ADAPTIVE

A Revolution in Algorithmic Trading

ADAPTIVE Intelligence

CLSA's **ADAPTIVE**, a revolution in Algorithmic Trading integrates the latest AI machine learning technology with contextual news and research. The supercharged CLSA Algorithmic Trading platform now enables our clients to take a more discreet, proactive and adaptive approach to execution. As non-traditional market participants continue to exert their influence on the Asian trading landscape, CLSA's **ADAPTIVE** levels the playing field for our clients in an ever-changing and increasingly volatile trading environment.

Anatomy of ADAPTIVE

CLSA's **ADAPTIVE** leverages the Neural Network, the machine learning technology behind 'The Brain' which utilises both public and proprietary data sources to train itself to identify volatility and predict intra-day price movements as well as market volume. Real-time trend momentum evaluation is supported by confidence levels and intensity screening of predicted price trend and market volume.

Live news feed analysis powered by a Natural Language Processing engine allows **ADAPTIVE** to detect and react to momentum shifts as they occur. Using diverse data sources including Bloomberg, Google Finance, Twitter and CLSA's award-winning research, 'The Brain' classifies data into five different sentiment levels applying contextual interpretations to live markets.

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Implications for algorithmic trading strategies

Increasingly volatile markets require accurate, effective and timely analysis of both data and momentum.

CLSA's **ADAPTIVE** addresses these requirements in order to ensure our clients remain on the front foot as markets move, whilst easing the impact from disruptive non-traditional market participants. By differentiating between long-term sentiment changes and short-term momentum moves, CLSA algorithms take advantage of momentum moves but also of mean reversion. Combinations of predictions are generated to boost the performance of strategies targeting various benchmarks.

ADAPTIVE generates price trend signals and performs real time volatility clustering (measurement) for its decision making. **ADAPTIVE** predicts short-term price, volume and projected target (i.e. VWAP projection) to adjust strategies' behaviour. Every signal is classified by a confidence level and intensity grade based on real-time trades. At the same time, **ADAPTIVE** makes long-term forecasts (i.e. closing volume prediction) and engineers the 'market direction indicator' to detect the presence of informed trading in the market. With directional market information, **ADAPTIVE** algorithms can dynamically alter the execution plan based on favourable or adverse market moves. The trade execution plan is dynamically revised throughout the trading day to adapt to market conditions as they evolve.

ADAPTIVE PRICE PREDICTION STATISTICS FOR MAJOR MARKETS

Market	% of time active trend signal detected	Up trend %	Down trend %	Signal prediction accuracy %	Actual market up trend price move (bps)	Actual market down trend price move (bps)
Japan	39.23	28.06	11.16	89.31	3.53 - 10.07	3.41 - 10.40
India	30.73	21.07	9.66	86.01	2.26 - 7.32	2.40 - 8.51
Hong Kong/ Australia	40.05	28.28	11.77	96.26	1.90 - 4.60	2.10 - 4.70

Note: Statistics compiled from all orders traded with CLSA ADAPTIVE algorithms in 1Q 2017.

