Interest rate uncertainty as a policy tool

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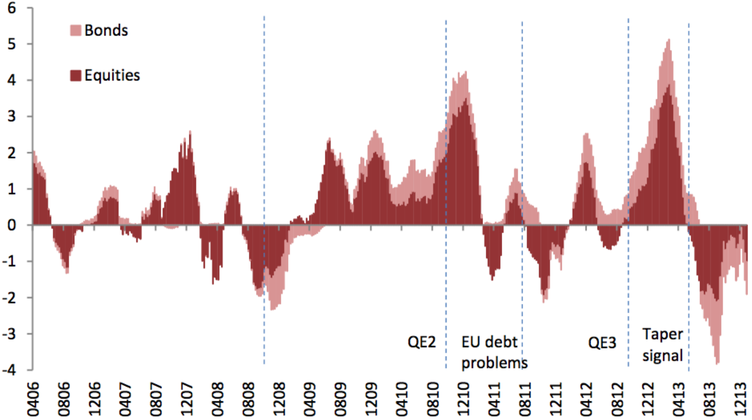
Introduction

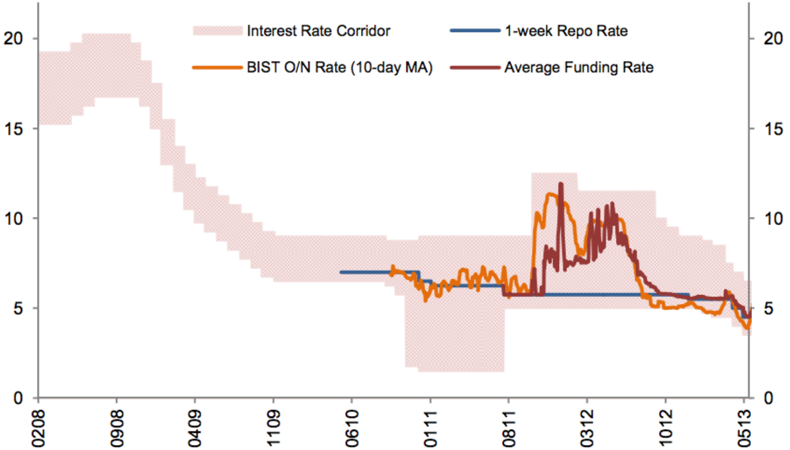
Figure: Portfolio Flows to Emerging Markets (13-week moving average, bn USD)



Source: CBRT

INTEREST RATE CORRIDOR

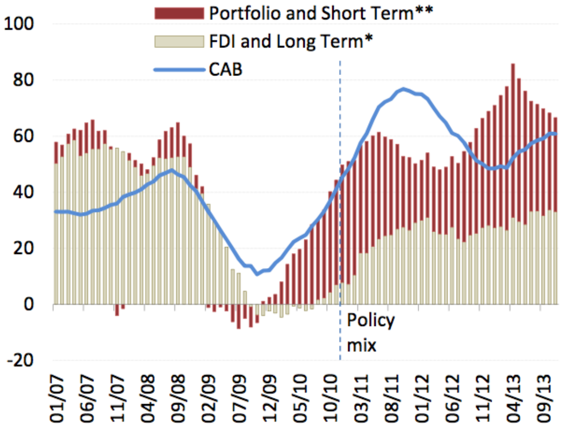
Figure: Interest rate corridor and average funding cost, Turkey



Source: CBRT

Portfolio and FDI Flows

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



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QUESTIONS

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- 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

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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)

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- 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

New insights (1)

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    - 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)

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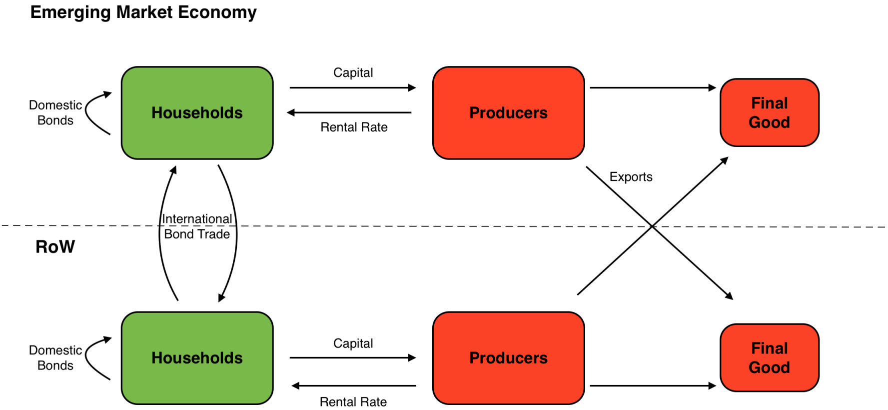
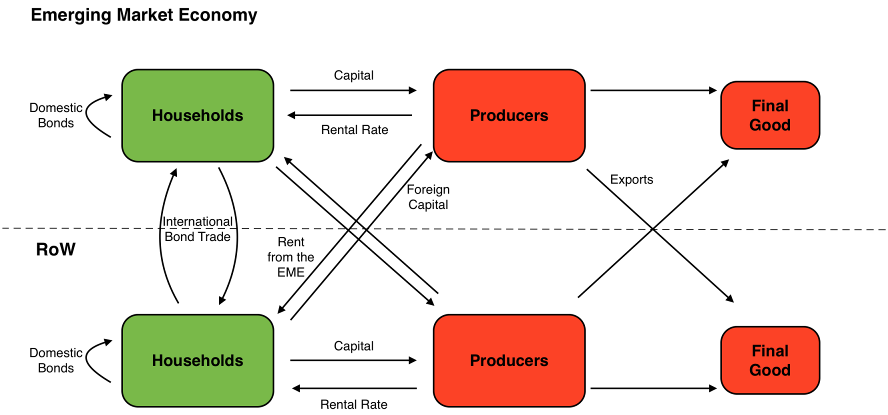
- Risk aversion of foreign agents is important:
  - Amplified reaction of the current account
  - Deviations in UIP imply short-term inflows

