Managing Capital Flows in the Presence of External Risks

Ricardo Reyes-Heroles
Federal Reserve Board

Gabriel Tenorio
The Boston Consulting Group

IEA World Congress 2017
Mexico City, Mexico

June 20, 2017

The views expressed in this presentation are those of the authors and do not necessarily reflect the position of the Federal Reserve Board or the Federal Reserve System.

Introduction

Risky Capital Flows and Policy

1. Large and volatile capital flows across countries carry risks
   - Reminded by recent events:
     * Global financial crisis and
     * Countercyclical policy in advanced economies
2. Policy prescriptions to prevent and reduce the effects of capital reversals.
   - Policy makers and international institutions have justified capital account intervention as a response to a perceived increase in external risks (volatility).

Introduction

Risky Capital Flows and Policy

1. Large and volatile capital flows across countries carry risks
   - Reminded by recent events:
     - Global financial crisis and
     - Countercyclical policy in advanced economies
2. Policy prescriptions to prevent and reduce the effects of capital reversals.
   - Policy makers and international institutions have justified capital account intervention as a response to a perceived increase in external risks (volatility).

IMF (2012): "Capital flows have grown significantly in both size and volatility [...] (these) carry risk. Because capital flows have a bearing on economic and financial stability in both individual economies and globally, an important challenge for policy makers is to develop a coherent approach to capital flows and the policies that affect them."

Motivation and Question

"New" Theoretical Framework and External Risks

- Emerging theoretical literature on macroprudential policy in small open economies ⇒ Benchmark theoretical framework → Jeanne (2012), Mendoza and Korinek (2014)
  - Overborrowing → pecuniary externalities → scope for intervention based on welfare.
  - Optimal policy response to domestic (output) shocks.
  - "Sudden Stops" rely on size of capital flows.

Motivation and Question

"New" Theoretical Framework and External Risks

- Emerging theoretical literature on macroprudential policy in small open economies ⇒ Benchmark theoretical framework → Jeanne (2012), Mendoza and Korinek (2014)
  - Overborrowing → pecuniary externalities → scope for intervention based on welfare.
  - Optimal policy response to domestic (output) shocks.
  - "Sudden Stops" rely on size of capital flows.
- However, literature silent on policy response to shocks to external risk.
  - Emerging economies face significant risks associated with external shocks (independent of fundamentals) → Second moment matter.

Motivation and Question

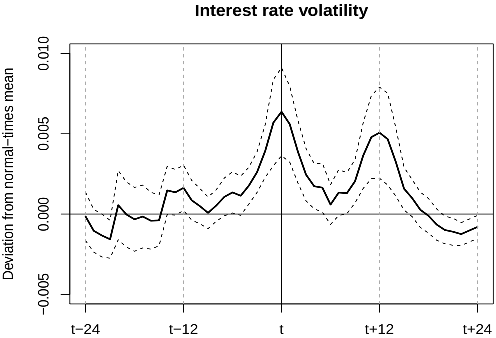
"New" Theoretical Framework and External Risks

- Emerging theoretical literature on macroprudential policy in small open economies $\Rightarrow$ Benchmark theoretical framework $\rightarrow$ Jeanne (2012), Mendoza and Korinek (2014)
  - Overborrowing $\rightarrow$ pecuniary externalities $\rightarrow$ scope for intervention based on welfare.
  - Optimal policy response to domestic (output) shocks.
  - "Sudden Stops" rely on size of capital flows.
- However, literature silent on policy response to shocks to external risk.
  - Emerging economies face significant risks associated with external shocks (independent of fundamentals) $\rightarrow$ Second moment matter.
- **Question**: How should optimal capital account policy respond to external shocks (international interest rates)?

Motivation and Question

"New" Theoretical Framework and External Risks

- Reyes-Heroles and Tenorio (2017) using same data as in Neumeyer and Perri (2005), Uribe and Yue (2006) and Fernández-Villaverde et al. (2011).



