

# Use of Intraday Alphas in Algorithmic Trading

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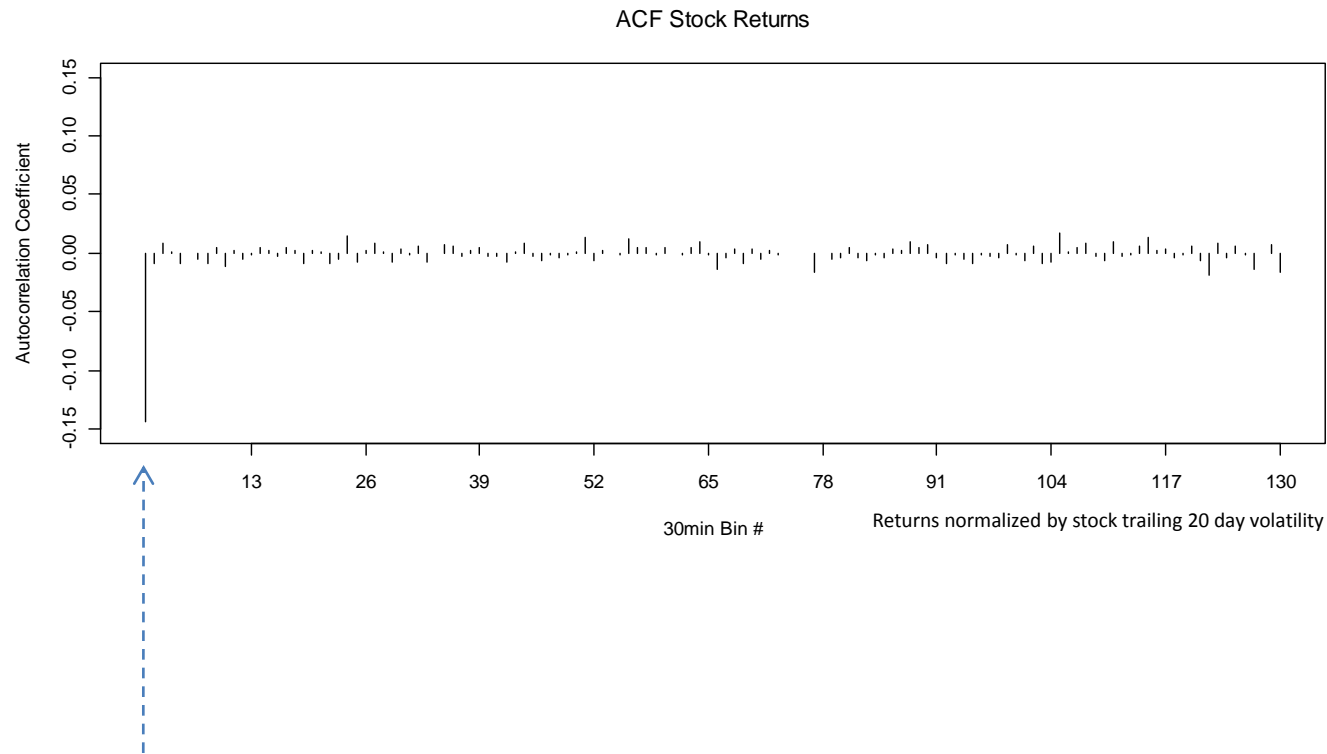
## Execution Algorithms: Traditional Area of Focus

- Minimize **market impact & volatility** of the result
- Vs a price **benchmark** (e.g. VWAP, arrival price, open, last close)
- **Techniques commonly used to execute efficiently:**
  - Forecast liquidity distribution across time and venues
  - Forecast adverse selection by venue (esp. dark pools)
  - Estimated price impact & high frequency volatility, optimize the trade-off between the two
  - Tactics to minimize signaling & information leakage (e.g. latency-adjusted Smart Router spraying)
  - Judicious spread-crossing
- **Not so widely exploited (yet):**
  - Generic alphas (“Micro Alpha Models”)
  - Portfolio implicit alphas (“Alpha Profiling”)

## Generic Alpha Example: “Periodicity”

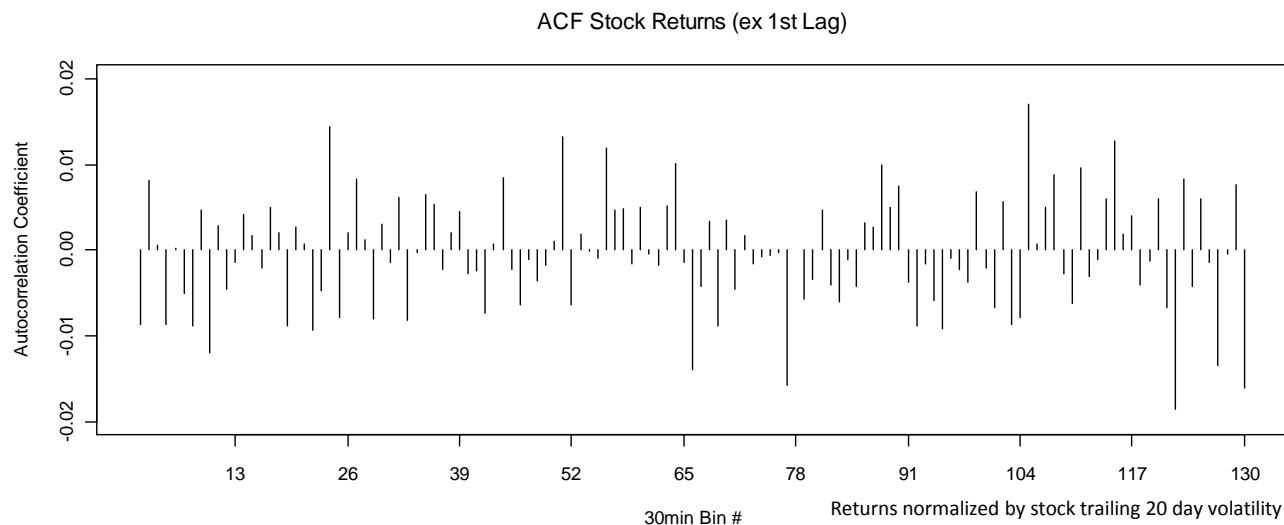
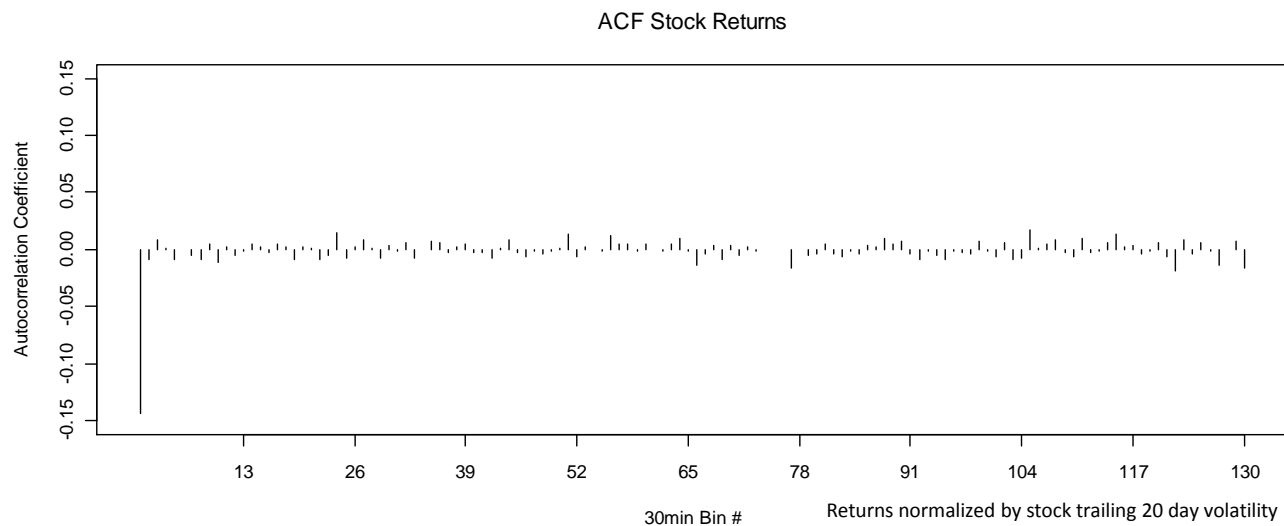
- **“Intraday Patterns in the Cross-section of Stock Returns”** (Heston, Korajczyk, Sadka 2010)
- Intra-day segment (excess) return **continuation** at daily intervals
- Documented for U.S. stocks for **8-year** time period 2001 – 2009
- Heston, Korajczyk, Sadka **robustness checks**:
  - Robust after correcting for bid-ask bounce
  - Not an artifact of thinly traded stocks
  - Not an artifact of intra-day spread changes
  - Magnitude of effect inversely proportional to market cap, but not limited to small cap stocks
  - Periodicity in volume doesn't explain return periodicity
- Let's explore if it is relevant in a more recent time period and how useful in **algorithmic execution trading** context

