A Simple Trading Strategy: Implemented using Python

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Organization of Presentation

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2. RSI.
3. Bollinger Bands.
4. Swing low's and high's.
5. The Strategy.
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Moving Averages

1. A q-**day moving average** for a time series $\{x_t\}$ is the average over the past q days

$$MA^q = \frac{1}{q}\sum_{i=0}^{q-1} x_{t-i}$$

2. Moving averages smooth a series and helps identify trends.
3. **Short-term or Faster:** MA^q for smaller q, captures local trends.
4. **Long-term or Slower:** MA^q for larger q, captures long-term trends.
5. **Crossover Trends:** For $q_1 < q_2$
   1. $MA^{q_1} > MA^{q_2}$. Market **Bullish**. Enter Long position.
   2. $MA^{q_1} < MA^{q_2}$. Market **Bearish**. Go Short.
6. Popular short-time moving averages: $MA^{15}, MA^{20}, MA^{50}$. Popular long-time moving averages: MA^{150}, MA^{200}.

Relative Strength Index: RSI

1. RSI indicates *upcoming reversal of trends*.
2. Let RS = Average of n days up-closes/Average of n days down-closes. Then

$$RSI = 100 - \frac{100}{1 + RS}.$$

   Usually, $n = 14$.
3. $\mathbf{RSI \geq 70}$: Security overbought(or undersold); go Short.
4. $\mathbf{RSI \leq 30}$: Security underbought(or oversold); go Long.
5. RSI works best when compared with a shorter time moving averages MA^q.

Bollinger Bands

1. Let S_t denote the series of closing prices of a security S and MA^q denote the q-period moving average of S_t.
2. For any q and k:

$$\underbrace{MA^q - k\sigma}_{\text{Lower Bollinger Band}} \leq MA^q \leq \underbrace{MA^q + k\sigma}_{\text{Upper Bolliger Band}}$$

   where, $\sigma = stdev(S_t)$ is the standard deviation. Popular choices are $q = 20$, $k = 2$.
3. **Bandwidth:** $2k\sigma$: indicates the volatility of the security. For more volatile securities greater bandwidth.
4. **Signals:** Trend reversal occurs when prices touch the Bollinger Bands.
   1. **Buy Signal**: $S_t \leq MA^q - k\sigma$.
   2. **Sell Signal**: $S_t \geq MA^q - k\sigma$.
5. Like RSI, Buy/Sell signals are better captured using Bollinger Bands, when used together with moving average crossovers.

Swing low's and high's

1. For a time series of an asset S_t denote
   1. S_t^L: Series for the daily lows.
   2. S_t^H: Series for the daily highs
2. **Swing Low:** S_t^L is a swing low if its a local minima i.e.,

$$S_t^L \leq S_{t-1}^L \ \& \ S_t^L \leq S_{t+1}^L.$$

3. **Swing High:** S_t^H is a swing high if its a local maxima i.e.,

$$S_t^H \geq S_{t-1}^H \ \& \ S_t^H \geq S_{t+1}^H.$$

4. **Uptrend Signal:** Higher swing high's and higher swing low's.
5. **Stop-loss order:** Usually issued on Long position, set just below the most recent swing low.
6. During an uptrend: $S_{t_1}^L \leq S_{t_2}^L \leq \ldots \leq S_{t_k}^L$ for $t_1 < t_2 < \ldots < t_k$, place Stop orders below each $S_{t_i}^L$.

The Strategy

When a price is within 2% of a prior swing low and exceeds the lower Bollinger Band with an RSI of atmost 30 and the 20-day moving average is atleast 5% above the current price enter Long at the current price. Exit at the current price if price falls more than 1% below the swing low.

