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Effectiveness of Stock Price Prediction Models and Affecting Factors

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ABSTRACT

This paper aims to improve effectiveness of stock price prediction model in terms of factors that contain both financial and non-financial. First introduced the different models containing ARIMA, GARCH, RNN and LSTM, their pros and cons and applied cases. Then introduced financial factors including profitability, efficiency, liquidity, solvency and investment-related. Finally, the non-financial factors in terms of four aspects: Cases, Investor preference, Policies and ESG. By analyzing these factors, deriving the conclusion of in which way and how the factors will affect the effectiveness of models.

KEYWORDS

Stock prediction; Models; Factors

1. INTRODUCTION

In a world where financial market has always been shed a light on, specific concerns towards stock price rise among people. Hence, models for predicting stock price emerged. Along with the quantity, it is also necessary to examine the quality--the accuracy on prediction, which is the effectiveness being a model. To achieve, factors to affect or even intervene should be a crucial topic. By analysing these possible factors, it is beneficial to improve the models' accuracy, helping investors predicting more effectively.

Scholars applied ARMA model and ARIMA model for early prediction (Ariyo, A.A., Adewumi, A.O. and Ayo, C.K., 2014) but these models had certain limitations and could only be improved by coming up with new models on the basis of time series such as GARCH model (Herwartz, H., 2017) Some predicted the stock prices using RNN model based on machine learning (Zhu, Y., 2020) and further proposed LSTM model for tackling the gradient dispersion, which is the problem that may occur if using RNN model. (Chang, G., Qiao, J., Liu, Y., Wang, Y. and Zhang, Z., 2021) With stock market constantly changing and being protean, scholars found that combining the previous methods can be an effective for raising the precision. For example, the GARCH-RNN model combined and tested by Yamei Hu, which accurately predicted most of the sample stocks chosen. (Yamei H., 2023)

Still, the application of improved models can be misinterpreting the signs of stock market. By using case study method, some scholars have analyzed the potential factors affecting stock price prediction. In the paper Jianxin and Yanan argued the shock towards traditional stock markets pricing in China coming from the popularization of internet. (Jianxin W., Yanan D., 2022) Another representative case which deeply affected the stock market is the pandemic. Mwanaidi Mgalla has found that during pandemic, the return of Chinese stock market has been negatively impacted but certain kinds of industries were able to mitigate the shock. (Mgalla, M., 2023)

Non-financial factors are also to be considered. The value of ESG (Environment, Social and Governance) has become ubiquitous worldwide among firms' annual reports. Transparency, accounting ability and the trust from stakeholders can enhance the firm value. (Gao, Y., Li, Y., Zhao, C. and Wang, Y., 2022) Besides, the investors' attention, sentiments and utility may also be the factors that contribute to the change to the market situation. Yuxin specifically analyzed the yield under the condition of taking investors' attention into account (Yuxin S., 2023) and others create an optimal portfolio model under the perspective of investors' utility. (Jiliang S., Zhiming W., Yuanxiu L., 2024) Uncertainties in policy-making, suggested by Yan Shen in her article, can be intensely leading the trend of markets and significantly affecting the precision of model prediction. (Yan S., 2019) Tiancai Xing and Xiao Wang as well argued that in terms of Chinese market, novel and transforming, economic policies uncertainties led to higher volatility and information sensitivity, hence elasticity. (Tiancai X., Xiao W., 2022)

In this paper, the effectiveness of models will be justified based on several aspects: qualification as a statistical tool, financial factors and outside strike. By assessing through these aspects, the relatively thorough view on the effectiveness of a model can be provided.

2. MODELS

2.1. Definition and Cases

2.1.1. ARIMA

ARIMA (Autoregressive Integrated Moving Average) model firstly brought out by Box and Jenkins in early 70s so that it is also called Box-Jenkins model. The basic foundation of applying the model can be explained as follow: the data formed by the predicted object over time is regarded as a random sequence, and this sequence is approximated by a certain mathematical model. Once recognized, the model can predict future values from past and present values of the time series. Hence ARIMA model is applied based on time series.

The steps applying ARIMA are separated into four parts: data preparation, identification, estimation and mode checking, application. For data preparation: to transform data to stabilize variance and to differentiate the series to achieve stationary. Then progress to the identification: the selection of models by examining data ACF and PACF. Followed by estimating the parameters, to determine the number of parameters in potential models hence selecting the best model to fit the criterions. After the selection, it is necessary to check the diagnostics: if residuals of ACF and PACF are white noise, if any area of the model is inadequate and to test whether the estimated model conforms to the specifications of a stationary univariate process. If yes, apply the model for forecasting. If no, back to the step of model selection.