# Honing in on the “Periodicity” Effect



The first intraday lag shows high negative autocorrelation due to temporary liquidity imbalances and bid-ask bounce.

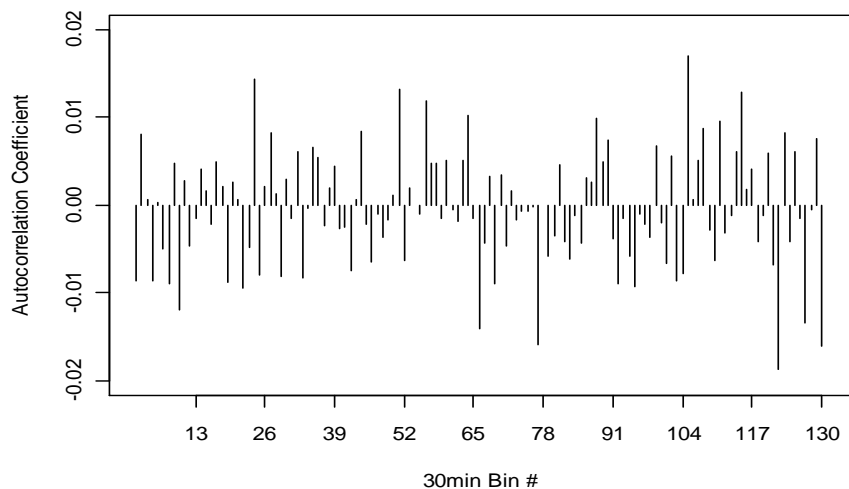
# Improved Visibility of “Periodicity” by Removing 1<sup>st</sup> Lag



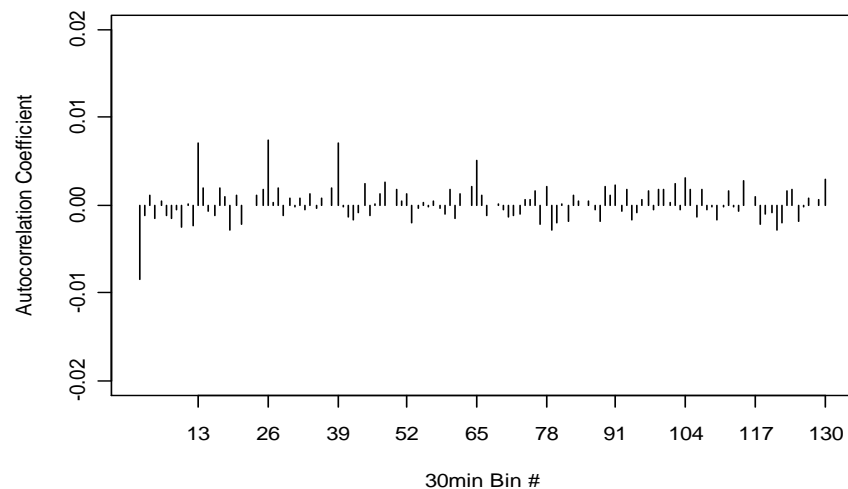
Universe: S&P 500 stocks \$5+, July 2010 – Feb 2011. The trading day has 390 minutes, i.e. there are 13 30min bins per day.

