INTEREST RATE UNCERTAINTY AS A POLICY TOOL

Fabio Ghironi\(^1\)   Galip Kemal Ozhan\(^2\)

\(^1\)University of Washington, CEPR, and NBER

\(^2\)Bank of Canada

July 24, 2019

CBC-IMF-IMF Economic Review Conference
Santiago, Chile
INTRODUCTION

Figure: Portfolio Flows to Emerging Markets (13-week moving average, bn USD)

Source: CBRT
INTEREST RATE CORRIDOR

Figure: Interest rate corridor and average funding cost, Turkey

Source: CBRT
PORTFOLIO AND FDI FLOWS

Figure: Financing the current account, Turkey (12-month cumulative, bn USD)

Source: CBRT
What are the implications of using the volatility of domestic interest rate as a policy tool in an open economy?
What are the implications of using the volatility of domestic interest rate as a policy tool in an open economy?

Does an increase in the volatility of domestic interest rate affect the composition of capital inflows between bonds and FDI?
What are the implications of using the volatility of domestic interest rate as a policy tool in an open economy?

Does an increase in the volatility of domestic interest rate affect the composition of capital inflows between bonds and FDI?

What are the possible trade-offs that are faced by a central banker in navigating among price stability and controlling the external account?
WHAT WE DO (1)

- Developing an open macroeconomic model in which the central bank uses the interest rate volatility as a policy tool
Developing an open macroeconomic model in which the central bank uses the interest rate volatility as a policy tool

- Distinguish between bond and FDI flows
What we do (1)

- Developing an open macroeconomic model in which the central bank uses the interest rate volatility as a policy tool
  - Distinguish between bond and FDI flows
  - Incomplete international financial markets: NFA important for transmission of volatility shocks
WHAT WE DO (1)

- Developing an open macroeconomic model in which the central bank uses the interest rate volatility as a policy tool
  - Distinguish between bond and FDI flows
  - Incomplete international financial markets: NFA important for transmission of volatility shocks
  - Endogenous movements in markups driven by nominal price and wage rigidities
WHAT WE DO (1)

- Developing an open macroeconomic model in which the central bank uses the interest rate volatility as a policy tool
  - Distinguish between bond and FDI flows
  - Incomplete international financial markets: NFA important for transmission of volatility shocks
  - Endogenous movements in markups driven by nominal price and wage rigidities

A New Keynesian Open Economy framework that enables us to decompose the current account into bond and FDI components easily (Bergin (2006), Obstfeld and Rogoff (1995))
WHAT WE DO (2)

- Stochastic volatility process (Justiniano and Primiceri (2008))
What we do (2)

- Stochastic volatility process (Justiniano and Primiceri (2008))
- Model solution using a third-order perturbation (Fernandez-Villaverde et alii (2015))
**WHAT WE DO (2)**

- Stochastic volatility process (Justiniano and Primiceri (2008))

- Model solution using a third-order perturbation (Fernandez-Villaverde et alii (2015))

- IRF calculation from the stochastic steady-state (Born and Pfeifer (2014a) and (2014b))
  - Ergodic distribution of the endogenous variables move away from their deterministic steady state
  - SSS: Ergodic Mean in the Absence of Shocks (EMAS)

Illustration of stochastic steady state
Using interest rate uncertainty as a policy tool has different implications on bond and FDI component of the current account:

- Portfolio risk and precautionary savings channels (Bond component)
- Markup channel (FDI component)
NEW INSIGHTS (1)

Using interest rate uncertainty as a policy tool has different implications on bond and FDI component of the current account

- Portfolio risk and precautionary savings channels (Bond component)
- Markup channel (FDI component)

★ The ability to create a negative comovement is dependent on the type of price stickiness
NEW INSIGHTS (1)

- Using interest rate uncertainty as a policy tool has different implications on bond and FDI component of the current account
  - Portfolio risk and precautionary savings channels (Bond component)
  - Markup channel (FDI component)
    - The ability to create a negative comovement is dependent on the type of price stickiness
- Using uncertainty as a policy tool might be useful in adjusting the current account, but at the expense of lower output and higher inflation
NEW INSIGHTS (2)