The Strategy: Mathematical details

1. Let at current time t price be S_t
2. For some $t' \leq t$ let the prior swing low be $S^L_{t'}$
3. The lower Bollinger Band at t be $BB_L(t)$
4. 20-day moving average at t be $N(t)$
5. RSI for $n = 14$ at time t be $RSI(t)$

   Then enter Long position at S_t if the following conditions are met:

$$S_t \leq 1.02S^L_{t'} \quad \& \quad S_t \geq BB_L(t) \tag{1}$$

$$RSI(t) \leq 30 \quad \& \quad N(t) \geq 1.05S_t \tag{2}$$

Exit Long position at current price if price falls 1% below swing low i.e.,

$$S_t \leq 0.99S^L_{t'}$$

Algorithm for Implementing the Strategy: I

1. Get Historical data over time frame $[0, T]$ and find all the swing lows:
$$S^L_{t_1} \leq S^L_{t_2} \leq \ldots \leq S^L_{t_k}$$
2. **Iteration over t_i:** For any $t_i \in \{t_1, \ldots, t_k\}$ consider the swing low $S^L_{t_i}$ and the price data S_t for $t \in [t_i, t_{i+1})$ and find the set of prices (depending on $[t_i, t_{i+1}]$)
$$Q = \{S_{t_{i_1}}, S_{t_{i_2}}, \ldots, S_{t_{i_j}}\}$$
satisfying conditions given by equation (1) and (2)
3. If Q is a non empty set enter Long on Date $t = t_{i_s}$ at the price
$$S_{t_{i_s}} = min(Q)$$
for some $t_{i_1} \leq s \leq t_{i_j}$
4. Set Sell-Stop order(Stop order) at 1% below the swing low $S^L_{t_i}$ i.e., set
$$\text{Stop order} = 0.99 S^L_{t_i}$$

Algorithm for Implementing the Strategy: II

5. **Case 1:** If a new swing low is achieved that is greater than prior swing low

$$S^L_{t_{i+1}} > S^L_{t_i}$$

Increase Sell-Stop Order to 1% below $S^L_{t_{i+1}}$ i.e., set

$$\text{Stop order} = 0.99 S^L_{t_{i+1}}$$

6. **Case 2:** If a new swing low is achieved that is lower than the prior swing low, i.e.,

$$S^L_{t_{i+1}} < S^L_{t_i}$$

   1. If current price falls 1% below current Stop order then exit Long position at Stop order.

7. Check whether current price S_t satisfies the conditions of Equation (1) and (2)
8. If Yes, Enter new Long position at current price S_t, and set new Sell-Stop order at 1% below the new swing low $S^L_{t_{i+1}}$.

Backtesting on Historical market data

1. **Data:** *'INTC','MSFT','AMZN'* stocks, Closing prices.
2. **Time frame:** start $=$ '2014-01-01' ; end $=$ '2016-09-30'
3. **Moving Average** $N(t) = MA^q(t)$**:** Taken for $q = 20$-days
4. **RSI:** Calculated for $n = 14$ days window.
5. **Bollinger Bands:** $MA^q \pm k\sigma$ with $k = 2$. (Actually used $k = 0.5$)

A Time Series Plot: 'INTC', '2014-01-01'-'2016-09-30'

