The Role of Dispersed Information in Maintaining Low Interest Rates

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Sovereign Debt and Having Your Currency

- Countries that borrow in their own currency more resilient to debt crises
- High-debt countries: Japan vs. Italy
- High-deficit countries: UK vs. Spain Plot
- Should all countries borrow in local currency?
- Why do we have “original sin?”

A Possible Explanation and a Puzzle

- The ability to print money avoids default risk
- $\Longrightarrow$ Interest rates do not jump in anticipation of default
- ... but printing money will cause inflation...
- $\Longrightarrow$ Interest rates should jump in anticipation of inflation
- Our story: Information frictions underlie differential response of bond prices to shocks

The “Original Sin”

- Some countries seem to be unable to issue domestic debt
- Perhaps because of time-inconsistency (Calvo, 1989)
- If this were the problem, we would expect interest rates to be *more* sensitive to bad news with domestic-currency debt
- Bordo-Meissner (2006): Currency mismatch not necessarily associated with more frequent crises
- Ability to devalue and mitigate recession not always relevant (in the 2008 crisis the yen appreciated)

Related Papers on Currency Denomination

Currency denomination of debt

- original sin and time inconsistency: Calvo (1989), Engel and Park (2016)
- crises and currency mismatch: Calvo, Izquierdo, and Talvi (2004), Bordo and Meissner (2006)

Related Papers on Information

- Global games: Morris-Shin (1998)
- Bayesian trading game: Hellwig, Mukherji, Tsyvinski (2006), Albagli, Hellwig, and Tsyvinski (2011), Allen, Morris, and Shin (2006)

Plan of the Talk

- Model: a two-period Bayesian trading game
- Analyze comparative statics with respect to relevant information precision
- Parameterization
- Numerical results

Government

- Auctions one unit of debt in period 1 (per capita per young strategic trader), price q_1
  - Foreign currency debt: Debt promise to pay 1 unit of goods in period 3 (foreign price level =1)
  - Domestic currency debt: debt promise a nominal amount 1 in period 3
- In period 3, gov't collects taxes, depending on the realization of $\theta \sim N(\mu_0, 1/\alpha_0)$:
  - If $\theta \geq \bar{\theta}$, full repayment
  - Otherwise, gov't pays back $\delta < 1$:
    - ★ Under foreign currency, default, haircut $1 - \delta$
    - ★ Under domestic currency, full nominal repayment, but FTPL implies a jump in the price level

Private agents: Preferences and Technology

- 2 OLGs living for two periods
- Endowed with goods when young
- Want to consume when old, risk neutral
- Strategic traders:
    - Can store
    - Can buy one unit of government bonds
- Noise traders:
    - Demand an (unobserved) fraction $\Phi(\epsilon_t^b)$, $\epsilon_t^b \sim N(0, 1/\psi_t^b)$, of gov't debt

Agent "Labels"

- Period 1: bondholders (sophisticated, have more precise information)
- Period 2:
  - Foreign currency: new gen. of sophisticated bondholders
  - Domestic currency: gov't can print money, so pivotal agents are price setters (less precise information)

Two Cases

1. Warm-up: No recall of past prices
2. Partial recall of past prices

The Simplest Case

- period-2 agents do not observe q_1

Period-t agents' information set

- prior
- private signal of θ: $x_{i,t}$, with conditional precision β_t
- can condition on period-t price $\Rightarrow$ demand schedules $d(x_{i,t}, q_t)$

Equilibrium Definition

Definition

A Perfect Bayesian Equilibrium consists of bidding strategies $d(x_{i,t}, q_t)$ for strategic players, a price function $q(\theta, \epsilon_t)$ and posterior beliefs $p(x_{i,t}, q_t)$ such that

(i) $d(x_{i,t}, q_t)$ is optimal given beliefs $p(x_{i,t}, q_t)$,

(ii) $q(\theta, \epsilon_t)$ clears the market for all (θ, ϵ_t), and

(iii) $p(x_{i,t}, q_t)$ satisfies Bayes' Law for all market clearing prices q_t.

