Algorithmic Trading Strategies[1]

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

Our primary focus is on limit order book dynamics

- Limit order book behavior affects:
  - Algorithmic trade execution systems & performance
  - Trading signals & execution for MMs
  - Regulatory implications

Algorithmic Trading

- algorithmic trading strategies
- typical architecture of algo trading systems
- implementation shortfall
- VWAP

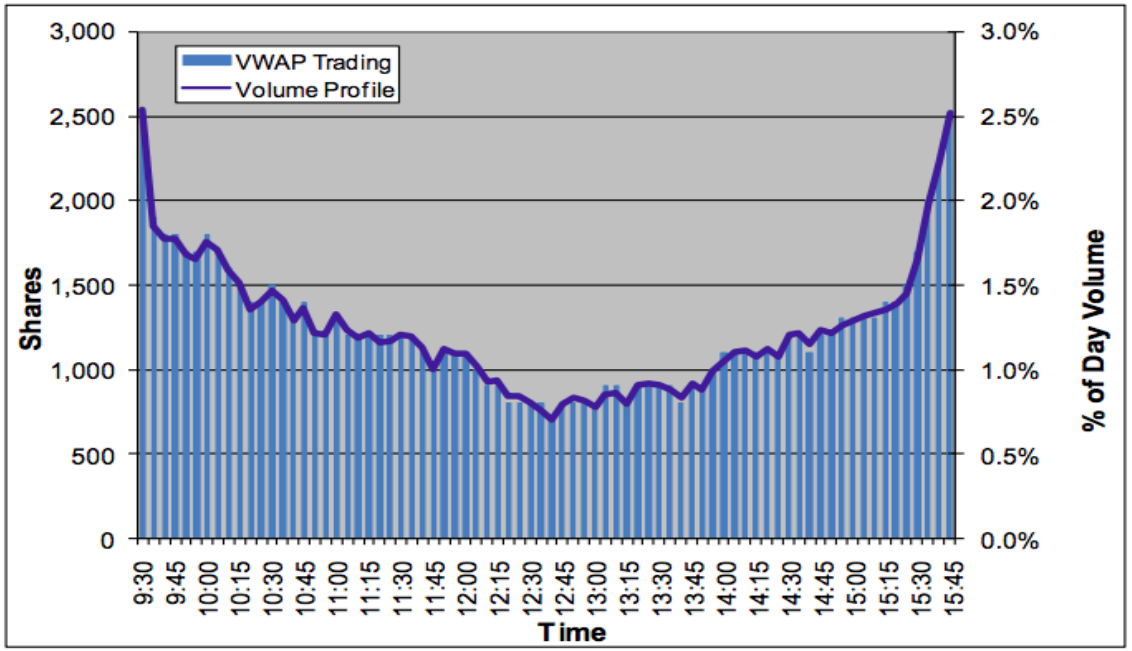
Algo Trading Strategies (90+% of institutional flow)

- **VWAP (Volume-Weighted-Average-Price):** Trades according to forecasted volume profile to achieve (or beat) the market VWAP
  - Passive strategy
  - Subject to significant market risk
  -

$$VWAP(t_1, t_2) = \frac{\sum_{t=t_1}^{t_2} \delta V(t) P(t)}{\sum_{t=t_1}^{t_2} \delta V(t)}$$

- **TWAP (Time-Weighted-Average-Price):** Trades uniformly over time to achieve (or beat) TWAP benchmark
  - Passive strategy
  - Market risk
  - Not very popular in practice

Volume-Weighted Average Price



- Algorithm:
  - Estimate the average volume traded in every 5-min interval.
  - Within interval, execute amount proportional to the normative volume.
- Properties:
  - Trade sizes are known in advance.
  - Volume function is estimated using historical data.

