Arbitrage and Short-Horizon Predictability in the Foreign Exchange Market

A Microstructure Perspective

Dagfinn Rime[a,b] and Lucio Sarno[c,d]
with Farooq Akram[a] and Elvira Sojli[c]

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www.norges-bank.no/research/rime/

Summary of two papers

1. High-frequency test of Covered Interest rate Parity (CIP)
   - *"Arbitrage in the Foreign Exchange Market: Turning on the Microscope"*,
     Farooq Akram, Dagfinn Rime and Lucio Sarno
     February 2008

2. Trading profits from a out-of-sample forecasting strategy
   - *"Exchange Rate Forecasting, Order Flow and Macroeconomic Information"*,
     Dagfinn Rime, Lucio Sarno and Elvira Sojli
     January 2008

$/€ $/£ ¥/$

High-frequency data from Reuters D2002-2

"Arbitrage in the Foreign Exchange Market: Turning on the Microscope",

Farooq Akram, Dagfinn Rime and Lucio Sarno

Risk-free arbitrage . . . (CIP)

. . . taking account of all microstructural details

$$\underbrace{-(1+i^a_{¥})}_{\text{borrow}} + \underbrace{\frac{1}{S^a_{¥/\$}}}_{\text{buy spot}} \underbrace{(1+i^b_{\$})}_{\text{lend}} \underbrace{F^b_{¥/\$}}_{\text{sell forward}} = \underbrace{0}_{\text{If CIP holds}} \qquad \text{(CIP, bid)}$$

- Frequency, Economic significance, and Duration of arbitrage
- 7 months of tick-frequency (Feb 04–Sep 04)
- 4 maturities: 1m, 3m, 6m and 1y
- Transaction costs: Bid-ask spread, broker fees, SWIFT, etc.

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- 7 months of tick-frequency (Feb 04–Sep 04)
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		a) All deviations			b) Profitable deviations			
		Mean	Ann. mean	IQ (sec)	No.Dev.	Share	Mean	Ann. mean
1M	Ask	-0.90	-11	2.9	1,975	0.10 %	0.26	3
	Bid	-1.00	-12	2.9	73	0.00 %	0.18	2
3M	Ask	-2.67	-11	2.9	30,116	1.46 %	0.85	3
	Bid	-2.77	-11	2.9	3,500	0.17 %	0.88	4
6M	Ask	-5.78	-12	2.6	12,844	0.56 %	1.44	3
	Bid	-5.31	-11	2.6	8,559	0.37 %	2.58	5
1Y	Ask	-12.43	-12	2.3	21,495	0.84 %	5.33	5
	Bid	-10.64	-11	2.3	8,966	0.35 %	3.29	3

- IQ = Time between two CIP deviations on average
- Shares small, but one every hour if No. dev.>1661
- Size economically significant compared to swaps spreads

▸ All

Risk-free arbitrage (CIP) (€)

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Number of profitable clusters and duration

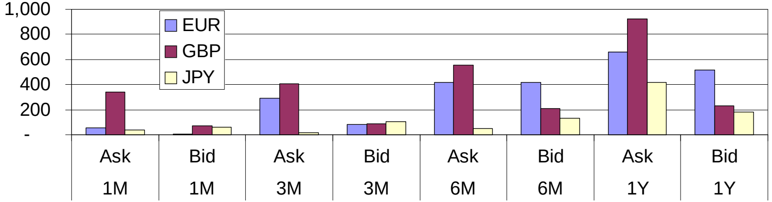

Table: Duration of clusters (min.)

		1M		3M		6M		1Y	
		Ask	Bid	Ask	Bid	Ask	Bid	Ask	Bid
EUR	Mean	1:35	4:03	4:44	1:36	0:57	0:44	1:06	0:36
	Median	0:49	0:39	1:04	0:57	0:26	0:18	0:23	0:14
GBP	Mean	4:11	11:02	5:54	8:47	2:18	1:10	1:20	0:48
	Median	1:30	0:39	1:43	0:37	0:25	0:27	0:19	0:18
JPY	Mean	10:14	3:28	5:22	7:32	3:15	1:20	1:20	1:47
	Median	4:34	1:36	0:16	3:01	0:27	0:23	0:29	0:41

