

Dynamic Analysis of The Impact of Northbound Funds On A-Share Market Based on VAR And GARCH Models

Yaru Jiang, Cong Lin, Zhaofei Wang *

Department of Statistics and Data Science, Ningbo University of Technology, Ningbo, China, 315211

* Corresponding Author Email: wzf1416@163.com

Abstract. 1 With the deepening of China's capital market opening to the outside world, northbound funds as an important channel for foreign investors to enter the A-share market, its scale and influence are increasing. Based on the VAR model and GARCH model, this paper divides the development process of northbound funds into two stages: growth stage and expansion stage, and analyzes its impact on the return rate and volatility of A-share market. It is found that the impact of northbound funds on A-share market presents dynamic evolution characteristics: in the growth period, northbound funds flow has no significant impact on the return rate and volatility of A-share market; In the expansion period, northbound fund flow has A significant impact on the A-share market yield and volatility, and the net purchase of northbound funds has A positive impulse response of 1-9 days on the A-share market yield. This shows that northbound funds have become the "weather vane" of market sentiment, and its investment style has an important impact on the trend of the A-share market.

Keywords: Northbound funds, A-share market, VAR model, GARCH model, Dynamic impact.

1. Introduction

With the deepening of China's capital market opening to the outside world, northbound funds, as an important channel for foreign investors to enter the A-share market, are increasing in scale and influence. Northbound funds not only bring international investment concepts and operating methods, but also affect market fluctuations and trends, and become an important embodiment of market confidence. Its profound impact on A-share market structure and ecology makes it particularly important to study northbound capital flow [1-3].

This study aims at in-depth analysis of the flow impact of northbound funds in A-share market, which has the following significance: First, at the theoretical level, this study expands the study of the impact of the Dry Port Connect on the A-share market, and discusses the impact of northbound funds on market connectivity, corporate governance structure, market liquidity, volatility and other aspects. Secondly, at the practical level, this study provides a reference for policy makers and investors, helping to guide the rational flow of capital, maintain market stability, and improve the regulatory system [4-6].

The research approaches include literature review, empirical analysis and policy recommendations. The key and innovative points are as follows: first, in-depth analysis of the role of northbound funds in the A-share market; The second is to use VAR model and GARCH model to carry out empirical research to reveal the relationship between northbound capital flow and market volatility [7-10].

The study focuses on the relationship between northbound capital flow and the CSI 300 index from 2017 to 2021, divides into two stages: growth period and expansion period, and comprehensively analyzes the behavioral characteristics and market impact of northbound capital. Through this research, it is helpful to better understand the role of northbound funds in the A-share market and provide support for the healthy development of the capital market.

2. Theoretical mechanism and empirical analysis

2.1. Theoretical analysis of the impact of northbound fund flows on A-share market transmission

The income fluctuation of A-share market is closely related to the flow of funds, and investors' decision-making behavior is reflected by the flow of funds. The influence of capital flow on stock price fluctuation can be discussed from four theoretical dimensions: herd effect, noise trading, demand shock and leverage amplification effect of weighted stocks.

The herd effect leads to investors blindly following the trend and exacerbates market volatility, especially when the influence of northbound funds on the market exceeds its actual size. Noise trading theory points out that differences in information interpretation produce market noise, and the initial influx of foreign capital increases market chaos. The demand shock hypothesis holds that additional capital inflows push up asset prices and raise stock market returns. The leverage amplification effect of weighted stocks indicates that northbound funds affect the market trend through weighted stocks.

This study believes that northbound capital flow has an important impact on the return and volatility of A-share market. Taking the expansion of Shanghai-Shenzhen-Hong Kong Stock Connect as the time node, VAR model is used to analyze the relationship between northbound capital flow and market changes. The research assumes that the net northbound capital inflow is positively correlated with market returns, especially in the expansion stage, and the northbound capital inflow may exacerbate market volatility, and the herd effect may aggravate stock price volatility in the expansion stage.

