Liquidity in the Foreign Exchange Market: Measurement, Commonality, and Risk Premiums

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Motivation

- Liquidity
  - key concept (LTCM, Subprime crisis, etc.)
  - relevant for investors, central bankers, regulators, etc.
- Liquidity in equity and bond markets studied extensively
- Only very few studies on FX liquidity (paucity of data)
- Liquidity in FX market important
  - Currency traders averse to liquidity shocks
  - Liquidity spirals aggravate currency crashes
  - International diversification through FX positions typically unhedged (only about 30% of FX risk is hedged)
  - etc.

Outline

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Foreign Exchange market

- Large market:
  - average daily turnover 4 trillion USD (BIS 2010)
  - $>$ 10-time daily turnover global equity markets (WFE 2009)
- Large variety of FX traders world-wide:
  central bankers, institutional traders, fund managers, daily traders, etc., algorithmic
- Open 24 hours a day
- FX spot market fragmented structure with several trading venues: dealer, broker, mixed dealer-broker, over-the-counter, internet, etc.
- Two leading trading platforms:
  Electronic Broking Services (EBS) and Reuters

Electronic Broking Services (EBS)

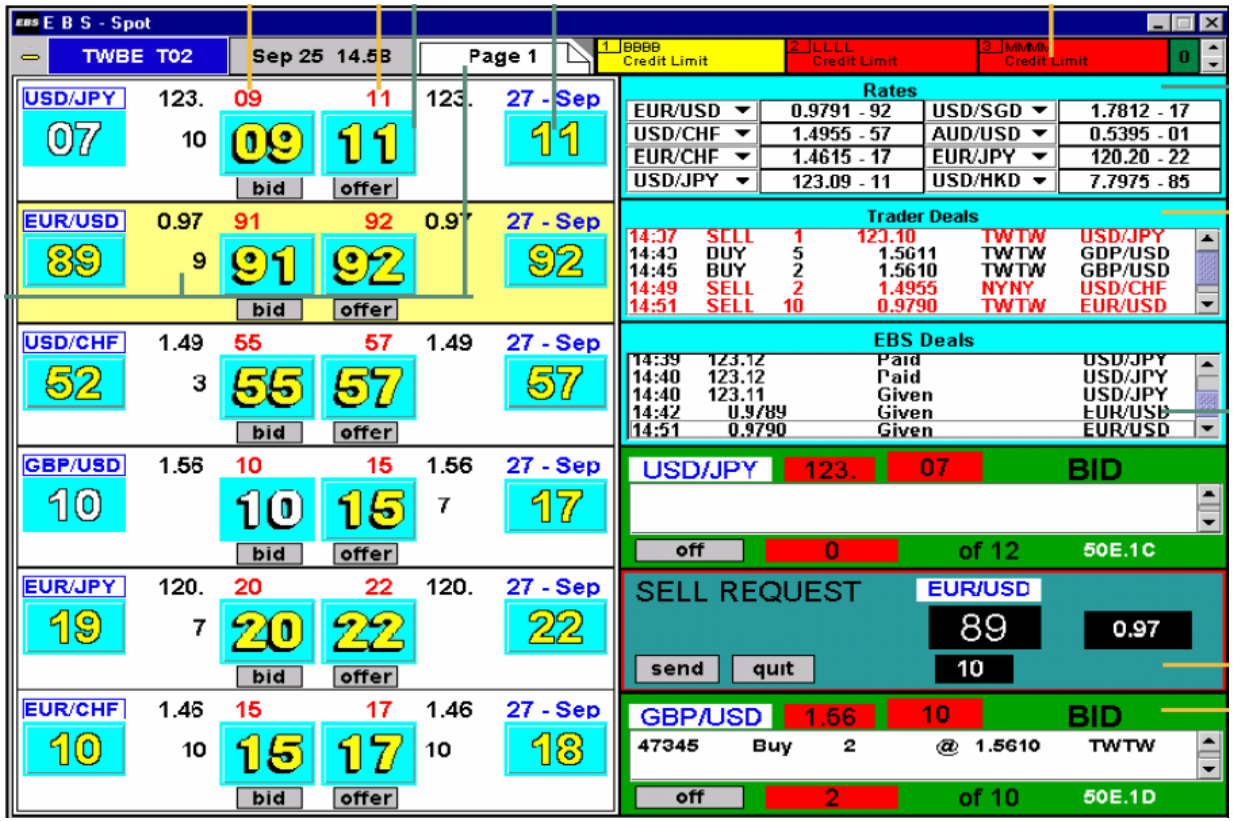
- Electronic limit order book
- Market share $> 60\%$
  $\Rightarrow$ global market place for spot FX interdealer trading
- Primary trading venue for EUR/USD, USD/JPY, EUR/JPY, USD/CHF, EUR/CHF
- Dealers pre-screened for credit
  $\Rightarrow$ counterparty risk not a concern
- All EBS quotes are transactable
  $\Rightarrow$ reliably represent prevalent FX rates
- First platform to facilitate algorithmic trading in spot FX