Period-2 Agents: Payoffs and Strategies

- Expected payoff

$$\underbrace{\delta \cdot \mathrm{Prob}(\theta < \bar{\theta} | x_{i,2}, q_2) + 1 \cdot \mathrm{Prob}(\theta \geq \bar{\theta} | x_{i,2}, q_2)} - q_2$$

(foreign currency) $\mathbb{E}_{i,2}$[bond repayment]

(domestic currency) $\mathbb{E}_{i,2}$[inverse inflation]

- Posterior beliefs on θ are FOSD-increasing in $x_{i,2}$
  - Buy if signal is above threshold:

$$d(x_{i,2}, q_2) = \mathbb{1}[x_{i,2} \geq \hat{x}_2(q_2)]$$

Period-2: Market Clearing and Beliefs

- Period-2 market clearing condition

$$\underbrace{\mathrm{Prob}(x_{i,2} \geq \hat{x}_2(q_2)|\theta)}_{\text{informed nominal-asset demand}} = \underbrace{1 - \Phi(\epsilon_2)}_{\text{nominal-asset supply (net of noise agents)}}$$

- Market clearing implies

$$z_2 := \theta + \frac{\epsilon_2}{\sqrt{\beta_2}} = \hat{x}_2(q_2)$$

- We focus on equilibria where z_t is informationally equivalent to q_t
- Second-period agents posterior beliefs

$$\theta|x_2, z_2 \sim N\left(\frac{\alpha_0\mu_0 + \beta_2 x_2 + \beta_2\psi_2 z_2}{\alpha_0 + \beta_2(1+\psi_2)}, \frac{1}{\alpha_0 + \beta_2(1+\psi_2)}\right)$$

Period-2: Equilibrium

- Marginal agent's indifference condition

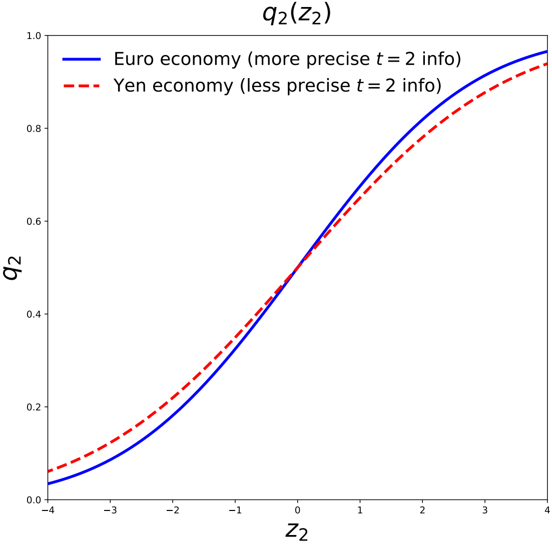
$$\delta + (1-\delta)\mathrm{Prob}(\theta \geq \bar{\theta} | x_{i,2} = \hat{x}_2(q_2), q_2) = q_2$$

- Equilibrium $t = 2$ price

$$q_2(z_2) = \delta + (1-\delta)\Phi\left(\frac{(1-w_S)\mu_0 + w_S z_2 - \bar{\theta}}{\sigma_S}\right)$$

$w_S := \frac{\beta_2(1+\psi_2)}{\alpha_0+\beta_2(1+\psi_2)}, \qquad \sigma_S^2 := \frac{1}{\alpha_0+\beta_2(1+\psi_2)}$

Comparative Statics (more precise info = higher β_2 or ψ_2)



Period-1: Strategies and Beliefs

- Expected payoff

$$\mathbb{E}[q_2(z_2)|x_{i,1}, q_1] - q_1$$

  - q_2 is increasing in z_2
  - posterior beliefs are FOSD-increasing in $x_{i,1}$

- Monotone threshold strategies again Demand schedules still monotone: $d(x_{i,1}, q_1) = \mathbb{1}[x_{i,1} \geq \hat{x}_1(q_1)]$
- Market clearing implies

$$z_1 := \theta + \epsilon_1/\sqrt{\beta_1} = \hat{x}_1(q_1)$$

  - again, z_1 observationally equivalent to q_1

- First-period agents posterior beliefs on z_2, not just s

$$z_2|(z_1, x_1) \sim N\left(\frac{\alpha_0\mu_0 + \beta_1 x_1 + \beta_1\psi_1 z_1}{\gamma_1}, \frac{1}{\gamma_1} + \frac{1}{\psi_2\beta_2}\right)$$