- If FDI irreversible, fluctuations in the FDI-component of the CA are milder
  - Wait-and-see effects (Bernanke, 1983; Stokey, 2016)
NEW INSIGHTS (2)

- If FDI irreversible, fluctuations in the FDI-component of the CA are milder
  - Wait-and-see effects (Bernanke, 1983; Stokey, 2016)

- Currency of export invoicing is important:
  - No pass-through of inflation to export prices → EME firms increase production to meet demand from abroad → More inputs needed
NEW INSIGHTS (2)

- If FDI irreversible, fluctuations in the FDI-component of the CA are milder
  - Wait-and-see effects (Bernanke, 1983; Stokey, 2016)

- Currency of export invoicing is important:
  - No pass-through of inflation to export prices → EME firms increase production to meet demand from abroad → More inputs needed

- ELB in the rest of the world:
  - Amplification effects
NEW INSIGHTS (2)

- If FDI irreversible, fluctuations in the FDI-component of the CA are milder
  - Wait-and-see effects (Bernanke, 1983; Stokey, 2016)

- Currency of export invoicing is important:
  - No pass-through of inflation to export prices → EME firms increase production to meet demand from abroad → More inputs needed

- ELB in the rest of the world:
  - Amplification effects

- Risk aversion of foreign agents is important:
  - Amplified reaction of the current account
  - Deviations in UIP imply short-term inflows
THE MODEL ARCHITECTURE

Emerging Market Economy

Households

Producers

Final Good

Domestic Bonds

Capital

Rental Rate

Exports

RoW

Households

Producers

Final Good

Domestic Bonds

International Bond Trade

Capital

Rental Rate
**HOUSEHOLD**

- **Expected intertemporal utility:**

  \[
  \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{C_t(h)^{1-\rho}}{1-\rho} - \chi \frac{L_t(h)^{1+\varphi}}{1+\varphi} \right]
  \]

- **Budget constraint:**

  \[
  P_t C_t(h) + B_{t+1}(h) + S_t B_{*,t+1}(h) + \text{adj}_t + P_t I_t(h) + S_t P_t^* I_{*,t}(h)
  \]

  \[
  = R_t B_t(h) + S_t R_t^* B_{*,t}(h) + W_t(h) L_t(h) + P_t r_K, t K_t(h) + S_t P_t^* r_K_{*,t} K_{*,t}(h)
  \]

  \[
  - \frac{\kappa}{2} W \left( \frac{W_t(h)}{W_{t-1}(h)} - 1 \right)^2 W_t(h) L_t(h) + \Pi_t + T_t^{f*}
  \]
Other constraints:

\[ L_t(h) = \left( \frac{W_t(h)}{W_t} \right)^{-\epsilon W} L_t \]

\[ K_{t+1}(h) = (1 - \delta) K_t(h) + I_t(h) \]

\[ K_{*,t+1}(h) = (1 - \delta) K_{*,t}(h) + I_{*,t}(h) \]
**HOUSEHOLDS**

FOCs:

\[ w_t = \mu_t^W \left( \frac{\chi L_t^\varphi}{C_t^{-\rho}} \right) \]

\[ 1 = q_t \]

\[ 1 = \beta \mathbb{E}_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{-\rho} (r_{K, t+1} + (1 - \delta)) \right] \]
Investment to the RoW:

\[ rer_t = q_{*, t} \]

\[ 1 = \beta E_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{rer_{t+1}}{rer_t} (r_{K, *, t+1} + 1 - \delta) \right] \]
**HOUSEHOLDS**

Investment to the RoW:

\[ rer_t = q_{*,t} \]

\[
1 = \beta E_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{rer_{t+1}}{rer_t} (r_{K,*_{t+1}} + 1 - \delta) \right]
\]

Similarly, price of FDI coming into the EME:

\[
1 = \beta E_t \left[ \left( \frac{C^*_{t+1}}{C^*_t} \right)^{-\rho} \frac{rer_t}{rer_{t+1}} (r^*_{K,t+1} + 1 - \delta) \right]
\]
Intermediate Goods producers:

\[ Y_{H.t}(i) + \left(\frac{1-n}{n}\right) Y_{H.t}^*(i) = (K_t(i))^{\alpha_1} (K_t^*(i))^{\alpha_2} L_t(i)^{1-\alpha_1-\alpha_2} \]

- IMF definition of FDI: “...initial transaction between the two (overseas) entities and all subsequent capital transactions between them...”
Firms

Intermediate Goods producers:

\[ Y_{H,t}(i) + \left(\frac{1-n}{n}\right) Y^*_H, t(i) = (K_t(i))^\alpha_1 \left(K^*_t(i)\right)^\alpha_2 L_t(i)^{1-\alpha_1-\alpha_2} \]

- IMF definition of FDI: “...initial transaction between the two (overseas) entities and all subsequent capital transactions between them ...”