VWAP vs. TWAP

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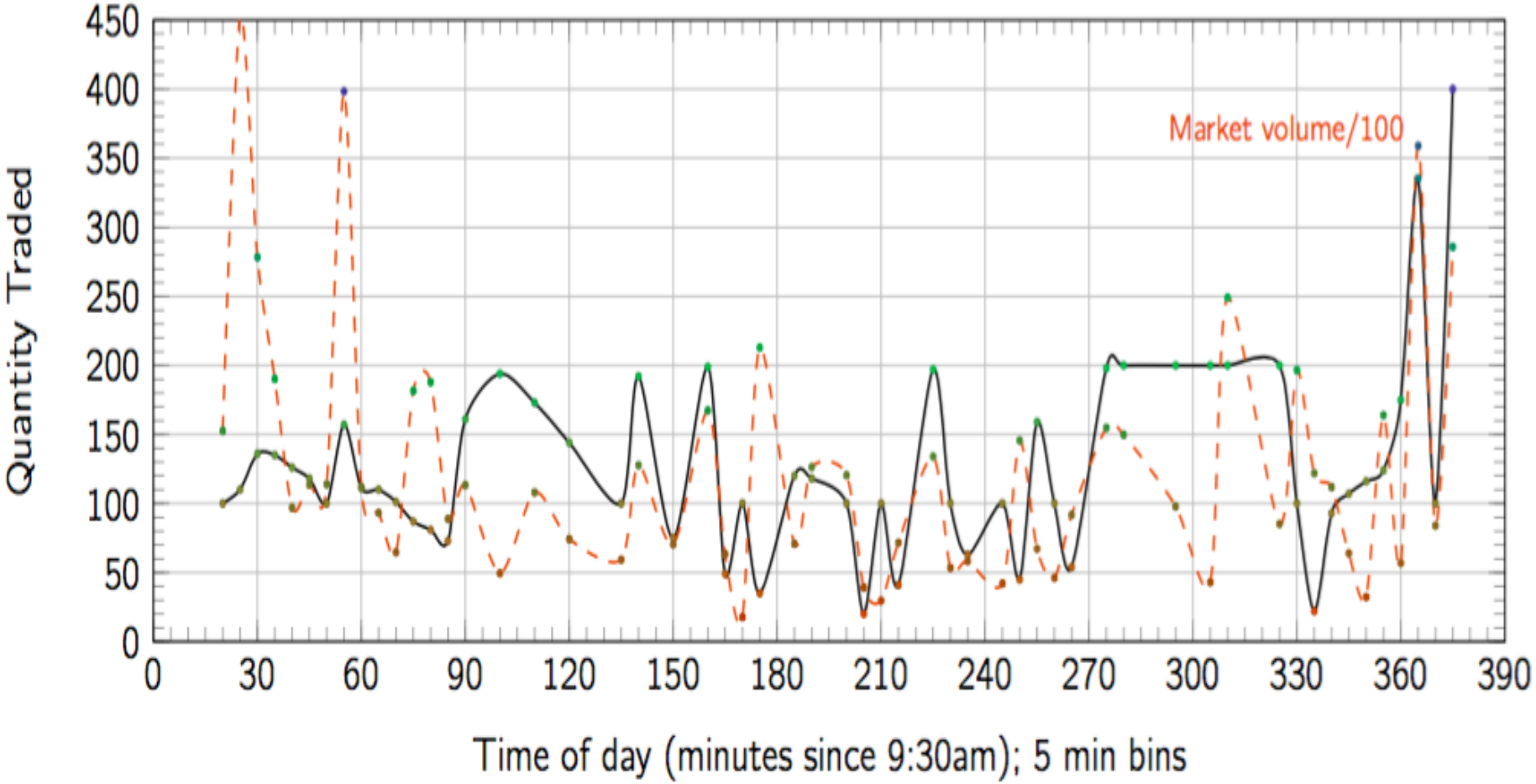
- During a slow trading day, the TWAP may be very similar to the VWAP, even to the penny at times. However, in a volatile session, or when volume is higher than usual, the two indicators may diverge.

[2] Yang (n.d.)