γ_1

Period-1: Equilibrium

- Marginal traders' indifference condition

$$\mathbb{E}[q_2(z_2)|x_{i,1} = \hat{x}_1(q_1), q_1] = q_1$$

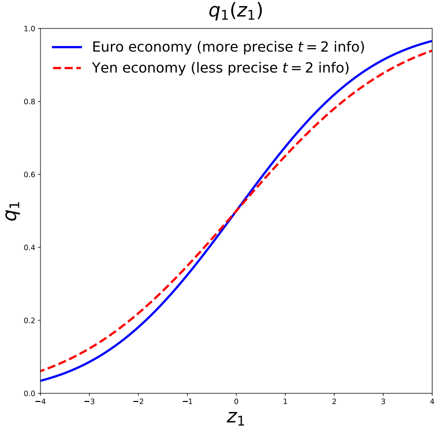
- Equilibrium $t = 1$ price

$$q_1(z_1) = \delta + (1-\delta)\Phi\left[\frac{\mu_0 - \bar{\theta}}{\sqrt{w_S^2\sigma_{S|B}^2 + \sigma_S^2}} + \frac{w_S w_B}{\sqrt{w_S^2\sigma_{S|B}^2 + \sigma_S^2}}(z_1 - \mu_0)\right]$$

$$w_B := \frac{\beta_1(1+\psi_1)}{\alpha_0+\beta_1(1+\psi_1)}, \qquad \sigma_{S|B}^2 := \frac{1}{\gamma_1} + \frac{1}{\psi_2\beta_2}$$

q_1 with recall

Comparative Statics (more precise info = higher β_2 or ψ_2)



Propositions 1&2

(Partial) Recall of the First-Period Price

- Now, add a signal of first-period price, observed by second-period agents
- In the equilibrium we constructed, z_1 was informationally equivalent to q_1
- Make the signal about z_1: period-2 agents observe $\rho := z_1 + \sigma_\eta \eta_1$, $\eta_1 \sim N(0, 1)$
- Implies that signal is more precise in the (flat) tails

New equilibrium

Period-2 price:

$$q_2(z_2, \rho) = \delta + (1-\delta)\Phi\left(\frac{(1-w_\rho - w_2)\mu_0 + w_2 z_2 + w_\rho \rho - \bar{\theta}}{\sigma_2}\right)$$

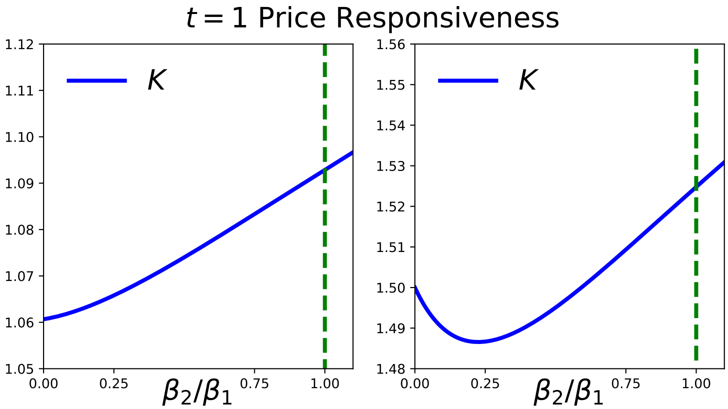
$$w_\rho := \frac{\tau_\rho}{\alpha_0 + \beta_2 + \tau_{q_2} + \tau_\rho}$$

$$w_2 := \frac{\beta_2 + \tau_{q_2}}{\alpha_0 + \beta_2 + \tau_{q_2} + \tau_\rho}$$

- τ_ρ : precision of signal ρ about θ
- τ_{q_2}: precision of z_2 about θ

p_1 price

Comparative Statics



Propositions 3&4

Numerical Challenges

- Model is a bit too simplistic for a full calibration
- Binary payoff
- 3-periods, with debt issued only once
- Two restrictions are too tight for the data:
  - Binary payoff implies tight connection between mean spreads and standard deviations
  - Pure Bayesian learning implies bounded degree of disagreement, UK households did not get the memo
- We choose parameter values that deliver a good fit, but are also reasonable
- (Calibration tends to push ψ and/or β to 0)

