Uncertainty Shocks, Financial Frictions and Business Cycle Asymmetries across Countries

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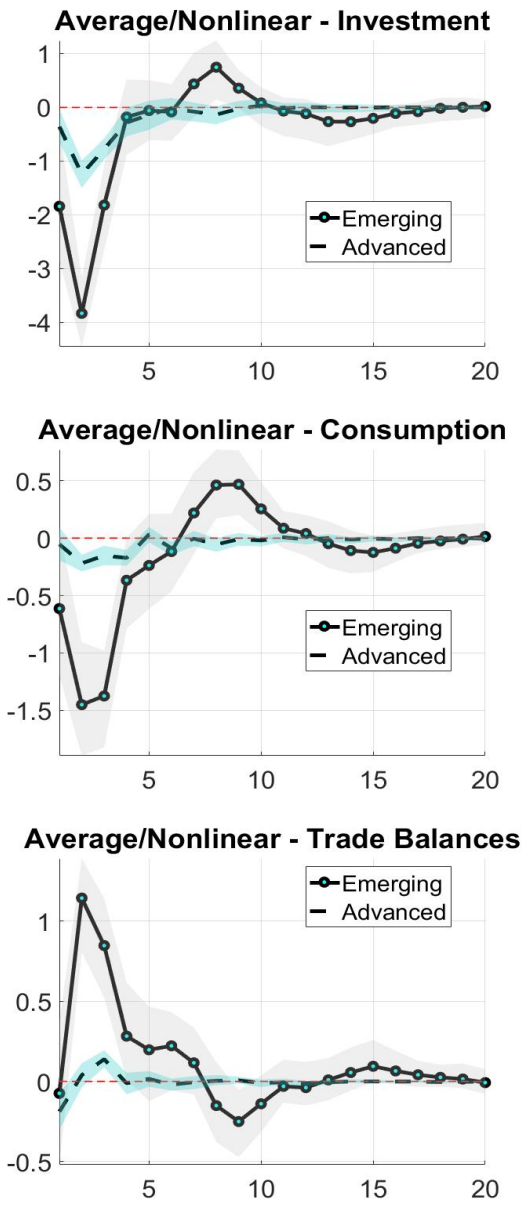
Uncertainty in Macroeconomics

- Measurement/Definition:
  Proxies such as VIX, volatility of stock market returns, dispersion of forecasts etc. in empirical analysis and stochastic volatility in theoretical models

- Empirical regularity observed by various scholars[1]:
  1. Increase in uncertainty leads to a simultaneous decline in C, I and Y
  2. The effects are larger for emerging countries in comparison to advanced countries
  3. The impact of uncertainty shocks are largely countercyclical

[1] Bloom (2009), Jurado, Ludwigson, and Ng (2015), Swallow and Cespedes (2013), Caggiano, Castelnuovo, Groshenny (2014), Chatterjee (2017)

Impulse Responses to a 1% Shock to Uncertainty in Recessions



Motivation for this paper

- Reconcile the empirical differences characterizing the impact of uncertainty shocks across AEs and EMs - provide micro-foundations generating the asymmetry - explain causes of excess volatility in EMs

- Extending the framework for analyzing uncertainty to an open economy model - addressing all three empirical features
  - Existing works focus on explaining the simultaneousness decline in C, I, and Y in closed economy models - fitted to match characteristics of AEs like the U.S.

Connections to Existing Literature

- Uncertainty as a driver of business cycle fluctuations in closed economy models
  - Bloom (2009), Bloom et al (2017), Basu and Bundick (2017),
- Uncertainty shocks in international macroeconomics
  - FV-GQ-RR-Uribe (2011), Swallow and Cespedes (2013)
- Emerging country business cycles - excess volatility
  - Differences in shocks - Aguiar and Gopinath (2007) and differences in fundamental features - Neumeyer and Perri (2005),
- Financial frictions/Interaction bw country fundamentals and borr. costs
  - Bernanke, Gertler and Gilchrist (1999), Uribe and Yue (2006), Gertler Gilchrist and Natalucci (2007), Fernandez and Gulan (2015) ,

Model Outline

- Small Open economy (SOE) New Keynesian Model - with 3 extra ingredients

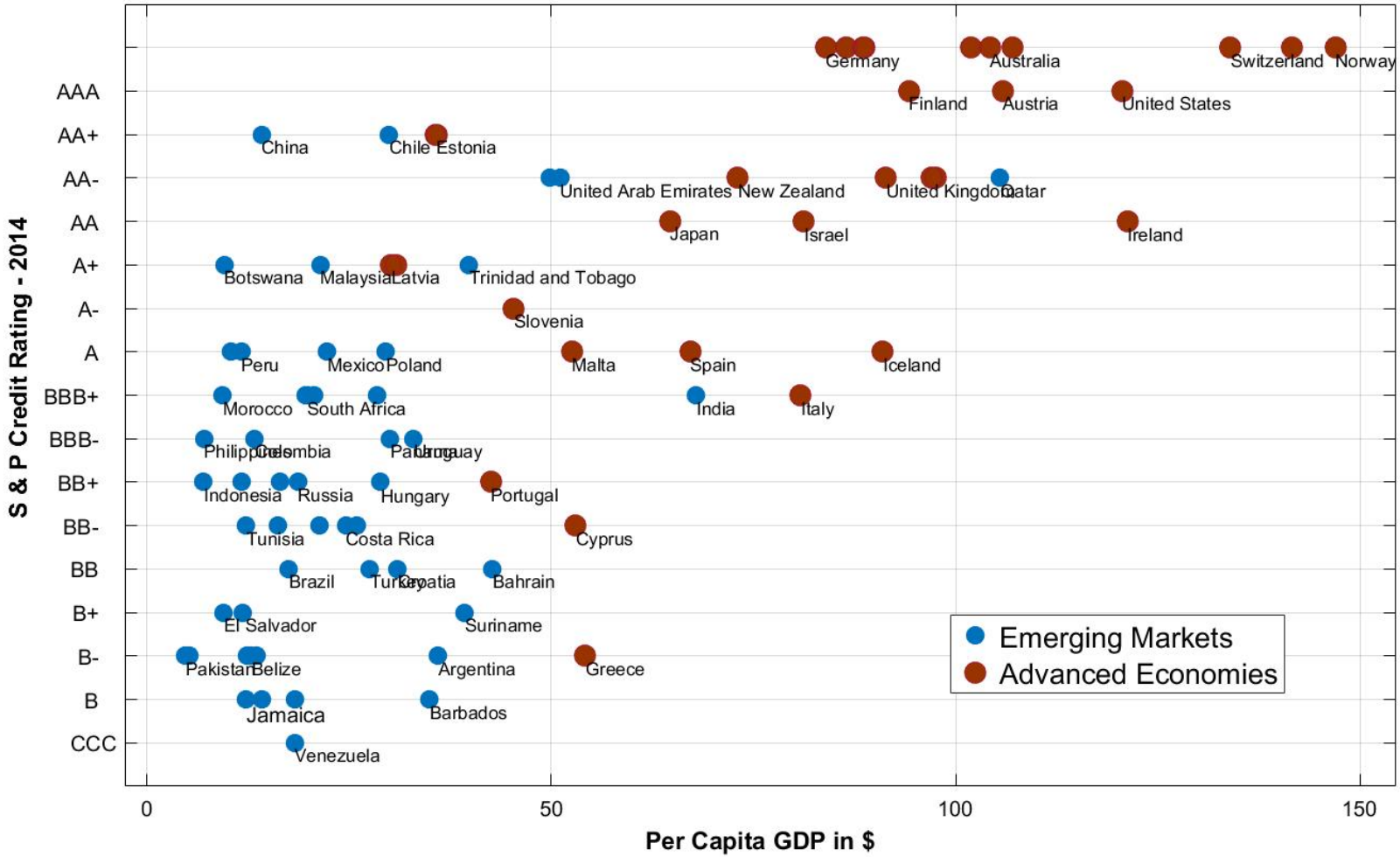
  1. Financial Accelerator - captures varying degrees of financial frictions across Advanced Economies and Emerging Countries - Bernanke, Gerlter, Gilchrist (1999) - Credit Ratings

  2. Uncertainty Shocks - time varying volatility of aggregate productivity and household discount factor - Basu and Bundick (2017), FV-GQ-RR-Uribe (2011) - Shocks to second moment

  3. Solved using third order approximation - capturing precautionary response to uncertainty (Andreasen et al 2017) - Model Solution

- SOE features - Gertler, Gilchrist and Natalucci (2007), Monacelli (2005)

Difference in country fundamentals - higher borrowing costs in emerging countries



