Carry Trades and Speculative Dynamics

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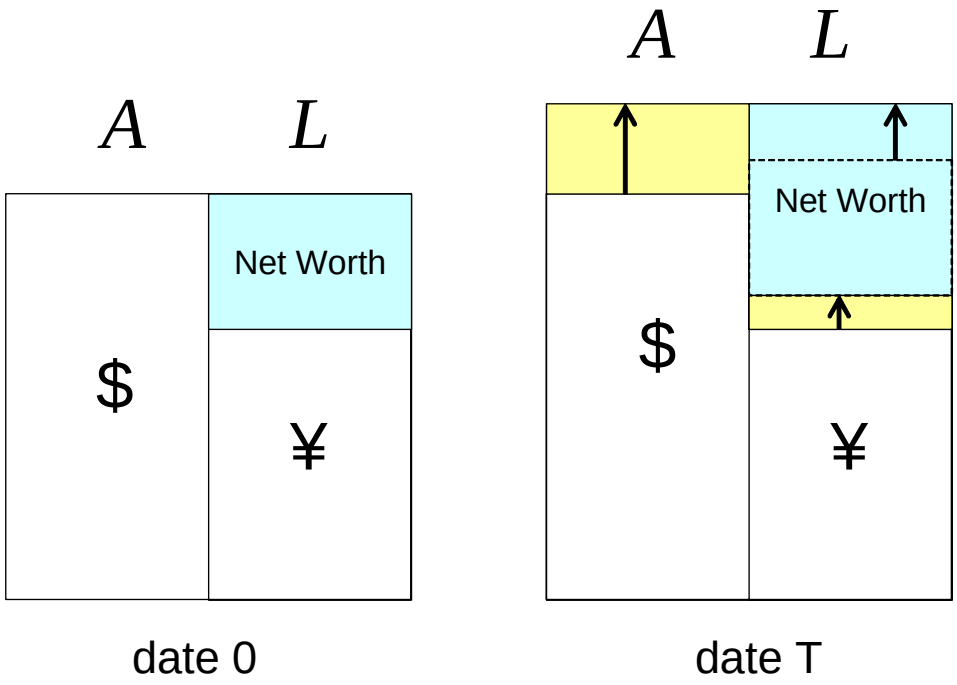
Carry Trades

Borrow yen at 1 percent and deposit proceeds in US dollars at 5 percent (or Kiwi dollar, Aussie dollar...). If the spot exchange rate remains unchanged, profit from interest rate differential.



(Strong) Failure of Uncovered Interest Parity

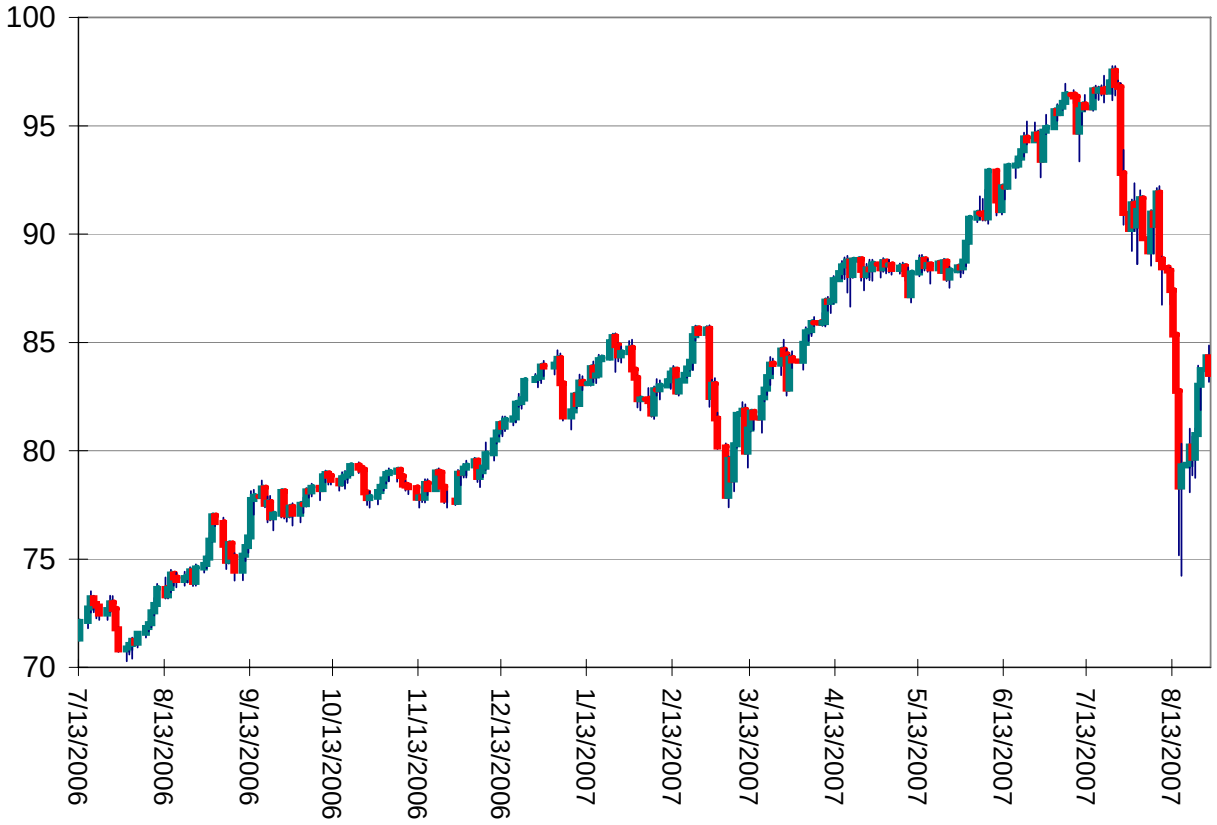
- Currency with *low* interest rate tends to *depreciate* relative to currencies with *high* interest rate.
- Carry trade gains from both
  - interest rate differential
  - exchange rate movement
- High Sharpe ratios that are difficult to square with risk premia (Backus et al. (2001), Burnside et al. (2006))

Reinforcement

Failure of uncovered interest parity is not only a **pre-condition** for carry trades, but is also a **consequence** of carry trades.

> "One obvious possibility is that the actions of carry traders are self-fulfilling; when they borrow the yen and buy the dollar, they drive the former down and the latter up."
>
> *Carry on Speculating*, Economist magazine, 2/22/07

"Up by the Stairs, Down in the Elevator": Example of NZD/JPY



Background

Central banks set short term interest rates with domestic monetary policy goals in mind (e.g. inflation targeting).

- FX traders face infinitely elastic demand/supply curves for short term funds at fixed interest rate

