The Influence of Shenzhen-Hong Kong Stock Connect on Stock Price Fluctuation

Yiwen Zhang

Xidian University, School of Economics and Management, No.266, Xinglong Section, Xifeng Road, Changan Zone, Xi'an City, Shanxi Province, China

Abstract: *The opening up of China's capital market follows a gradual opening process. The inclusion of QFII, QDII, RQFII, Shanghai-Hong Kong Stock Connect, Shenzhen-Hong Kong Stock Connect, and A-shares into the international mainstream index are several major events in China's opening up process. The Shanghai-Hong Kong Stock Connect and Shenzhen-Hong Kong Stock Connect policies have established a two-way open channel between the mainland capital market and the Hong Kong capital market. On December 5, 2016, Shenzhen-Hong Kong Stock Connect was officially implemented. Shenzhen-Hong Kong Stock Connect is an upgraded version of the interconnection mechanism. It's opening not only helps deepen the integration of the mainland and Hong Kong capital markets, but also helps Hong Kong and the mainland capital markets to form a good complementary effect, providing more options for the allocation of overseas capital on A shares. Based on this background, this article selects 2014-2018 as the sample period, and through the establishment of the double differential model, explores the impact of the Shenzhen-Hong Kong Stock Connect opening on general fluctuation, systematic fluctuation, heterogeneous fluctuation of stock price. The empirical results show that the Shenzhen-Hong Kong Stock Connect Policy has significantly reduced the overall and heterogeneous fluctuations in stock prices. Based on the empirical results, this article makes recommendations to policy makers, listed companies and investors: policy makers should adhere to the gradual opening of the capital market; listed companies should strengthen information disclosure ; Small and medium-sized investors can properly learn from the experience of foreign investors to invest.*

Keywords: Shenzhen-Hong Kong Stock Connect Policy, General fluctuation of stock price, Systematic fluctuation of stock price, Heterogeneous fluctuation of stock price

1. Introduction

The level of capital market opening to the outside world is one of the main symbols of a country's capital market development. In recent years, China has implemented a series of policies to explore the road of gradual capital market opening to the outside world. The qualified foreign investor mechanism (QFII), qualified domestic investor mechanism (QDII), RMB qualified foreign institutional investor mechanism (RQFII), Shanghai-Hong Kong stock connect, Shenzhen-Hong Kong stock connect and inclusion in the international mainstream index are major events in the process of opening the capital market to the outside world. The QFII system allows qualified foreign institutional investors to convert foreign exchange into renminbi to invest in the domestic securities market. The QDII system allows qualified domestic institutional investors to invest their foreign exchange holdings in overseas capital markets. The RQFII system is also aimed at qualified foreign institutional investors (QFIIS), which allow offshore renminbi to invest in the domestic market. The Shanghai-Hong Kong stock connect and the Shenzhen-Hong Kong stock connect have opened up a two-way channel between the capital markets of the mainland and those of Hong Kong. The scheme allows Hong Kong and overseas investors to buy shares directly through the Hong Kong stock exchange and through the Shenzhen stock connect, while mainland investors can buy shares directly through the Shanghai and Shenzhen stock exchanges. The inclusion of a-shares in the MSCI index has further increased the internationalization of the a-share market.

The Shenzhen-Hong Kong stock connect was officially launched on December 5, 2016, marking another step forward in the connectivity between the capital markets of the mainland and Hong Kong on the basis of the shanghai-Hong Kong stock connect policy. In the first batch, A total of 881 stocks were included in the Shenzhen stock index, among which 267 were from the main board, 411 were from the same board and 203 were from the gem board. Shenkangjia A was the first Shenzhen stock to be traded. The Shenzhen-Hong Kong stock connect (Shenzhen-Hong Kong stock connect) basically extends the rule framework of the Shanghai-Hong Kong stock connect. However, the Shenzhen-Hong Kong stock connect system mainly has two new features. 2. The market in Shenzhen is more diversified, with the underlying stocks greatly expanded, the small and medium-sized enterprise board and the growth enterprise board stocks added, and the level of opening up of the capital market is greatly enriched.

The significance of the opening of the capital market to the outside world mainly includes: 1. It provides convenience for foreign investors to invest in the a-share market, helps to introduce foreign capital, improves the structure of investors in the domestic capital market, and deepens the connection between onshore and offshore RMB. 2. Force the reform of domestic financial system to promote the maturity and perfection of China's capital market. The opening of the Shenzhen-Hong Kong stock connect has A new significance: 1. The Shenzhen-Hong Kong stock connect policy has abolished the limit on the total amount of capital flow each year, expanded the openness of the a-share market, and established A more reasonable pricing mechanism. 2. The Shenzhen-Hong Kong stock connect policy has enriched the level of opening-up, making it structurally different from the Shanghai-Hong Kong stock connect policy. The markets of Shanghai, Shenzhen and

Hong Kong can form a good complementary effect and effectively attract foreign investors.

China has implemented a series of opening-up policies, which provide unimpeded channels and institutional guarantee for domestic investors to invest in the overseas capital market and for overseas investors to enter the domestic capital market, and also provide practical experience for China to further expand the opening of the capital market. In the long run, the opening up of the capital market will promote the healthy development of the capital market. However, the risks and challenges brought by the opening of the capital market to the capital market should not be underestimated due to the fact that the overseas capital may contain speculative capital, the imperfect development of China's capital market, the large number of small and medium investors and the low efficiency of the market.