FDI Main Features

Uncertainty Shocks

Shock to hh intertemporal discount factor (z_t) and aggr. productivity in production func. of wholesale goods for entrepreneurs (a_t)

$$a_t = (1-\rho_a)\overline{A} + \rho_a a_{t-1} + \boldsymbol{\sigma_t^a} u_t^a$$
$$z_t = (1-\rho_z)\overline{z} + \rho_z z_{t-1} + \boldsymbol{\sigma_t^z} u_t^z$$

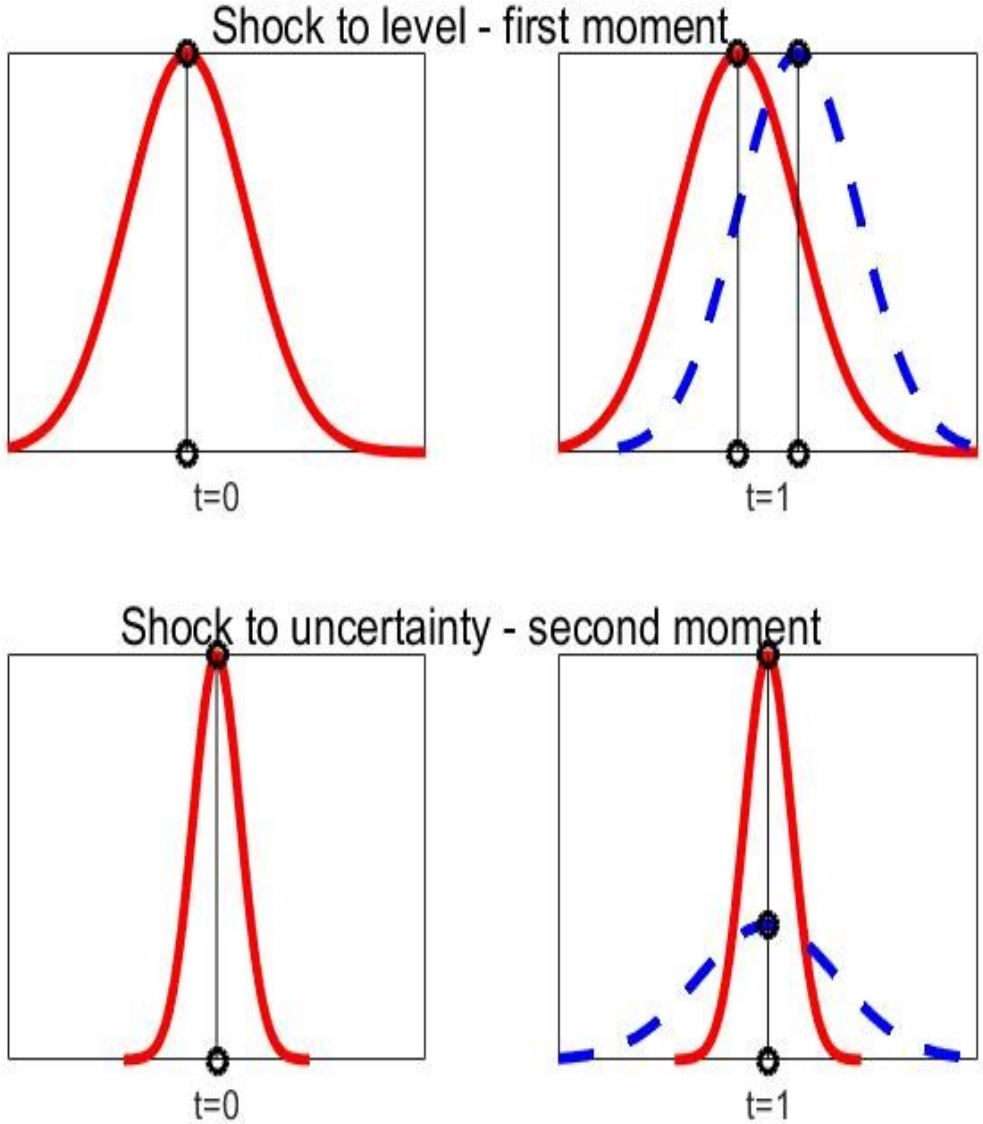
$$\boldsymbol{\sigma_t^a} = (1-\rho_\sigma^a)\overline{\sigma^a} + \rho_\sigma^a \sigma_{t-1}^a + \eta_C \underbrace{\overbrace{\boldsymbol{u_t^C}}}_{Common}$$

$$\boldsymbol{\sigma_t^z} = (1-\rho_\sigma^z)\overline{\sigma^z} + \rho_\sigma^z \sigma_{t-1}^z + \eta_C \underbrace{\overbrace{\boldsymbol{u_t^C}}}_{Common}$$

- $u_t^C \overset{\text{iid}}{\sim} (0,1)$
- $\overline{\sigma^a}, \overline{\sigma^z}$ - average level of uncertainty, η_C - extent of stochastic volatility

Main Features

What do these shocks look like?



Main Features

Numerical solution

- Uncertainty shocks - property of higher order moments
- 1^{st} order solution - exhibits certainty equivalence - no role for precautionary behavior
- 2^{nd} order solution - std. dev of shocks affects steady state - no effect on model dynamics - Schmidt-Grohè and Uribe 2004
- Consider at least a 3^{rd} approximation for uncertainty to matter - use solution technique suggested in Andreasen, Fernandez-Villaverde and Rubio-Ramirez (2016)

Main Features

Environment

- 5 agents in the model economy
  - 1 - Households
  - 2 - Entrepreneurs
  - 3 - Capital Producers
  - 4 - Retailers
  - 5 - Central Bank

- Foreign sector
- Uncertainty Shocks

Environment...1

Benchmark SOE model - following Monacelli (2005). Key players:

- Households:
  1. Consume (C_t), supply labor (L_t), save in domestic (b_t) and foreign assets (F_t^*)
  2. Utility function is additively separable in habit adjusted consumption (h) and labor - with CRRA preferences - parameter (ρ)
  3. Incomplete asset markets with portfolio holding costs - domestic (ϕ_B), foreign (ϕ_F^*)
  4. Consumption CES aggregate of domestic goods $(C_{H,t})$ and imports $(C_{F,t})$
  5. Exogenous shock to hh discount factor (z_t)

Environment...2

- Entrepreneurs:
  1. Raise resources to fund capital (K_t) - combining net-worth they own (N_t) and foreign currency denominated debt (D_t)
     - Face financial frictions in international capital markets - modeled using the financial accelerator mechanism
     - Borrowing costs - $R_t^* k_t^{\nu}$ with $k_t = \frac{Q_t K_t}{N_t}$
     - $\nu^{Emerging} > \nu^{Advanced}$
  2. Capital becomes effective with a period lag in production
  3. Produce wholesale goods by hiring labor from hhs with capital that they own using CRS technology
  4. Cobb-Douglas production function contains shock to aggregate productivity (a_t)

Environment...3

- Capital Producers
  1. Covert investment to capital capital goods - face inv. adjustment costs
  2. Investment is a CES aggregate of domestic goods ($I_{H,t}$) and imports ($I_{F,t}$)

- Retailers
  1. Domestic retailers buy wholesale goods from entrepreneurs, differentiate them and sell final good for $P_{H,t}$ to hhs, capital producers and ROW as exports ($C^*_{H,t}$)
  2. Retailers of imported goods buy wholesale goods from ROW, differentiate them and sell final good for $P_{F,t}$ to hhs and capital producers
  3. Both retailers face nominal rigidities while selling the final good

Environment...4

- Prices
  1. CPI (P_t) - CES aggregate of GDP deflator ($P_{H,t}$) and Import Price Index ($P_{F,t}$)
- Central Bank:
  1. Conducts monetary policy according to Taylor rule (R_t)
- Foreign Sector
  1. Approximated as rest of world
  2. Evolves exogenously of the small open economy in concern
  3. Exports - no rigidities - Law of One Price holds

Environment...5

- Exogenous processes
  1. Shock to hh inter-temporal discount factor (z_t)
  2. Shock to aggregate productivity in production function of wholesale goods for entrepreneurs (a_t)

- Notion of uncertainty
  1. Time varying volatility of shock to household preferences and aggregate productivity process
  2. Standard deviation of shocks follow a correlated structure

Important Equilibrium Conditions

Marginal Financing Condition

$$E_t R^K_{t+1} = R^*_t(k_t)^{\boldsymbol{\nu}} E_t \frac{q_{t+1}}{q_t}$$

- For a given value of leverage - k_t - a higher value of ν will imply a lower equilibrium value of capital K_t
- Foreign currency denominated debt - depreciation of currency will increase leverage k_t by eroding value of capital (V_t) -