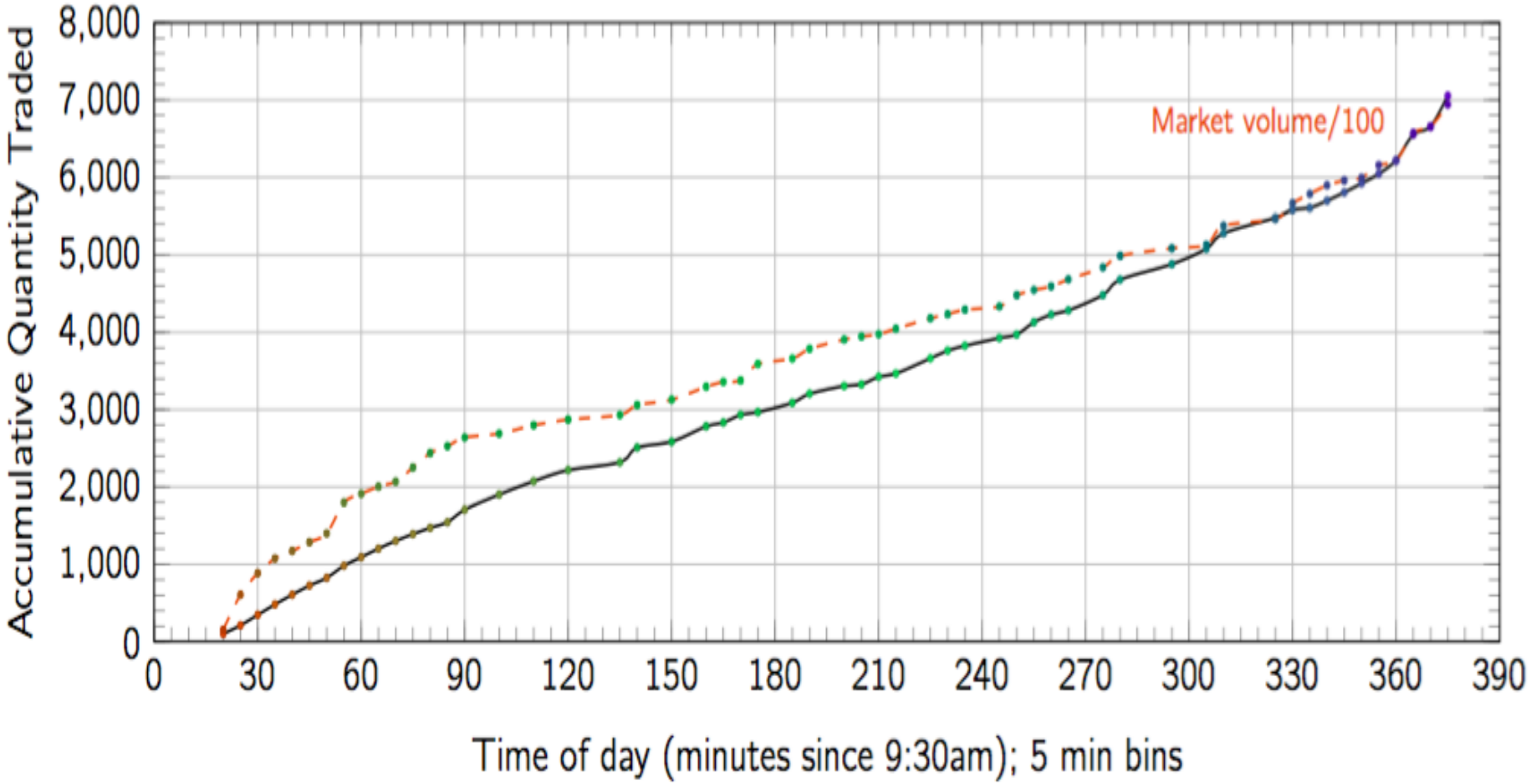
Algo Trading Strategies (Cont'd)

- **POV (Percent-of-Volume):** Executes while tracking the realized volume profile at a target participation rate, e.g., buy IBM at 15% participation rate
  - Controls behavior during volume spikes to avoid excessive cost
  - Popular in practice $\sim 5\% - 30\%$ participation rates
  - Participation rate is highly related to transaction cost
- **IS (Implementation Shortfall):** Schedules trade so as to optimally tradeoff expected shortfall (cost) against execution risk
  - Variable execution speed; adapts wrt changes in market conditions
  - Popular, especially with portfolios with intricate cost/risk tradeoff