Final Goods producers:

\[ Y_t = \left(a^{\frac{1}{\omega}} Y_{H,t}^{\frac{\omega-1}{\omega}} + (1-a)^{\frac{1}{\omega}} Y_{F,t}^{\frac{\omega-1}{\omega}}\right)^{\frac{\omega}{\omega-1}} \]

- Firms’ problem
- Resource Constraints
NET FOREIGN ASSET ACCUMULATION

\[ b_{t+1} + rer_t b_{*,t+1} + \left( \frac{1-n}{n} \right) rer_t K_{*,t+1} - K_{t+1} \]

\[ = \frac{R_t}{\Pi_t} b_t + \frac{R^*_t}{\Pi^*_t} rer_t b_{*,t} + \left( \frac{1-n}{n} \right) rer_t (rK_{*,t} + 1 - \delta) K_{*,t} - \left( r^*_{K,t} + 1 - \delta \right) K_t \]

\[ + \left( \frac{1-n}{n} \right) \mu^*_{H,t} mc_t Y^*_H,t - rer_t \mu_{F,t} mc_t Y_{F,t} \]

\[ \text{Trade Balance} \]
Decomposing the current account

\[
(b_{t+1} - b_t) + \text{rer}_t (b^*,_{t+1} - b^*,_t)
\]

Bond component

\[
+ \left( \frac{1-n}{n} \right) \text{rer}_t (K^*_{t+1} - K^*_t) - (K^*_{t+1} - K^*_t) \equiv CA_t
\]

FDI component
Fisher relation:

\[ R_{t+1} = (1 + r_{t+1}) \mathbb{E}_t \Pi_{t+1} \]

Domestic interest rate rule:

\[
\frac{R_t}{R} = \left( \frac{R_{t-1}}{R} \right)^{\rho_R} \left( \frac{\Pi_t}{\Pi} \right)^{(1-\rho_R)\rho_\Pi} \left( \frac{Y_t}{Y} \right)^{(1-\rho_R)\rho_Y} e^{u_t}
\]

with

\[ u_t = \rho^u u_{t-1} + \sigma^R_t \varepsilon_t \]

and

\[ \sigma^R_t = (1 - \rho^{\sigma^R}) \sigma^R + \rho^{\sigma^R} \sigma^R_{t-1} + \varepsilon^\sigma_t \]
Portfolio Risk

- Relative risk premia between the RoW investor’s assets:

\[
RR_{B^*, B^*, t+1} \equiv \frac{\text{Cov}_t \left( \beta^*_{t, t+1}, \frac{R^*_{t+1}}{\Pi^*_t} - \frac{r_{t+1}}{r_{t+1}} \frac{R_{t+1}}{\Pi_{t+1}} \right)}{\mathbb{E}_t \left[ \beta^*_{t, t+1} \right]}
\]

\[
RR_{K^*, K^*, t+1} \equiv \frac{\text{Cov}_t \left( \beta^*_{t, t+1}, R_{K^*, t+1} - \frac{r_{t+1}}{r_{t+1}} R_{K^*, t+1} \right)}{\mathbb{E}_t \left[ \beta^*_{t, t+1} \right]}
\]

\[
RR_{B^*, K^*, t+1} \equiv \frac{\text{Cov}_t \left( \beta^*_{t, t+1}, \frac{r_{t+1}}{r_{t+1}} \left( \frac{R_{t+1}}{\Pi_{t+1}} - R_{K^*, t+1} \right) \right)}{\mathbb{E}_t \left[ \beta^*_{t, t+1} \right]}
\]

where \( R_K \equiv 1 - \delta + r_K \).
Our experiment

First Moment Shock

Normal Distr. N~(0,1)  Level (A)