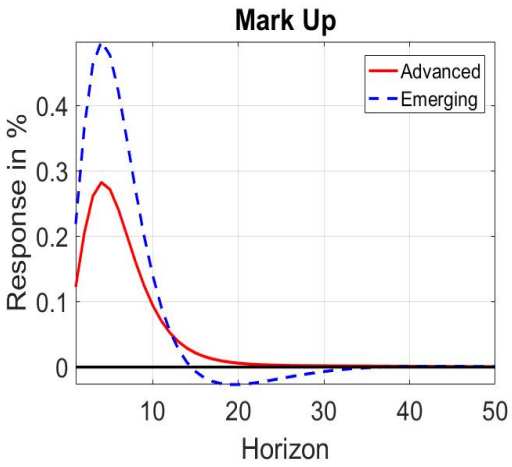
$$V_t = \left[R^K_t Q_{t-1} K_{t-1} - R^*(k_{t-1})^{\boldsymbol{\nu}} q_t D_{t-1} \right]$$

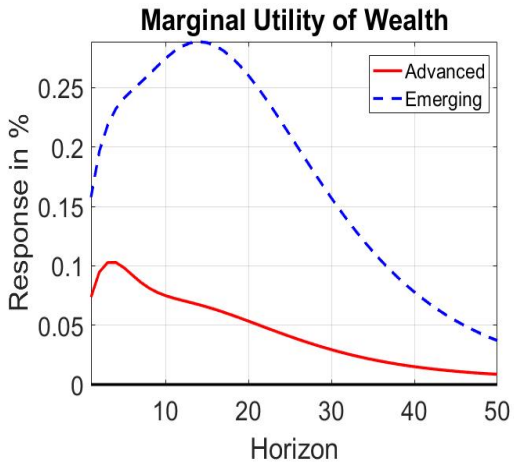
Main findings - outline

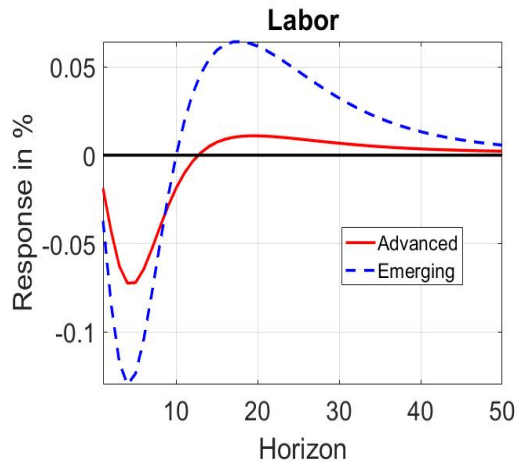
1. Transmission of uncertainty shock in model using baseline calibration
   - Explore model features in replicating stylized facts 1 and 2

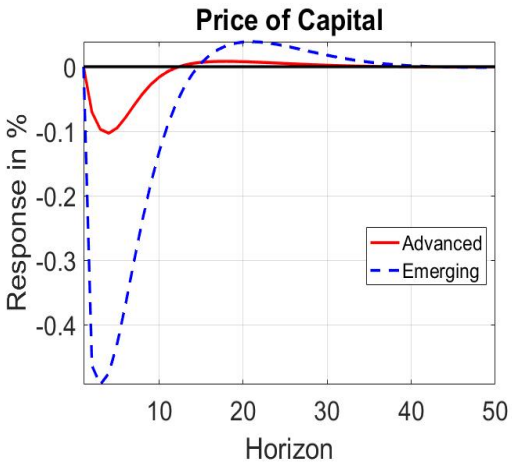
2. Estimate interaction of financial frictions and uncertainty shocks along with key behavioral parameters in recessionary episodes for advanced and emerging countries

