Roadmap

- Motivation
  - UIP, Forward Premium Puzzle
  - Conditional Skewness

- Theory
  - “Overshooting/Bubble view”
  - “Undershooting view”

- Empirical evidence
Example of Carry Trade

- Yen-Aussie carry trade
  - Borrow at 0.87% JPY LIBOR 3 months
    “Funding currency”
  - Invest at 7% AUD LIBOR 3 months
    “Investment currency”
  - Hope that JPY doesn’t appreciate too much

- Using currency futures $F_t = S_t e^{i^* - i}$
  - Sell futures if $F_{t,T} > E_t[S_T]$
  - Buy futures if $F_{t,T} < E_t[S_T]$
Empirical: two stylized facts

1. Forward Premium Puzzle – Random Walk

- UIP (in risk-neutral world)
- “Fama regression” \( H_0: \alpha = 0, \beta = 1 \)
  \[
  \frac{S_{t+1} - S_t}{S_t} = \alpha + \beta \frac{F_t - S_t}{S_t} + \varepsilon_{t+1}
  \]
  Data (25 major currencies w.r.t. US$ 1976-2007 median)

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<th>( \hat{\alpha} )</th>
<th>( \hat{\beta} )</th>
<th>( R^2 )</th>
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<td>0.0007</td>
<td>-0.682</td>
<td>0.012</td>
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<td>(0.0025)</td>
<td>(0.727)</td>
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- Carry trade profitability is due to interest rate diff.
- Difficult to explain high Sharpe ratio as “risk premium”
- Backus et al. (2001), Burnside et al. (2006)
Empirical: two stylized facts

2. Cond. **Skewness** of exchange movements
   - “Going up by the stairs and down by the elevator”
Theory: two views

1. **Bubble (overshooting) view:**
   - Carry trades **delay** currency adjustments
   - Wile E. Coyote Effect *(Abreu-Brunnermeier 2002+03)*
Theory: two views united

2. Undershooting view:
   - Carry trade activity is limited due to funding liquidity risk
     Brunnermeier-Nagel-Pedersen (2008)
   - Both views lead to forward premium puzzle

- Next: United view
Theory: Stylized example

- Positive interest diff for random length
  - \( i^* - i > 0 \) from \( t=0 \) to \( t = t_0 + T' \), where
    - \( t_0 \) is random with \( F(t_0) = 1 - \exp\{-\lambda t_0\} \) with \( \lambda > (i^* - i) \)
    - \( T' \) is “large”
  - \( i^* = i \), otherwise

- Exchange rate
  - \( S(t_0) = S(t + T') = 1 \)
Theory: frictionless benchmark

\[ S \]

\[ t \]

\[ t_0 \]

\[ t_0 + T' \]
Theory: frictionless benchmark

- **After knowing** $t_0$
  - UIP implies $S(t \mid t_0) = Ae^{-(i^*-i)t}$ s.t. $S(t_0 + T' \mid t_0) = 1$
  - Hence, $S(t \mid t_0) = e^{(i^*-i)(t_0 + T' - t)}$

- **Before knowing** $t_0$
  - $S(t) = S(0)$ due to exponential structure
  - $S(0)$ is given by UIP

\[
\Delta_t \lambda \frac{S(0) - S(t_0 \mid t_0)}{S(0)} S(0) = (1 - \Delta_t \lambda)(i^* - i) \Delta_t S(0)
\]

\[
S(0) = \frac{\lambda}{\lambda - (i^* - i)} e^{(i^* - i)T'}
\]