Our EBS database

- Access via Swiss National Bank
- Tick-by-tick trades, quotes, volume indicators, signs
  $\Rightarrow$ **exact** calculation of price impact and liquidity measures
- $\approx$ 90'000 observations each, per currency per day
- Sample period: from 1/2007 to 12/2009
- 9 FX rates: AUD/USD, EUR/CHF, EUR/GBP, EUR/JPY, EUR/USD, GBP/USD, USD/CAD, USD/CHF, USD/JPY

How EBS screen looks like

EBS



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Outline

Measures of liquidity

Liquidity has many aspects $\Rightarrow$ various measures

Estimated *daily*, using *intraday* data:

1. Price impact
2. Return reversal
3. Bid-ask spread
4. Effective cost
5. Price dispersion (volatility)
6. Latent liquidity (Principal Component Analysis)

Price impact and return reversal

- Intuition: if currency is illiquid, net buying pressure leads
  - Excessive appreciation of the currency
  - Followed by a reversal to the fundamental value
- Model:
  - Regression of one-minute returns on contemporaneous and lagged imbalance order flows:

$$p_t - p_{t-1} = \theta + \varphi(v_{b,t} - v_{s,t}) + \gamma(v_{b,t-1} - v_{s,t-1}) + \varepsilon_t$$

  - φ **price impact**
    $\uparrow$ asymmetric information $\Rightarrow \uparrow$ illiquidity
  - γ **return reversal**
    market maker's inventory risk and transaction costs
- Compute benchmark liquidity measures: no need of proxies
  e.g. Amihud (2002), Pastor and Stambaugh (2003)

Trading costs and price dispersion

- Proportional **bid-ask spread** $= (P^A - P^B)/P^M$
  cost aspect of illiquidity
- **Effective cost** $=$

$$\begin{cases} (P - P^M)/P^M, & \text{for buyer-initiated trades} \\ (P^M - P)/P^M, & \text{for seller-initiated trades} \end{cases}$$

  account for inter-quote trading
- **Price dispersion** $=$ volatility (TSRV)
  $\uparrow$ volatility $\Rightarrow$ MM requires more compensation for risk

^{A} Ask, ^{B} Bid, ^{M} Mid quote, P transaction price

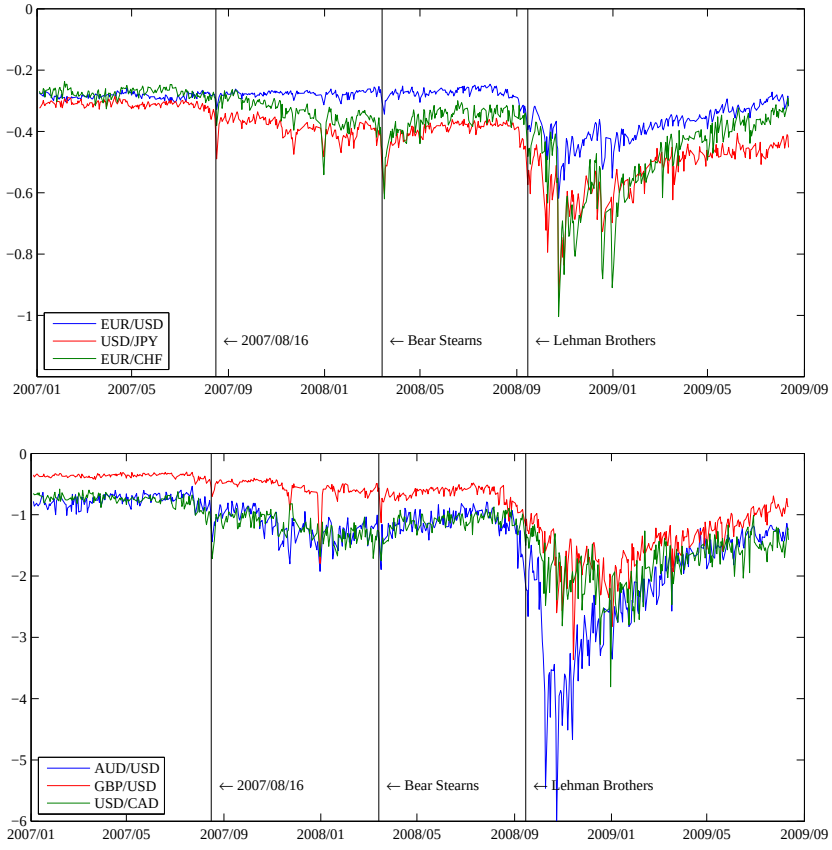
Outline

Liquidity of individual FX rates

Summary statistics show that

- EUR/USD, USD/JPY traded most frequently
- AUD/USD, USD/CAD traded least frequently
- Average price impact φ positive
- Average return reversal γ negative
- EUR/USD most liquid
- GBP/USD rather illiquid (mostly traded on Reuters)
- EUR/CHF, USD/CHF highly liquid (flight-to-quality, CHF safe haven; Ranaldo and Söderlind 2010)
- AUD, GBP depreciated, EUR, CHF, JPY appreciated vs. USD