Deviation of interest rate volatility from normal-times country-specific mean (23 emerging economies). Interest rate volatility is measured as the seven-month centered moving standard deviation. t denotes the month in which the sudden stop begins. Dotted lines represent one standard error intervals.

Methodology

What do we do?

1. Study response of optimal policy to shocks to 1st and 2nd moments of international interest rates in a benchmark SOE framework with external borrowing constraints.
   - Estimate stochastic process for international interest rates with regime-switches in volatility.
2. Model: SOE subject to endowment + interest rate shocks and collateral constraint that depends on asset prices:
   - Endogenous sudden stop nested within business cycles; and pecuniary externalities $\Rightarrow$ ex ante policy intervention
   - Microfoundation of collateral constraint.
3. Numerical analysis of time-consistent optimal policy across interest rate levels and volatility regimes.

Findings

1. Simulations of sudden stop episodes and the evolution of external shocks are consistent with the data.
   - Reyes-Heroles and Tenorio (2017)

Findings

1. Simulations of sudden stop episodes and the evolution of external shocks are consistent with the data.
   - Reyes-Heroles and Tenorio (2017)
2. In the competitive equilibrium, allocations and prices are sensitive to external interest rate shocks, but not to their volatility.
   - Fernández-Villaverde et al. (2011)

Findings

1. Simulations of sudden stop episodes and the evolution of external shocks are consistent with the data.
   - Reyes-Heroles and Tenorio (2017)
2. In the competitive equilibrium, allocations and prices are sensitive to external interest rate shocks, but not to their volatility.
   - Fernández-Villaverde et al. (2011)
3. The borrowing decisions that solve the time-consistent constrained efficient allocation depend on the level and volatility of external shocks.
   - Incidence and severity of crises shape optimal policy $\rightarrow$ Shocks to volatility affect pecuniary externality.

Findings

1. Simulations of sudden stop episodes and the evolution of external shocks are consistent with the data.
   - Reyes-Heroles and Tenorio (2017)
2. In the competitive equilibrium, allocations and prices are sensitive to external interest rate shocks, but not to their volatility.
   - Fernández-Villaverde et al. (2011)
3. The borrowing decisions that solve the time-consistent constrained efficient allocation depend on the level and volatility of external shocks.
   - Incidence and severity of crises shape optimal policy $\rightarrow$ Shocks to volatility affect pecuniary externality.
4. No monotone relation between macroprudential tax on external debt and external shocks.
   - "Volatility paradox" that is contrary to *conventional wisdom*.

Related Literature

- Capital Flows, Sudden Stops and Optimal Policy:
  - Positive analysis: Mendoza and Smith (2002) and Mendoza (2010).
  - Optimal policy: *Jeanne and Korinek (2010)*, Korinek (2011), Bianchi (2011) *Bianchi and Mendoza (2011, 2013, 2016)*, Benigno et al. (2016, 2012), Iacoviello et al. (2016)
  - Optimal capital controls: Schmitt-Grohé and Uribe (2016a,b)
- Emerging Market Business Cycles and Global Shocks:
  - Neumeyer and Perri (2005), Uribe and Yue (2006), Fernández-Villaverde et al. (2011)
  - Mackowiak (2007), Chang and Fernández (2013), Eichengreen and Gupta (2016) [capital reversals]
  - Sovereign default: Longstaff et al. (2011), Johri et al. (2015)

The Model

Akin to Jeanne and Korinek (2010), and Bianchi and Mendoza (2013)

- SOE with an infinitely lived unit continuum of identical households that consume a single traded good c_t.
  - Access to international bonds markets and domestic asset markets.
- Sources of risk:
  - Stochastic external interest rate $R_t = R \times \exp(r_t)$.
  - Variance of interest rate process depends on regime: σ_t^r .
  - Stochastic endowment (Lucas tree) pays a dividend $d_t = d \times exp(z_t)$.
- Only a fraction κ of the value of assets can be used as collateral with foreign lenders.
- Endogenous sudden stop occurs when collateral constraint binds.