2.2. Variable selection and model setting

2.2.1 Sample data selection and interval division

Since the Shenzhen Stock Connect was officially launched on December 5, 2016, it has provided international investors with new access to China's A-share market. The time series data selected in this study covers the period from January 3, 2017 to November 19, 2021, and contains a total of 1131 observations. In order to further analyze the specific impact of northbound funds on the A-share market, the study divides this period into two key stages: the first stage, from January 3, 2017 to May 1, 2018, is regarded as the initial growth stage of northbound funds; The second phase, which runs from June 1, 2018 to November 19, 2021, is defined as the expansion phase of northbound funds. To reduce data uncertainty, data for May and June 2018 were excluded from the analysis. This division is based on two landmark events: the significant increase in the stock connect quota for Shanghai and Shenzhen on May 1, 2018, and the inclusion of A-shares in the MSCI index in June of the same year, both of which greatly enhanced the international status of the A-share market and attracted A large influx of foreign capital. In this study, the closing price and daily return rate data of CSI 300 index are from Wind Financial terminal, while the daily net inflow data of northbound funds are from EastMoney.com and Ifind financial terminal.

This study focuses on three core variables: the daily net purchase of northbound funds, the daily return rate of the stock market and the volatility of the stock market. Among them, the daily net purchase amount of northbound funds (recorded as $\ln nf$) is measured by calculating the natural logarithm of the total daily net purchase amount of Shanghai Stock Connect and Shenzhen Stock Connect. This conversion aims to reduce the data heteroscedasticity and improve the robustness of the model. The daily return rate of the stock market (recorded as return) is calculated based on the logarithmic processing result of the closing price of the CSI 300 index. Given the high liquidity and wide representativeness of the CSI 300 Index, it has become A key yardstick to measure the overall return of the A-share market. As for the volatility of the stock market (vol), it is estimated by fitting the volatility of the daily return rate of the CSI 300 Index with the GARCH model. This model performs well in the volatility analysis of financial time series, and is especially suitable for describing the volatility characteristics of financial assets.

2.2.2 Establishment of stock market volatility index

Generalized autoregressive conditional heteroscedasticity (GARCH) model can effectively overcome the assumption of constant difference in traditional econometrics, and can capture the change of time series volatility. The model assumes that the conditional variance at time t depends on the square of the error term in the preceding p period and the conditional variance in the preceding q period. GARCH (1,1) model is widely used because of its small number of parameters and good fitting effect. Using this model, the volatility characteristics of stock market returns can be described more accurately, and it provides solid data support for in-depth analysis of the impact of northbound capital flows on the A-share market.

It can be clearly seen from Figure 1 that the yield fluctuation of CSI 300 index shows significant differences in different periods, and has obvious volatility aggregation characteristics. In particular, in the fourth quarter of 2018, the second quarter of 2019, the first quarter of 2020 and the third quarter of 2020, the volatility of the yield is large and concentrated; In contrast, in the first quarter of 2019, the first quarter of 2021 and the fourth quarter of 2021, there was relatively little volatility. The probability distribution diagram of the rate of return presents the feature of "peak", and the P-value of Jarque-Bera (JB) test is 0, indicating that it does not conform to the hypothesis of normal distribution, which initially indicates that the variance of this series has a clustering effect.