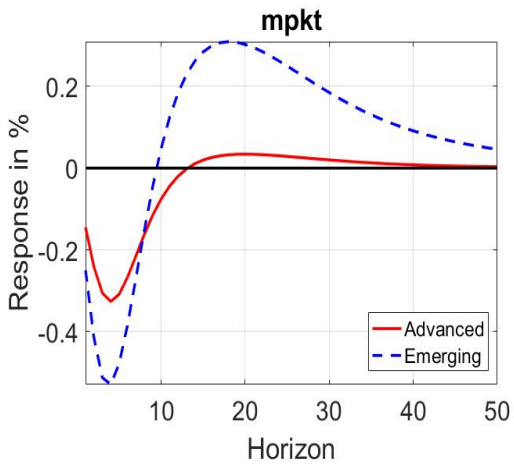
Transmission of uncertainty shock

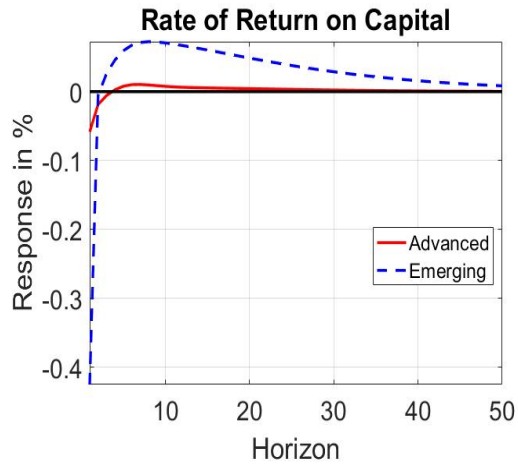

Mark Up
Advanced
Emerging
Response in %
Horizon

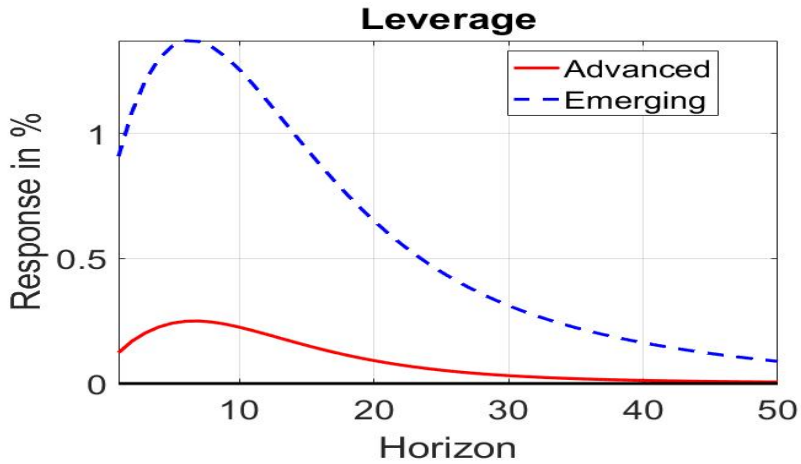

Marginal Utility of Wealth
Advanced
Emerging
Response in %
Horizon

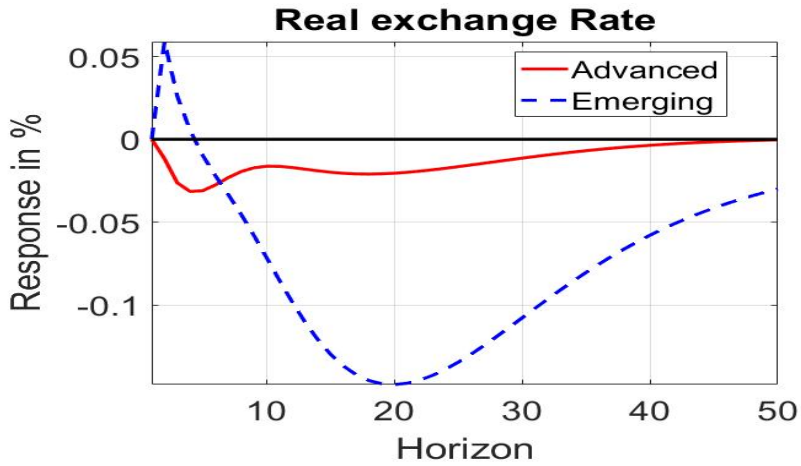

Labor
Advanced
Emerging
Response in %
Horizon


Price of Capital
Advanced
Emerging
Response in %
Horizon

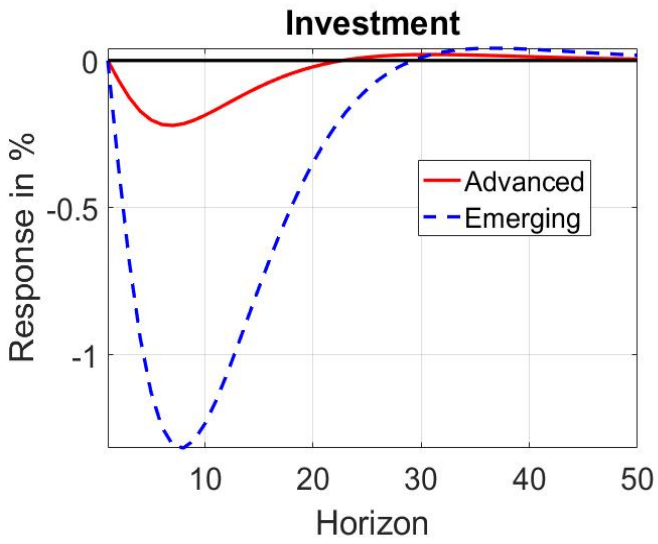

mpkt
Advanced
Emerging
Response in %
Horizon

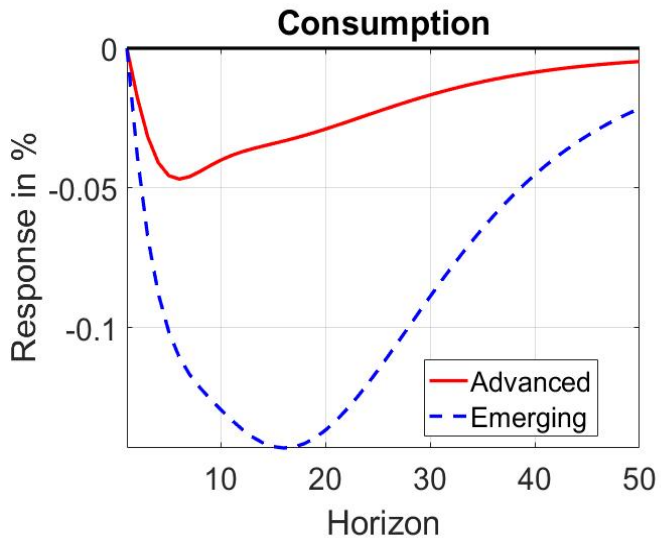

Rate of Return on Capital
Advanced
Emerging
Response in %
Horizon





$$E_t R^K_{t+1} = R^* k_t^{\nu} \frac{q_{t+1}}{q_t}$$


Investment
Response in %
Horizon
Advanced
Emerging
0
-0.5
-1
10
20
30
40
50


Consumption
Response in %
Horizon
Advanced
Emerging
0
-0.05
-0.1
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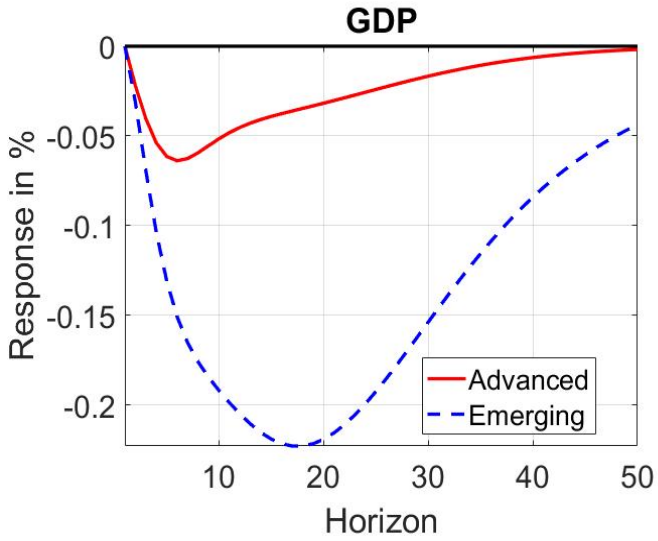
GDP
Response in %
Horizon
Advanced
Emerging
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-0.05
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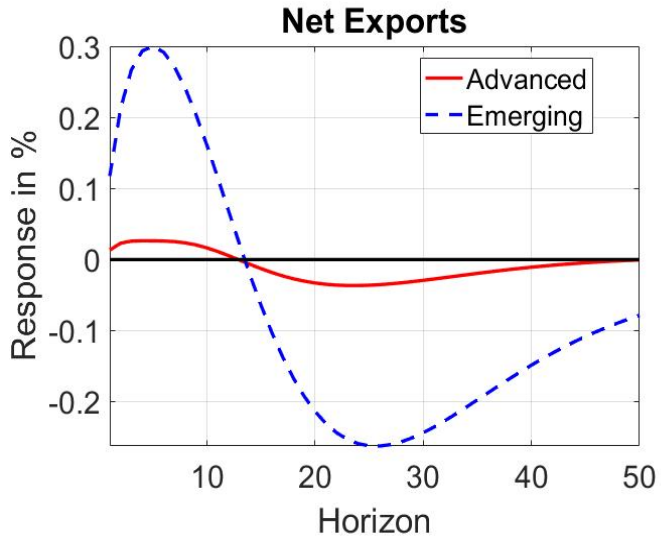
Net Exports
Response in %
Horizon
Advanced
Emerging
0.3
0.2
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0
-0.1
-0.2
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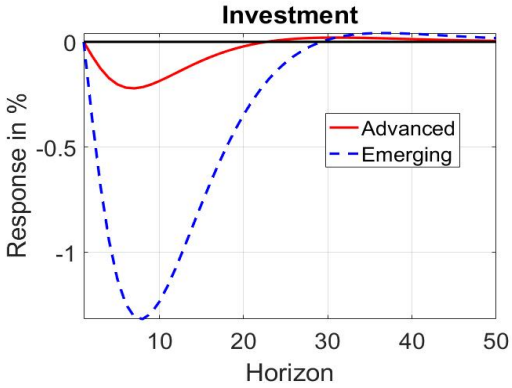
Investment
Response in %
Horizon
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Emerging
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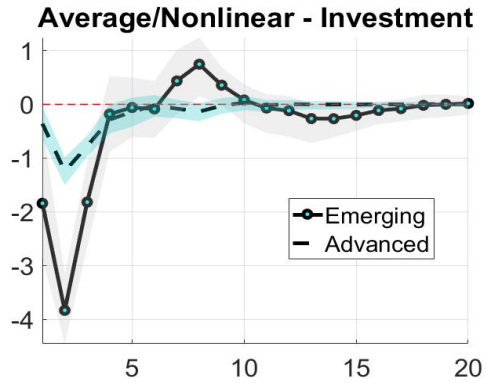
Average/Nonlinear - Investment
Emerging
Advanced
1
0
-1
-2
-3
-4
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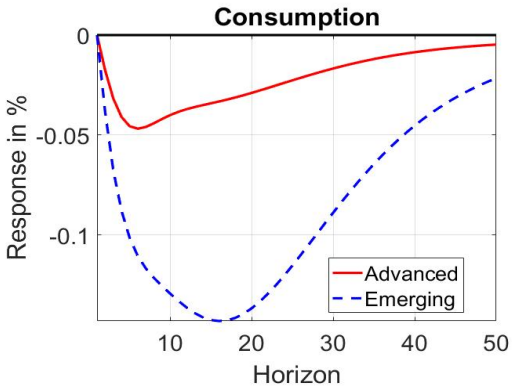
Consumption
Response in %
Horizon
Advanced
Emerging
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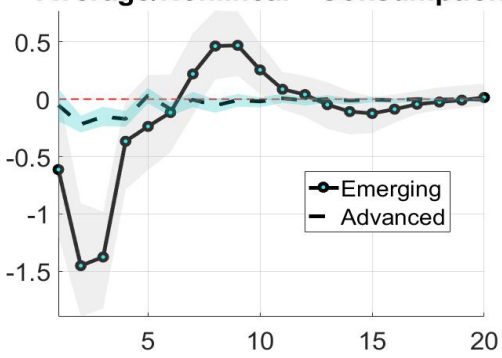
Average/Nonlinear - Consumption
Emerging
Advanced
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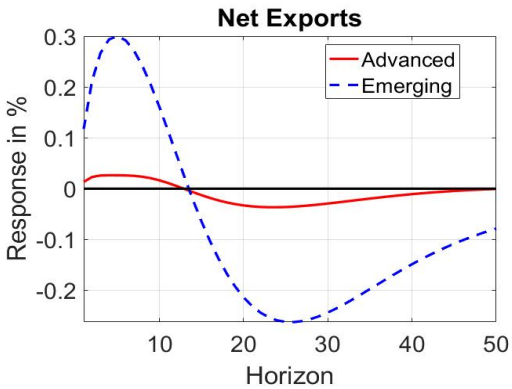
Net Exports
Response in %
Horizon
Advanced
Emerging
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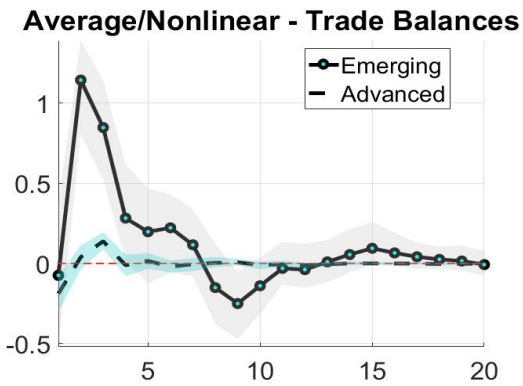
Average/Nonlinear - Trade Balances
Emerging
Advanced
1
0.5
0
-0.5
5
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15
20

