for the 3BE benchmark shutting down trend shocks in the SOE. In general this version of the model has a good fit in terms of the patterns in international correlations; this model also has a good fit with the data in terms of within-country moments except for predicting excessive relative consumption volatility in the SOE (more than 2 times its data counterpart). To better examine the fit of the NTS specification, in the last column of Table 4 (NTS_2) I make an additional calibration. I pick the home bias parameter $a_h = 0.9$ to match relative consumption volatility in the SOE and examine the implications on the other simulated moments. The NTS_2 version has a good match in terms of within-country moments; however in terms of international correlations the fit is somewhat poorer relative to column 7 (NTS_1). Specifically, 1) the model predicts counter factually a more severe Backus-Smith correlation in the LOE than in the SOE; and 2) the international consumption correlation in the SOE switches sign to positive counter factually.

Taken together, these results confirm that the benchmark 3BE model (BM) with 1) low trade elasticity and 2) trend shocks in the SOE has a better fit in matching within- and across-country moments for both SOE and LOEs. The simulations suggest that the main advantage of trend shocks in my multi-country framework is twofold. First, as discussed previously, trend shocks reduce relative consumption volatility instead of increasing it. Second, due to a small share of trade in the SOE, trend shocks help to further decouple international price and quantity co-movements resulting in a better match of the distinct patterns of international correlations observed between SOEs and LOEs in the data.

		2-country Bond Economy			3-country Bond Economy			
Model specification	**Data**	BM	ω_{high}	NTS	BM	ω_{high}	NTS_1	NTS_2
			Standard deviations					
$\sigma_{c_{MEX}}/\sigma_{y_{MEX}}$	0.96	0.22	0.16	0.96	0.95	0.37	2.41	0.96
$\sigma_{c_{US}}/\sigma_{y_{US}}$	0.73	0.48	0.44	0.49	0.68	0.57	0.63	0.62
$\sigma_{c_{ROW}}/\sigma_{y_{ROW}}$	0.90				0.72	0.57	0.75	0.64
$\sigma_{i_{MEX}}/\sigma_{y_{MEX}}$	4.08	2.25	2.27	1.26	5.47	5.44	4.17	3.31
$\sigma_{i_{US}}/\sigma_{y_{US}}$	4.00	2.08	2.12	2.07	2.80	2.75	2.62	2.84
$\sigma_{i_{ROW}}/\sigma_{y_{ROW}}$	4.11				2.84	2.83	2.83	2.84
$\sigma_{RER_{MEX}}/\sigma_{y_{MEX}}$	4.17	1.85	0.81	13.8	1.41	0.95	3.59	2.16
$\sigma_{RER_{US}}/\sigma_{y_{US}}$	7.72				4.58	1.26	3.41	4.95
			International correlations					
$\rho(RER_{MEX}, \frac{C_{MEX}}{C_{US}})$	-0.63	-0.61	0.56	-0.60	-0.95	-0.76	-0.74	-0.16
$\rho(RER_{US}, \frac{C_{US}}{C_{ROW}})$	-0.09				-0.59	0.68	-0.52	-0.26
$\rho(C_{MEX}, C_{US})$	-0.13	-0.23	0.11	-0.32	-0.12	-0.02	-0.02	0.05
$\rho(Y_{MEX}, Y_{US})$	0.14	-0.00	0.01	-0.15	0.04	-0.03	0.22	0.05
$\rho(C_{US}, C_{ROW})$	0.43				0.06	0.52	0.11	0.29
$\rho(Y_{US}, Y_{ROW})$	0.50				0.43	0.34	0.40	0.38
$\rho(I_{MEX}, I_{US})$	0.29	0.01	0.01	-0.02	0.07	0.03	0.34	0.09
$\rho(I_{US}, I_{ROW})$	0.29				0.43	0.39	0.43	0.42

Table 4. Data *vis-à-vis* Simulated Moments: Transmission mechanisms

5 Robustness

To investigate the validity of the 3-country framework in accounting for international and business cycle moments of emerging economies *vis-à-vis* industrial economies I perform several standard modifications to the canonical two-country model in order to determine if alternative specifications of the latter framework can better account for the empirical facts discussed in this paper. First, I control separately for country size and openness.[12] Second, I introduce financing frictions to the SOE and not to the LOE(s). My results suggest that neither of these specifications improves the model fit with the data relative to the benchmark 3-country model.