THE MODEL ARCHITECTURE



The model architecture



HOUSEHOLDS

- 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:

$$P_t C_t(h) + B_{t+1}(h) + S_t B_{*,t+1}(h) + adj_t + P_t I_t(h) + S_t P_t^* I_{*,t}(h)$$

$$= R_t B_t(h) + S_t R_t^* B_{*,t}(h) + W_t(h) L_t(h) + P_t r_{K,t} K_t(h) + S_t P_t^* r_{K,*,t} K_{*,t}(h)$$

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

HOUSEHOLDS

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:

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

$$1 = q_t$$

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

Households

Investment to the RoW:

$$rer_t = q_{*,t}$$

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

HOUSEHOLDS

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Similarly, price of FDI coming into the EME:

$$\frac{1}{rer_t} = q_t^*$$

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

Intermediate Goods producers:

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

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

FIRMS

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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

$$b_{t+1} + rer_t b_{*,t+1} + \left(\frac{1-n}{n}\right) rer_t K_{*,t+1} - K^*_{t+1}$$

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

$$+ \underbrace{\left(\frac{1-n}{n}\right) \mu^*_{H,t} mc_t Y^*_{H,t} - rer_t \mu_{F,t} mc^*_t Y_{F,t}}_{\text{Trade Balance}}$$

Decomposing the current account

$$\underbrace{(b_{t+1} - b_t) + rer_t\,(b_{*,\,t+1} - b_{*,\,t})}_{\text{Bond component}}$$

$$+\underbrace{\left(\frac{1-n}{n}\right) rer_t\,(K_{*,\,t+1} - K_{*,\,t}) - \left(K^*_{t+1} - K^*_t\right)}_{\text{FDI component}} \equiv CA_t$$

Monetary authority

- 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

$$u_t = \rho^u u_{t-1} + e^{\sigma_t^R} \varepsilon_t$$

and

$$\sigma_t^R = (1 - \rho^{\sigma^R})\sigma^R + \rho^{\sigma^R} \sigma_{t-1}^R + \varepsilon_t^\sigma$$

Portfolio Risk

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

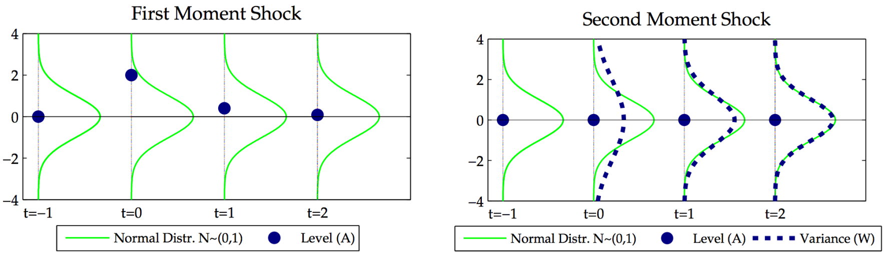
$$RR_{B^*_*, B^*, t+1} \equiv \frac{Cov_t\left(\beta^*_{t,t+1}, \frac{R^*_{t+1}}{\Pi^*_{t+1}} - \frac{rer_t}{rer_{t+1}} \frac{R_{t+1}}{\Pi_{t+1}}\right)}{\mathbb{E}_t\left[\beta^*_{t,t+1}\right]}$$

$$RR_{K^*_*, K^*, t+1} \equiv \frac{Cov_t\left(\beta^*_{t,t+1}, R_{K^*_*, t+1} - \frac{rer_t}{rer_{t+1}} R_{K^*, t+1}\right)}{\mathbb{E}_t\left[\beta^*_{t,t+1}\right]}$$

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

where $R_K \equiv 1 - \delta + r_K$.