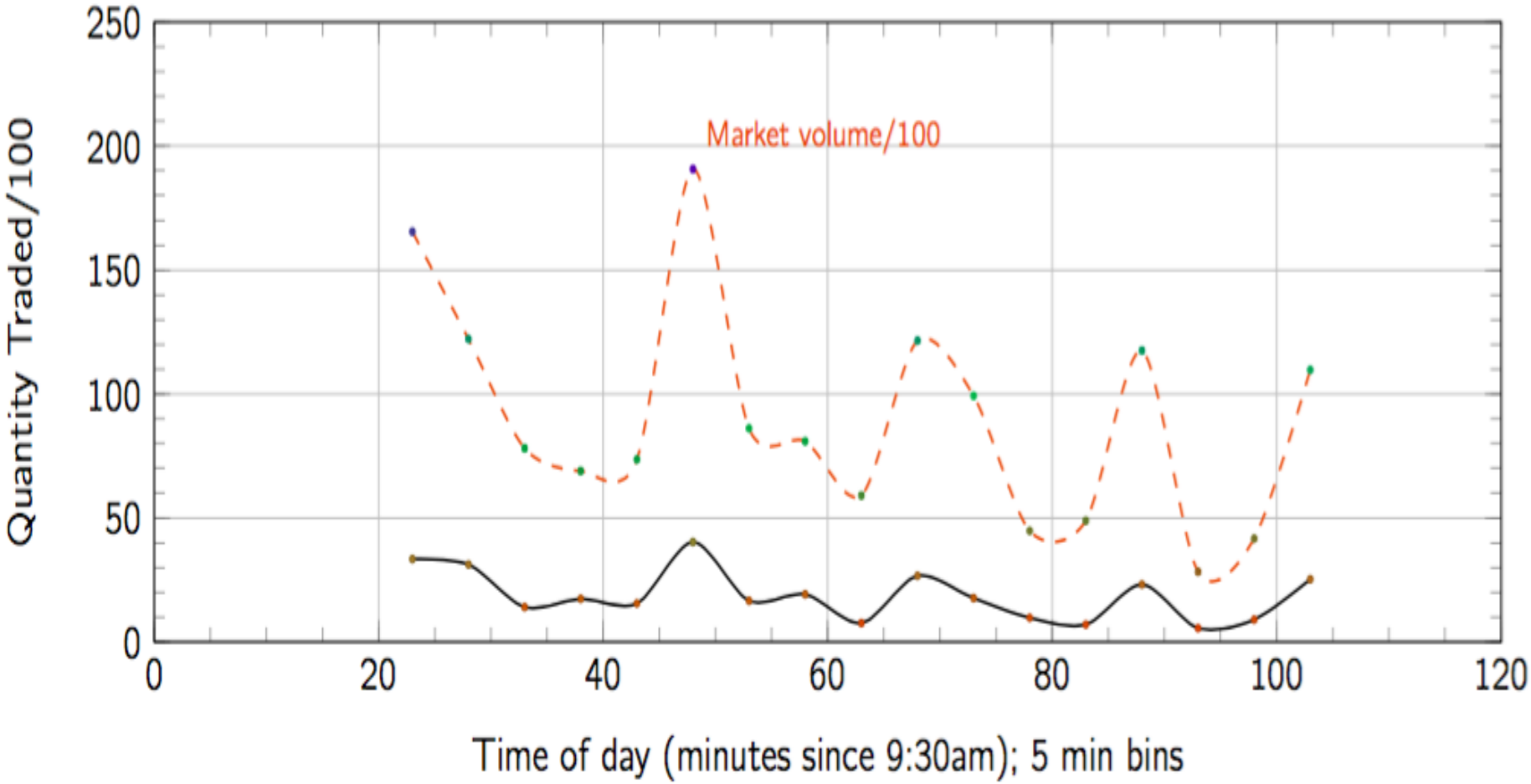
VWAP, XLY, 07/22/2013 (.15%ADV)