[12] I'm indebted to Fabio Ghironi for valuable feedback in suggesting this.

5.1 Controlling for size in the two-country model

In the 2BE version of the model of the previous section country-size and home-bias are captured by the same parameter. Here I separate the country-size parameter from home-bias. The 2 countries are composed by a SOE (home) and a LOE (foreign); each country is populated by atomistic identical households of unit mass within the interval [0,n] for the SOE and (n,1] for the LOE. The firms in each economy are also composed of a continuum of perfectly competitive firms of unit mass. The firms in the SOE occupy the interval [0,n] producing the home tradable good and the firms in the LOE are in the interval (n,1] producing the foreign tradable good. As n (the number of households and producers in the SOE) approaches 0, the SOE is small and consumes mainly goods produced by the LOE (due to the small number of goods produces in the SOE). In contrast the LOE with size $(1-n)$ is a large economy that consumes mainly its own domestically produced goods.

Denoting foreign variables with $*$, the consumption index of tradable goods for each country is given by:

$$C^T = \left[a_h^{\frac{1}{\omega}} n^{\frac{\omega-1}{\omega}} C_h^{\frac{\omega-1}{\omega}} + (1-a_h)^{\frac{1}{\omega}} (1-n)^{\frac{\omega-1}{\omega}} C_f^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}},$$

$$C^{*T} = \left[a_h^{*\frac{1}{\omega}} (1-n)^{\frac{\omega-1}{\omega}} C_h^{*\frac{\omega-1}{\omega}} + (1-a_h^*)^{\frac{1}{\omega}} n^{\frac{\omega-1}{\omega}} C_f^{*\frac{\omega-1}{\omega}} \right]^{\frac{\omega-1}{\omega}}, \quad \omega > 0$$

where the parameters $(a_h, a_h^*) > 0.5$ denote home bias in consumption.

The country size factor n imposes one further condition in international bond market clearing, namely:

$$nB_t + (1-n)B_t^* = 0$$

For the empirical calibration exercise I set the parameter n governing country size to 0.05, equivalent to the size of trade linkages between Mexico *vis-à-vis* US used in the 3-country setup.

Table 5, column 1 shows the empirical implications of the above specification for the moments of interest. The quantitative exercise shows that this richer specification has a worse fit even than the baseline 2-country model without country size when matching most of the observed moments in the data. Namely, this specification has counter factual implications for the risk sharing puzzle and relative consumption volatility in Mexico being lower than relative consumption volatility in US. The only exception is the negative consumption correlation that matches the sign of its data counterpart.

The failure in the fit of this specification can be explained by the implied symmetry in the country size parameter n. The interpretation applied to the current empirical exercise is that this specification presupposes that Mexican households consume the majority of their goods from US producers due to the fact that most of the goods are produced in US to begin with. What this means is that shocks to trend growth in the SOE contribute a small fraction to the variability of consumption in Mexico where its households consumption basket is mainly composed of US goods.

5.2 Financing frictions in the emerging economy

I look into the implications of an alternative transmission mechanism in the SOE within the multi-country framework. Namely, I implement financing frictions in the SOE as in Garcia-Cicco, Pancrazi, and Uribe (2010), henceforth GPU 2010. In their paper, the authors use two financing frictions applied to the canonical SOE model in the form of a country-credit spread and a wage-financing bill (NP (2005), Uribe and Yue (2006)). GPU 2010 are able to match a set of within-country business cycles statistics of emerging economies and argue that their mechanism is more robust than the stochastic trend mechanism of AG 2007 insofar as they are able to match additional features of emerging countries business cycles such as the autocorrelation function of the trade balance.

The first friction, the country-specific credit-spread is meant to capture the fact that interest rates of emerging economies contain a credit-risk premia reflecting idiosyncratic investment and saving environments of emerging markets. Specifically the credit-risk premia is modeled as a decreasing function of the expected productivity in the emerging economy. One could interpret a rise in the premium as indicating higher risk of the emerging country defaulting on its sovereign debt due to low productivity prospects. The country-risk premium S_t and the interest rate R_t in the SOE are given by:

$$\log\left(\frac{S_t}{S}\right) = -\eta E_t[\log z_{t+1}],$$
$$R_t = S_t R_t^*$$

where z_{t+1} is next period's expected productivity process, η is the elasticity of the country-spread, R_t is the SOE's interest rate, and R_t^* is the world interest rate.

