Algorithmic Trading Strategies[1]

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[1] Reference: Avellaneda (2011), Maglaras (2015)

Algo Trading Systems: Typically Decomposed into 3 Steps

- **Trade scheduling (macro-trader):** splits parent order into $\sim$ 5 min slices (**Lecture 2**)
  - Relevant time-scale: minutes-hours
  - Schedule follows user selected strategy (VWAP, POV, IS, ...)
  - Reflects urgency, alpha, risk/return tradeoff
  - Schedule updated during execution to reflect price/liquidity/...
- **Optimal execution of a slice (micro-trader):** further divides slice into child orders (**Lecture 3**)
  - Relevant time-scale: secondsminutes
  - Strategy optimizes pricing and placing of orders in the LOB
  - Execution adjusts to speed of LOB dynamics, price momentum, ...
- **Order routing:** decides where to send each child order (**Lecture 4**)
  - Relevant time-scale: $\sim 1 - 50$ ms
  - Optimizes fee/rebate tradeoff, liquidity/price, latency, etc

Algo Trading Strategies: VWAP

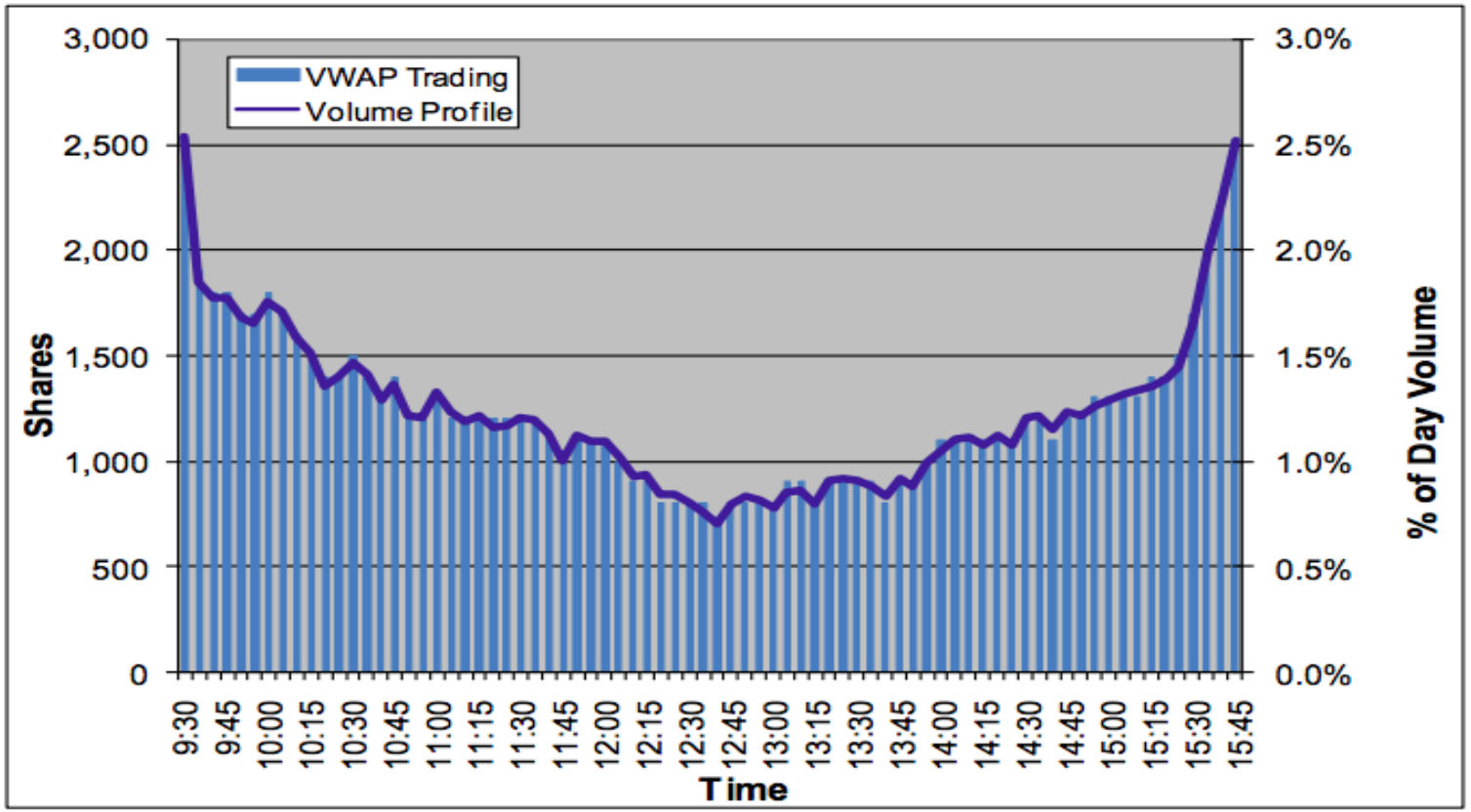
- **VWAP (Volume-Weighted Average Price):** Trades according to forecasted volume profile to achieve (or beat) the market VWAP.
  - [2] If an asset during some time interval has N trades with price p_k and volume v_k , its VWAP is

$$VWAP = \sum_{k=1}^{N} v_k p_k / \sum_{k=1}^{N} v_k$$

  - Passive strategy.
  - Subject to significant market risk.
- Algorithm:
  - Estimate the average volume traded in every 5 minute interval using historical data.
  - In each time-interval, execute an amount proportional to the normative volume for that interval.