# Enhanced “Periodicity” Signal via Removal of Market and Sector Noise

1) ACF Stock Returns



2) ACF CAPM Excess Returns, normalized by Tracking Error

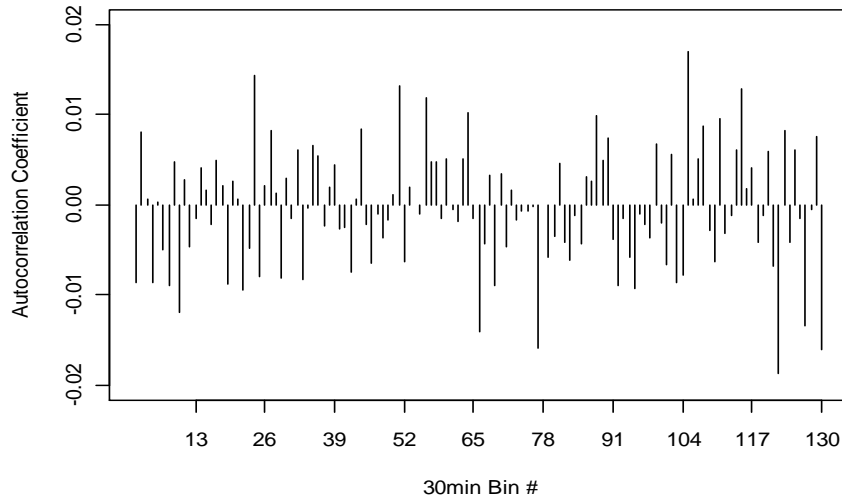


All ACF charts are without the 1<sup>st</sup> Lag

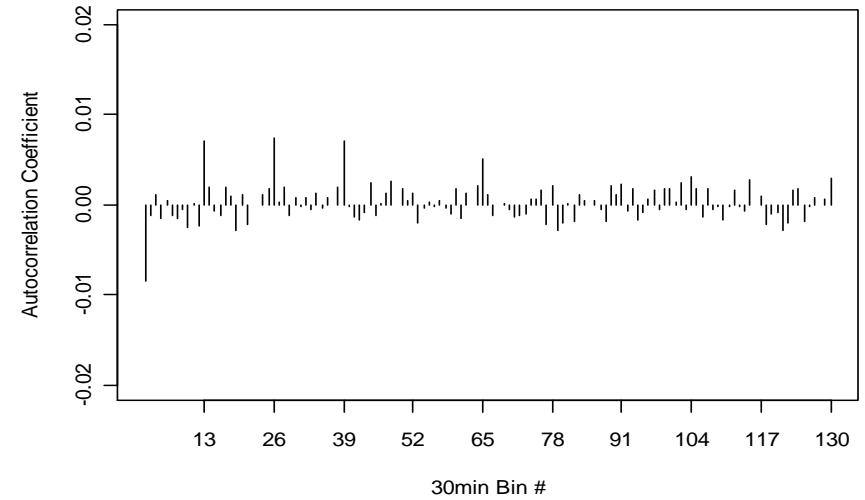
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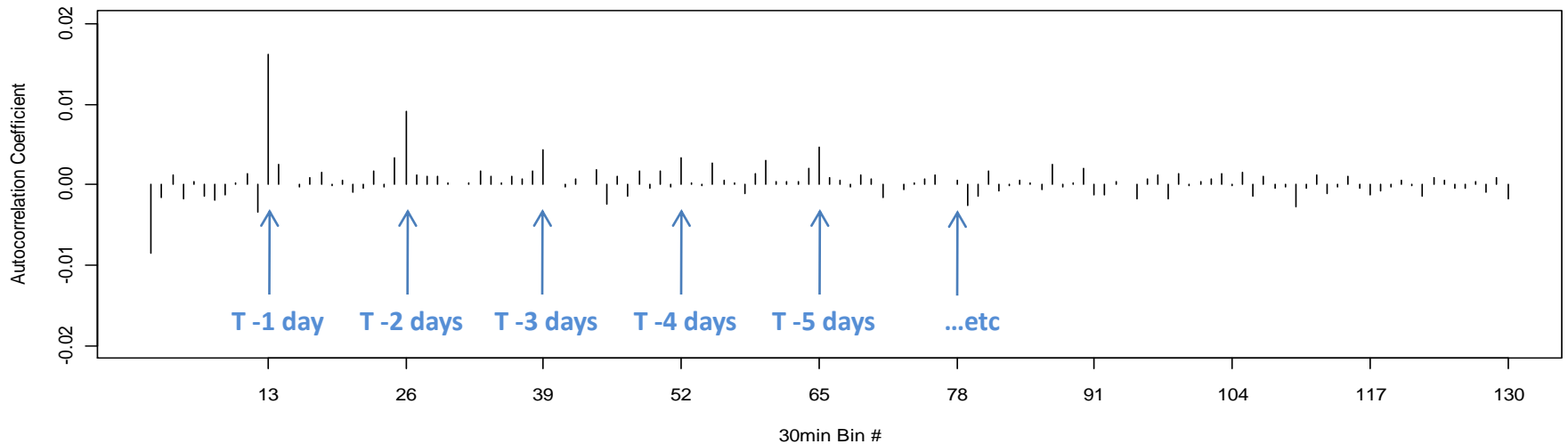
1) ACF Stock Returns



2) ACF CAPM Excess Returns, normalized by Tracking Error



3) ACF 2-Factor Model Market/GICS Sector Residuals, normalized by Residual Volatility



Universe: S&P 500 stocks \$5+, July 2010 – Feb 2011. The trading day has 390 minutes, i.e. there are 13 30min bins per day.

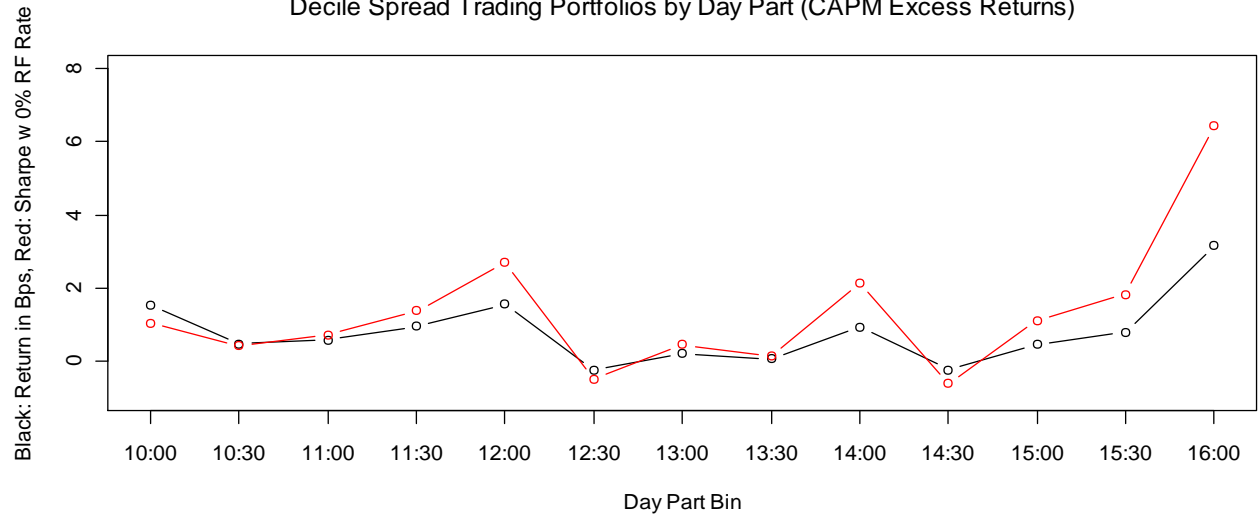
# Decile Spread High Frequency Trading Portfolios by Day Part

Best risk-adjusted returns with sector & market noise removed.

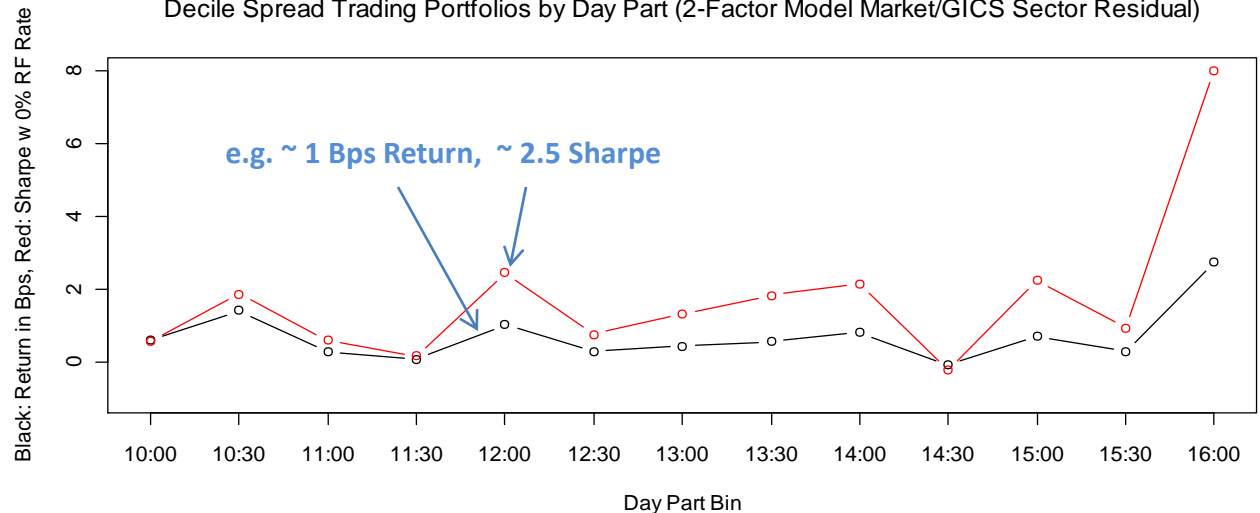
Strongest effect can be seen end-of-day, but that might be artifact of recent momentum regime.