Second Moment Shock

Normal Distr. N~(0,1)  Level (A)  Variance (W)

Calibration

Model Solution
INTEREST RATE UNCERTAINTY AND PORTFOLIO RISK

Relative Risk $B^* \& B^*$

Relative Risk $K^* \& K^*$

Relative Risk $B^* \& K^*$

Bond Component of CA

FDI Component of CA

Volatility of $R$

% deviation

% deviation

% deviation

% deviation

% deviation
INTEREST RATE UNCERTAINTY AND PORTFOLIO RISK

\[ RR_{B^*, B^*, t+1} \equiv \frac{\text{Cov}_t \left( \beta_{t, t+1}^*, \frac{R_{t+1}^*}{\Pi_{t+1}^*} - \frac{\text{rer}_t}{\Pi_{t+1}} \frac{R_{t+1}}{\Pi_{t+1}} \right)}{\mathbb{E}_t \left[ \beta_{t, t+1}^* \right]} \]
\[RR_{K^*, K^*, t+1} \equiv \frac{\text{Cov}\left(\beta^*_{t,t+1}, R_{K^*, t+1} - \frac{\text{rer}_{t+1} \ R_{K^*, t+1}}{\text{rer}_{t+1}}\right)}{\mathbb{E}_t\left[\beta^*_{t,t+1}\right]}\]
INTEREST RATE UNCERTAINTY AND PORTFOLIO RISK

\[ RR_{K^*, \delta t+1} \approx -E_t \left[ R_{K^*, t+1} - \frac{rer_t}{rer_{t+1}} R_{K^*, t+1} \right] \]
Interest Rate Uncertainty and Portfolio Risk

\[ RR_{B^*, K^*, t+1} \equiv \frac{\text{Cov}_t \left( \beta_{t, t+1}^* \frac{\text{rert}_{t+1}}{\Pi_{t+1}} \left( \frac{R_{t+1}}{\Pi_{t+1}} - R_{K^*, t+1} \right) \right)}{\mathbb{E}_t \left[ \beta_{t, t+1}^* \right]} \]
Precautionary savings → Savings flow abroad where risk is lower (both bond and FDI)

Rising markups (asymmetric profit): Inflationary pressure → Prices do not adjust to accommodate demand → Output ↓ → Demand for FDI ↓
INTEREST RATE UNCERTAINTY AS A POLICY TOOL

- Precautionary savings again but savings go to domestic investment
- No time-varying markups in producer prices: Take advantage of volatility if there are no frictions (Oi-Hartman-Abel effect) $\rightarrow$ Demand for incoming FDI $\uparrow$
No time-varying markups in wages → Fall in $R_K$ and $R_{K^*}$ is more pronounced (through factors of production) → Cut production → Cut input demand → Demand incoming FDI ↓
Using domestic interest rate risk as a policy affects the composition of bond and FDI component of the current account

- Portfolio risk and precautionary savings channels: discouraging bond inflows
- Price markup channel: discouraging FDI inflows

Uncertainty can be used to adjust the external account at the expense of higher inflation and lower output
CONCLUSIONS

- Using domestic interest rate risk as a policy affects the composition of bond and FDI component of the current account
  - Portfolio risk and precautionary savings channels: discouraging bond inflows
  - Price markup channel: discouraging FDI inflows

- Uncertainty can be used to adjust the external account at the expense of higher inflation and lower output

- Additional cases:
  - Time-to-build FDI (against the policymaker)
  - LCP (in favor of the policymaker)
  - Effective-lower-bound in the RoW (against the policymaker)
  - Risk averse RoW investors (Epstein-Zin-Weil Preferences) (against the policymaker)
**Firms**

Intermediate Goods producers:

Producer Currency Pricing (PCP)

- Period profits:

\[
rp_{H,t}(i) Y_{H,t}(i) + \left( \frac{1-n}{n} \right) rp_{H,t}^*(i) Y_{H,t}^*(i) - mc_t \left( Y_{H,t}(i) + \left( \frac{1-n}{n} \right) Y_{H,t}^*(i) \right) \\
- adj_{H,t} - adj_{H,t}^*
\]