Note for $\lambda < (i^* - i)$, $E(0)$ goes to infinity
Theory: frictions

S

undershooting

t₀

overshooting

t₀ + T'

crash
Theory: frictions

UIP is violated in both “views”

funding friction
synchronization friction

undershooting
overshooting
Theory: “bubble view” first

- common action of \( \kappa \) arbitrageurs
- sequential awareness
  (random \( t_0 \) with \( F(t_0) = 1 - \exp\{\lambda t_0\} \))
- position limits

\[
S_0 \quad \text{random starting point}
\]
\[
t_0 \quad \kappa \text{ traders are aware of the overshooting}
\]
\[
(t_0 + \eta \kappa) \quad \text{all traders are aware of the overshooting}
\]
\[
t_0 + T' \quad 1/\eta
\]

\[
\exp((r-i)(t_0 + T' - t))
\]
Focus on
- “when does currency crash occurs” (carry trade returns are skewed)
- one random variable \( t_0 \), all other variables are CK

Cash Payoffs (difference)
- Exit carry trade at \( t - \Delta \) instead of at \( t \).

\[
S_{t-\Delta} e^{r\Delta} - S_t
\]

where \( S_t = S_0 \) prior to crash vs. \( e^{(i^*-i)(t_0+T'-t)} \) after crash

Risk-neutrality but max/min stock position
- max long position
- max short position
- due to capital constraints, margin requirements etc. (more details later)
Theory: exit condition

- Exit carry trade iff
  \[ \Delta_i h(t \mid t_i) \frac{S_0 - e^{(i^* - i)(t_0 + T' - t)}}{S_0} \geq (1 - \Delta_i h(t \mid t_i))(i^* - i)S_0\Delta_i \]
  
  Suffer currency crash \hspace{2cm} Cash in interest rate differential

  \[ h(t \mid t_i) \geq \frac{[i^* - i]}{[1 - e^{(i^* - i)(T' - T)/S_0}]}, \]

  where \( t_0 + T = \text{time of (endogenous) currency crash} \)
  \( T \text{ is known in equilibrium} \)

- RHS is “greed-to-fear ratio”
Sequential Awareness

Distribution of $t_0$

Distribution of $t_0 + T$
(time of currency crash)

trader $t_i$

since $t_i \leq t_0 + \eta$
since $t_i \geq t_0$

$t_0$

$t_0 + T$
Sequential Awareness

Distribution of $t_0$

since $t_i \leq t_0 + \eta$

Distribution of $t_0 + T$
(time of currency crash)

since $t_i \geq t_0$

trader $t_i$

trader $t_j$

$t_j - \eta$

$t_j$

$t_0$

$t_0 + T$
Sequential Awareness

Distribution of $t_0$

- $t_i - \eta$ since $t_i \leq t_0 + \eta$
- $t_i$ since $t_i \geq t_0$

Distribution of $t_0 + T$
(time of currency crash)

- $t_0$
- $t_k$
- $t_0 + \bar{\tau}$
Conjecture: immediate attack

⇒ Crash at $t_0 + \eta \kappa$

when $\kappa$ traders are aware
Conjecture: immediate attack

\[ \Rightarrow \text{ Crash at } t_0 + \eta \kappa \]

when \( \kappa \) traders are aware

If \( t_0 < t_i - \eta \kappa \), the bubble would have burst already.
Conjecture: immediate attack

\[ \Rightarrow \text{ Crash at } t_0 + \eta \kappa \]

when \( \kappa \) traders are aware

Distribution of \( t_0 \)

\[ \lambda / (1 - e^{-\lambda \eta \kappa}) \]

\[ t_i - \eta \quad \quad t_i - \eta \kappa \quad \quad t_i \]

If \( t_0 < t_i - \eta \kappa \), the bubble would have burst already.
Conjecture: immediate attack

⇒ Crash at $t_0 + \eta \kappa$

when $\kappa$ traders are aware

If $t_0 < t_i - \eta \kappa$, the crash would have already happened.
Conjecture: immediate attack