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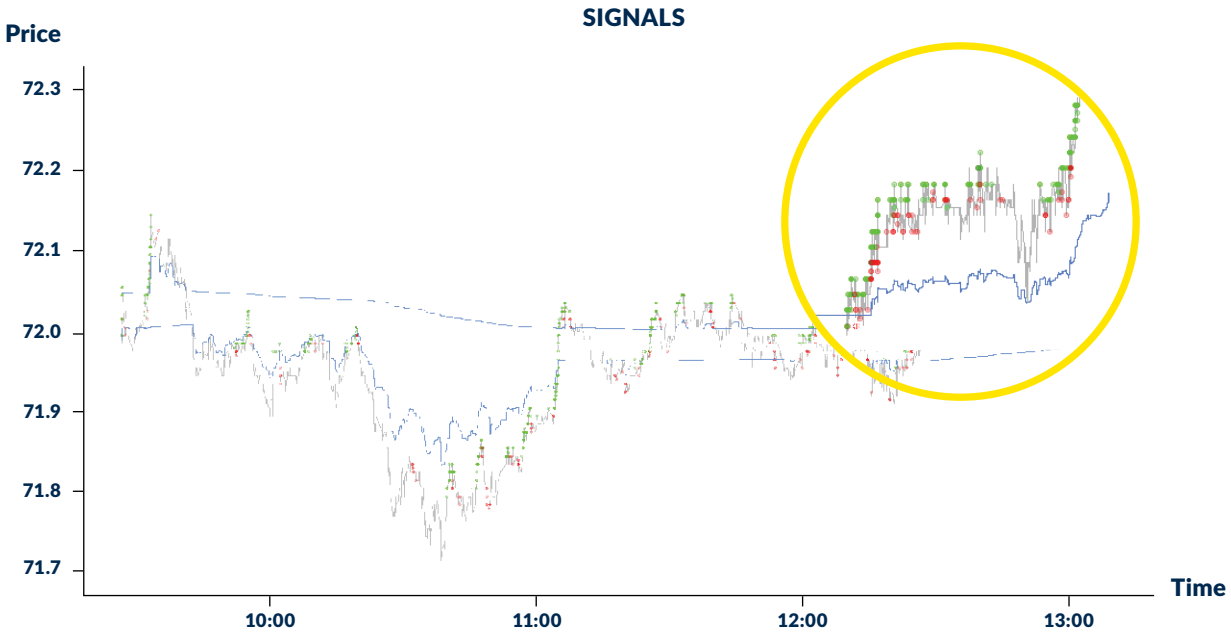
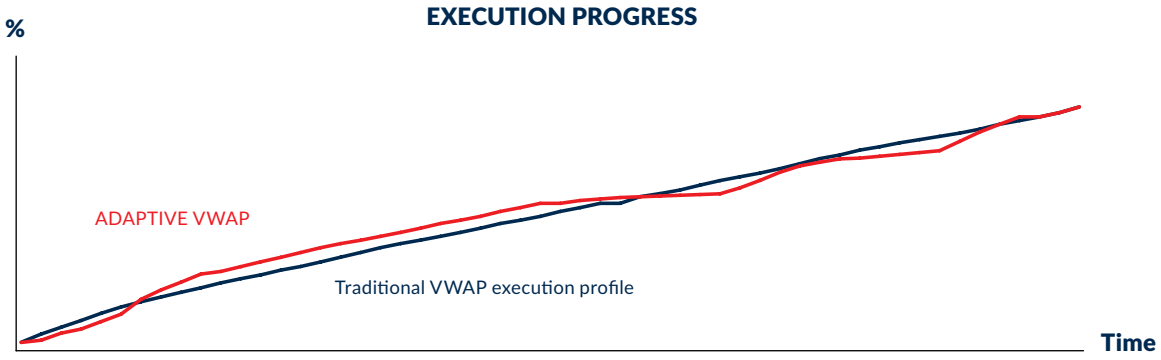
ADAPTIVE STRATEGIES

ADAPTIVE VWAP (VWAP)

With **ADAPTIVE**, strategies such as VWAP no longer need to stick to a traditional time-based fixed slicing schedule. It now reacts to real-time market price and volume movements. Price and volatility signals enable the VWAP strategy to capture small price misplacements in the market. With a dynamic view of future forecast volumes and price levels, **ADAPTIVE** VWAP achieves outperformance with reduced risk.



The analytical engine generates trend signals characterised by intensity based on real time trades. It also constructs a volatility band (the blue lines) around the stock price, highlighting normal vs. abnormal (favourable or unfavourable swings) volatility.



