Apple Inc. (AAPL)  
Add to watchlist

NasdaqGS - NasdaqGS Real Time Price. Currency in USD

111.57  -0.22 (-0.20%)  110.85  -0.72 (-0.65%)
At close: November 28 4:00 PM EST  
Pre-Market: 9:14AM EST

Earnings Estimate

<table>
<thead>
<tr>
<th>Earnings Estimate</th>
<th>Current Qt.</th>
<th>Next Qt.</th>
<th>Current Year</th>
<th>Next Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Analysts</td>
<td>36</td>
<td>36</td>
<td>42</td>
<td>35</td>
</tr>
<tr>
<td>Avg. Estimate</td>
<td>3.22</td>
<td>2.16</td>
<td>9.05</td>
<td>10.09</td>
</tr>
<tr>
<td>Low Estimate</td>
<td>3.04</td>
<td>1.94</td>
<td>8.05</td>
<td>8.24</td>
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<tr>
<td>High Estimate</td>
<td>3.77</td>
<td>2.44</td>
<td>10.01</td>
<td>12.12</td>
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<tr>
<td>Year Ago EPS</td>
<td>3.28</td>
<td>1.9</td>
<td>8.31</td>
<td>9.05</td>
</tr>
</tbody>
</table>

Recommendation Trends

- Strong Buy
- Buy
- Hold
- Underperform
- Sell

Analyst Firms Making Recommendations

- ACCOUNTABILITY
- BAIRD R W
- CLSA AMERICAS
- DEUTSCHE BK SEC
- J.J.B.HILLIARD
- MORGAN STANLEY
- PACIFIC CREST
- RAYMOND JAMES
- WELLS FARGO SEC

B OF A M L
BREAN CAPITAL
COWEN & COMPANY
EDWARD JONES
JP MORGAN SECUR
OPPENHEIMER HLD
PIPER JAFFRAY
STIFEL NICOLAUS
WILLIAM BLAIR
Suppose the expert model gives us a “buy/sell” rating at the beginning of every day. We will sell our position at the close of every day. They are correct if their recommendation makes us money.
Given $n$ expert opinions for $T$ days, can we devise a strategy that performs almost as well as the **BEST** expert *in hindsight*?
1. All experts begin with weight $w^0(e) = 1$. 

Weighted Majority (1)
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2. Repeat for all timesteps:
   Query each expert. Take weighted average as final action.
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   For each incorrect expert, reduce weight
   
   $$w^t(e) \leftarrow (1-\epsilon)w^{t-1}(e)$$
Weighted Majority

<table>
<thead>
<tr>
<th>Weight $W_0$</th>
<th>Recs</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert 1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Expert 2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Expert 3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expert 4</td>
<td>1</td>
<td></td>
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</tbody>
</table>
Weighted Majority

Weight \( W_0 \)

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<th>Action</th>
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<tbody>
<tr>
<td>Expert 1</td>
<td></td>
<td>“Buy”</td>
<td></td>
</tr>
<tr>
<td>Expert 2</td>
<td></td>
<td>“Buy”</td>
<td></td>
</tr>
<tr>
<td>Expert 3</td>
<td></td>
<td>“Sell”</td>
<td></td>
</tr>
<tr>
<td>Expert 4</td>
<td></td>
<td>“Buy”</td>
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<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert 1</td>
<td>“Buy”</td>
<td>3 buys, 1 sell —&gt; BUY</td>
</tr>
<tr>
<td>Expert 2</td>
<td>“Buy”</td>
<td></td>
</tr>
<tr>
<td>Expert 3</td>
<td>“Sell”</td>
<td></td>
</tr>
<tr>
<td>…</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expert 4</td>
<td>“Buy”</td>
<td></td>
</tr>
</tbody>
</table>
## Weighted Majority

<table>
<thead>
<tr>
<th>Weight $W_1$</th>
<th>Recs</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expert 1</strong></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Expert 2</strong></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Expert 3</strong></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td><strong>Expert 4</strong></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

...
Weighted Majority

Weight \( W_i \) | Recs | Action
--- | --- | ---
Expert 1 | 1 | “Sell”
Expert 2 | 1 | “Sell”
Expert 3 | 0.5 | “Sell”
... | ... | ...
Expert 4 | 1 | “Buy”
Weighted Majority

Weight $W_1$

Expert 1

Expert 2

Expert 3

...  