Summarizing findings

- Successfully generated stylized fact 1 and 2
  - Simultaneous decline in C,I,Y
  - Emerging countries experience an amplified decline

- Next, estimate key parameters that guide the differences in response during recessions

Estimating the strength of the financial frictions channel in generating business cycle asymmetries

- Implement Impulse Response Matching technique - limited information method - using model implied and empirically generated IRFs in recessions to uncertainty shocks
- Use the Smooth Transition Vector Auto Regression model to get the recession specific shock Details
- Compute Generalized Impulse Response Functions (GIRFs) - using local projection technique from Jorda (2005) using shock from step 1

Impulse Response Function Matching Estimator

$$\begin{pmatrix} \hat{\phi}_1(\overline{\phi}, h) \\ \hat{\phi}_2(\overline{\phi}, h) \\ \dots \\ \hat{\phi}_{n_1}(\overline{\phi}, h) \end{pmatrix} = \underset{\hat{\phi}_1(\overline{\phi},h),..,\hat{\phi}_{n_1}(\overline{\phi},h)}{\arg\min} [\hat{\gamma} - g(\hat{\phi}, \overline{\phi}, h)]' \hat{\Omega}_T(h) [\hat{\gamma} - g(\hat{\phi}, \overline{\phi}, h)]$$

- $\hat{\gamma}$ - IRFs from STVAR + GIRF method
- $g(\hat{\phi}, \overline{\phi}, h)$ - IRFs from the theoretical model
  - $\hat{\phi}$ - estimated parameters, $\overline{\phi}$ - calibrated parameters
- $\hat{\Omega}_T(h)$ is the identity matrix of dimension 2
- Match impulse responses of C and I for horizon h

Parameters I want to estimate

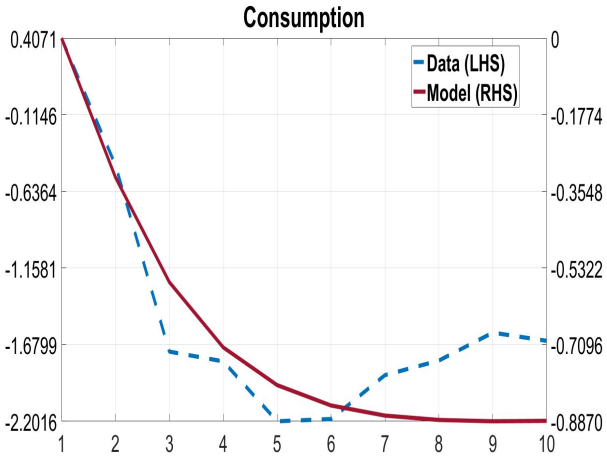
Parameter	Definition
ν	Elasticity of borrowing costs wrt leverage
$\overline{\sigma^a} = \overline{\sigma^z}$	Mean Volatility
$\rho_{\sigma_a}, \rho_{\sigma_z}$	Persistence of demand and supply specific uncertainty
h	Strength of external habits
κ_F	Degree of exchange rate pass-through
ψ	Inverse Frisch elasticity of labor supply

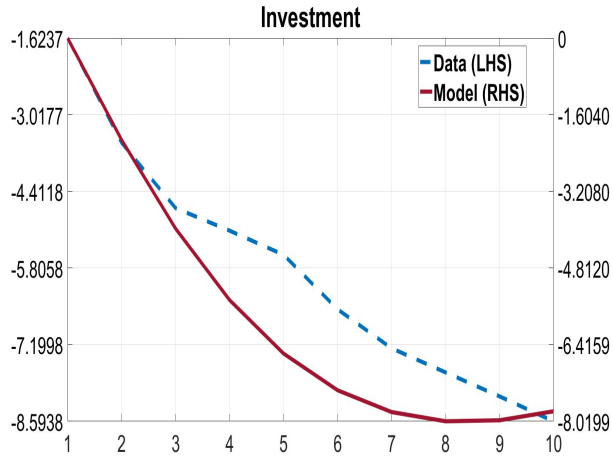
Estimated values of parameters...1

Parameter	Mexico	United Kingdom
ν - Elasticity of borrowing costs wrt leverage	**0.07**	**0.0384**
$\sigma_{\overline{a}} = \sigma_{\overline{z}}$ - Average uncertainty	**0.2484**	**0.2705**
ρ_{σ_z} - Persistence of second-moment shock - preference	0.8624	0.8541
ρ_{σ_a} - Persistence of second-moment shock -productivity	0.9491	0.9088
κ_F - Degree of exchange rate pass through - extent of nominal rigidities in imports	**0.2481**	**0.4995**
h - Persistence of external habits	0.4704	0.5032
ψ - Frisch elasticity of labor supply	2.0124	3.0027
Est. R^K_{t+1}	**1.07679**	**1.046**

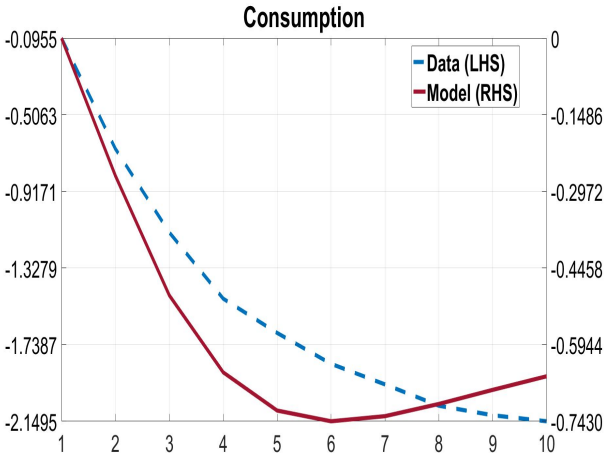
Expanded Sample

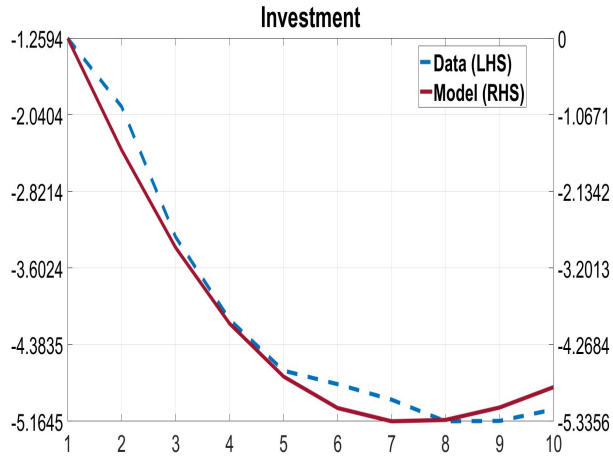
Mexico





United Kingdom





X-Axis: Horizon, Y-Axis: Response in %

Welfare Costs - What hurts more?