Not tradable for investors except HFTs as expect return is less than typical spread.

Decile Spread Trading Portfolios by Day Part (CAPM Excess Returns)



Decile Spread Trading Portfolios by Day Part (2-Factor Model Market/GICS Sector Residual)



# Decile Spread Portfolios are Constantly Recomposed throughout the Trading Day...

Correlation Matrix of All-day Returns\*  
Sector-Market Model Periodicity Decile Spread Trading Portfolios on same Trading Day

	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00
10:00	1.00	0.00	-0.04	0.08	0.00	0.01	-0.02	-0.07	0.06	-0.08	-0.04	-0.04	-0.02
10:30	0.00	1.00	-0.12	0.12	0.02	0.06	0.07	-0.08	0.01	0.05	0.00	0.10	0.03
11:00	-0.04	-0.12	1.00	-0.01	-0.19	-0.03	0.07	0.03	-0.01	-0.07	0.02	0.13	-0.06
11:30	0.08	0.12	-0.01	1.00	-0.08	0.04	0.12	0.00	0.02	-0.04	0.00	0.12	-0.03
12:00	0.00	0.02	-0.19	-0.08	1.00	0.07	-0.15	-0.07	0.06	0.03	-0.02	-0.13	0.05
12:30	0.01	0.06	-0.03	0.04	0.07	1.00	0.03	-0.01	0.10	0.02	0.05	0.08	0.12
13:00	-0.02	0.07	0.07	0.12	-0.15	0.03	1.00	0.01	0.04	-0.04	0.01	0.04	0.03
13:30	-0.07	-0.08	0.03	0.00	-0.07	-0.01	0.01	1.00	0.03	-0.01	-0.02	0.07	0.02
14:00	0.06	0.01	-0.01	0.02	0.06	0.10	0.04	0.03	1.00	0.03	0.07	0.00	-0.06
14:30	-0.08	0.05	-0.07	-0.04	0.03	0.02	-0.04	-0.01	0.03	1.00	0.05	-0.02	0.07
15:00	-0.04	0.00	0.02	0.00	-0.02	0.05	0.01	-0.02	0.07	0.05	1.00	0.01	0.11
15:30	-0.04	0.10	0.13	0.12	-0.13	0.08	0.04	0.07	0.00	-0.02	0.01	1.00	0.13
16:00	-0.02	0.03	-0.06	-0.03	0.05	0.12	0.03	0.02	-0.06	0.07	0.11	0.13	1.00

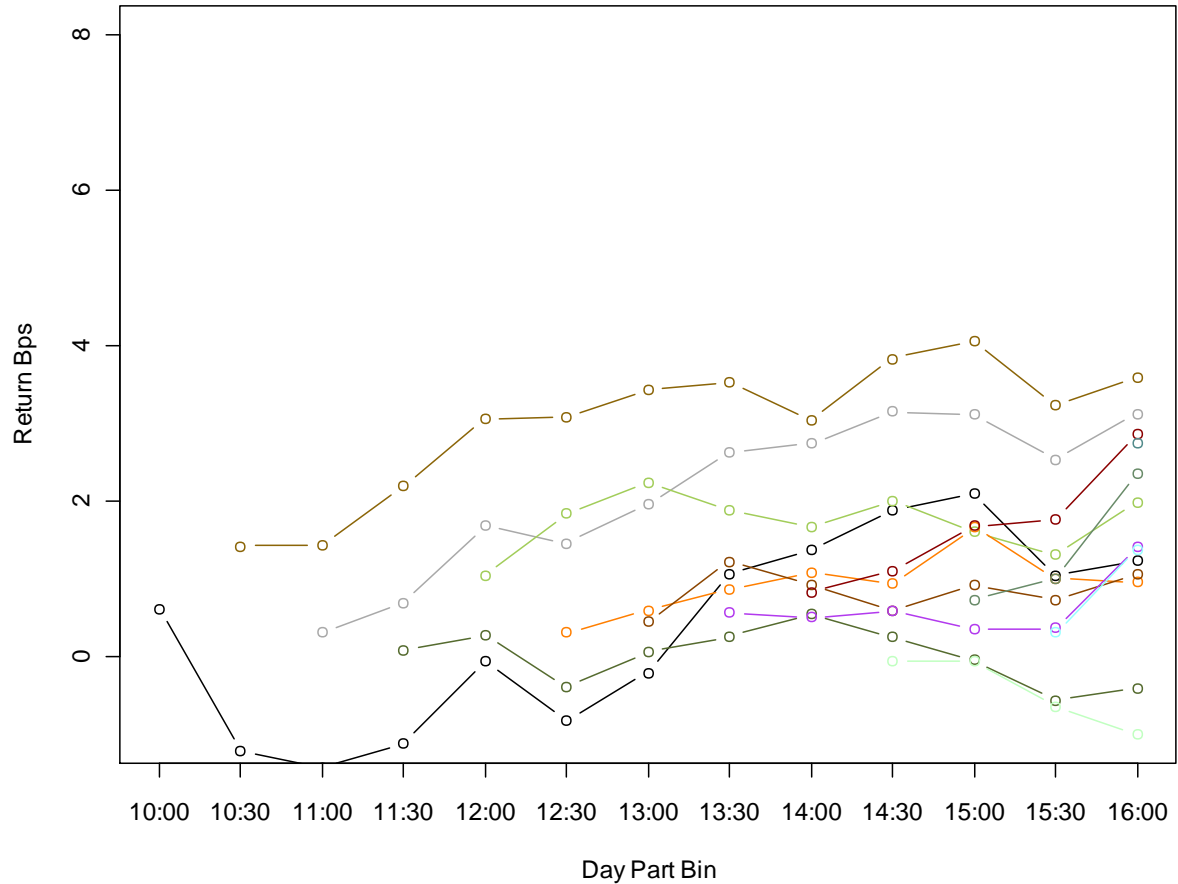
Low and negative correlations of all-day returns of adjacent decile spread portfolios shows that their make-up changes throughout the day.

Does this mean that a “winning” portfolio in one bin becomes a losing one in the next?

\* As proxy for similarity of Decile Spread Portfolio Composition

...however, Returns do not fully Decay, but show some Staying Power.

