University of Zurich[UZH]

Department of Economics

# Financial Frictions and the Business Cycle in Emerging Markets

**Stefan Notz and Peter Rosenkranz**

**$5^{th}$ FIW Research Conference**
**"International Economics"**

Friday, April 13, 2012

# Empirical Regularities

Why are **Emerging Market Economies (EMEs)** of special interest?

EMEs share certain business cycle features:

- business cycles are more volatile than in developed economies
- strongly countercyclical trade balance
- consumption volatility exceeds output volatility
- real interest rates are countercyclical and lead the cycle

# Emerging versus Industrialized Economies

| | Volatility | | | Relative Volatility | Correlations |
|---|---|---|---|---|---|
| | *y* | *c* | *TB/Y* | *c to y* | *TB/Y and Y* |
| **BRIC** | | | | | |
| Brazil | 0.0259 | 0.1235 | 0.0243 | 4.1719 | – 0.2834 |
| Russia | 0.0463 | 0.0803 | 0.0507 | 1.7366 | – 0.4801 |
| India | 0.0212 | 0.0370 | 0.0133 | 1.7441 | – 0.1829 |
| China | 0.0312 | 0.0380 | 0.0300 | 1.2188 | 0.0094 |
| *Mean* | 0.0321 | 0.0697 | 0.0295 | 2.2179 | – 0.2342 |
| **CIVETS** | | | | | |
| Colombia | 0.0266 | 0.0401 | 0.0361 | 1.5103 | – 0.2033 |
| Indonesia | 0.0433 | 0.0500 | 0.0443 | 1.1544 | – 0.3769 |
| Vietnam | 0.0128 | 0.0223 | 0.0424 | 1.7361 | – 0.4919 |
| Egypt | 0.0188 | 0.0284 | 0.0407 | 1.5111 | – 0.4187 |
| Turkey | 0.0515 | 0.0713 | 0.0279 | 1.3845 | – 0.5923 |
| South Africa | 0.0203 | 0.0312 | 0.0359 | 1.5351 | – 0.4955 |
| *Mean* | 0.0248 | 0.0348 | 0.0325 | 1.2627 | – 0.3684 |

| | Volatility | | | Relative Volatility | Correlations |
|---|---|---|---|---|---|
| | *y* | *c* | *TB/Y* | *c to y* | *TB/Y and Y* |
| **Dow Jones List** | | | | | |
| Argentina | 0.0900 | 0.1331 | 0.0386 | 1.4804 | – 0.4753 |
| Chile | 0.0550 | 0.0750 | 0.3660 | 1.3617 | – 0.2639 |
| Jordan | 0.0618 | 0.0784 | 0.1175 | 1.2690 | – 0.2816 |
| Malaysia | 0.0387 | 0.0611 | 0.0979 | 1.5793 | – 0.3808 |
| Mauritius | 0.0479 | 0.0791 | 0.0638 | 1.6523 | – 0.1161 |
| Mexico | 0.0517 | 0.0726 | 0.0325 | 1.4036 | – 0.1913 |
| Morocco | 0.0317 | 0.0416 | 0.0537 | 1.3146 | – 0.1117 |
| Thailand | 0.0414 | 0.0419 | 0.0511 | 1.0121 | – 0.5031 |
| *Mean* | 0.0523 | 0.0729 | 0.1026 | 1.3841 | – 0.2905 |
| | | | | | |
| **Developed** | | | | | |
| Australia | 0.0305 | 0.0165 | 0.0121 | 0.5413 | – 0.0833 |
| Austria | 0.0206 | 0.0212 | 0.0228 | 1.0298 | 0.0659 |
| Canada | 0.0220 | 0.0225 | 0.0192 | 1.0236 | 0.0053 |
| Sweden | 0.0214 | 0.0228 | 0.0311 | 1.0643 | – 0.0420 |
| *Mean* | 0.0236 | 0.0207 | 0.0213 | 0.9148 | – 0.0135 |