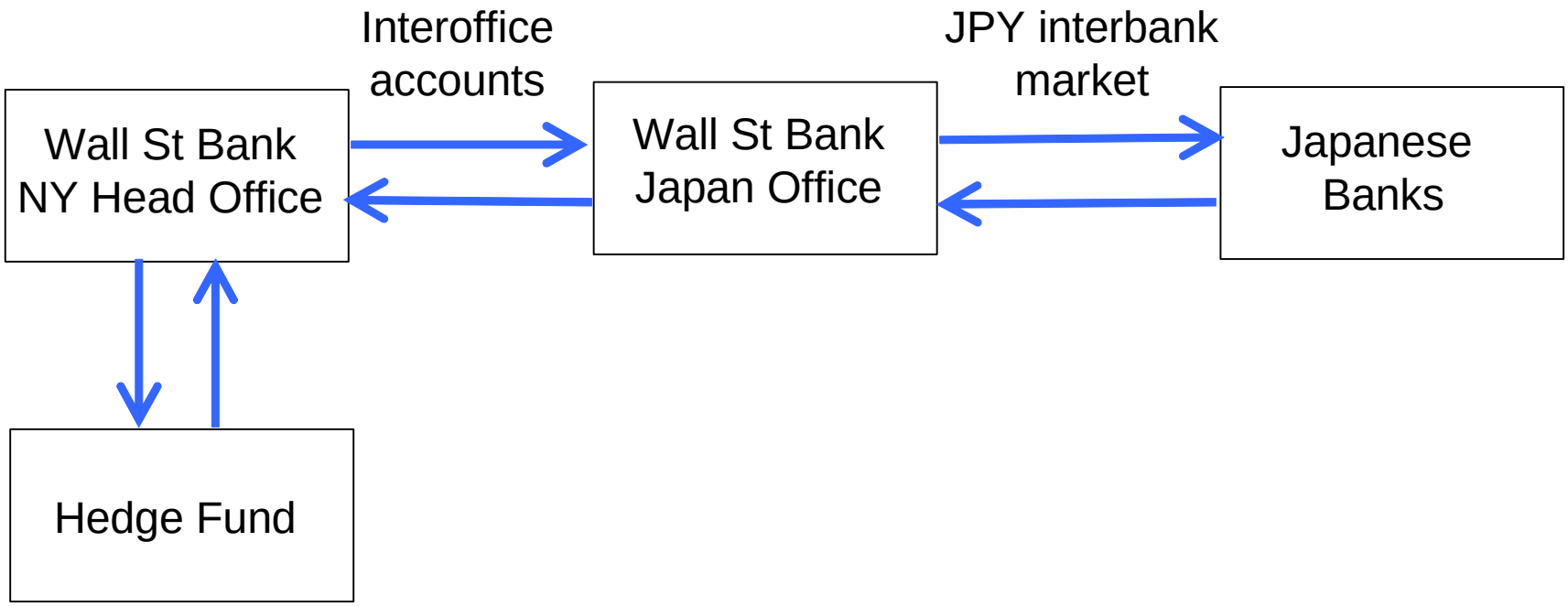
- By contrast, their carry trades have an impact on exchange rate

As traders pile into the carry trade, they move the exchange rate in their favor, magnifying any gain from the carry element.

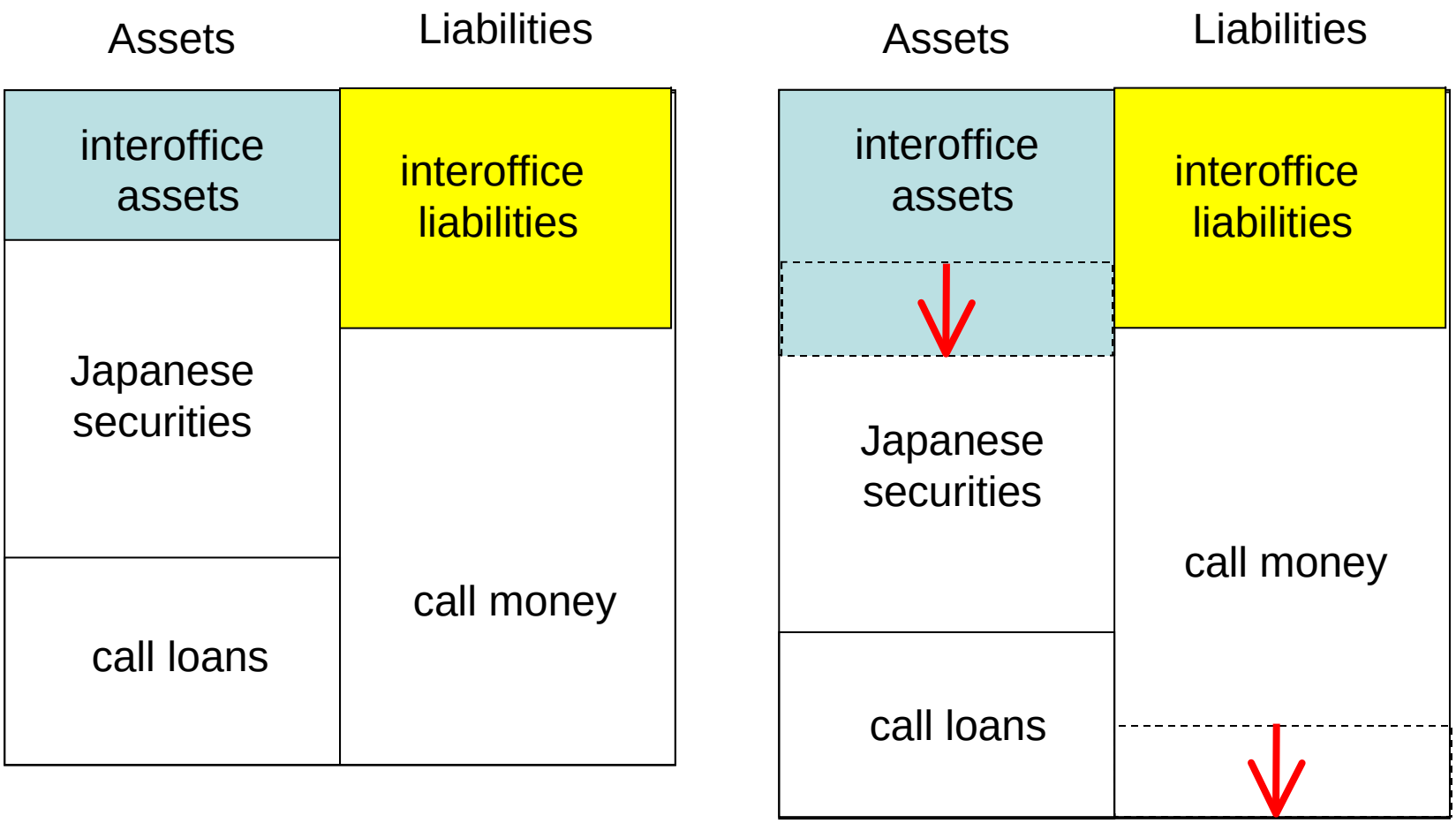
Can this story be told coherently in an economic model?