Decile Spread Trading Portfolios by Day Part (Cumulative Returns for Remainder of Day)



The effect is not so fleeting as to subsequently fully erase any returns within the same day.

This means there should be value in this Alpha factor for longer duration trades.

# Can the “Periodicity” Alpha be Utilized to Improve Typical All-day Institutional Orders?

- **Our experiment:** Create hypothetical VWAP orders comprising the entire S&P 500 (\$5+) universe for every trading day of our 168 day sample (79,557 hypothetical orders)
- **Long/short mix:** Approximately same number of buys and sells every day, randomly assigned each day using binomial distribution
- **Volume forecast:** We use trailing 20-day stock-specific volume distribution, smoothed by a 5<sup>th</sup> order polynomial fit, to build our “VWAP curve” forecast. This is for both operational (order placement) and economical (market impact) reasons.

- **Our Alpha signal:**

$$Z = (R_{\text{stockT-1bin}} - R_{\text{marketT-1bin}} * \beta_{\text{market}} - R_{\text{sectorT-1bin}} * \beta_{\text{sector}} - \alpha) / \sigma_{\text{residuals}}^1$$

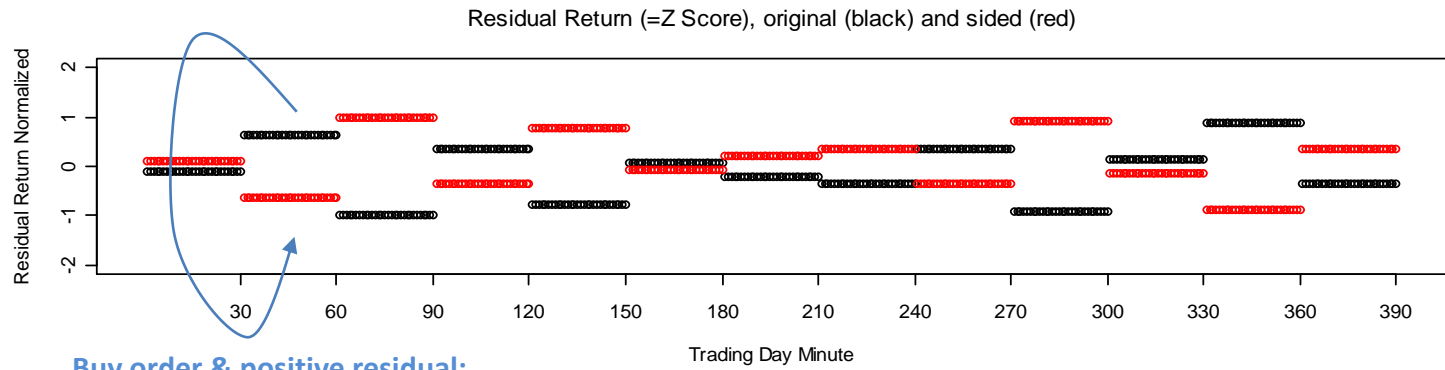
<sup>1</sup> volatility of residuals is calculated for the entire rolling factor model estimation window of trailing 60 days

# Transforming our Alpha Z Score into reweighted VWAP “Curves”

- TradeDummy is 1 for buys, -1 for sells
- $Z_{\text{sided}} = Z * \text{TradeDummy} * -1$
- E.g. we are a VWAP buyer and Z is positive,  $Z_{\text{sided}}$  will be negative because we want to underweight this “expensive” bin
- We want to **overweight positive  $Z_{\text{sided}}$  bins and underweight negative  $Z_{\text{sided}}$  bins, proportional to the size of  $Z_{\text{sided}}$**
- We super-impose our 13 “coarse grid”  $Z_{\text{sided}}$  per stock/day on our “refined grid” of 390 1-min VWAP bins.
- $\omega_{\text{reweighted}} = \omega_{\text{trailingavg}} * ( (Z_{\text{sided}} - \overline{Z_{\text{sided}}}) * (1/390) + 1 ) ^{\text{scalefactor}}$
- $\omega_{\text{reweighted}}$  is then rescaled to sum to 1 for every stock/day
- The VWAP “curves” are then refitted based on  $\omega_{\text{reweighted}}$  using a 5<sup>th</sup> order polynomial

# Example in Visuals: Creating reweighted VWAP Curve. Step 1

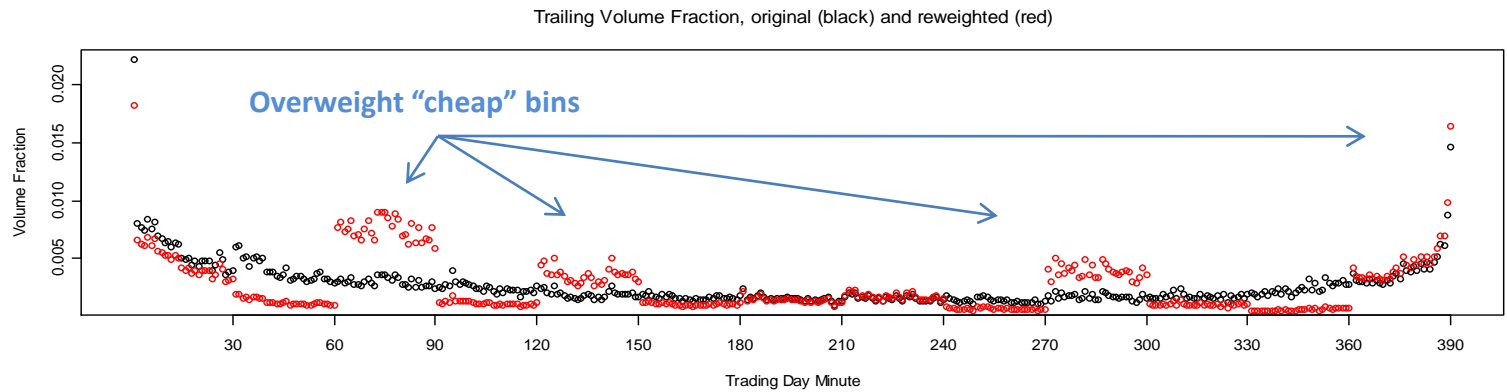
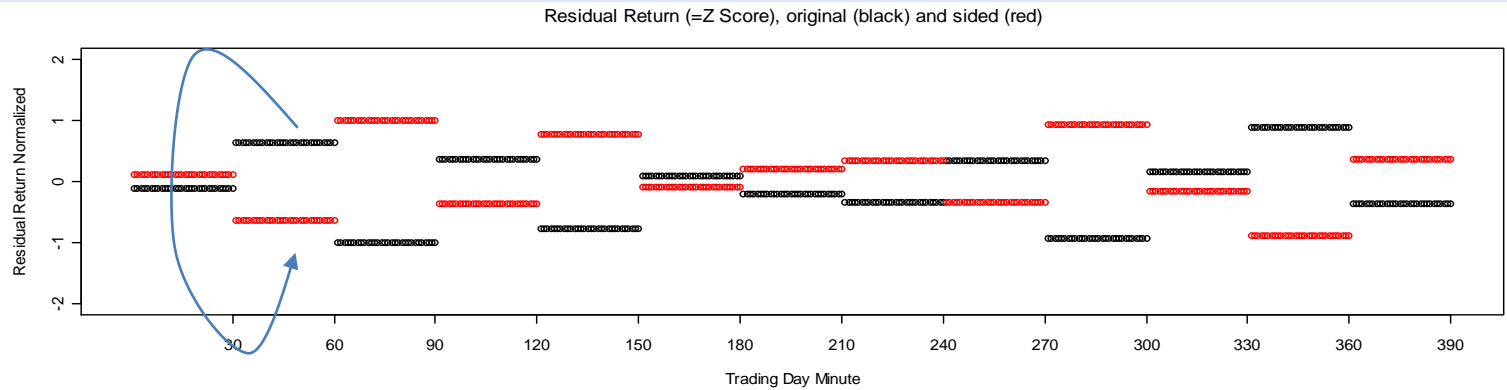
Hypothetical  
all-day  
VWAP buy  
order for  
AAPL on  
12/06/2010



