Exchange Rate Manipulation and Constructive Ambiguity

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Transparency or Opacity?

- Relevant question for many aspects of economic policymaking
  - Focus on central bank foreign exchange interventions
- Prevalence of exchange rate interventions
  - Calvo and Reinhart (2002)
  - Japan in September 2010
- Disagreement about the desirability of transparency in practice
  - Size and timing of interventions
  - Desired movements of the exchange rate
  - Monetary and other policies
  - Different approaches, different justifications
  - Canales-Kriljenko (2003), Chiu (2003), BIS (2005)

Mexico, Russia, and the Financial Crisis

- Bank of Mexico
  - Longtime commitment to transparent intervention
  - In February 2009, an abrupt switch to a deliberately secretive policy
- Bank of Russia
  - Many small changes to the target band for the ruble
  - Predictable and extensive interventions at the margin
  - In late January 2009, a large adjustment to the band and a switch to a looser and more ambiguous intervention policy
- What is the meaning of these different policies?

Key Elements of the Benchmark Model and Extensions

1. Heterogeneous information
   - Investors observe private signals of interventions and fundamentals
2. Publicly observable exchange rate
   - Rational Bayesian investors combine public and private information
   - Grossman and Stiglitz (1976)
3. Noise traders
   - Misalignment between fundamentals and the exchange rate
   - Imperfect learning

- Extension 1: Policy as a signal of fundamentals
- Extension 2: Infinite horizon, higher-order beliefs

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- Extension 2: Infinite horizon, higher-order beliefs

Transparency

- Compare transparent policy with ambiguous policy
  - Either CB announces its intervention or remains silent
- An announcement has two distinct effects on the beliefs of investors:
  - The truth-telling effect, which reduces currency mispricing
  - The signal-precision effect, which magnifies currency mispricing
- Under certain circumstances, the signal-precision effect is larger
  - Transparency can exacerbate existing misalignment between the exchange rate and fundamentals
  - How much information can the central bank credibly reveal?

Truth-Telling and Signal-Precision Effects

- A foreign exchange intervention is a source of:
  1. Information about fundamentals
  2. Noise in the exchange rate
- If an intervention is revealed to investors, this has two effects:
  1. Information is revealed (the truth-telling effect)
  2. Noise in the exchange rate is reduced (the signal-precision effect)
- Less noise $\Longrightarrow$ more weight on exchange rate signal in expectations
  - Magnifies misalignment of beliefs and also the exchange rate
- Partial information revelation is crucial
  - Mussa (1981), Dominguez and Frankel (1993)

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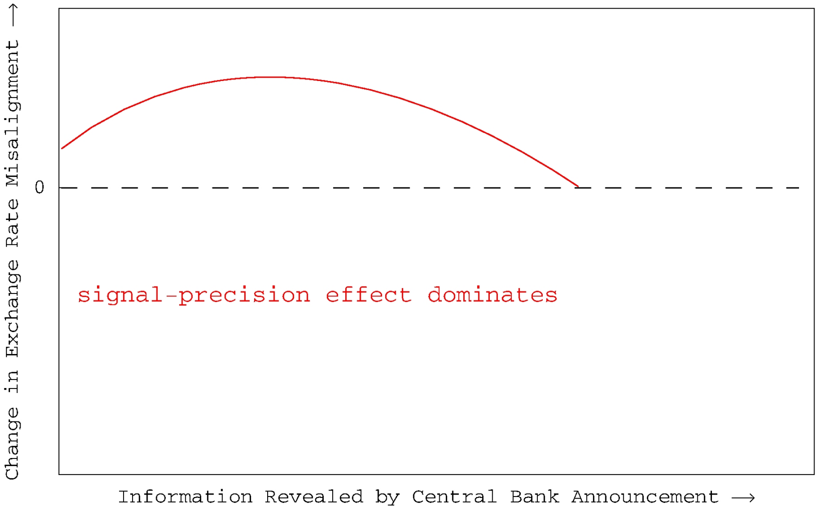
Exchange Rate Misalignment and Information Revelation