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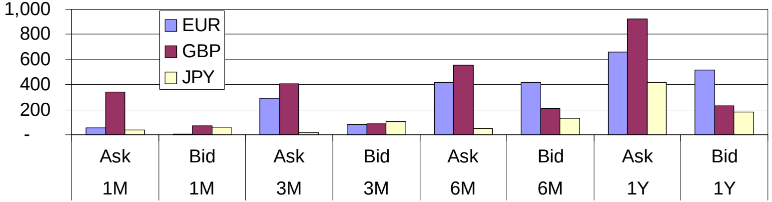

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Depth of market (€)

Number of spot limit orders

			Total spot depth		Spot deviation	
		Pa dev	Mean	Median	Mean	Median
1M	Ask	52	4.14	2	0.08	0.03
	Bid	1,685	4.92	3	0.16	0.14
3M	Ask	3,215	6.63	5	0.78	0.56
	Bid	26,254	9.47	6	0.75	0.29
6M	Ask	6,789	10.30	8	2.48	2.33
	Bid	10,529	7.64	5	1.34	1.20
1Y	Ask	6,969	9.72	8	3.20	2.04
	Bid	17,519	13.36	11	5.23	4.59

Judging from the spot market there are sufficient numbers of orders available for trading 10-20 million

"*Exchange Rate Forecasting, Order Flow and Macroeconomic Information*",
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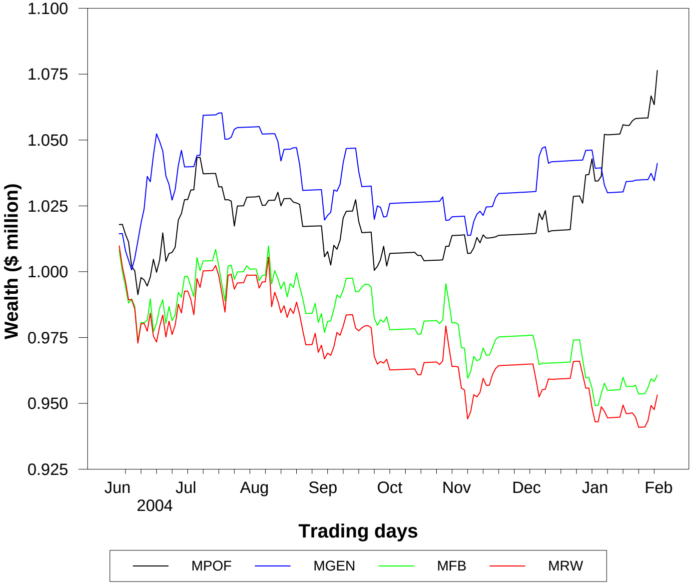
Evolution of wealth from trading



Forecasting setup

1. Mean-variance maximizing investor with initial wealth of \$1 mio
   - Invests in three risky assets (currencies) and risk free asset (LIBOR overnight)
   - Re-balances daily (no shorting)
2. Re-estimate coefficients daily, but use the same *model*
3. Compare 4 models (Order flow, forward bias, RW, ..)
   (*order flow* = *signed transactions*)
4. Performance criteria:
   1. End of period Sharpe Ratio: $SR = \frac{r_p - r_f}{\sigma_p}$
   2. Performance fee: The return a risk-averse investor would pay
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	M^{POF}	M^{GEN}	M^{FB}	M^{RW}
Sharpe ratio	1.06	0.44	-1.08	-1.27
Performance fee	16.75	12.54	1.38	-
Break-even cost	4.77	4.17	-	-

- M^{POF}: Only order flow
- M^{GEN}: Order flow and lagged return
- And, you can do better!
  - ⋆ Enter a limit order in the morning at a desired rate.
    If not executed, close with a market order at end of day

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- **BUT!** There are numerous tradable and economic significant arbitrage opportunities. **WHY?**
  - *Grossman-Stiglitz view on efficiency:*
    Short-term profit-opportunities arises, and are exploited, making it worthwhile to study/analyze markets
- Order flow has economic value for forecasting? **WHY?**
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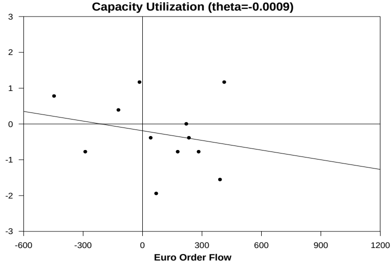
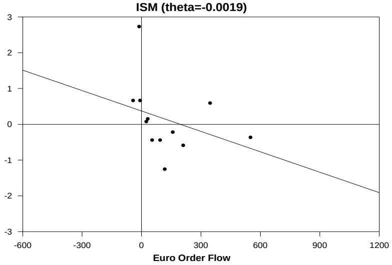
Order flow and Expectations
US Production news and € order flow as example