Data are annual and taken from the IFS. All series, except for the Trade Balance over Output ratio, are real per capita variables, have been logged and filtered using the HP filter with smoothing parameter $\lambda = 100$. The samples are: Brazil, 1980–2009; Russia, 1995–2008; India, 1975–2009; China, 1986–2008; Colombia, 1968–2009; Indonesia, 1965–2009; Vietnam, 1995–2009; Egypt, 1982–2009; Turkey, 1987–2009; South Africa, 1954–2009; Argentina, 1972–2009; Chile, 1970–2009; Malaysia, 1970–2009; Mauritius, 1963–2009; Mexico, 1970–2009; Morocco, 1964–2008; Jordan, 1976–2007; Thailand, 1953–2009; Australia, 1959–2009; Austria, 1978–2009; Canada, 1950–2009; and Sweden, 1950–2009.

▸ Figure

# Motivation

Why do EMEs exhibit common business cycle features?

**Related Literature:**

- Schmitt-Grohé and Uribe (2003): Overview on how to model a small open economy in a DSGE framework
- Neumeyer and Perri (2005): Real interest rates are countercyclical and lead the cycle
- Aguiar and Gopinath (2007): *The cycle is the trend* – The non–stationary TFP process drives macroeconomic fluctuations
- García-Cicco, Pancrazi, and Uribe (2010): Financial frictions are crucial in order to model an EME, non–stationary TFP process rather plays a negligible role

# Goal of This Project

Can we think of a model that succeeds in mimicking and explaining these stylized facts?

- Specific **financial frictions** and **permanent productivity shocks** in a standard small open economy DSGE model
- Exploit a **broader selection of EMEs**
  - Account for potential heterogeneity across countries
  - Mixture of country specific calibration and Bayesian estimation
  - Assess the role of financial frictions in EMEs versus developed countries
- In how far can the **structural model account for fluctuations** in macroeconomic time series?
- Importance of **valuation effects**
- Financial market imperfections **and** growth trend shocks play a role for explaining business cycle patterns in EMEs

# Benchmark Model

Small open economy model a la Schmitt-Grohé and Uribe (2003) and Aguiar and Gopinath (2007), augmented with financial frictions as proposed by García-Cicco et al. (2010)

– **Production Function**

$$Y_t = z_t K_t^{1-\alpha}(\Gamma_t L_t)^{\alpha}$$

– **Technology Processes**

$$z_t = z_{t-1}^{\rho_z} \exp(\epsilon_t^z), \qquad \epsilon_t^z \sim N(0, \sigma_z^2) \quad \textit{stationary TFP}$$

$$\Gamma_t = g_t \Gamma_{t-1} = \prod_{s=0}^{t} g_s, \quad \textit{non–stationary TFP}$$

$$\text{where} \qquad g_t = \mu_g^{1-\rho_g} g_{t-1}^{\rho_g} \exp(\epsilon_t^g), \qquad \epsilon_t^g \sim N(0, \sigma_g^2)$$

– **Resource Constraint**

$$Y_t + \frac{D_{t+1}}{1 + r_t} = C_t + I_t + D_t$$

– **Law of Motion of Capital**

$$K_{t+1} = (1-\delta)K_t + I_t - \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - \mu_g\right)^2 K_t$$

– **Trade Balance**

$$TB_t = Y_t - C_t - I_t = \left(D_t - \frac{D_{t+1}}{1+r_t}\right)$$

– **Interest Rate**

$$r_t = r^\star + \psi\left(\exp\left(E_t\frac{D_{t+1}}{Y_{t+1}} - \frac{D}{Y}\right) - 1\right)$$

$\Rightarrow$ $\boldsymbol{\psi}$ determines the debt elasticity of the country premium

The variables $Y_t$, $C_t$, $I_t$, $K_t$, and $D_t$ are de–trended as follows:

$$x_t = \frac{X_t}{\Gamma_{t-1}}$$

Representative household maximizes expected lifetime utility at time $t$:

$$\max_{\{c_\tau, l_\tau, k_{\tau+1}, d_{\tau+1}\}} \mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} (\Gamma_{\tau-1}^{\gamma(1-\sigma)} u(c_\tau, l_\tau))$$

s.t.