Crash at $t_0 + \eta \kappa$

Distribution of $t_0$

$t_i - \eta$
$t_i - \eta \kappa$
$t_i$
$t_i + \eta \kappa$

$\lambda/(1-e^{\lambda \eta \kappa})$
Conjecture: immediate attack

Crash at $t_0 + \eta \kappa$

Distribution of $t_0$

\[ \lambda/(1-e^{-\lambda \eta \kappa}) \]

crash for sure!
Conjecture: immediate attack

Crash at $t_0 + \eta \kappa$
Conjecture: immediate attack

Crash at $t_0 + \eta \kappa$
Conjecture: immediate attack

Crash at $t_0 + \eta \kappa$

hazard rate of crash

$$h = \frac{\lambda}{1 - \exp\{-\lambda(t_0 + \eta \kappa - t)\}}$$

Distribution of $t_0$

$\frac{\lambda}{1 - e^{\lambda \eta \kappa}}$

$t_i - \eta$

$t_i - \eta \kappa$

$t_i$

$t_i + \eta \kappa$

crash for sure!
Conjecture: immediate attack

Crash at $t_0 + \eta \kappa$

hazard rate of the bubble
$h = \lambda/(1 - \exp\{-\lambda(t_i + \eta \kappa - t)\})$

Recall exit condition:
$h(t|t_i) \geq [i^*-i]/[1 - e^{(i^*-i)(T'-T)/S_0}]$

where $T = \eta \kappa$

Distribution of $t_0$
Conjecture: immediate attack

Crash at $t_0 + \eta \kappa$

hazard rate of the bubble
$h = \lambda/(1 - \exp\{-\lambda(t_i + \eta \kappa - t)\})$

Recall exit condition:
$h(t|t_i) \geq [i^* - i]/[1 - e^{(i^* - i)(T' - T)/S_0}]$

Distribution of $t_0$

$\lambda/(1 - e^{\lambda \eta \kappa})$

optimal time to attack $t_i + \tau_i$ ⇒ “delayed attack is optimal”
Preliminary results

- Immediate price correction is not an equilibrium
- Mispricing grows over time
Equilibrium delay $\tau^*$

$\Rightarrow$ Crash at $t_0 + T = t_0 + \eta \kappa + \tau^*$

Hazard rate of crash

$h = \lambda / (1 - \exp{-\lambda (t_i + \eta \kappa + \tau' - t)})$

Equilibrium delay $\tau^*$

Greed $(i^* - i) /

Fear \quad 1 - e^{(i^* - i)(T' - T)} / S_0$

$t_i - \eta \quad t_i - \eta \kappa \quad t_i \quad t_i - \eta + \eta \kappa + \tau^* \quad t_i + \tau^* \quad t_i + \eta \kappa + \tau^*$

Conjectured attack

Optimal
Results: delay $\tau^* + \text{crash}$

- Proposition
  - Each speculator only exits its carry trade $\tau^*$ periods after learning that the exchange rate is too high, i.e. at $t_i + \tau^*$, where
    \[
    \tau^* = T' - \frac{1}{i^*-i} \left\{ \ln S_0 + \ln \left[ 1 - \frac{1 - e^{-\lambda \eta \kappa}}{\eta \kappa} (i^*-i) \right] \right\} - \eta \kappa
    \]
  - The exchange rate correction occurs at
    \[
    T = \tau^* + \eta \kappa = T' - \frac{1}{i^*-i} \left\{ \ln S_0 + \ln \left[ 1 - \frac{1 - e^{-\lambda \eta \kappa}}{\lambda} (i^*-i) \right] \right\}
    \]
  - Size of crash is
    \[
    (i^*-i) \frac{1 - e^{-\lambda \eta \kappa}}{\lambda} S_0
    \]

- Proposition (Comparative Static)
  - Crash size is increasing $(i^*-i)$, $\eta$, $\kappa$, $S_0$ (less undershooting, more overshooting)
  - Delay of price correction is increasing in $S_0$
    - Fear: larger crash size leads to earlier correction
    - Greed: larger $(i^*-i)$ makes carry trades more profitable

- Negative skewness of carry trade returns
Lack of common knowledge

⇒ standard backwards induction can’t be applied

If one interprets $\eta$ as difference in opinion, lack of common knowledge gets a different meaning too.