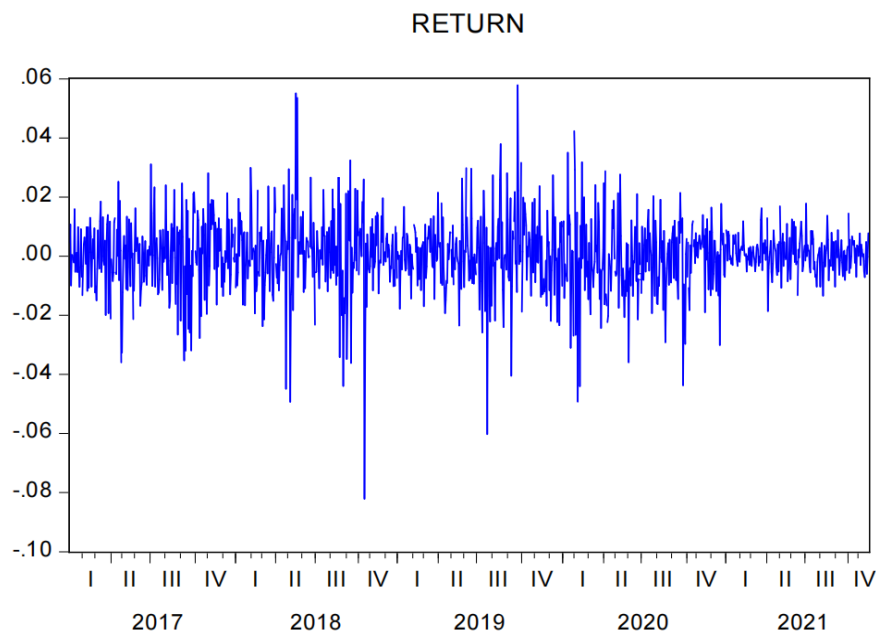


Figure 1. Yield fluctuation of the CSI 300 Index from 2017 to 2021

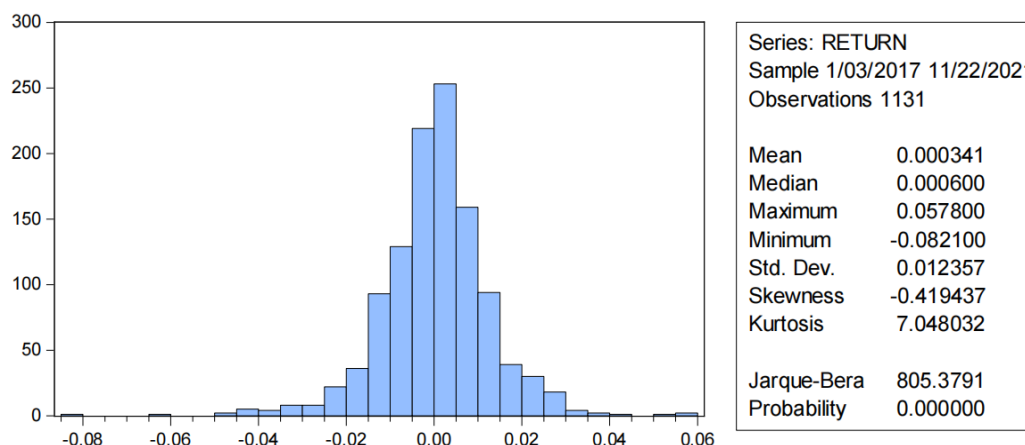


Figure 2. Probability distribution of returns

The ARCH-LM test of conditional heteroscedasticity was performed on the mean equation, and the test results with a lag of one order were obtained as follows. Here, the P-values were all less than 0.05, and the null hypothesis was rejected at the significance level of 1%, indicating that ARCH effect existed in the residual sequence and GARCH modeling was meaningful (Table 1).

Table 1. ARCH-LM test of conditional heteroscedasticity was performed on the mean value equation

F-statistic	10.86285	P-value	0.0010
Obs*R-squared	10.77832	P-value	0.0010

In the variance equation, the coefficients of ARCH term and GARCH term are both significantly greater than 0 and less than 1, which satisfies the constraints of the model and is statistically significant at the significance level of 1%, indicating that the GARCH (1,1) model can effectively fit the data. The ARCH-LM test of heteroscedasticity was further performed on the model. When the order was 1, the P-value obtained was 0.15, which meant that we accepted the null hypothesis that there was no ARCH effect in the residual sequence, indicating that the GARCH (1,1) model successfully removed the conditional heteroscedasticity (Table 2).

Table 2. Variance results

F-statistic	2.073980	P-value	0.1501
Obs*R-squared	2.073845	P-value	0.1498

The return volatility obtained by the above GARCH model is shown in Figure 3 below. The maximum volatility period is concentrated in 2018Q4, 2019Q2, 2020Q1, and 2020Q3, which is consistent with the intuitive analysis results in the figure. The volatility data obtained by GARCH model is directly used as the research variable in this paper.