Buy order & positive residual:  
Positive Z score "flipped" to  
negative Zsided for this bin

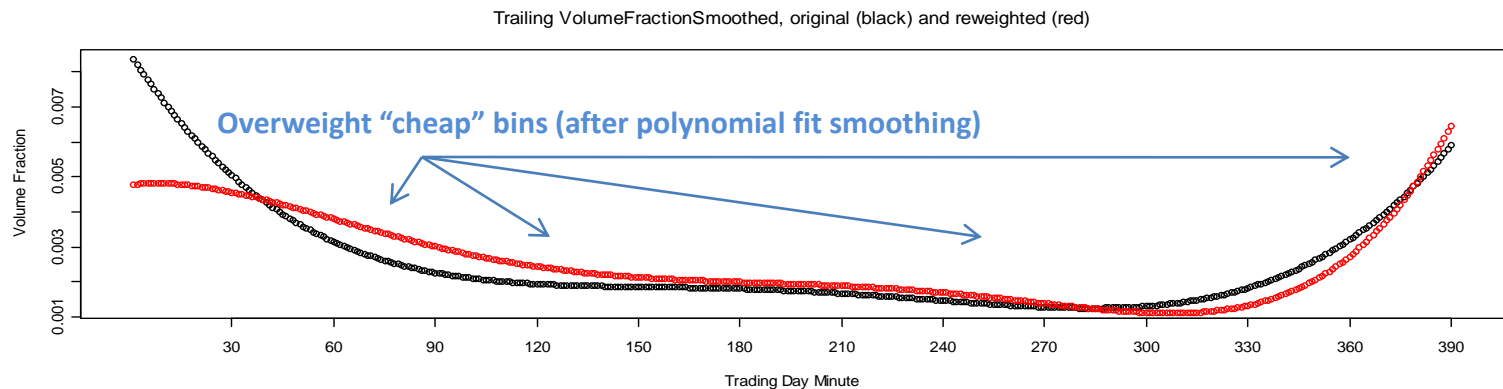
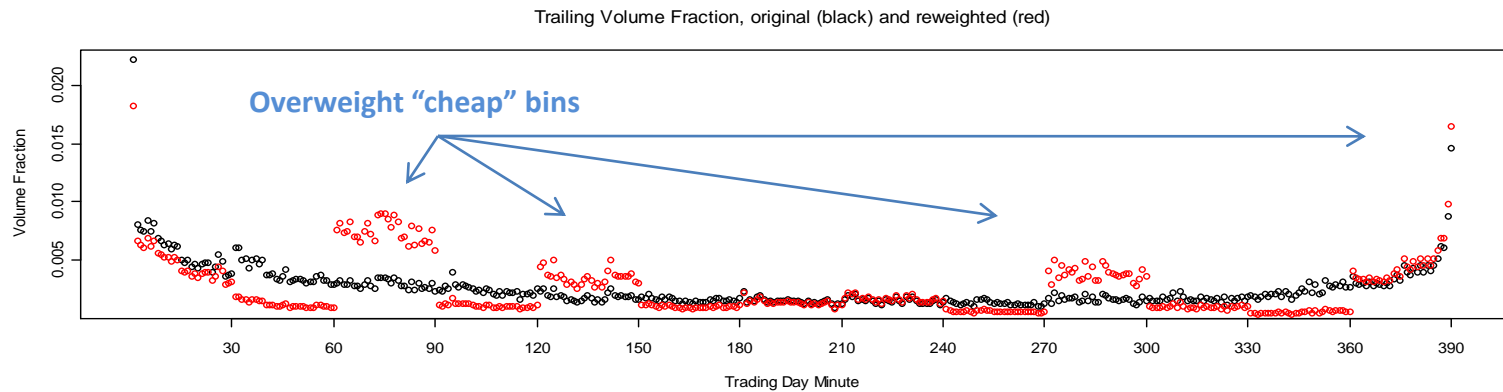
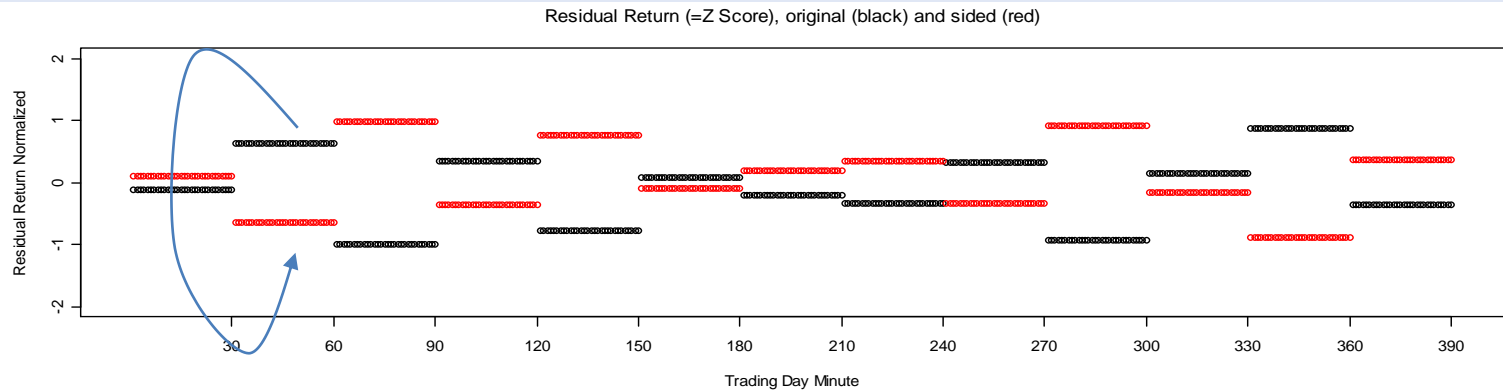
# Example in Visuals: Creating reweighted VWAP Curve. Step 2