[2] Yang (n.d.)

Volume-Weighted Average Price



- Properties:
  - The algorithm always concludes (trade sizes are known in advance).
  - Volume function is estimated using historical data. This may not correspond exactly to *ex-post* VWAP.

Algo Trading Strategies: TWAP

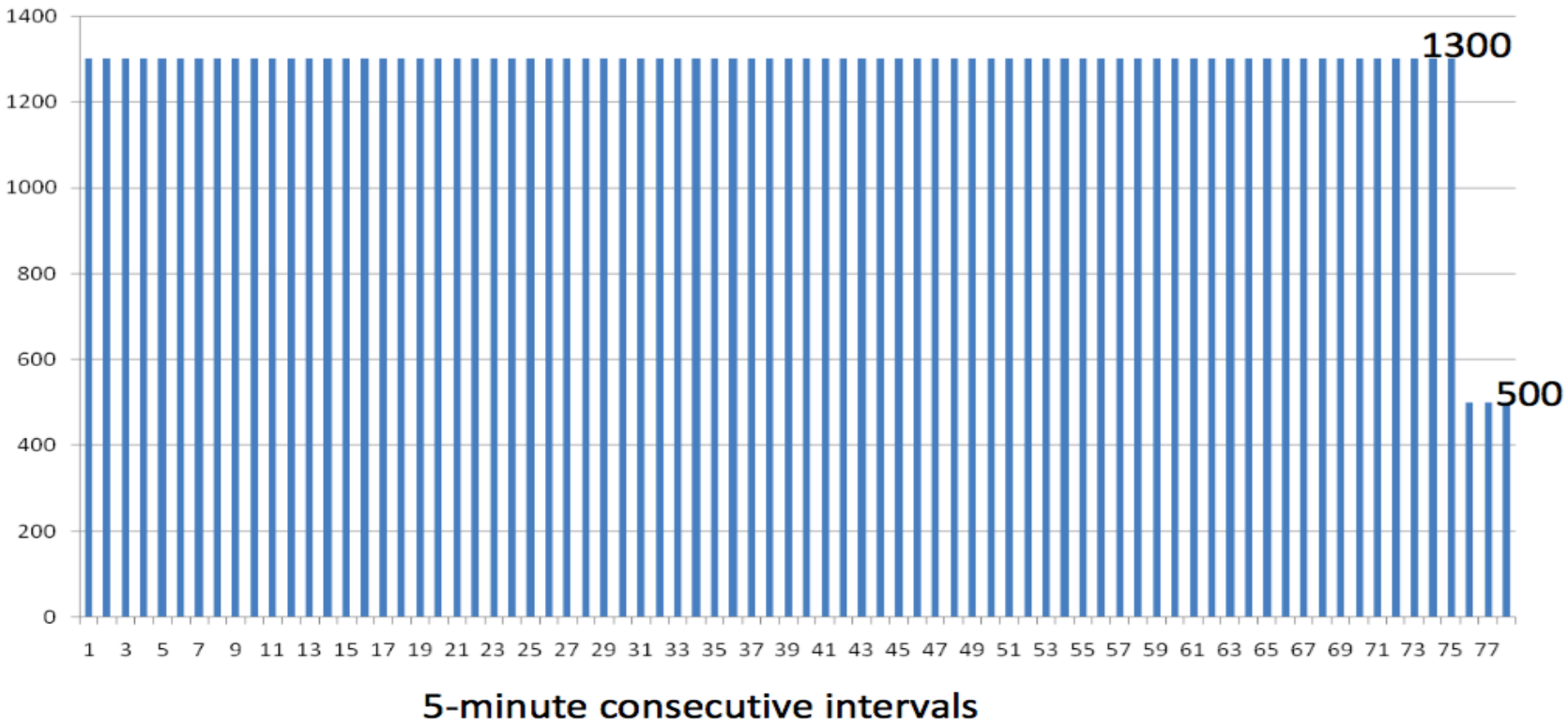
- **TWAP (Time-Weighted Average Price):** Trades uniformly over time to achieve (or beat) TWAP benchmark.
  - Passive strategy
  - Also subject to market risk
- [3] Such a simple protocol has a risk of exposure of the traders intentions to other market participants:
  - *For example, some scalpers may realize that a large order is being traded and start trading the same instrument in expectation that the large trading volume will inevitably move the price.*
- To prevent information leak, TWAP schedule may be randomized in terms of size and submission time of child orders.
  - *For example, if the trading interval is four hours, 25% of the trading volume must be executed each hour, and the child order size may be adjusted deterministically for each hour.*

[3] Yang (n.d.)