The Shenzhen-Hong Kong stock connect has realized the two-way interconnection between the Hong Kong stock connect and the Shenzhen-Hong Kong stock connect, bringing opportunities and challenges to China's capital market. Therefore, it is of great practical significance to explore the impact of the implementation of the Shenzhen-Hong Kong stock connect policy on the fluctuation of China's stock market. This paper USES DID dual difference model to explore the influence of Shenzhen-Hong Kong stock connect policy on overall, systematic and heterogeneous stock price fluctuations. The empirical results show that the opening of the Shenzhen-Hong Kong stock connect policy has significantly suppressed the overall and heterogeneous fluctuations of stock prices and played a role in stabilizing shenzhen securities market.

2. Literature Survey

2.1. Research on stock price fluctuation

The research on stock price fluctuation mainly focuses on three aspects: the general fluctuation of stock price, the synchronicity of stock price and the heterogeneous fluctuation of stock price.

2.1.1. General fluctuation of stock price
The study of the total volatility of stock prices is relatively simple. Wang Xiaowei (2017) used the standard deviation of the stock price to measure the fluctuation of the stock price. In order to eliminate the difference in the absolute value of the stock price of different companies, the paper used the relative value of the return rate of the stock price to describe the stock price, and established the DID model to explore the impact of the shanghai-Hong Kong stock connect policy on the stock price volatility. Ding Shuo (2019) [1] used the closing price of the Shanghai composite index to measure the stock price volatility, and explored the influence of macroeconomic indicators on China's stock price volatility through the co-integration test.

2.1.2. Synchronicity of stock price and heterogeneous fluctuation of stock price
Stock price synchronicity refers to the part of stock price fluctuation that can be explained by market fluctuation, while stock price heterogeneity refers to the part of stock price fluctuation that cannot be explained by market fluctuation. These two variables describe two aspects of the same event. Therefore, this paper mainly introduces the literature related to the heterogeneous fluctuation of stock price, including the measurement method and the influence way.

1) The method of measurement
Markowitz (1952) [2] first deduced the construction model of optimal asset portfolio by mathematical methods in his works, but it was difficult to apply it in practice at that time due to complicated calculation. On the basis of Markowitz's research, Treynor, Sharpe, Lintner, Mossin and other scholars simplified the theory, and capital asset pricing model (CAPM) was born.

CAPM divides the risks affecting the expected returns of assets into systematic risks and non-systematic risks, so the total risks of assets are expressed as follows: total risks = systematic risks + non-systematic risks

Therefore, the mathematical model of capital asset pricing theory is:

$$R_i = R_f + \beta_i(R_m - R_f) + \varepsilon_i \qquad (1)$$

R_i is the yield of asset i; R_f is risk-free rate; R_m is market yield; R_m - R_f is the market risk premium, that is, the difference between the market yield and the risk-free rate; β_1 measures the systemic risk of asset i; ε_i measures the non-systemic risk of asset i.

Systemic risk is a risk that cannot be eliminated through diversification, so it is also known as non-diversification risk. This risk is usually systemic, affecting all assets in the market. Non - systematic risk is the risk that can be eliminated by diversification of investment, also known as diversification risk. It mainly affects individual assets in the market, also known as heterogeneous risk.

For a portfolio, the unsystematic risks of a single underlying asset offset each other within the portfolio through a diversified investment strategy. In other words, after the full asset portfolio is adopted, only systemic risk is left for portfolio asset risk: portfolio risk = systemic risk.

The model after full diversification of investment can be expressed as:

$$E(R) = R_f + \beta_i[E(R_m) - R_f] \qquad (2)$$

(R) is the expected yield of portfolio i; β_i measures the systemic risk of portfolio i, the meaning of the other symbols does not change. The interference item ε disappears from the model, that is, after full of diversification, the non-systematic risk of portfolio is eliminated.

CAPM model is used to calculate heterogeneity volatility of stock price, usually by computing the standard deviation of disturbance ε_t to describe the heterogeneity volatility of share price.

Fama-French three-factor model was developed on the basis of CAPM model, which solved the problem that CAPM model could not fully explain the difference in stock return

rate in reality. Fama and French (1992) [3] established a Fama-French three-factor model with stronger explanatory power, and used the book-to-market ratio, price-to-earnings ratio and market value of listed companies to explain the difference. The basic model is:

$$R_{i,t} - R_t = \beta_{i,1}RP_t + \beta_{i,2}SMB_t + \beta_{i,3}HML_t + \varepsilon_{i,t} \quad (3)$$

$R_{i,t}$ stands for yield of stock i at time t; R_t is risk-free interest rate for time t; RP_t、 SMB_t、 HML_t are three factors at time t; ε_t is a random disturbance term. The disturbance ε_t reflects the heterogeneous information of stock i. The same as the CAPM model, the heterogeneity volatility of share price is usually described by the standard deviation of disturbance ε_t.

CAMP model and Fama-French three-factor model are the basic models for calculating the heterogeneity of stock price fluctuations, and other methods for calculating the heterogeneity of stock price fluctuations are derived from these two models.