- Domestic and export demand:

\[
Y_{H,t}(i) = \left( \frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\epsilon} Y_{H,t} \\
Y_{H,t}^*(i) = \left( \frac{P_{H,t}^*(i)}{S_t P_{H,t}^*} \right)^{-\epsilon} Y_{H,t}^*
\]
Intermediate Goods producers:

FOCs:

\[ rp_{H,t} = \mu_{H,t} mc_t \]

\[ rp^*_{H,t} RER_t = \mu^*_{H,t} mc_t \]
FIRMS

Intermediate Goods producers:

FOCs:

\[ \begin{align*}
    rp_{H,t} &= \mu_{H,t} mc_t \\
    rp_{H,t}^* RER_t &= \mu_{H,t}^* mc_t
    \end{align*} \]

Final Goods producers:

\[ Y_t = \left( a \frac{1}{\omega} Y_{H,t}^{1-\omega} + (1-a) \frac{1}{\omega} Y_{F,t}^{\omega-1} \right)^{\frac{\omega}{\omega-1}} \]
Resource Constraints

\[ Y_t = C_t + I_t + I^*_t + adj_{t}^{w} + adj_{t}^{P_H} + adj_{t}^{P^*_H} \]

\[ Y^*_t = C^*_t + I^*_t + I^*_t + adj_{t}^{w^*} + adj_{t}^{P^*_F} + adj_{t}^{P^*_F} \]
• Contractionary shock with national absorption
• Downward pressure on prices and wages
TIME-TO-BUILD FDI

- Given the long-run nature of FDI, we also study dynamics under the condition that it requires multiple periods to build the physical capital that will be used overseas.
TIME-TO-BUILD FDI

- Given the long-run nature of FDI, we also study dynamics under the condition that it requires multiple periods to build the physical capital that will be used overseas.

- Introducing a time-to-build process for the FDI captures also irreversibility.
Law of motion of capital will be replaced by the following conditions:

\[
K_{*,t+1}(h) = (1 - \delta)K_{*,t}(h) + I_{*,1,t}(h),
\]

\[
l_{*,j-1,t+1}(h) = l_{*,j,t}(h); \quad j = 2, \ldots, J.
\]

\[
l_{*,t}(h) = \sum_{j=1}^{J} \frac{1}{J} l_{*,j,t}(h)
\]
TIME-TO-BUILD FDI

- Law of motion of capital will be replaced by the following conditions:

\[
K_{*, t+1}(h) = (1 - \delta)K_{*, t}(h) + l_{*, 1, t}(h),
\]

\[
l_{*, j-1, t+1}(h) = l_{*, j, t}(h); \quad j = 2, \ldots, J.
\]

\[
l_{*, t}(h) = \sum_{j=1}^{J} \frac{1}{J} l_{*, j, t}(h)
\]

- Notation:

\(\frac{1}{J}\): Fixed fraction of total investment expenditures allocated to projects that are \(j\) periods away from completion

\(l_{*, j, t}(h)\): Project that is initiated in period \(t\) and \(j\) periods away from completion.
Euler equation for Home capital that will be used in RoW and the respective pricing equation for the outgoing FDI:

\[ q_{*, t+J-1} = \mathbb{E}_{t+J-1} \left[ \beta_{t+J-1, t+J} \left( \text{rer}_{t+J} \text{r} \text{K}_{*, t+J} + q_{*, t+J} (1 - \delta) \right) \right], \]

\[ \mathbb{E}_t [\beta_{t, t+J-1} q_{*, t+J-1}] = \frac{1}{J} \left( \text{rer}_t + \mathbb{E}_t [\beta_{t, t+1} \text{rer}_{t+1}] + \ldots + \mathbb{E}_t [\beta_{t, t+J-1} \text{rer}_{t+J-1}] \right). \]
**TIME-TO-BUILD FDI**

Euler equation for Home capital that will be used in RoW and the respective pricing equation for the outgoing FDI:

\[
q_{*,t+J-1} = \mathbb{E}_{t+J-1} \left[ \beta_{t+J-1,t+J} \left( rer_{t+J} \rho_{t+J} + q_{*,t+J} (1 - \delta) \right) \right],
\]

\[
\mathbb{E}_t [\beta_{t,t+J-1} q_{*,t+J-1}] = \frac{1}{J} (rer_t + \mathbb{E}_t [\beta_{t,t+1} rer_{t+1}] + \ldots + \mathbb{E}_t [\beta_{t,t+J-1} rer_{t+J-1}]).
\]