$$y_\tau + (1-\delta)k_\tau + \frac{g_\tau d_{\tau+1}}{(1+r_t)} \geq c_\tau + g_\tau k_{\tau+1} + \frac{\phi}{2}\left(g_\tau \frac{k_{\tau+1}}{k_\tau} - \mu_g\right)^2 k_\tau + d_\tau,$$

▸ Optimality Conditions ▸ Steady State

# Liability Dollarization

- **EMEs mainly borrow in foreign currency**

  $\Rightarrow$ incorporate exchange rate movements in the model

- Modify our interest rate rule to:

$$r_t = r^\star + \psi \left( \exp \left( E_t \frac{D_{t+1}}{e_{t+1} Y_{t+1}} - \frac{D}{eY} \right) - 1 \right),$$

  where $e_t$ denotes the real exchange rate following an exogenous process $e_t = e_{t-1}^{\rho_e} \exp(\epsilon_t^e)$ with $\epsilon_t^e \sim N(0, \sigma_e^2)$.

- Resource constraint of the economy adjusts to

$$Y_t + \frac{D_{t+1}}{e_t(1 + r_t)} = C_t + I_t + \frac{D_t}{e_t}.$$

▸ Optimality Conditions & Steady State

# Calibration

| Parameter/ Variable | Description | Value | | |
|---|---|---|---|---|
| **General** | | | | |
| $\gamma$ | weight of consumption in utility function | 0.36 | | |
| $\sigma$ | curvature of utility function | 2 | | |
| $\phi$ | weight of capital adjustment costs | 4 | | |
| $\alpha$ | capital share in production | 0.32 | | |
| $\delta$ | depreciation rate | 0.05 | | |
| $z$ | mean of stationary productivity process | 1 | | |
| $e$ | mean of real exchange rate process | 1 | | |
| **Country–specific** | | *Mexico* | *South Africa* | *Canada* |
| $\beta$ | subjective discount factor | 0.9502 | 0.9866 | 0.9937 |
| $\frac{d}{y}$ | external debt ratio | 0.3563 | 0.2436 | 0.3108 |
| $r$ | domestic interest rate | 0.0553 | 0.0172 | 0.0136 |
| $\mu_g$ | mean gross growth rate | 1.0021 | 1.0026 | 1.0053 |

# Model Solution

- Log–linearization and solving the model using the method of Klein (2000)

- Debt elastic interest rate rule in log–linear form:

$$\widehat{r_t}\, r = \frac{d}{y}\psi\left[E_t\widehat{d_{t+1}} - E_t\widehat{y_{t+1}}\right] \quad \text{(Benchmark)}$$

$$\widehat{r_t}\, r = \frac{d}{ey}\psi\left[E_t\widehat{d_{t+1}} - E_t\widehat{y_{t+1}} - E_t\widehat{e_{t+1}}\right] \quad \text{(Liability Dollarization)}$$

- **State space representation** of the model

$$\begin{aligned} \mathbf{y_t} &= \mathbf{Z}\alpha_\mathbf{t} + \boldsymbol{\epsilon}_\mathbf{t} \\ \alpha_t &= \mathbf{T}\alpha_\mathbf{t-1} + \mathbf{R}\boldsymbol{\eta}_\mathbf{t}; \qquad \boldsymbol{\eta}_\mathbf{t} \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Sigma}) \end{aligned}$$

allowing for a VAR structure in the measurement error (Ireland, 2004):

$$\boldsymbol{\epsilon}_t = \mathbf{A}\boldsymbol{\epsilon}_\mathbf{t-1} + \boldsymbol{\xi}_\mathbf{t}; \qquad \boldsymbol{\xi}_\mathbf{t} \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Omega})$$

# Bayesian Estimation

– Quarterly data on output, consumption, real interest rates, and the real exchange rate (source: IFS)

– Three countries – two EMEs and one developed country
  – **Mexico** (1981Q1–2007Q4)
  – **South Africa** (1960Q1–2007Q4)
  – **Canada** (1960Q1–2007Q4)

