

# Regression Analysis and Quantitative Trading Strategies

$\chi$ Trading

## Butterfly Spread Strategy

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# Overview

- 1 Strategy
- 2 Construction
- 3 Backtesting
- 4 Risk Management



## Butterfly Strategy

- Exploits fluctuations in the implied volatility of options
- Buys (sells) a call and put at-the-money to the nearest strike (levels of 5)
- Sells (buys) a call and put  $B$  units above and below the nearest at-the-money strike respectively
- Butterfly is re-evaluated daily
- Spread is hedge-able using delta



## Butterfly Strategy

- Outer options (wings) reduce capital requirements
- Robust strategy with controllable results
- Applicable to several options markets
- Backtest suggests annualized returns of 14.7%
- Backtest suggests Sharpe ratio of 0.09
- Backtest suggests Sortino ratio of 0.18



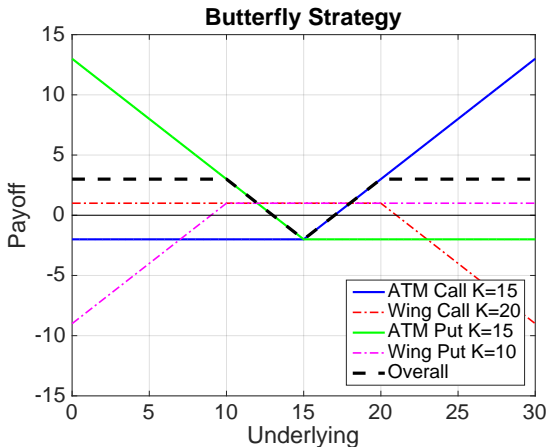
# Investment Universe and Securities

- Potential underlying assets: all exchange traded securities with options
- Requires liquid options with multiple strikes
- Four options (two at-the-money and two wings), and
- The underlying for an optional delta hedge
- Can be long or short the butterfly



# Investment Universe and Securities

A payoff illustration:





## Competitive Edge

- Employs exponentially weighted moving averages (EWMA) for analyzing implied volatility
  - Flexibility – adjustable days used for EWMA
- Ability to exploit multiple markets
- Adds alpha to an already diversified portfolio
- Low cost structure
  - Wing options trade on the opposite side to at-the-money options
- Does not require view on market direction



## Model Construction

This strategy takes advantage of the changing implied volatility **level**:

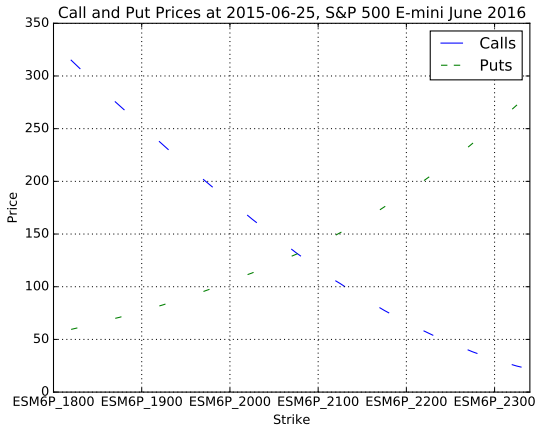
- ❶ Obtain daily implied volatilities of options
  - Entire strip of strikes
  - Accurate minimization techniques
  
- ❷ Track implied volatility (at-the-money and near strikes) against EWMA
  - Search for large deviations between EWMA and implied volatility
  
- ❸ Buy or sell the butterfly spread appropriately
  - Captures returns from increasing and decreasing volatility





## Empirical Exploration

Options can only exist at certain strikes when far from maturity. The S&P 500 E-mini June 2016 contracts are assessed:

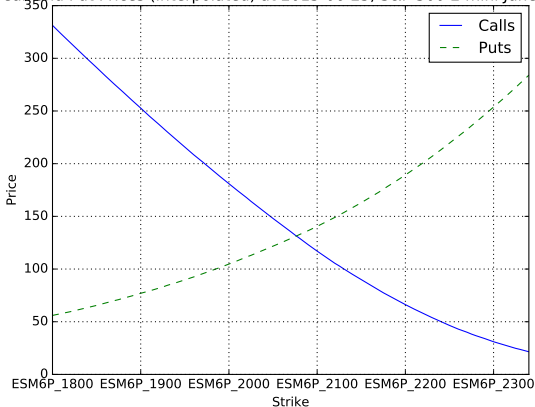




# Empirical Exploration

Missing prices can be interpolated for backtesting purposes:

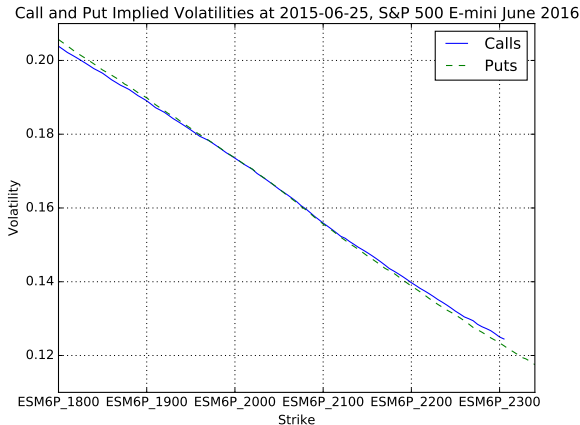
Call and Put Prices (Interpolated) at 2015-06-25, S&P 500 E-mini June 2016





## Empirical Exploration

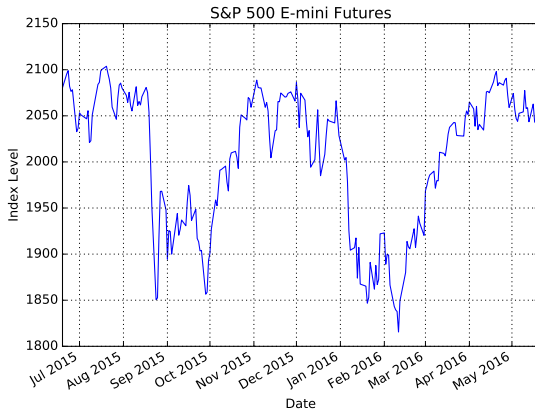
Most important is the change in **level** of implied volatility (Sinclair, 2008). Calls and puts have slightly different implied volatilities:





# Empirical Exploration

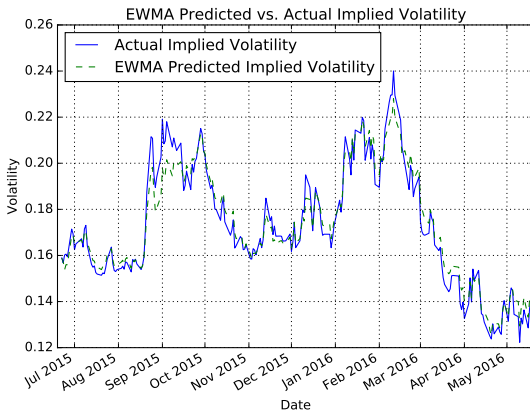
Average index level: 2006, standard deviation of index level: 73.75





## Empirical Exploration

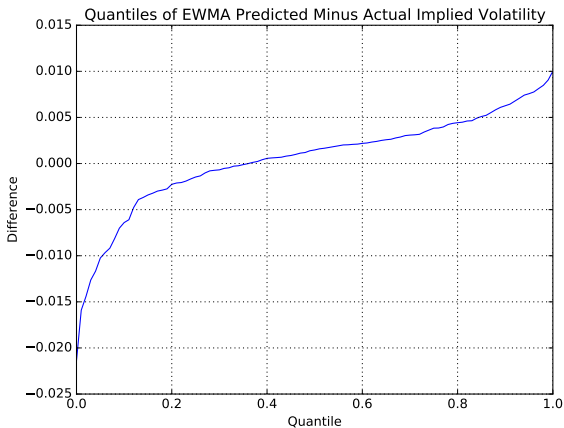
A shorter history for EWMA increases agility; a longer history increases stability:





# Empirical Exploration

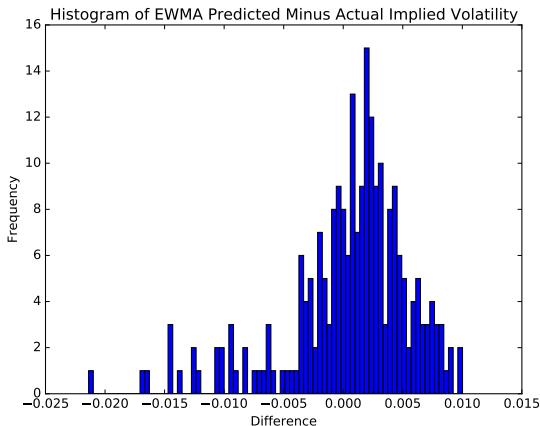
Choosing thresholds to buy/sell the butterfly is quantiles based:





## Empirical Exploration

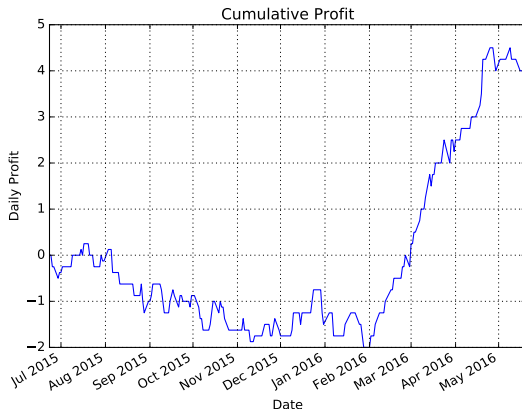
EWMA predictions are higher on average compared to realized implied volatility. The difference is also negatively skewed:





## Empirical Exploration

Butterfly wingspan: 20, EWMA history: 10 days, buy/sell thresholds are  $\pm 0.3$  standard deviations from the mean. 185 trades are made:







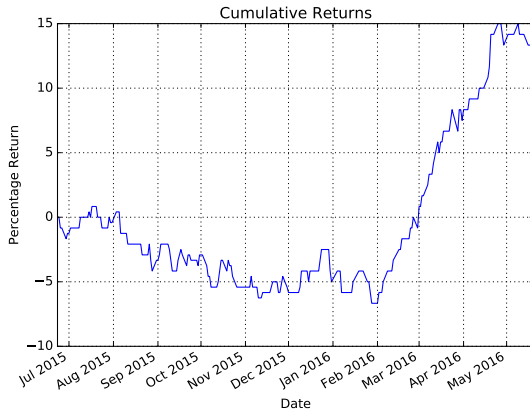
## Implications of Empirical Exploration

- Strategy performs best when closer to maturity (within 6 months)
- Call and put implied volatilities are averaged around the at-the-money strike for an overall level
- Maximum cost of the spread is half the wingspan (arbitrage arguments)
- Capital set at 3 times the above is cost



# Implications of Empirical Exploration

Capital set at \$30 yields a profit over 13.3%:





# Implementation

- Positions are reviewed at the beginning of each day
- Position sizes are scaled to the desired level of investment
- Refrain from delta hedging for symmetrical volatility trading
- Set buying and selling thresholds based on the empirical difference between EWMA predicted and realized implied volatilities



# Investment Process

- Mechanism of strategy diversifies well in a factor-based portfolio
- Can apply the butterfly strategy across different asset classes
- Candidate assets are selected through a rigorous process
- Chosen assets are reassessed for each option expiration



## Results

- June 2015 - May 2016
- Fees and costs are to be incorporated
- Strategy focuses on liquid assets
- Long and short butterfly positions
- Consistent performance over time



## Return and Risk

- Cumulative return: 13.3%
- Annualized cumulative return: 14.7%
- Annualized standard deviation of returns: 11.7%
- Sharpe ratio: 0.09
- Sortino ratio: 0.18
- Maximum drawdown: 7.5%



## Portfolio Structure

- Possible diversified portfolio of butterfly spreads
- Aim for diversification benefits in markets with different foundations of volatility
- Diversification across different option expiration dates



## Process

- Frequent revision of positions
- Wings of butterfly are stops
- Monitor returns versus capital outlay





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## About the Manager

MICHAEL BEVEN graduated as a National Merit Scholar from the Australian National University in 2012 with a Bachelor of Actuarial Studies and a Bachelor of Finance (Majors in Quantitative and Corporate Finance). He is currently completing a Master of Science in Financial Mathematics at the University of Chicago. Prior to starting at the University of Chicago, Michael was an Actuarial Analyst in Sydney at Quantum, a data analytics focused actuarial consultancy. He has also interned at Macquarie Group and Westpac Institutional Bank in quantitative risk analytics. Michael is deeply interested in electronic trading and sees Chicago as a great place to progress his career.