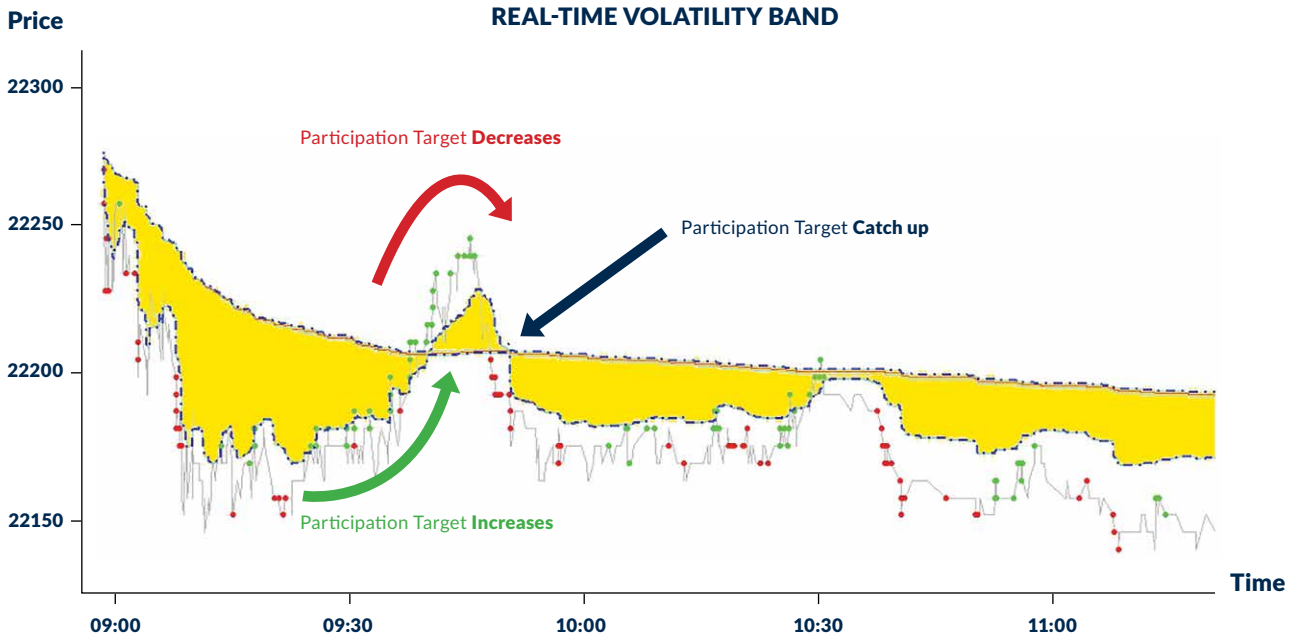
Traditional VWAP execution profile (blue line) vs. ADAPTIVE VWAP (red line) trading around the VWAP curve based on ADAPTIVE signals.

ADAPTIVE STRATEGIES

ADAPTIVE Inline (Volume Inline)

ADAPTIVE's signal detection, price and volume prediction science puts Alpha into Inline strategies.

Compared to a pure volume reactive Inline strategy, the new **ADAPTIVE** Inline differentiates momentum and mean reversion scenarios, allowing the algorithm to adjust trading patterns to optimise execution performance.



ADAPTIVE Inline Algorithm

For an optimal execution, **ADAPTIVE** Inline manages the overall participation rate on the order within trader defined aggression bands.

ADAPTIVE Inline calculates participation targets based on short-term predicted price, real-time volatility and price signals. The same price level at different times and market situations can result in a variable participation target. **ADAPTIVE** Inline trades up to the top of its range ahead of adverse moves, slowing down during the adverse, allowing for catch-up post reversion price moves.

ADAPTIVE BENCHMARK FOR DYNAMIC STRATEGY

Dynamic strategy, CLSA's most popular participation rate algorithm, is empowered with **ADAPTIVE**'s short-term price prediction model. Dynamic alternates between two volume participation rates based upon not only a real-time benchmark but also a prediction benchmark anticipating where the stock price will go within the next few minutes. **ADAPTIVE** Benchmark works best in high volatility and strong momentum market conditions by predicting the target price.