Data

- We will use UK data
- Has liquid market for inflation-protected securities
- $\Longrightarrow$ can disentangle real risk-free rate from inflation expectations
- Also, we have good micro data on inflation expectations
  - Unsophisticated agents (period-2 agents): Bank of England/ Ipsos Inflation Attitudes Survey (UK population)
  - Sophisticated agents (period 1): Professional forecasters as reported in UK Treasury "Forecasts for the UK Economy: a comparison of independent forecasts."
- Externally set parameter: $\delta = 0.63$ (calibrated to recovery rate from sovereign debt in Cruces and Trebesch, 2013)

Moments that we use - part 1

Data	Model
Avg inflation spreads on gilts	Avg. period-1 yield to maturity $(1/q_1 - 1)$
St dev of inflation spreads	St. dev of period-1 YTM
St dev of inflation	St. dev of $1/q_2$ (price at which sellers accept money in period 2)

Moments that we use - part 2

Data	Model
Avg reporting error about *current* inflation by UK population	$\overline{\text{FEV}}_\rho := \frac{\mathbb{V}(z_1 \mid \rho)}{\mathbb{V}(z_1)} = \frac{\tau_{z_1}}{\tau_\eta + \tau_{z_1}}$
Avg cross-sectional dispersion of inf forecast: professional	$D_1 := \sqrt{\frac{\mathbb{V}(\mathbb{E}[\theta \mid x_{i,1}, z_1] \mid \theta, z_1)}{\mathbb{V}(\theta)}} = \frac{\sqrt{\alpha_0 \beta_1}}{\alpha_0 + \beta_1 + \tau_{q_1}}$
Avg cross-sectional dispersion of inf forecast: UK population	$D_2 := \sqrt{\frac{\mathbb{V}(\mathbb{E}[\theta \mid x_{i,2}, z_2, \rho] \mid \theta, z_2, \rho)}{\mathbb{V}(\theta)}} = \frac{\sqrt{\alpha_0 \beta_2}}{\alpha_0 + \beta_2 + \tau_{q_2} + \tau_\rho}$

Note: all data moments normalized by st. dev. of inflation

Parameter Configuration

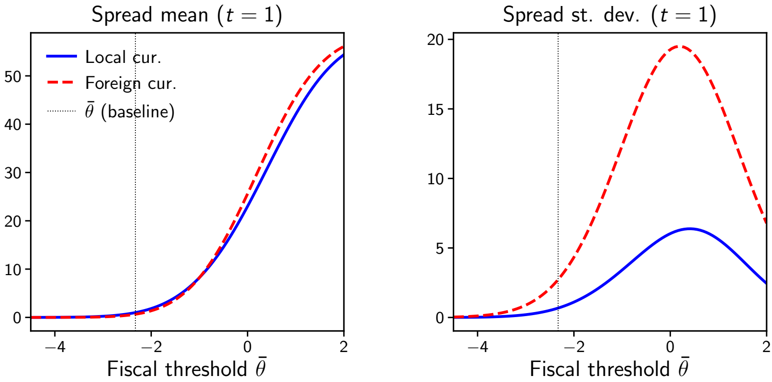
Variable	Value	Target	Model	Data
$\bar{\theta}$	-2.33	Breakeven inflation spreads (mean)	1.00	1.07
ψ_1	1.80	Breakeven inflation spreads (st. dev.)	0.68	0.49
ψ_2	0.35	YoY CPI Inflation (st. dev.)	2.97	3.44
β_1	1.04	Informed forecast dispersion (mean)	0.26	0.20
β_2	0.24	Uninformed forecast dispersion (mean)	0.33	0.49
τ_η	0.15	Uninformed error on past inflation (mean)	0.59	0.24

Counterfactuals

- More precision
  - $\beta_2 = \beta_1$, $\psi_2 = \psi_1$, $\tau_\eta = \infty$
  - Interpretation: foreign-currency debt, second-period agents are sophisticated bondholders
- Perfect information benchmark: θ common knowledge ex ante

Statistic	Baseline	Counterfactuals	
		More precision	Perfect info
Bond spreads (mean)	1.00	0.65	0.58
Bond spreads (st. dev.)	0.68	2.72	5.83
Inflation (st. dev.)	2.97	3.47	5.83

