Inventory prediction in foreign exchange markets

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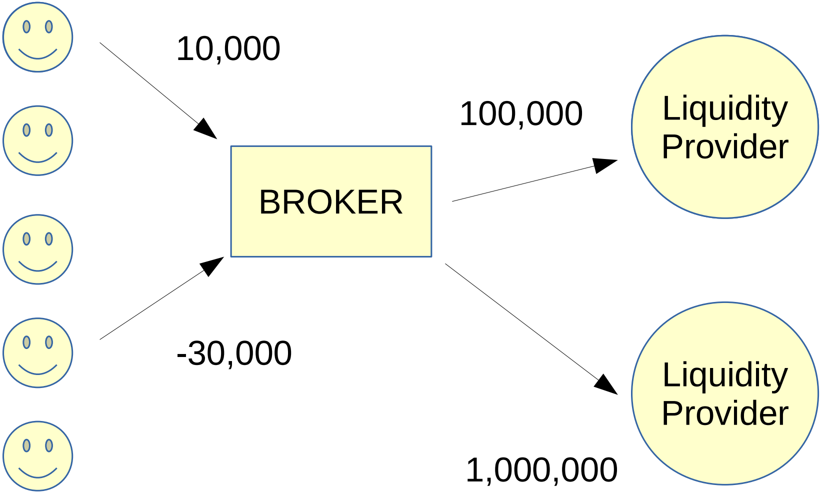
Near-prejudices in Finance

Public data:	price nearly unpredictable
Proprietary data:	nearly unaccessible, underexploited
Machine learning:	nearly useless, too much noise

Foreign exchange market structure

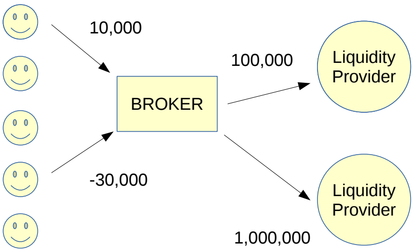
Exchange EUR $\rightarrow$ USD



Broker inventory

- Minimum amount to Liquidity Provider
- Broker aggregates small amounts

  → ***inventory***
- Order matching: save exchange fees



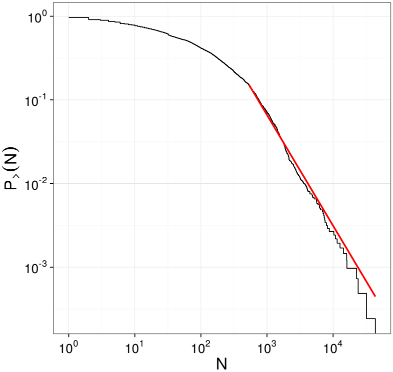
Inventory management

- Set maximum inventory $\Phi_{MAX} \in [100,000,\ 10,000,000]$
- Random client order flow $\phi_t \sim P(\phi)$
- Keep orders in inventory $\Phi_t = \sum_{t' \le t} \phi_t$
- Flush inventory to liquidity provider if $|\Phi_t| > \Phi_{MAX}$
- Random price changes $\frac{dP_t}{P_t} = trend + noise_t$
- Mathematical Finance: optimise risk as a function of Φ_{MAX} and time horizon T

Big data approach to inventory management

- $O(10^4)$ clients
- $O(10^7)$ transactions

Number of transactions per client



Financial markets *are* predictable with client IDs

Prediction problems = Science + Engineering

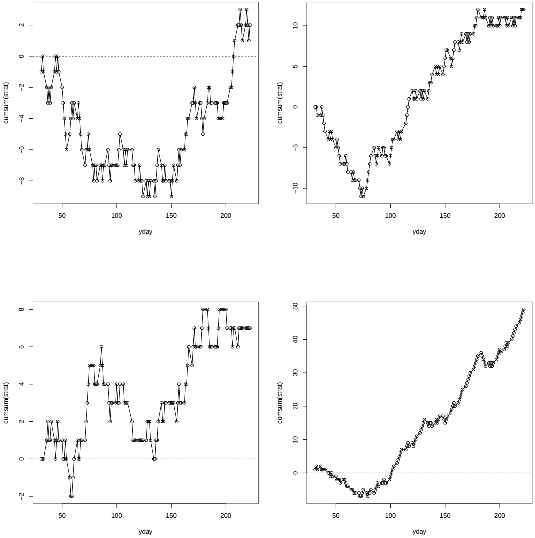
Science: flux

1. cluster clients
2. lead-lag networks
3. machine learning
4. ENJOY!