The other friction used by GPU 2010 is a wage financing bill which they motivate based on the notion that producers must finance a portion of their wage bills in advance. The equilibrium condition equates the wage after financing costs to the marginal product of labor:

$$W_t[1 + \theta(R_{t-1} - 1)] = F_L(K, L)$$

I implement the two frictions within the context of the 2-country model (2BE) controlling for country size. Further I shut off stochastic trend shocks from the model to determine whether such mechanism improves the fit of the model to the data. Finally I also turn on the stochastic trend shock with financial frictions included.

To calibrate the parameters of the financing frictions I draw from the estimates on Mexican data for these SOE models by Chang and Fernandez(2010). I also draw on this latter paper for the specification of the credit-spread when using financing frictions and stochastic trend shocks combined, namely:

$$\log\left(\frac{S_t}{S}\right) = -\eta_1 E_t[\log z_{t+1}] - \eta_2 E_t[\log g_{t+1}]$$

where z_{t+1} represents the transitory shock and g_{t+1} denotes the shock to trend growth. Specifically, for the calibration exercise I use the following parameter values $\eta = 0.73$, $\theta = 0.69$ and $\bar{S} = 1.0120$.

Columns 2-5 in Table 5 show the moments implied by the model with wage-bill friction, credit-spread, wage-bill and credit-spread together as well as both frictions turning on stochastic trend shocks. In general, none of these specifications does a good job at fitting the simulated moments with the data. A simple examination of the key statistics indicates that the country size assumption dominates the dynamics of the model although not in the intended way. Another alternative explanation for the poor fit could be attributed to the Cobb-Douglas preferences specification. GPU 2010 and Chang and Fernandez (2010) use GHH (quasi-linear) preferences which are known to eliminate the income effect on labor supply. This issue however has also being discussed by AG (2007, 2008) who find that the relative importance of the trend shock mechanism is robust to this preference specification.[13]

5.3 Benchmark model with financing frictions

As a last check on the benchmark model's fit I add financing frictions in the form of wage financing bill to the 3- country model. The results are indicated in columns 6-7 in Table 5. Column 6 adds the wage bill friction while shutting off the trend shock. Even without the stochastic trend mechanism, the 3-country model with WB friction outperforms all the other 2-country specifications in several empirical dimensions. First, it matches the risk sharing puzzle as well as the negative correlation of trade balance and output. Second, although by a large margin, consumption is more volatile than output in the emerging economy, while the converse is true in the large

[13] In contrast, the implications of the papers using financing frictions to match emerging economies business cycles appear to hinge strongly on the GHH assumption.

economy. This specification however fails were the previous ones did not, namely by predicting a positive international consumption correlation. The implication of the benchmark model replacing the TS transmission mechanism for the WB alternative gives further confidence that its structure is more robust in predicting international and business cycle statistics of the SOE. In the last column of Table 5 the financing friction is combined with the trend shock. Enabling the stochastic trends improves the fit with the data relative to the previous specification in particular by reducing relative consumption volatility in the SOE and by matching the negative consumption correlation. Nonetheless, this latter specification predicts counter factually a negative international output correlation.

Model		2-country					3-country	
		TS		*NTS*		*TS*	*NTS*	*TS*
specification	**Data**	NF	WB	CR	WB+CR	WB+CR	WB	WB
		Standard deviations						
$\sigma_{c_{MEX}}/\sigma_{y_{MEX}}$	0.96	0.20	0.84	0.18	0.18	0.18	2.86	0.98
$\sigma_{c_{US}}/\sigma_{y_{US}}$	0.73	0.87	1.16	0.66	0.69	0.73	0.62	0.74
$\sigma_{c_{ROW}}/\sigma_{y_{ROW}}$	0.90						0.67	0.81
$\sigma_{i_{MEX}}/\sigma_{y_{MEX}}$	4.08	2.17	1.42	1.83	1.73	2.10	3.44	5.52
$\sigma_{i_{US}}/\sigma_{y_{US}}$	4.00	2.00	1.77	1.14	1.25	1.80	2.72	2.73
$\sigma_{i_{ROW}}/\sigma_{y_{ROW}}$	4.11						2.83	2.84
		International correlations						
$\rho(RER_{MEX}, \frac{C_{MEX}}{C_{US}})$	-0.63	0.76	0.42	0.82	0.87	0.82	-0.83	-0.95
$\rho(RER_{US}, \frac{C_{US}}{C_{ROW}})$	-0.09						-0.36	-0.75
$\rho(C_{MEX}, C_{US})$	-0.13	-0.76	-0.58	-0.08	-0.02	-0.43	0.02	-0.35
$\rho(Y_{MEX}, Y_{US})$	0.14	-0.49	0.04	-0.73	-0.71	-0.59	0.26	-0.06
$\rho(I_{MEX}, I_{US})$	0.29	0.84	0.48	0.89	0.94	0.92	0.42	0.09