	Non-Stochastic Steady State		Stochastic Steady State	
Variable	k=2.5 & $\nu = 0.04$ (a)	k=2.5 & $\nu = 0.07$ (b)	k=2.5 & $\nu = 0.04$ (c)	k=2.5 & $\nu = 0.07$ (d)
GDP	5.21	4.32 ($\%\Delta_{b/a}$=-17%)	3.62 ($\%\Delta_{c/a}$=**-31%**)	2.01 ($\%\Delta_{d/c}$=**-45%**, $\%\Delta_{d/b}$=**-54%**)
Investment	1.36	0.93 ($\%\Delta_{b/a}$=**-31%**)	0.82 ($\%\Delta_{c/a}$=**-40%**)	0.18 ($\%\Delta_{d/c}$=**-78%**, $\%\Delta_{d/b}$=**-81%**)
Consumption	3.26	3.08 ($\%\Delta_{b/a}$=-5%)	3.32 ($\%\Delta_{c/a}$=**2%**)	2.52 ($\%\Delta_{d/c}$=**-24%**, $\%\Delta_{d/b}$=**-18%**)

Comparing stochastic and non-stochastic steady states

Comparing stochastic steady states in EMs vs AEs

Big Picture

1. Motivated topic by examining empirical regularities of uncertainty shocks across countries using nonlinear model
2. Using interaction of fin. frictions and uncertainty shocks in SOE model + 3^{rd} order solution to explain the empirical feature/excess volatility in emerging countries
3. Used sample of 8 countries to estimate parameters and demonstrate that borrowing costs are 64%-67% higher in emerging countries
4. Welfare losses attributed to the interaction of uncertainty and fin. frictions leads to a 45% reduction in GDP in emerging countries

Next Steps

- Explore Bayesian estimation procedures
- Decompose entrepreneurial debt into domestic and foreign components and analyze what happens when I deviate from the assumption of 100% of debt being denominated in foreign currency
- Provide micro-founded explanation towards why $\nu^{Emerging} > \nu^{Advanced}$

Appendix

Environment - Households

- Households:
  1. Consume (C_t), supply labor (L_t), save in domestic (b_t) and foreign assets (F_t^*)
  2. Consumption CES aggr. of domestic goods ($C_{H,t}$) and imports ($C_{F,t}$)
  3. Exogenous shock to hh discount factor (z_t)

$$E_0 \sum_{t=0}^{\infty} \beta^t z_t \left(\frac{(C_t - hC_{t-1})^{1-\rho}}{1-\rho} - \frac{L_t^{1+\psi}}{1+\psi} \right)$$

Subject to:

$$P_t C_t + P_t \Gamma_t + B_t + X_t F_t^* = P_{H,t} W_t^r L_t + \Pi_t + R_{t-1} B_{t-1} + R_{t-1}^* X_t F_{t-1}^*$$

$$\Gamma_t = \frac{\phi_B}{2} \left(\frac{B_t}{P_t} \right)^2 + \frac{\phi_F^*}{2} \left(\frac{X_t F_t^*}{P_t} \right)^2$$

P_t=CPI, $P_{H,t}$=GDP deflator, X_t=Nominal Exchange Rate, R_t^*=Global risk free interest rate, Π_t= residual profits from firm ownership

Environment

Specification of Borrowing Costs for Entrepreneurs

- Model cost of credit as a function of a global and a country specific component - Neumeyer and Perri (2005)

$$R_t^* \Psi(t)$$

- Country specific component is an increasing function of **leverage** - Gertler, Gilchrist and Natalucci (2007)

$$\Psi(t) = \mathbf{k_t}^{\nu} \quad \text{where } k_t = \frac{Q_t K_{t+1}}{N_t}$$

- Country specific difference introduced by making borrowing costs more responsive to leverage for emerging countries

$$\nu^{Emerging} > \nu^{Advanced}$$

Environment - Entrepreneurs

1. Entrepreneur chooses capital K_{t+1} t for use in $t+1$ - using net worth (N_t) and foreign currency denominated debt D_t :

   Maximize the ex ante value of capital by choosing: D_t

$$\max_{D_t} V_t = E_t \left[R^K_{t+1} Q_t K_{t+1} - R^* k_t{}^{\nu} \frac{X_t}{P_t} D_t \right]$$

   subject to

$$Q_t K_{t+1} = N_t + \frac{X_t D_t}{P_t}$$

2. Choose Labor (L_t) to max. profits from selling wholesale goods

$$\arg\max_{\{L_t\}} P_{W,t} a_t (K_t)^{\alpha} (L_t)^{1-\alpha} - W_t L_t$$

Environment

- Following BGG (1999) fraction θ survive each period
- Net Worth - $N_t = \theta V_t + (1-\theta)E$
- Exiting entrepreneurs consume $C_t^e = V_t - E$

Environment

Equilibrium conditions - Entrepreneurs

Marginal Financing Condition

$$E_t R^K_{t+1} = R^*_t(k_t)^{\nu} E_t \frac{q_{t+1}}{q_t}$$

- For a given value of leverage - k_t - a higher value of ν will imply a lower equilibrium value of capital K_t
- Foreign currency denominated debt - depreciation of currency will increase leverage k_t by eroding value of capital (V_t)

Environment

Capital Producers

- Choose capital K_t st

$$\max_{\{I_t\}} E_t \sum_{t=0}^{\infty} \beta^t \frac{\lambda_{t+1}}{\lambda_t} \left[Q_t K_{t+1} - (1-\delta) Q_t K_t - I_t \right]$$

$$\text{subject to } K_{t+1} = (1-\delta) K_t + [1 - S(\frac{I_t}{I_{t-1}})] I_t$$

$$S = S'(.) = 0$$

- Investment is a CES aggregate of domestic goods ($I_{H,t}$) and imports ($I_{F,t}$)

Environment

Environment - Retailers

- Sticky prices imp. to generate co movement in C, I, Y in response to uncertainty shock
- Introduce nominal rigidities $\grave{a}$ la Calvo
  - Retailers - Domestic goods - κ_H
  - Retailers - Imported goods - κ_F
- Consequently,

$$P_{H,t}^{1-\epsilon} = \kappa_H P_{H,t-1}^{1-\epsilon} + (1-\kappa_H)\hat{P_{H,t}}^{1-\epsilon}$$

$$P_{F,t}^{1-\epsilon} = \kappa_F P_{F,t-1}^{1-\epsilon} + (1-\kappa_F)\hat{P_{F,t}}^{1-\epsilon}$$

- κ_F - dual role - stickiness in import prices + degree of exchange rate pass-through

Environment

Central Bank + Market Clearing

- CPI (P_t) - CES aggr. of GDP deflator ($P_{H,t}$) and Import Price Index ($P_{F,t}$)
- Taylor Rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{(1-\chi)} \left[\left(\frac{Y_{H,t}}{Y_H}\right)^{\chi_y} \left(\frac{\pi_t}{\pi}\right)^{\chi_\pi}\right]^{\chi} \left(\frac{Y_{H,t}}{Y_{H,t-1}}\right)^{\chi_{\Delta y}}$$

- Market clearing

$$Y_{H,t} = \underbrace{\frac{P_t}{P_{H,t}}(C_t + I_t)}_{Domestic\ Demand} + \underbrace{C^*_{H,t} - \frac{P_{F,t}}{P_{H,t}} Y_{F,t}}_{Net\ Exports} + \underbrace{K_H + \frac{P_{F,t}}{P_{H,t}} K_F}_{Fixed\ Costs} + C^e_t$$

- Supply of domestic assets fixed: $b_t = \bar{b}$

Environment

Foreign Sector - Demand for exports

- Export Demand evolves as:

$$C^*_{H,t} = [\gamma_2 \left(\frac{P^*_{H,t}}{P^*_{F,t}} \right)^{-\eta} C^*_t]^{\rho_\star} C^*_{H,t}{}^{1-\rho_\star}$$

- Law of one price holds for exports:

$$P^*_{H,t} = \frac{P_{H,t}}{X_t}$$

η=Elasticity of substitution between exports and domestically produced goods for the foreign sector, γ_2=Share of goods produced at home in the consumption basket for the foreign sector, ρ^*=AR(1) coefficient on exports Assume that foreign sector CPI $\approx P^*_{F,t}$

Environment

Estimating empirical IRFs in recessions

Use the Smooth Transition Vector Auto Regression Model - Auerbach and Gorodnichenko (2012) - Results from Chatterjee (2017)

$$Y_t = F(z_{t-1})B_R(L)Y_t + (1 - F(z_{t-1}))B_{NR}(L)Y_t + \epsilon_t \tag{1}$$

$$\epsilon_t \sim N(0, \Omega_t) \tag{2}$$

$$\Omega_t = F(z_{t-1})\Omega_R + (1 - F(z_{t-1}))\Omega_{NR} \tag{3}$$

$$F(z_t) = \frac{exp(-\gamma z_t)}{1 + exp(-\gamma z_t)} \text{ and } \gamma > 0 \tag{4}$$

$$E(z_t) = 0 \text{ and } Var(z_t) = 1 \tag{5}$$

Estimation

Data Description

- Data
  - Countries chosen: U.K., U.S., France, Canada, Mexico, Chile, Argentina, and South Korea
  - Uncertainty (U_t)
    - CBOE VIX - for the U.S
    - Volatility of stock market returns for the U.K., France, Canada, Mexico, Chile, Argentina, and South Korea
  - Macroeconomic variables
    - Investment (I_t), Consumption (C_t) - log first differences taken
    - Trade Balances (TB_t) - First difference of net exports expressed as a % of GDP
    - Inflation (Π_t) - Calculated using the GDP deflator
    - Interest rate (r_t) - Policy rate or closest available proxy is used
- Identification - Cholesky
  - Model: $[U_t, I_t, C_t, TB_t, \Pi_t, r_t]'$ or $[U_t, I_t, C_t, TB_t]'$