Current account:

\[
(b_{t+1} - b_t) + rer_t (b_{*,t+1} - b_{*,t}) + \frac{1}{J} \left[ \left( \frac{1-n}{n} \right) rer_t (K_{*,t+J} - K_{*,t}) - (K_{t+J} - K_t) \right] \equiv CA_t
\]

Bond component

FDI component
TIME-TO-BUILD FDI

Time-to-build comparison

- Output
- Consumption
- Domestic Investment
- Investment for RoW Capital
- Inflation
- Wage Markup
- Domestic Price Markup
- Export Price Markup
- Real Exchange Rate
- Bond Component of CA
- FDI Component of CA
- Exog Change in Interest Rate Level
TIME-TO-BUILD FDI

Real options channel:

- Irreversibility $\rightarrow$ Dampening in the net outflow of FDI
Real options channel:

- Irreversibility → Dampening in the net outflow of FDI
- EME households shift investment to RoW capital (where risk is lower)
TIME-TO-BUILD FDI

Real options channel:

- Irreversibility $\rightarrow$ Dampening in the net outflow of FDI

- EME households shift investment to RoW capital (where risk is lower)

- It takes 4-periods to complete FDI $\rightarrow$ No immediate rental gain
  - Borrow from international markets to compensate the fall in consumption
Real options channel:

- Irreversibility → Dampening in the net outflow of FDI

- EME households shift investment to RoW capital (where risk is lower)

- It takes 4-periods to complete FDI → No immediate rental gain
  - Borrow from international markets to compensate the fall in consumption

- Wait-and-see effects (Stokey, 2016)
Baseline model: PCP

- Nature of price rigidity is central for the real effects of exchange rate fluctuations
Currency of Export Invoicing

- Baseline model: PCP
  - Nature of price rigidity is central for the real effects of exchange rate fluctuations
- LCP: No inflation pass-through
The Rotemberg cost of adjusting the export price:

\[
\left( \frac{1 - n}{n} \right) \frac{\kappa^*}{2} \left( \frac{P_{H,t+s}^*(i)}{P_{H,t+s-1}^*(i)} - 1 \right)^2 \frac{S_{t+s} P_{H,t+s}^*(i)}{P_{t+s}} Y_{H,t+s}^*.
\]
The Rotemberg cost of adjusting the export price:

\[
\left( \frac{1-n}{n} \right) \kappa^* \left( \frac{P_{H,t+s}^*(i)}{P_{H,t+s-1}^*(i)} - 1 \right)^2 \frac{S_{t+s}P_{H,t+s}^*(i)}{P_{t+s}} \frac{Y_{H,t+s}^*}{Y_{H,t+s}}.
\]

Relative price of Home output for domestic sales (i.e. \( rp_H \equiv \frac{P_H}{P} \)):

\[
rp_{H,t} = \mu_{H,t}mc_t,
\]

Relative price of Home output for export sales:

\[
rp_{H,t}^* = \frac{\mu_{H,t}^*mc_t}{rer_t},
\]
CURRENCY OF EXPORT INVOICING
LCP

- LCP reverses the behavior of bond and FDI components of the current account
LCP

- LCP reverses the behavior of bond and FDI components of the current account

- Inflation does not pass-through to export prices → Exports are cheaper → Export demand ↑ → Demand on EME and RoW capital ↑
LCP

- LCP reverses the behavior of bond and FDI components of the current account

- Inflation does not pass-through to export prices → Exports are cheaper → Export demand ↑ → Demand on EME and RoW capital ↑
  - Increase in net FDI inflows to the EME
LCP reverses the behavior of bond and FDI components of the current account

Inflation does not pass-through to export prices → Exports are cheaper → Export demand ↑ → Demand on EME and RoW capital ↑
  ▶ Increase in net FDI inflows to the EME

Precautionary savings channel still at work:
LCP

- LCP reverses the behavior of bond and FDI components of the current account

- Inflation does not pass-through to export prices → Exports are cheaper → Export demand ↑ → Demand on EME and RoW capital ↑
  - Increase in net FDI inflows to the EME