– Bayesian techniques to estimate the financial frictions parameter $\psi$ and the parameters governing the exogenous structural shocks

– Markov Chain Monte Carlo (MCMC) simulation using the Metropolis Hastings algorithm within the Gibbs sampler

MH within Gibbs

# Parameter Distributions – Mexico

| | Prior Dist. | Prior 90% Bands | Posterior Median | Posterior 90% Bands | Posterior Median | Posterior 90% Bands |
|---|---|---|---|---|---|---|
| | | | Benchmark Economy | | Liability Dollarization | |
| | | | | Mexico | | |
| $\psi$ | $\mathcal{U}(0.001, 5)$ | – | **4.083** | **[2.842, 4.830]** | **0.293** | **[0.203, 0.417]** |
| $\rho_z$ | $\mathcal{N}(0.5, 0.02)$ | [0.269,0.733] | 0.863 | [0.795, 0.923] | 0.884 | [0.818, 0.945] |
| $\rho_g$ | $\mathcal{N}(0.5, 0.02)$ | [0.269,0.733] | 0.766 | [0.682, 0.843] | 0.586 | [0.493, 0.674] |
| $\rho_e$ | $\mathcal{N}(0.5, 0.02)$ | [0.269,0.733] | | | 0.848 | [0.790, 0.903] |
| $\rho_{\epsilon y}$ | $\mathcal{N}(0, 0.05)$ | [-0.367,0.367] | 0.627 | [0.356, 0.828] | 0.525 | [0.281, 0.753] |
| $\rho_{\epsilon c}$ | $\mathcal{N}(0, 0.05)$ | [-0.367,0.367] | 0.671 | [0.491, 0.798] | 0.648 | [0.394, 0.806] |
| $\rho_{\epsilon r}$ | $\mathcal{N}(0, 0.05)$ | [-0.367,0.367] | 0.224 | [-0.040, 0.509] | 0.611 | [0.411, 0.759] |
| $\sigma^2_z$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00062 | [0.00051, 0.00076] | 0.00052 | [0.00042, 0.00065] |
| $\sigma^2_g$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00068 | [0.00054, 0.00087] | 0.00113 | [0.00085, 0.00152] |
| $\sigma^2_e$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | | | 0.00402 | [0.00356, 0.00457] |
| $\sigma^2_{\epsilon y}$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00036 | [0.00030, 0.00044] | 0.00036 | [0.00030, 0.00044] |
| $\sigma^2_{\epsilon c}$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00060 | [0.00049, 0.00073] | 0.00066 | [0.00052, 0.00085] |
| $\sigma^2_{\epsilon r}$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00685 | [0.00291, 0.01382] | 0.02174 | [0.01489, 0.03009] |

**Notes:** Results are based on 150,000 draws from the posterior distribution after the initial 100,000 draws were burned.

# Parameter Distributions – South Africa

| | Prior Dist. | Prior 90% Bands | Posterior Median | Posterior 90% Bands | Posterior Median | Posterior 90% Bands |
|---|---|---|---|---|---|---|
| | | | BENCHMARK ECONOMY | | LIABILITY DOLLARIZATION | |
| | | | | SOUTH AFRICA | | |
| $\psi$ | $\mathcal{U}(0.001, 5)$ | – | **1.369** | **[0.945, 2.089]** | **0.125** | **[0.081, 0.189]** |
| $\rho_z$ | $\mathcal{N}(0.5, 0.02)$ | [0.269,0.733] | 0.860 | [0.778, 0.921] | 0.911 | [0.847, 0.959] |
| $\rho_g$ | $\mathcal{N}(0.5, 0.02)$ | [0.269,0.733] | 0.812 | [0.748, 0.873] | 0.722 | [0.629, 0.803] |
| $\rho_e$ | $\mathcal{N}(0.5, 0.02)$ | [0.269,0.733] | | | 0.920 | [0.885, 0.954] |
| $\rho_{\epsilon y}$ | $\mathcal{N}(0, 0.05)$ | [-0.367,0.367] | 0.756 | [0.578, 0.878] | 0.709 | [0.517, 0.857] |
| $\rho_{\epsilon c}$ | $\mathcal{N}(0, 0.05)$ | [-0.367,0.367] | 0.853 | [0.790, 0.908] | 0.838 | [0.710, 0.909] |
| $\rho_{\epsilon r}$ | $\mathcal{N}(0, 0.05)$ | [-0.367,0.367] | 0.142 | [-0.134, 0.417] | 0.849 | [0.555, 0.941] |
| $\sigma_z^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00020 | [0.00017, 0.00022] | 0.00028 | [0.00024, 0.00034] |
| $\sigma_g^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00020 | [0.00017, 0.00023] | 0.00038 | [0.00029, 0.00056] |
| $\sigma_e^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | | | 0.00280 | [0.00256, 0.00308 |
| $\sigma_{\epsilon y}^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00021 | [0.00018, 0.00024] | 0.00024 | [0.00020, 0.00028] |
| $\sigma_{\epsilon c}^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00037 | [0.00032, 0.00043] | 0.00051 | [0.00036, 0.00081] |
| $\sigma_{\epsilon r}^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00280 | [0.00157, 0.00522] | 0.02375 | [0.01196, 0.04065] |