Table 5. Alternative model specifications. All 2-country models are adjusted for country size ($n = 0.05$).[14]

[14] Acronyms: TS (trend shock), NTS(without trend shock), NF(no frictions model), WB(wage bill), CR(country-risk), 2-C(2-country), 3-C(3-country).

6 Conclusion

The literature that studies the puzzles of international economics is by-and-large concerned about explaining these puzzles from the perspective of industrial economies. However, less is known about how such puzzles may be relevant within the domain of emerging economies. Few studies such as Kose and Prasad (2010), KPT (2003, 2007), and Kim, Kim and Wang(2004) that look in this direction have documented empirical properties of risk sharing in developing and emerging economies. In contrast, little has been done to study these properties from the theoretical side. This paper attempts to add to this literature in both the empirical and theoretical sides.

My contribution to the literature is twofold. On the empirical side, I document two new facts about international risk sharing in emerging economies. First, the Backus-Smith condition is more severe in emerging economies than in industrial economies. Second, international investment correlations are stronger in industrial countries than in emerging countries. Further, I confirm two findings in the literature, namely: 1) international consumption correlations in emerging economies are low and often negative; and 2) consumption volatility is greater than income volatility in emerging economies while the converse is true for industrial economies. Overall, the empirical findings suggest that there is a lower degree of risk sharing in emerging economies relative to industrial economies. On the theoretical side, I posit a 3-country general equilibrium international trade model that explains the international risk sharing facts of both emerging and industrial economies simultaneously. In contrast, previous literature focuses on either 2-country general equilibrium models or 1-country small open economy partial equilibrium models.

My 3-country general equilibrium model is composed of two large open economies (LOEs) and one small open economy (SOE). The model nests the canonical 2-country open economy as a special case. The model uses two key transmission mechanisms to explain the observed patterns of international risk sharing: 1) inelastic trade, and 2) stochastic shocks to the rate of trend growth. On the one hand, due to inelastic trade a negative shock to productivity at home can lead to a terms of trade depreciation as well as strong negative wealth effects that result in an actual drop in total demand of the domestic good. This explains the lack of international risk sharing as measured by international prices and quantities' correlations. On the other hand, stochastic shocks to trend growth and a small share of trade in the emerging economy further decouple international output and consumption correlations helping to match the relative rankings in international correlations between emerging and industrial economies in a way that is consistent with the evidence of lower risk international risk sharing in emerging economies.

Lastly, I compare the fitness of the 3-country model relative to different specifications of its 2-country counterpart. Overall I find that the 3-country bond economy model outperforms the 2-country bond economy specifications not only in matching the international risk sharing facts of emerging economies but also because this framework allows me to match within-country and across-country moments of industrial economies that would not be possible to match otherwise.

The 3-country model in this paper assumes a simple incomplete markets structure. One interesting direction for further research would be to include macro-financial linkages into the 3-country model. In the future, I plan to implement sophisticated asset market structures as in the country portfolio theory of Devereux and Sutherland (2008, 2009, 2010) to study the properties of the international transmission of financial shocks.

References

Aguiar, M., and G. Gopinath (2007). "Emerging Markets Business Cycles: The Cycle is the Trend". Journal of Political Economy, 115, 69-102.

Aguiar, M., and G. Gopinath (2008). "The Role of Interest Rates and Productivity Shocks in Emerging Market Fluctuations", manuscript prepared for the Tenth Annual Conference on the Central Bank of Chile. "Current Account and External Financing".

Backus, D., Kehoe, P. and F. Kydland (1995). "International Business Cycles: Theory and Evidence", in T.F. Cooley (ed.) *Frontiers of Business Cycle Research*. Princeton: Princeton University Press, 331-356.