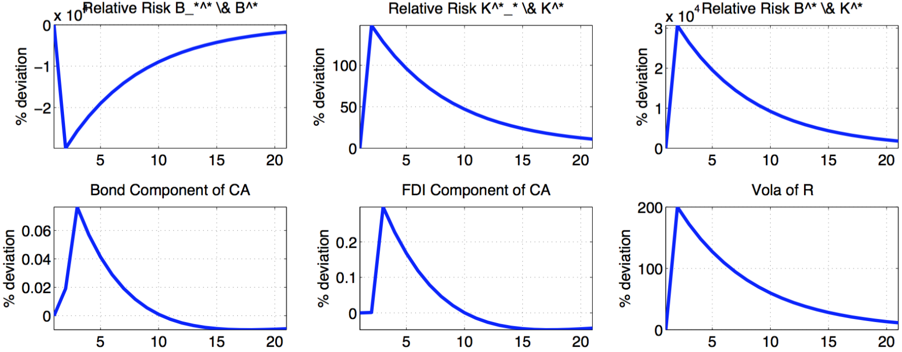
Our experiment



▸ Calibration

▸ Model Solution

Interest Rate Uncertainty and Portfolio Risk



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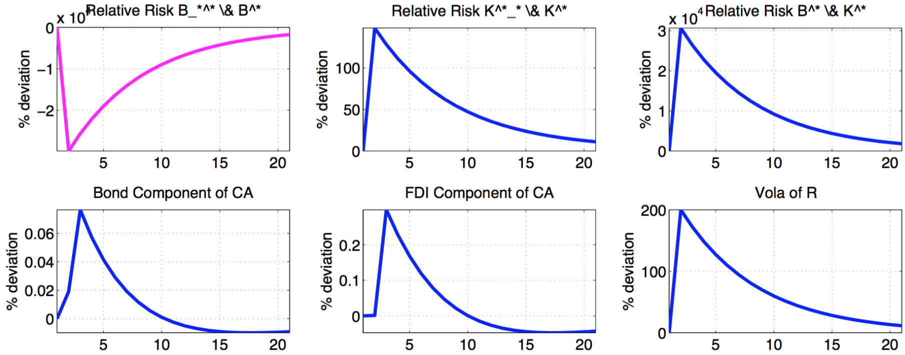

$$RR_{B^*_*,B^*,t+1} \equiv \frac{Cov_t\left(\beta^*_{t,t+1}, \frac{R^*_{t+1}}{\Pi^*_{t+1}} - \frac{rer_t}{rer_{t+1}}\frac{R_{t+1}}{\Pi_{t+1}}\right)}{\mathbb{E}_t\left[\beta^*_{t,t+1}\right]}$$

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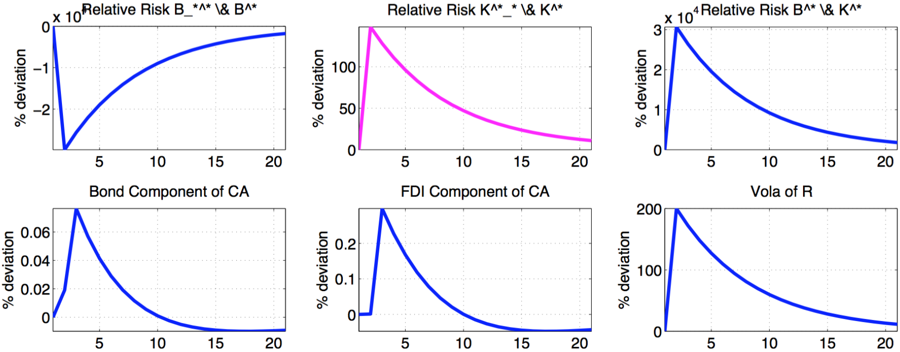

$$RR_{K_*^*,K^*,t+1} \equiv \frac{Cov_t\left(\beta^*_{t,t+1}, R_{K_*^*,t+1} - \frac{rer_t}{rer_{t+1}} R_{K^*,t+1}\right)}{\mathbb{E}_t\left[\beta^*_{t,t+1}\right]}$$