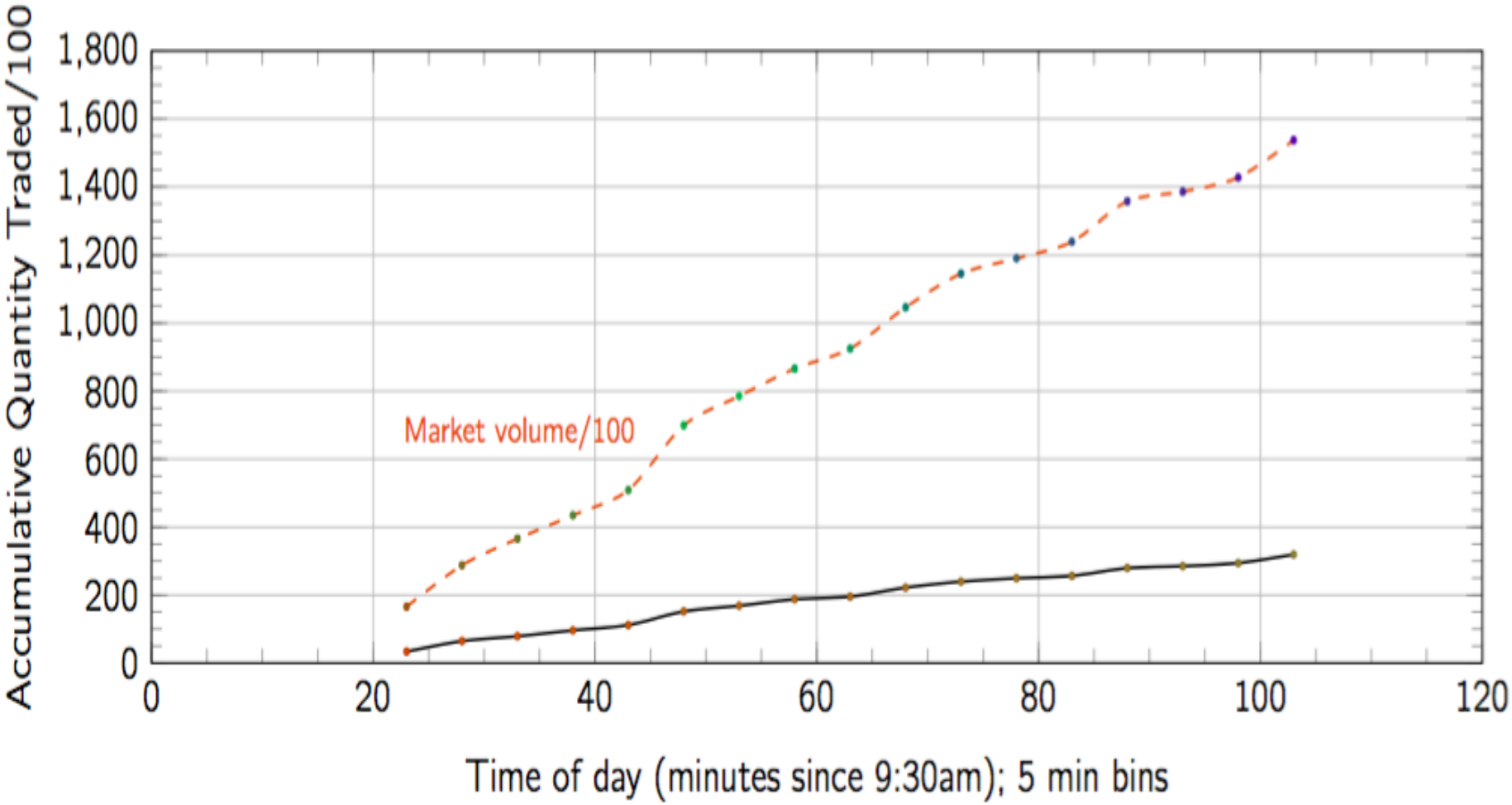
VWAP, XLY, 07/22/2013 (cumulative quantity)