2) The way of influence
According to the existing literature, the information pathway and the noise pathway are the two main ways to influence the heterogeneous fluctuation of stock price.

The research on explaining the heterogeneity of stock price fluctuation from the perspective of information includes three levels: macro institutional level, micro corporate management level and information insider level. You Jiaxing (2006) [4] explored and found that the improvement of China's securities market system would significantly enhance the heterogeneity and volatility of stock prices. Ferreira and Laux (2007) [5] found that the higher the degree of control, the greater the heterogeneity of the stock price of the company. For example, for companies with fewer restrictions on anti-m&a, their stock prices have higher heterogeneity and volatility. Zhu Hongjun (2007) [6] explored the influence of information insiders on the heterogeneous fluctuation of stock prices. The empirical results show that the greater the number of analysts tracking, the greater the heterogeneity of stock price fluctuation. The reason is that share prices reflect more information gathered by analysts.

Some literatures explored the causes of heterogeneous fluctuation of stock price through noise approach. Based on Chinese stock data, Lin Zhongguo (2012) [7] found that the greater the noise, the greater the heterogeneity of stock price fluctuation. Kelly (2015) found that the information environment of a company was negatively correlated with the heterogeneity of stock price fluctuations, which could not be explained by the information approach. He supported the noise theory of Roll (1988) [8] to explain the heterogeneity of stock price fluctuations.

2.2. Research on the opening of the capital market to the outside world

2.2.1. Research on the influence of capital market opening to the outside world on stock price fluctuation
The research on capital market opening to the outside world mainly focuses on the influence of capital market opening to the outside world on stock price fluctuation. Some scholars

have explored the influence of the opening of capital market on the general fluctuation of stock price. Kou Yane (2018) explored the influence of QFII and shanghai-Hong Kong stock connect on stock price volatility with shanghai-Hong Kong stock connect as the background. The empirical results show that the inhibition effect of QFII on stock price is enhanced after the launch of shanghai-Hong Kong stock connect, and there is a certain substitution relationship between QFII and the inhibition effect of shanghai-Hong Kong stock connect on stock price. Some other literatures have explored the influence of the opening of capital market on the heterogeneous fluctuation of stock price. Taking the shanghai-Hong Kong stock connect as the background, Zhong kai and Sun Changling et al. (2018) [9] explored the influence of the opening of the capital market on the heterogeneous fluctuation of stock prices of shanghai-Hong Kong stock connect by establishing the DID model. The author used Fama-French three-factor model to calculate the heterogeneous fluctuation of stock price. The empirical results show that the shanghai-Hong Kong stock connect policy significantly reduces the heterogeneity of stock price volatility, and has a more obvious inhibitory effect on the stock price volatility with active transactions.

2.2.2. Study on the influence of Shenzhen-Hong Kong stock connect policy on stock price fluctuation
On December 5, 2016, the Shenzhen-Hong Kong stock connect policy was officially launched. The Shenzhen-Hong Kong stock connect included the small and medium-sized board and gem stocks as the target stocks, greatly enriching the market level. Some scholars have explored the impact of the Shenzhen-Hong Kong stock connect on the overall volatility of the Shenzhen stock exchange, while others have explored the impact on the prices of specific sectors or specific types of stocks. Wang Hao (2018) took Shenzhen stock index, Shenzhen sme innovation index, sme board index and gem index as research objects, and found that the Shenzhen-Hong Kong stock connect policy reduced the volatility of Shenzhen stock market through the establishment of GARCH model. Tang Guangsheng (2019) only explored the influence of Shenzhen-Hong Kong stock connect policy on the heterogeneous fluctuation of gem stocks, and found that the heterogeneous fluctuation of gem stocks increased after the launch of Shenzhen-Hong Kong stock connect through the PSM-DID model.

3. Descriptive Statistics

The Shenzhen-Hong Kong stock connect policy was officially launched on December 5, 2016, deepening the opening of China's capital market to the outside world. The Shenzhen-Hong Kong stock connect policy has enabled the Shenzhen stock exchange to connect with the stock exchange of Hong Kong.
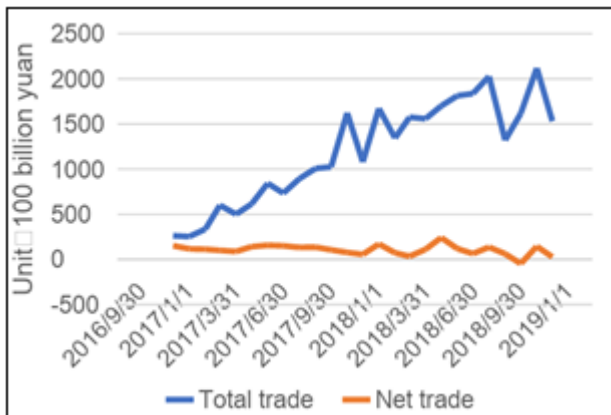
Figure 1: Total and net trade of Shenzhen stock exchange

Figure1 is the time series diagram of the monthly transaction amount and net amount of Shenzhen stock connect. In the early days of the Shenzhen-Hong Kong stock connect, investors knew little about the new policies, so there was less investment enthusiasm in the market and the monthly transaction volume of Shenzhen-Hong Kong stock connect was relatively low. Based on the Shenzhen-Hong Kong stock connect policy, we have made innovations in removing the annual total capital quota limit and expanding the market level. With the advance of the policy, the trading enthusiasm of overseas investors has increased. But monthly net transactions remained low, suggesting more short-term capital was flowing in from abroad.