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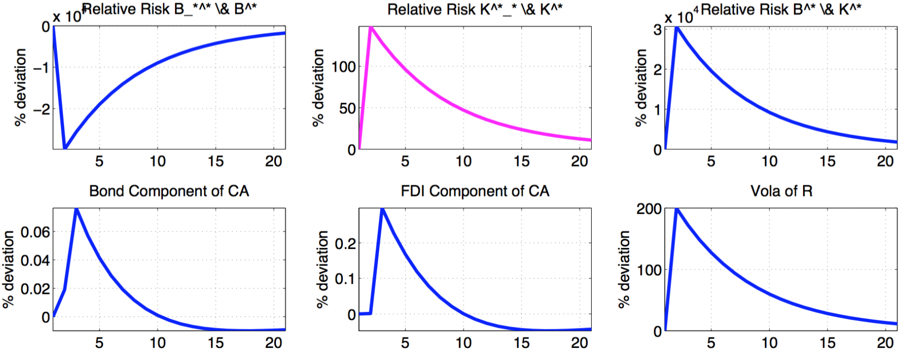
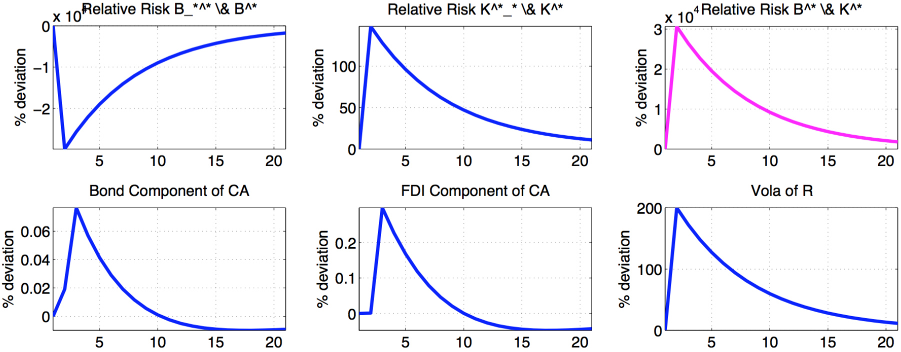


$$RR_{K^*_*,K^*,t+1} \approx -\mathbb{E}_t \left[R_{K^*_*,t+1} - \frac{rer_t}{rer_{t+1}} R_{K^*,t+1} \right]$$

Interest Rate Uncertainty and Portfolio Risk



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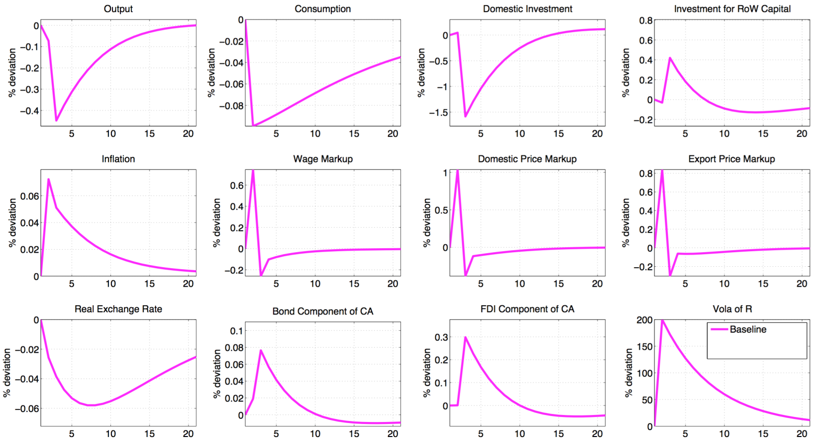
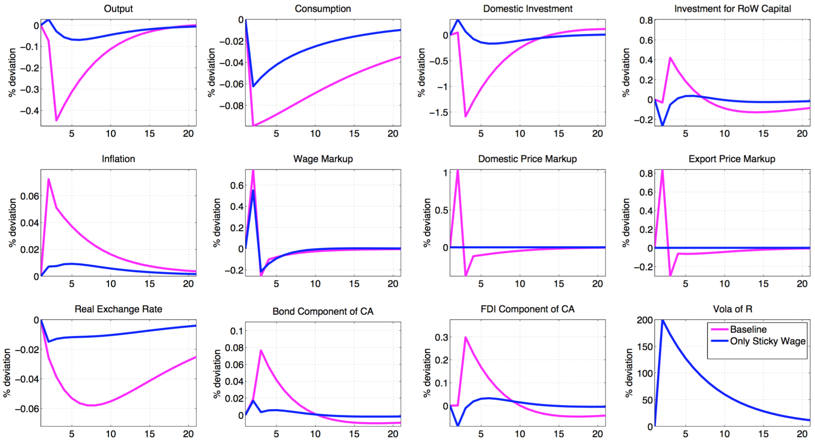
Interest Rate Uncertainty as a Policy Tool



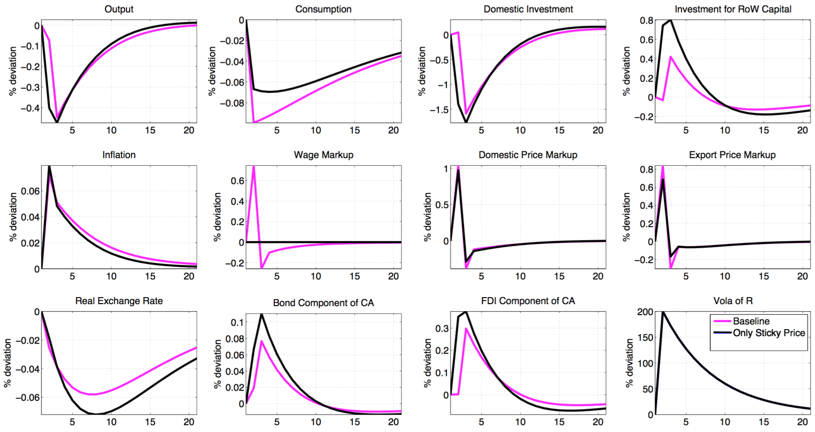
- Precautionary savings → Savings flow abroad where risk is lower (both bond and FDI)
- Rising markups (asymmetric profit): Inflationary pressure → Prices do not adjust to accommodate demand → Output ↓ → Demand for FDI ↓

