Time Series Based Data Analysis and Prediction for the Relationship Between China Concept Stock Price and Government Regulatory Policy

Jiahe Fang[1, *,†], Jianheng Huang[2, †]
*Corresponding author: Fang0908@connect.hku.hk, Jianheng.huang@mail.utoronto.ca

[1]Decision Analysis BSc Dept of Statistics and Actuarial Science, Faculty of Science The University of Hong Kong Hongkong, China

[2]Economics for Management Study and Statistics, Faculty of Arts and Science University of Toronto Scarborough Toronto, Canada

[†]These authors contributed equally.

Abstract—Government regulatory policy often significantly impacts the stock price trend, which is rarely studied in past studies. This research explored the relationship between China concept stock price and Chinese government regulatory policy. The generalized autoregressive conditional heteroskedasticity (GARCH) model, empirical distribution model, and Long Short Term Memory (LSTM) machine learning model were used to examine the influence of Chinese government policy on China concept stock price using data and policy information from credible sources. Based on the model results, this study also came up with valuable conclusions and recommendations for investors and the government. For financiers, investing in China concept real estate stocks is advantageous in the short term. Set a 10% stop loss range and a 20% stop profit range based on the empirical distribution of effect percentage. The experimental results suggest that the government releases policies in a particular industry less frequently to ensure that the market works smoothly.

Keywords-Stock price; Government regulatory policy; GARCH model; Empirical distribution model; LSTM model

1 INTRODUCTION

The stock market is a trading platform on which investors can sell and buy shares according to market price. The stock market works as a trusty platform among sellers and buyers. When the stock price goes up, the stakeholders can profit with available stocks for sale. In the other case, the stakeholders will face losses if the stock price goes down. Hence, the fluctuations in stock price directly affect the returns of stakeholders.

The China concept stocks are a bunch of stocks of companies whose assets, earnings, and operations are mainly in Mainland China. China Concepts Stocks are listed overseas, from HKEX and SGX to NYSE and NASDAQ. Historically Chinese stock exchanges have strict restrictions on foreign capital investments, which has driven the formation of China concept

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stocks. With China's capital market development, the China concept stocks are expected to be a critical financing source for Chinese companies.

The past few years have seen the rapid development of China's stock market. Meanwhile, as the China capital market is opening for foreign investors, the Chinese stock market is playing an increasingly influential role in international capital markets. However, China's economy is more centrally planned than a mature capitalist market economy. Excessive government control is the most outstanding feature of China's stock market [1]. Former studies have shown that the China stock market is policy-oriented, and some policies can cause extreme volatility in some industries and their stocks [1].

As previously mentioned, China's government regulation policy significantly affects the China concept stock prices. For example, an instruction released on Mar 16th by China Securities Regulatory Commission (CSRC) stated that CSRC would do all it could to ensure the operation of the capital market. Most China concept stocks' stock prices jumped from 20% to 50% in a day. For example, BABA increased from 75.1 USD per share (opening price) to 105.74 USD (today's high price) per share, and JD, increased from 51.53 USD per share (opening price) to 64.28 USD (today's high). On the other side, the regulatory policy can cause a steep fall in stock price. On Mar 11th, the China State Tobacco Monopoly Administration (CSTMA) released an e-cigarette regulation. The regulation policy banned the sale of flavored e-cigarettes with flavors other than tobacco. Within two trading days, the stock price of RLX, a China e-cigarette company, fell by 38%, from 2.41 USD (opening price) per share to 1.49 USD (ending price). Therefore, investigating the relation between the volatility of China concept stocks and Chinese government regulatory policy is demanded.

With many advances in technology, artificial intelligence (AI) supports many fields of life. Machine learning (ML) is a field of AI in which some algorithms serve prediction functions [2, 3]. Research on stock market predictability has a long history in stock markets [4-6], and ML is an effective tool in stock market prediction.

Though there have been many former studies on China concept stocks, China's government policy analysis, and machine learning in stock price prediction, there has not been any research on the relationship between the stock price of China concept stocks and China's government regulation policy using machine learning method. Therefore, the fundamental motivation of our research is to establish a quantitative model to predict the timing and the impact of China's government regulation policy on China concept stocks on the global stock market. Consequently, our research will assist investors and policymakers in making decisions.

This article focuses on predicting the timing of the regulation policy introduction of the Chinese government and evaluating the effect of policy on certain China concept stocks' prices. This article looks into some China concept stocks that are highly policy-sensitive. The machine learning model LSTM will be used for stock price prediction (SPP) [7-9]. Then, the article will demonstrate the stocks we investigated and the methods we applied. In the end, we state the significant findings and conclude this article.

