SIX Swiss Exchange

Trading InfoSnack #11: Crumble In The Jungle

13 September 2022

Crumble In The Jungle

Crumbling quote arbitrage, or the seeking of arbitrage profits via predicting and trading ahead of a probable price change, is a legitimate trading strategy deployed in global equity markets. In one regard, it is an extension of stale price arbitrage strategies (for further on this topic see our Trading InfoSnack #9 on Stale Prices). Rather than relying on speed to capture stale price liquidity after an actual price change, it relies on making accurate predictions of future price changes based on the current order book state. We combine Order Book Imbalance (OBI) analysis with a constructed Crumbling Quote Signal to illustrate the trade-off between fill probability and adverse selection.

In our previous Trading InfoSnack #10 The Rule of Three we demonstrated that order arrival dynamics (and the resulting executions) are influenced by the order book imbalance (OBI) state. At a high level, the OBI compares the depth of liquidity displayed on each side of the book and assesses how balanced (or not it is) in relation to the side of interest (i.e. bid or offer). A highly positive OBI suggests that on the side of interest (i.e. bid or offer) the displayed liquidity is very thin compared to the other side of the book.

When the OBI reaches a threshold state of imbalance, quote crumbling behaviour can typically be observed. Crumbling quotes (CQ) refers to a phenomenon in which removals of liquidity at the EBBO across venues (either via executions or cancellations) begins to see the number of venues displaying liquidity at the current EBBO reducing (i.e. the available liquidity at this price point begins to evaporate, indicating a potential price change). In this InfoSnack, we extend the use of OBI and CQ signals to explore how fill probability and execution performance evolve with changes in the order book state.

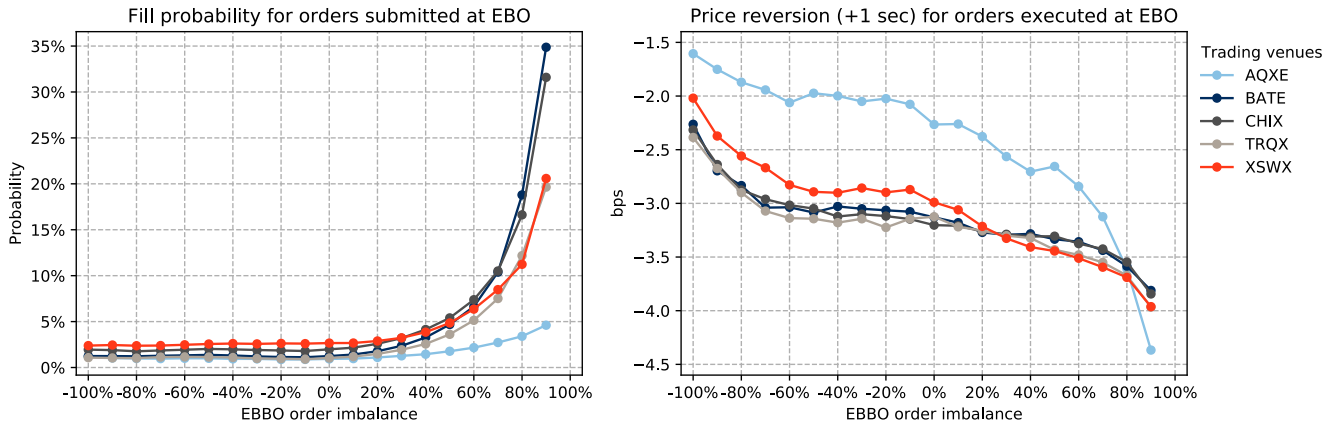
Utilising OBI to explore the likelihood vs performance trade-off

Chart 01 below depicts the evolution of fill probability[1] and price reversion[2] relative to the EBBO OBI state. With respect to fill probability, it can be observed that the primary exchange (SIX) has the highest fill probability when the OBI is negative, neutral and mildly positive. When the OBI is strongly positive, which is indicative of significant price instability and a potential price change, the fill probability across all venues increases significantly. This trend is even more prevalent on the MTFs, with fill probabilities on the CXE and BXE books exceeding that observed on the primary exchange (SIX) during such states of significant price instability.