Time-Weighted Average Price

- [4]

Figure 1: Example: 100,000 shares TWAP/all day



- Equal amount of shares in each period of time.
- Not very popular in practice.

[4] Avellaneda (2011)

VWAP vs. TWAP

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- During a slow trading day, the TWAP may be very similar to the VWAP, even to the penny at times. However, in a volatile session, or when volume is higher than usual, the two indicators may diverge.

[5] Yang (n.d.)

Algo Trading Strategies: POV

- **POV (Percent of Volume):** Submit child orders with sizes equal to a certain percentage of the *total trading volume*.
  - Execute while tracking the realized volume profile at a constant target participation rate, e.g., buy IBM at 15% participation rate.
  - Controls behavior during volume spikes to avoid excessive cost.
  - Popular in practice with $\sim 5\% - 30\%$ participation rates.
  - Participation rate is highly related to transaction cost.

Price of Volume

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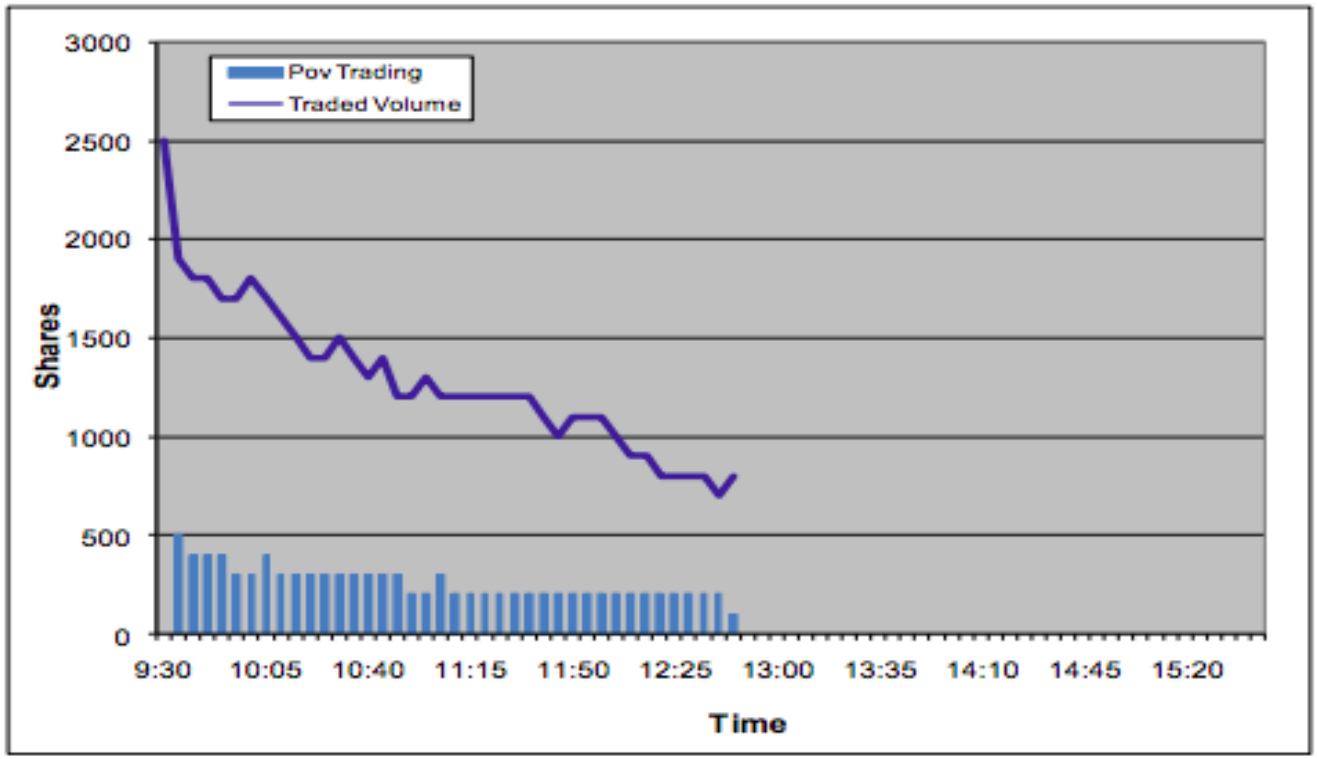


- The POV (Percentage of Volume) algorithm addresses the problem of VWAP by using the actual total traded volume of the day as benchmark.

[6] Avellaneda (2011)

Algo Trading Strategies: IS

- **IS (Implementation Shortfall):** Schedules trade so as to optimally tradeoff *expected shortfall* (cost) against *execution risk*.
  - Objective functions is usually a weighted linear sum of execution cost and execution risk.
  - Execution speed adapts with respect to changes in market conditions.
  - Popular, especially with portfolios with intricate cost/risk tradeoff.