Further Background

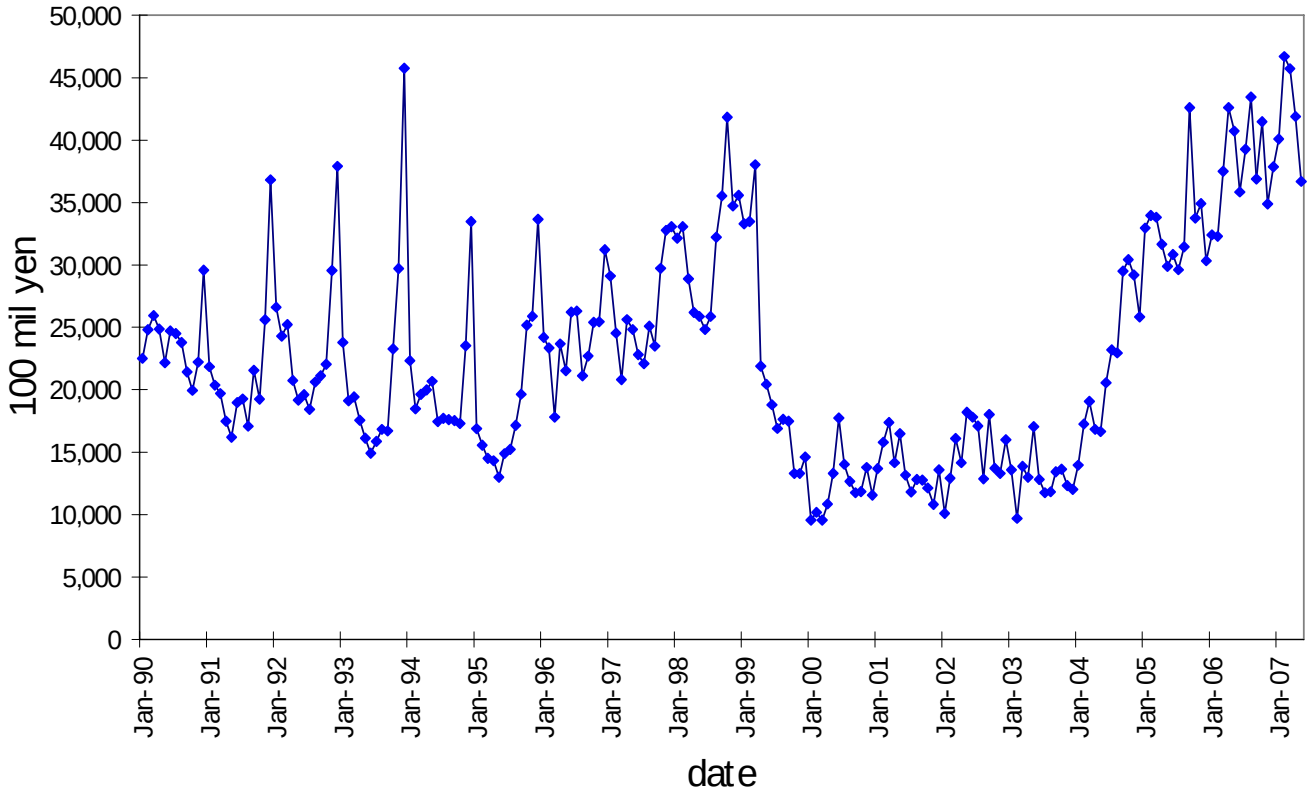
Following the trail of leverage bets



Interoffice Accounts

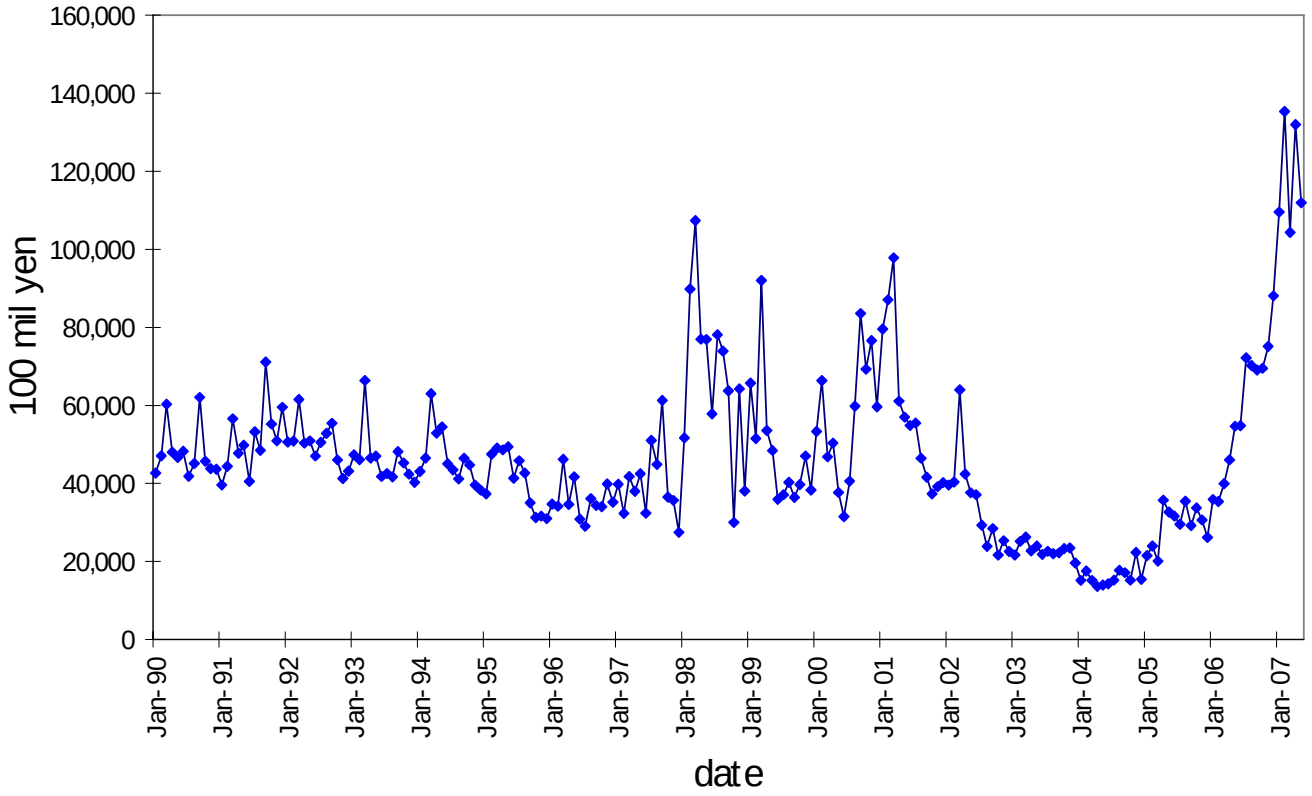


Interbank Assets of Foreign Banks in Japan



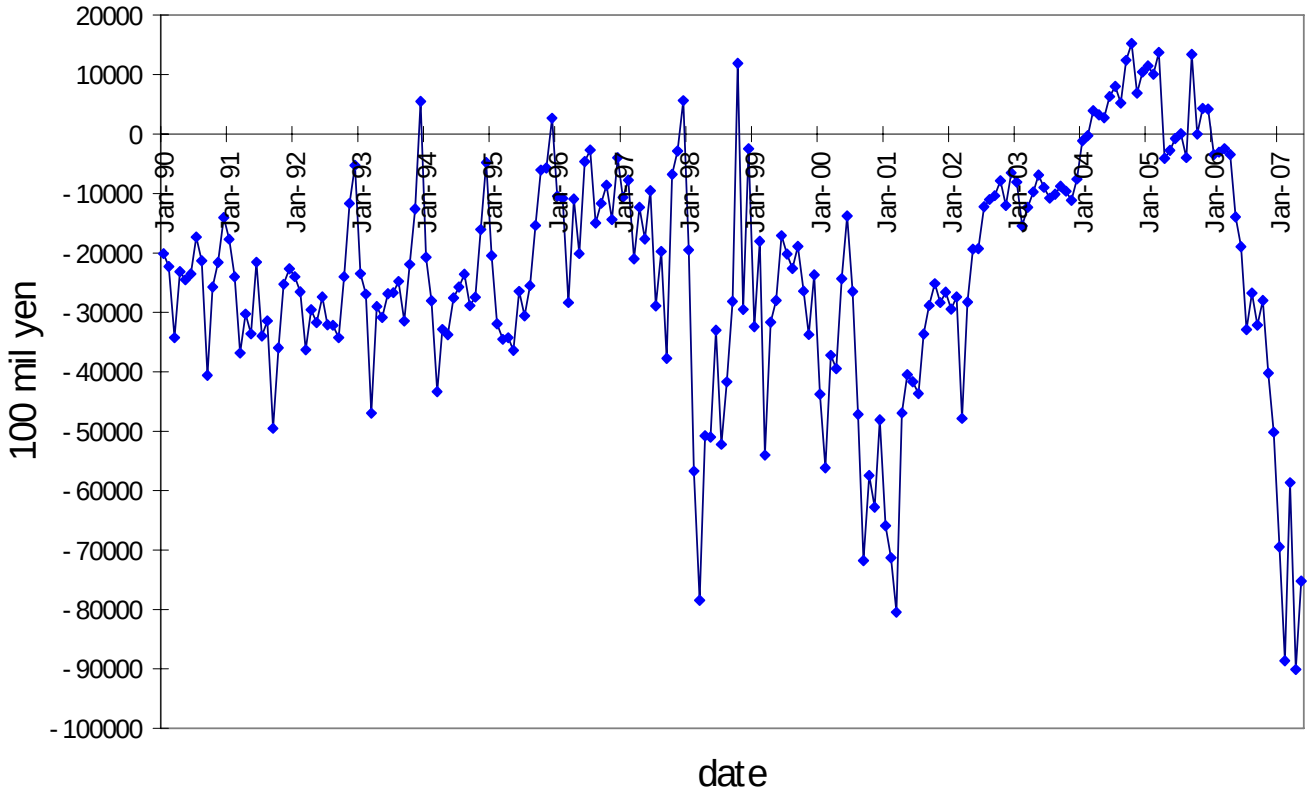
Interbank Assets (Call Loan) of Foreign Banks in Japan