**Notes:** Results are based on 150,000 draws from the posterior distribution after the initial 100,000 draws were burned.

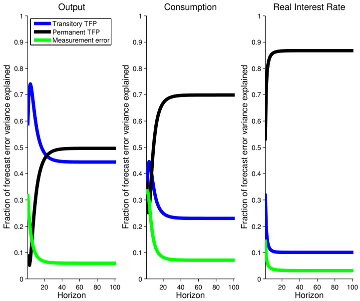
# Parameter Distributions – Canada

| | Prior Dist. | Prior 90% Bands | Posterior Median | Posterior 90% Bands | Posterior Median | Posterior 90% Bands |
|---|---|---|---|---|---|---|
| | | | BENCHMARK ECONOMY | | LIABILITY DOLLARIZATION | |
| | | | | CANADA | | |
| $\psi$ | $\mathcal{U}(0.001, 5)$ | – | **0.482** | **[0.360, 0.659]** | **0.247** | **[0.182, 0.347]** |
| $\rho_z$ | $\mathcal{N}(0.5, 0.02)$ | [0.269,0.733] | 0.877 | [0.801, 0.932] | 0.915 | [0.865, 0.959] |
| $\rho_g$ | $\mathcal{N}(0.5, 0.02)$ | [0.269,0.733] | 0.760 | [0.678, 0.840] | 0.696 | [0.619, 0.768] |
| $\rho_e$ | $\mathcal{N}(0.5, 0.02)$ | [0.269,0.733] | | | 0.973 | [0.950, 0.992] |
| $\rho_{\epsilon y}$ | $\mathcal{N}(0, 0.05)$ | [-0.367,0.367] | 0.733 | [0.579, 0.858] | 0.745 | [0.581, 0.865] |
| $\rho_{\epsilon c}$ | $\mathcal{N}(0, 0.05)$ | [-0.367,0.367] | 0.776 | [0.654, 0.878] | 0.809 | [0.701, 0.890] |
| $\rho_{\epsilon r}$ | $\mathcal{N}(0, 0.05)$ | [-0.367,0.367] | 0.142 | [-0.095, 0.396] | 0.271 | [0.041, 0.537] |
| $\sigma_z^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00017 | [0.00015, 0.00020] | 0.00018 | [0.00016, 0.00021] |
| $\sigma_g^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00014 | [0.00012, 0.00017] | 0.00020 | [0.00017, 0.00025] |
| $\sigma_e^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | | | 0.00044 | [0.00040, 0.00049] |
| $\sigma_{\epsilon y}^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00018 | [0.00016, 0.00021] | 0.00019 | [0.00016, 0.00021] |
| $\sigma_{\epsilon c}^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00021 | [0.00018, 0.00024] | 0.00026 | [0.00023, 0.00031] |
| $\sigma_{\epsilon r}^2$ | $\mathcal{IG}(2.5, 0.015)$ | [0.003,0.019] | 0.00206 | [0.00131, 0.00343] | 0.00598 | [0.00356, 0.00923] |

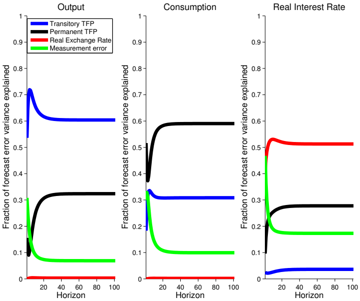
**Notes:** Results are based on 150,000 draws from the posterior distribution after the initial 100,000 draws were burned.