Implementation Shortfall

- (Almgren and Chriss, 2000) **Expected Fall**
  - Stock price is subject to price impact.

$$\tilde{S}_t = S_t - \eta \frac{dQ(t)}{dt}.$$

  - *Expected execution cost* is the volume-weighted execution price along the time:

$$E = -\mathbb{E}[\int_{t=0}^{T} \tilde{S}_t \frac{dQ(t)}{dt} dt].$$

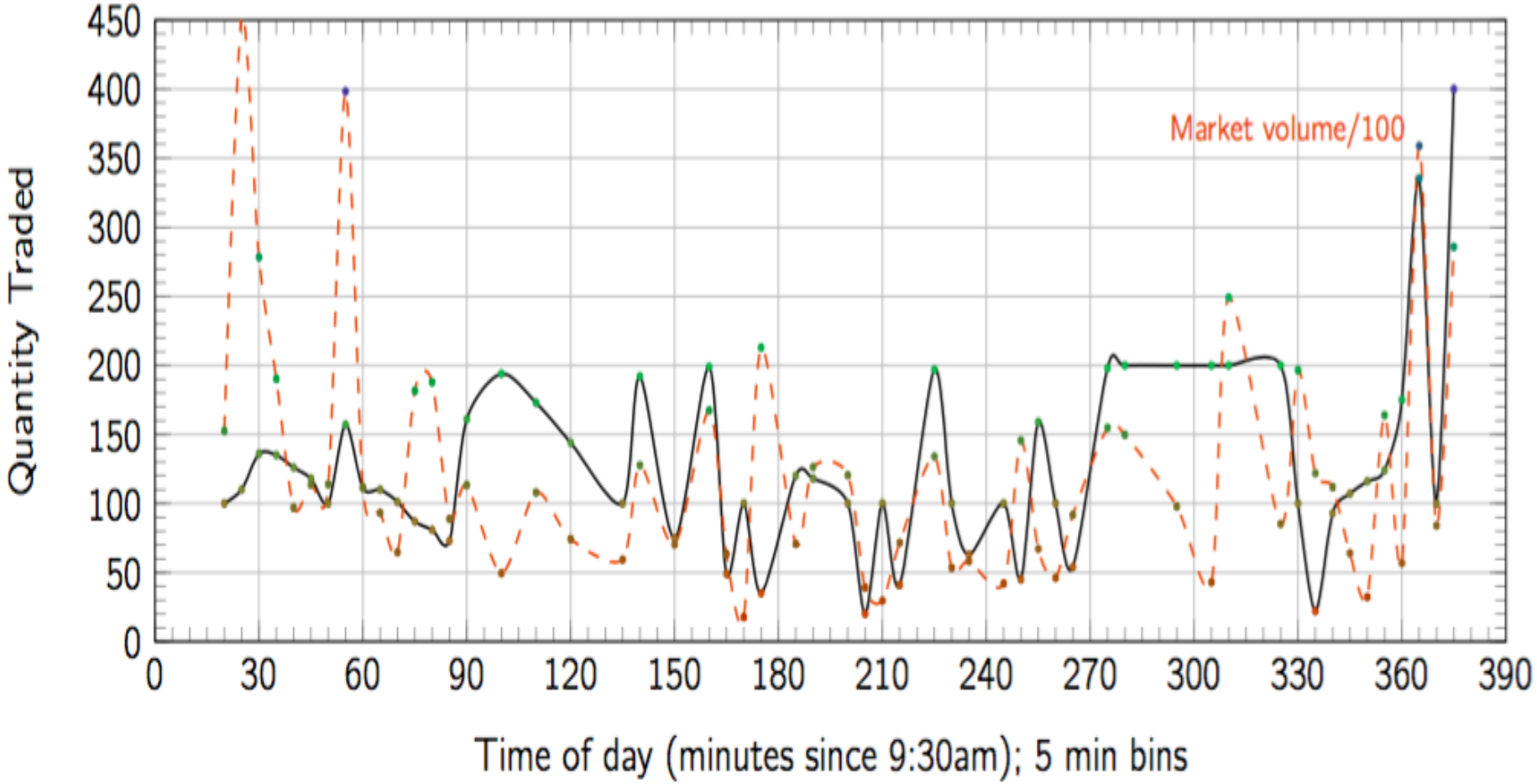
  - *Execution risk* is the variance of execution position:

$$V = \text{Var}[\int_{t=0}^{T} Q(t) dS_t]$$

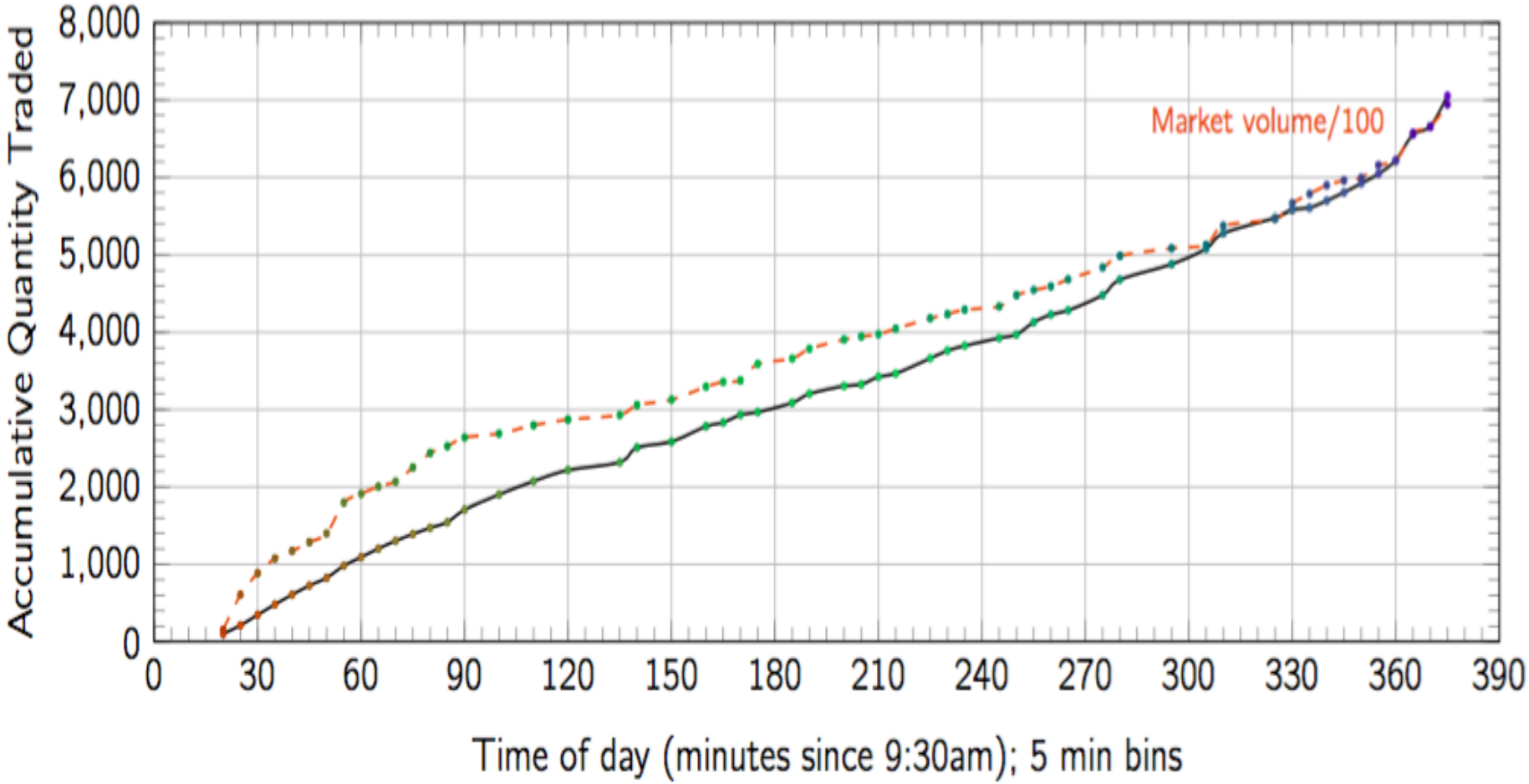
  - The optimal position is the one that minimizes the sum of *execution cost* and *execution risk*:

$$\min_{Q} \{E + \lambda V\}$$

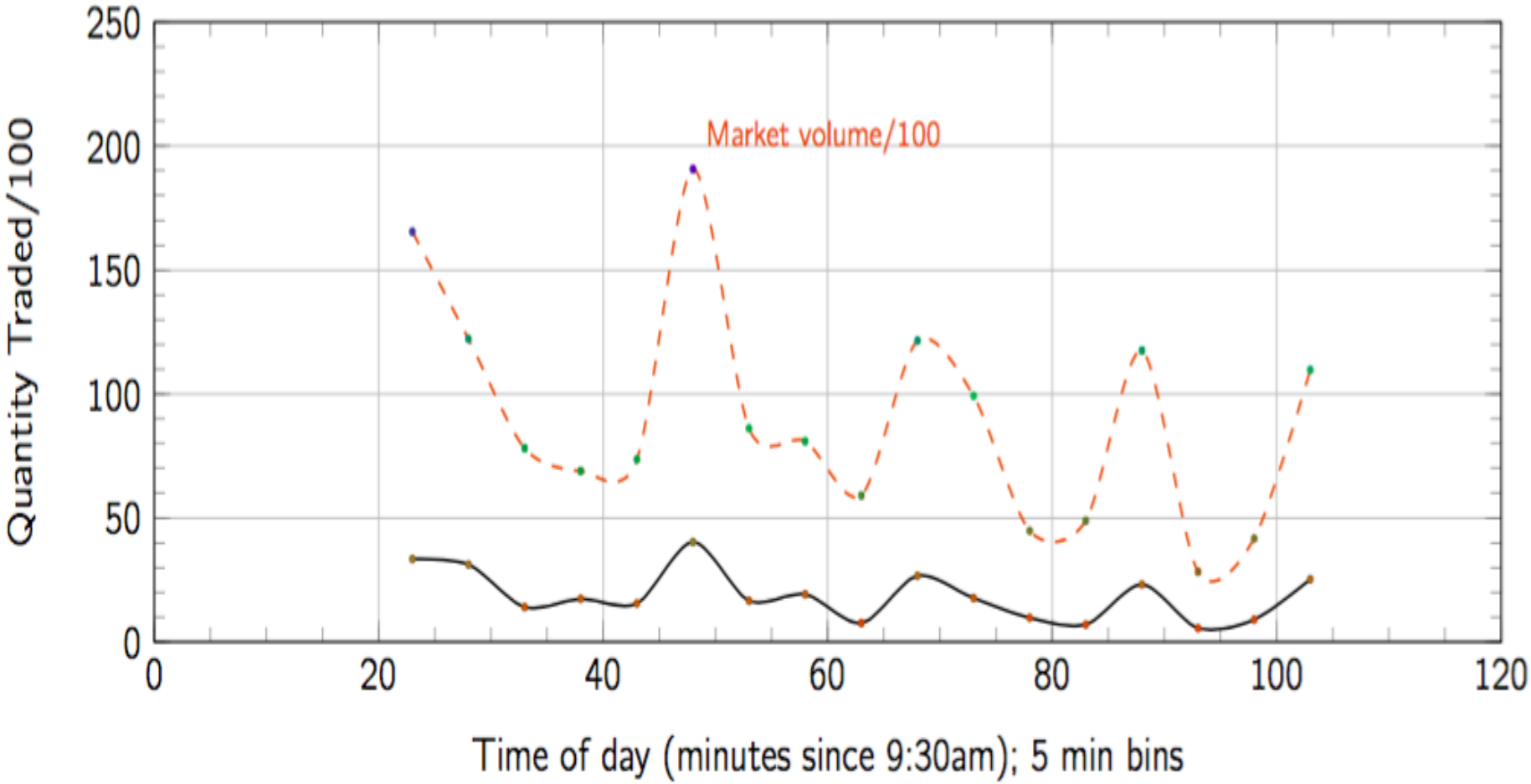
VWAP, XLY, 07/22/2013 (.15%ADV)