$\kappa$ traders know of overshooting

(same reasoning applies for $\kappa$ traders)
Synchronizing events

- Most sharp price movements occur without fundamental news
- Example: Dollar/Yen Oct 7/8, 1998

- Fair (2002): no news on most crashes
Synchronizing events

- News may have an impact disproportionate to any intrinsic informational (fundamental) content
  - News can serve as a synchronization device

- Fads & fashion in information
  - Which news should traders coordinate on?

- When “synchronized attack” fails, the crash is even further postponed
Synchronizing events

- Exchange rate drop as a synchronizing event
  - through psychological resistance line
  - by more than, say 5%

- Exogenous price drop
  - after a price drop
    - if mispricing is ripe
      $\implies$ crash occurs and price drops further
    - if mispricing is not ripe yet
      $\implies$ exchange rate bounces back and the mispricing is strengthened for some time
“Bubble view” – take aways

- Bubbles
  - Dispersion of opinion among arbitrageurs causes a synchronization problem which makes coordinated price corrections difficult
  - Arbitrageurs time the market and continue carry trades
  - Exchange rate distortions persist and crashes are larger
    - Wile E. Coyote effect
    - Sknewness

- Crashes
  - can be triggered by unanticipated news without any fundamental content, since
    - it might serve as a synchronization device.

- Crash is larger for larger interest rate differential

- Even more extreme view: “Carry trades CAUSE bubbles”
Roadmap

- Motivation
  - UIP, Forward Premium Puzzle
  - Skewness

- Theory
  - “Overshooting/Bubble view”
  - “Undershooting view”

- Empirical evidence
“Underreaction view”

UIP is violated in both “views”

funding friction

synchronization friction

undershooting

overshooting
Illiquidity arises due to frictions which
- prevent fund flows to investors with expertise
- limits optimal risk sharing

Causes of frictions
- asymmetric information
  - market breakdowns/credit rationing, market for lemons
- non-verifiable info - incomplete contracts/markets

Funding liquidity frictions = limits to arbitrage

Speed of arbitrage (dynamic)
- experts only build up capital slowly ...
Flavors of Funding Liquidity

- **Margin funding risk**
  - Margin has to be covered by HF’s own capital
  - Margins increase at times of crisis

- **Rollover risk**
  - Inability to roll over short-term commercial paper

- **Redemption risk**
  - Outflow of funds for HF's and banks
Funding constraint

- So far, simple position limits
  - to ensure that not a single market participant alone can cause crash

- Now, more specific
  - Margins
    - Buy AUS on margins $m_{AUS}^+ = \text{VaR}(AUS)$
    - Borrow JPY on margins $m_{JPY}^- = \text{VaR}(JPY)$
      \[
      \sum_j x_t^{j+} m_t^{j+} + x_t^{j-} m_t^{j-} \leq W_t
      \]
  - With cross-margining (portfolio margining)
    \[
    M(x_t^1, \ldots, x_t^J) \leq W_t
    \]
Funding constraint

- Exchange margins
- Regulatory Capital Requirements
  - Basel accord: banks
  - SEC Net Capital Rule: brokers
  - Regulation T: customers of brokers
Balance Sheet Channel

- **Borrowers’ balance sheet** — Brunnermeier-Pedersen (2008)

  - **Loss spiral**
    - Net wealth > $\alpha x$
    - for asym. info reasons
    - (constant or increasing leverage ratio)
    - Bernanke-Gertler, ...