Effective cost



Most liquid (up) and least liquid (bottom) FX rates.

$$\text{Effective cost} = \begin{cases} (P - P^M)/P^M, & \text{for buyer-initiated trades} \\ (P^M - P)/P^M, & \text{for seller-initiated trades} \end{cases}$$

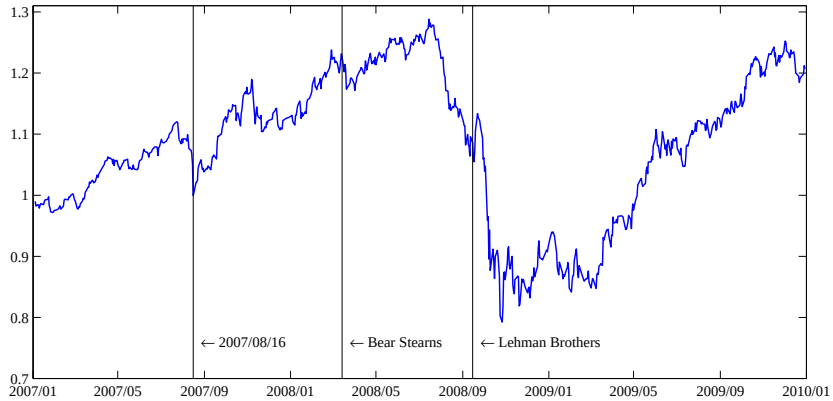
Sign adjusted to measure liquidity. Daily base.

Cost of illiquidity: carry trade example

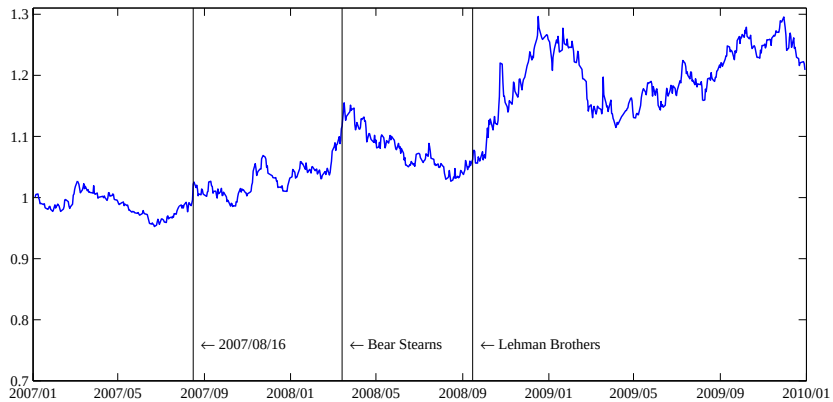
- U.S. investor engages in AUD-JPY carry trade:
  - borrow at low interest rate (1%) in Japan
  - invest at high interest rate (8%) in Australia
- Carry trade initiated:
  - selling JPY vs. USD
  - buying AUD vs. USD
- Unwind carry trade under two liquidity scenarios:
  - High liquidity, i.e. small bid-ask spreads:
    2.64bps AUD/USD, 0.90bps USD/JPY
    cost due to **illiquidity** = 0.5% of profit
  - Low liquidity, i.e. large bid-ask spreads:
    54.03bps AUD/USD (as in 10/2008)
    cost due to **illiquidity** = 10.7% of profit!
- Additional costs when FX liquidity low: usually
  - Funding currency (JPY) appreciates,
    Investment currency (AUD) depreciates
  - Low liquidity in fixed income market too

Carry trade AUD-JPY

Cumulative AUD/USD carry trade return



Cumulative JPY/USD carry trade return



Outline

Commonality in liquidity

Commonality means FX liquidity is driven by shocks that affect the entire FX market rather than individual FX rates

- Is there any commonality in liquidity across FX rates?
- Consistent with liquidity spirals (Brunnermeier and Pedersen 2009)
- Unexpected shocks to market-wide liquidity affect investors, regulators, etc.
- Commonality necessary for liquidity risk premium

Market-wide liquidity

Two approaches:

1. Cross-sectional average of FX rate liquidities, $L_{j,t}$:

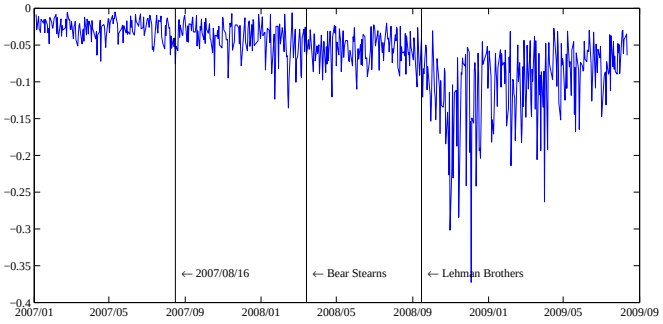
$$L_t^M = \frac{1}{N} \sum_{j=1}^{N} L_{j,t}$$

   (e.g. Chordia, Roll and Subrahmanyam 2000)