# Forecast Error Variance Decomposition – Mexico

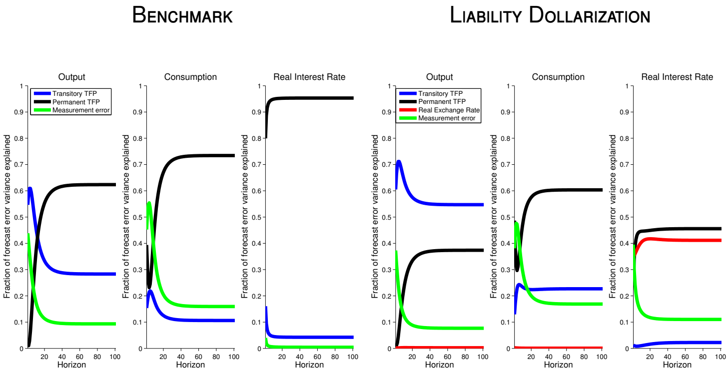
## Benchmark




## Liability Dollarization

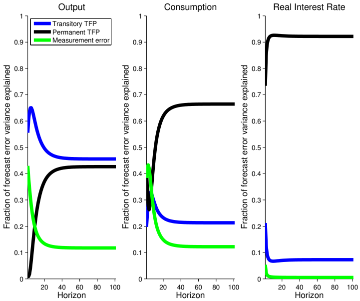


# Forecast Error Variance Decomposition – South Africa

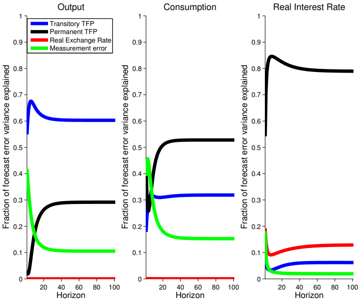


# Forecast Error Variance Decomposition – Canada

## Benchmark




## Liability Dollarization



# Business Cycle Moments

| | Data | Benchmark | Liability Dollarization | Data | Benchmark | Liability Dollarization | Data | Benchmark | Liability Dollarization |
|---|---|---|---|---|---|---|---|---|---|
| | | **Mexico** | | | **South Africa** | | | **Canada** | |
| $\sigma(y)$ | 0.0310 | 0.0974 | 0.0823 | 0.0156 | 0.0692 | 0.0759 | 0.0140 | 0.0543 | 0.0596 |
| $\sigma(c)$ | 0.0458 | 0.1192 | 0.1012 | 0.0229 | 0.0845 | 0.0915 | 0.0139 | 0.0616 | 0.0650 |
| $\sigma(tby)$ | 0.0351 | 0.7580 | 1.5167 | 0.0299 | 1.7329 | 7.3417 | 0.0192 | 3.3297 | 4.9780 |
| $\sigma(c)/\sigma(y)$ | **1.4774** | **1.2239** | **1.2300** | **1.4716** | **1.2204** | **1.2062** | **0.9934** | **1.1358** | **1.0904** |
| $\rho(tby, y)$ | **– 0.3077** | **– 0.3835** | **– 0.3484** | **– 0.3888** | **– 0.2923** | **– 0.1835** | **– 0.0615** | **– 0.2704** | **– 0.2265** |
| $\rho(c, y)$ | 0.5709 | 0.9644 | 0.9376 | 0.6479 | 0.9452 | 0.9120 | 0.7665 | 0.9313 | 0.9329 |
| $\rho(y_t, y_{t-1})$ | 0.8579 | 0.9491 | 0.9217 | 0.9936 | 0.9654 | 0.9597 | 0.9995 | 0.9527 | 0.9577 |
| $\rho(c_t, c_{t-1})$ | 0.9399 | 0.9327 | 0.8700 | 0.9981 | 0.9524 | 0.9229 | 0.9992 | 0.9336 | 0.9245 |
| $\rho(tby_t, tby_{t-1})$ | 0.9161 | 0.1449 | 0.3878 | 0.8227 | 0.2521 | 0.4870 | 0.9241 | 0.3402 | 0.3810 |
| $\rho(tby_t, tby_{t-2})$ | 0.8013 | 0.0156 | 0.1260 | 0.7416 | 0.0657 | 0.2031 | 0.8544 | 0.0839 | 0.0998 |
| $\rho(tby_t, tby_{t-3})$ | 0.7073 | – 0.0069 | – 0.0234 | 0.6397 | 0.0145 | 0.0516 | 0.7742 | – 0.0116 | – 0.0192 |
| $\rho(tby_t, tby_{t-4})$ | 0.6383 | – 0.0126 | – 0.0103 | 0.5532 | – 0.0030 | – 0.0247 | 0.7052 | – 0.0439 | – 0.0625 |