Conversely, price reversion worsens the more positive the OBI state is, with it being 1x to 2x worse in highly positive OBI states than in all other OBI states. This highlights the trade-off between enhancing likelihood of execution and deteriorating execution performance, especially when trading in highly positive OBI states. The above suggests: (i) the importance of OBI as a dynamic input to algorithmic / order-routing logic; and (ii) that strategies with a higher proportion of executions occurring in highly positive OBI states will likely suffer from worse execution performance.

[1] Is defined as the average fill probability of orders submitted at the EBO within queue positions 1 to 5, where fill probability is calculated as the likelihood that an order submitted gets executed within one second (Kaplan-Meier estimator of order survival).
[2] Is defined as the price reversion for orders executed at the EBO, where the execution price is compared against the EBO price one second after execution, and expressed in basis points.

Chart 01: Likelihood of execution and execution performance



Data sources: BMLL, SIX | Securities: Swiss Blue Chips | Sample period: 02 May 2022 - 31 Aug 2022
Sampling frequency: The EBBO order imbalance (x-axis) is sampled at 10 percentage points.

From OBI to crumbling quotes

As OBI increases beyond a certain threshold, price instability increases, and the order book enters a 'crumbling' state whereby quotes/orders on the thin side of the book tend to be removed (either via executions or cancellations) with increasing rapidity. This typically happens over a very short-time horizon and typically leads to a price change, with OBI typically returning to a neutral state (i.e. between -20% and +20% OBI) [3] once said price change has occurred. As such, 'crumbling' signals (otherwise known as "Crumbling Quotes") provide an opportunity for participants to predict and position themselves ahead of a potential price change by buying (or selling) now and then unwinding at a more advantageous price within a very short time-horizon. They can also be utilised as an input into scheduled based algorithms and order-routing strategies to help optimise spread-crossing and venue-preferencing logic (ideally dynamically, if strategy and roundtrip latencies permit).

Construction of a "Crumbling Quote Signal"

To construct a "Crumbling Quote" (CQ) signal, we take inspiration from the important work of IEX in the US[4], who have embedded a CQ signal in a 'smart' order type to protect investors against crumbling quote arbitrage. As such, we count how many lit order books (Aquis, Cboe BXE, Cboe CXE, Turquoise and SIX Swiss Exchange) are at EBB or EBO, check whether this count changes within a defined time frame (the 'prediction window': set at 10ms), and use these variables to predict the likelihood of an EBB or EBO change in subsequent future time frame (the 'firing window': set to 20ms).

To do this, we take an iteration of the IEX crumbling quote logistic model as also summarized by Peng et al (2019)[5] to predict a downward EBB and upward EBO price moves, where the explanatory variables include: (i) the number of venues at EBB, (ii) the number of venues at EBO, (iii) the number of venues at EBB 10ms ago and (iv) the number of venues at EBO 10 ms ago. Moreover, we require the consolidated order book order imbalance to be negative (positive) for a downward (upward) tick of the EBB (EBO) and the EBB (EBO) to be stable within the 10ms. The logistic model $F(x;\widehat{\beta}) \geq \bar{p}$ has been fitted for each security individually with $\bar{p}$ set to 0.50. It is worth noting that we set a more conservative (and standard) $\bar{p}$ threshold than that adopted by IEX (i.e. $\bar{p} = 0.32$). This means that when firing the signal generates relatively more true positives (and thus less false positives). This improves the signals accuracy, but also reduces the % of time that it is 'on' overall.

[3] Supplementary data, not shown
[4] Bishop, Allison, The Evolution of the Crumbling Quote Signal (April 21, 2017). Available at SSRN: https://ssrn.com/abstract=2956535
[5] Peng, Z., Guo, D. and Meng, D., IEX's Speed Bump and Its Effect on Adverse Selection (February, 2019). Submitted to SSRN and available at: P081_Named.pdf (sydney.edu.au)

When applying the above CQ signal to Swiss Blue Chip equities data (02 May 2022 to 31 August 2022), we can draw several insights. Firstly, Table 01A shows the proportion of time each of the venues order book's is in a 'crumbling' state whilst the CQ signal is 'switched-on'. In particular, the table shows how often the EBB (EBO) price level on a venue disappears, when the market is crumbling at the EBB (EBO) as per the CQ signal. It can be observed that the pattern of price-level 'crumbling' across venues does not align with each venues respective market share position. The overall accuracy of the CQ signal can be observed in Table 01B below. It can be observed that the CQ signal correctly predicts the direction of the price movement on near side of the book in around 75% of the cases and incorrectly predicts the near side price movements in almost 0% of the cases. This suggests that the CQ signal is accurate at predicting adverse price changes.