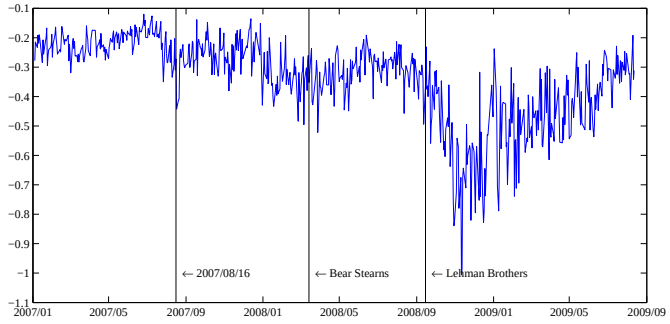
2. Principal Component Analysis (PCA)
   (e.g. Korajczyk and Sadka 2008)

Cross-sectional average liquidity

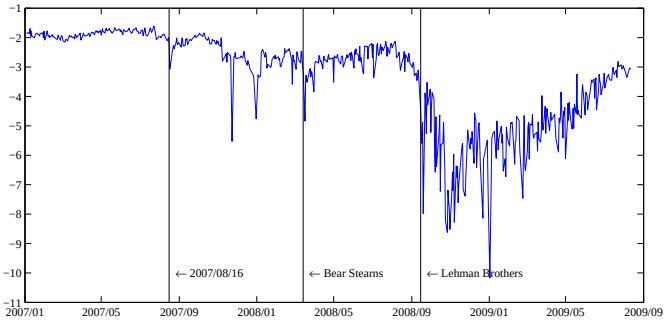
Price impact



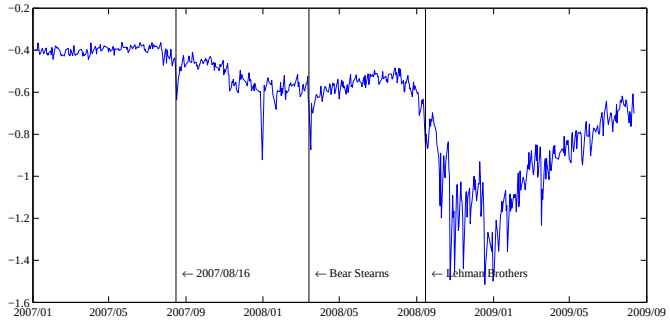
Return reversal



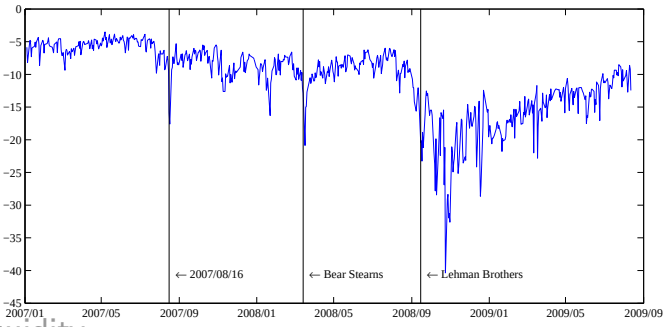
Bid-ask spread



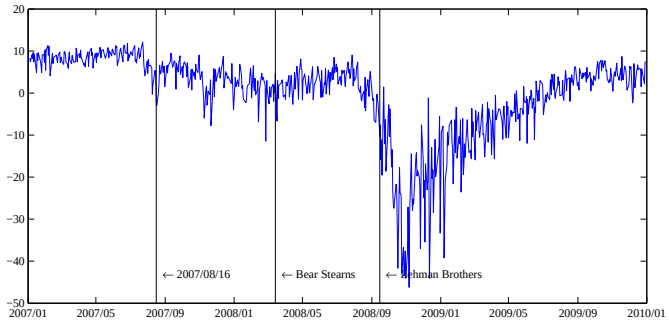
Effective cost



Price dispersion



Latent liquidity (PCA)



Latent liquidity within measure

Commonality within a liquidity measure:

- Consider one liquidity measure (e.g. effective cost), $L_{j,t}$
- *Cross-sectional* PCA, i.e. across FX rate liquidities $\{L_{j,t}, j = 1, \ldots, N\}$
  $\Rightarrow$ Latent common factors $L_t^{(1)}, L_t^{(2)}, \ldots$
- *Time series* regression for each FX rate liquidity $L_{j,t}$:
  - Regression 1: $L_{j,t} = \theta_0 + \theta_1 L_t^{(1)} + \varepsilon_{j,t}$
  - Regression 2: $L_{j,t} = \theta_0 + \theta_1 L_t^{(1)} + \theta_2 L_t^{(2)} + \varepsilon_{j,t}$
  - etc.
- Repeat above procedure for each liquidity measure

Evidence for commonality in liquidity

	Factors		
Measure	*1*	*1,2*	*1,2,3*
Return reversal ($K = 1$)	0.28	0.41	0.53
Return reversal ($K = 3$)	0.32	0.44	0.56
Return reversal ($K = 5$)	0.32	0.44	0.55
Price impact	0.63	0.74	0.82
Bid-ask spread	0.72	0.80	0.88
Effective cost	0.89	0.93	0.95
volume-weighted	0.90	0.94	0.96
Price dispersion (TSRV, 1 min.)	0.80	0.86	0.91
Price dispersion (TSRV, 5 min.)	0.81	0.86	0.90

Table: Average (across FX rates) adjusted-R^2. Daily base.