The Model

Exogenous Shocks

- $(z_t, r_t)'$ follows the VAR specification

$$\begin{pmatrix} z_t \\ r_t \end{pmatrix} = A_0 + A_1 \begin{pmatrix} z_{t-1} \\ r_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_t^z \\ \varepsilon_t^r \end{pmatrix}.$$

- $(\varepsilon_t^z, \varepsilon_t^r)' \sim N(0, \Sigma_t)$ where

$$\Sigma_t = \begin{pmatrix} (\sigma^z)^2 & \rho \cdot \sigma^z \cdot \sigma_t^r \\ \rho \cdot \sigma^z \cdot \sigma_t^r & (\sigma_t^r)^2 \end{pmatrix}.$$

- Regime-switching: $\sigma_t^r \in \{\sigma_L^r, \sigma_H^r\}$, with $0 < \sigma_L^r < \sigma_H^r$, and switching between regimes governed by first-order Markov process with transition matrix Π.

The Model

Household's Problem

- Given prices, each household solves:

$$\max_{c_t, b_{t+1}, s_{t+1}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t\right)$$

subject to

$$c_t + q_t s_{t+1} + \frac{b_{t+1}}{R_t} = \left(q_t + d_t\right) s_t + b_t$$

$$-\frac{b_{t+1}}{R_t} \leq \kappa q_t^c s_{t+1},$$

where

- b_t: face value of bonds held at beginning of period t.
- s_t: share of the asset held at the beginning of period t (only trades domestically).
- q_t: market value of the asset.
- q_t^c : price at which collateral is valued. Derivation of CC

The Model

Competitive Equilibrium

Definition

Sequences $\{c_t, b_{t+1}, s_{t+1}\}_{t=0}^{\infty}$ for each household, and prices $\{q_t, q_t^c\}_{t=0}^{\infty}$ such that given prices households' problems are solved, and there are no arbitrage opportunities and markets for stocks clear, $s_{t+1} = 1$, in each interim period for all $t = 0, 1, \ldots$

Lemma

The optimality conditions that characterize the competitive equilibrium are

$$q_t u'(c_t)\left(1 + \frac{\kappa\mu_t}{u'(c_t)}\right)^{-1} = \mathbb{E}_t\left[\beta u'(c_{t+1})(q_{t+1} + d_{t+1})\right] \text{ and}$$

$$u'(c_t) - \mu_t = R_t \mathbb{E}_t\left[\beta u'(c_{t+1})\right]$$

where q_t^c *is such that* $q_t u'(c_t) - \kappa\mu_t q_t^c = q_t^c u'(c_t)$.

The Model

Competitive Equilibrium

Definition

Sequences $\{c_t, b_{t+1}, s_{t+1}\}_{t=0}^{\infty}$ for each household, and prices $\{q_t, q_t^c\}_{t=0}^{\infty}$ such that given prices households' problems are solved, and there are no arbitrage opportunities and markets for stocks clear, $s_{t+1} = 1$, in each interim period for all $t = 0, 1, \ldots$