Given the increasingly important role of China stock markets in the international capital market, this article is significant for global investors affected by the China stock market and the attendant risk of its regulatory policies. Moreover, considering the China stock market is greatly affected by policies, evaluating the changes in the China stock market under government regulation policy

and predicting the timing of the policies are significant for both domestic investors and global investors. When designing policies, policymakers can consider the intensity, timing, and types of the policies more cautiously based on this research.

2 DATA ANALYSIS

The data analysis section will first demonstrate the data source and the range of data to ensure the credibility of the research material and a comprehensive research perspective. Then, it will show how we selected and justified the data calculation formula.

2.1 Data preparation

The data range includes three industries in China: the real estate industry, the e-cigarette industry, and the K12 education industry. The criteria for selecting the industries is the degree to which these industries are affected by the regulatory policy. The policy information sources are two corporate websites for the real estate industry, Zhong fang wang (i.e., the Official website of the China Real Estate Association) and CRIC Real Estate Research. For the e-cigarette industry, the policy information comes from the official website of CSTMA. For the K12 education industry, the policy information is mainly from the research report released by Soochow Securities. Stock prices are from yahoo finance, taking the adjusted closing price. To evaluate the impact of a policy on stock price, we take the formula:

$$PolicyImpact = \frac{P^O_{t_0} - P^E_{t_0+5}}{\frac{P^O_{t_0} + P^E_{t_0+5}}{2}} \quad (1)$$

where P^O and P^E stands for opening and ending price t_o is the policy issue day.

Brooks, Patel, and Su [10] have pointed out that the stock market responds to an unexpected event in 15 minutes. They also mentioned that according to efficient market theory, an anticipated event would be priced into the stock value by the market at the moment [10]. Nevertheless, for a policy change, it takes days for the stock price to interpret the impact on the fundamental outlook. The weekend effect is a general theoretical conclusion to this phenomenon in the stock market. The weekend effect is that stock returns on Mondays are often significantly lower than those immediately preceding Friday, leading to higher volatility of stock prices and the markets. To smooth out the fluctuations, the Chinese government usually chooses Friday as the day to announce the policy changes that may negatively affect the stock market. The purpose is to leave enough buffer time for the market to digest the impact of policy change. We choose the impact calculation formula because, within a week of trading, the changes in stocks' fundamental outlooks caused by policy changes have been fully recognized by investors and triggered corresponding trading behaviors. Consequently, they are fully reflected in the stock price.

3 EXPERIMENTAL SETTING AND RESULTS

3.1 Assessment of the risk of the financial market

In financial markets, volatility is the degree to which a series of trading prices change over time. When analyzing stock market risk, market volatility cannot represent the market risk, but it is an excellent way to measure risk. It is crucial to observe and analyze the daily volatility table calculated within a given time frame to analyze the risk of an industry or a specific stock. Among the related real estate companies listed in the US stock market, BEKE, known as Ke.com, is the most representative company. BEKE is an online real estate marketing platform and real estate brokerage. Thus, analyzing this stock can help to analyze the risk of the real estate stock market. To obtain the volatility table of the BEKE, we introduce the auto-regressive conditional heteroskedasticity (ARCH) model, which is a statistical model for time series data that describes the variance of the current error term. Also, it describes how the variance of error evolves. Volatility clustering describes the tendency for large changes in asset prices to follow significant changes and minor changes to follow small changes. In order to get the volatility table, we specify the risky asset and the time horizon first. Then we download the specific data, and we can calculate the daily returns (Figure 1). Thirdly, we specify and estimate the ARCH model. Last, we plot the residuals and the conditional volatility (Figure 2).

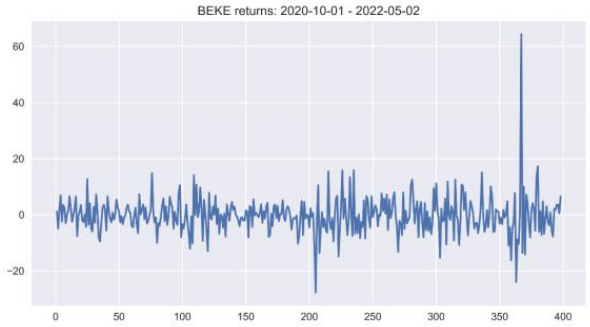

Figure 1. Daily returns of the stock.