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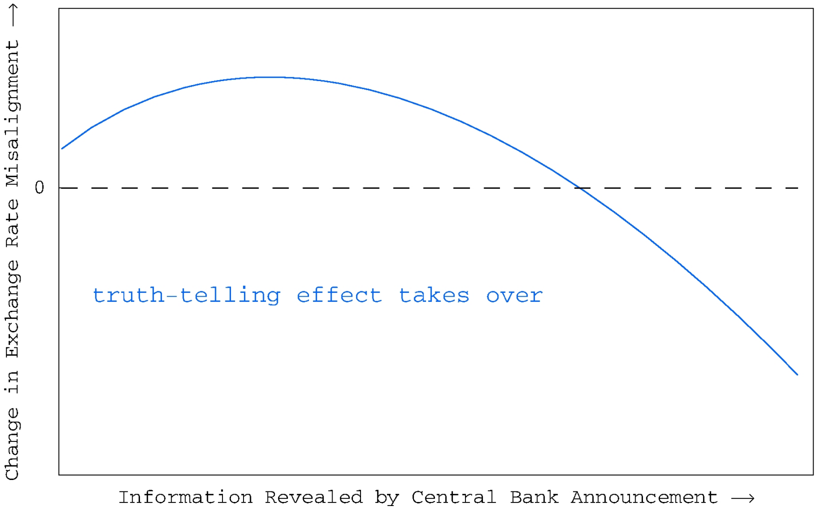

Benchmark: Basics

- Two periods, $t \in \{1, 2\}$
- Two countries, home (dollar) and foreign (peso)
- One consumption good, price is linked by LOP: $e_t + p_t^* = p_t$
  - p_t and p_t^* are log prices in the home and foreign countries, respectively
  - e_t is the log dollar price of one peso
- Three assets are traded (all payoffs are in period two):
  1. Nominal dollar bond with return i_1
  2. Nominal peso bond with return i_1^*
  3. Risk-free technology with real return r

More Basics

- Let $p_1 = p_2 = 0$ and $i_1 = i_1^* = r$
- Excess real return on peso bonds then equals peso appreciation:

$$-p_2^* - e_1 + i_1^* - i_1 = e_2 - e_1$$

- The exchange rate in period two is given by $e_2 = f + \kappa$
  - $f \in \mathbb{R}$ is exchange rate fundamentals
    - Infinite-horizon extension: interest rate spreads, risk premia
    - Future intervention policies
  - $\kappa \sim \mathrm{N}(0, \sigma_\kappa^2)$ is a shock to the exchange rate

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Investors

- Continuum of investors $i \in [0,1]$
- Each investor is endowed with real wealth $w_{i1} > 0$ in period one
- Investors have CARA preferences over consumption in period two:

$$\max_{b_{i1} \in \mathbb{R}} -E_{i1}\left[e^{-\gamma c_{i2}}\right], \quad \text{s. t.} \;\; c_{i2} = (1+i_1)w_{i1} + (e_2 - e_1)b_{i1}$$

If e_2 is normally distributed, then the demand for peso bonds by investor i is given by

$$b_{i1} = \frac{E_{i1}[e_2] - e_1}{\gamma \, \mathrm{Var}_{i1}[e_2]}$$

Foreign Exchange Intervention

- The foreign central bank purchases $\nu \in \mathbb{R}$ dollars of peso bonds
- Exchange rate fundamentals contain two parts:

$$f = \theta_f f_0 + \theta_\nu f_\nu$$

  - f_0 is unrelated to intervention
  - f_ν is related to intervention: CB's intervention ν is a function of f_ν
  - $\theta_f, \theta_\nu > 0$ measure the relative importance of each part
    - ★ High θ_f, low $\theta_\nu \implies$ little connection between interv. and fund.
    - ★ Low θ_f, high $\theta_\nu \implies$ large connection between interv. and fund.

Interventions and Fundamentals

- Recall that $f = \theta_f f_0 + \theta_\nu f_\nu$, where ν is a function of f_ν
- What does θ_ν capture?
  - Correlation between fundamentals and interventions
    - Bhattacharya and Weller (1997), Vitale (1999)
  - Signal of future policies, direct effect on risk premium
- To simplify, suppose that $\nu = f_\nu$, so that $f = \theta_f f_0 + \theta_\nu \nu$
- Transparency: foreign central bank announces the value of ν
  - Public, credible, truthful
  - θ_ν measures the extent of information revelation

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Public and Private Information

- Each investor i observes two private signals:
  - $x_i = f_0 + \epsilon_i$, where $\epsilon_i \sim \mathrm{N}(0, \sigma_\epsilon^2)$
  - $y_i = \nu + \eta_i$, where $\eta_i \sim \mathrm{N}(0, \sigma_\eta^2)$
- All investors also observe the exchange rate
  - Rational expectations equilibrium: ex rate is signal of fundamentals f
  - Noise traders purchase $\xi \sim \mathrm{N}(0, \sigma_\xi^2)$ dollars worth of peso bonds
    - Creates misalignment, prevents full revelation
- If CB announces the value of ν, then this is common knowledge

The Equilibrium Exchange Rate

In equilibrium, the exchange rate in period one is given by

$$e_1 = \underbrace{f}_{\text{fundamentals}} + \underbrace{\gamma\sigma^2\nu}_{\text{risk premium}} + \underbrace{\lambda\xi}_{\text{misalignment}}$$

- If CB announces the value of ν, write $\tilde{e}_1 = f + \gamma\tilde{\sigma}^2\nu + \tilde{\lambda}\xi$
- σ^2 is the conditional variance of e_2
- The goal is to compare the terms $\tilde{\lambda}$ and λ
  - Exchange rate misalignment
  - Price informativeness

What Determines λ?