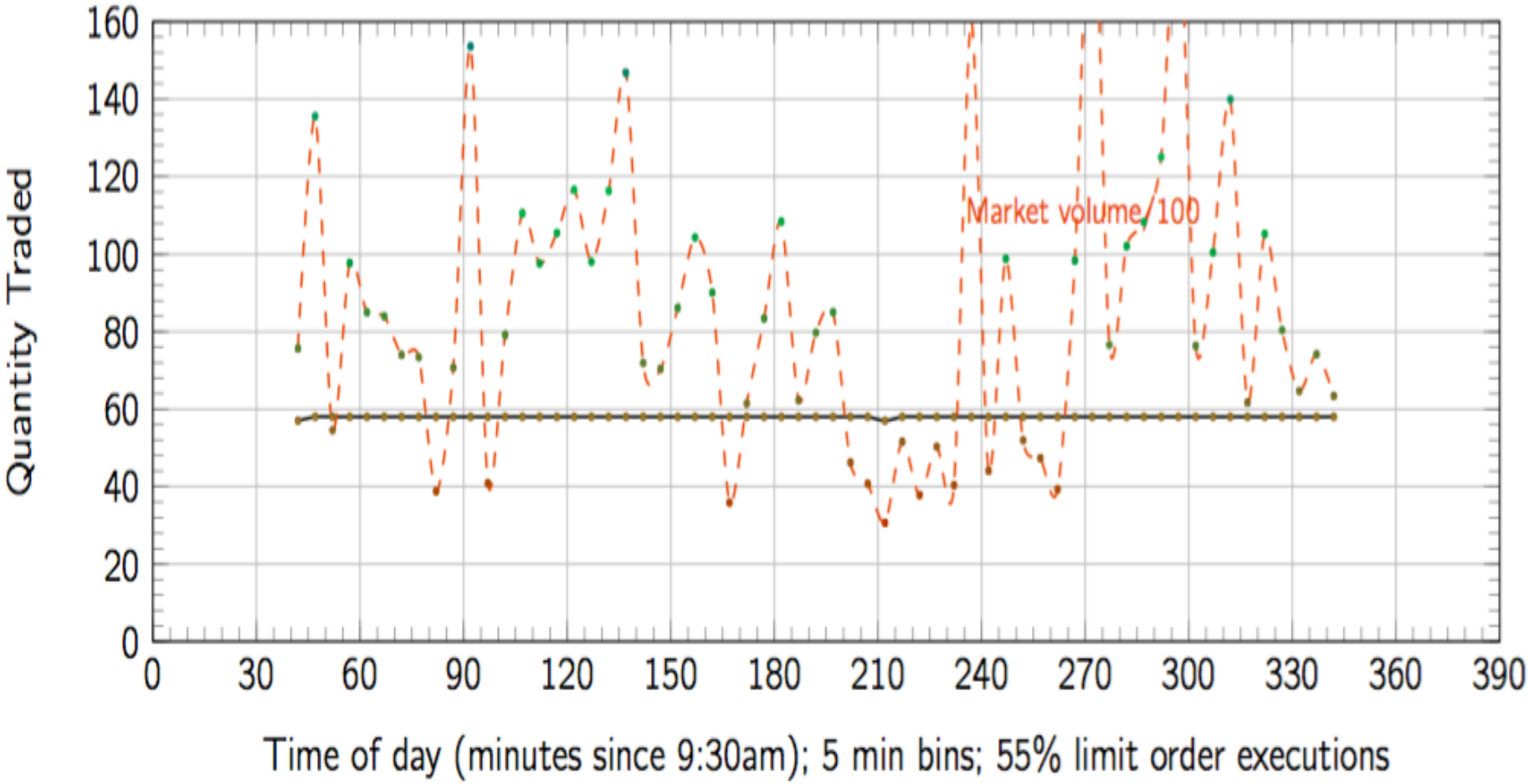
POV 20% ACT, 07/08/2013



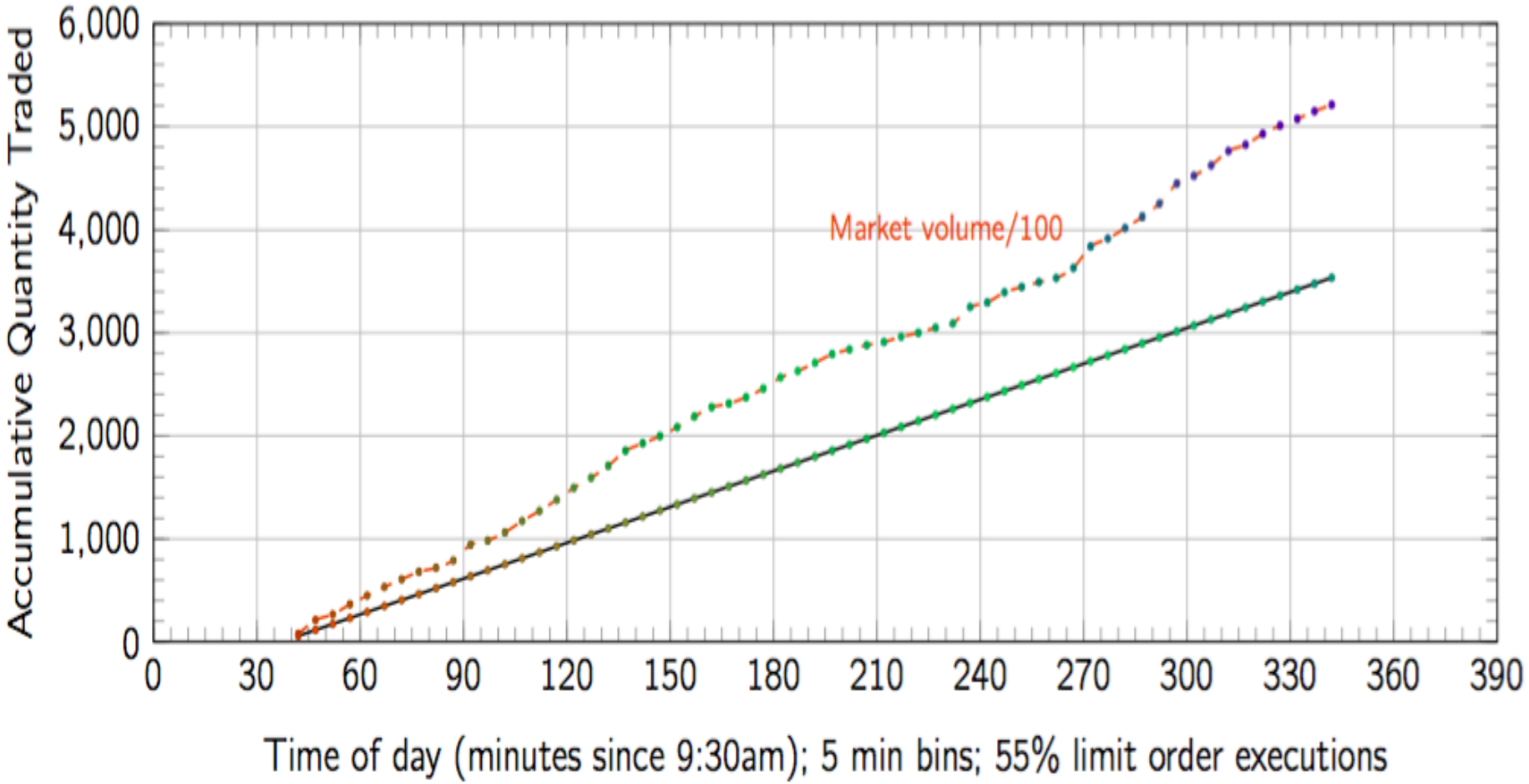
POV, ACT, 07/08/2013 (cumulative quantity)



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



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



Algo Trading Systems: Typically Decomposed into 3 Steps

- **Trade scheduling (macro-trader):** splits parent order into $\sim$ 5 min slices
  - 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
  - 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
  - Relevant time-scale: $\sim 1 - 50$ ms
  - Optimizes fee/rebate tradeoff, liquidity/price, latency, etc

Algorithmic Trading Systems: basic building blocks

- forecasts for intra-day trading patterns
  – volume
  – volatility
  – bid-ask spread
  – ...
- real-time market data analytics
- market impact model
- risk model
  – of the shelf risk models calibrated using EOD closing price data do not incorporate intra-day correlation structure
  – intra-day data? (tractable for liquid securities, e.g., S&P500 universe)
  – cross-asset liquidity model & market impact model

Essential building block: market impact model

- Optimizing the trade schedule, i.e., how to split a large trade over smaller waves to be executed over time, requires a cost function for:
  - immediate costs due to current trading decisions (e.g., next 3 min)
  - impact of current decisions on future prices (and future trades)
- Key considerations:
  - transient costs: impact of current trading decisions on price
  - decay of transient costs: instantaneous? impact decays over time?
  - permanent costs: is there a permanent cost (information content)?
  - time-scales: interpretation of transient, decay, permanent
- Calibration
  - how to model? functional forms? (depends on relevant time-scale)
  - what data is needed
  - stock segmentation

References I

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