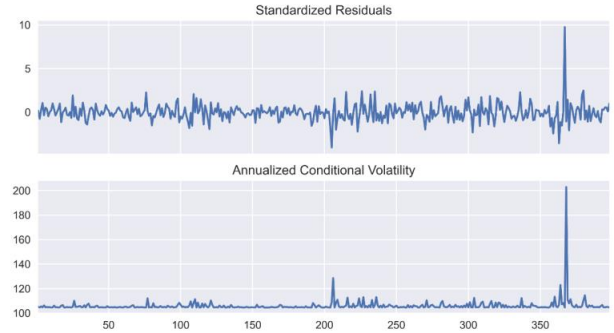

Figure 2. Residuals and conditional volatility.

As shown in Figure 2, this stock is relatively volatile, and volatility can increase substantially at a particular time. Figure 2 also shows that the stock is very risky, indicating that the real estate market is also precarious. Not only the stocks listed on the US stock market but also China's leading real estate companies listed on the Hong Kong stock market, such as Country Garden or the former leading company Evergrande, under China's top-down policy, especially China's "three red lines" policy introduced by Chinese government, their stock prices are at their lowest points. The three red line policies are the indicators proposed by the central bank, the China Banking and Insurance Regulatory Commission, and other institutions for real estate companies in January 2021. The asset-liability ratio after excluding advance receipts should not exceed 70%, the net debt ratio should not exceed 100%, and the short-term cash debt ratio should be greater than 1. The dividends of financial, real estate ended because of this policy, the real estate market was also hit hard, and all real estate stocks fell to their limits one after another. Without the support of the central policy, real estate companies can only survive in the cracks, and investors also suffer heavy losses. In other industries, such as K12 education, after the central government's crackdown on K12 education policies, all Chinese education stocks listed in the U.S. market fell by more than 90%. Therefore, the central government's policy has become one of the most significant risks in the stock market. In general, China's government regulation policy significantly impacts the stock market's performance. If an investor does not have the source of the policy ahead of time and does not have a high risk-tolerance level, we recommend that the investors should not invest in the real estate stock market.

3.2 Chinese Government Policy Time Interval Analysis

Table 1. Policy number and the time interval.

Policy number		**Time Interval**
1		53
2		1
3		2
4		5
5		2
6		25
7		39
	Sample number:7	
	Average:18.14	
	SD Squared:383.55	

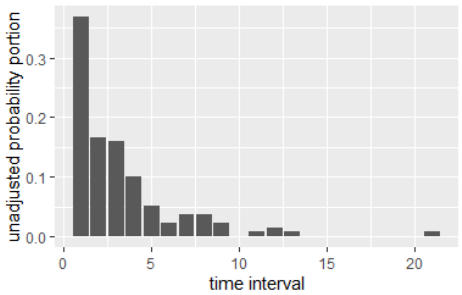

Figure 3. The number of policies and corresponding time intervals.

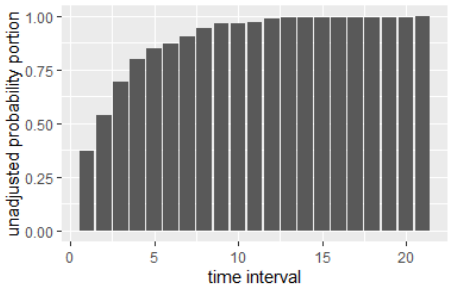

Figure 4. The probability density function of time intervals.

To predict the policy's time interval, we first list the former policies in time series and the corresponding time intervals (see Figure 3). Considering the page size, we only use the K12 education industry data as an example. Then we use the empirical distribution model to describe the probability density function of time intervals (See Figure 4). Lastly, we test if the probability density function is memoryless to ensure prediction accuracy. It is worth mentioning that due to the small sample size of policies in the e-cigarette industry and the K12 education industry, after consideration, we only investigate the real estate industry in this section.

The first finding is that the real estate industry policy time intervals are memoryless. Intuitively thinking, the policymakers have the memory of the published policies. Hence, the probability density function of policy time interval presents memory traits. However, we sampled the policies and tested them with the equation:

$$P(A + t|A) = P(A) \tag{2}$$

It turned out that the real estate industry policy time intervals are basically memoryless. This finding means that we can directly predict the future policy time intervals based on the empirical probability distribution without concerning the former policies. We proposed a possible reason for the anti-common finding. Though the government of each level and district has the memory of decision making, their decision-making processes are relatively independent, not transparent to each other, and they do not share the decision-making memory. Hence, the whole set of policies presents memory lessness in a unified stock market.

