Machine Learning and Computational Finance

2 case studies

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STUDY No. 1 - Trading Volatility

- automated trading of straddles
- Why volatility?
- Why straddles?
- How to estimate future volatility?
- Experimental framework
Straddles

- Options on an underlying asset
  - Put - want to sell
  - Call - want to buy

- If we buy both at a reasonably long time to maturity, all we need is a volatile market.

- Straddle - a couple of Put and Call options
  - on the same underlying asset
  - with the same time to maturity
  - of the same state (e.g. in-the-money)
Volatility and the Price of Straddles

- **Volatility**
  - The amount of fluctuations (e.g. in price) of the underlying asset at a particular point in time.
  - Unfortunately - unobservable
  - Many methods (parametric/nonparametric) for estimating the volatility

- **Trend**: if volatility \( \uparrow(\downarrow) \), then the price of straddles \( \uparrow(\downarrow) \)
Estimating Volatility

- Model based, e.g.
  - ARCH, GARCH
  - Implied Volatility (e.g. from option prices)

- non-parametric, e.g.
  - historical volatility
Data

- Underlying assets - financial indexes
  - FTSE100
  - DAX
- High-frequency data
- In-the-money options
- Concentrated on time to maturity - around 1 month
Volatility Prediction Methods

- Volatility estimated as
  - GARCH
  - implied
  - historical volatility

- Future volatility - estimated based on historical volatility patterns
  - finite/potentially unbounded memory
  - continuous/discretized data

- 2nd order moments are more predictable than 1st order ones
Trading Strategies

- Every trading day, predict the change in volatility for the next trading day. If volatility is predicted to increase, buy near-the-money straddles (strike price closest to the at-the-money point) worth a fixed amount of money, otherwise sell them.

- On the next trading day, close the position and restart by predicting the next volatility change.

- Fixed but otherwise arbitrary investment – facilitate the interpretation of results with respect to transactions costs.
Experimental Setup

- Series of daily volatility differences
- Train
- Valid
- Test

- Series of average block-profits
- block 1
- block 2
- block 3
- block n

- Series of daily test set profits
### Sample of Results - FTSE100

<table>
<thead>
<tr>
<th>Model class</th>
<th>% profit per-day</th>
<th>Highest TC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std.</td>
</tr>
<tr>
<td>ACP</td>
<td>2.706</td>
<td>1.109</td>
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<tr>
<td>Simple</td>
<td>1.562</td>
<td>1.135</td>
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<tr>
<td>NPRVM</td>
<td>3.234</td>
<td>2.804</td>
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<tr>
<td>NPRVM+Simple</td>
<td>2.018</td>
<td>1.615</td>
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<tr>
<td>NN(10)</td>
<td>1.331</td>
<td>1.095</td>
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<tr>
<td>NN(10)+Simple</td>
<td>1.432</td>
<td>1.131</td>
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<tr>
<td>MM(5)</td>
<td>1.551</td>
<td>0.833</td>
</tr>
<tr>
<td>MM(5)+Simple</td>
<td>1.551</td>
<td>0.833</td>
</tr>
</tbody>
</table>
STUDY No. 2 - Does Money Matter?

- **What is money?** - Traditional interpretations:
  - Store of value
  - Unit of account
  - Medium of exchange

- **Changing environment**
  - New monetary assets
  - Banks blend with Building Societies, etc.

- **Need to adequately measure money** ... - ... in order to construct money supply (monetary policy), but ...
  - how to combine and measure different objectives in a changing environment?
Aggregate $m^{\text{certain}}$

- Assets where we know the value (rate of return)
- Personal sector monetary aggregate containing:
  1. Notes and coins
  2. Non-interest bearing time deposits
  3. Interest bearing savings (short term)
  4. Interest bearing time deposits (long term)
  5. Building society deposits (long term)

Interest rate captures liquidity: $L \downarrow \implies IR \uparrow$
Divisia Monetary Index

- Capture "services" provided by monetary assets
- "consumer price index" for money
- Compare with a high yielding non-monetary asset - what else we could have done with the money ...
- more liquid monetary asset $\Rightarrow$ more services
Predicting Inflation Rates - Data

- Monthly data
- 4 Levels of aggregation: M1, M2, MZM, M3
  - aggregation levels currently monitored in USA
  - narrow → broad
- At each aggregation level:
  - Simple sum
  - Weighting
    - non-monetary benchmarks
      - BAA (a long bond in USA)
      - upper envelope
    - St Louis Fed Reserve Bank style
Interest rates
- short term
- long term
- Important?
  Short term IR are currently used in UK to control inflation.

Jan ’61 - Jun ’05
Baseline - Random Walk

- Predict that in T months (prediction horizon) we will observe the current inflation rate.
- Corresponds to random walk hypothesis with moves governed by a symmetrical zero-mean density function.
- Measures "the degree to which the efficient market hypothesis applies".
- Report model performance as % Improvement in RMSE over baseline (RW)
Hypothesis

- USA MSI (divisia) - superior indicators of monetary conditions.
- Such evidence could reinstate monetary targeting.
- All models implicitly included past inflation rates as input variable.
- Capture regularities in past inflation rates and monetary indexes.
- Does inclusion of measures of money (or interest rates) improve predictive performance?
### Sample of Results - KRLS

<table>
<thead>
<tr>
<th>KRLS</th>
<th>In Lag</th>
<th>KW</th>
<th>$\nu$</th>
<th>$\lambda$</th>
<th>IORW</th>
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<tbody>
<tr>
<td>$M_1$</td>
<td>10</td>
<td>1.5</td>
<td>0.21</td>
<td>0.1</td>
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<td>$M_2$</td>
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<td>$M_3$</td>
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<td>$M_4$</td>
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<td>1.2</td>
<td>0.27</td>
<td>0.1</td>
<td>43.42</td>
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</tbody>
</table>
Lessons Learnt

1. It seems that enough information is present in the inflation rates alone, no standard additional measures of money are helpful.

2. Other compound measures of money may be useful, but they may be
   - model/task dependent
   - non-linear in nature

3. Further work required to develop the construction of Divisia (Risk adjusted Divisia).

4. Bank of England – need to be transparent and accountable with their funding.