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) → Demand for incoming FDI ↑

Interest Rate Uncertainty as a Policy Tool



- 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 ↓

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

Conclusions

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- 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)

Intermediate Goods producers:

Producer Currency Pricing (PCP)

- Period profits:

$$rp_{H,t}(i)\,Y_{H,t}(i)+\left(\tfrac{1-n}{n}\right)rp^{*h}_{H,t}(i)\,Y^{*}_{H,t}(i)-mc_t\left(Y_{H,t}(i)+\left(\tfrac{1-n}{n}\right)Y^{*}_{H,t}(i)\right)$$
$$-adj_{H,t}-adj^{*}_{H,t}$$

- Domestic and export demand:

$$Y_{H,t}(i)=\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon}Y_{H,t}$$
$$Y^{*}_{H,t}(i)=\left(\frac{P^{*h}_{H,t}(i)}{S_tP^{*}_{H,t}}\right)^{-\epsilon}Y^{*}_{H,t}$$

Firms

Intermediate Goods producers:

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$$rp_{H,t} = \mu_{H,t} mc_t$$

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

▸ Back

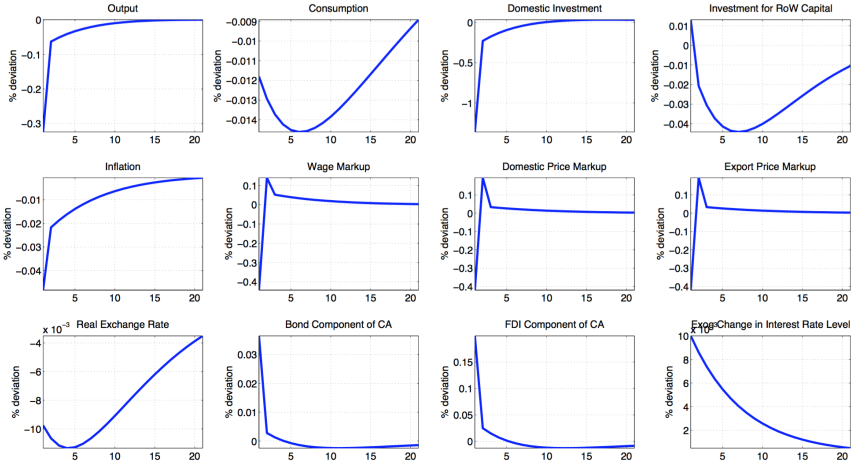
Resource constraints

$$Y_t = C_t + I_t + I_t^* + adj_t^w + adj_t^{P_H} + adj_t^{P_H^{*h}}$$

$$Y_t^* = C_t^* + I_{*t}^* + I_{*t} + adj_t^{w^*} + adj_t^{P_F^*} + adj_t^{P_F^f}$$

Back

Model outcome with level shocks



- Contractionary shock with national absorption
- Downward pressure on prices and wages

Back to presentation

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

Time-to-build FDI

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

$$K_{*,t+1}(h) = (1-\delta)K_{*,t}(h) + I_{*,1,t}(h),$$
$$I_{*,j-1,t+1}(h) = I_{*,j,t}(h); \qquad j = 2,\ldots,J.$$
$$I_{*,t}(h) = \textstyle\sum_{j=1}^{J} \frac{1}{J} I_{*,j,t}(h)$$

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- Notation:

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

$I_{*,j,t}(h)$: Project that is initiated in period t and j periods away from completion.

Time-to-build FDI

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

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

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

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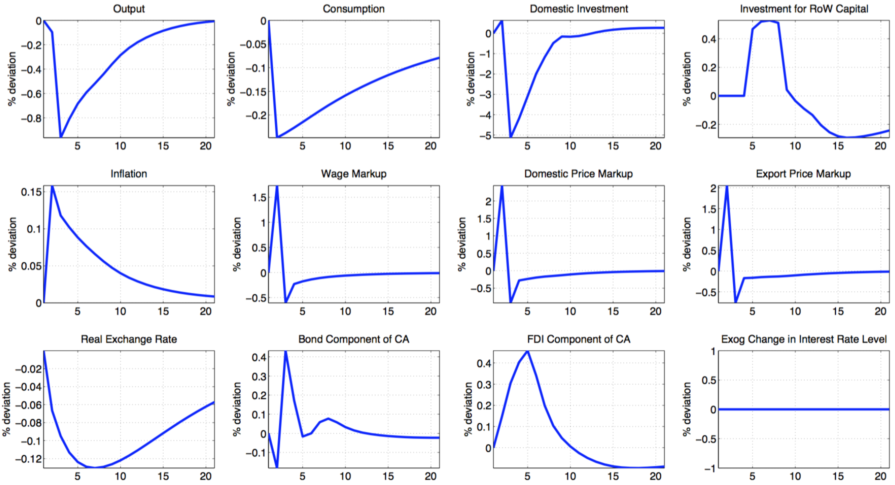
Current account:

$$\underbrace{(b_{t+1} - b_t) + rer_t\left(b_{*,t+1} - b_{*,t}\right)}_{\textit{Bond component}} + \underbrace{\frac{1}{J}\left[\left(\frac{1-n}{n}\right) rer_t\left(K_{*,t+J} - K_{*,t}\right) - \left(K^*_{t+J} - K^*_t\right)\right]}_{\textit{FDI component}} \equiv CA_t$$

TIME-TO-BUILD FDI



▸ Time-to-build comparison

Time-to-build FDI

Real options channel:

- Irreversibility → Dampening in the net outflow of FDI

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  - Borrow from international markets to compensate the fall in consumption

Time-to-build FDI

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)

Back to conclusion

Currency of Export Invoicing

- Baseline model: PCP
  - Nature of price rigidity is central for the real effects of exchange rate fluctuations

Currency of Export Invoicing

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  - Nature of price rigidity is central for the real effects of exchange rate fluctuations
- LCP: No inflation pass-through

Currency of Export Invoicing

The Rotemberg cost of adjusting the export price:

$$\left(\frac{1-n}{n}\right)\frac{\kappa^*}{2}\left(\frac{P^*_{H,t+s}(i)}{P^*_{H,t+s-1}(i)}-1\right)^2\frac{S_{t+s}P^*_{H,t+s}(i)}{P_{t+s}}Y^*_{H,t+s}.$$

Currency of Export Invoicing

The Rotemberg cost of adjusting the export price:

$$\left(\frac{1-n}{n}\right)\frac{\kappa^*}{2}\left(\frac{P^*_{H,t+s}(i)}{P^*_{H,t+s-1}(i)}-1\right)^2\frac{S_{t+s}P^*_{H,t+s}(i)}{P_{t+s}}Y^*_{H,t+s}.$$

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:

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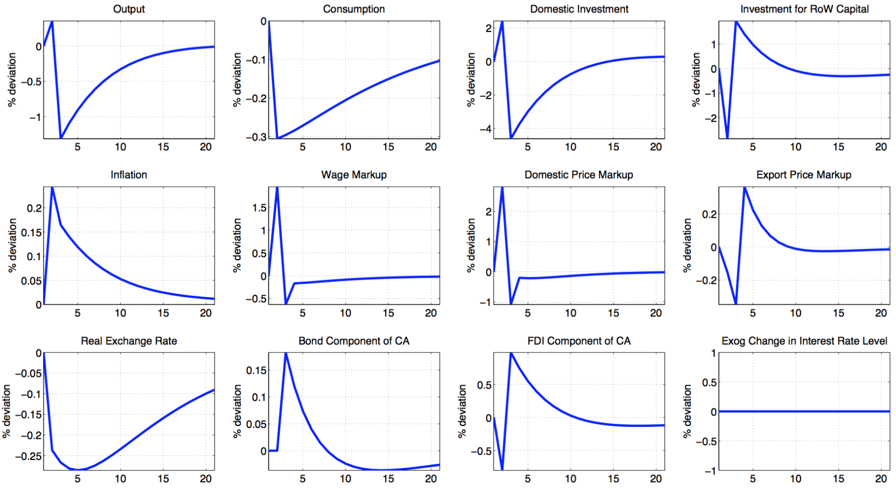
Currency of export invoicing



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  - EME debt riskier → Short-term outflows

▸ Time-to-build and LCP

▸ Back to conclusion

Epstein-Zin-Weil Preferences

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Epstein-Zin-Weil Preferences

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  - 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:

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

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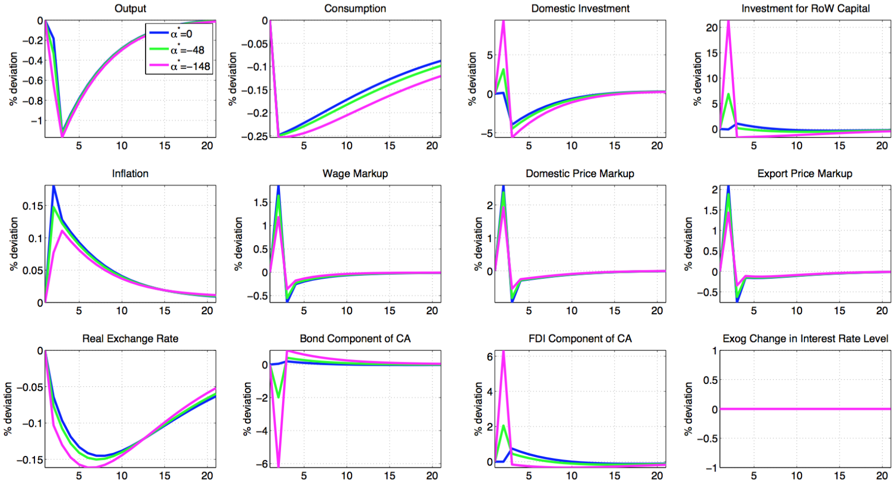
The discount factor of RoW agents, $\beta^*_{t,t+1}$, becomes

