HAiV

Stock movement as a Markov Process

Business Lab for Financial Engineering

Nguyen Minh Duc

20202026

Contents

- Trading Strategy
- Stock Movement as Markov Process
- Experiment

Trading Strategy

Just buy low and sell high, simple!

How?

Trading Strategy

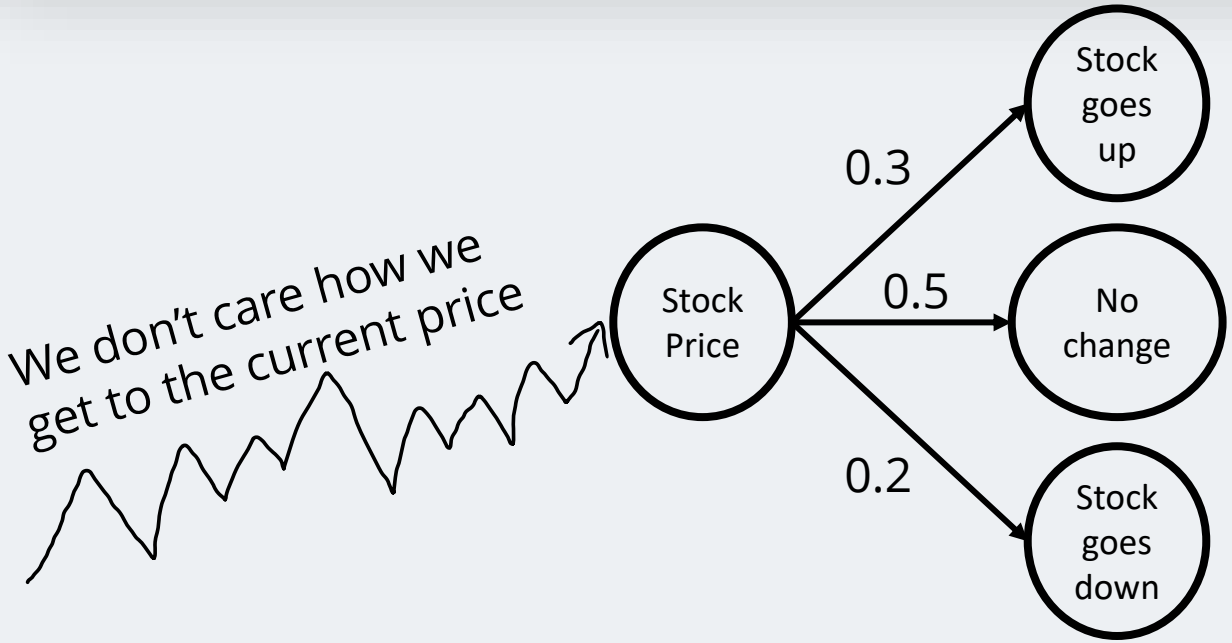
Just buy low and sell high, simple!

Then, how to predict the future?

Stock Movement as a Markov Process

1 What is a Markov process?

Given the historical states of a random system $X_1, X_2, \dots, X_t$, the probability of moving to the next state depends only the current state, i.e., $P(X_{t+1} = x | X_1, X_2, \dots, X_t) = P(X_{t+1} = x | X_t)$



Stock Movement as a Markov Process

2 Stock Movement as a Markov process

We consider the daily return of the stock: $\mathrm{r_t} = \frac{P_t}{P_{t-1}} - 1.$

Classify each $\mathrm{r_t}$ as

- High Increase (HI): $\mathbf{r_t} > \boldsymbol{Q_{inc}}(\mathbf{75\%})$
- Moderate Increase (MI): $\boldsymbol{Q_{inc}}(\mathbf{50\%}) \leq \mathbf{r_t} < \boldsymbol{Q_{inc}}(\mathbf{75\%})$
- Slight Increase (SI): $\boldsymbol{Q_{inc}}(\mathbf{25\%}) \leq \mathbf{r_t} < \boldsymbol{Q_{inc}}(\mathbf{50\%})$
- Neutral (Ne): $\boldsymbol{Q_{dec}}(\mathbf{25\%}) \leq \mathbf{r_t} < \boldsymbol{Q_{inc}}(\mathbf{25\%})$
- Slight Decrease (SD): $\boldsymbol{Q_{dec}}(\mathbf{25\%}) \leq \boldsymbol{r_t} < \boldsymbol{Q_{dec}}(\mathbf{25\%})$
- Moderate Decrease (MD): $\boldsymbol{Q_{dec}}(\mathbf{25\%}) \leq \boldsymbol{r_t} < \boldsymbol{Q_{dec}}(\mathbf{25\%})$
- High Decrease (HD): $\boldsymbol{r_t} < \mathbf{Q_{dec}}(\mathbf{25\%})$

Stock Movement as a Markov Process

2 Stock Movement as a Markov process

We define a hyperparameter: *lookback* – The number of prior prices to consider

The sequence of prices can be encoded as a tuple based on the daily return
Example: (HI, SD Ne, HD, MI)