Lemma

The optimality conditions that characterize the competitive equilibrium are

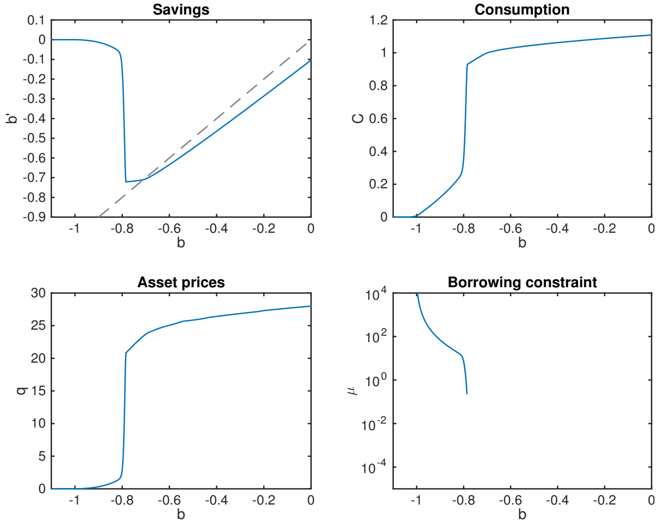
$$q_t u'(c_t) \left(1 + \frac{\kappa \mu_t}{u'(c_t)}\right)^{-1} = \mathbb{E}_t \left[\beta u'(c_{t+1})(q_{t+1} + d_{t+1})\right] \text{ and}$$
$$u'(c_t) - \mu_t = R_t \mathbb{E}_t \left[\beta u'(c_{t+1})\right]$$

where q_t^c is such that $q_t u'(c_t) - \kappa \mu_t q_t^c = q_t^c u'(c_t)$.

- Fundamental trade-off between impatience and insurance when $\beta R_t < 1$.
- **Sudden Stop**: constraint binds ($\mu_t > 0$) $\rightarrow c_t \downarrow$, $q_t \downarrow$ and tightens constraint.
  - Feedback effect not internalized in competitive equilibrium
- External shocks $\implies$ volatile capital flows.

The Model

Recursive Competitve Equilibrium

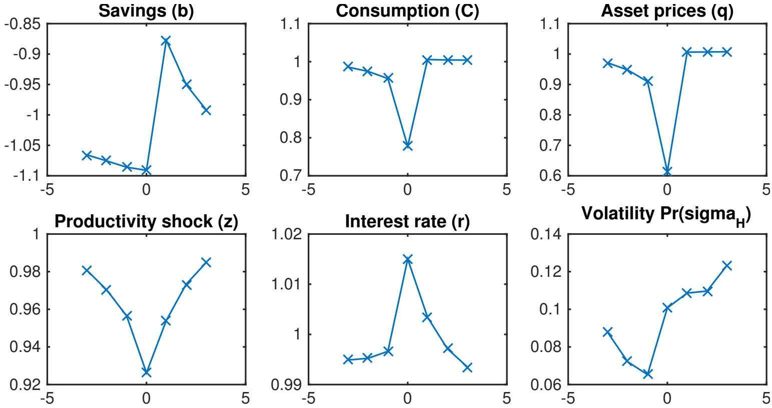


Estimation and Parameters

Competitive Equilibrium

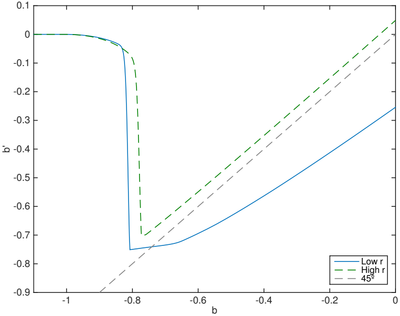
Finding 1

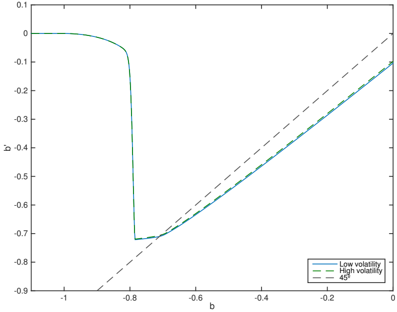
1. Simulations of sudden stop episodes and the evolution of external shocks are consistent with the data.
    - Reyes-Heroles and Tenorio (2016)



Competitive Equilibrium
Finding 2

2. In the competitive equilibrium, allocations and prices are sensitive to external interest rate shocks, but not to their volatility.
   - Fernández-Villaverde et al. (2011)





The Model

Constrained-Efficient Allocation

- Consider a social planner that internalizes externality on borrowing capacity and:
    1. Can choose aggregate debt, subject to economy's borrowing constraint,
    2. Cannot commit to future policies.
- Solve for constrained efficient allocations that a social planner would implement through time-consistent policies:
    - Following Klein et al. (2005, 2008) we restrict attention to time-consistent Markov policies: $B' = \Psi(B, X)$, where B is current aggregate debt and X is the vector of current exogenous shocks.
    - Focus on recursive formulation.