Interbank Liabilities of Foreign Banks in Japan



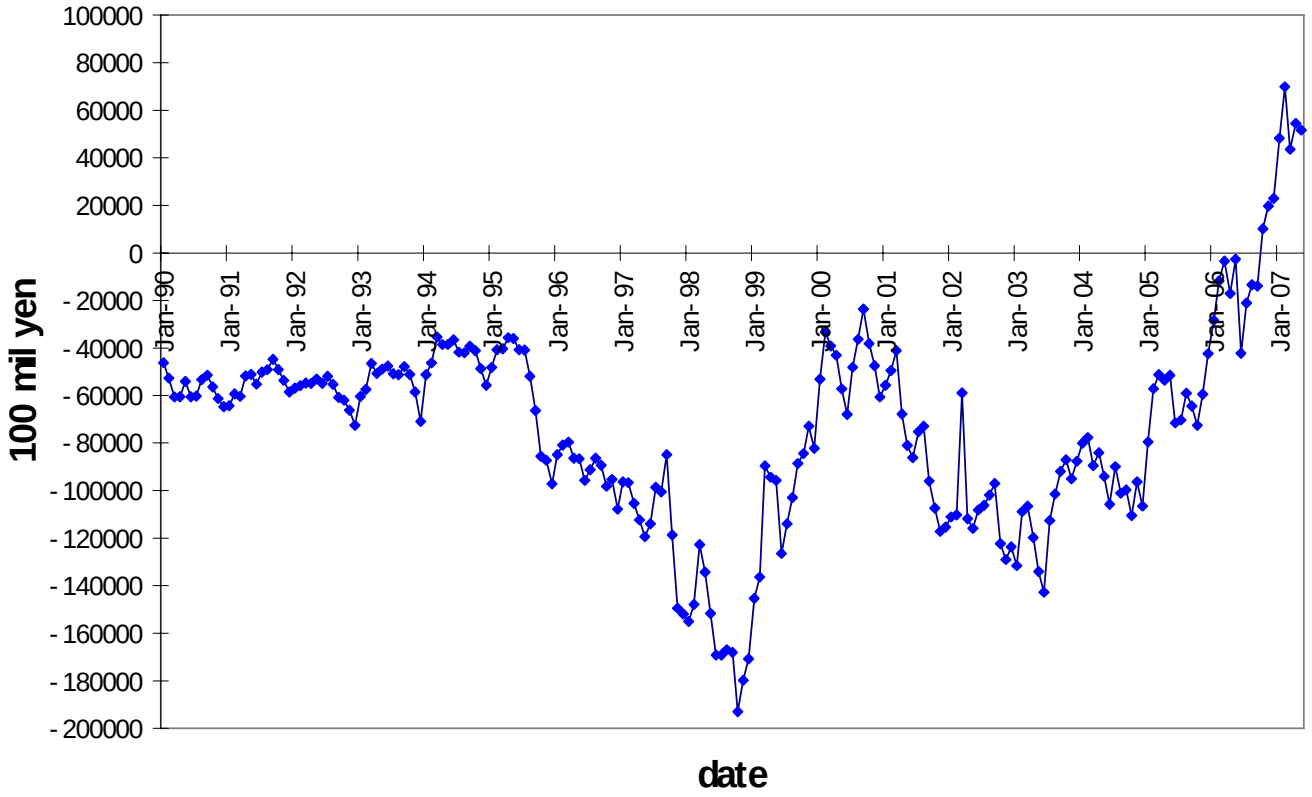
Interbank Liabilities (Call Money) of Foreign Banks in Japan

Net Interbank Assets of Foreign Banks in Japan



Net Interbank Assets of Foreign Banks in Japan

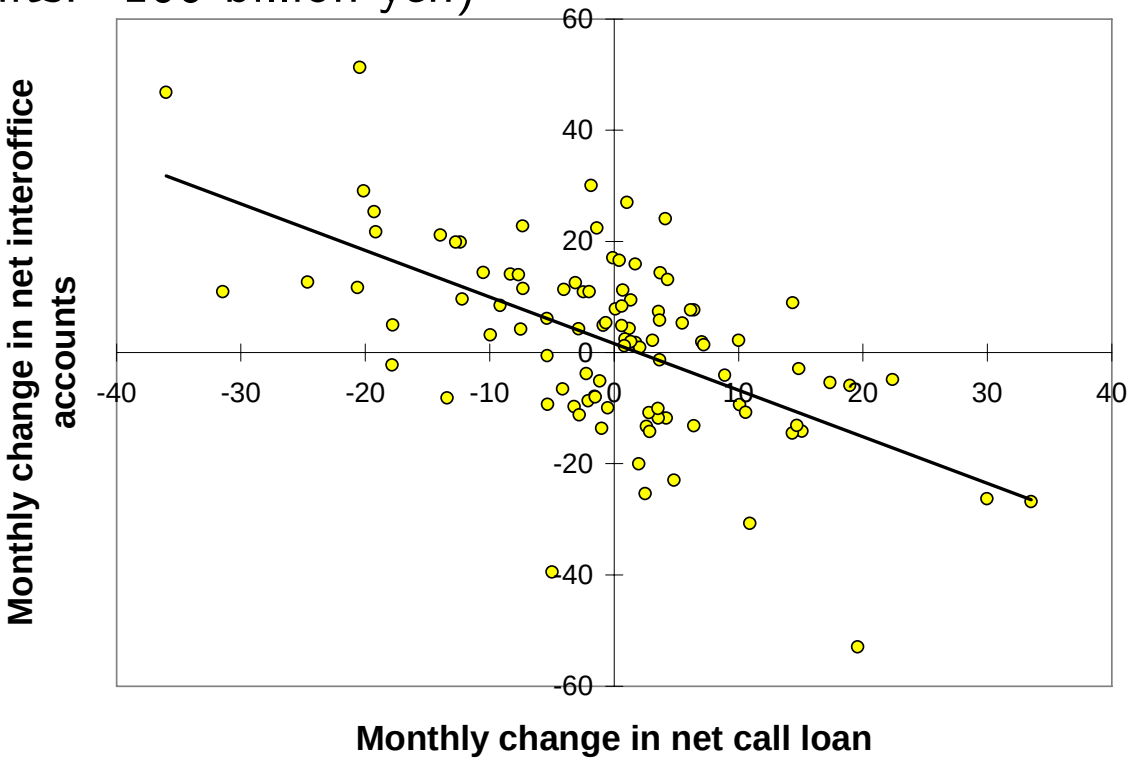
Net Interoffice Accounts of Foreign Banks in Japan



Net Interoffice Accounts of Foreign Banks in Japan

Channeling of Yen Liquidity out of Japan

Scatter chart of change in net interoffice accounts against change in net call loans (units: 100 billion yen)



Outline

- Baseline model
  - Long positions only, no carry element
  - Speculation can be ruled out in a strong sense
- Carry element and funding externalities
  - Speculators' actions can become *strategic complements*
  - Potential multiplicity of equilibrium
- Stochastic carry element
  - Unique, dominance solvable equilibrium
  - Speculative dynamics: "up by the stairs, down in the elevator"

1. Baseline Model

- Time is continuous, JPY is numeraire
- Binary choice (long only)
  - JPY deposit or USD deposit, no interest rate differential
  - p_t is price of dollars in yen (p_t is "dollar/yen" $\simeq 123$ at the moment)
- Fundamental anchor
  - exogenous stopping time at which p_t snaps back to fundamental value $v \in (0, 1)$ ("day or reckoning"), with Poisson arrival rate ρ
- Consumption only at the end

- Two types of agents:
  - traders, unit mass
  - dealers with heterogenous valuations provides residual demand/supply curves

$$p_t = x_t$$

  - x_t is proportion of traders who hold USD

- Small trading frictions: trading date arrives at Poisson rate λ
  - λ/ρ is expected number of trades before day of reckoning.
  - Let λ/ρ become large

Dominance Solution

For price path $(p_{t+u})_{u\geq 0}$, expected gain on USD is

$$\int_t^{\infty} (\lambda \underbrace{(p_{t+u} - p_t)}_{\text{speculative gain}} + \underbrace{\rho (v - p_t)}_{\text{fundamental risk}}) e^{-(\lambda+\rho)} du$$

Holding USD is *dominant* if expected gain is positive even in the worst case scenario (everyone holds JPY from t onwards)

$$\int_t^{\infty} (\lambda(p_t e^{-\lambda u} - p_t) + \rho (v - p_t)) e^{-(\lambda+\rho)} du \geq 0$$

USD is dominant if

$$p \leq \underline{p}^0 \equiv \frac{(1+2\theta) v}{(1+\theta)^2}$$

So, $\underline{p}^0$ is floor on p provided traders use undominated trading strategies.