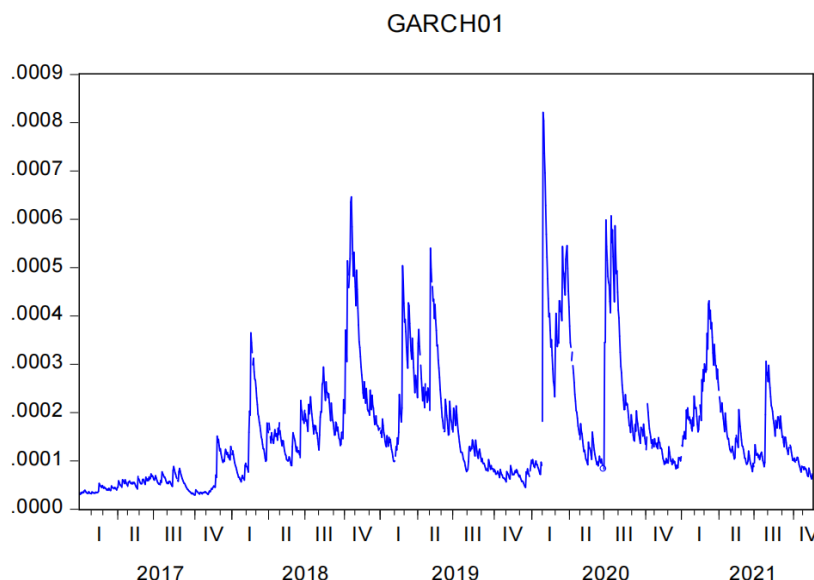


Figure 3. return volatility obtained by GARCH model

2.2.3 Model building

The core idea of the vector autoregression (VAR) model is to treat each endogenous variable in the system as a function of the lag value of the other endogenous variables. This model captures the dynamic relationship between endogenous variables by constructing multiple simultaneous regression equations, each containing the lag values of all other endogenous variables in the system. The advantage of VAR model is that it can bypass the limitations of structured model and effectively predict the time series data with interdependent relationship.

In this study, considering the potential dynamic relationship between northbound fund flow and A-share market, we chose VAR model to analyze the interaction among the net purchase amount of northbound funds (lnnf), daily stock market return (return) and stock market volatility (vola). The model is composed of three simultaneous equations. The dependent variable of each equation is the net purchase of northbound funds, the return rate of the stock market and the volatility of the stock market, and the explanatory variable is the corresponding lag value of these three variables. In this way, we can systematically predict and analyze the interactions between these variables.

In the equations, n,r and v are shorthand for northbound net purchase of funds, stock market return rate and stock market volatility respectively, while the number of lagging periods should be selected according to specific data and information criteria. Table 3 describes the variable names and meanings that will appear in the subsequent empirical analysis.

Table 3. Variable names and their meanings

Variable name	symbol	Description
Northbound funds were net buyers	Lnnf	Land stock Connect daily net purchase amount
Stock market yield	Retur.	Shanghai and Shenzhen 300 closing daily return
Stock market volatility	Vola	GARCH fitted volatility of Return (standard deviation)

2.3. Empirical analysis

The analysis of this part divides the empirical research into two stages: the development period of northbound funds and the expansion period of northbound funds, and uses the data of these two stages to explore the impact of northbound funds flow on the A-share market. First, the time series data of northbound net buying amount, stock market return rate and volatility are tested to ensure the stability of the data. Then, the optimal lag period of the model is determined, which is achieved by considering the information criteria and the fitting effect of the model.