Hypothetical  
all-day  
VWAP buy  
order for  
AAPL on  
12/06/2010



# Example in Visuals: Creating reweighted VWAP Curve. Step 3

Hypothetical  
all-day  
VWAP buy  
order for  
AAPL on  
12/06/2010

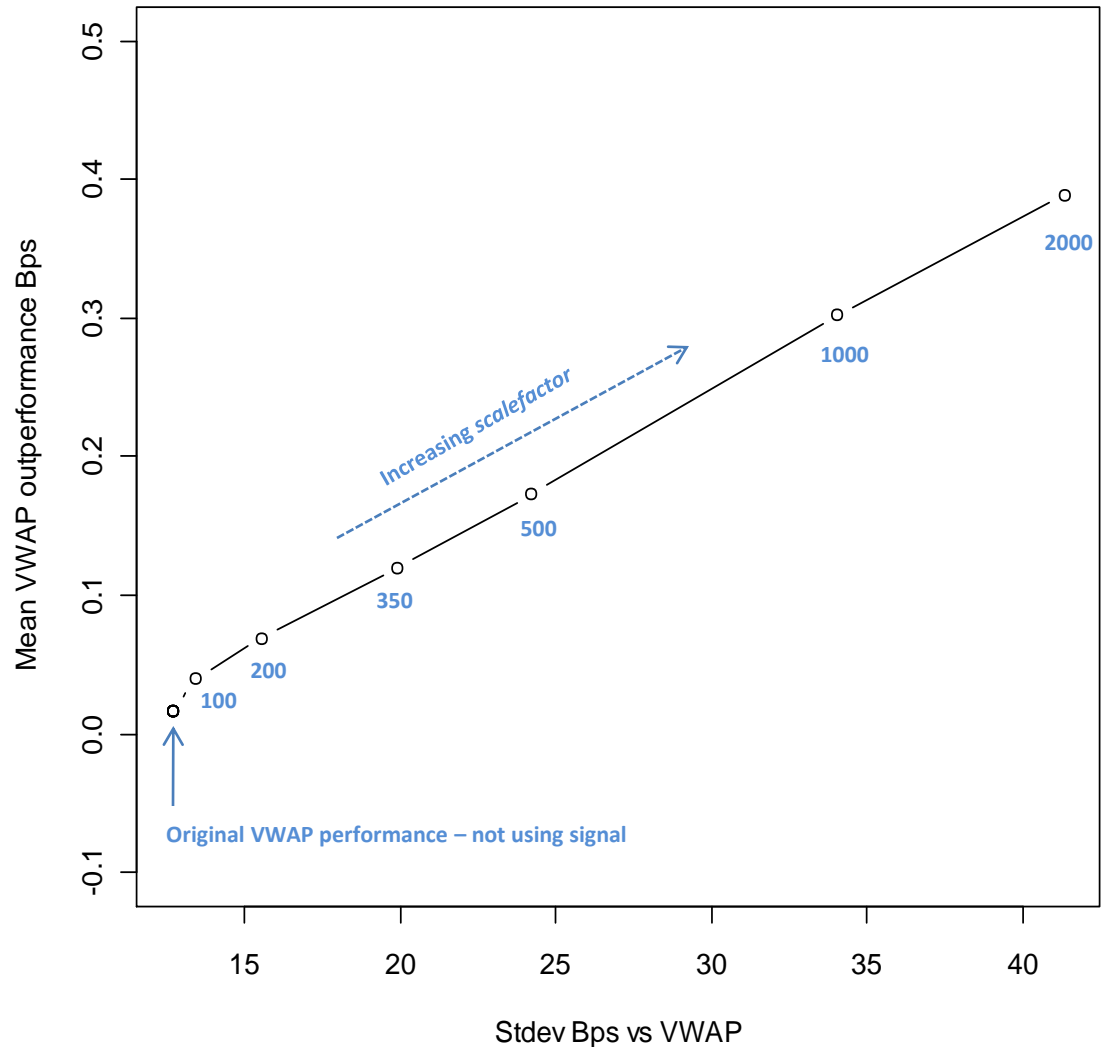


# Result: “Periodicity” Alpha Signal can Enhance S&P 500 VWAP Performance

Enhanced mean VWAP outperformance can be traded off for increased volatility, as function of *scalefactor*, i.e. the extent to which we introduce the signal in building of VWAP curves.

Achieves up to 0.4 bps of mean VWAP outperformance in our S&P 500 universe simulation.

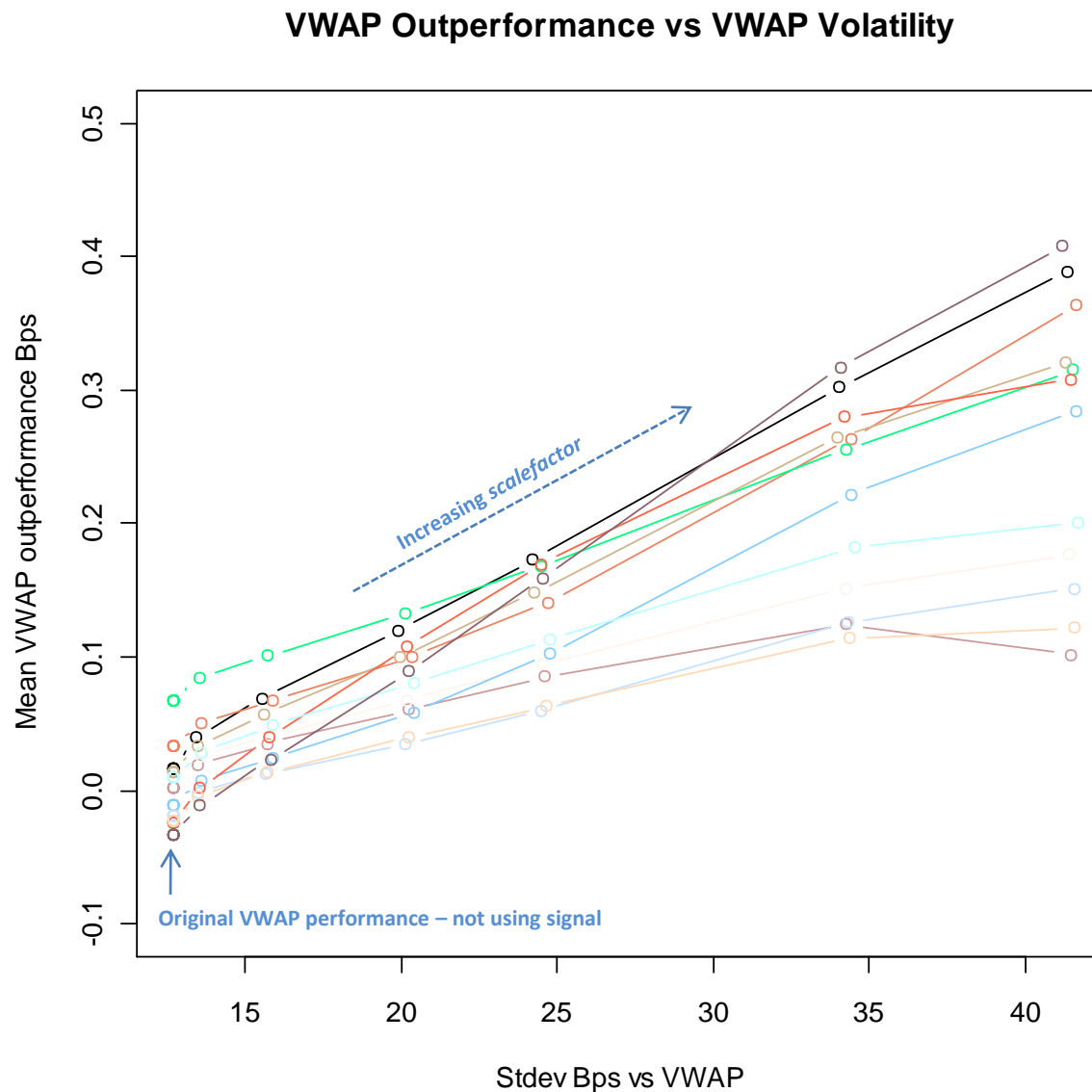
### VWAP Outperformance vs VWAP Volatility



# Additional Simulation Runs: Performance Varies, but Positive Relationship is Robust

A total of 954,684  
hypothetical orders,  
randomly sided.