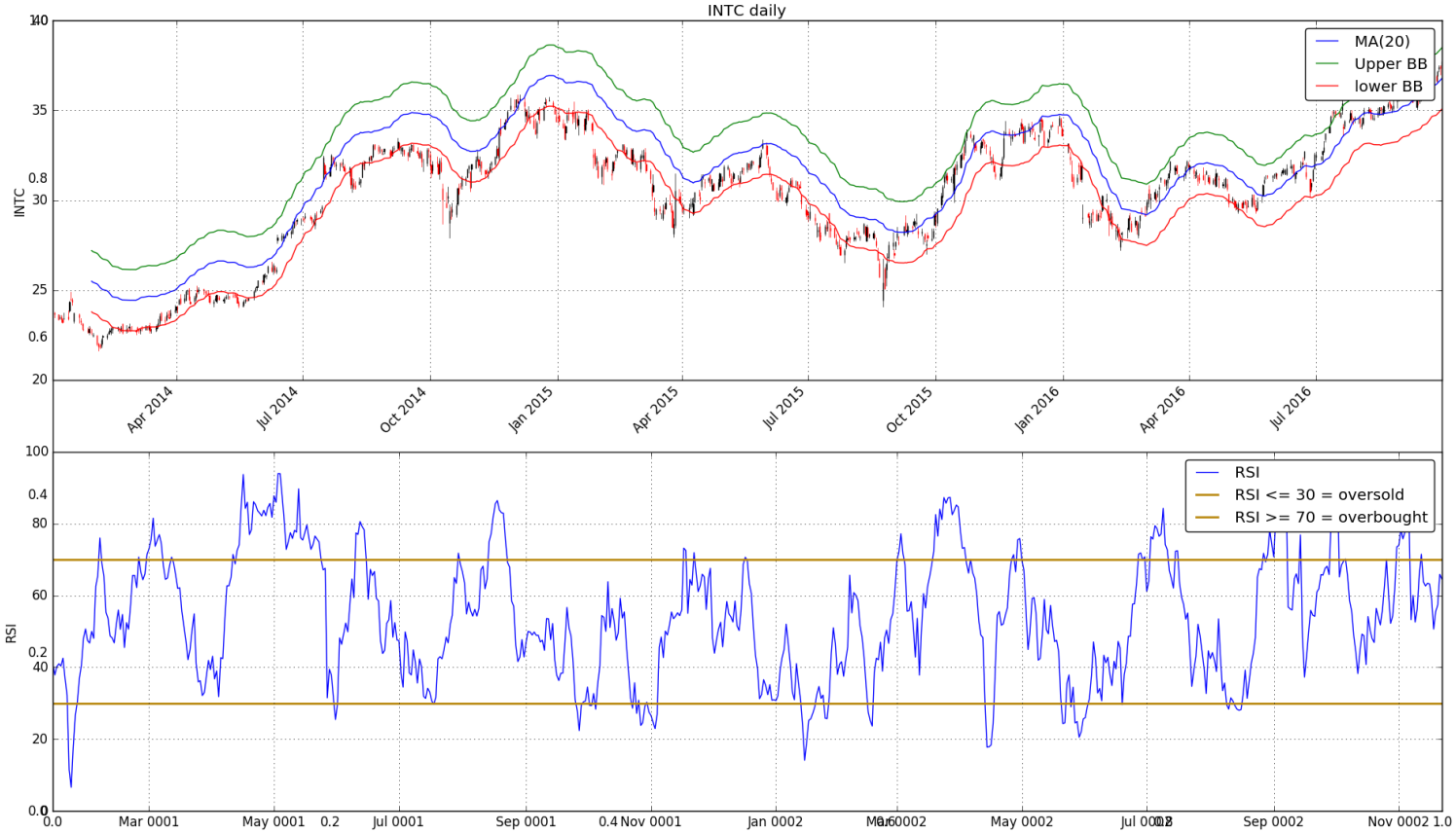

Figure: TIme Series Plot: Ticker: 'INTC' with 'RSI'

Trading Signals on INTC Stocks from 2014-01-01 to 2016-09-30: I

Enter first long position on 2014-02-04 at $ 23.82

Sell-stop order now at $ 24.4332

Exit Long position on 2014-02-03 at $ 23.950001

Enter new long on 2014-02-05 at $ 23.52

Sell-stop order decreased on 2014-02-05 to $ 23.2848

Sell-stop order increased on 2014-02-19 to $ 24.255

Sell-stop order increased on 2014-02-25 to $ 24.37380099

Sell-stop order increased on 2014-02-27 to $ 24.5124

... ...

Exit Long position on 2015-10-29 at $ 34.029999

Enter new long on 2015-11-13 at $ 32.110001

Trading Signals on INTC Stocks from 2014-01-01 to 2016-09-30: II

Sell-stop order decreased on 2015-11-13 to $ 33.52140099

Exit Long position on 2015-11-09 at $ 33.349998

Enter new long on 2015-11-16 at $ 32.099998
Sell-stop order decreased on 2015-11-16 to $ 31.77899802

Sell-stop order increased on 2015-11-24 to $ 34.01640099

Sell-stop order increased on 2015-12-08 to $ 34.4025

. . . . . .