New most pessimistic path:

$$\left(\max\left[\underline{p}^0, p_t e^{-\lambda u}\right]\right)_{u \geq 0}$$

gives new threshold $\underline{p}^1$. Iterating,

$$\underline{p}^0 \leq \underline{p}^1 \leq \underline{p}^2 \leq \cdots \leq \underline{p}^n \leq \cdots$$

with limit $\underline{p}$. Argument from "above" gives

$$\bar{p}^0 \geq \bar{p}^1 \geq \bar{p}^2 \geq \cdots$$

with limit $\bar{p}$, with $\underline{p} \leq \bar{p}$. We must also have

$$\underline{p} \geq v \geq \bar{p}$$

otherwise trader strictly prefers USD at $\underline{p}$ and JPY at $\bar{p}$. So, dominance solvable outcome

$$\underline{p} = v = \bar{p}$$

Speculation is stabilizing (Friedman (53))

Proposition. In the absence of carry element and leverage, speculation is stabilizing.

Externalities across Traders

- Expected gain to holding USD

$$\int_t^\infty [\lambda(\overset{\uparrow}{p_{t+u}} - \underset{\downarrow}{p_t}) + \rho(v - \underset{\downarrow}{p_t})]e^{-(\lambda+\rho)u}du.$$

- Preceding traders exert
  - *positive* externality by raising p_{t+u}
  - *negative* externality by raising p_t.

- Without carry element and leverage, the negative externality outweighs the positive externality

2. Carry Element and Leverage

- USD/JPY interest rate differential is δ

- Binary choice is between
  - Holding JPY deposit worth h dollars ($= h \cdot p_t$ yen)
  - Enter (or maintain) carry trade, given by balance sheet :

Assets	Liabilities
p_t USD	$h \cdot p_t$ Equity
	$(1-h)\, p_t$ JPY

(in JPY)

Assets	Liabilities
1 USD	h Equity
	$1-h$ JPY

(in USD)

- Flow payoff from carry trade (in JPY) is

$$(\delta - \Delta h)\, p_t$$

  - Δ is opportunity cost of capital
  - h is the "haircut" on the carry trade

- Traders have limited liability: losses limited to equity $h \cdot p_t$

- Expected return from carry element alone:

$$\frac{1}{p_t} \int_t^\infty p_t \cdot (\lambda + \rho)\, (\delta - \Delta h)\, u e^{-(\lambda+\rho)u} du$$

- Expected return from carry trade as a whole

$$\frac{1}{p_t}\int_t^{\infty}\left(\lambda \max\left\{p_{t+u}-p_t,-hp_t\right\}+\rho\max\left\{v-p_t,-hp_t\right\}\right)e^{-(\lambda+\rho)u}du$$

speculative gain *fundamental risk*

$$+\int_t^{\infty}(\lambda+\rho)\left(\delta-\Delta h\right)ue^{-(\lambda+\rho)u}du$$

expected carry

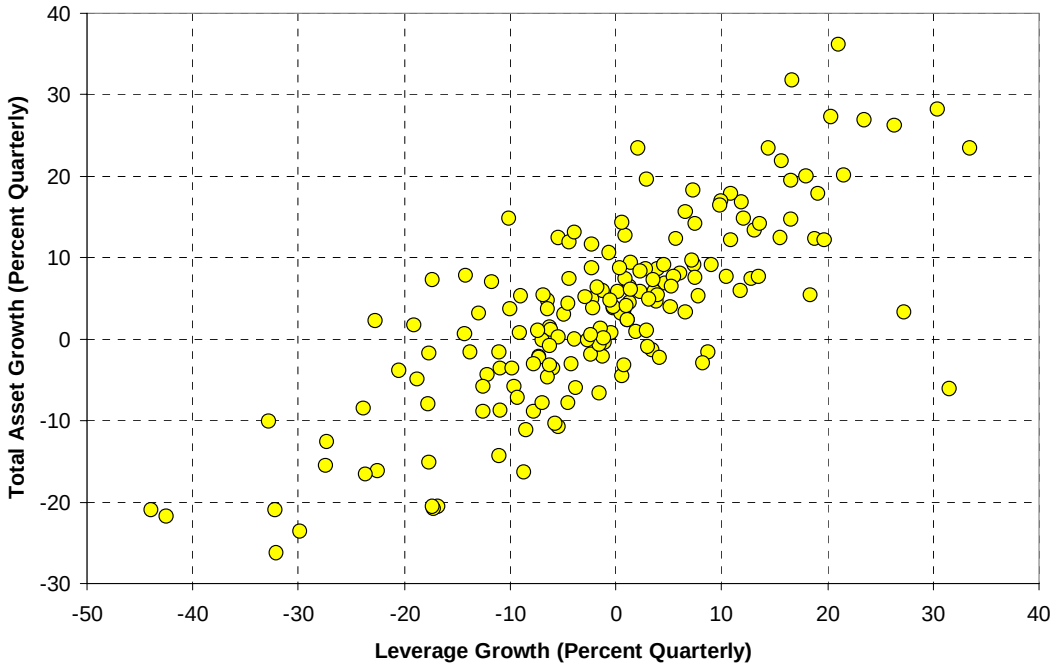
Funding Externality

Key assumption: h is decreasing in p_t

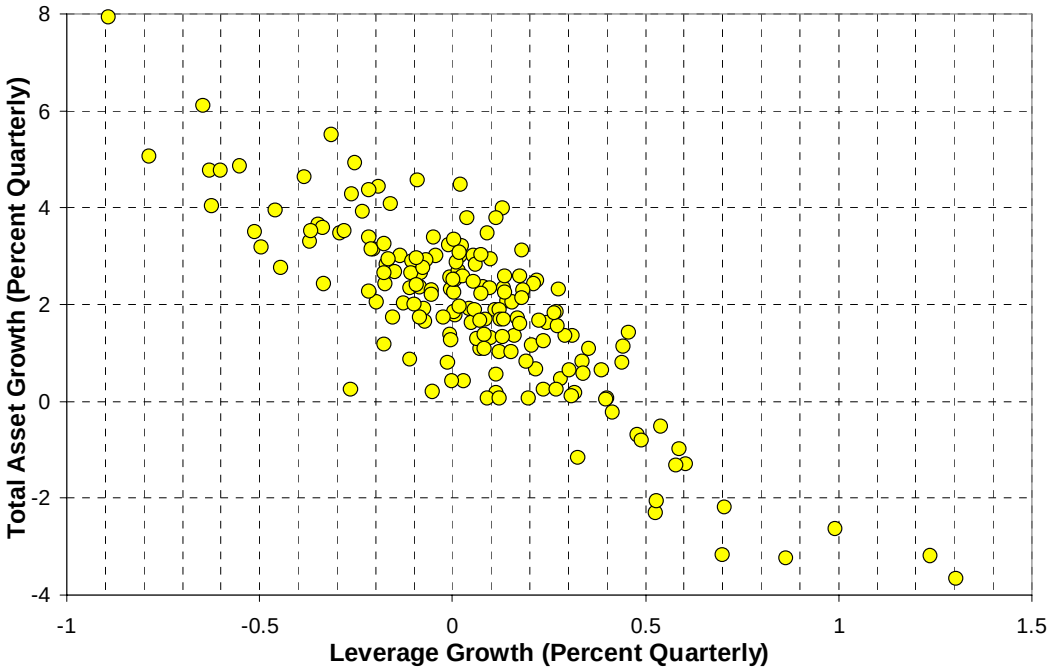
- Brunnermeier and Pedersen (2007)
- Haircut is small when asset prices are buoyant
- Leverage is high when balance sheets are large
- Leverage is pro-cyclical