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- Markets perceive this as bad US news,
- and rationally expect this,

⇒ they sell \$, buy €, in days *between* survey expectation and announcement

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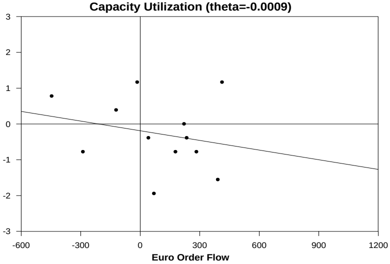

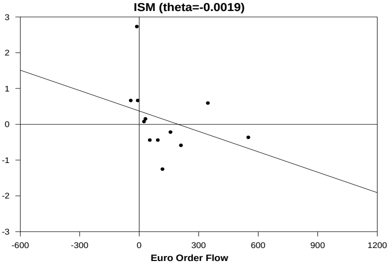

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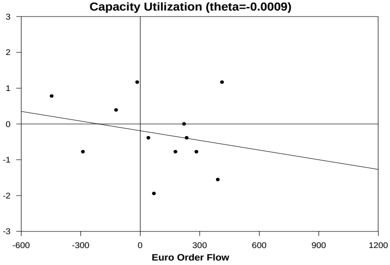

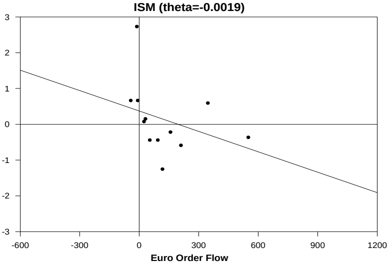

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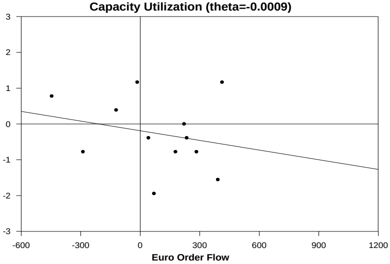

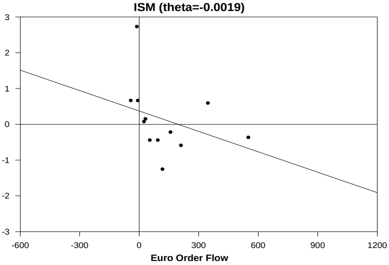

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Risk-free arbitrage (CIP) (£)

Return

		a) All deviations			b) Profitable deviations			
		Mean	Ann. mean	IQ (sec)	No.Dev.	Share	Mean	Ann. mean
1M	Ask	-1.36	-16	2.4	35,110	1.44 %	0.35	4
	Bid	-1.72	-21	2.4	16,835	0.69 %	0.69	8
3M	Ask	-4.06	-16	2.4	57,523	2.35 %	2.13	9
	Bid	-4.25	-17	2.4	24,124	0.98 %	2.90	12
6M	Ask	-7.91	-16	2.3	37,820	1.46 %	4.91	10
	Bid	-9.43	-19	2.3	5,950	0.23 %	1.70	3
1Y	Ask	-16.01	-16	2.2	37,987	1.38 %	9.09	9
	Bid	-17.85	-18	2.2	4,593	0.17 %	4.52	5

- Shares larger than €, several every hour as Pa dev. > 1661
- Size economically significant compared to swaps spreads

Risk-free arbitrage (CIP) (¥)

Return

		a) All deviations			b) Profitable deviations			
		Mean	Ann. mean	IQ (sec)	No.Dev.	Share	Mean	Ann. mean
1M	Ask	-1.04	-12	7.3	1,545	0.19 %	0.37	4
	Bid	-1.02	-12	7.3	2,068	0.26 %	0.23	3
3M	Ask	-2.66	-11	7.2	491	0.06 %	3.86	15
	Bid	-2.85	-11	7.2	2,891	0.35 %	1.83	7
6M	Ask	-4.61	-9	7.0	718	0.09 %	4.71	9
	Bid	-5.69	-11	7.0	4,140	0.49 %	1.45	3
1Y	Ask	-8.37	-8	6.6	3,403	0.38 %	6.21	6
	Bid	-13.42	-13	6.6	4,358	0.49 %	3.50	4

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