Similar results when only including FX rates vs. USD

$\Rightarrow$ commonality not induced by triangular relationships

Liquidity sensitivity

- **Individual** FX rate liquidity, $L_{j,t}^{(ec)}$:
  Effective cost for FX rate j
- **Market-wide** liquidity measure, $L_{M,t}^{(ec)}$:
  Average across FX rates of effective costs, excluding FX rate j
- **Idiosyncratic** liquidity, $L_{j,t}^{(i)}$:

$$L_{j,t}^{(ec)} = a_j + b_j L_{M,t}^{(ec)} + L_{j,t}^{(i)}$$

i.e. residual

Liquidity sensitivity: Estimates

	AUD/ USD	EUR/ CHF	EUR/ GBP	EUR/ JPY	EUR/ USD
b_j	3.15	0.35	1.09	0.56	0.17
	(0.066)	(0.005)	(0.023)	(0.007)	(0.003)
R^2	0.76	0.85	0.76	0.90	0.81

Table: Sensitivity to market-wide liquidity, b_j, from regression:

$$L_{j,t}^{(ec)} = a_j + b_j L_{M,t}^{(ec)} + L_{j,t}^{(i)}$$

Robust standard errors in parentheses.

Market-wide liquidity across measures

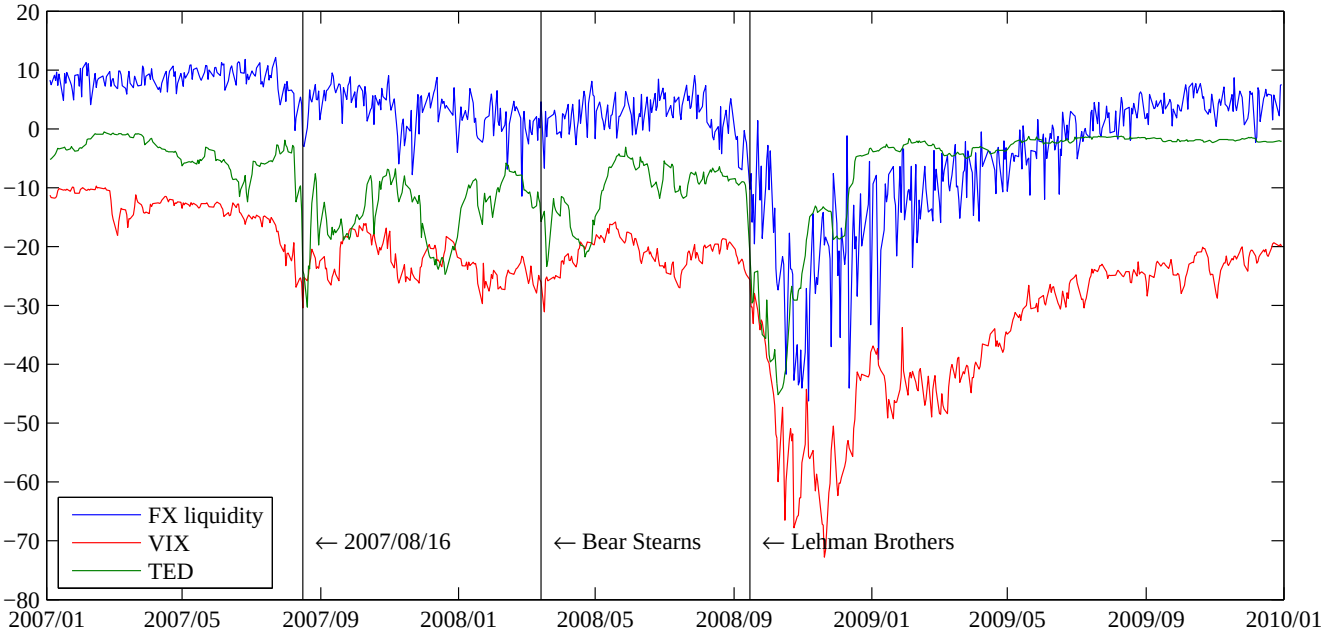
- All liquidity measures proxy **liquidity**
- Correlations up to 0.8 for weekly liquidity measures
- To extract all common information
  $\Rightarrow$ PCA across liquidity measures *and* across FX rates
  (Korajczyk and Sadka 2008)

Interpretation of market-wide liquidity

	AUD/ USD	EUR/ CHF	EUR/ GBP	EUR/ JPY	EUR/ USD
	First Principal Component loadings				
Return reversal	0.31	0.32	0.23	0.36	0.31
Price impact	0.42	0.46	0.42	0.46	0.47
Bid-ask spread	0.47	0.48	0.46	0.46	0.48
Effective cost	0.50	0.48	0.54	0.48	0.47
Price dispersion	0.49	0.45	0.51	0.45	0.46
cum. explained	72%	77%	59%	80%	80%
	Second Principal Component loadings				
Return reversal	0.92	0.93	0.94	0.92	0.94
Price impact	−0.34	−0.02	0.09	−0.18	−0.13
Bid-ask spread	−0.09	−0.15	−0.23	−0.09	−0.16
Effective cost	−0.13	−0.18	−0.15	−0.15	−0.20
Price dispersion	−0.06	−0.26	−0.13	−0.29	−0.13
cum. explained	87%	91%	77%	91%	94%

Liquidity: global phenomenon?