The descriptive statistical results of the three dependent variables of the total volatility of stock price V1, systematic volatility of stock price V2 and heterogeneous volatility of stock price V3 are shown in Table1.

Table 1: Descriptive statistics of stock price fluctuations

	Treat	Post		
		0	1	Total
V1	0	0.084	0.058	0.074
	1	0.079	0.053	0.068
	Total	0.082	0.056	0.071
V2	0	0.046	0.030	0.040
	1	0.044	0.028	0.037
	Total	0.045	0.029	0.039
V3	0	0.066	0.048	0.059
	1	0.062	0.043	0.054
	Total	0.064	0.046	0.057

Table1 describes the mean values of dependent variables in different groups of samples. The statistical results show that after the launch of the Shenzhen-Hong Kong stock connect, the mean value of the total stock price fluctuations decreased from 0.081922 to 0.055805, the mean value of the systematic stock price fluctuations decreased from 0.045210 to 0.029019, and the mean value of the heterogeneous stock price fluctuations decreased from 0.064274 to 0.045997. In other words, the launch of the Shenzhen-Hong Kong stock connect reduced the stock price fluctuations. The statistical results also showed that the total volatility of stock price was the largest, followed by the heterogeneous volatility, and the systematic volatility was the smallest. The total volatility of stock price was mainly explained by the heterogeneous volatility.

4. Empirical study on the influence of Shenzhen-Hong Kong stock connect on stock price fluctuation

The implementation of the Shenzhen-Hong Kong stock connect policy is another important measure to open China's capital market to the outside world. The launch of the Shenzhen-Hong Kong stock connect has introduced a large number of overseas investors with information advantages to China, which is bound to have an impact on the fluctuation of Shenzhen stock prices. In this chapter, the panel model will be used to examine the impact of Shenzhen-Hong Kong stock connect implementation on overall, systematic and heterogeneous stock price fluctuations.

4.1. Theoretical analysis and research hypotheses

On December 5, 2016, the Shenzhen-Hong Kong stock connect policy was officially launched, marking another step forward in the opening of China's capital market to the outside world. The Shenzhen stock market is rich in layers, and its sectors and styles are different from those of the Shanghai stock market. Therefore, the launch of the Shenzhen-Hong Kong stock connect has increased the enthusiasm for capital going to the north and formed a complementary effect with the Shanghai stock market. China's capital market system is not perfect, there are many small and medium-sized investors in the market, who chase the rise and kill the fall, and there are many irrational behaviors such as crowd effect and insider trading. Foreign investors from developed capital markets, relying on their rich investment experience and advanced technology, can usually bring incremental information to the local market. Their investment behaviors are more rational, which can guide the investment behaviors of domestic investors and enhance the effectiveness of the market. In the early stage of its establishment, the Shenzhen-Hong Kong stock connect only allowed foreign institutional investors to invest in the gem market, which greatly improved the structure of investors in the domestic market. At the same time, the opening up of the capital market will force internal reforms. In order to better integrate the a-share market with the international capital market, policy makers have improved A series of supporting systems, such as the information disclosure system. Under the effect of these factors, China's capital market will become more and more perfect and stable. Therefore, this chapter makes the following assumptions:

Hypothesis 1: the launch of the Shenzhen-Hong Kong stock connect can reduce the volatility of stock prices and play a role in stabilizing the Shenzhen stock market.

4.2. Study design and variables

4.2.1. Study design
In this chapter, DID model is adopted to evaluate the effect of policy implementation. This method has been widely used in the fields of economy and finance by foreign scholars in recent years.

DID dual difference model, as the name implies, is the difference of the dependent variable twice. Di=1 if sample I is the policy implementation group or the experimental group, Di=0 if sample I is the policy non-implementation group or the control group. If we directly take the mean value of the dependent variables of the experimental group and the control group, and subtract them, that is, E(Yi|Di=1)-E(Yi|Di=0), then we can calculate the difference between the mean values of the dependent variables of the two samples. But this difference does not measure the pre-policy difference between the two groups. In order to solve this problem, the observation period needs to be extended, the first period is before the implementation of the policy, and the second period is after the implementation of the policy. We first make the difference between two periods for the dependent variable of the sample, that is:

$$\Delta y_i = (y_{i,1} - y_{i,0}) \tag{4}$$

This is the first difference, which is used to calculate the trend of the dependent variable of each sample. The second difference is calculated according to the first difference:

$$\Delta\Delta y_i = E(D_i = 1) - E(D_i = 0) \tag{5}$$

This is the treatment effect of policy.

During the empirical test, DID model was set as follows:

$$y_i = \alpha + \beta_1 Treat_i + \beta_2 Post_i + \beta_3 Treat_i \times Post_i + \varepsilon_i$$

$Treat_i$ is policy virtual variable, when individual i belongs to the the group that implemented the policy (experimental group), $Treat_i = 1$, when individual i belongs to the control group, $Treat_i = 0$, its coefficient β_1 measures the difference between groups; $Post_i$ is time virtual variable, before the implementation of policy, $Post_i = 0$, after the implementation of policy, $Post_i = 1$, the coefficient β_2 measures the time difference, $Treat_i \times Post_i$ is the interaction of time virtual variable and policy virtual variable, its coefficient β_3 measures the net effect of the policy.