The second finding is the short time intervals. According to Figure 3, more than 50% percent of time intervals fall in 1 to 3 days. With a 95% confidence interval, the time interval is under 13 days.

Based on our findings, we recommend government reduce the frequency of introducing policies. Though overall, the policies positively impact the stock price, artificially created excessive volatility will affect market confidence and generate a large number of speculators, which is not conducive to the purpose of the market for financing companies.

3.3 Policy Impact Prediction

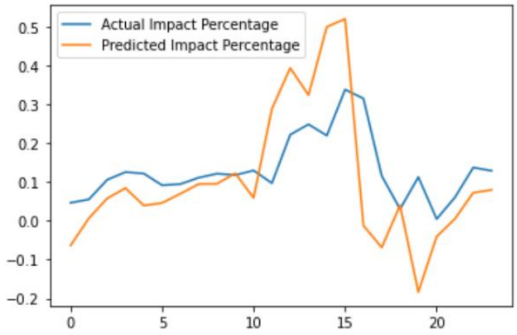

Figure 5. Prediction performance compared to the actual impact percentage.

The data we use have two dimensions, number and impact percentage. The number is ranked by the policy issuing time, and the formula measures the impact. This data type allows us to apply time series analysis. To overcome the lack of data, we choose time series as the data type and use LSTM to train the model by dividing the test set and training set. In this way, we can test and correct the model without additional policy data.

Moreover, we expand the dimension of test set data from 2-dimension to 3-dimension. This can enhance the data processing efficiency of the TensorFlow model and avoid underfitting. Then we reduce 20% of neurons to reduce the overfitting problem. In simple terms, the overfitting problem in our study is that the prediction result fits the training set, but it fails to fit the test set. Lastly, we visualize the former policy impact data, showing a well-fitted prediction curve (Figure 5).

The prediction result shows four significant findings of Chinese government regulatory policy and China concept stock price. The first one is that the accumulated positive impact of Chinese government regulatory policy on China concept stock price is much more significant than the negative impact (Table 1). The second finding is that the impact percentage is getting more significant, which could bring more financial risk, together with more significant potential gains from volatility (see Figure 3). The third finding is that with a 95% confidence interval, the volatility caused by one single policy will not exceed -20% and 30%. This shows that the government is trying to ensure the stock market is running smoothly (see Figure 3). The last finding is based on our prediction result. In the near future, the Chinese government will introduce favorable policies for the rea estate China concept stocks. Based on this, we recommend that investors invest in China's concept real estate stocks, BEKE, in the near future. Also, investors can set a stop loss range of -10% and a stop profit range of 20% according to the distribution of impact percentage. The expectation of profit is positive if investors follow this strategy.

3.4 Limitation of this study

The major limitations of our study are the small sample size and disturbing factors. There are mainly three factors that lead to the small sample size problem. Firstly, China concept real estate stocks are rarely listed in the US. Secondly, most listed China concept real estate stocks are too

illiquid. The only qualified one, BEKE, went public on 2020 Aug 1st, and has a short history. Thirdly, for the e-cigarette and K12 education industry, the number of policies is too small. Thus their data samples are not suitable for evaluation through statistical methods or machine learning. As for disturbing factors, there are Chinese government monetary policies, USA government monetary policies, trade war, and COVID-19. These are important factors but are not ideal for impact prediction based on machine learning. For example, COVID-19 was a bearish event for the real estate industry, and we expected the stock price to fall.

Nevertheless, the US government may adopt the quantitative easing policy that pushes the stock price. These factors are enough to enlarge the impact when Chinese government policies cause effects in the same direction and can obscure the impact of Chinese government policies when they affect the stock price in opposite directions. Nevertheless, most of the disturbing factors are not as vital as the Chinese government policies and can be ignored for most of this study.

4 CONCLUSION

This research explored the relationship between China concept stock price and Chinese government regulatory policy. Based on three industries' data and policy information we got from multiple sources, we applied the GARCH model, empirical distribution model, and LSTM machine learning model to analyze the impact of Chinese government policy on China concept stock price. Also, based on the model results, we figured out some valuable findings and recommendations for investors and the government. For investors, it is beneficial for investors to invest in China concept real estate stocks in the short term. Based on the empirical distribution of impact percentage, it is beneficial for investors to set a 10% stop loss range and a 20% stop profit range. For the government, we recommend it issue policy in a particular industry with less frequency to ensure the market runs smoothly.

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