Evidence on Procyclical Leverage

From Adrian and Shin (2007)

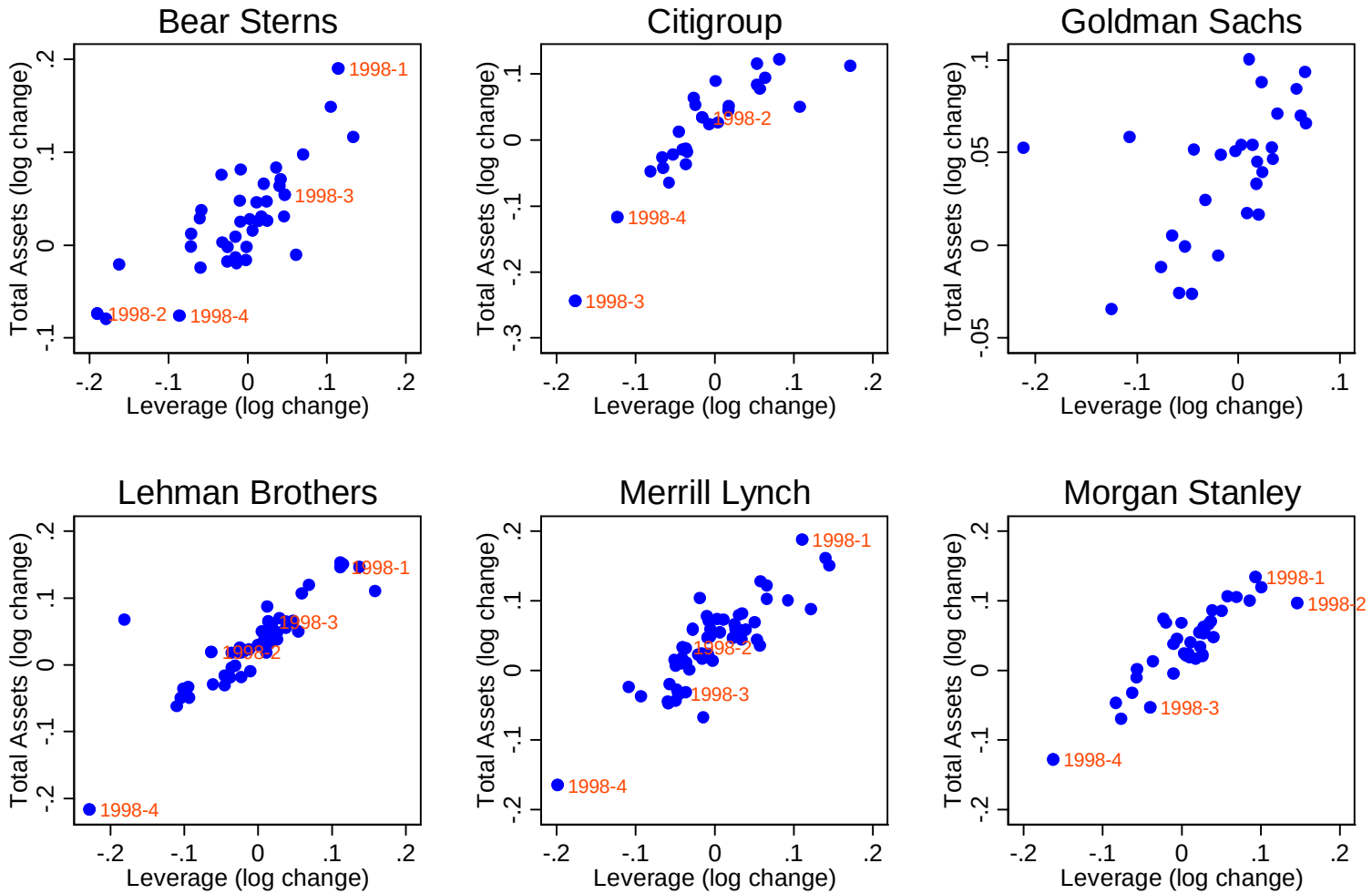


Security Dealers and Brokers , U.S. Flow of Funds (1963 - 2006)



Households, U.S. Flow of Funds (1963 - 2006)

Total Assets and Leverage



Value at Risk

Economic capital K meets total value at risk

$$K = V \times A$$

A is total assets

V is value at risk per unit of assets.

Leverage L satisfies

$$L = \frac{A}{K} = \frac{1}{V}$$

Procyclical leverage arise from *counter*-cyclical nature of value at risk.

Measured risk is low during booms and high during busts.

Multiple Equilibria

When h is decreasing in p, traders create positive funding externalities for each other

- Element of strategic complementarity
- If strategic complementarity is large enough, speculators' actions can become mutually reinforcing.

Proposition. When λ is large enough and ρ is small enough, there are multiple equilibria - either everyone engages in carry trade, or no-one engages in carry trade.

Intuition for Strategic Complementarity

Suppose everyone piles into carry trade.

Expected return from carry trade:

$$\frac{1}{p_t}\int_t^\infty (\lambda \max\{p_{t+u}-p_t,-hp_t\} + \rho \max\{v-p_t,-hp_t\})e^{-(\lambda+\rho)u}du$$

speculative gain *fundamental risk*

$$+\int_t^\infty (\lambda+\rho)(\delta-\Delta h)\,ue^{-(\lambda+\rho)u}du$$

expected carry

When λ is large, speculative gain is large

When ρ is small, fundamental risk is small, unless p_t is very large

But if p_t is large, expected carry is large

3. Stochastic Fundamentals

Same model, except USD/JPY interest differential satisfies:

$$\delta_t = \delta + \mu t + \sigma W_t$$

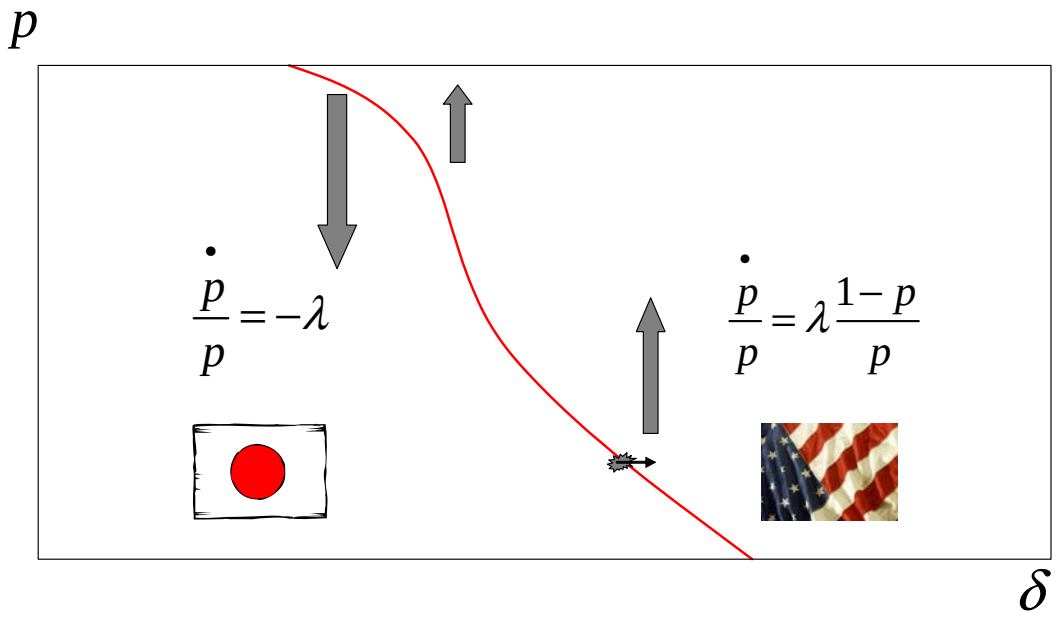
where W_t is standard Brownian motion

Plus some regularity conditions...