- Precautionary savings channel still at work:
  - EME debt riskier → Short-term outflows

Time-to-build and LCP

Back to conclusion
**Epstein-Zin-Weil Preferences**

- Epstein-Zin-Weil preferences relax the assumption that EIS=1/RRA
  - Trade-offs between *smoothing across states vs. smoothing across time*
Epstein-Zin-Weil Preferences

- Epstein-Zin-Weil preferences relax the assumption that EIS=1/RRA
  - Trade-offs between smoothing across states vs. smoothing across time
- What are the implications when RoW agents are more risk averse?
**Epstein-Zin-Weil Preferences**

Generalize expected discounted sum of utility to:

\[ V_t \equiv (1 - \beta)U(C_t(h), L_t(h)) - \beta \mathbb{E}_t (V_{t+1}^{1-\alpha})^{1/(1-\alpha)} \]

- When \( \alpha = 0 \), it reduces to the standard utility as before
**Epstein-Zin-Weil Preferences**

Generalize expected discounted sum of utility to:

\[
V_t \equiv (1 - \beta) U(C_t(h), L_t(h)) - \beta \left[ \mathbb{E}_t (-V_{t+1})^{1-\alpha} \right]^{1/(1-\alpha)}
\]

- When \(\alpha = 0\), it reduces to the standard utility as before

The discount factor of RoW agents, \(\beta^*_{t, t+1}\), becomes

\[
\beta^*_{t, t+1} \equiv \frac{\beta U^*_{C, t+1}}{U^*_C} \left( \frac{-V^*_t}{\mathbb{E}_t \left[ -V^*_{t+1} \right]^{1/(1-\alpha^*)}} \right)^{-\alpha^*}
\]

- Additional term reflecting the early resolution of uncertainty
- With \(\alpha^* < 0\), unfavorable changes in utility imply a higher discount factor for RoW agents
Epstein-Zin-Weil Preferences

Output

Consumption

Domestic Investment

Investment for RoW Capital

Inflation

Wage Markup

Domestic Price Markup

Export Price Markup

Real Exchange Rate

Bond Component of CA

FDI Component of CA

Exog Change in Interest Rate Level
**Precautionary pricing channel is amplified**

- Hike in prices → Lower rental rates → RoW agents cut their investment
Precautionary pricing channel is amplified
- Hike in prices → Lower rental rates → RoW agents cut their investment

International comovement in consumption → RoW consumption ↓ and RoW savings ↑
**Epstein-Zin-Weil Preferences**

- Precautionary pricing channel is amplified
  - Hike in prices → Lower rental rates → RoW agents cut their investment
- International comovement in consumption → RoW consumption ↓ and RoW savings ↑

- Amplified precautionary savings channel imply a more pronounced appreciation in RER (from EME perspective)
  - EME risk premium ↑ → Short-term inflows ↑

\[
R_t - R^*_t \approx E_t \Delta s_{t+1} + \frac{1}{2} \text{Var}_t(\Delta s_{t+1}) + \text{Cov}_t(\beta^*_t, \Delta s_{t+1})
\]

\[
= \frac{1}{2} \text{Var}_t(\beta^*_t) - \frac{1}{2} \text{Var}_t(\beta_{t+1})
\]

▶ Back to conclusion
When accumulation function is concave, at the deterministic steady-state, accumulation will be greater than in absence of risk due to precautionary motive.

It is point C that defines stochastic steady state.
Third-order approximation of the model is needed to single out the individual effects of volatility shocks.
Solution method

- Third-order approximation of the model is needed to single out the individual effects of volatility shocks

- Solutions using higher-order perturbation techniques tend to yield explosive time-paths due to accumulation of terms higher-order
  - Pruning all higher-order terms (Andreasen et alii (2013))
SOLUTION METHOD

Simulated paths of states and controls move away from their non-stochastic steady-state values.
**Solution Method**

Simulated paths of states and controls move away from their non-stochastic steady-state values.

- Simulate the system for 4000 periods with all shocks set to zero, starting from the deterministic steady-state.
Simulated paths of states and controls move away from their non-stochastic steady-state values.