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

- 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



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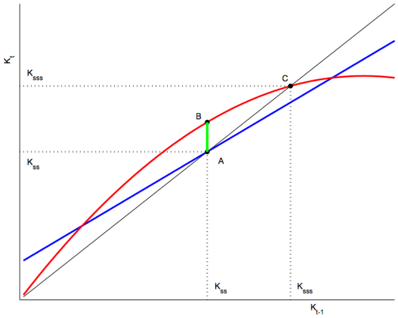
- Amplified precautionary savings channel imply a more pronounced appreciation in RER (from EME perspective)
  - EME risk premium ↑ → Short-term inflows ↑

$$R_t - R_t^* \approx \mathbb{E}_t \Delta s_{t+1} + \underbrace{\frac{1}{2} Var_t(\Delta s_{t+1}) + Cov_t(\beta_{t+1}^*, \Delta s_{t+1})}_{= \frac{1}{2} Var_t(\beta_{t+1}^*) - \frac{1}{2} Var_t(\beta_{t+1})}$$

Back to conclusion

STOCHASTIC STEADY STATE: ILLUSTRATION

Figure: Accumulation decision function in a linearized model and in a nonlinear model



- 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.

Back to what we do

Back to solution method

Solution method

- 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.

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- Starting from the ergodic mean in the absence of shocks, hit the model with a 2 std deviation shock to the volatility process, ε_t^σ
- Calculate IRFs as deviation from the ergodic mean in the absence of shocks

Back to presentation

Illustration of the Stochastic Steady State

Calibration

Parameter		Value	Comments
Discount factor	β	*0.9804*	*2% Real Rate*
Relative risk aversion	ρ	*2*	*Literature*
Relative weight of labor in utility	χ	*1*	*Literature*
Frisch elasticity	φ	*0.25*	*Literature*
Deposit adjustment	ψ	*0.0025*	*Literature*
Rotemberg wage adjustment	κ^W	*116*	≈ 3 *period stickiness*
Elas. of substitution of differentiated labor	ϵ^W	*11*	*Wage markup of 10%*
Home bias	a	*.65*	*Unsal (2013)*
Share of domestic capital	α_1	*.30*	*ABK (2016)*
Share of foreign capital	α_2	*0.15*	*ABK (2016)*
Rotemberg domestic price adj.	κ	*116*	≈ 3 *period stickiness*
Rotemberg export price adj.	κ^*	*116*	≈ 3 *period stickiness*
Elas. of substitution in goods production	ϵ	*11*	*Price markup of 10%*
Smoothing coefficient	ρ_R	*0.7*	*Literature*
SS response to inflation	ρ_Π	*1.5*	*Literature*
SS response to output	ρ_Y	*0.5/4*	*Literature*

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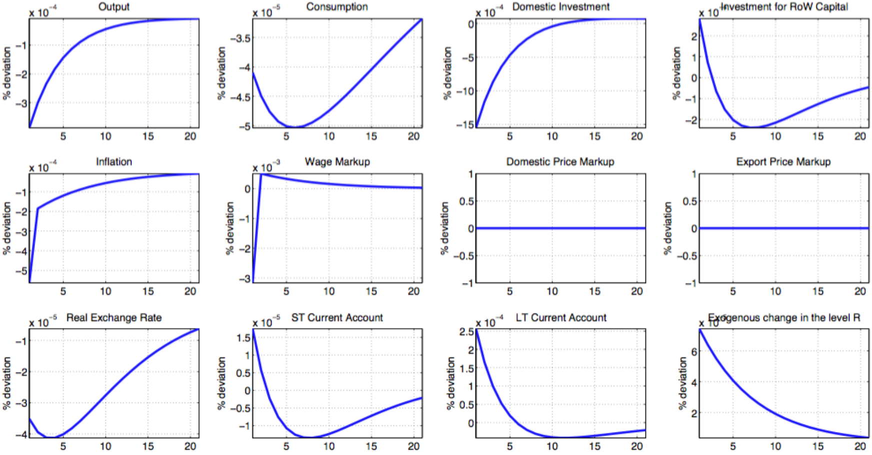
Model outcome with level shock