Backus, D. and G. Smith (1993). "Consumption and Real Exchange Rates in Dynamic Economies with Non-Traded Goods". Journal of International Economics, 35, 297-316.

Calderon, C., Chong, A., and E. Stein (2002). Trade Intensity and Business Cycle Synchronization: Are Developing Countries Any Different?. Central Bank of Chile Working Papers, No. 195.

Chang, R. and A. Fernandez (2010). "On the Sources of Aggregate Fluctuations in Emerging Economies". NBER working paper.

Corsetti, G., Dedola L., and S. Leduc (2008). "International Risk Sharing and the Transmission of Productivity Shocks". The Review of Economic Studies, 75, 443-473.

Devereux, M. (2011). "International Risk Sharing: Models and Empirical Tests". NBER Working Paper.

Devereux, M. and A. Sutherland (2008). "A Portfolio Model of Capital Flows to Emerging Markets". mimeo.

Devereux, M. and A. Sutherland (2009). "Country Portfolio in Open Economy Macro Models". mimeo.

Devereux, M. and A. Sutherland (2010). "Country Portfolio Dynamics". Journal of Economic Dynamics & Control, 34, 1325-1342.

Dedola, L., Lombardo, G. and R. Straub (2011). "Home Bias and Portfolio Dynamics in a Multi-Country Model". mimeo.

Dejong, D. and C. Dave (2007). Structural Macroeconomics. Princeton University Press.

Garcia-Cicco, J., Pancrazi, R. and M. Uribe (2010). "Real Business Cycles in Emerging Countries?". American Economic Review, 100, 2510-2531.

Karabarbounis, L. (2009). "Labor Wedges and Open Economy Puzzles". Job market paper. Harvard University.

Kose, A. and E. Prasad (2010). Emerging Markets. Brookings Institution Press.

Kose, A., Prasad, E. and M. Terrones (2003). "How Does Globalization Affect the Synchronization of Business Cycles?". American Economic Review Papers and Proceedings, 57-64.

Kose, A., Prasad, E. and M. Terrones (2007). “How Does Financial Globalization Affect Risk Sharing? Patterns and Channels”. IMF Working Paper, WP/07/238.

Mendoza, E. (1991). "Real Business Cycles in a Small Open Economy". American Economic Review, 81, 797-818.

Neumeyer, A. and F. Perri (2005). "Business Cycles in Emerging Economies: The Role of Interest Rates". Journal of Monetary Economics, 52, 345-380.

Obstfeld, M. and K. Rogoff (1996). Foundations of International Macroeconomics. The MIT Press.

Schmitt-Grohe, S. and Uribe, M. (2003). "Closing Small Open Economy Models". Journal of International Economics, 61, 163-185.

Stockman, A. and L. Tesar (1995). "Tastes and Technology in a Two-Country Model of the Business cycle: Explaining International co-movements". American Economic Review, 83, 473-486.

A Matrix of Shock Processes

Let $\Lambda = [Z^T_{i,t}, Z^N_{i,t}, Z_{E,t}, z_t]$, $i, j = \{D1, D2\}$, $i \neq j$ be the state matrix of shock processes. I assume that shocks to the SOE are orthogonal to the shocks to the LOEs. The parameters ruling the exogenous productivity shocks are drawn from relevant estimates for the US *vis-à-vis* RoW composite (see main text for details) drawn from CDL 2008 (i.e. I set the drift component $\gamma_j = 0$) and Mexican SOE estimates found in AG 2007. Therefore all off-diagonal elements of Λ_t between LOEs and the SOE are zero. The matrix of AR(1) coefficients governing the innovation processes is as follows:

$$\Lambda = \begin{bmatrix} 0.82 & -0.06 & 0.10 & 0.24 & 0.00 & 0.00 \\ -0.06 & 0.82 & 0.24 & 0.10 & 0.00 & 0.00 \\ -0.02 & 0.02 & 0.96 & 0.01 & 0.00 & 0.00 \\ 0.02 & -0.02 & 0.01 & 0.96 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.95 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.01 \end{bmatrix}$$

a. Productivity shocks

The standard deviations of the shock processes are given by the variance covariance matrix $\sum$ below. All covariances between the LOEs and the SOE are set to zero.