- Market clearing implies that

$$\frac{\overline{E}_1[e_2] - e_1}{\gamma\sigma^2} + \nu + \xi = 0$$

- Because $e_2 = f + \kappa$, it follows that $\overline{E}_1[e_2] = \overline{E}_1[f]$ and hence

$$\begin{aligned} e_1 &= \overline{E}_1[f] + \gamma\sigma^2\nu + \gamma\sigma^2\xi \\ &= f + \gamma\sigma^2\nu + \lambda\xi \end{aligned}$$

- The goal is to evaluate $\overline{E}_1[f]$ and $\gamma\sigma^2$
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  - How much weight do expectations place on ξ?

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Expectations and Information

- How is $\overline{E}_1[f]$ evaluated?
- Recall that $f = \theta_f f_0 + \theta_\nu \nu$ and $e_1 = f + \gamma\sigma^2\nu + \lambda\xi$
- Bayesian inference yields

$$E_{i1}[f] = \theta_f x_i + \theta_\nu y_i + \frac{\mathrm{Cov}_i[f, e_1]}{\mathrm{Var}_i[e_1]}(e_1 - E_i[e_1])$$

$$\implies \overline{E}_1[f] = f + \frac{\mathrm{Cov}_i[f, e_1]}{\mathrm{Var}_i[e_1]}\lambda\xi$$

- What happens when CB makes an announcement?
  - Learn ν and hence part of $f \implies \mathrm{Cov}_i[f, e_1] \downarrow$ (truth-telling effect)
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Theorem (Transparency Theorem)

There exists a unique threshold $\hat{\theta}_\nu$ such that $\tilde{\lambda} > \lambda$ if and only if $\theta_\nu < \hat{\theta}_\nu$. If information revelation is sufficiently partial, then transparency magnifies exchange rate misalignment.

- Fundamentals: $f = \theta_f f_0 + \theta_\nu \nu$
  - θ_ν measures the information content of CB intervention
- Exchange rate: $e_1 = f + \gamma\sigma^2\nu + \lambda\xi$
  - λ and $\tilde{\lambda}$ measure exchange rate misalignment (for a given ξ)
  - If $\tilde{\lambda} > \lambda$, transparency $\implies$ more misalignment
- Two important special cases:
  1. $\theta_\nu = 0$: Intervention reveals nothing about fundamentals, and $\tilde{\lambda} > \lambda$
  2. $\theta_f = 0$: Intervention fully reveals fundamentals, and $\tilde{\lambda} < \lambda$

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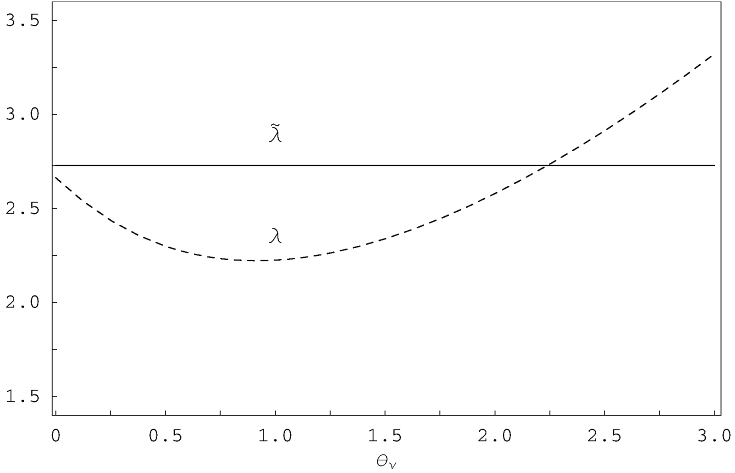