  - **Margin spiral**
    - (forces to deleverage)

- Both spirals reinforce each other

Source: Brunnermeier & Pedersen (2008)
## Margin spirals

### Margins/Haircuts:

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<tr>
<td><strong>Bond</strong></td>
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<tr>
<td>Investment grade</td>
<td>0-3</td>
<td>3-7</td>
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<tr>
<td>High yield</td>
<td>0-5</td>
<td>10+</td>
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<td><strong>Leveraged Loan</strong></td>
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<td>Senior</td>
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<td>15-20</td>
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<td>18-25</td>
<td>30+</td>
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<tr>
<td>Equity</td>
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Source: Citigroup, IMF Stability report 2007
Margin Spiral

CME’s Margins for S&P 500 Futures

- Black Monday: 10/19/87
- US/Iraq war
- LTCM
- 1989 mini crash
- Asian crisis
1. **Volatility of collateral increases**
   - Permanent price shock is accompanied by higher future volatility (e.g. ARCH)
     - Realization how difficult it is to value structured products
   - Value-at-Risk shoots up
   - Margins/haircuts increase = collateral value declines
   - Funding liquidity dries up
   - Note: all “expert buyers” are hit at the same time, SV 92

2. **Adverse selection of collateral**
   - As margins/ABCP rate increase, selection of collateral worsens
Margin Spiral – Increased Vol.

\[ v_t = v_{t-1} + \Delta v_t = v_{t-1} + \sigma_t \varepsilon_t \]
\[ \sigma_{t+1} = \sigma + \theta |\Delta v_t| \]
Margin - VaR

\[ \pi = \Pr (- \Delta S_{t+1} \leq m_t) = 1 - \Phi \left( \frac{m_t}{\sigma_{t+1}} \right) \]

\[ m_t = \sigma_{t+1} \Phi^{-1}(1-\pi) \]

Recall that due to ARCH effect

\[ \sigma_{t+1} = \sigma + \theta |\Delta v_t| \]

if financiers (margin setters)

- Do not observe liquidity shocks
- Liquidity shocks are rare then
  \[ \sigma_{t+1} = \sigma + \theta |\Delta S_t| \]

Positions \[ x^+_t \leq \mathcal{W}_t / m^+_t \]
$$x_1 < W_1/m_1 = W_1/\left(\sigma + \bar{\theta}|\Delta p_1|\right)$$

customers’ supply
Results

- Backward bending demand curves
  - Due to forced deleveraging
- Discontinuous prices – fragility
- Amplification - spiral
Deleveraging of I-Banks

Leverage and Total Assets Growth
Asset weighted, 1992Q3-2008Q1. Source: SEC

Source: Adrian-Shin (2008)

Evidence for margin spiral
Skewness: unwinding of carry trades

- Early unwinding of carry trades
  - since funding constraint binds
  - crowded trades
- Adverse fundamental movement
  - good news on funding currency
  - losses for carry trade speculators on other trades (VIX)
- Funding liquidity tightens — forces unwinding of carry trades
- Note asymmetry: good news for investment currency relaxes constraint
- Conditional skewness of exchange rate

- Ex-ante: funding liquidity risk
  - Pricing kernel is given by shadow cost of binding funding constraint (not risk aversion given by utility function)
**Undershooting view - takeaways**

- **Skewness** is due to forced unwinding of carry trades (sign of congestion)
  - Note carry trades are leveraged positions
- **Undershooting** is due to danger of potential future unwinding of carry trades
  - Limits to arbitrage – funding liquidity risk
  - Pricing kernel is given by shadow costs of funding liquidity (Lagrange multiplier $\phi_{t+1} = 1 + $ expected profit from extra $)
    \[
    S_t = E\left[ \frac{\phi_{t+1}}{E[\phi_{t+1}]} S_{t+1} \right] \quad \text{for } \phi_t = 1
    \]
  - **Not** by risk aversion – curvature of utility function
  - Hint: difference hedging demand – since adverse shocks lead to unwinding, cautious ex-ante
More related theoretical research

- Afonso (2007)
  - AB framework applied to currency attacks

- Plantin-Shin (2008)
  - Carry trades cause bubble
  - Margin spiral à la BP(2008) needed
  - Strategic complements + trading friction
  - Assumes no exchange rate jumps
    - assumed underreaction

- Farhi-Gabaix (2008)
  - Skewness is due to rare (fundamental) events
Empirical Analysis is next

- .... New set of slides ...