Now, we can use the historical prices to estimate the probability distribution of the next price state

$$P(X_{t+1} = (x_{t+1}, x_{t+2}, \dots, x_{lookback}) \mid X_t = (x_{t-lookback+1}, x_{t-lookback+2}, \dots, x_t))$$

Stock Movement as a Markov Process

3 Use prediction in the strategy

$$P[X_{t+1} = (x_{t+1}, x_{t+2}, \dots, x_{lookback}) \mid X_t = (x_{t-lookback+1}, x_{t-lookback+2}, \dots, x_t)]$$

The prediction of future trend is the price state with the highest probability

$$\hat{X}_{t+1} = \text{argmax}_x \left(P[X_{t+1} = x \mid X_t = (x_{t-lookback+1}, x_{t-lookback+2}, \dots, x_t)]\right)$$

Experiment

1 Experimental setup

```
perf = markov_benchmark(
    ticker=ticker,
    train_start_date='2010-01-01',
    train_end_date='2022-12-31',
    test_start_date='2023-01-01',
    test_end_date='2023-12-31',
    threshold_to_buy=threshold_to_buy,
    threshold_to_sell=threshold_to_sell,
    lookback=lookback,
    initial_cash=1000,
    num_share_per_trade=1,
)
```

Experiment

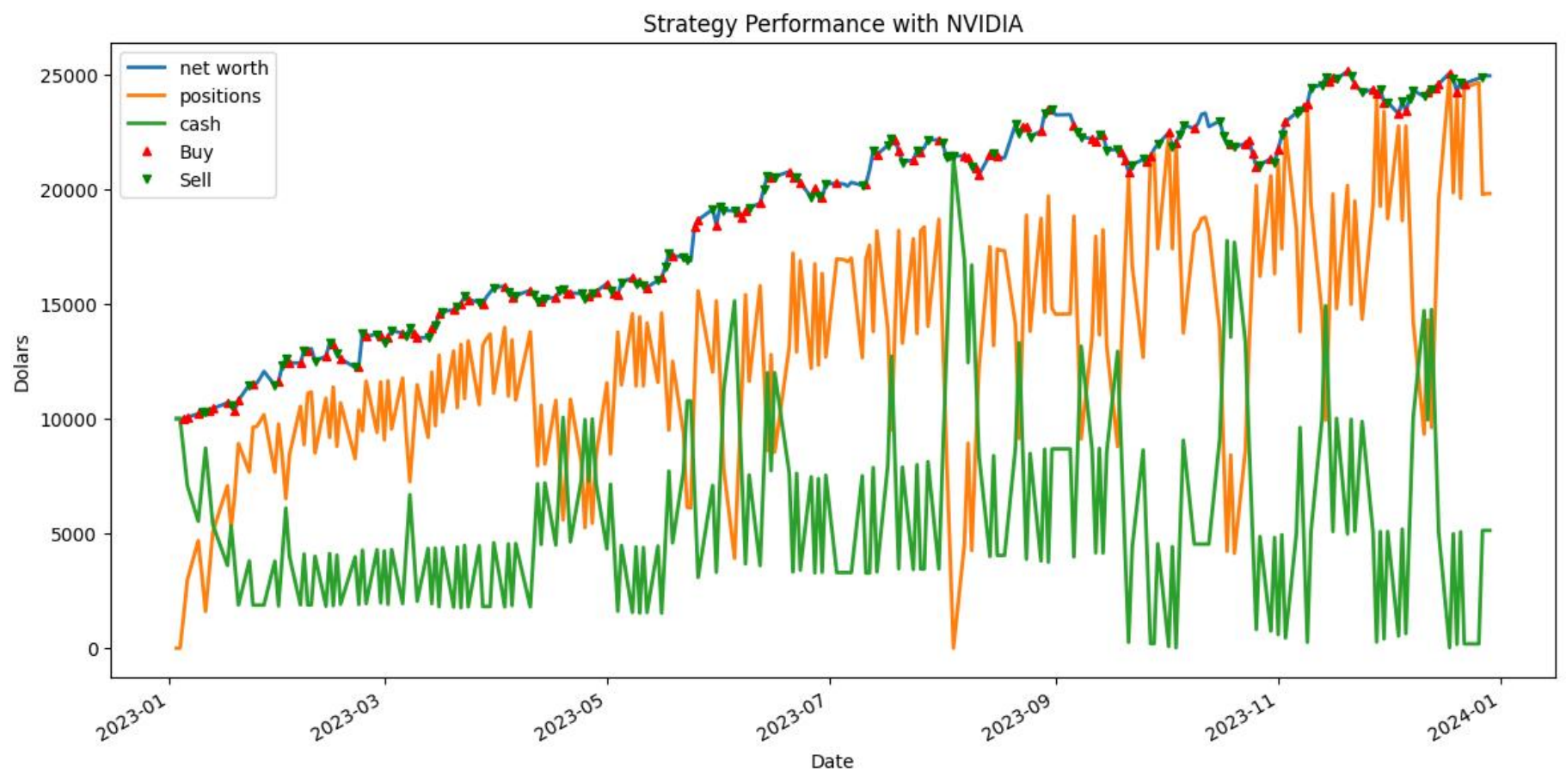
2 Experimental results

Table 1: Comparison of Stock Performance Metrics

Ticker	Metric	Markov	Stock	Better
ACN	Sharpe ratio	0.101	0.086	
	Expected return	0.001	0.001	1
	Volatility	0.009	0.014	
AMD	Sharpe ratio	0.104	0.127	
	Expected return	0.003	0.004	0
	Volatility	0.024	0.030	
APH	Sharpe ratio	0.085	0.097	
	Expected return	0.001	0.001	0
	Volatility	0.010	0.012	
ADI	Sharpe ratio	0.065	0.061	
	Expected return	0.001	0.001	1
	Volatility	0.013	0.016	
AAPL	Sharpe ratio	0.117	0.144	
	Expected return	0.001	0.002	0
	Volatility	0.010	0.013	
ANET	Sharpe ratio	0.117	0.107	
	Expected return	0.003	0.003	1
	Volatility	0.025	0.029	
AVGO	Sharpe ratio	0.154	0.153	
	Expected return	0.002	0.003	1
	Volatility	0.010	0.020	
NTAP	Sharpe ratio	0.081	0.102	
	Expected return	0.001	0.002	0
	Volatility	0.015	0.017	
NVDA	Sharpe ratio	0.193	0.178	
	Expected return	0.004	0.005	1
	Volatility	0.020	0.031	
PTC	Sharpe ratio	0.090	0.122	
	Expected return	0.001	0.002	0
	Volatility	0.011	0.013	
QCOM	Sharpe ratio	0.064	0.075	
	Expected return	0.001	0.002	0
	Volatility	0.016	0.020	
