Price Signatures
“Best Execution and Transaction Cost Analysis”

FXCG meeting
Frankfurt, June 2019

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What do these have in common?

- Electronic FX trading
- The temperature in Stockholm
- The physical activity level of angry children
The temperature in Stockholm

Stockholm temperatures by year (1767 – 2016)

Stockholm temperature by 50-year period

Source: https://bolin.su.se/data/stockholm.
7-year old’s physical activity level

Daily activity level of 432 children

Activity level by emotional state

I acknowledge: the Centre for Longitudinal Studies, Institute of Education for the use of these data; the UK Data Service for making them available; the MRC Centre of Epidemiology for Child Health (Grant reference G0400546), Institute of Child Health, University College London for creating the accelerometer data resource which was funded by the Wellcome Trust (grant reference 084686/Z/08/A). The institutions and funders acknowledged bear no responsibility for the analysis or interpretation of these data.
Market impact

30,000 post-deal price paths*

Source: Deutsche Bank.

* Chart draws only a stratified subset of the full sample. Paths are signed for direction of trade.
All these examples can be studied using Functional Data Analysis or FDA
The price signature

Define a price “signature” as:

$$S(\delta) = \frac{1}{q'} \sum_n q_n d_n (P_{t_n + \delta} - P_{t_n}), \quad \text{for} \ \delta \in [-\delta, \delta].$$

It is the volume weighted ($q$), trade direction adjusted ($d$), average price movement, over an interval ($\delta$) centred around the point of trading ($t$).

- it can be calculated over any and multiple subsets for comparison
  ... by currency pair, by venue, by order size, etc
  ... by time of the day, by trader / user, etc

- it can be applied more generally
  ... to quotes, to rejects, to hypothetical backtest trading signals, etc
  ... to construct volume signatures, spread signatures, liquidity or activity signatures, etc
Signature construction
Signature interpretation

- post-deal ($\delta > 0$), the signature measures the marked-to-market revenues or margin
- pre-deal ($\delta < 0$), the signature measures the opportunity cost of not having traded earlier
Signature examples at macroscopic level

Momentum strategy

Reversal strategy
Signature examples at macroscopic level

**Alpha / impact**

**Sequential delayed impact**
Signature examples at microscopic level

Adverse selection

Latency arbitrage / run-over
FDA or functional data analysis

Two key questions are often asked:

1. is a signature statistically different from zero, i.e. $S(\delta) = 0$ or not?
   
   \[
   \ldots \text{ do I have true alpha or was it just a lucky episode?} \\
   \ldots \text{ do I get systematically run over on my passive algo fills?}
   \]

2. is one signature different from another, i.e. $S_k(\delta) = S_m(\delta)$ or not?

   \[
   \ldots \text{ is my momentum signal stronger in USD/MXN than in USD/ZAR?} \\
   \ldots \text{ is the market impact I incur across venues the same?}
   \]

Different from the “usual” statistics, this involves inference of functions or curves → FDA provides the statistical foundations to answer such questions.

Game theory context

- **Aggregation.** Traders in the FX market routinely place liquidity providers (LPs) in competition for their flow.

- **Winner’s curse.** Because “true” price is unobserved and the LPs are unaware of competitors’ prices, the more LPs in the aggregator, the stronger the adverse selection on deals won.

- **Prisoner’s dilemma.** Externalising LP creates impact that adversely impacts internalising LP. When mixing them in aggregation process, all LPs may externalise and making everyone worse off.

- **Efficient execution.** Select a moderate number of LPs (say 5, not 50), trade full amount, and *do not mix internalisers and externalisers*.

See Oomen (2017a,b), and Butz and Oomen (2018) for further details.
Signature case studies
A trader executes using an aggregator with multiple LPs but . . .

- trade request rejects complicate the workflow
- addition of LPs has meant spreads are gradually widening out

They are open to a radical change or experiment to improve matters.

DB proposes a “firm” feed and tighter spreads than what the trader receives in aggregate across all LPs, on the basis that they become the trader’s exclusive liquidity partner.