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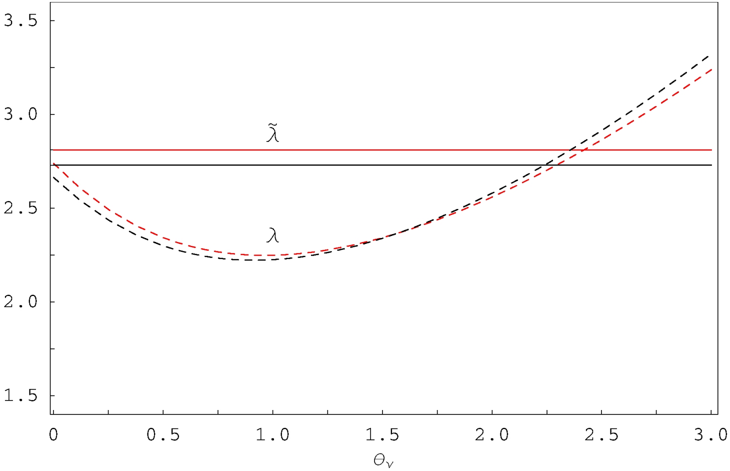
Less Unpredictability from Noise Traders



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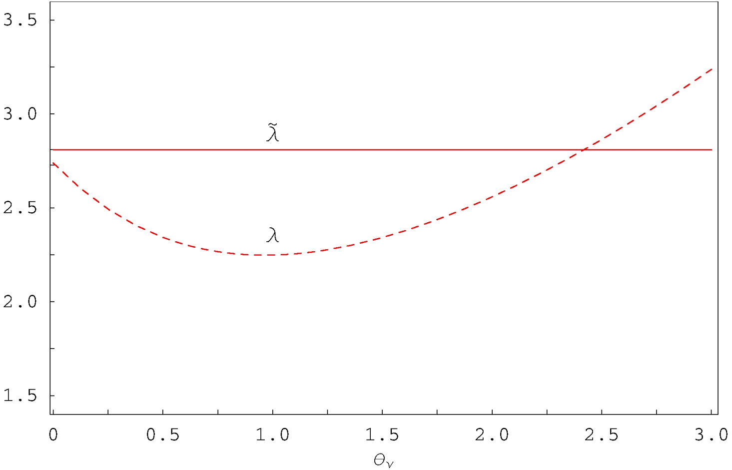

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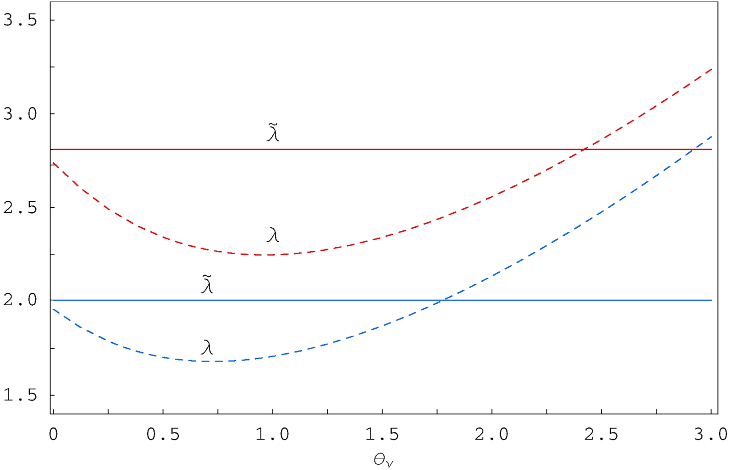
Less of Fundamentals Unrelated to Interventions



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The Benchmark Model in the Real World

- Transparency can in fact magnify exchange rate misalignment
  - How much information can the central bank credibly reveal?
  - When is the exchange rate misaligned?
- Mexico, Russia, and the Financial Crisis
  - Rapid currency depreciation, eventually some recovery
  - Difficult to calm markets via public announcements
  - Ambiguous, unpredictable intervention policies likely better
- Partial transparency $<$ No transparency $<$ Full transparency
- Setup is general and can be applied to other settings
  - Bond and Goldstein (2010)

Infinite-Horizon | Conclusion

Signalling: Motivation

- The benchmark model implicitly assumes that investors are naive
  - Tractable
  - Misses a piece of reality
- Central bank's choice of transparency policy is actually strategic
- Rational investors are aware of this strategic element
  - CB policy yields information about state of the economy
- What happens to the model's predictions?
  - Bayesian signalling game: pooling vs. separating equilibria

Signalling: Basics

- Benchmark setup, but central bank's policy choice is now a signal
- The bank's objective is to increase the peso exchange rate
  - Defense against a falling exchange rate
  - The bank knows all of fundamentals, but this could be relaxed
- Partially-separating Bayesian equilibrium
  - CB has two actions, chooses both depending on misalignment
  - Matches the analysis from the benchmark model
  - Truth-telling and signal-precision effects determine equilibrium actions

More

Partially-Separating Bayesian Equilibrium

Theorem

Given a set of assumptions for the model's primitives, there exists a partially-separating Bayesian equilibrium in which the foreign central bank announces the size of its intervention if and only if $\xi \geq \hat{\xi}(\nu)$.