VIX = SPX implied volatility index, "fear index"
TED-spread = Interbank loans − T-bill
proxy for credit-risk and funding liquidity



Sign adjusted to measure liquidity. Daily base.
Correlation: FX liquidity-VIX −0.8; FX liquidity-TED −0.5

Evidence for liquidity spirals

Link between traders' funding liquidity and market-wide FX liquidity.

$$L^{pca}_{FX,t} = const + \beta_{VIX}\, VIX_{t-1} + \beta_{TED}\, TED_{t-1} + error_t$$

	$const$	VIX_{t-1}	TED_{t-1}	Adj. R^2
Coeff.	18.94	-0.69	-1.26	0.76
Std. err.	(0.98)	(0.04)	(0.44)	

Daily data from January 2007 to December 2009.

When $VIX_{t-1} \uparrow 1\sigma_{VIX} \Rightarrow L^{pca}_{FX,t} \downarrow 0.8\sigma_{FX}$

Outline

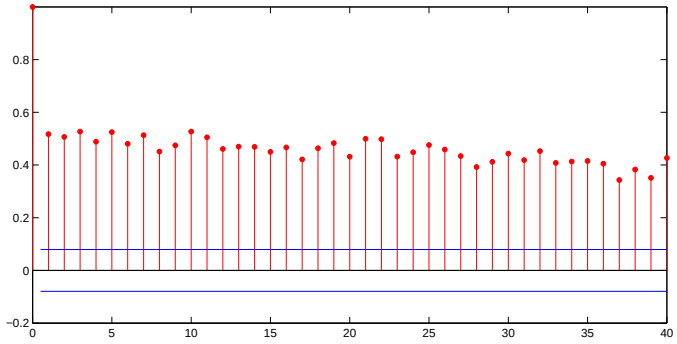
Liquidity risk premium

Documented commonality in liquidity:

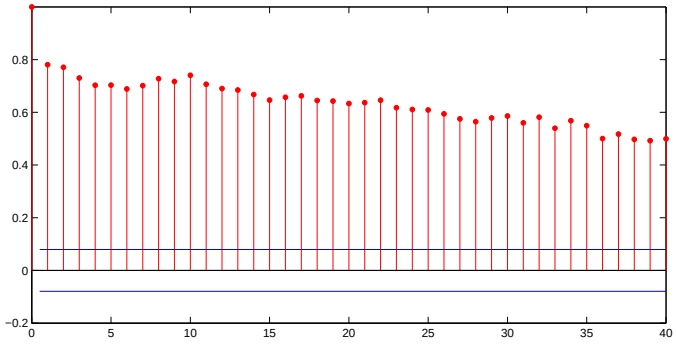
- Is liquidity risk priced in FX market?
- Investors are averse to shocks in market-wide liquidity
  E.g. Currency crashes
  (Brunnermeier, Nagel and Pedersen 2009)
  $\Rightarrow$ FX liquidity risk priced
- Have shocks to market-wide liquidity a persistent impact?