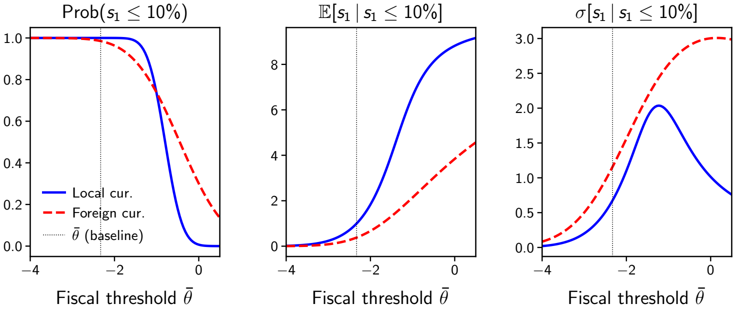
The role of default risk



Is local currency always good?

- Previous picture: must always issue debt (even at 60% spread)
- What if gov't gives up issuing debt above some threshold?
- Let the threshold be 10%

Debt issuance under a threshold rule



Contrast to “Argentina”: Moments that we Adapt

Data	Model
Avg spread on 5-year CDS	Avg. period-1 yield to maturity $(1/q_1 - 1)$
St dev of CDS spreads	St. dev of period-1 YTM
Avg cross-sectional dispersion of inf forecast: professional	$D_1 := \sqrt{\frac{\mathbb{V}(\mathbb{E}[\theta \mid x_{i,1}, z_1] \mid \theta, z_1)}{\mathbb{V}(\theta)}} = \frac{\sqrt{\alpha_0 \beta_1}}{\alpha_0 + \beta_1 + \tau_{q_1}}$

Argentina Parameters: Other Details

- Use dispersion of inflation forecast as a proxy, assume same ratio of dispersion to volatility for inflation and default risk
- (Drop periods with 100% annual inflation to compute moment above)
- Set $\delta = 0.25$ (standard for distressed economies, with $\delta = 0.63$ spread too small even with 100% default prob).
- Baseline: foreign currency, so $\beta_2 = \beta_1$, $\psi_2 = \psi_1$, $\tau_\eta = \infty$
- Counterfactual (domestic currency): choose same ratio β_2/β_1 and ψ_2/ψ_1 and same τ_η as UK

Argentina Parameter Values

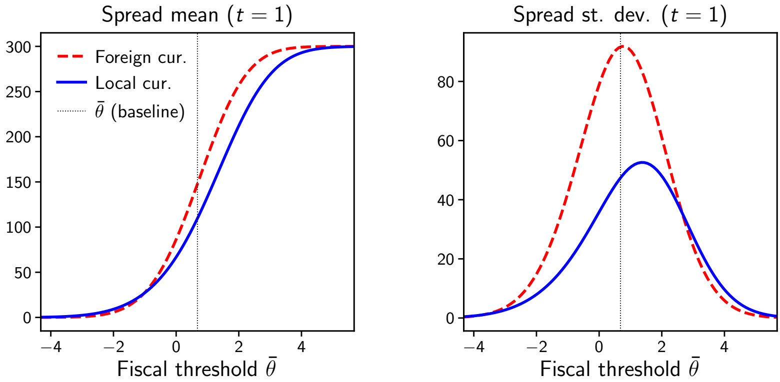
Table: Parameter configuration.

Variable	Value	Target	Data	Model
$\bar{\theta}$	0.68	CDS upfront price (mean)	47.25	47.25
ψ_1	1.91	CDS upfront price (st. dev.)	19.79	19.79
β_1	0.44	Informed forecast dispersion (mean)	0.37	0.37

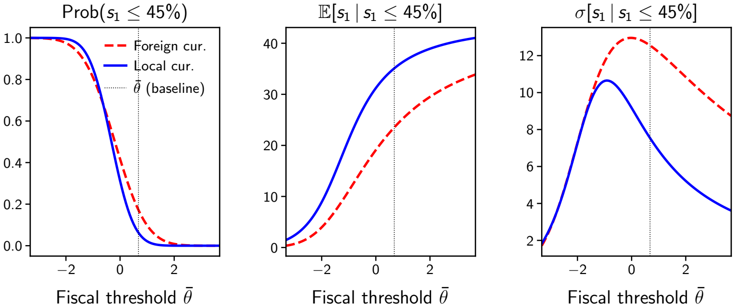
Argentina Counterfactuals

Statistic	Baseline	Counterfactuals	
		Less precision	Perfect info
CDS upfront price (mean)	47.3	50.1	43.6
CDS upfront price (st. dev.)	19.8	11.2	32.4