The Model

Constrained-Efficient Allocation

- **Assumption [Jeanne & Korinek (2010)]** Parameters and stochastic processes are such that the equilibrium pricing function satisfies $1 + \kappa R(X)\xi(B, X) > 0$ where $\xi(B, X) \equiv \partial \bar{Q}(B, \Psi(B, X), X)/\partial B$. ▸ Formal Definition $\bar{Q}$

Lemma

The optimality condition that characterizes the constrained-efficient allocation is

$$u'(\mathcal{C}(B, X)) - \mu(B, X) = R(X)\beta\mathbb{E}\left[u'\left(\mathcal{C}\left(B', X'\right)\right) - \kappa\mu\left(B', X'\right)\psi\left(B', X'\right)\right]$$

where $\psi(B, X) = \partial \bar{Q}(B, \Psi(B, X), X)/\partial B$ *and* $\mu(B, X)$ *is the multiplier on the borrowing constraint.*

- Solution to the planner's problem $\Leftrightarrow \mathcal{Q}(B, X) = \bar{Q}(B, \Psi(B, X), X)$.

The Model

Constrained-Efficient Allocation

- **Assumption [Jeanne & Korinek (2010)]** Parameters and stochastic processes are such that the equilibrium pricing function satisfies $1 + \kappa R(X)\xi(B,X) > 0$ where $\xi(B,X) \equiv \partial\bar{Q}(B,\Psi(B,X),X)/\partial B$. Formal Definition $\bar{Q}$

Lemma

The optimality condition that characterizes the constrained-efficient allocation is

$$u'(\mathcal{C}(B,X)) - \mu(B,X) = R(X)\beta\mathbb{E}\left[u'(\mathcal{C}(B',X')) - \kappa\mu(B',X')\psi(B',X')\right]$$

where $\psi(B,X) = \partial\bar{Q}(B,\Psi(B,X),X)/\partial B$ *and* $\mu(B,X)$ *is the multiplier on the borrowing constraint.*

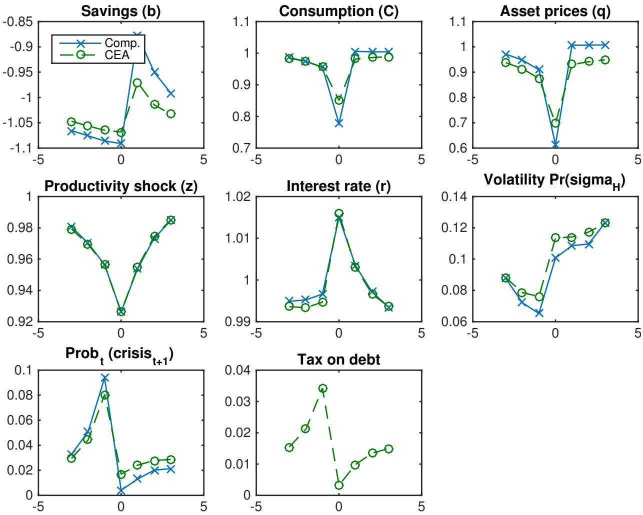
- Solution to the planner's problem $\Leftrightarrow \mathcal{Q}(B,X) = \bar{Q}(B,\Psi(B,X),X)$.
- Implementation through macroprudential tax on external borrowing:

$$\tau(B,X) = \frac{\mathbb{E}\left[\kappa\psi(B',X')\mu(B',X')|X\right]}{\mathbb{E}\left[u'(\mathcal{C}(B',X'))|X\right]}.$$

- Considers interaction of *severity*, $\kappa\psi(B,X)$, and *incidence*, $\mu(B,X)$, of potential future crises.