ARIMA model is frequently used in multiple cases. Mostly the stock price prediction. Yuxia Wu and Xin Wen focused on the short-term stock price prediction of Chinese Growth Enterprise Market (GEM). They have chosen the closing price from 2014 March 24th to 2015 March 31st of Huatai Securities as the data due to the robustness. They found that the ARIMA model is feasible predicting the trend, the good fitting effect indicated that the model established contains most of the Huatai Securities' stock information and that the predictions are more accurate when static compared with dynamic. Yuxia and Xin also found that the error is small, representing that the results are satisfying. They suggested, after applying the model to the short-term prediction, that ARIMA is effective in seizing the timing and averting the risk.

2.1.2. GARCH

GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model is firstly created by Bollerslev on the basis of ARCH (Autoregressive Conditional Heteroskedasticity) model by Engle in 1982. GARCH further models the variance of error compared to ARCH, which is more suitable for

the analysis and prediction of volatility of complex time series. The variance equation of GARCH is written as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{q=1}^{m} \alpha_q \mu_{t-q}^2 + \sum_{p=1}^{m} \beta_p \sigma_{t-p}^2 \quad (1)$$

Steps applying GARCH model can be summarized as follow: test the ARCH effect in residuals and develop the best GARCH (p, q) model. There should be no autocorrelation or ARCH effect existing. Finally, test the VaR (Value-at-Risk).

Scholars have applied GARCH model to the market risk prediction of CSI (Chinese Securities Index) 300 Index. Firstly, they chose daily closing price of CSI as data from Jan 2010 to March 2024, total number 3452. Secondly, they examine the stationary, autocorrelation test and ARCH effect. Then they conducted the VaR examination and empirical test, showing the result that the model is effective was proven.

2.1.3. RNN and LSTM

With the development and the progress of technology, people tend to dwell on the possibility from introducing machine learning to the traditional method of stock price prediction. RNN (Recurrent Neural Network) model is therefore developed. RNN is the artificial neural networks that is applied especially for dealing with sequence data or time series data. While LSTM is a model developed on the basis of RNN, magnifying the latter's flaw.

2.2. Advantages and Limitations

As mainstream models for stock price predicting. These models above all have shown their outstanding ability in accomplishing the task. ARIMA model has its pros such as good performance in short-term predicting, only requirement of historical data and the capability to model non-stationary data. However, ARIMA is considered of not being capable of handling multivariate time series. And the situation ARIMA assumes is usually not what reality is.

GARCH model is superior to ARCH model due to its characteristic of parsimonious model, corresponding to ARCH's over-parameterized model. It means that GARCH uses variants and parameters as few as possible to explain the data and to reach the fact that simple but understandable. Although GARCH can be effective, it has certain restrictions such as the hypothesized requirement of stationarity and normality of data selected. Besides, overfitting may occur if the number of sample data is small.

As for RNN and LSTM, it introduced machine learning into stock prediction, providing a novel view. RNN is a model that has memory and every output is related to and dependent on input and previous state. If the series is long enough, the new output may not remain stably in function responding the very first output. LSTM, based on the neural network, improved the limitation of RNN as it is able to cope with long-term dependency in the series. However, LSTM has its limitations as well. It might take time and specific knowledge base to learn LSTM for its complexity, and LSTM may not be suitable coping with all types of data. For example, data that are highly nonlinear or with multiple noises.

3. FACTORS

3.1. Financial Factors

According to Efficient Market Hypothesis (EMH), the market stock price fluctuation is totally dominated by information disclosed. Hence financial indices (ratios) can be essential to the stock price. There are five aspects of consideration. Profitability is one valued index within the mainstream. Profitability Index (PI) measures the costs and benefits of conducting a proposed project. It is written

as: PV of future cash flow over initial investment (PV of future cash flow / Initial investment). With the formula given, it is easy to derive that firms with higher PI may have projects that contribute to good benefits on hold, thus potentially increase the possibility of gaining more profit.