Table 2 : DID policy effect

	Post=0	Post=1	Difference
Treat=0	$\alpha + \varepsilon_i$	$\alpha + \beta_2 + \varepsilon_i$	β_2
Treat=1	$\alpha + \beta_1 + \varepsilon_i$	$\alpha + \beta_1 + \beta_2 + \beta_3 + \varepsilon_i$	$\beta_2 + \beta_3$
Difference	β_1	$\beta_1 + \beta_3$	$\beta_3 (DID)$

4.2.2. Variable selection and model setting

1. Variable selection
(1) Explained variables
This paper mainly explores the impact of the launch of the Shenzhen-Hong Kong stock connect on stock price volatility, which includes overall stock price volatility, systematic stock price volatility and heterogeneous stock price volatility. Therefore, this paper sets up three explained variables V1, V2 and V3 to explore the influence of the launch of Shenzhen-Hong Kong stock connect on the three.
Volatility V1 reflects the overall volatility of stock prices. In this paper, the standard deviation of weekly stock returns during the year is used to measure the total stock price fluctuation of listed companies V1. In this paper, the standard deviation of the relative value of stock price return is used to measure the overall volatility of the stock price of listed companies, rather than the standard deviation of the absolute value of stock price, so as to avoid overestimating

the volatility of stocks with low stock price. The index calculation formula is as follows:

$$V1 = \sqrt{\frac{\sum_{i=1}^{n} (r_i - \underline{r})^2}{n}} \tag{7}$$

$$r_i = \frac{p_i - p_{i-1}}{p_{i-1}} \tag{8}$$

In the formula, V1 represents the standard deviation of the stock's annual weekly return rate, r_i represents the stock's weekly return rate, and n represents the number of weeks of stock trading in the year. The formula shows that the weekly stock return rate r_i is calculated by the weekly stock closing price p. The bigger V1 is, the more volatile the overall stock price is and the more unstable the stock market is.

The systematic fluctuation of stock price V2 and the heterogeneous fluctuation of stock price V3 are calculated by the CAPM model, and the formula of the CAPM model is as follows:

$$R_i - R_f = \beta_i(R_m - R_f) + \varepsilon_i \tag{9}$$

Among them, the R_i for stock i at time t return on stocks, R_f as the risk-free interest rate at time t, R_m for point t market yields, ε_i is the error term.

Take the variance of both sides of this equation: (6)

$$Var(R_i) = Var(\beta_i R_m) + Var(\varepsilon_i) \tag{10}$$

Therefore, the formula for calculating the systematic fluctuation of stock price V2 and the heterogeneous fluctuation of stock price V3 is as follows:

$$V2 = Var(\beta_i R_m) \tag{11}$$
$$V3 = Var(\varepsilon_i) \tag{12}$$

Type in the same standard deviation calculation method with the calculation method of V1, beta I and ε I obtained through the establishment of CAPM regression model. The larger the value of V2, the greater the systematic fluctuation of the stock price. The greater the value of V3, the greater the heterogeneity of the stock price.

(2) Explanatory variables
The impact of the Shenzhen-Hong Kong stock connect implementation on the stock price volatility of shenzhen can be divided into two aspects: the first aspect is the underlying company of Shenzhen-Hong Kong stock connect. On the other hand, after the launch of the Shenzhen-Hong Kong stock connect, the stock price volatility of the companies that join the Shenzhen-Hong Kong stock connect and the companies that do not join the Shenzhen-Hong Kong stock connect is not synchronous. Based on these two factors, the independent variables of this model are two dummy variables, Treat and Post, and the cross-multiplying item of these two dummy variables, Treat* Post:

Post is a dummy variable for the implementation of the Shenzhen-Hong Kong stock connect transaction system, which is used to distinguish whether the data at a certain point is the data after the Shenzhen-Hong Kong stock connect is opened. The Shenzhen-Hong Kong stock connect trading system was implemented in 2016, with the value of 0 in the previous year and 1 in the subsequent years.

Treat is the dummy variable of the company with deep stock pass target, which is used to distinguish whether a company is the stock with deep stock pass target at a certain time point. When the stock is the stock with deep stock pass target, the value is 1, otherwise it is 0.

Treat* Post is the interaction term of the first two variables, which is 1 if and only if the stock is the underlying stock of Shenzhen-Hong Kong stock connect and the time is after the Shenzhen-Hong Kong stock connect trading system is implemented, otherwise, it is 0. According to the significance of this interaction term, the sign and significance of its coefficient have a direct impact on the verification of the hypothesis in this paper. If the sign is significantly positive, it means that the Shenzhen-Hong Kong stock connect policy has increased the volatility of shenzhen stocks; otherwise, it means that the Shenzhen-Hong Kong stock connect policy has reduced the volatility of shenzhen stocks, and its regression coefficient measures the net effect of the policy.