Empirical moments are calculated using quarterly data taken from the IFS. All series, except for the Trade Balance over Output ratio, are real per capita variables, have been logged and filtered using the HP filter with smoothing parameter $\lambda = 1,600$. Theoretical moments of the models are derived at the median of the posterior distributions.

# Conclusion and Outlook

## Summary

- Co–existence of **financial frictions** and **permanent shocks** helps to explain business cycle patterns in EMEs
  - excess volatility in consumption over output
  - countercyclical trade balance
  - higher business cycle volatility compared to developed countries
  - downward sloping autocorrelation function of the trade balance to output ratio

- Accounting for **real exchange rate movements** reduces the degree of financial frictions
  - additional channel affecting the real interest rate
  - importance of exchange rate fluctuations for macroeconomic dynamics

## Outlook

- Endogenous exchange rates in the setup
- Further expand the set of countries

# References I


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

García-Cicco, J., R. Pancrazi, and M. Uribe (2010). Real business cycles in emerging countries? *American Economic Review 100*, 2510–2531.

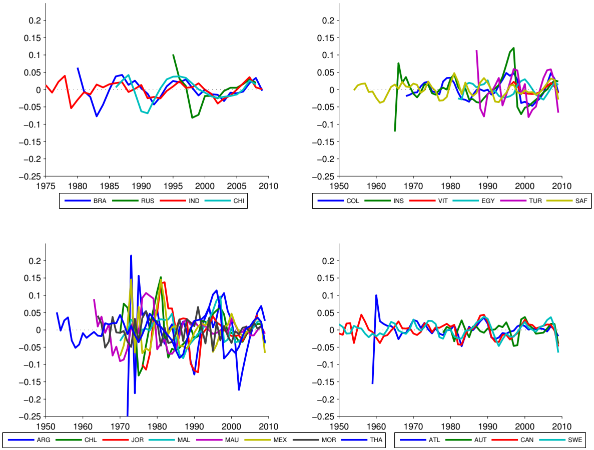
Ireland, P. (2004). A method of taking the model to the data. *Journal of Economic Dynamics & Control 28*, 1205–1226.

Klein, P. (2000). Using the generalized schur form to solve a multivariate linear rational expectations model. *Journal of Economic Dynamics and Control 24*, 1405–1423.

Neumeyer, P. and F. Perri (2005). Business cycles in emerging economies: the role of interest rates. *Journal of Monetary Economics 52*(2), 345–380.

Schmitt-Grohé, S. and M. Uribe (2003). Closing small open economy models. *Journal of International Economics 61*(1), 163–185.