Engineering

1. Predict price returns
2. Inventory constraints
3. PROFIT!

Cluster traders



Unsupervised classification: synchronous actions

Tumminello et al. (2011a)

1. Agent i, $state_i(t) \in \{1, \cdots, S\}$

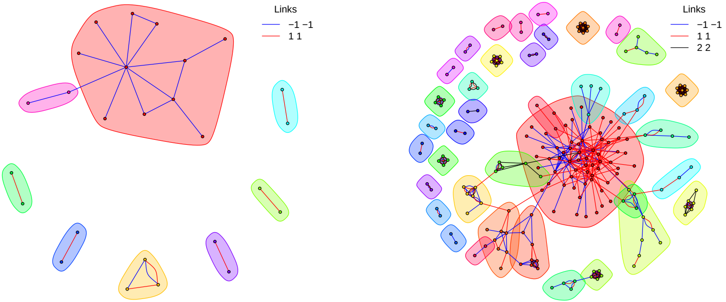
$$s_i(t) = \text{sign}\, \frac{Buy(t) - Sell(t)}{Buy(t) + Sell(t)} \in \{-1, 0, 1, 2 = \emptyset\}$$

- H_0 : states of agents i and j are Poisson processes
- $O(N^2)$ pairs
  $\rightarrow$ multiple hypothesis correction
  $\rightarrow$ NETWORK

Synchronized traders

Challet et al. (2017) EUR.USD SQ

daily hourly



Predictability of order flow

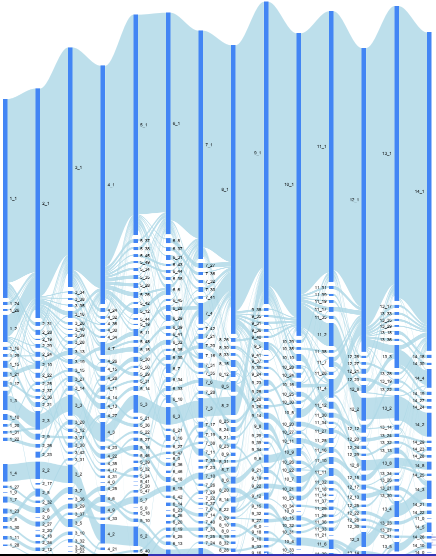
Conditions:

1. Clusters of agents are stable

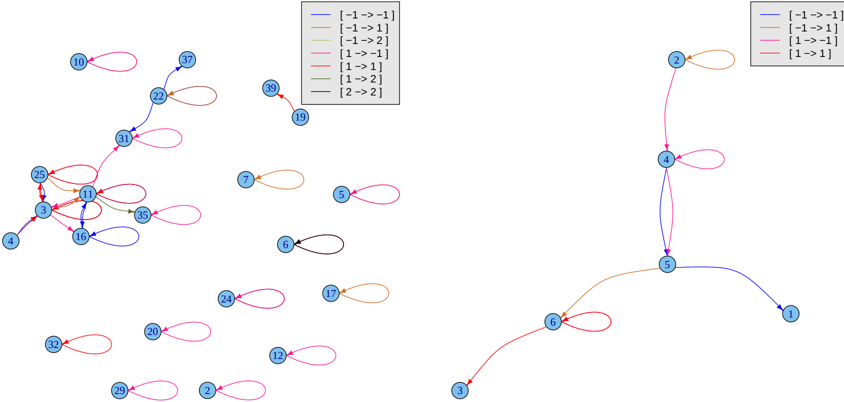
2. Cluster activity is predictable

   $\equiv$ persistent lead-lag cluster networks

Cluster stability



Compute p-value of $\{s_g(t), s_{g'}(t+1)\}$



Origin of lead-lag

Explicit/implicit communication

Delayed reaction

1. faster news
2. same strategy, faster parameters
   MA(CD) 12, 26, 5 $\rightarrow$ 10, 25, 4:
3. Master in Finance