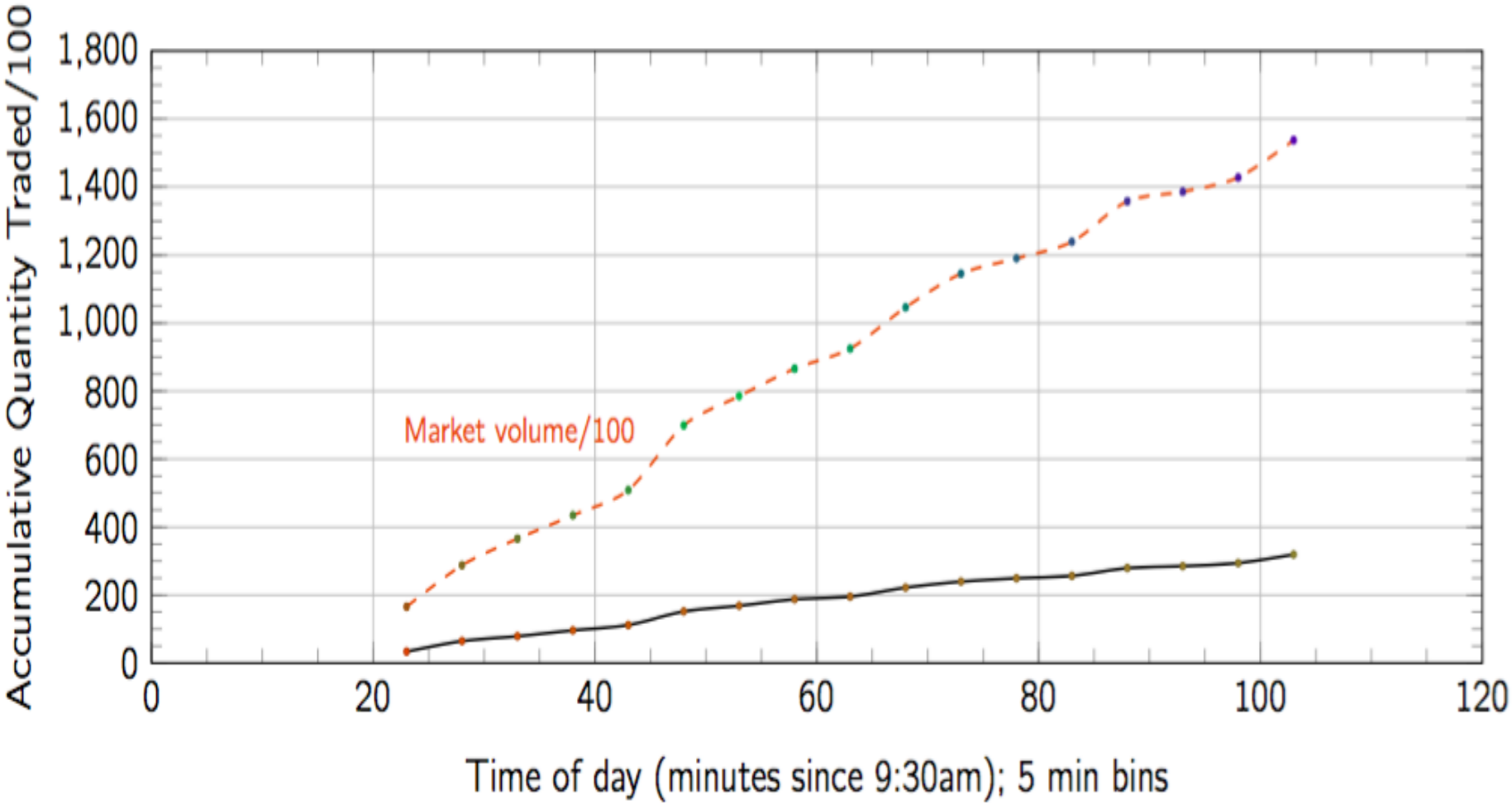
VWAP, XLY, 07/22/2013 (cumulative quantity)