Sell-stop order increased on 2016-09-13 to $ 35.25390099

Sell-stop order increased on 2016-09-20 to $ 36.76859901

Close out position: Go Short on Stop-order at $ 36.76859901

Performance Metrics: Strategy return and Market return: Sharpe Ratio I

1. Vector of Simple Strategy Returns $= [(M_{t+1} - M_t)/M_t]_{t=1}^{n}$, where M_{t+1} is Short position at $t+1$ preceded by Long position M_t at t.
2. Define *time-weighted* True Strategy Return $= r$ as:
$$1 + r = \prod_{t=1}^{n} \frac{M_{t+1} - M_t}{M_t} = (M_2 - M_1)/M_1 \times \ldots \times (M_{n+1} - M_n)/M_n$$
3. **Sharpe Ratio:**(Measure of reward to risk) $S = \frac{\sqrt{n} Avg(d)}{Std(d)}$, where, $d =$ vector of daily market return for a period of n days and Avg and Std are Average and Standard deviation of d.
4. Tabulated below is a Comparison between the True Strategy return (r) and the Sharpe ratio (S) calculated from Market return data between '2014-01-01' and '2016-09-30', $n = 693$:

Stocks	True Strategy Return(r)	Sharpe Ratio
'INTC'	0.99	1.17
'MSFT'	1.00	1.30
'AMZN'	1.00	1.64

Performance Metrics: Strategy return and Market return: Sharpe Ratio II

5. Plot the vector of the average periodic returns obtained from the Signals.

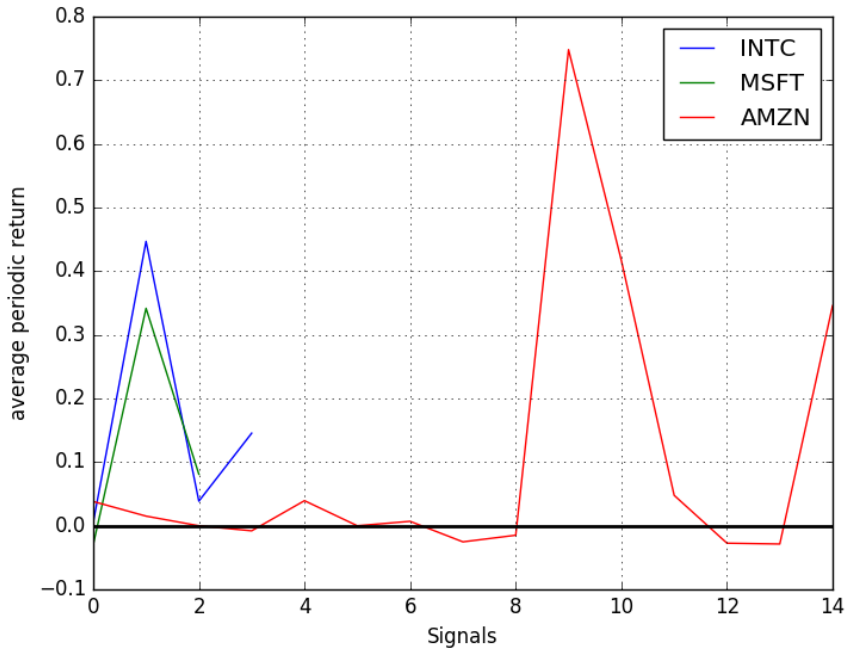

Figure: Average Periodic Returns

Conclusion and Future works:

Strategy Advantages:

1. **Implementation:** Easy to implement.
2. **Robust:** Takes account of not only moving average crossover trend but also important index like RSI and Bollinger bands.
3. **Monitoring:** Can be easily automated and does not require constant monitoring like in day trading.

Strategy Disadvantages:

1. **Trading Signals:** Trading Signals are fewer in number, can lead to significant loss.
   Operation time: Longer operation time than simpler strategies.

Further Performance Statistics:

1. **Risk Analysis:** Perform risk analysis, robust risk-adjusted returns (Drawdown)
2. **Optimization:** Calibrate parameter set $\mathcal{P}$ =(RSI window, Bandwidth, distance from swing low, MA crossover) to maximize returns. Monte Carlo simulations to select starting points.