After establishing a suitable VAR model, Granger causality test is used to analyze whether there is a causal relationship between northbound fund flow and the return rate and volatility of CSI 300 index. This step helps reveal whether northbound flows are predictive of market yields and volatility, or whether market movements affect northbound inflows. Then, impulse response function analysis is used to evaluate the dynamic impact of one variable on another variable in the model. This helps to understand the immediate and long-term effects of northbound flows on stock market yields and volatility. Variance decomposition is used to quantify the contribution of each variable to the volatility of the system, so as to assess the impact of northbound capital flows on market stability. Finally, the empirical results of the two stages are compared and analyzed to identify the dynamic change of the impact of northbound capital flows on the A-share market. Based on these findings, this paper will propose corresponding policy recommendations aimed at optimizing capital market opening strategies, enhancing market stability, and providing investors with more effective market operation information. These recommendations will help regulators and market participants better understand and address the challenges and opportunities presented by northbound capital flows.

2.3.1 The first stage: Empirical analysis of the development period of northbound capital flow

(1) ADF stationarity test

The prerequisite for constructing VAR model is the stationarity of the selected data, so as to ensure the research significance of the subsequent regressions. Non-stationary time series will lead to the generation of pseudo-regressions. First, the unit root test is performed on the variables in Table 3. If there is a unit root, it means that the sequence is not stationary, and first-order difference or logarithm processing needs to be performed first. In this paper, the method of ADF test is used to detect.

According to the results of ADF unit root test shown in Table 4, we can observe that in the first half of 2017 to 2018, that is, the growth stage of northbound funds, the ADF statistics of the three variables, the net purchase amount of northbound funds, the return rate of the stock market and the

volatility of the stock market, are all lower than the critical value of 1%, and the P-value is less than 0.05. This means that we can reject the null hypothesis and show that all three variables are stationary. Therefore, they can be used directly as the three basic variables to build a VAR model.

(2) The optimal lag period is determined

In the estimation process of vector autoregressive (VAR) model, the lag value of endogenous variables is used to capture the dynamic relationship between variables. After confirming the stationarity of time series data, the next key step is to select an optimal lag order. When determining this parameter, the complexity of the model and the degree of freedom should be carefully balanced to prevent the model from being too complex leading to overfitting, or from being oversimplified leading to underfitting. For this purpose, we usually use statistical indicators such as (LogL), Akaike Information criteria (AIC) and likelihood ratio test (LR) for comprehensive evaluation. These indexes help us to compare the goodness of fit of models with different lags, so as to find an optimal lag order that can fully extract information from the data and maintain the simplicity of the model. For data from 2017 to the first half of 2018, we have exhaustively tested the order of lag of the sequence using these test criteria

FPE, AIC, SC and HQ test criteria all agree that phase 1 is the optimal lag order, and LR test criteria believes that phase 4 is the optimal order. In this case, this paper adopts the opinion of most test criteria and chooses the first period as the optimal lag order of the model. Therefore, for the VAR model of the northbound fund development period, we determined that the dependent variables of the three equations were the current value of Lnnf (net purchase amount of northbound funds), Return (stock market return rate) and Vola (stock market volatility), while the explanatory variables were the first-phase lag values of these three variables. This setup allows the model to capture the short-term relationship between northbound capital flows and A-share market dynamics.

(3) Granger causality test

The Granger causality test logically tests whether the lag variable of x variable can be introduced into the equation of y variable. If y can be affected by the lag of x, they are said to have Granger causality. However, Granger causality test is not a causal relationship of practical significance, but a dynamic correlation of data.

The test results reveal the significant Granger causality between stock market Return (Return) and stock market volatility (Vola). However, this finding is not of great significance in practical applications, as the Vola data in this paper is itself generated by the GARCH model based on Return sequences. It is worth noting that at the significance level of 1%, the Return of the stock market can Granger the net purchase amount of northbound funds (Lnnf), but this relationship is not reversible. This indicates that foreign investors may rely on the recent performance of the A-share market to predict the future market trend and make investment decisions accordingly, which is consistent with the actual operation logic of the market.