- If the exchange rate is undervalued, transparency is not desirable
- In this setting, a central bank announcement has two effects:
  - The expectation of fundamentals decreases
  - The variance of fundamentals decreases
- Some central banks will benefit more from the lower variance

Conclusion

Infinite-Horizon: Basics

- Time is discreet and indexed by t
- One consumption good (price is linked by LOP) and three assets
- Domestic interest rate policy: $i_t = r$ and $p_t = 0$ for all t
- Foreign interest rate and intervention policy:
  - $i_t^* = ap_t^* + f_t + r$, where $a > 0$ is the response to price deviations
  - $f_t = \rho_f f_{t-1} + \zeta_t$, where $0 < \rho_f < 1$ and $\zeta_t \sim \mathrm{N}(0, \sigma_\zeta^2)$
  - $\nu_t = \rho_\nu \nu_{t-1} + \delta_t$, where $0 < \rho_\nu < 1$ and $\delta_t \sim \mathrm{N}(0, \sigma_\delta^2)$
- Investors publicly learn the value of ν_{t-1} in period t

Common Knowledge: Connection to Benchmark Model

- As in the two-period model, equilibrium exchange rate is of the form

$$e_t \;=\; \text{fundamentals} \;+\; \text{risk premium} \;+\; \lambda\xi_t$$

- λ and $\tilde{\lambda}$ again measure exchange rate misalignment (for a given ξ_t)

- Compare e_2 from the two-period model with e_{t+1} from this model:

$$e_2 = \theta_f f_0 + \theta_\nu \nu + \kappa \qquad \text{vs.} \qquad e_{t+1} = \frac{\psi_f}{\alpha} f_{t+1} + \rho_\nu \psi_\nu \nu_t + \text{noise}$$

  - ρ_ν measures the persistence of central bank interventions
  - ψ_ν measures time-discounted changes in the risk premium
  - λ should be increasing relative to $\tilde{\lambda}$ as ρ_ν grows from zero to one

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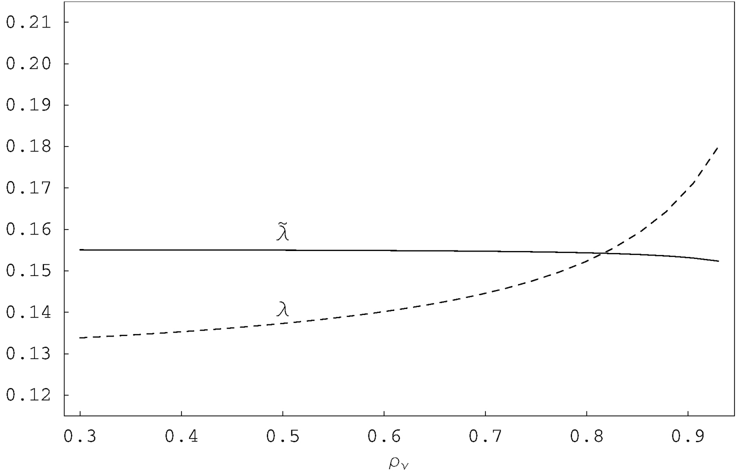
Transparency and Persistence



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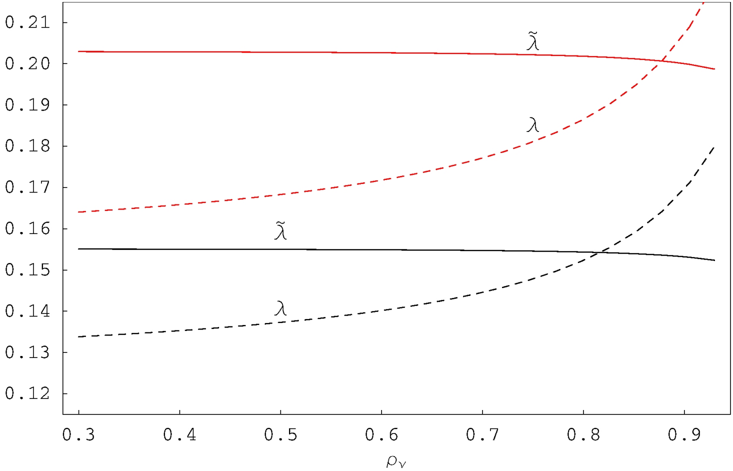