. . . trader believes the flow at source is latency sensitive and directional

. . . DB believes the flow is benign at source, but that the aggregator design is the issue
Case-study I: Aggregation versus LP exclusivity

- Trader tries out exclusivity arrangement for one main currency pair
- It appears to radically lower post-deal impact (i.e. aggregator design explains the difference)
- But is it significant?
- FDA + resampling → yes, it is highly significant!
Epilogue

Trader adopts the exclusive feed
(with backup LP for resilience)

✓ improved trader experience
  ... response time ↓
  ... rejects ×
  ... spreads ↓
  ... costs ↓
  ... workflow simplification ↑

✓ improved LP experience
  ... volume ↑
  ... winner’s curse ×
  ... prisoner’s dilemma ×

<table>
<thead>
<tr>
<th></th>
<th>aggregator</th>
<th>exclusivity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trader’s execution setup</strong></td>
<td></td>
<td></td>
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<tr>
<td># LPs</td>
<td>&gt; 5</td>
<td>1</td>
</tr>
<tr>
<td>externalisers</td>
<td>probably</td>
<td>no</td>
</tr>
<tr>
<td>stack sweep</td>
<td>yes</td>
<td>N/A</td>
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<tr>
<td><strong>DB liquidity configuration</strong></td>
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<tr>
<td>nominal spread</td>
<td>1.2</td>
<td>0.3</td>
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<tr>
<td>response time</td>
<td>100ms</td>
<td>1ms</td>
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<tr>
<td>reject rate</td>
<td>≈ 10%</td>
<td>0.0%</td>
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<tr>
<td><strong>Trader’s transaction costs</strong></td>
<td></td>
<td></td>
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<tr>
<td>observed spread</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>effective spread</td>
<td>&gt; 0.5</td>
<td>0.3</td>
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</tbody>
</table>

Note: figures are for illustrative purposes only.
Case-study II: Consistency of LP risk management style

A trader executes using an aggregator with 7 LPs but is unsure it’s working well.

- mixed experience on selected execution (impact, reject rates)
- regularly speaks with LPs’ sales representatives about the liquidity offering, but can’t quite identify (whether there is) an issue

A quantitative data-driven analysis is conducted using an anonymised trade set
Case-study II: Consistency of LP risk management style

macro signature across all trades

post-deal micro signature by LP
## Case-study II: Consistency of LP risk management style

Apply **FDA** on the pair-wise micro signatures . . . does post-deal impact vary by LP?

<table>
<thead>
<tr>
<th></th>
<th>LP 1</th>
<th>LP 2</th>
<th>LP 3</th>
<th>LP 4</th>
<th>LP 5</th>
<th>LP 6</th>
<th>LP 7</th>
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<tbody>
<tr>
<td>LP 1</td>
<td></td>
<td>≈</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>LP 2</td>
<td>40.8%</td>
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<tr>
<td>LP 3</td>
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<td>0.0%</td>
<td>≈</td>
<td>≈</td>
<td>≈</td>
<td>≈</td>
<td>≈</td>
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<tr>
<td>LP 4</td>
<td>0.1%</td>
<td>0.2%</td>
<td>≈</td>
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<td>≈</td>
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<tr>
<td>LP 5</td>
<td>0.0%</td>
<td>0.0%</td>
<td>9.8%</td>
<td>17.5%</td>
<td>≈</td>
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<tr>
<td>LP 6</td>
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<td>0.0%</td>
<td>28.7%</td>
<td>39.4%</td>
<td>79.2%</td>
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<td></td>
</tr>
<tr>
<td>LP 7</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
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<td>0.0%</td>
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</tr>
</tbody>
</table>
Case-study II: Consistency of LP risk management style

Natural classification into:

a) passive internalisers,

b) impatient internalisers,

c) aggressive internalisers or externalisers

(as discussed in Butz and Oomen, 2018)
Case-study II: Consistency of LP risk management style

signatures over split sample

- signature $S(\delta)$ (in chps)
- signature horizon $\delta$ (in seconds)

- blue: passive internaliser (1st half)
- green: impatient internaliser (1st half)
- red: aggressive internaliser / externaliser (1st half)
- dashed blue: passive internaliser (2nd half)
- dashed green: impatient internaliser (2nd half)
- dashed red: aggressive internaliser / externaliser (2nd half)
Epilogue

Trader reduces # of LPs and intensifies relationship with passive internalisers

✓ reducing post-deal impact

✓ reducing direct and indirect execution costs

✓ simplifying the liquidity pool, reducing overheads
Thank you for your attention!

Note: the paper is now published in *Quantitative Finance*, 19 (5), 733 – 761