Expert 4

Recs

“Sell”  

“Sell”  

“Sell”  

“Buy”  

Action

2.5 Sell, 1 Buy $\rightarrow$ SELL
Thm: After $T$ days, let $m_i^{(T)}$ be number of times $i$ was wrong and let $M(T)$ be the number of times our strategy was wrong. Then

$$M^{(T)} \leq 2(1 + \epsilon)m_i^{(T)} + \frac{2 \ln n}{\epsilon}$$
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Our strategy makes roughly $2x + \text{additive more mistakes}$ than the best expert.
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Proof:
Thm: After T days, let $m_i^{(T)}$ be number of times $i$ was wrong and let $M(T)$ be the number of times our strategy was wrong. Then

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Proof: $$(1 - \epsilon)m_i^{(T)} \leq \phi^{(T)} \leq n \cdot (1 - \epsilon/2)^{M^{(T)}}$$
$y = -x$

$y = \ln(1-x)$

$y = -x - x^2$
Thm: After $T$ days, let $m_i^{(T)}$ be number of times $i$ was wrong and let $M(T)$ be the number of times our strategy was wrong. Then

$$M^{(T)} \leq 2(1 + \epsilon)m_i^{(T)} + \frac{2 \ln n}{\epsilon}$$

Proof:

$$(1 - \epsilon)m_i^{(T)} \leq \phi^{(T)} \leq n \cdot (1 - \epsilon/2)^{M^{(T)}}$$

$$M^{(T)} \leq m_i^{(T)} \frac{\ln(1 - \epsilon)}{\ln(1 - \epsilon/2)} - \frac{\ln(n)}{\ln(1 - \epsilon/2)}$$
Thm: After T days, let $m_i^{(T)}$ be number of times i was wrong and let $M(T)$ be the number of times our strategy was wrong. Then

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Can we do better than 2x?
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$$M^{(T)} \leq 2(1 + \epsilon)m_i^{(T)} + \frac{2 \ln n}{\epsilon}$$

Can we do better than $2\epsilon$?

Unfortunately, this deterministic strategy can’t do better than $2\epsilon$. 
Weighted Majority (1)

A

1. All experts begin with weight $w^0(e) = 1$.

2. Repeat for all timesteps:
   
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   $$w^t(e) \leftarrow (1-\text{epsilon}) w^{t-1}(e)$$

Imagine an adversarial stock ADV.

Consider two experts, Opt: always buy, Pess: always sell.

At every timestep, ADV does the opposite of what A recommends.

After $t$ steps, one of our experts will be incorrect at most $t/2$ times.

After $t$ steps, our strategy will be incorrect $t$ times!
Solution: randomize!
Random Weighted Majority

1. All experts begin with weight $w^0(e) = 1$.

Randomly sample expert $j$ with probability $\rho_j = \frac{w_j^{(t-1)}}{\phi^{t-1}}$

Do what your sampled expert would do.
Random Weighted Majority

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1. All experts begin with weight $w^0(e) = 1$.

2. Repeat for all timesteps:
   Randomly sample expert $j$ with Pr $\rho_j = \frac{w_j^{(t-1)}}{\phi^{t-1}}$
   Do what your sampled expert would do.
   For each incorrect expert, reduce weight
   \[ w^t(e) \leftarrow (1-\text{epsilon}) w^{t-1}(e) \]
Thm 2: After $T$ days, let $m_i^{(T)}$ be number of times $i$ was wrong and let $M(T)$ be the number of times our strategy was wrong. Then

\[ M^{(T)} \leq (1 + \epsilon)m_i^{(T)} + \frac{\ln n}{\epsilon} \]
Need to show: \[ \Phi(T) \leq n e^{-\epsilon M(T)} \]

\[ a_i^{(t)} = \begin{cases} 
1 & i \text{ is wrong} \\
0 & \text{otherwise}
\end{cases} \]
Need to show: \( \Phi(T) \leq ne^{-\epsilon M(T)} \)

\[
a_i^{(t)} = \begin{cases} 
1 & \text{if } i \text{ is wrong} \\
0 & \text{otherwise}
\end{cases}
\]

\[
b(t) = \frac{\sum a_j^{(t)} w_j^{(t)}}{\Phi(t)}
\]

Pr that we make mistake @ t