Proposition. When λ/ρ is large enough, there is a unique dominance-solvable outcome. There is a decreasing boundary $Z(p_t)$ such that a trader enters the carry trade at t if and only if

$$\delta_t \geq Z(p_t)$$

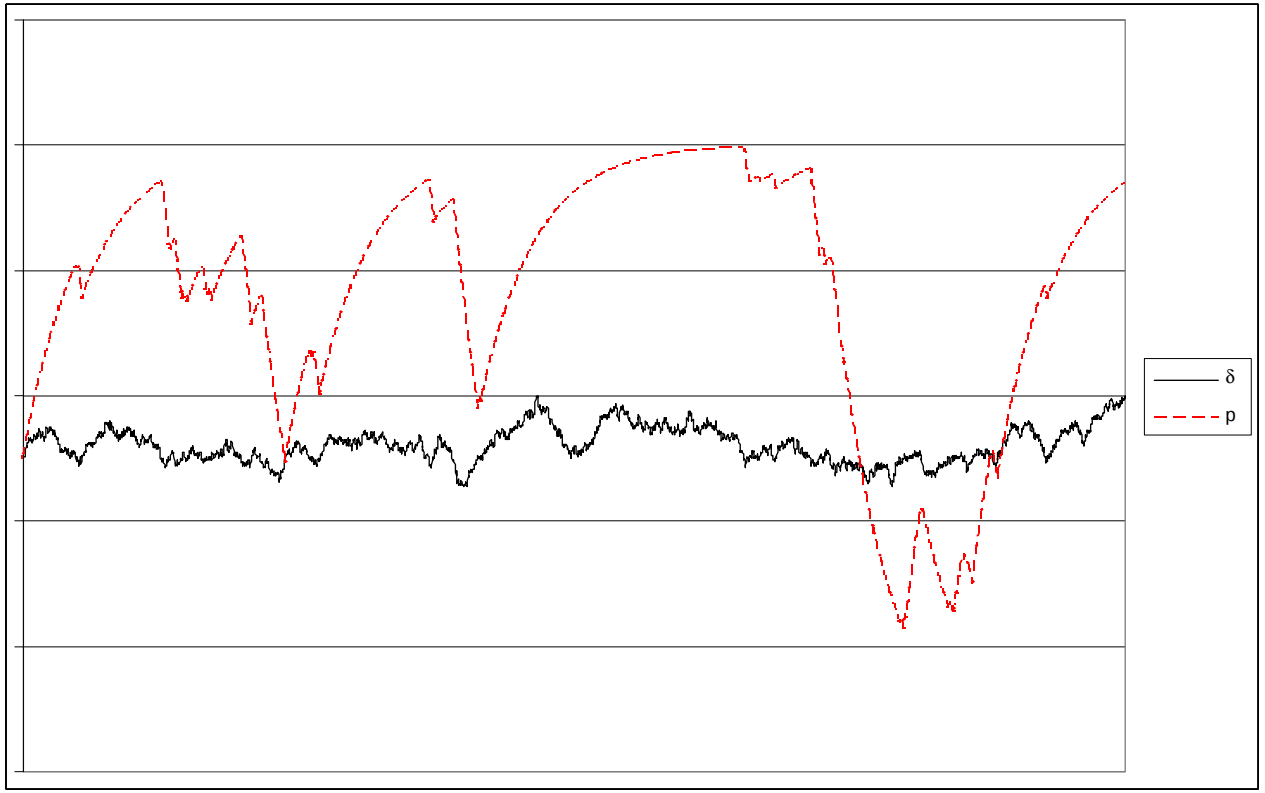
Speculative Dynamics



Price follows *stochastic bifurcation* (Burdzy et al. (1998))

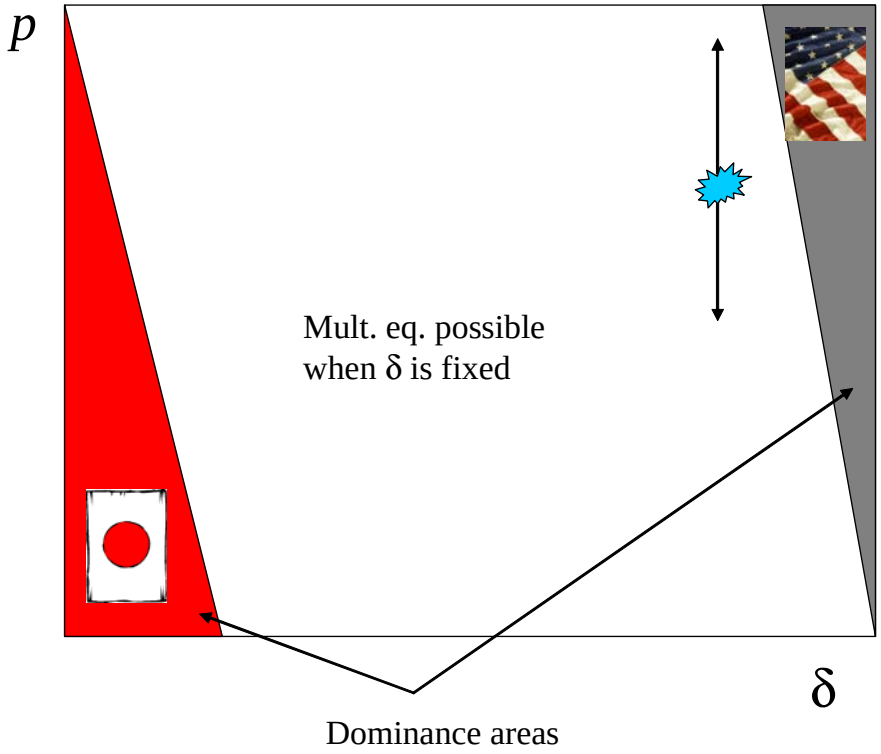
$$\dot{p}_t = \begin{cases} \lambda (1 - p_t) & \text{if } \delta_t > Z(p_t) \\ -\lambda p_t & \text{if } \delta_t \leq Z(p_t) \end{cases}$$

"Up by the stairs, down in the elevator"