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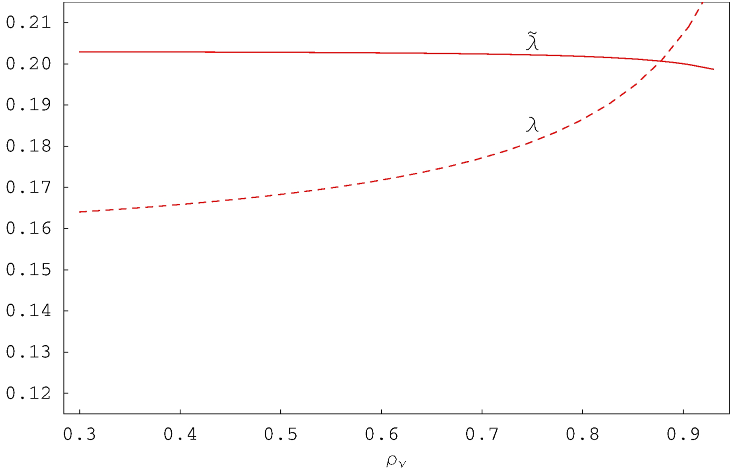

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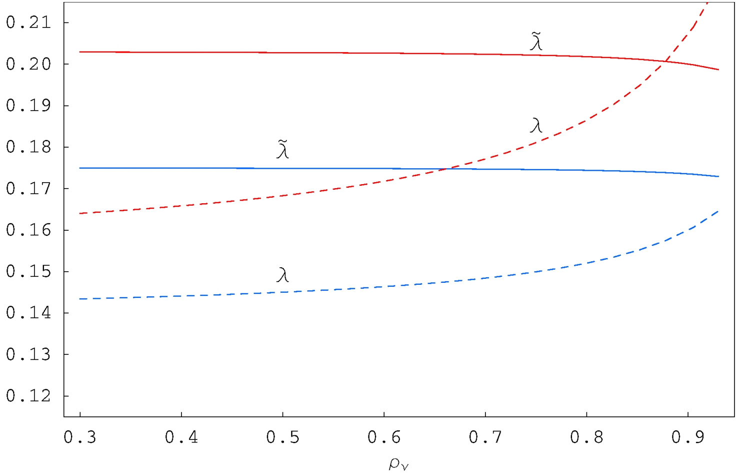
Less Persistent Shocks to Interest Rates



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Imperfect Common Knowledge of the Past

- Investors do not learn the value of ν_{t-1} in period t
- Peso bond interest rate is $i_t^* = ap_t^* + f_t + \chi_t + r$, with $\chi_t \sim \mathrm{N}(0, \sigma_\chi^2)$
  - Imperfect common knowledge about the value of f_t
- Higher-order expectations are part of the equilibrium exchange rate
  - Bacchetta and van Wincoop (2006), Lorenzoni (2009)
  - Townsend (1983), Kasa, Walker, and Whiteman (2007)
- Nimark (2010) presents a technique for approximating such models
  - Bound the order of agents' expectations
  - No need to exogenously assume common knowledge of the past

▸ More

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More

Persistent Misalignment and Transparency

- The technique involves solving for a system of equations of the form

$$e_t = AQ_t + \alpha\gamma\sigma^2\xi_t,$$
$$Q_t = MQ_{t-1} + Nw_t$$

- Q_t is a vector of higher-order expectations of f_t and ν_t
- w_t is a vector of disturbances $(\zeta_t, \delta_t, \chi_t, \xi_t)$
- Transitory noise trades permanently affect investors' expectations
- Persistent misalignment often magnified by transparency, much like the benchmark two-period model

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Summary

- Heterogeneous information is key in benchmark model and extensions
  - Exchange rate is a source of others' information
  - Noise traders prevent full revelation
- In this setting, there are two distinct effects of transparency:
  1. The truth-telling effect
     - ★ Full information revelation $\Longrightarrow$ truth-telling effect is largest
  2. The signal-precision effect
     - ★ Partial information revelation $\Longrightarrow$ signal-precision effect is largest
- Partial transparency is worse than no transparency, while full transparency is best

Implications

- How much information can the central bank credibly reveal?
- When is the exchange rate misaligned?
- CB intervention during periods of crisis and large capital outflows
  - Asymmetric information, pro-cyclical liquidity provision, psychology
    - Brunnermeier and Pedersen (2009), Shleifer and Vishny (1997)
  - Excessive sales of risky assets, undervalued currencies
  - Ambiguity, unpredictability can increase intervention's effectiveness
  - Prevent the spread of pessimism, preserve some credibility
- Extensions
  - General price manipulation
  - Competitive devaluation, specific intervention policies