Comparative Statics wrt $\bar{\theta}$



Threshold rule at 45%



Conclusion

- Heterogeneity of information has important implications for debt management
- Domestic-currency debt more resilient to bad news
- As prior becomes worse, even more valuable to issue domestic-currency debt
- Eventually, it is so expensive that might as well concentrate debt issuance in the good states
- A theory of original sin: bad prior $\Longrightarrow$ only sophisticated agents willing to buy (sometimes)

THANK YOU!

Setup and actors

- Three periods
- Bond traders: strategic and noise
- Workers: strategic and noise
- Government (described by a mechanical rule)

Workers: Preferences and Technology

- Only alive in periods 2 and 3
- Strategic workers
  - One unit of endowment in period 2
  - Wish to consume in period 3, risk neutral
  - Can store good (zero return) or sell it
- Noise workers
  - (Unobserved) relative mass $\Phi(\epsilon_2^w)$, $\epsilon_2^w \sim N(0, 1/\psi_2^w)$
  - Can produce in period 3
  - Demand 1 unit of consumption in period 2

Bond Traders: Preferences and Technology

- 2 OLGs living for two periods
- Endowed with goods when young
- Want to consume when old, risk neutral
- Strategic traders:
  - Can store
  - Can buy one unit of government bonds
- Noise traders:
  - Demand an (unobserved) fraction $\Phi(\epsilon_t^b)$, $\epsilon_t^b \sim N(0, 1/\psi_t^b)$, of gov't debt
- Mass of bond traders negligible compared to workers

Government - "Euro" scenario

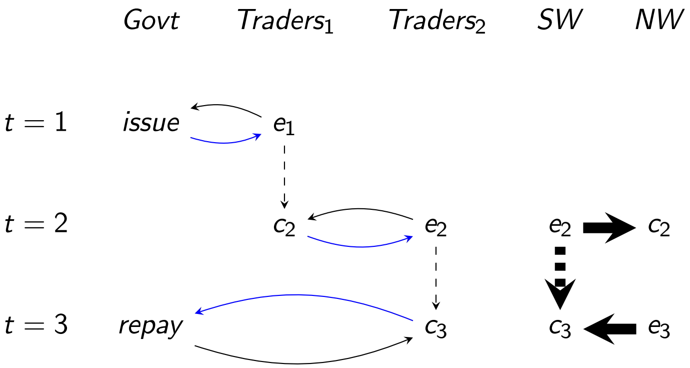
- Auctions one unit of debt in period 1 (per capita per young strategic trader), price q_1
- Debt is a promise to pay $\hat{s}(q_1)$ Euros (goods) in period 3. Examples:
  - $\hat{s}(q_1) \equiv 1$ (Eaton and Gersovitz)
  - $\hat{s}(q_1) \equiv 1/q_1$ (Calvo)
- In period 3, gov't collects taxes, depending on the realization of $s \sim N(\mu_0, 1/\alpha_0)$:
  - If $s \geq \hat{s}(q_1)$, full repayment
  - Otherwise, haircut $1 - \delta$, gov't pays back $\delta \hat{s}(q_1)$

Government - "Yen" scenario

- Auctions one unit of debt in period 1 (per capita per young strategic trader), price q_1
- Debt is a promise to pay $\hat{s}(q_1)$ Yens.
- In period 2, gov't prints Yen, pays debt back.
- In period 3, gov't collects taxes, depending on the realization of $s \sim N(\mu_0, 1/\alpha_0)$:

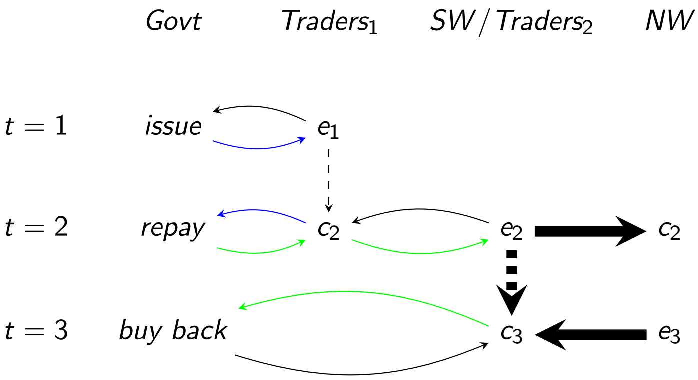
  $$\left.\begin{array}{l}\text{- If } s \geq \hat{s}(q_1)\text{, collects } \hat{s}(q_1) \\ \text{- Otherwise, collects } \delta\hat{s}(q_1)\end{array}\right\}\text{(same as Euro scenario)}$$
- Period-3 taxes used to buy Yen back. Price level is either 1 or $1/\delta$.

Euro Markets



goods; bonds; storage (dashed)

Yen Markets



goods; bonds; cash; storage (dashed)

Euro vs. Yen: the Key Difference

- Eventual default/inflation is the same at the end, period 3
- Identity of primary-market participants the same at the beginning, period 1
- Period 2 Identity of secondary-market participants different:
  - Under Euro, bonds offloaded to new bond traders
  - Under Yen, offloaded to workers (through cash)

Period 2: Euro vs. Yen

	Euro	Yen
Identity of marginal buyer	bond trader	worker
Goods given up	$\hat{s}(q_1)q_2$	1
Goods received:		
w/o default/inflation:	$\hat{s}(q_1)$	$P_2/P_3 = P_2$
with default/inflation:	$\delta\hat{s}(q_1)$	$P_2/P_3 = \delta P_2$

Collapse the 2 scenarios into a single problem: in the Yen case $q_2 := 1/P_2$

Information

- Strategic traders observe $s + \xi^b_{i,t}$, with $\xi^b_{i,t} \sim N(0, 1/\beta^b_t)$
- Strategic workers observe $s + \xi^w_{i,2}$, with $\xi^w_{i,2} \sim N(0, 1/\beta^w_2)$
- Comparative statics with respect to:
  - β^w_2 vs. β^b_2 signal precision
  - ψ^w_2 vs. ψ^b_2 (inverse of) confusion from noise traders

Precision of first-period posterior beliefs

- Precision of first-period posterior beliefs

$$\frac{1}{\gamma_1} := \frac{1}{\alpha_0 + \beta_1(1 + \psi_1)}$$

Case 1: beliefs Case 1: comp stat

- Aggregate noise term of first-period price (case with recall)

$$S := \sqrt{w_{2,S}^2 \left(\frac{1}{\gamma_1} + \frac{1}{\beta_2 \psi_2} \right) + \sigma_S^2}$$

Back

Back

Period-1 price with partial recall

$$q_1(z_1) = \delta + (1-\delta)\Phi\left(\frac{\mu_0(1 - w_\rho - w_2 w_1) + z_1(w_\rho + w_2 w_1) - \bar{\theta}}{\sqrt{w_2^2 \sigma_{2|1}^2 + w_\rho^2 \sigma_\eta^2 + \sigma_2^2}}\right)$$

$$\sigma_{2|1}^2 := \frac{1}{\alpha_0 + \beta_1 + \tau_{q_1}} + \frac{1}{\tau_{q_2}}$$

$$w_1 := \frac{\beta_1 + \tau_{q_1}}{\alpha_0 + \beta_1 + \tau_{q_1}}$$

τ_{q_1}: precision of information embedded in first-period price Back to period-2 price

Comparative Statics: Some Intuition

$$q_1(z_1) = \delta + (1-\delta)\Phi\left[\frac{\mu_0 - \bar{\theta}}{S} + K(z_1 - \mu_0)\right]$$

$$K := \frac{(w_{1,S} + w_{2,S}w_B)}{\sqrt{w_{2,S}^2\left(\frac{1}{\gamma_1} + \frac{1}{\beta_2\psi_2}\right) + \sigma_S^2}}$$

- Always get single crossing, as before
- Direction of crossing dictated by K

- Effect of β_2, ψ_2 on K more involved:
  - $\beta_2 \uparrow \Longrightarrow$ period-2 agents give less weight to prior, but also to q_1
  - Less weight on prior $\Longrightarrow$ q_2 tracks s better
  - Less weight on q_1 $\Longrightarrow$ q_2 tracks s better, but potentially less correlated with q_1, ambiguous

Back to period-2 price