$$\Sigma = \begin{bmatrix} 0.047 & 0.022 & 0.009 & 0.004 & 0.000 & 0.000 \\ 0.022 & 0.047 & 0.004 & 0.009 & 0.000 & 0.000 \\ 0.009 & 0.004 & 0.009 & -0.001 & 0.000 & 0.000 \\ 0.004 & 0.009 & -0.001 & 0.009 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.002 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.079 \end{bmatrix}$$

b. Variance-Covariance Matrix (percent)

B Tables

Moment	$\frac{\sigma_c}{\sigma_y}$	$\frac{\sigma_i}{\sigma_y}$	$\rho(y, y^*)$	$\rho(c, c^*)$	$\rho(\frac{c}{c^*}, rer)$	$\rho(i, i^*)$
Argentina	1.39	3.63	-0.06	-0.13	-0.66	0.19
Brazil	1.11	2.82	0.08	-0.04	-0.33	0.22
Chile	0.94	4.45	0.38	-0.06	-0.72	0.47
China P.R.	0.99	2.35	-0.23	-0.14	-0.24	-0.21
Colombia	1.09	3.84	0.18	-0.10	-0.53	0.00
Egypt	1.17	4.37	-0.21	-0.08	-0.22	-0.05
Hungary	1.12	3.65	0.41	0.25	-0.02	0.51
India	0.68	3.14	0.15	-0.01	-0.28	0.22
Indonesia	0.91	2.69	-0.07	-0.32	-0.54	-0.17
Israel	1.12	3.66	0.25	0.04	-0.29	0.08
Jordan	1.42	2.56	-0.15	0.01	-0.26	-0.04
South Korea	0.98	2.56	0.44	0.30	-0.53	0.34
Malaysia	1.16	3.62	0.29	-0.14	-0.51	0.13
Mexico	0.94	3.45	0.36	0.14	-0.58	0.31
Morocco	1.02	1.55	0.21	0.08	-0.28	0.14
Pakistan	1.41	2.10	0.09	0.00	-0.06	0.16
Peru	0.92	2.77	-0.09	-0.21	0.04	0.07
Philippines	0.37	3.15	0.26	-0.21	-0.23	0.03
Poland	1.13	2.75	0.20	0.09	-0.08	0.49
South Africa	0.90	3.57	0.26	-0.02	-0.20	0.30
Thailand	0.94	4.27	0.18	0.15	-0.54	0.20
Turkey	1.13	4.47	0.31	0.08	-0.61	0.30
Venezuela	0.99	5.07	0.20	-0.09	-0.42	0.10
mean	**1.04**	**3.33**	**0.15**	**-0.02**	**-0.35**	**0.17**
median	**1.02**	**3.45**	**0.20**	**-0.02**	**-0.29**	**0.16**
stdev	0.23	0.86	0.20	0.15	0.22	0.19

Table 6A. Emerging market economies: Within- and across-country moments (1980-2009) of price and quantity growth rates. Foreign country is a trade-weighted aggregate of G7 countries. (Canada, France, Germany, Italy, Japan, UK, US). Data sources: Quantities from Penn World Tables 7.0. Prices from IFS.