The End

Thank You

Assumptions

1. There is a positive net supply of peso bonds denoted by $S > 0$
2. The central bank's intervention ν is bounded, so that $|\nu| \leq \bar{\nu} < S$
   - Ensures a positive net supply of peso bonds
   - Ensures a positive risk premium on peso bonds
   - Transparency reduces uncertainty and also risk premium
3. Investors' common prior for ν is uniform over the interval $[-\bar{\nu}, \bar{\nu}]$
   - Technical assumption, keeps expectations tractable

Partially-Separating Bayesian Equilibrium

Theorem

There exist bounds $\hat{S}, \hat{\nu}, \hat{\sigma}_\xi > 0$ such that if $S \geq \hat{S}$, $\bar{\nu} \geq \hat{\nu}$, and $\sigma_\xi \leq \hat{\sigma}_\xi$, then there exists a partially-separating Bayesian equilibrium in which the foreign central bank announces the size of its intervention if and only if $\xi \geq \hat{\xi}(\nu)$. In this equilibrium, the threshold function $\hat{\xi}(\nu)$ is positive and decreasing in ν.

- If the exchange rate is undervalued, transparency is not desirable
- In this setting, a central bank announcement has two effects:
  - The expectation of fundamentals decreases
  - The variance of fundamentals decreases
- Some central banks will benefit more from the lower variance

What About Pooling Equilibria?

- The exchange rate in period one is approximately of the form

$$e_1 = \overline{E}_1[f] + \gamma\sigma^2(\nu + \xi)$$

- In this case, strange and unintuitive out-of-equilibrium beliefs are necessary to construct pooling equilibria
  - One possibility is that $\overline{E}_1[f]$ is not finite either with or without a central bank announcement
  - Another possibility is that $\sigma^2 = \tilde{\sigma}^2$

Self-Fulfilling Equilibria 1

- Investors' interpretation of CB policy might dictate its meaning
  - Interpret no transparency as bad sign, force CB to always announce
  - Interpret transparency as bad sign, force CB to never announce

- Forget about two parts of fundamentals, suppose that

$$\tilde{e}_1 = f + \tilde{\lambda}(\xi - \hat{\xi})$$

- Investors observe an announcement, so they learn that $\xi \geq \hat{\xi} > 0$

- This is equivalent to learning that $f \leq \tilde{e}_1$, which implies that

$$\begin{aligned}\lim_{\sigma_\xi \to 0} \overline{E}_1 \exp\{-f\} &= \lim_{\sigma_\xi \to 0} \exp\{-\tilde{e}_1\} \\ &= \lim_{\sigma_\xi \to 0} \exp\{-f - \tilde{\lambda}(\xi - \hat{\xi})\}.\end{aligned}$$

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\end{aligned}$$

Self-Fulfilling Equilibria 2

- It follows that e_1 is normally distributed in the limit:

$$\lim_{\sigma_\xi \to 0} \tilde{e}_1 = \lim_{\sigma_\xi \to 0} f + \tilde{\lambda}(\xi - \hat{\xi}).$$

- In a similar manner, it can be shown that

$$\lim_{\sigma_\xi \to 0} e_1 = \lim_{\sigma_\xi \to 0} f + \lambda \xi.$$

- For σ_ξ small, the difference between e_1 and $\tilde{e}_1$ is approximately

$$e_1 - \tilde{e}_1 = \xi(\lambda - \tilde{\lambda}) + \tilde{\lambda}\hat{\xi}$$

- $\tilde{\lambda} > \lambda \implies$ no equilibria where CB makes an announcement iff $\xi < \hat{\xi}$

Back to Main Conclusion

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Proof Sketch: Truncation of Higher-Order Expectations 1

- The technique involves solving for a system of equations of the form

$$e_t = AQ_t(k) + \alpha\gamma\sigma^2\xi_t,$$
$$Q_t(k) = MQ_{t-1}(k) + Nw_t$$

- Higher-order expectations are truncated at k, so that

$$q_{jt} = \left(\overline{E}_t \cdots \overline{E}_t[f_t] \quad \overline{E}_t \cdots \overline{E}_t[\nu_t]\right)',$$

with the expectation repeated $0 \leq j \leq k$ times, and

$$Q_t(k) = \begin{pmatrix} q'_{0t} & q'_{1t} & \cdots & q'_{kt} \end{pmatrix}',$$
$$w_t = \begin{pmatrix} \sigma_\zeta^{-1}\zeta_t & \sigma_\delta^{-1}\delta_t & \sigma_\chi^{-1}\chi_t & \sigma_\xi^{-1}\xi_t \end{pmatrix}'$$