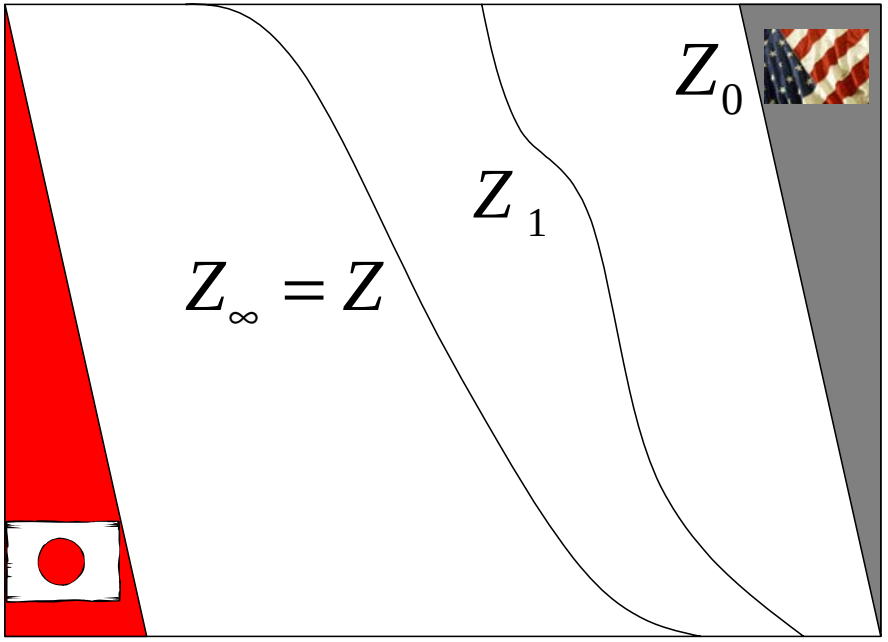


Sketch of Argument for Dominance Solvability

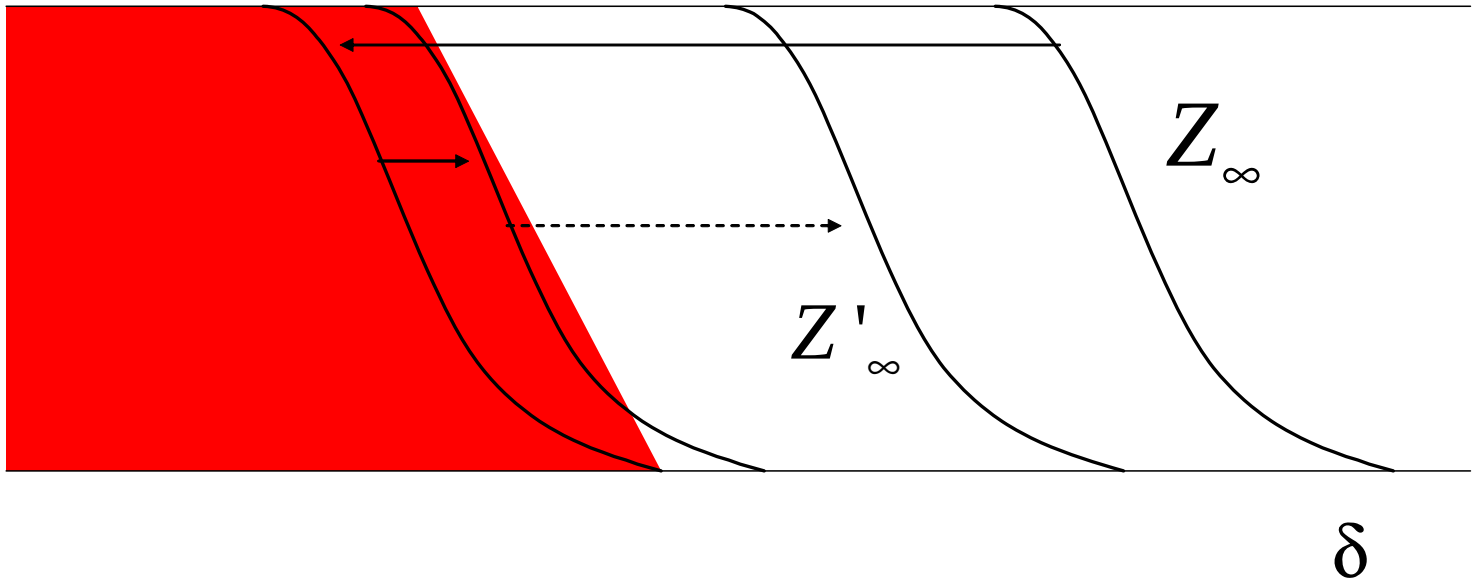
Construction follows Frankel and Pauzner (2000)



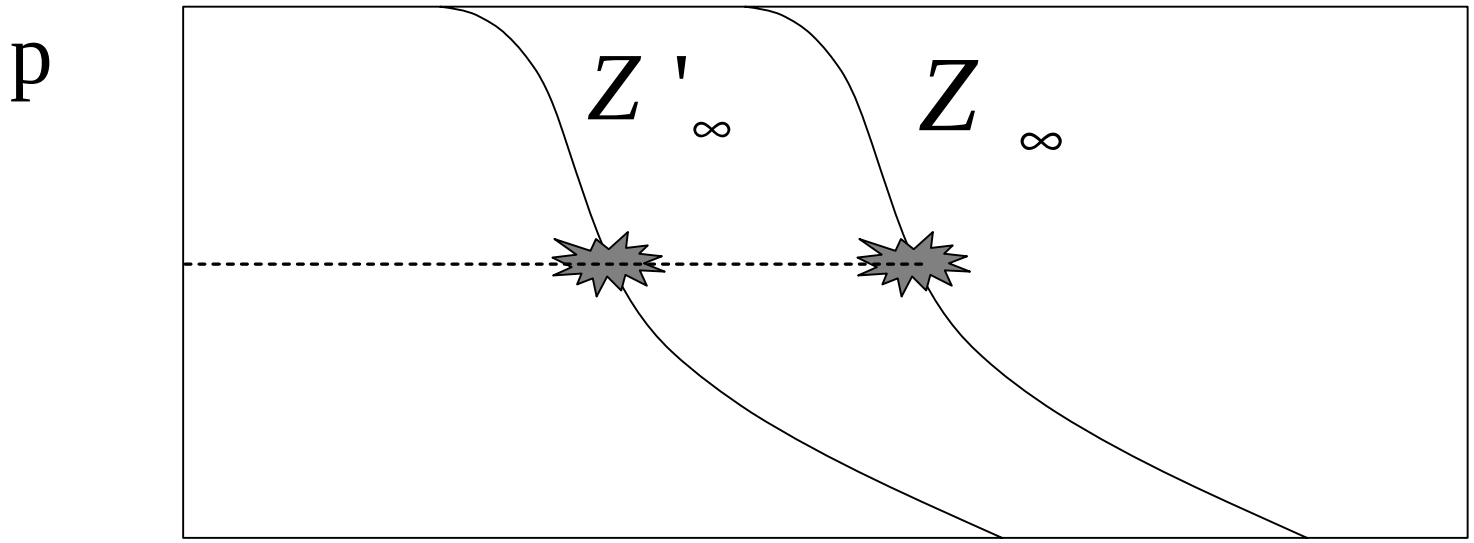
Step 1



Step 2



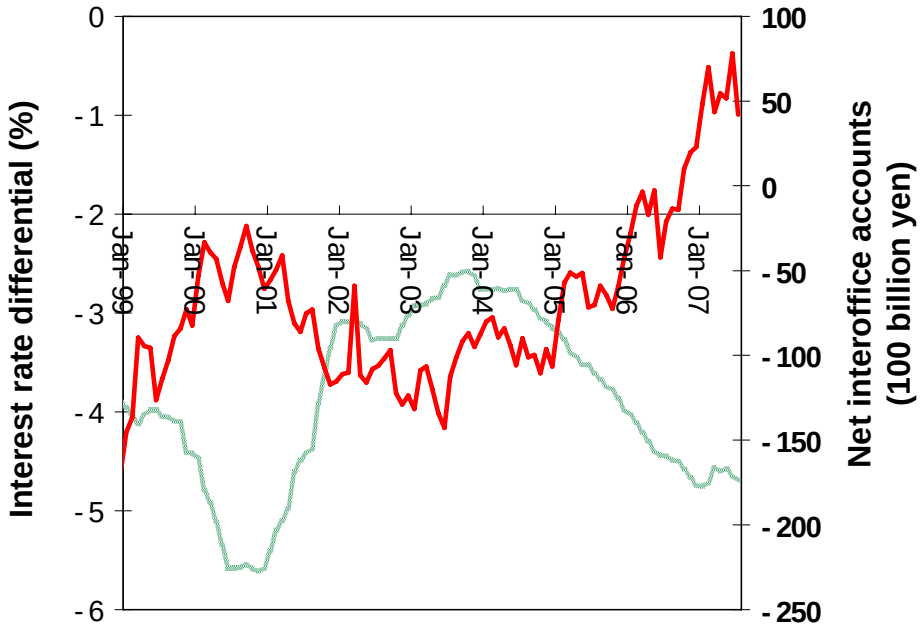
Step 3



$$Z'_{\infty} = Z_{\infty}$$

Interest Rate Differential

Net interoffice accounts and difference between overnight rates in Japan and simple average of USD, EUR and AUD overnight rates



Interest Rate Differential

Scatter chart of the net interoffice accounts and interest rate differential