Table 01A: Which venues are crumbling?[6]

Venue	% of time venue is crumbling when CQ is turned 'on'
AQXE	52%
BATE	67%
CHIX	81%
TRQX	44%
XSWX	62%

Table 01B: Price movements in firing window after signal on[6]

Side	Bid price ↑	Bid price ↓	Ask price ↑	Ask price ↓
Ask	9%	17%	76%	0%
Bid	0%	75%	18%	8%

Further to this, Table 02A below summarises proportion of trades per venue that occur during either the CQ signal prediction window, the CQ signal firing window or when the CQ signal is 'off'. Similarly, Table 02B measures the price reversion (+1 sec) per venue on trades occurring within the same windows outlined above. Taken together they provide a view of the likelihood and impact of executions on different venues occurring during crumbling order book states. It can be observed in Table 02A that (except for Aquis) trades executed on MTFs are more likely to occur when the CQ signal is turned on (i.e. in either the prediction or firing window). In particular, the relative difference between the proportion (%) of trades occurring in prediction window versus the firing window on MTFs (compared with that observed on the primary) is suggestive that 'crumbling' first begins on MTFs before spreading to the primary and Aquis. Following on from this, Table 02B illustrates that the price reversion on executions that occur when the CQ signal is turned on is higher by approximately 0.8bps compared to executions that occur when the CQ signal is off. This signifies the additional cost of interacting with contra order flow that more efficiently predicts short-term price movements and positions itself accordingly to benefit from them.

Table 02A: Share of 'crumbling window' trades[6]

Venue	Prediction window	Firing window	Signal Off
AQXE	5%	3%	92%
BATE	16%	4%	80%
CHIX	12%	4%	84%
TRQX	13%	7%	80%
XSWX	9%	3%	88%

Table 02B: Price reversion of 'crumbling window' trades[6]

Venue	Prediction window	Firing window	Signal Off
AQXE	-4.1	-3.4	-2.5
BATE	-4.1	-3.5	-3.3
CHIX	-4.1	-3.1	-3.3
TRQX	-4.1	-3.9	-3.3
XSWX	-4.0	-3.7	-3.2

[6] Data Sources: BMLL, SIX | Securities: Swiss Blue Chips | Sample period: 02 May 2022 – 31 Aug 2022

Key Considerations

Pulling together the above insights surrounding the application of OBI and CQ we surmise the following:

- OBI and CQ signals are important indicators of impending price changes and thus impending adverse selection;
- They can be utilised by trading participants to assess the state of evolution of fill probability and adverse selection and provide an indication of current price / liquidity stability;
- When utilising OBI and CQ signals as contemplated above, the trade-off between likelihood of execution (fill probability) and execution performance (adverse selection) can be clearly observed;
- Fill probability and adverse selection dynamically evolve across venues according to OBI state, with both fill probability and adverse selection at their highest when the OBI is highly positive;
- In all other states adverse selection is better and fill probability is higher on the primary, with OBI returning to a neutral state immediately after a price change occurs;
- Given that CQ signals estimate the likelihood that cross-venue liquidity removal patterns lead to a price change, they provide an accurate, forward-looking prediction of short-term price movements which can be utilised to either seek arbitrage opportunities or avoid adverse selection; and
- As such, both CQ and OBI signals can be incorporated into trading strategies by participants to optimise liquidity provision, statistical arbitrage, scheduled-based algorithms and intra-venue order-routing strategies.

Food for thought.

Authors

Adam Matuszewski	**Phone** +41 58 399 4047	**E-Mail** adam.matuszewski@six-group.com
Simon McQuoid Mason	**Phone** +44 788 910 0020	**E-Mail** simon.mcquoid-mason@six-group.com
Fabian Ochsner	**Phone** +41 58 399 4212	**E-Mail** fabian.ochsner@six-group.com
Dr Ekaterina Azarnyh	**Phone** +41 58 399 5069	**E-Mail** ekaterina.azarnyh@six-group.com

Visit our website: www.six-group.com/trading

SIX Swiss Exchange AG
Pfingstweidstrasse 110
P.O. Box
CH-8021 Zurich
T + 41 58 399 5454
F + 41 58 499 5455
info@six-swiss-exchange.com
www.six-swiss-exchange.com