The Model

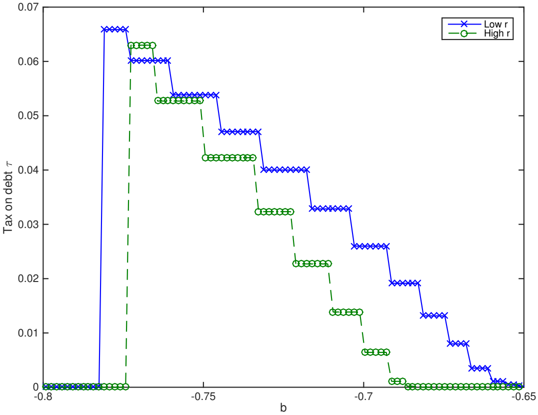
Constrained-Efficient Allocation



Constrained-Efficient Allocation

Findings 3 and 4

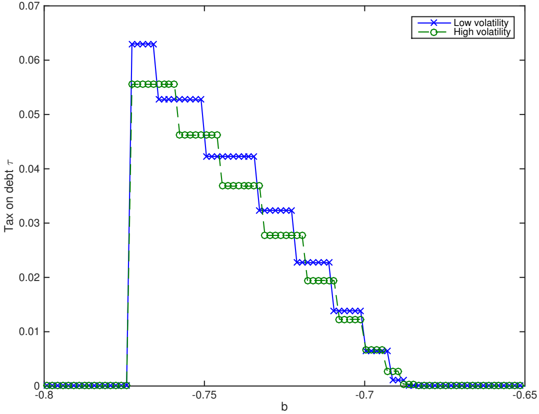
- Across steady states, the μ effect dominates (JK (2010)), but off steady state, policy responds to $\psi - \mu$ interaction. Non-monotonicity also differs from result in Bianchi and Mendoza (2016).



Constrained-Efficient Allocation

Findings 3 and 4

- Policy response to volatility shocks is non-monotonic → Interaction between μ and ψ key for understanding: price effect on constraint.



▸ Simulations

Constrained-Efficient Allocation

Findings 3 and 4

- Shocks to interest rate levels.
  - Clear message $\rightarrow$ consider effect of shocks to interest rates on asset prices in crisis zones.
- "Volatility paradox" $\rightarrow$ Intuition:
  - Finding 1 $\Rightarrow$ mechanism works entirely through effect on pricing function $\mathcal{Q}(B, X)$.
  - Quantitatively, individual precautionary savings argument is not very relevant $\implies$ all through price effect.
  - Individual precautionary saving incentives have relevant effects only on very particular regions of the state space.

Conclusions

- Increases in external volatility do not necessarily call for higher macroprudential intervention.
  - Important policy lesson: capital controls should not simply be justified on volatility in international financial markets.
- The interaction between externalities and stringency of the constraint shape the planner's policy.
  - Not only weigh the possibility of current account reversals; but also consider how external shocks affect the size of pecuniary externalities and the borrowing capacity of the country.

Conclusions

- Increases in external volatility do not necessarily call for higher macroprudential intervention.
  - Important policy lesson: capital controls should not simply be justified on volatility in international financial markets.
- The interaction between externalities and stringency of the constraint shape the planner's policy.
  - Not only weigh the possibility of current account reversals; but also consider how external shocks affect the size of pecuniary externalities and the borrowing capacity of the country.

Thank You!