(3) Control variables
Company size, stock liquidity, institutional investor shareholding ratio and so on will have a certain impact on the stock price, and then affect the volatility of the stock price. Therefore, this part selects it as a control variable to control the interference caused by other factors on the empirical results, and studies the direct impact of the Shenzhen-Hong Kong stock connect policy on the volatility of Shenzhen stock market. The selection of control variables is shown in the table:

Table 3: Variable definitions

Control variables	Meaning
Bsize	Board size
Indep	Proportion of independent directors
Ins	Shareholding ratio of Institutional investor
Topshare	Shareholding ratio of the top 10 shareholders
Turnover	Stock turnover rate
ROA	Return on assets
Bm	Book-to-market ratio

2. Model setting

$$V1_{i,t} = \alpha_0 + \alpha_1 Treat_{i,t} + \alpha_2 Post_{i,t} + \alpha_3 Treat_{i,t} \times Post_{i,t} + \sum X_{i,t} + \varepsilon_{i,t} \qquad (13)$$

$$V2_{i,t} = \alpha_0 + \alpha_1 Treat_{i,t} + \alpha_2 Post_{i,t} + \alpha_3 Treat_{i,t} \times Post_{i,t} + \sum X_{i,t} + \varepsilon_{i,t} \qquad (14)$$

$$V3_{i,t} = \alpha_0 + \alpha_1 Treat_{i,t} + \alpha_2 Post_{i,t} + \alpha_3 Treat_{i,t} \times Post_{i,t} + \sum X_{i,t} + \varepsilon_{i,t} \qquad (15)$$

4.2.3. Sample selection and data processing
The Shenzhen-Hong Kong stock connect was officially launched on December 5, 2016. This paper selected five years from 2014 to 2018 as the sample period. The list of underlying stocks of Shenzhen-Hong Kong stock connect was obtained from CSMAR database, while the list of non-underlying stocks and variable data were obtained from RESSET database. This paper uses Stata software for data

processing and empirical analysis. Data acquisition and processing process are as follows:
1) Selection of experimental group samples. From CSMAR database for the port of the underlying stock list, from the list on December 6, 2016 to December 2018, 31 delisted stocks in the day, and at the same time eliminating on December 6, 2016 to December 31 2018 call in or out deep pass mark list shares, namely the retain sample processing group is a deep port access policy implementation always existence during the period of the samples after deep on the underlying stocks, a total of 653.
2) Selection of control group samples. The control group selected all the listed companies not included in the Shenzhen stock exchange. All the stocks listed on Shenzhen stock exchange before 2014 were obtained from RESSET database, and the stocks that were delisted in 2018 and before were excluded. Meanwhile, the stocks that were transferred into or out of Shenzhen stock market during the period from December 6, 2016 to December 31, 2018 were also excluded, leaving a total of 1,526 stocks. The remaining 873 stocks were selected as the sample range of the selected control group, that is, the stocks that were not included in the Shenzhen stock connect list during the sample period after the implementation of the Shenzhen stock connect policy.
3) Get variable data. The relevant data of control variables and dependent variables were obtained from RESSET database, and the samples of experimental group and control group containing missing values were excluded. Finally, 631 experimental group samples and 824 control group samples were retained.
4) Basic data processing. The data of control variables can be used directly or after basic processing. For example, the logarithmic processing of Bsize can be carried out, and the quarterly data can be converted into annual data by means of average calculation.
5) Processing of special data. For the dependent variable data, it needs to be computed. V1 is the annual standard deviation of the weekly return rate of a single stock. When calculating V2 and V3 through CAPM model, the index rate of return of Shenzhen stock index is used to replace the market rate of return in the formula. V2 is the annual standard deviation of the product term of regression coefficient of CAPM model and rm of market yield rate. V3 is the annual standard deviation of the residual term of the CAPM regression model.

4.3. Empirical testing and interpretation of results

Table 4: Stock price volatility DID empirical results (V1)

	V1	
	coef	z
Treat	0.004***	4.87
Post	-0.004***	-4.40
P*T	-0.005***	-4.36
Bsize	-0.001	-0.67
Indep	-0.004	-1.36
Ins	-0.002	-1.56
Topshare	0.027	11.94
Turnover	0.010	54.91
ROA	-0.080	-10.97
Mb	-0.022	-16.85

Cons	0.049	14.34
N	7274	
R2	0.467	
*** represents significant at the 1% significance level, ** represents significant at the 5% significance level, and * represents significant at the 10% significance level.		

Table4 reports the regression results of model (13). As can be seen from the regression results, the model as a whole passed the significance test. The coefficient of the interaction item Post×Treat is significantly negative at the significance level of 1%, which means that the opening of the Shenzhen-Hong Kong stock connect has a significant impact on the overall volatility of stock prices. The opening of the Shenzhen-Hong Kong stock connect reduces the overall volatility of Shenzhen stock prices.

In model (13), the coefficient of Treat, a variable, is significantly positive at the confidence level of 1%. The overall volatility of the underlying stock of Shenzhen shares is greater than that of non-underlying stocks. The overall volatility of the underlying stock of Shenzhen shares is on average 0.37% higher than that of the underlying stock of Shenzhen shares. The coefficient of the variable Post was significantly negative at the confidence level of 1%, indicating that the implementation of the Shenzhen-Hong Kong stock connect policy reduced the overall volatility of all stocks by about 0.39%. The coefficient of the interactive item Post*Treat is significantly negative at the confidence level of 1%, which indicates that the opening of the Shenzhen-Hong Kong stock connect makes the standard deviation of the return rate of the underlying stock of Shenzhen-Hong Kong stock connect drop more, and the overall stock price fluctuation drop more, which is 0.5% lower than that of the non-underlying stock, indicating that the opening of the Shenzhen-Hong Kong stock connect inhibits the overall stock market fluctuation.