Estimation

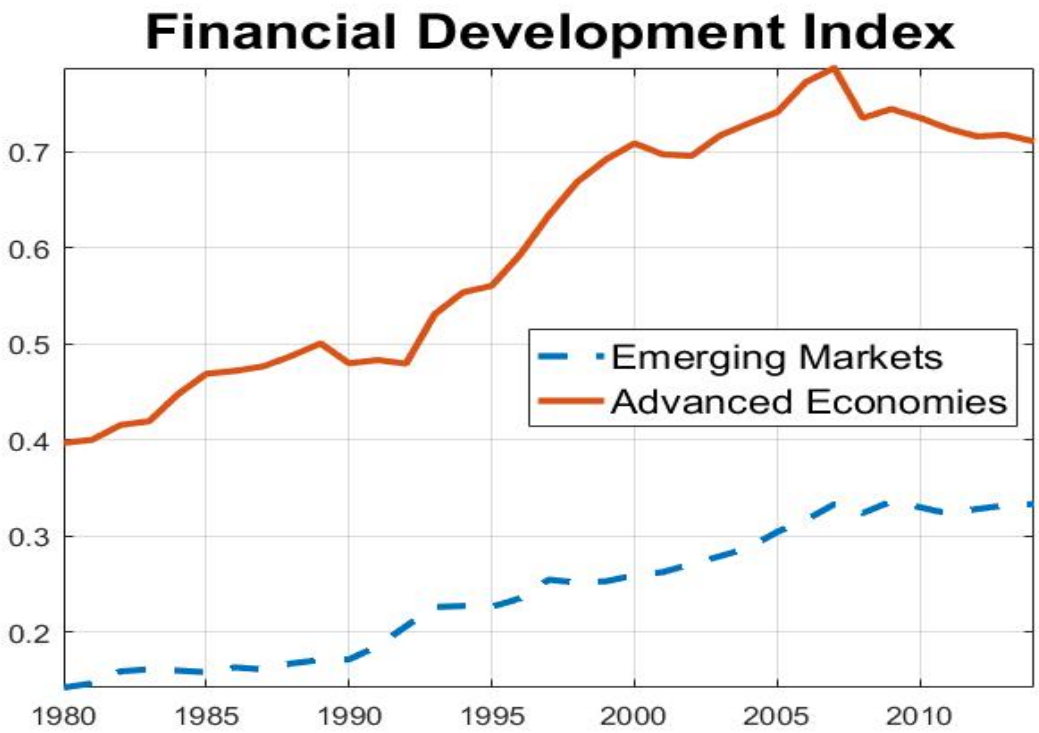
Estimating parameters for representative EM and AE specification...2

Parameter	Average - Emerging Markets	Average - Advanced Economies
ν - Elasticity of borrowing costs wrt leverage	**0.1064**	**0.0621**
$\sigma_{\overline{a}} = \sigma_{\overline{z}}$ - Average uncertainty	**0.1163**	**0.1518**
ρ_{σ_z} - Persistence of second-moment shock - preference	0.821	0.9225
ρ_{σ_a} - Persistence of second-moment shock -productivity	0.8201	0.9015
h - Persistence of external habits	0.4508	0.5044
κ_F - Degree of exchange rate pass through - extent of nominal rigidities in imports	**0.2498**	**0.4998**
ψ - Frisch elasticity of labor supply	2.0001	3.0006
Est. R^K_{t+1}	**1.1132**	**1.06903**

AEs: U.K., U.S., France, Canada
EMs: Mexico, Chile, Argentina, South Korea

Baseline

Financial Development Index



Financial Development Index calculated using the access, depth and efficiency of financial institutions and markets for advanced and emerging countries. Source: International Monetary Fund.

Credit Ratings Calibration

Calibrating uncertainty shocks ..1

- Calibrate $\overline{\sigma^a}, \overline{\sigma^z}$ by using empirical counterpart of model definition
- Use the volatility of stock market returns

Country type		Average volatility of quarterly stock market returns $(1993Q1 - 2014Q4)$
Representative Country	Advanced	0.0758 (U.K.)
Representative Country	Emerging	0.1128 (Mexico)

Calibration - Key

Calibrating key parameters

- Calibrate $\overline{\sigma^a}, \overline{\sigma^z}$ by using empirical counterpart of model definition
- Use the volatility of stock market returns Details

Parameter	Definition	Calibrated Values
$\overline{\sigma^a} = \overline{\sigma^z}$	Mean Volatility	0.112
η_C	Stochastic Volatility	0.00112
ρ_{σ^a}	Persistence: σ_t^a	0.83
ρ_{σ^z}	Persistence: σ_t^z	0.85
ρ_a	Persistence: a_t	0.75
ρ_z	Persistence: z_t	0.85
$\overline{a} = \overline{z}$	Mean: Level	1

A 1 std deviation shock to uncertainty $\Longrightarrow$ a 1% increase above steady state

Calibration of elasticity of borrowing costs wrt leverage

Model type	Leverage (k)	Elasticity of borrowing costs wrt leverage (ν)
Representative Advanced Country	2.5	0.04
Representative Emerging Country	2.5	0.07

- Calibration captures asymmetry in borrowing costs for a given level of leverage
- Parameters imply borrowing costs of 7.6% in EMs and 4.67% in AEs
- ν reduced form representation of country specific characteristics FDI
- $R^* = 1.0099$
- Standard calibration for remaining behavioral parameters Details

Calibration of remaining parameters

Calibration

Parameter	Definition	Calibrated Value
	Households	
$\frac{1}{\rho/(1-h)}$	Intertemporal Elasticity of substitution (after adjusting for habits)	0.25
h	Habit	0.5
ψ	Frisch elasticity of labor supply	2
η_1	Elasticity of substitution between home and foreign goods for consumption	0.89 Gertler, Gilchrist and Natalucci (2007)
ϕ_B , ϕ_F^*	Portfolio Holding Costs	0.00009, 0.0009
β	Discount Factor	0.997
γ_1	Share of home goods in aggregate consumption	0.55
	Foreign Sector	
η	Elasticity of substitution between home and foreign goods for foreign country	1 Gertler, Gilchrist and Natalucci (2007)
γ_2	Share of goods produced at home -exports for rest of the world	0.0187
C^*	Aggregate consumption for rest of the world	200
P_F^*	CPI for Rest of the world	1
R^*	Gross foreign Interest Rate (quarterly)	1.0099 (1.04% Annualized after quarterly compounding)
$1-\rho'$	Persistence of export demand from rest of the world	0.75
	Entrepreneurs	
α	Share of capital in production process	0.5, Gertler, Gilchrist and Natalucci (2007)
θ	Exit rate of entrepreneurs	0.915, Fernandez and Gulan (2015) estimate 0.9

Calibration of remaining parameters

Calibration

Parameter	Definition	Calibrated Value
	Capital Producers	
η_2	Elasticity of substitution between home and foreign goods for investment	0.89
δ	Depreciation rate	0.05
S''	Elasticity of investment adjustment costs	6 Smets and Wouters (2007) use 5.74
	Retailers	
ϵ	Elasticity of substitution across varieties for domestically produced goods	8
ϵ_1	Elasticity of substitution across varieties for foreign goods	8
κ_H	Calvo price stickiness for retailers of domestic goods	0.75 Gertler, Gilchrist and Natalucci (2007)
κ_F	Calvo price stickiness for retailers of imported goods	0.25
	Monetary Policy: Taylor Rule Coefficients	
χ_y	Output deviation from steady state	0.08 - Smets and Wouters (2007)
$\chi_{\Delta y}$	Output growth	0.22 Smets and Wouters (2007)
χ_π	CPI inflation	1.5

Households...1

Households consume (C_t), supply labor (L_t) and save in domestic (B_t) and foreign assets (F_t^*) so as to maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t z_t \left(\frac{(C_t - hC_{t-1})^{1-\rho}}{1-\rho} - \frac{L_t^{1+\psi}}{1+\psi} \right)$$

Subject to:

Budget constraint:

$$P_t C_t + P_t \Gamma_t + B_t + X_t F_t^* = P_{H,t} W_t^r L_t + \Pi_t + R_{t-1} B_{t-1} + R_{t-1}^* X_t F_{t-1}^*$$

Portfolio holding costs

$$\Gamma_t = \frac{\phi_B}{2} \left(\frac{B_t}{P_t} \right)^2 + \frac{\phi_F^*}{2} \left(\frac{X_t F_t^*}{P_t} \right)^2$$

P_t=CPI, $P_{H,t}$=GDP deflator, X_t=Nominal Exchange Rate, R_t^*=Global risk free interest rate, Π_t= residual profits from firm ownership