The Model

Derivation of Collateral Constraint: Timing of Events

- Incentive compatibility constraint from limited enforcement problem.
- Recursive setup: state (b, s, B, X) given. HH's constraint:

$$c + \mathcal{Q}(B, X)s' + \frac{b'}{R(X)} = [\mathcal{Q}(B, X) + d(X)]s + b,$$

Morning	Afternoon	Night
- *HH*: choose optimaly (b', s', c) given $\mathcal{Q}$ and R $\rightarrow$ c just a plan	- *L*: does not oberve HH's actions - *HH*: given (b', s', c) $\rightarrow$ can divert $(1-\kappa)s'$ and default without costs	- *L*: actions revealed $\rightarrow$ confiscate $\kappa s'$ in country and sell for $\mathcal{Q}^c$ and lend at R - *HH*: consume original plan c

- To avoid diversion and default: $-\frac{b'}{R(X)} \leq \kappa \mathcal{Q}^c(B, X)s'$.
- No arbitrage $\Leftrightarrow$ $\mathcal{Q}(B, X)u'(\mathcal{C}(B, X)) - \kappa\mu(B, X)\mathcal{Q}^c(B, X) = \mathcal{Q}^c(B, X)u'(\mathcal{C}(B, X))$.

Back

Estimation and Calibration

Table: Baseline parameterization

Parameter		Value	Target
Time discount	β	0.96	Standard value
Relative risk aversion	γ	2	Standard value
Dividends	d	1	Normalization
Collateral constraint	κ	0.04	Debt-to-output ratio

- Result of estimation:

$$\begin{pmatrix} z_t \\ r_t \end{pmatrix} = \begin{pmatrix} 0.0052 \\ 0.0025 \end{pmatrix} + \begin{pmatrix} 0.6079 & -0.1321 \\ 0.1289 & 0.8261 \end{pmatrix} \begin{pmatrix} z_{t-1} \\ r_{t-1} \end{pmatrix} + \begin{pmatrix} \epsilon_t^z \\ \epsilon_t^r \end{pmatrix},$$

and the covariance and transition matrices are composed of:

$$\begin{aligned} \sigma^z &= 0.0312, & \rho &= -0.4048, & \pi_L &= 0.9610, \\ \sigma_L^r &= 0.0150, & \sigma_H^r &= 0.0661, & \pi_H &= 0.7468. \end{aligned}$$

Back

The Model

Constrained-Efficient Allocation

Lemma

Given an arbitrary future policy rule, $\Psi(B, X)$ *and the associated asset pricing function,* $\mathcal{Q}(B, X)$*, the social planner solves*

$$W(B, X) = \max_{c, B'} \left\{ u(c) + \beta \mathbb{E}\left[W\left(B', X\right) | X \right] \right\} \text{ s.t.}$$

$$c + \frac{B'}{R(X)} = d(X) + B,$$

$$\frac{B'}{R(X)} \leq \kappa \bar{Q}\left(B, B', X\right)$$

and the valuation of callateral is consistent with the household's trading of the stocks of the tree

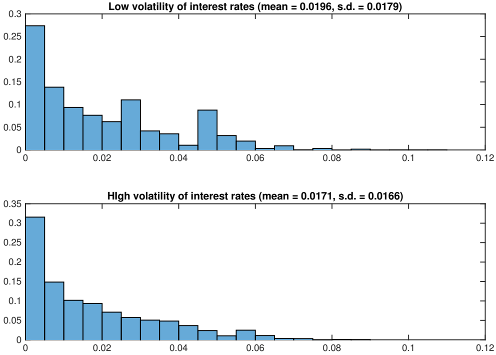
$$\bar{Q}\left(B, B', X\right) = \beta \mathbb{E}\left[\frac{u'\left(B' + d(X') - \frac{\Psi(B', X')}{R(X')}\right)\left(\mathcal{Q}\left(B', X'\right) + d(X')\right)}{u'\left(d(X) + B - \frac{B'}{R(X)}\right)} \middle| X \right].$$

Back

Constrained-Efficient Allocation

Finding 4

- Should the planner intensify his intervention when external volatility increases? $\rightarrow$ Not necessarily.



Prevalence of $\tau = 0$: Low Volatility $\rightarrow$ 55.3%, High Volatility $\rightarrow$ 59.6%. Back