Efficiency is also an important considering factor. The relatively representative ratio is asset turnover, which is constructed by sales / total assets, giving the state of how effectively the firm is to generate asset. Certain industries may have a better performance on asset turnover ratio as high asset turnover means that the firm is efficient in generating asset into cash. Such industries include retail, clothing or dairy and such commodities. And industries like real estate are those which might not performing outstandingly in terms of efficiency.

Liquidity means that the ability of a firm to convert assets or security into ready cash. It is an essential factor that affect the stock price of a firm as it is widely considered by every investor. Current ratio is consisted by current asset and current liability, by which formula is current asset / current liability. This ratio represents the sufficiency of available assets to cover short-term obligations. The usual benchmark of current ratio is between 1.5 to 3, lower than this may imply that the firm is at higher risk of dilemma or default. Similarly, if the ratio is higher than the benchmark, it is saying that the management of the firm is not using its assets efficiently.

Solvency is the ability of a firm to meet its long-term debt and other financial obligations. Analyzing gearing ratio may effectively reflect the state of solvency. It is shown as debt over debt plus equity (Debt / (Debt + Equity)). It compares shareholders' equity to debt borrowed by the firm. Its aim is to measure the firm's financial stability and leverage. The benchmark of gearing is between 25% and 50%. Higher gearing ratio can represent that the firm is likely to be susceptible to the economic downturn due to the fact that the firm has more debt hanging than the equity.

Finally comes to the investment-related ratios. P/E (Price-to-Earnings) ratio measures the firms' share price relative to their earnings per share, reflecting the profitability state of a firm. High P/E ratio may represent that the firm value is overestimated or that the investors are expecting a better return from it. Vice versa, the lower the P/E ratio is, the lower the investment risk is. But there are exceptions: when the P/E ratio is low, it is possible that the situation of the firm is actually without a prospective future so that it disappoints investors, contribute to a low P/E ratio.

3.2. Non-Financial Factors

3.2.1. Cases

Case study is an efficient method of analyzing affecting factors. To conduct the case study, it is required to analyze the stock price before and after a specific case happening. First case to be introduced is the internet. With the rapid development of technology, the birth of internet has really subverted lives. In daily life, internet popularization provided more convenient ways to improve well-being, such as online payment which replaced the need of carrying cash, videos and chatting applications making communication easier. For financial market, internet has its crucial impact as well. The global economy is in a key period of transition, including Chinese stock market. Xiqian was well aware of this fact and concluded in her article that the influences brought by the internet is worthy of discussion. One of the characteristics of the internet is its high speed of information spreading. In an era of information explosion, a large amount of news emerges, hence providing more references for investors to make judgement of their choices, impacting the overall stock market and subsequently the stock price. Xiqian has exemplified both Shenzhen stock market and Shanghai stock market and analyzed to what extend the news impacts differ to each of them. In her research, Shanghai market firstly reacts to the news one day before the disclosed and peaked on the third or fourth day. Shenzhen market reacts to the news on the day it is disclosed and may reach the summit after five days. This could be due to their magnitude as Shanghai market is gathered with large or medium-sized state-owned enterprises, while in Shenzhen market there are a majority of small, medium-sized and venture capital enterprises. Hence in the article Xiqian concluded that smaller the size of a firm,

the greater impact it receives. Another factor varies the influence coming from news could be the state of market, whether its bear or bull. For bear, investors tend to be more sensitive.

Covid-19 is a representative event recently that may have serious impact towards stock market. Scholars over the world have carried out researches which in pandemic, the changes and comparison happened in stock market. In Chinese stock market, it is reflected as huge negative impact especially the shock to the real economy. The cost of hiring from firms raised, causing the production level decline. The uncertainties brought by pandemic has led investors a lost path, affected by numerous unclear information hence herd effect emerged, increasing the volatility of capital market. Pandemic also has destructive impact on labor-intensive industries such as retailing, catering and traffic due to the fact that people stayed at home and having less opportunity to consume. Besides, enterprises of different nature received the shock to different extent. Private ones are smaller in size, having more difficulty in raising fund, hence less able to handle the risk. State-owned enterprises are more advantageous in being subsidized by authorities, having buttress confronting with the shock so that less affected by the pandemic. The shock lasts in post-pandemic era. US market have experienced the structural pressure, long-term monetary policy leads to high inflation rate. Commodities market fluctuates anomalously, along with the decline of energy market price.