Trader-trader: explicit communication

Implicit communication: prices

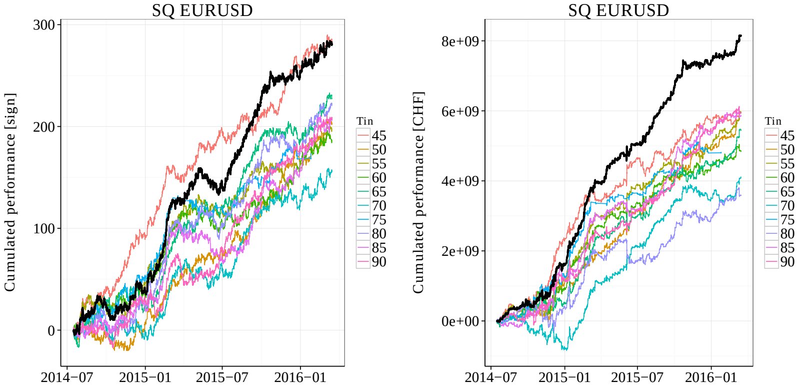
How to predict order flow

1. Determine groups
2. Determine group state $\sigma_{g,t}$
3. Learn on-line sign of next global order flow

$$P_{t_0,t_1} = \begin{pmatrix} \sigma_{1,t_0} & \sigma_{2,t_0} & \sigma_{1,t_0-1} & \sigma_{2,t_0-1} & h(t_0) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \sigma_{1,t_1} & \sigma_{2,t_1} & \sigma_{1,t_1-1} & \sigma_{2,t_1-1} & h(t_1) \end{pmatrix} \sim \begin{pmatrix} \hat{s}_s(t_0+1) \\ \vdots \\ \hat{s}_s(t_1+1) \end{pmatrix}$$

4. $\sim$: vanilla Random Forest (15 seconds / day)

Results


SQ EURUSD
Cumulated performance [sign]
300
200
100
0
2014−07
2015−01
2015−07
2016−01
Tin
45
50
55
60
65
70
75
80
85
90
SQ EURUSD
Cumulated performance [CHF]
8e+09
6e+09
4e+09
2e+09
0e+00
2014−07
2015−01
2015−07
2016−01
Tin
45
50
55
60
65
70
75
80
85
90

How to predict VWAP

VWAP= Value-Weighted Average Price *of next orders*

1. Determine groups
2. Determine group state $\sigma_{g,t}$
3. Learn on-line sign of next VWAP difference

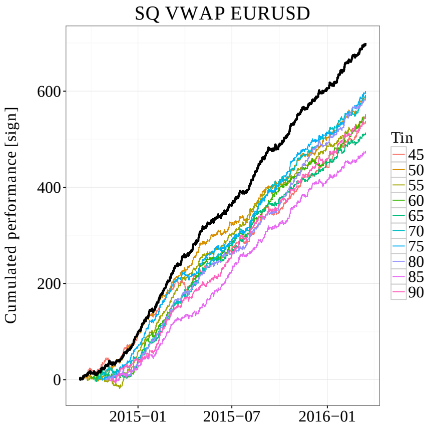
$$P_{t_0,t_1} = \begin{pmatrix} \sigma_{1,t_0} & \sigma_{2,t_0} & \sigma_{1,t_0-1} & \sigma_{2,t_0-1} & h(t_0) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \sigma_{1,t_1} & \sigma_{2,t_1} & \sigma_{1,t_1-1} & \sigma_{2,t_1-1} & h(t_1) \end{pmatrix} \sim \begin{pmatrix} \hat{s}_s(t_0+1) \\ \vdots \\ \hat{s}_s(t_1+1) \end{pmatrix}$$

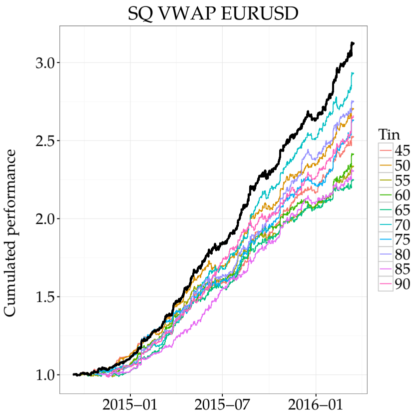
4. $\sim$: vanilla Random Forest

Conditions of success

1. VWAP predictable if order flow is predictable
2. Order flow depends on past prices
3. FX traders: systematic strategies

Result: VWAP


SQ VWAP EURUSD
Cumulated performance [sign]
0
200
400
600
2015−01
2015−07
2016−01
Tin
45
50
55
60
65
70
75
80
85
90


SQ VWAP EURUSD
Cumulated performance
1.0
1.5
2.0
2.5
3.0
2015−01
2015−07
2016−01
Tin
45
50
55
60
65
70
75
80
85
90

Summary

1. Order flux — OK
2. VWAP — OK
3. Trader's activity is triggered by that of other traders

Todo

- Reverse engineer strategy of groups
- Other fields
- Other time horizons
- ...