# Business Cycles in Output




Back

# Representative Household's Optimality Conditions

– **Labor–Leisure Trade–off**

$$-\frac{\frac{\partial u(c_t,l_t)}{\partial l_t}}{\frac{\partial u(c_t,l_t)}{\partial c_t}} = \frac{\partial y(k_t,l_t)}{\partial l_t}$$

– **Investment Euler Equation**

$$\frac{\frac{\partial u(c_t,l_t)}{\partial c_t}}{E_t\frac{\partial u(c_{t+1},l_{t+1})}{\partial c_{t+1}}} =$$

$$g_t^{\gamma(1-\sigma)-1}\beta E_t\left[\frac{\left(\frac{\partial y(k_{t+1},l_{t+1})}{\partial k_{t+1}} + (1-\delta) + \phi\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu g\right)g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \frac{\phi}{2}\left(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu g\right)^2\right)}{\left(1+\phi\left(g_t\frac{k_{t+1}}{k_t} - \mu g\right)\right)}\right]$$

– **Bond Euler Equation**

$$\frac{\frac{\partial u(c_t,l_t)}{\partial c_t}}{E_t\frac{\partial u(c_{t+1},l_{t+1})}{\partial c_{t+1}}} = \beta g_t^{\gamma(1-\sigma)-1}\frac{1}{(1+r_t)}$$

Back

# Steady State

No interest rate spread in steady state:

$$r^\star = r$$

The remaining steady state conditions are:

$$q = (1 + r)^{-1}$$
$$\beta = (\mu_g)^{1-\gamma(1-\sigma)} q$$
$$\frac{k}{y} = \frac{\alpha}{r^* + \delta}$$
$$\frac{c}{y} = 1 + (1 - \delta - \mu_g)\frac{k}{y} + (q\mu_g - 1)\frac{d}{y}$$

Back

# Optimality & Steady State – Liability Dollarization

- Labor–Leisure Trade–off and Investment Euler Equation remain unchanged. Only the Bond Euler Equation adjusts to

$$\frac{\frac{\partial u_t(c_t,l_t)}{\partial c_t}}{E_t \frac{\partial u_{t+1}(c_{t+1},l_{t+1})}{\partial c_{t+1}}} = \beta g_t^{\gamma(1-\sigma)-1} E_t \frac{e_t}{e_{t+1} q_t}.$$

- Deterministic long–run equilibrium equivalent to the benchmark economy. Only one additional condition

$$e = 1.$$

Back

# MH Algorithm within Gibbs

## Gibbs Sampler

– Estimate persistence parameters and variance of the exogenous processes, $\rho_z, \sigma_z^2, \rho_g, \sigma_g^2, \rho_e, \sigma_e^2$, $\mathbf{A}$, and $\mathbf{\Omega}$

$$g(\boldsymbol{\theta}|\mathbf{y}) = \frac{f(\mathbf{y}|\boldsymbol{\theta})g(\boldsymbol{\theta})}{f(\mathbf{y})} \propto f(\mathbf{y}|\boldsymbol{\theta})g(\boldsymbol{\theta})$$

$$g(\boldsymbol{\theta}|\mathbf{y}) = g(\theta_1|\theta_2, \mathbf{y})g(\theta_2|\mathbf{y}) = g(\theta_2|\theta_1, \mathbf{y})g(\theta_1|\mathbf{y}) = g(\theta_1, \theta_2|\mathbf{y})$$

– Given starting values $\boldsymbol{\theta}^{\mathbf{0}} = (\theta_1^0, \theta_2^0)$ for n=1:N

(i) Solve the model given $\boldsymbol{\theta}^{n-1} = (\theta_1^{n-1}, \theta_2^{n-1})$
(ii) Generate time series of unobservable states $\mathbf{y}_{n-1}$ using the Kalman Filter
(iii) Draw from conditional posterior of each hyperparameter, i.e. $g(\theta_1^n|\theta_2^{n-1}, \mathbf{y}_{n-1})$ and $g(\theta_2^n|\theta_1^n, \mathbf{y}_{n-1})$

## Metropolis-Hastings Algorithm

– At each simulation iteration, conditional on current Gibbs draw, add MH step to generate posterior of $\psi$

– RW MH algorithm, choosing the variance of the proposal density to obtain acceptance ratio of about 25 to 40 percent

Back