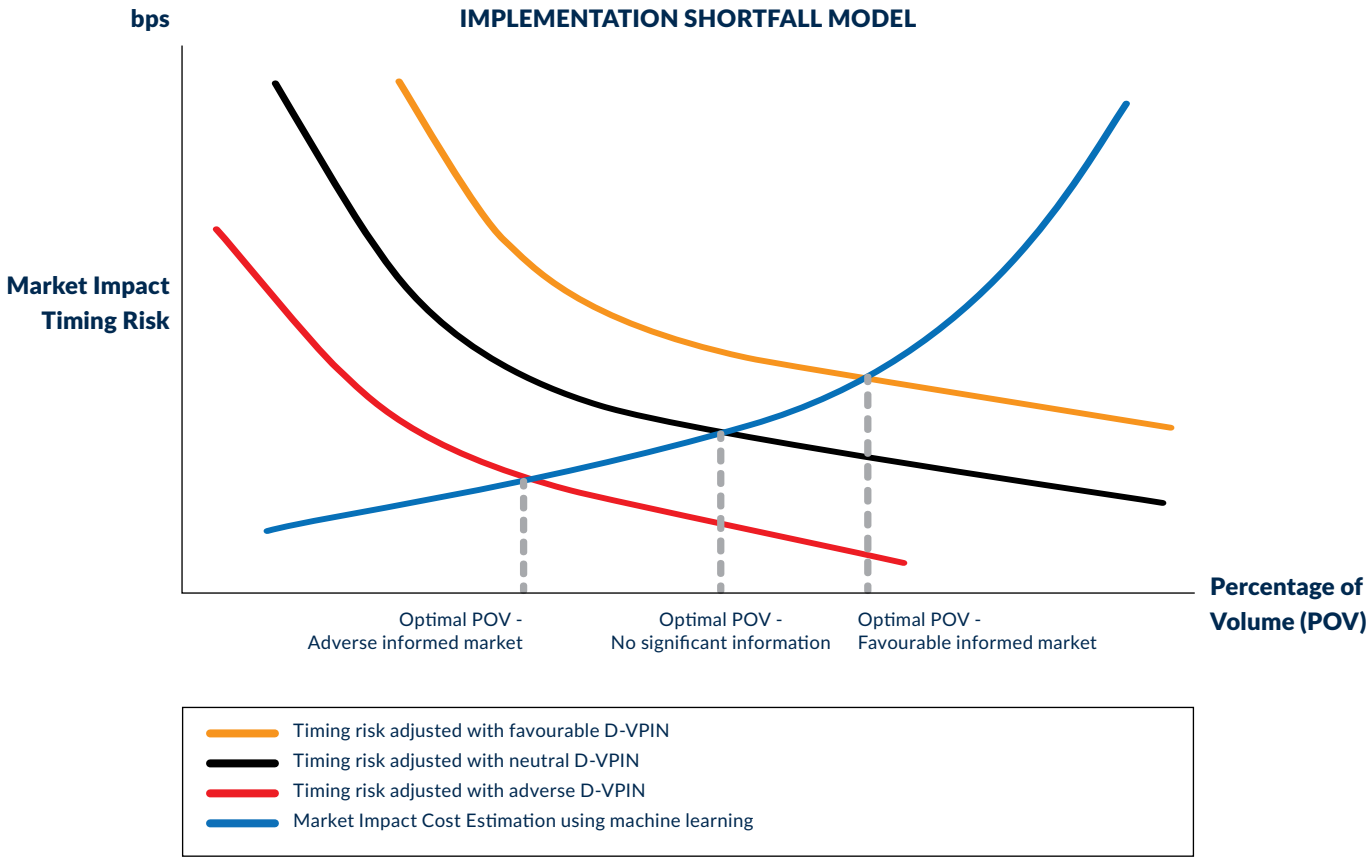
ADAPTIVE STRATEGIES

ADAPTIVE IS (Arrival Price)

ADAPTIVE empowers the Implementation Shortfall model to optimise transaction costs by balancing market impact cost and timing risk. By continuously measuring the intraday volatility, D-VPIN (Directional Volume Synchronised Probability of Informed Trading Indicator) and volume prediction from Neural Networks, the Arrival Price strategy keeps adjusting the optimal participation rate in real time.

Optimal participation rate is derived by balancing market impact cost estimation and D-VPIN adjusted timing risk. VPIN is a metric which measures the probability of informed trading in the market with a dimension of volume imbalance between buy and sell initiated trades. Based on VPIN, CLSA introduced the directional element to create D-VPIN as an adjustment indicator for timing risk estimate.

Real time volume prediction model further enhances the accuracy of market impact cost and timing risk estimation from the Implementation Shortfall model.



ADAPTIVE STRATEGIES

ADAPTIVE market on close (QMOC)

The QMOC strategy's volume estimation model is refined with **ADAPTIVE** to provide a more timely and dynamic volume prediction.

The QMOC strategy may start early if predicted volume is low in the close and keeps revising the execution plan based on real time closing volume prediction.

ADAPTIVE's volume prediction model is powered by the neural network to provide an accurate prediction of closing volume in a sporadic liquidity environment. The model takes into account the day's volume traded in the market as input to compare against historical volume profile for volume prediction and continuously evaluates the projection as the market trades in real time. The strategy execution plan is adjusted accordingly to allocate volume reserved for the close and find an optimal time to trade pre-close.

D-VPIN is applied on top of the volume prediction model, thus a buy and sell order on the same day maybe executed differently.

The upper chart shows the execution progress of a buy and sell QMOC order.