- The goal is to solve for the matrices M and N and the vector A

Proof Sketch: Truncation of Higher-Order Expectations 2

- In each period t, each investor i observes

$$z_{it} = \begin{pmatrix} x_{it} \\ y_{it} \\ \bar{i}_t \\ e_t \end{pmatrix} = DQ_t(k) + R \begin{pmatrix} \sigma_\epsilon^{-1}\epsilon_{it} \\ \sigma_\eta^{-1}\eta_{it} \\ \sigma_\zeta^{-1}\zeta_t \\ \sigma_\delta^{-1}\delta_t \\ \sigma_\chi^{-1}\chi_t \\ \sigma_\xi^{-1}\xi_t \end{pmatrix},$$

where $\bar{i}_t = i_t^* - ap_t^* - r = f_t + \chi_t$ and $R = \begin{pmatrix} R_1 & R_2 \end{pmatrix}$

- If K is the Kalman gain matrix, then Bayesian updating implies that

$$E_{it}[Q_t(k)] = ME_{it-1}[Q_{t-1}(k)] + K\left(z_{it} - DME_{it-1}[Q_{t-1}(k)]\right)$$

Proof Sketch: Truncation of Higher-Order Expectations 3

- Averaging over all investors yields

$$\begin{aligned}\overline{E}_t[Q_t(k)] &= K\left(DMQ_{t-1}(k) + (DN + R_2)w_t - DM\overline{E}_{t-1}[Q_{t-1}(k)]\right) \\ &\quad + M\overline{E}_{t-1}[Q_{t-1}(k)] \\ &= KDMQ_{t-1}(k) + K(DN + R_2)w_t \\ &\quad + (M - KDM)\overline{E}_{t-1}[Q_{t-1}(k)]\end{aligned}$$

- The Kalman gain matrix K is given by

$$K = (PD' + NR_2')(DPD' + RR')^{-1},$$

where P satisfies the matrix Riccati equation

$$P = M\left(P - (PD' + NR_2')(DPD' + RR')^{-1}(PD' + NR_2')'\right)M' + NN'$$

Persistent Misalignment and Transparency

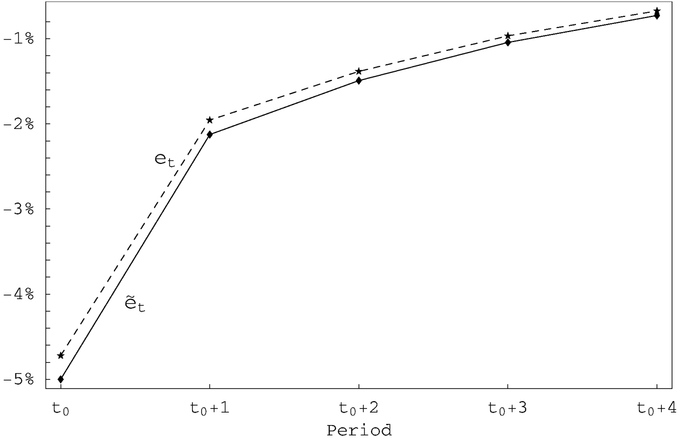

Figure: The response of the exchange rate to a shock to the noise traders' demand for peso bonds ξ_t in period t_0. ($\sigma_\epsilon = 0.35$, $\sigma_\eta = 0.35$, $\sigma_\xi = 0.1$, $\sigma_\zeta = 0.03$, $\sigma_\delta = 0.07$, $\sigma_\chi = 0.005$, $\alpha = 0.92$, $\gamma = 5$, $\rho_f = 0.7$, $\rho_\nu = 0.1$, $k = 50$)

Summary

- Heterogeneous information is key in benchmark model and extensions
  - Exchange rate is a source of others' information
  - Noise traders prevent full revelation
- In this setting, there are two distinct effects of transparency:
  1. The truth-telling effect
     - ⋆ Full information revelation $\Longrightarrow$ truth-telling effect is largest
  2. The signal-precision effect
     - ⋆ Partial information revelation $\Longrightarrow$ signal-precision effect is largest
- Partial transparency is worse than no transparency, while full transparency is best

Implications

- How much information can the central bank credibly reveal?
- When is the exchange rate misaligned?
- CB intervention during periods of crisis and large capital outflows
  - Asymmetric information, pro-cyclical liquidity provision, psychology
    - Brunnermeier and Pedersen (2009), Shleifer and Vishny (1997)
  - Excessive sales of risky assets, undervalued currencies
  - Ambiguity, unpredictability can increase intervention's effectiveness
  - Prevent the spread of pessimism, preserve some credibility
- Extensions
  - General price manipulation
  - Competitive devaluation, specific intervention policies

The End

Thank You