Households Equilibrium

Households...2

Final consumption (C_t) is a CES aggregator over domestic goods and imported goods

$$C_t = \left[(1-\gamma_1)^{\frac{1}{\eta_1}} C_{H,t}^{\frac{\eta_1-1}{\eta_1}} + \gamma_1^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta_1-1}{\eta_1}}\right]^{\frac{\eta_1}{\eta_1-1}} \text{ such that}$$

$$C_{H,t} = \left[\int_0^1 C_{H,t}(i)^{\frac{\epsilon-1}{\epsilon}} di\right]^{\frac{\epsilon}{\epsilon-1}}, C_{F,t} = \left[\int_0^1 C_{F,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}$$

γ_1=Share of Imports in consumption, η_1=Elasticity of substitution bw home goods and imports, ϵ=Elasticity of substitution across varieties

Households Equilibrium

Entrepreneurial Choices ...1

Entrepreneur (indexed by net-worth N) chooses capital for use in $t+1$: K_{t+1}^N and foreign currency denominated debt D_t^N to finance K_{t+1}^N :

- Maximize the ex ante value of capital by choosing: D_t

$$\underset{D_t}{max}\ V_t^N = E_t\left[R_{t+1}^K Q_t K_{t+1}^N - R^* {k_t}^{\nu} \frac{X_t}{P_t} D_t^N\right]$$

subject to

$$Q_t K_{t+1}^N = N_t^N + \frac{X_t {D_t}^N}{P_t}$$

where $k_t^N = \frac{Q_t K_{t+1}^N}{N_t^N}$

- FOC implies:

$$E_t R_{t+1}^K = R^* {k_t}^{\nu} \frac{q_{t+1}}{q_t} \text{ where } q_t = \frac{X_t}{P_t}$$

$$k_t^N = k_t\ \forall N$$

Entrepreneurs Equilibrium

Entrepreneurial Choices ...2

- Produce wholesale goods using capital they own from previous period and labor hired from households:

$$Y_{H,t}^{N} = A_t {K_t^N}^{\alpha} {L_t^N}^{1-\alpha}$$

- Equilibrium choice of labor implies:

$$A_t \frac{P_{W,t}}{P_{H,t}}(1-\alpha)\left(\frac{K_t^N}{L_t^N}\right)^{\alpha} = W_t^r$$

$$\frac{K_t^N}{L_t^N} = \frac{K_t}{L_t} \; \forall N$$

Entrepreneurial Choices ...3

- Ex post value of capital

$$V_t = \left[R_t^K Q_{t-1} K_t - R^*(k_{t-1})^{\nu} \underbrace{\frac{X_t}{P_t}}_{=q_t} D_{t-1} \right]$$

- Expost rate of return on capital is given by:

$$R_t^K = \frac{mpk_t \frac{P_{H,t}}{P_t} + (1-\delta)Q_t}{Q_{t-1}}, mpk_t = \alpha \frac{P_{W,t}}{P_{H,t}} A_t \left(\frac{K_t}{L_t} \right)^{\alpha - 1}$$

- Net-worth evolves as:

$$N_t = \theta V_t + (1-\theta)E, \text{ E is exogenous}$$

θ exit rate of entrepreneurs

Retailers of domestic goods

- Buy wholesale goods from entrepreneurs - costlessly differentiate them and resell to households, capital producers and rest of the world as CES aggregate
- Demand faced by retailer j -

$$Y_{H,t} = \left[\int_0^1 Y_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} - K_H$$

- Optimal reset price:

$$\hat{P_{H,t}} = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{s=0}^{\infty} (\beta \kappa_H)^s \frac{\Lambda_{t+s}}{\Lambda_t} \Pi_{H,t}^{\epsilon} \frac{P_{W,t+s}}{P_{H,t+s}} Y_{H,t+s}}{E_t \sum_{s=0}^{\infty} (\beta \kappa_H)^s \frac{\Lambda_{t+s}}{\Lambda_t} \Pi_{H,t}^{1-\epsilon} Y_{H,t+s}}$$

- GDP deflator evolves as

$$P_{H,t}^{1-\epsilon} = \kappa_H P_{H,t-1}^{1-\epsilon} + (1 - \kappa_H) \hat{P_{H,t}}^{1-\epsilon}$$

Retailers of imported goods - Monacelli 2005

- Buy wholesale goods from entrepreneurs - costlessly differentiate them and resell to households, capital producers and rest of the world as CES aggregate
- Demand faced by retailer j -

$$Y_{F,t} = \Big[\int_0^1 Y_{F,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \Big]^{\frac{\epsilon}{\epsilon-1}} - K_F$$

- Optimal reset price:

$$\hat{P_{F,t}} = \frac{\epsilon}{\epsilon-1} \frac{E_t \sum_{s=0}^{\infty} (\beta\kappa_F)^s \frac{\Lambda_{t+s}}{\Lambda_t} \Pi_{F,t}^{\epsilon} \frac{X_t P^*_{F,t+s}}{P_{F,t+s}} Y_{F,t+s}}{E_t \sum_{s=0}^{\infty} (\beta\kappa_H)^s \frac{\Lambda_{t+s}}{\Lambda_t} \Pi_{F,t}^{1-\epsilon} Y_{F,t+s}}$$

- Import price index evolves as

$$P_{F,t}^{1-\epsilon} = \kappa_F P_{F,t-1}^{1-\epsilon} + (1-\kappa_F) \hat{P_{F,t}^{1-\epsilon}}$$

Retailers Equilibrium

Uncertainty Shocks

Shock to hh intertemporal discount factor (z_t) and aggr. productivity in production func. of wholesale goods for entrepreneurs (a_t)

$$a_t = (1-\rho_a)\overline{A} + \rho_a a_{t-1} + \sigma_t^a \boldsymbol{u_t^a}$$

$$z_t = (1-\rho_z)\overline{z} + \rho_z z_{t-1} + \sigma_t^z \boldsymbol{u_t^z}$$

$$\boldsymbol{\sigma_t^a} = (1-\rho_\sigma^a)\overline{\sigma^a} + \rho_\sigma^a \sigma_{t-1}^a + \eta_C \underbrace{\boldsymbol{u_t^C}}_{Common}$$

$$\boldsymbol{\sigma_t^z} = (1-\rho_\sigma^z)\overline{\sigma^z} + \rho_\sigma^z \sigma_{t-1}^z + \eta_C \underbrace{\boldsymbol{u_t^C}}_{Common}$$

- $u_t^C \overset{\text{iid}}{\sim} (0,1)$
- $\overline{\sigma^a}, \overline{\sigma^z}$ - average level of uncertainty, η_C - extent of stochastic volatility

Environment

Uncertainty Shocks

Shock to hh intertemporal discount factor (z_t) and aggr. productivity in production func. of wholesale goods for entrepreneurs (a_t)

$$a_t = (1-\rho_a)\overline{A} + \rho_a a_{t-1} + \boldsymbol{\sigma_t^a} u_t^a$$

$$z_t = (1-\rho_z)\overline{z} + \rho_z z_{t-1} + \boldsymbol{\sigma_t^z} u_t^z$$

$$\boldsymbol{\sigma_t^a} = (1-\rho_\sigma^a)\overline{\sigma^a} + \rho_\sigma^a \sigma_{t-1}^a + \eta_C \overbrace{\boldsymbol{u_t^C}}^{Common}$$

$$\boldsymbol{\sigma_t^z} = (1-\rho_\sigma^z)\overline{\sigma^z} + \rho_\sigma^z \sigma_{t-1}^z + \eta_C \overbrace{\boldsymbol{u_t^C}}^{Common}$$

- $u_t^C \overset{\text{iid}}{\sim} (0,1)$
- $\overline{\sigma^a}, \overline{\sigma^z}$ - average level of uncertainty, η_C - extent of stochastic volatility

Environment

Parameter bounds in Estimation

- Restrict the bounds on the average level of uncertainty ($\overline{\sigma^a} = \overline{\sigma^z}$) to empirical limits

Model type	Minimum	Average	Maximum
Mexico	0.0424	0.1128	0.2885
United Kingdom	0.0362	0.07582	0.2778

- Restrict the bounds on the gross rate of return on capital by using data on 3 month treasury bill yield

Model type	Minimum (%)	Average (%)	Maximum (%)
Mexico	2.883	10.259	41.760
United Kingdom	2.454	5.220	7.530

- These restrictions + leverage=2.5 + $R^* = 1.0099$ imply the following limits on ν

Model type	Minimum	Average	Maximum
Mexico	0.020	0.096	0.370
United Kingdom	0.016	0.045	0.068