By analyzing the time series data from January 2017 to May 2018, we find that northbound capital flows are not effective in predicting the trend of the A-share market. Instead, it is the volatility of the A-share market that has affected northbound inflows. Moreover, there is no Granger causality between stock market volatility (Vola) and northbound net inflows (Lnnf). This may be because in the early stage of the development of Lustock Connect, the daily trading volume of northbound funds accounted for A relatively low proportion in the total trading volume of the A-share market, so its influence on the market was limited and it was not enough to show statistically significant Granger causality effect. This period of northbound flows was driven more by the market itself than by external inflows.

(4) Impulse response

The impulse response chart reflects the dynamic influence relationship between variables, from which we can intuitively see the response of y variable when it is impacted by another shock variable. According to the Granger causality test results in the above section, only the A-share stock return rate has A significant impact on northbound fund flow.

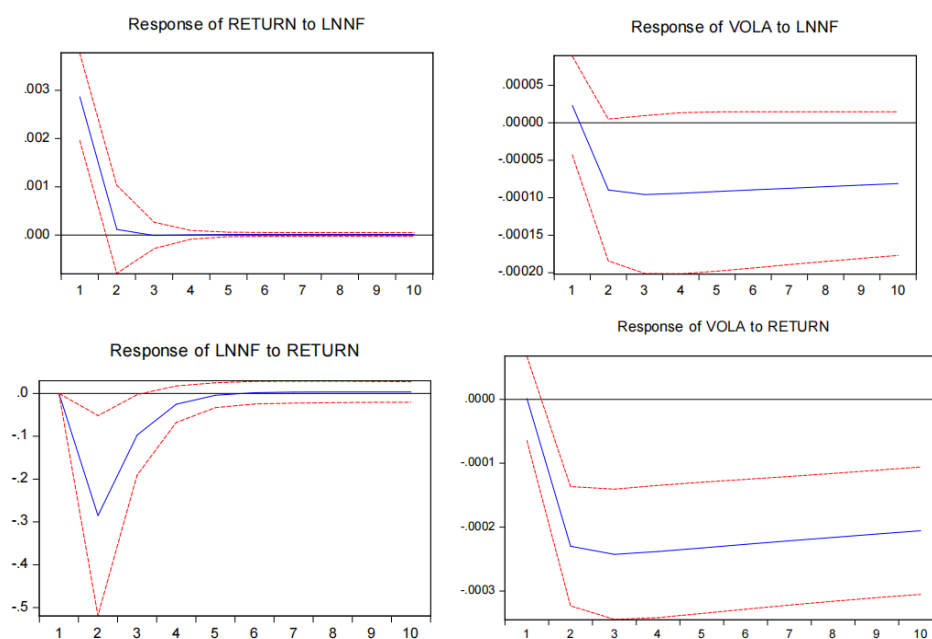


Figure. 4 Impulse response diagram shows the dynamic influence relationship between variables

As shown in the impulse response analysis results shown in Figure 4, when the positive impact of one unit on the A-share market Return (Return) is exerted, the net purchase amount of northbound funds (Lnnf) shows A downward trend in the short term and recovers to zero level in the fifth period. This phenomenon reveals that the A-share yield has A negative impact on northbound capital inflow during the period examined. This study speculates that this result may be due to the fact that from 2017 to the first half of 2018, when foreign investors entered the A-share market through the Dry Port Connect route, they mainly followed the concept of value investment, that is, they chose to buy when the stock price was low, and sell when the stock price rose to A reasonable or overvalued level to realize profit. As A result, when A-share yields rise, it may mean that market valuations have moved out of the range of these investors' expectations, prompting them to tend to sell shares to lock in profits; In contrast, when the market valuation is lower than they expected, they are more likely to buy stocks in the hope of benefiting from a future market rebound. This behavior pattern is consistent with the typical operation strategy of value investors, and further reflects the contrarian investment strategy of northbound funds reducing inflows when the market valuation is high and increasing inflows when the market valuation is low.

(5) Analysis of variance

The purpose of variance decomposition analysis is to assess the extent to which the fluctuations of each endogenous variable contribute to the overall impact of a specific structural shock, so as to determine the relative importance of different structural shocks. In this section, variance decomposition analysis is used to study the extent to which A-share market returns affect northbound capital inflows.