ROP	Sharpe ratio	0.135	0.098	
	Expected return	0.001	0.001	1
	Volatility	0.006	0.010	
CRM	Sharpe ratio	0.157	0.152	
	Expected return	0.002	0.003	1
	Volatility	0.013	0.019	
STX	Sharpe ratio	0.080	0.107	
	Expected return	0.001	0.002	0
	Volatility	0.018	0.022	
NOW	Sharpe ratio	0.060	0.132	
	Expected return	0.001	0.003	0
	Volatility	0.013	0.020	
SMCI	Sharpe ratio	0.147	0.127	
	Expected return	0.006	0.006	1
	Volatility	0.039	0.047	
ROP	Sharpe ratio	0.135	0.098	
	Expected return	0.001	0.001	1
	Volatility	0.006	0.010	
CRM	Sharpe ratio	0.157	0.152	
	Expected return	0.002	0.003	1
	Volatility	0.013	0.019	
STX	Sharpe ratio	0.080	0.107	
	Expected return	0.001	0.002	0
	Volatility	0.018	0.022	
NOW	Sharpe ratio	0.060	0.132	
	Expected return	0.001	0.003	0
	Volatility	0.013	0.020	
SMCI	Sharpe ratio	0.147	0.127	
	Expected return	0.006	0.006	1
	Volatility	0.039	0.047	
SNPS	Sharpe ratio	0.101	0.118	
	Expected return	0.001	0.002	0
	Volatility	0.010	0.017	
TYL	Sharpe ratio	0.098	0.071	
	Expected return	0.001	0.001	1
	Volatility	0.012	0.017	
VRSN	Sharpe ratio	0.021	0.011	
	Expected return	0.000	0.000	1
	Volatility	0.008	0.012	
WDC	Sharpe ratio	0.060	0.096	
	Expected return	0.001	0.002	0
	Volatility	0.020	0.024	
ZBRA	Sharpe ratio	0.048	0.020	
	Expected return	0.001	0.001	1
	Volatility	0.017	0.026	
JNPR	Sharpe ratio	-0.011	-0.013	
	Expected return	-0.000	-0.000	1
	Volatility	0.013	0.015	
KEYS	Sharpe ratio	-0.012	-0.008	
	Expected return	-0.000	-0.000	0
	Volatility	0.014	0.018	
KLAC	Sharpe ratio	0.080	0.093	
	Expected return	0.001	0.002	0
	Volatility	0.013	0.022	
LRCX	Sharpe ratio	0.145	0.126	
	Expected return	0.002	0.003	1
	Volatility	0.015	0.023	
MCHP	Sharpe ratio	0.041	0.065	
	Expected return	0.001	0.001	0
	Volatility	0.018	0.021	
MU	Sharpe ratio	0.080	0.104	
	Expected return	0.002	0.002	0
	Volatility	0.019	0.023	
MSFT	Sharpe ratio	0.109	0.123	
	Expected return	0.001	0.002	0
	Volatility	0.011	0.016	
MPWR	Sharpe ratio	0.069	0.096	
	Expected return	0.001	0.003	0
	Volatility	0.017	0.030	
MSI	Sharpe ratio	0.053	0.074	
	Expected return	0.000	0.001	0
	Volatility	0.008	0.012	

Experiment

3 Case study with NVIDIA



Thank you