Autocorrelation systematic liquidity

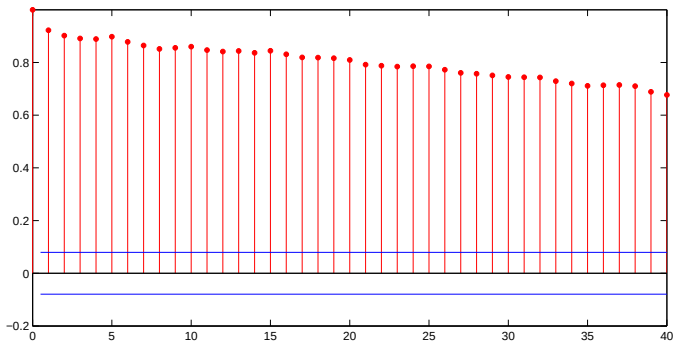
Price impact



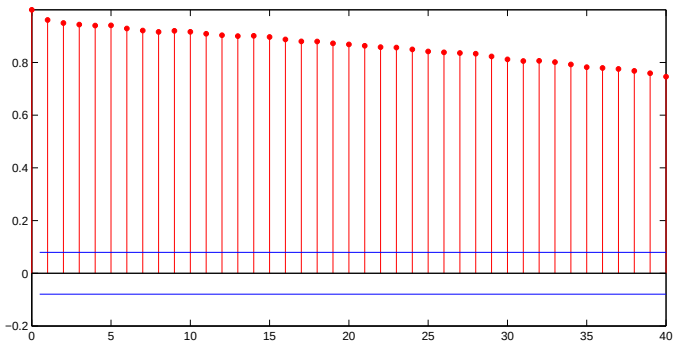
Return reversal



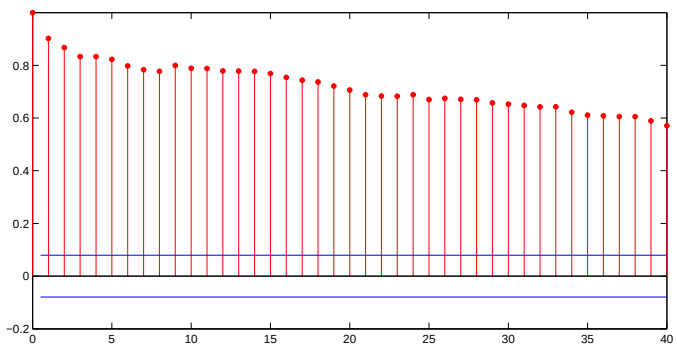
Bid-ask spread



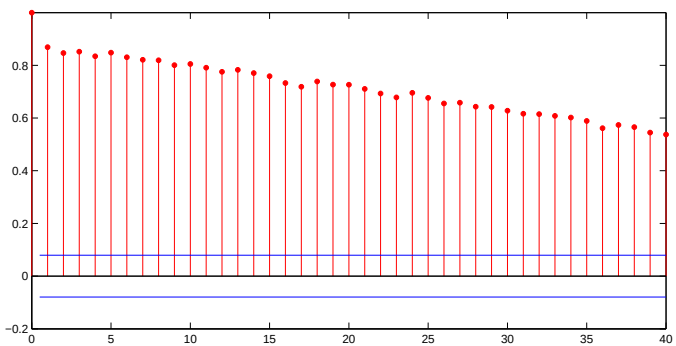
Effective cost



Price dispersion



Latent liquidity (PCA)



Carry trade returns

- Daily carry trade returns

$$r^e_{j,t+1} = i^f_t - i^d_t - \Delta p_{j,t+1}$$

- Base currency: USD
- USD appreciated $> 15\%$ vs. major currencies in 2 and 1/2 months after Lehman bankruptcy!

Risk factors for FX returns

- Liquidity risk factor, *IML*:
  return of portfolio
  long two FX rates most illiquid and
  short two FX rates most liquid
- Market risk factor, *AER*:
  Average Excess Return for U.S. investor

Carry trade and liquidity risk

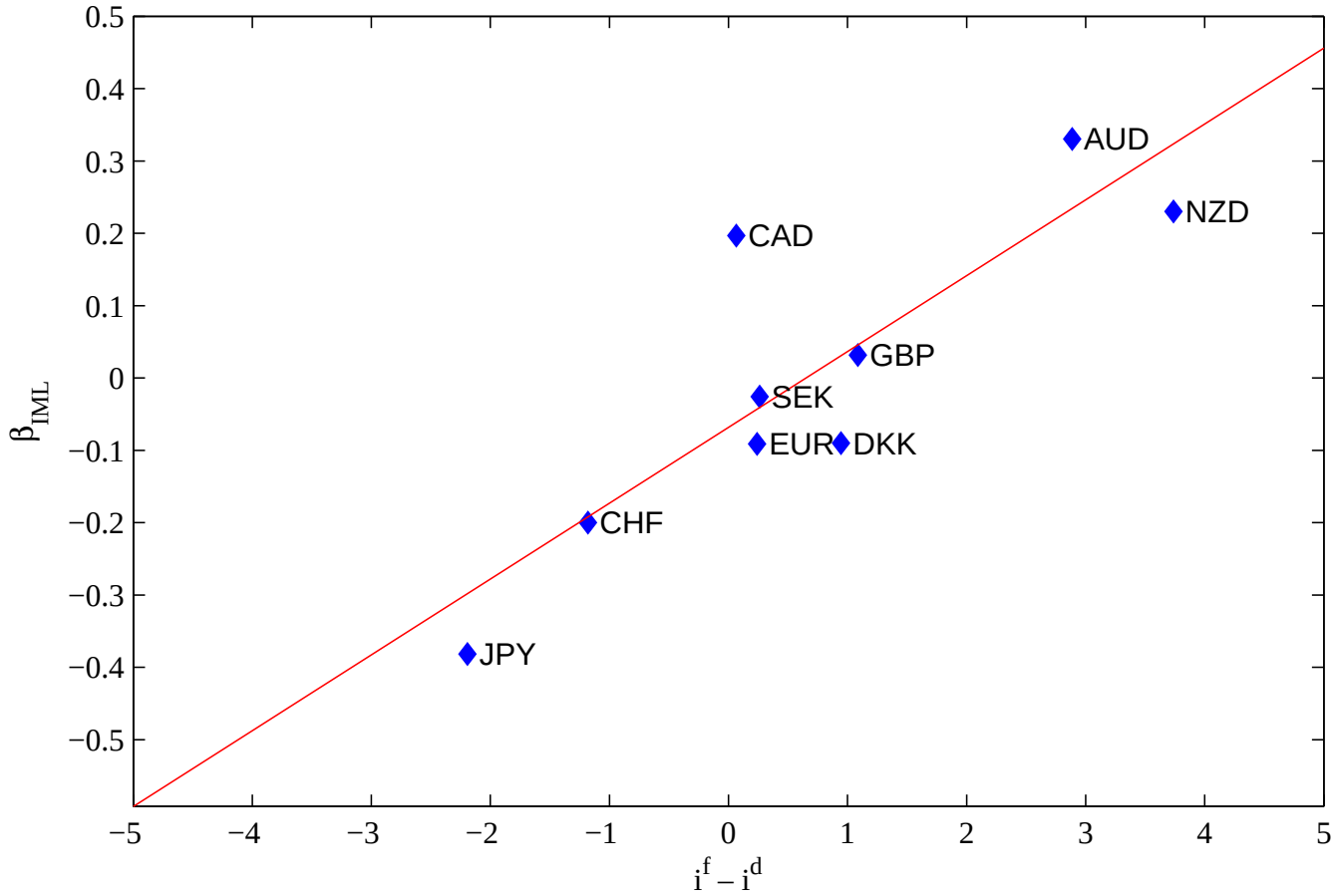
Asset pricing model:

$$r^e_{j,t} = \alpha_j + \beta_{IML,j}\, IML_t + \beta_{AER,j}\, AER_t + error_{j,t}$$

	JPY	CHF	EUR	CAD	AUD
α	0.018	0.018	0.001	0.006	0.014
	(0.016)	(0.013)	(0.008)	(0.017)	(0.016)
β_{AER}	0.608	1.137	1.093	0.651	1.050
	(0.026)	(0.021)	(0.014)	(0.029)	(0.026)
β_{IML}	−0.382	−0.200	−0.091	0.197	0.330
	(0.009)	(0.007)	(0.005)	(0.010)	(0.009)
R^2	0.730	0.803	0.903	0.714	0.892

Daily data from January 2007 to December 2009.

Liquidity betas and interest rate differentials

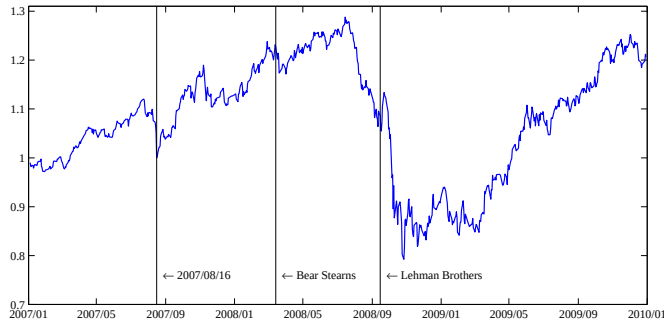


Main message

- High interest rate currencies (e.g., AUD, NZD):
  - low liquidity
  - high liquidity sensitivity
  - large positive liquidity beta, $\beta_{IML} > 0 \Rightarrow$
    - exposure to liquidity risk
    - compensation for poor liquidity
- Low interest rate currencies (e.g., JPY, CHF):
  - high liquidity
  - low liquidity sensitivity
  - large negative liquidity beta, $\beta_{IML} < 0 \Rightarrow$
    - insurance against liquidity risk
    - "insurance premium" to pay for high liquidity

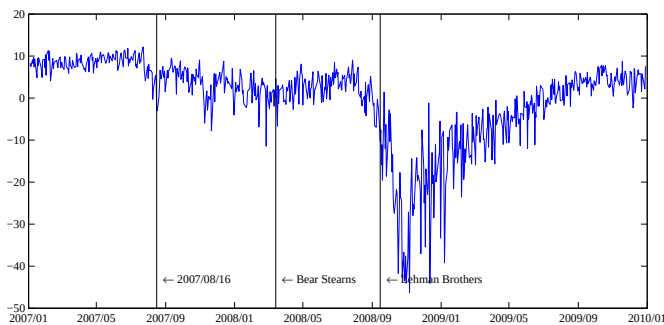
Carry trade return and liquidity

Cumulative AUD/USD carry trade return



Cumulative JPY/USD carry trade return

Market-wide FX liquidity (PCA)



Conclusion

- Liquidities of individual FX rates:
  - large temporal and cross sectional variation
  - respond differently to shocks in market-wide liquidity
  - drop quickly after Lehman bankruptcy
  - recover slowly during 2009
- Strong commonality in liquidity across FX rates:
  When central bank injects liquidity in its own currency
  - Spill over effects to other currencies
  - High interest rate currencies react more
    (may boost speculation)
- Liquidity risk "priced" in FX market:
  - High interest rate currencies expose to liquidity risk
  - Low interest rate currencies insure against liquidity risk
  - Liquidity spirals trigger the mechanism