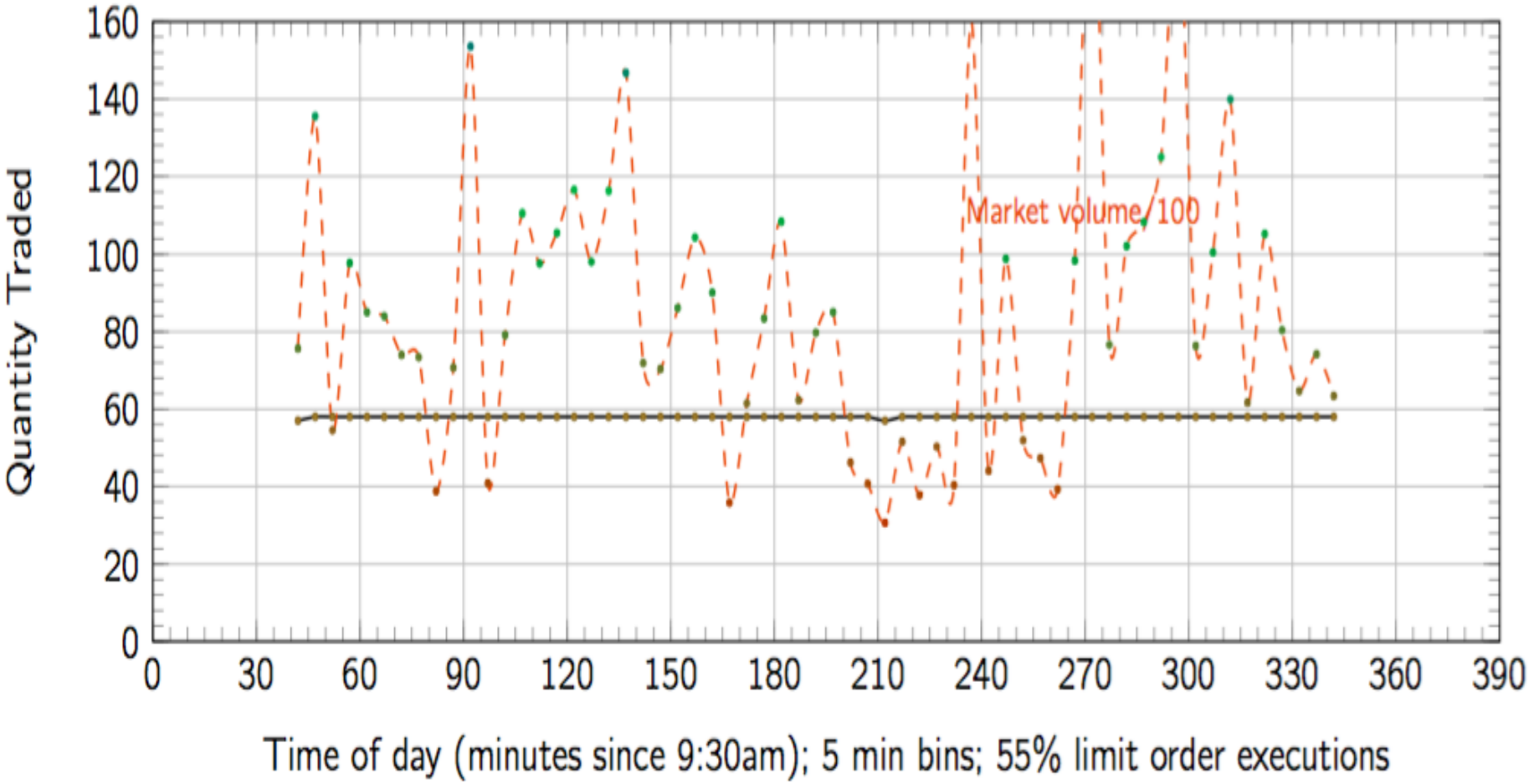
POV 20% ACT, 07/08/2013



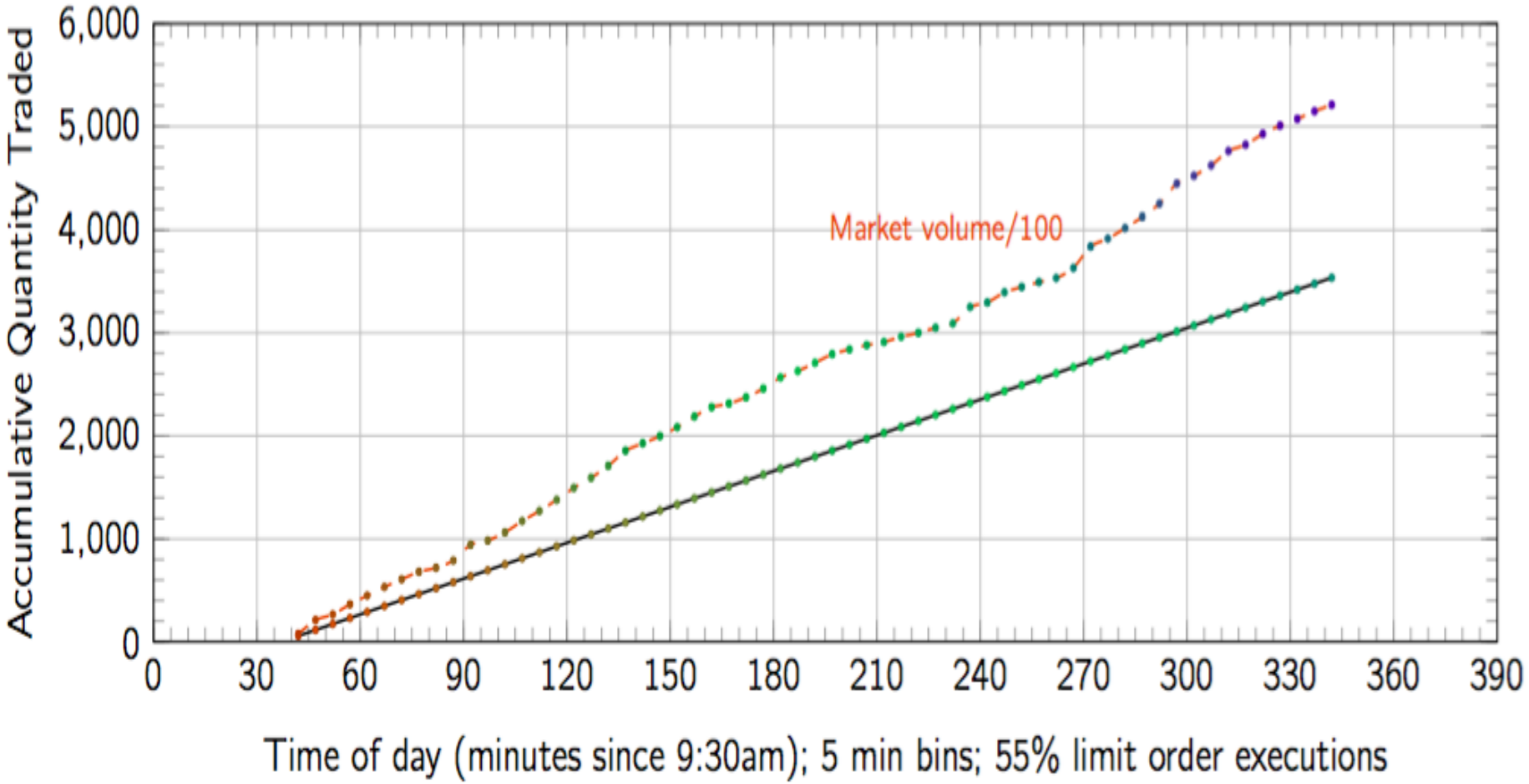
POV, ACT, 07/08/2013 (cumulative quantity)



Schematic of execution profiles: TWAP, XLY, 07/02/2013



TWAP, XLY, 07/02/2013 (cumulative quantity)



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