3.2.2. Investor preferences

For determining stock price, what investors would react and do is one of the most crucial factors to be analyzed. As investors' actions of buy and sell are directly affecting the fluctuation of stock price. Efficient Market Hypothesis assumes that all investors are rational, which means that they only pursue the optimization of own economic benefit, such as profit or satisfaction. However, in reality, not all investors are rational due to inefficient market condition hence information asymmetry. Scholars have conducted researches based on several angles. One of the most typical reaction of investors is the herd behavior, which represents that the investors would choose to follow blindly with others' moves. It is often considered as the main cause of market inefficiency and price bubble. It has serious impact on stock market. Rational herd may well enhance the market liquidity, but the irrational herd behavior that is unsupported by information can be an important inducement stock price anomaly. The investor attention is intensely relevant to the herd effect. For example, there is research proving that investor attention can significantly affect the occurrence of herd behavior. Firstly, the attention drawn from independent investors can have a positive effect to the herd effect of stock market and compared to buyers', it is more influential to sellers'. As investors not only search for information of stocks not held, but also holding stocks. Besides, the context media chose to publish is intendedly eye-catching in negative side, leading investors to sell their holding stocks. Secondly, it is more obvious for the effect to occur when the stock rises or falls to the daily limit. A stock which rose or fell to its limit may more easily attract attention from investors on the buy side instead of sell side, hence promoting buyers' herd effect. And investors who held this stock are relatively less concerned. The third assumption being proven is that the investors attention to small market capitalization companies affecting more to the market herd effect.

Furthermore, the attitudes investors have towards risk is also a potential factor that affect the stock price. It can be separated into three types: risk averse, risk neutral and risk lover. As the name suggests, different types of investors choose different strategies when they make decisions. Therefore, it is important for analysts to identify the percentage of investors with distinct attitudes for a more accurate stock price prediction.

3.2.3. Policies

Another important factor is the policies made from the government. Under the situation where the policies made are uncertain, which means that whether the economic body change the current policies and the time and way of changing cannot be accurately known, hence promoting instable policy expectation. The policy uncertainty may lead to the pricing efficiency of capital market to be lowered, causing the increase of market volatility and systematic risk, equity financing scale decline and the

rising of net international capital outflows. Macroeconomic policy uncertainties directly affect the information disclosing, further associating with investors' trade actions and market liquidity. Dzielinsky (2012) measured the uncertainties based on Google, concluded that when the searching frequency of words such as "uncertainty" increases, the stock market fluctuates correspondingly. On the other hand, the more serious stock market fluctuates, the more uncertain information discloses. Vice versa, if the policies made are under expectation with certainty, it instead has positive effect to the stock market. Under a certain circumstance, the information investors being disclosed is clear and guiding, benefiting investors on making decision and effectively reducing the blind following behavior within market, giving a clearer pattern of stock price hence promoting a more accurate prediction.

3.2.4. ESG

ESG (Environment, Social and Governance) is a valued indicator of worldwide investors recently. The three aspects respectively represent a firm's performance in contribution to the environment, to social responsibilities and to internal governance of itself. The evaluation of ESG is as important as financial indicators. For investors who insist in value investment and care for the sustainable development prospect, good ESG performance provides a clear and strong support for firms' potential. Hence these value investors are more likely and more willing to keep investing even if the stocks are shocked by outside force and perform less than expected, hence having the possibility of stabling stock price, lowering the fluctuation of market. However, it is not certain that the ESG reported by firms are always accurate. Situations such as exaggerating or deliberately belying anything may emerge if possible. This would cause the information asymmetry to occur, hence leading to the decline of transparency, decreasing the density of disclosed stock price information. Nevertheless, there are multiple standards for assessing ESG performance and numbers of debates exist. These differences among criteria contribute to less comparability and consistency as the data or weighting institutes choose are distinct. This huge divergence is not benefiting the participation of investors nor promoting the pricing efficiency, hence affecting the stock price, making the situation less predictable.

4. CONCLUSION

This paper analyzed the different factors' impact towards the effectiveness of stock prediction models by firstly introduced steps to conduct models and their pros and cons, then listed out both the financial and non-financial factors that may affect the effectiveness of prediction. By expanding through cases, investor preference, policies and ESG, the influences to the stock price fluctuation are exemplified and explained. It is derived that the outside factors can impact the accuracy of stock price prediction in multiple aspects such as information disclosing, inscrutable behaviors and so on. This paper aims to provide reference to stock price prediction model users for avoiding known risk and improving the prediction accuracy.

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