- Simulate the system for 4000 periods with all shocks set to zero, starting from the deterministic steady-state
- Point in state-space where agents choose to remain although they are taking future volatility into account
  - “Stochastic Steady State”
**Solution Method**

Simulated paths of states and controls move away from their non-stochastic steady-state values.

- Simulate the system for 4000 periods with all shocks set to zero, starting from the deterministic steady-state.
- Point in state-space where agents choose to remain although they are taking future volatility into account.
  - “Stochastic Steady State”

- Starting from the ergodic mean in the absence of shocks, hit the model with a 2 std deviation shock to the volatility process, $\varepsilon_t^\sigma$. 

Illustration of the Stochastic Steady State
Simulated paths of states and controls move away from their non-stochastic steady-state values.

- Simulate the system for 4000 periods with all shocks set to zero, starting from the deterministic steady-state point in state-space where agents choose to remain although they are taking future volatility into account
  ▶ “Stochastic Steady State”

- Starting from the ergodic mean in the absence of shocks, hit the model with a 2 std deviation shock to the volatility process, $\varepsilon_t^\sigma$

- Calculate IRFs as deviation from the ergodic mean in the absence of shocks
## Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>0.9804</td>
</tr>
<tr>
<td>Relative risk aversion</td>
<td>$\rho$</td>
<td>2</td>
</tr>
<tr>
<td>Relative weight of labor in utility</td>
<td>$\chi$</td>
<td>1</td>
</tr>
<tr>
<td>Frisch elasticity</td>
<td>$\varphi$</td>
<td>0.25</td>
</tr>
<tr>
<td>Deposit adjustment</td>
<td>$\psi$</td>
<td>0.0025</td>
</tr>
<tr>
<td>Rotemberg wage adjustment</td>
<td>$\kappa^W$</td>
<td>116</td>
</tr>
<tr>
<td>Elas. of substitution of differentiated labor</td>
<td>$\epsilon^W$</td>
<td>11</td>
</tr>
<tr>
<td>Home bias</td>
<td>$a$</td>
<td>0.65</td>
</tr>
<tr>
<td>Share of domestic capital</td>
<td>$\alpha_1$</td>
<td>0.30</td>
</tr>
<tr>
<td>Share of foreign capital</td>
<td>$\alpha_2$</td>
<td>0.15</td>
</tr>
<tr>
<td>Rotemberg domestic price adj.</td>
<td>$\kappa$</td>
<td>116</td>
</tr>
<tr>
<td>Rotemberg export price adj.</td>
<td>$\kappa^*$</td>
<td>116</td>
</tr>
<tr>
<td>Elas. of substitution in goods production</td>
<td>$\epsilon$</td>
<td>11</td>
</tr>
<tr>
<td>Smoothing coefficient</td>
<td>$\rho_R$</td>
<td>0.7</td>
</tr>
<tr>
<td>SS response to inflation</td>
<td>$\rho_\Pi$</td>
<td>1.5</td>
</tr>
<tr>
<td>SS response to output</td>
<td>$\rho_Y$</td>
<td>0.5/4</td>
</tr>
</tbody>
</table>

2% Real Rate, Literature, Unsal (2013), ABK (2016), ≈ 3 period stickiness, Wage markup of 10%, Price markup of 10%
MODEL OUTCOME WITH LEVEL SHOCK
TIME-TO-BUILD COMPARISON

Bond Component of CA

FDI Component of CA

% deviation

Time to Build Comparison
TIME-TO-BUILD COMPARISON

**Bond Component of CA**

- **LCP**
- **LCP with 2-period time-to-build**
- **LCP with 3-period time-to-build**
- **LCP with 4-period time-to-build**

**FDI Component of CA**

- **% deviation**

- **2**  **4**  **6**  **8**  **10**  **12**  **14**  **16**  **18**  **20**

- **% deviation**

- **2**  **4**  **6**  **8**  **10**  **12**  **14**  **16**  **18**  **20**
**Effective-Lower-Bound in the RoW**

- Output
- Consumption
- Domestic Investment
- Investment for RoW Capital
- Inflation
- Wage Markup
- Domestic Price Markup
- Export Price Markup
- Real Exchange Rate
- Bond Component of CA
- FDI Component of CA

\[ R^2 \times 10^{-3} \]
Effective-lower-bound in the RoW (High Home Bias)