The coefficient of variable Topshare is positive and significant at the confidence level of 1%, which means that the shareholding ratio of the top ten shareholders of Shenzhen companies has a positive impact on the overall volatility of stocks. The coefficient of variable Turnover is positive and significant at the 1% confidence level, indicating that the Turnover rate of Shenzhen stock company has a positive effect on the overall volatility of its stock. The coefficient of variable ROA is negative and significant at the confidence level of 1%, indicating that the return on assets is negatively correlated with the overall volatility of stock price. The variable Bm coefficient is negative and significant at the 1% confidence level, indicating that the book-to-market ratio is negatively correlated with the overall volatility of its stock price. There is no significant correlation between the stock holding ratio of institutional investors, board size, independent director ratio, operating income growth rate and the general fluctuation of stock price.

Table 5: Stock price volatility DID empirical results (V2)

	V2	
	coef	z
Treat	0.002***	2.89
Post	-0.007***	-7.90
P*T	-0.002	-1.38

Bsize	-0.004	-3.61
Indep	-0.013	-4.16
Ins	0.002	1.29
Topshare	-0.004	-1.69
Turnover	0.005	27.72
ROA	-0.024	-3.30
Mb	-0.009	-6.73
Cons	0.048	14.25
N	7274	
R2	0.210	
*** represents significant at the 1% significance level, ** represents significant at the 5% significance level, and * represents significant at the 10% significance level.		

Table5 reports the regression results of model (14). As can be seen from the regression results, the model as a whole passed the significance test. The coefficient of the interactive item Post×Treat is not significant at the significance level of 10%, which means the opening of the Shenzhen-Hong Kong stock connect has no significant impact on the systematic fluctuation of stock prices.

Table 6： Stock price volatility DID empirical result (V3)

	V3	
	coef	z
Treat	0.003***	5.10
Post	0.002**	2.11
P*T	-0.005***	-5.25
Bsize	0.002	1.72
Indep	0.003	0.94
Ins	-0.004	-3.08
Topshare	0.033	17.53
Turnover	0.008	53.84
ROA	-0.075	-12.16
Mb	-0.020	-18.22
Cons	0.025	8.57
N	7274	
R2	0.440	
*** represents significant at the 1% significance level, ** represents significant at the 5% significance level, and * represents significant at the 10% significance level.		

Table6 reports the regression results of model (15). As can be seen from the regression results, the model as a whole passed the significance test. The coefficient of the interaction item Post×Treat is significantly negative at the significance level of 1%, which means that the opening of the Shenzhen-Hong Kong stock connect has a significant impact on the heterogeneity of stock price fluctuations. The opening of the Shenzhen-Hong Kong stock connect reduces the heterogeneity of Shenzhen stock price fluctuations.

In model (15), the coefficient of Treat is positive and significant at the confidence level of 1%, which indicates that compared with the non-deep underlying stock, the heterogeneity fluctuation of the underlying stock price is greater, and the heterogeneity fluctuation of the underlying stock price of the deep underlying stock is 0.33% higher than that of the non-deep underlying stock on average. The coefficient of the variable Post is not significant at the 1% confidence level. The coefficient of the interactive item Post*Treat was significantly negative at the confidence level of 1%, indicating that the opening of the Shenzhen-Hong Kong stock connect reduced the heterogeneity of the underlying stock price by more than 0.51% compared with

the non-underlying stock price, indicating that the opening of the Shenzhen-Hong Kong stock connect inhibited the heterogeneity of the Shenzhen stock market.

The coefficient of variable Topshare is positive and significant at the confidence level of 1%, which means that the shareholding ratio of the top ten shareholders of Shenzhen companies is positively correlated with the heterogeneous fluctuation of their stocks. The variable Ins coefficient is negative and is significant at the confidence level of 1%, which means that the shareholding ratio of institutional investors in Shenzhen companies is negatively correlated with the heterogeneous fluctuation of their stock prices. The coefficient of variable Turnover is positive and significant at the 1% confidence level, indicating that the Turnover rate of Shenzhen stock is positively correlated with the heterogeneity fluctuation of the stock. The ROA coefficient of the variable was negative and was significant at the confidence level of 1%, indicating that the return on assets was negatively correlated with the heterogeneity fluctuation of stock price. The variable Bm coefficient is negative and significant at the 1% confidence level, indicating that the book-to-market ratio is negatively correlated with the heterogeneity volatility of stock price. There was no significant correlation between the variables board size, the proportion of independent directors, the growth rate of operating revenue and the heterogeneous fluctuation of stock price.

5. Conclusions and Suggestions

5.1. Conclusions

Based on the hypothesis put forward, the influence of the Shenzhen-Hong Kong stock connect policy on Shenzhen stock price fluctuations was empirically tested above, and the corresponding conclusion was drawn: the launch of the Shenzhen-Hong Kong stock connect policy significantly reduced the overall and heterogeneous fluctuations of stock prices, but had no significant impact on the systematic fluctuations of stock prices, thus playing a role in stabilizing the Shenzhen stock market.

