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Markov Chain Model for Stock Market Move Prediction

Using the S&P 100 stock price data, new approaches for decision making in buying and selling the security were introduced applying the Markov modelswith continuous & discrete time and discrete states and were compared with technical analysis indicators.

With the development of economic relations in the field of international trading, there is an increase in the company's shareholders, which leads to the expansion of the company's management. The process of increasing the Management Board comes at the expense of the purchase of shares of additional issue. Therefore, current in our time there are vacancies that are associated with the intermediation of securities (brokers, traders, etc.). Technical analysis allows to predict changes in the value of material value in the future based on the analysis of price changes in the past. In many financial tasks, the state of the investigated system can be modeled as the Markov chain (MC), in which each state does not depend on the previous state.

The goal of this work is to propose a new approach for decision-making on stock trading using a model based on the Markov chains and to make a comparative analysis of its profitability with the system based on the MACD indicator on the shares of the S&P 100 index [1].

Using the following rules, we define the four states of the system**S**:

- S_1 – rapid growth with

$$p > \mathrm{EMA}(p, 200)\ ,\ \mathrm{EMA}(\mathrm{ROC}(p), 200) > 0\ ,$$

where *p* – stock price;

EMA – exponential moving average [2];

ROC – Rate of Change:

$$\mathrm{ROC}(p_i) = \frac{p_i}{p_{i-1}} - 1\ .$$

- S_2 – the change of the trend from growth to fall:

$$p < \mathrm{EMA}(p, 200)\ ,\ \mathrm{EMA}(\mathrm{ROC}(p), 200) > 0\ ,$$

- S_3 – the change of the trend from fall to growth:

$$p > \mathrm{EMA}(p, 200)\ ,\ \mathrm{EMA}(\mathrm{ROC}(p), 200) < 0\ ,$$

- S_4 – rapid fall:

$$p < \mathrm{EMA}(p, 200)\ ,\ \mathrm{EMA}(\mathrm{ROC}(p), 200) < 0\ ,$$

and the system transition from the state S_i to the state S_j is only possible at the times:

$$t_1, t_2, ..., t_k, ...,$$

which are the trading days.

The simplified graph of the system described above when intensities (λ_{ij}) of the transition from state to state are independent of time, is shown on the figure below (Fig. 1)

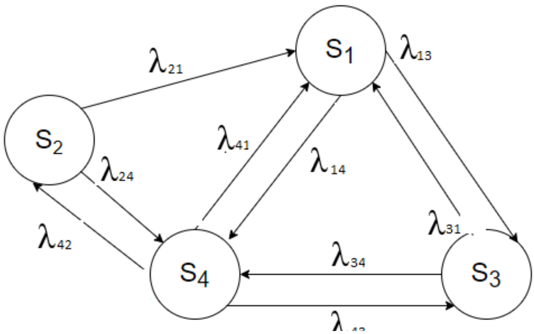

Fig. 1. Typical circuit of the LED

Let’s determine the following rules buy/sell decision making using the Markov chain model:

- Buy:

$$\arg\max\{p(S_1), p(S_2), p(S_3), p(S_4)\} = S_1 ,$$

- Sell:

$$\arg\max\{p(S_1), p(S_2), p(S_3), p(S_4)\} = S_4 .$$

Let’s consider the MACD indicator from the technical analysis [3]:

$$MACD(x) = SMA(x, 12) - SMA(x, 26)$$

where SMA is a simple moving average. Using MACD, we can propose the following strategy for decision-making:

- Buy:

$$MACD(x) > 0,$$

- Sell:

$$MACD(x) < 0.$$

To compare proposed models and model based on technical analysis we will use the cumulative $ profit:

$$\text{Cumulative \$ profit} = \sum_{i}^{N_{trades}} \text{profit}_i ,$$

where

$$\text{profit}_i = p_{sell} - p_{buy} \text{ for long positions}$$

and

$$\text{profit}_i = p_{buy} - p_{sell} \text{ for short positions.}$$

The cumulative $ profit statistics is shown in the table (tbl. 2)

Table 2

Comparison of decision-making models: MACD, Buy & Hold, Markov chain model with discrete states & discrete times, Markov chain models with discrete states & continuous time

№	Weight in the S&P 100	Share	Markov chains with cont. time & discrete states	Markov chains with discrete time & states	MACD	Buy & Hold
1	**12.08**	AAPL	795.55	975.55	-11059.80	217.30
2	**9.74**	AMZN	9556.81	9293.06	-190530.0	1862.69
3	**9.55**	MSFT	752.51	395.69	-2097.35	49.92
4	**5.60**	FB	188.57	690.80	-13456.30	124.81
5	**4.76**	GOOG	-3538.50	4420.25	-31763.70	1114.98
…						
50	**0.40**	FOX	-103.02	151.85	-765.05	28.03
51	**0.40**	ACN	-328.41	633.15	-8898.96	153.90
52	**0.38**	UTX	90.94	308.41	291.01	100.76
53	**0.38**	CAT	964.23	403.33	-1554.86	117.00
54	**0.38**	NKE	405.75	320.48	-1221.84	74.28
…						
75	**0.22**	LOW	69.73	429.77	824.44	96.65
76	**0.22**	BLK	1261.21	1187.45	-10149.20	454.82
77	**0.21**	CVS	293.25	211.34	-4438.28	58.38
78	**0.21**	OXY	-1111.16	-5.75	1887.68	66.68
79	**0.21**	FDX	-521.03	802.41	-8920.38	203.03
…						
96	**0.14**	BK	-587.11	117.25	-1141.66	12.96
97	**0.14**	MDLZ	-639.69	71.84	1397.98	11.27
98	**0.12**	BIIB	-650.57	1460.28	-13336.70	308.57
99	**0.09**	RTN	1026.04	740.21	-7737.27	174.25
100	**0.08**	DHR	-357.48	377.03	-10818.10	95.84

From the analysis of the above results, it can be concluded that the Markov chains model with the discrete time and states has higher profit.

Conclusions

We propose a model based on the Markov chains with discrete or continuous time and discrete state and its use in decision making tasks on the purchase and sale of stocks. Using S&P 100 data it's shown that the Markov model with discrete time & states is more profitable than technical analysis model (MACD) and Buy & Hold.

References

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