Moment	$\frac{\sigma_c}{\sigma_y}$	$\frac{\sigma_i}{\sigma_y}$	$\rho(y, y^*)$	$\rho(c, c^*)$	$\rho(\frac{c}{c^*}, rer)$	$\rho(i, i^*)$
Algeria	2.12	3.63	0.06	-0.47	-0.28	-0.02
Bolivia	1.00	7.56	-0.09	-0.11	-0.26	0.04
Cameroon	1.14	3.28	-0.12	0.06	-0.06	-0.47
Costa Rica	1.11	5.09	0.30	0.19	-0.46	0.45
Cote d'Ivoire	1.47	14.40	-0.11	0.00	-0.25	-0.30
Dominican Republic	1.28	3.77	-0.06	-0.21	-0.26	0.45
Ecuador	0.70	4.67	-0.05	-0.32	-0.11	-0.11
El Salvador	1.47	4.84	0.34	0.21	-0.02	0.36
Fiji	1.35	4.15	0.14	0.20	0.01	0.01
Gabon	2.88	3.02	0.05	-0.12	-0.02	-0.02
Ghana	1.09	3.08	0.00	-0.07	0.12	0.28
Guatemala	1.03	6.56	-0.21	-0.17	-0.22	0.21
Haiti	1.48	3.79	0.00	0.02	-0.05	0.08
Honduras	0.81	5.14	0.04	0.00	-0.34	0.62
Iran, Islamic Republic of	0.88	3.25	-0.21	-0.49	0.24	-0.06
Jamaica	1.65	3.76	0.25	0.06	-0.41	0.21
Mauritius	1.25	5.70	0.37	0.45	-0.13	0.30
Nicaragua	1.28	2.69	-0.20	0.00	0.51	-0.08
Papua New Guinea	3.08	3.04	-0.23	-0.22	0.00	-0.04
Paraguay	1.51	3.19	0.30	-0.10	-0.48	0.01
Senegal	0.67	3.13	0.00	0.04	0.05	0.10
Sri Lanka	1.46	3.62	0.04	-0.04	-0.41	0.02
Togo	1.21	7.13	0.29	0.06	0.17	0.20
Trinidad and Tobago	1.92	4.15	0.00	-0.34	0.20	0.07
Tunisia	0.64	3.53	-0.04	-0.32	0.00	-0.13
Uruguay	1.07	2.95	0.07	0.00	-0.64	0.14
Zimbabwe	1.43	2.90	-0.03	-0.09	-0.54	0.15
mean	**1.37**	**4.52**	**0.03**	**-0.07**	**-0.14**	**0.09**
median	**1.28**	**3.76**	**0.00**	**-0.04**	**-0.11**	**0.07**
stdev	0.58	2.37	0.18	0.21	0.27	0.23

Table 6B. Developing economies: Within- and across-country moments (1980-2009) of price and quantity growth rates. Foreign country is a trade-weighted aggregate of G7 countries. (Canada, France, Germany, Italy, Japan, UK, US). Data sources: Quantities from Penn World Tables 7.0. Prices from IFS.

Moment	$\frac{\sigma_c}{\sigma_y}$	$\frac{\sigma_i}{\sigma_y}$	$\rho(y, y^*)$	$\rho(c, c^*)$	$\rho(\frac{c}{c^*}, rer)$	$\rho(i, i^*)$
Australia	0.79	4.79	0.31	0.20	-0.17	0.23
Austria	0.88	3.29	0.77	0.26	0.12	0.80
Belgium	0.53	4.02	0.81	0.49	0.12	0.66
Canada	0.72	3.98	0.75	0.54	0.02	0.73
Denmark	0.85	4.18	0.70	0.35	-0.24	0.65
Finland	0.66	3.02	0.68	0.50	-0.08	0.66
France	0.62	4.45	0.80	0.61	0.01	0.70
Germany	0.68	3.25	0.80	0.57	-0.23	0.69
Greece	0.77	4.33	0.46	0.20	-0.17	0.43
Honk Kong	0.88	2.18	0.47	0.26	-0.21	0.20
Ireland	0.79	3.22	0.64	0.63	0.17	0.64
Italy	0.83	2.86	0.90	0.76	0.03	0.74
Japan	0.60	2.51	0.73	0.55	-0.03	0.60
Netherlands	0.92	3.89	0.70	0.41	-0.24	0.79
New Zealand	1.06	4.95	0.21	0.36	-0.32	0.30
Norway	0.93	4.71	0.54	0.11	0.05	0.49
Portugal	0.75	3.54	0.52	0.43	-0.10	0.32
Singapore	0.72	3.41	0.38	0.42	-0.12	0.17
Spain	1.02	3.33	0.79	0.74	-0.25	0.70
Sweden	0.72	4.42	0.78	0.57	-0.10	0.79
Switzerland	0.50	2.97	0.70	0.54	0.09	0.49
United Kingdom	0.88	3.89	0.85	0.85	-0.05	0.76
United States	0.69	3.99	0.86	0.83	-0.03	0.83
mean	**0.77**	**3.70**	**0.66**	**0.49**	**-0.08**	**0.58**
median	**0.77**	**3.89**	**0.70**	**0.50**	**-0.08**	**0.66**
stdev	0.15	0.74	0.19	0.20	0.14	0.21

Table 6C. Industrial market economies: Within- and across-country moments (1980-2009) of price and quantity growth rates. Foreign country is a trade-weighted aggregate of G7 countries. (Canada, France, Germany, Italy, Japan, UK, US). Data sources: Quantities from Penn World Tables 7.0. Prices from IFS.