Shows performance  
gains are not result of  
some “lucky” buy/sell  
distribution of orders.



# Important Disclaimers

## Other factors also affect VWAP performance:

- The study does not factor in any **other performance contributors**, such as spread costs/savings, market impact, more sophisticated volume forecasting.
- These vary based on the algorithm provider and can both **enhance or deteriorate** results.
- Polynomial fit smoothing will **avoid any “radical” overweighting** of specific time bins. This is important as the intent of VWAP is to trade “with volume” to **minimize market impact**.
- Any **extreme overweighting** of a specific day part could **more than offset** the positive effect of the alpha signal, especially with larger % ADV orders.

## Important Disclaimers (cont'd)

### Suitability:

- In practice, one would likely allow the **user to control the *scalefactor***, i.e. the extent to which the signal reweights VWAP curves.
- Users with many orders would be in a better position to stomach the increased volatility to harvest the expected performance gain.
- Exploiting the signal is **not limited to VWAP orders**, can be used for Implementation Shortfall orders, tactical child orders, etc.
- Results from Heston, Korajczyk, Sadka paper indicate **performance gains should be greater on smaller caps**, but not tested as part of this study.

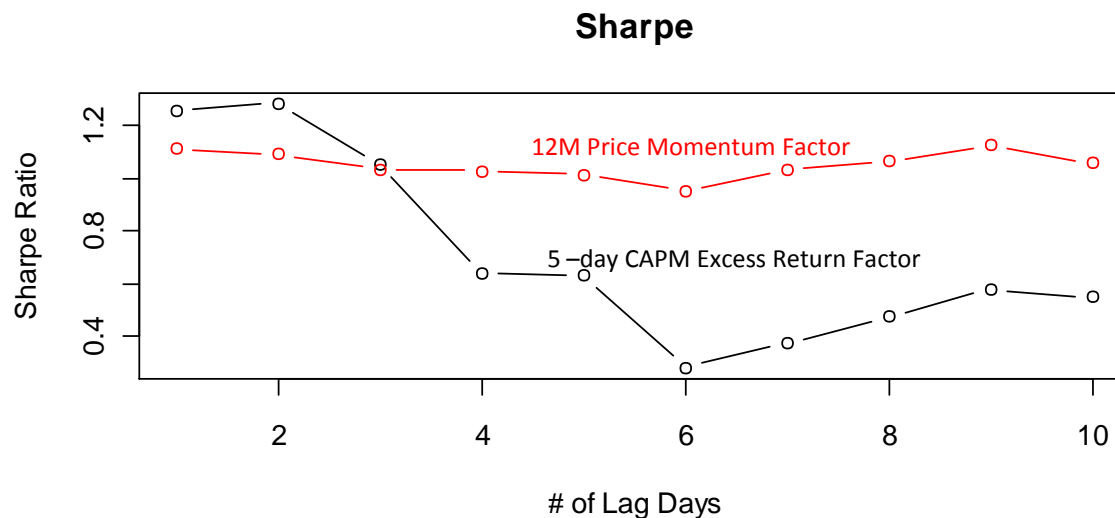
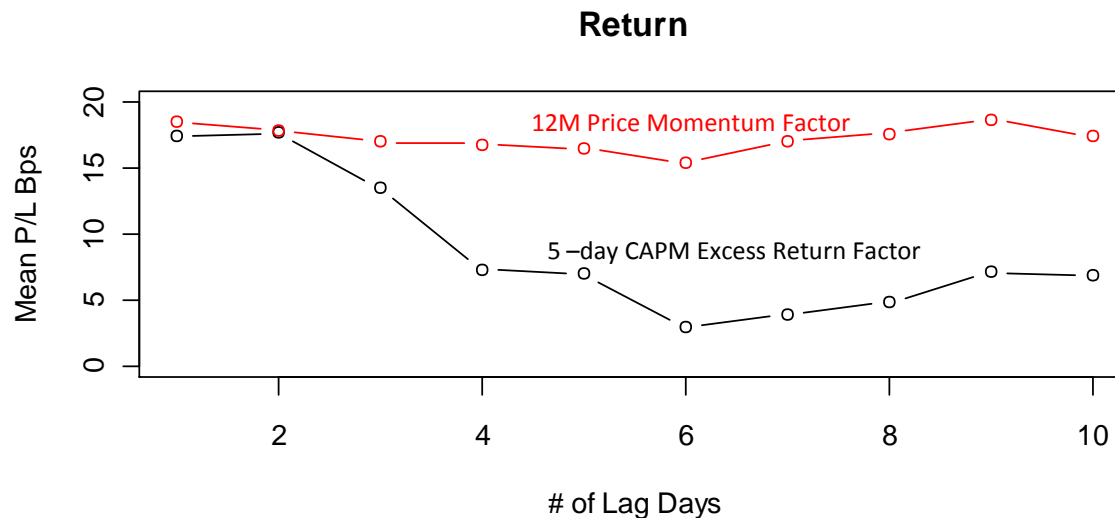
## Areas for Improvement and Further Research

- **Consider inter-day signal memory:** The “Periodicity” effect has an memory of multiple days. There are some small benefits of incorporating multiple days in the signal via an EWMA process.
- **Consider intra-day spill over:** The process works well for 30min bins, but autocorrelation shows up in surrounding bins. Explore effect of “spill-over” from adjacent bins.
- **Bin structure:** Explore equal “volume time” bins vs. “clock time” bins.
- **Effect of noise reduction model:** Market-Sector works well, but could use PCA model, proprietary risk model.
- **Volume distribution forecasting:** Could help reduce volatility of result through more sophisticated volume forecasting (volume PCA decomposition, exchange-specific curves.)
- **Other Alphas:** There are other generic alphas as well as those implicit in the portfolio you are trading. This is a subject for another presentation. But I will touch on it briefly...

# Example other Intraday Alphas Decay Considerations: 10-day Decay Profile 12M Price Momentum vs 5-day CAPM Excess Return.

Different Alpha factors have different decay speeds.

Understanding the Alpha decay profile of your portfolio (i.e. its underlying factor returns) will allow you to trade MUCH more intelligently.



Thank you

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