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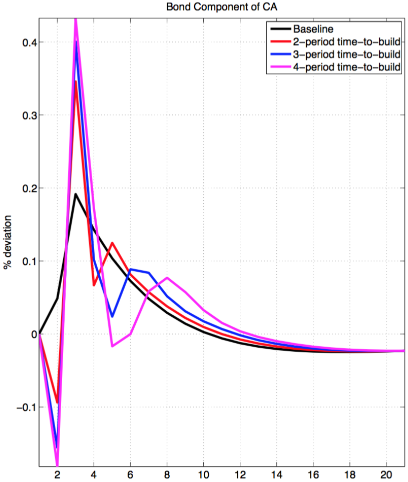
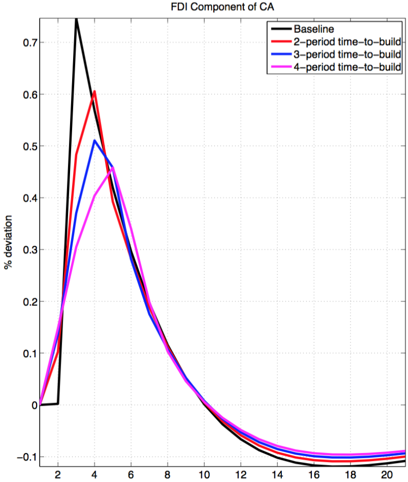
Time-to-build comparison





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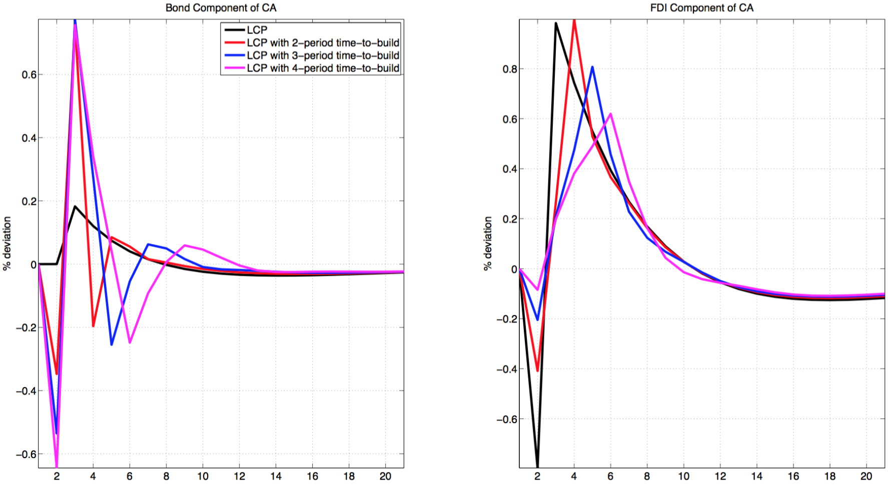
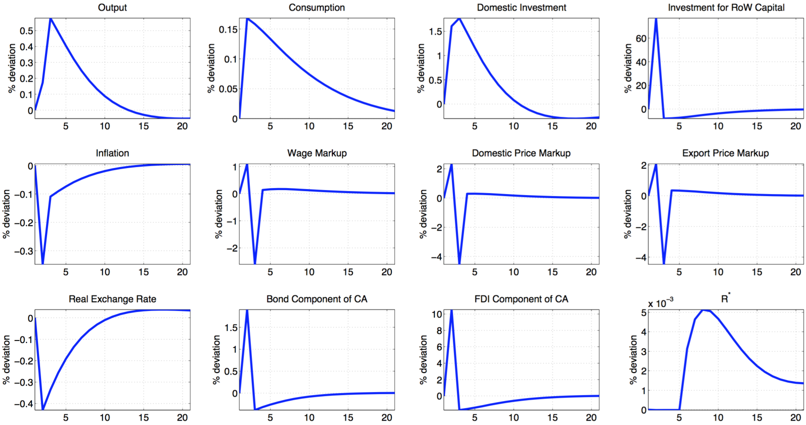
Time-to-build comparison

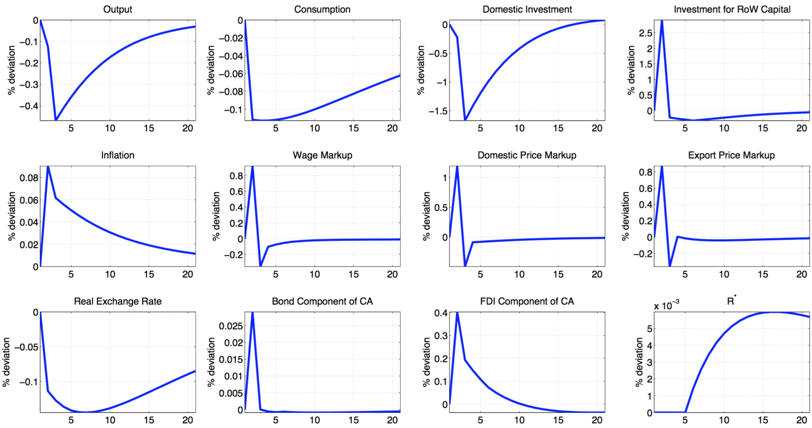


▸ Back

Effective-lower-bound in the RoW



Effective-lower-bound in the RoW (high home bias)



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