5.2. Suggestions

According to the research conclusion, this paper puts forward the following Suggestions.

5.2.1. Suggestions for policy makers
We will follow the principle of gradually opening the capital market to the outside world. The Shenzhen-Hong Kong stock connect is an important milestone in the process of opening up China's capital market to the outside world. Theoretical analysis and empirical results show that the implementation of the Shenzhen-Hong Kong stock connect policy will affect the stock price volatility. Therefore, the gradual opening of the capital market is beneficial to buffer the market and reduce the risk of capital market fluctuation. In addition, policy makers can more accurately assess the impact of the opening of the capital market, which is conducive to the government departments to adjust the policies in a timely and reasonable manner and provide more reliable experience for the implementation of the new

policies, so as to promote the opening of the capital market to play a positive role in economic development and reduce its negative impact.

While continuing to open the capital market wider to the outside world, we will effectively prevent the penetration of international financial risks into the domestic market. Opening up the capital market is a double-edged sword. On the one hand, foreign investors have their unique advantages, and the opening of the capital market is conducive to improving market efficiency. The advantages of foreign investors mainly focus on information acquisition, investment experience, valuation model and professionalism. Foreign investors from relatively developed capital market relying on its advanced technology and rich experience in the investment, can find more information at a lower cost, including the information on the level of mining enterprises in mainland China, so more advantages in terms of information relative to local investors, can pass the information content to increase market trade. In A more efficient capital market, the valuation accuracy of a-share capital market is improved and the market efficiency is enhanced. In addition, the integration of foreign investors into the local capital market will indirectly improve the level of local investors and further realize the endogenous improvement of the efficiency of the capital market. Therefore, in view of the promotion of the development of the real economy, we can continue to expand the opening of the capital market, optimize the structure of investors, and expand the level of opening of the capital market to the outside world. The shanghai-Hong Kong stock connect and the Shenzhen-Hong Kong stock connect are mainly aimed at Hong Kong investors. The ongoing Shanghai-London stock connect has brought in British investors. On the other hand, capital markets are open to international speculative capital. Such investors obtain speculative gains through frequent turnover of funds, which will lead to the increase of market noise and the aggravation of market volatility, and lead to mass irrational investment behaviors, which will even endanger the economic operation as a result of market turbulence. Therefore, it is necessary to strengthen the supervision of foreign investors, increase the penalties for abnormal transactions, improve the control measures of cross-border speculation, and formulate policies to prevent and defuse relevant risks. Strengthen the education and protection of local investors, improve their ability to acquire and discriminate information, avoid herd mentality, cultivate information intermediary market, and enhance their role in information acquisition and transmission. We will strengthen communication and cooperation between domestic and overseas exchanges, clarify the responsibilities of both sides, and promote the sound development of the connectivity mechanism.

5.2.2. Suggestions for public companies
The improvement of the quality of corporate information disclosure is conducive to reducing market information asymmetry and further attracting foreign investors in the context of the opening of the capital market to the outside world. Therefore, listed companies should cultivate a good sense of information disclosure.

The quality of corporate information disclosure is usually closely related to the corporate internal governance structure. The improvement of corporate governance structure is conducive to strengthening internal control. The higher the quality of corporate internal control, the higher the quality of information disclosure. Therefore, the listed company should focus on improving its internal governance structure, which can be achieved by strengthening the functions of independent directors and board of supervisors and strengthening the functions of internal audit supervision. While paying attention to improving the quality of legal information disclosure, listed companies should pay attention to strengthening the quality of voluntary information disclosure. Under the background of Internet, listed companies can expand the channels of information disclosure, such as news media.

### 5.2.3. Suggestions for investors

On the one hand, small and medium investors can learn from the experience of foreign investors for investment. In the context of the opening of the capital market, institutional investors account for a large proportion of foreign investors. Those investors from the developed capital market have rich investment experience and technical advantages, so they can obtain the incremental information of the capital market, and their investment behaviors are more rational. Taking the current situation of Shenzhen-Hong Kong stock connect as an example, the data shows that capital flowing to the north tends to flow to companies with strong profitability, strong development ability and favorable fundamentals. In the mainland capital market, small and medium-sized investors account for a large proportion, and they lack relevant financial knowledge and the ability to obtain information, and their investment behavior is irrational. Therefore, the flow of overseas funds usually has certain reference value.

On the other hand, investors should enhance the cognition of information disclosure of listed enterprises. Investors generally prefer favorable information, and will magnify bad news. This will have a negative impact on enterprises that strictly abide by the rules on information disclosure, leading to the problem of adverse selection. This will discourage companies from disclosing information, and companies will turn to selectively disclose information, which will reduce the quality of information disclosure and reduce the transparency of information in the market as a whole. Therefore, investors should view the information disclosed by listed companies in an objective and comprehensive manner, promote the overall market to comply with the atmosphere of information disclosure system, and ensure the implementation of relevant laws and regulations on information disclosure.

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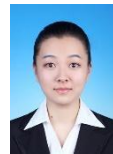
Yiwen Zhang received the B.S. degree in statistics from Zhongnan University of Economics and Law in 2016, and received the M.S. degree in finance from Xidian University in 2020.