According to the variance decomposition results, the net purchase amount of northbound funds (Lnnf) is completely explained by its own factors in the first phase, which indicates that the initial northbound capital flow is mainly driven by its internal factors. From the second phase, the impact of A-share market yield (Return) on the net purchase of northbound funds began to appear, and tended to stabilize in the 10th phase, with A contribution of about 2.03%. This shows that during the first half of 2017 to 2018, although the A-share market yield has A certain impact on northbound fund flows, overall, northbound fund flows are mainly dominated by its internal factors, and the A-share market changes have relatively little impact on it. This finding reveals that northbound capital flows are relatively independent during this period, and their response to the A-share market is not significant.

2.3.2 The second stage: empirical analysis of northbound capital flow expansion period

(1) ADF stationarity test

The steps and development period of the empirical analysis of the expansion period of northbound capital flows are basically the same, so this section will not repeat the methods and theories, but mainly elaborate the empirical results, focusing on the results and explanations of Granger, pulse and variance decomposition.

ADF test was adopted similar to the first stage, and the test results were listed in Table 4.

Table 4. ADF test results

Sequence name	Test form	ADF statistics	1% critical value	p-value	conclusion
Lnnf	(C,0,1)	14.74711	3.438288	0.0000	Smooth and steady
Return	(C,0,0)	27.77138	3.438278	0.0000	Smooth and steady
Vola	(C,0,0)	4.013952	3.438278	0.0014	Smooth and steady

According to the ADF unit and test results in Table 7, during the period of rapid growth of northbound capital from 2018H2-2021, the ADF statistics of the three variables of northbound capital net purchase, stock market return rate and stock market volatility are all less than 1% critical value, and the P-value is less than 0.05, rejecting the null hypothesis, indicating that the three variables are all stable variables. Can be used directly as three variables to build the VAR system.

(2) The optimal lag period is determined

LR, FPE, AIC and test criteria all agree that phase 2 is the optimal lag order, while SC and HQ test criteria believe that phase 1 is the optimal order. In this paper, most criteria are followed to determine the results, and the optimal lag order is selected as the second order. So far, the VAR model of the northbound capital development period has been constructed in this paper. The dependent variables in the three equations are the current values of Lnnf, Return and Vola respectively, while the explanatory variables are the lagged second-phase values of the three equations (Table 5).

Table 5 LR, FPE, AIC, inspection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	3646.209	NA	2.17e-08	-9.130850	-9.113248	-9.124087
1	4692.479	2082.052	1.61e-09	-11.73052	-11.66012*	-11.70347*
2	4707.786	30.34410*	1.59e-09*	-11.74633*	-11.62312	-11.69899
3	4711.409	7.155540	1.61e-09	-11.73285	-11.55683	-11.66523
4	4714.496	6.072909	1.63e-09	-11.71803	-11.48921	-11.63012
5	4718.070	7.006236	1.66e-09	-11.70444	-11.42281	-11.59623

(3) Granger causality test

In the northbound capital expansion stage from the second half of 2018 to 2021, the Granger test results show several important new findings that are different from the first stage (Table 6).

1) At the 1% confidence level, there is A two-way Granger causality between the A-share market yield (Return) and the northbound net purchase of funds (Lnnf). This not only validates the same conclusion as in the first stage, that is, the A-share market yield can affect the net purchase amount of northbound funds, but also further reveals that the net purchase amount of northbound funds can also affect the return rate of A-share market in turn. This finding provides strong evidence that "northbound funds are smart funds". The reason is likely to be due to the expansion of the mainland stock Connect quota and the inclusion of A-shares in the MSCI index, which has significantly increased the market value proportion, market visibility and influence of northbound funds in A-shares. In this context, some "follow the trend" investors began to imitate the investment strategy of northbound funds, resulting in A significant "herd effect", and then the daily flow of up to 10 billion yuan in land stocks, which had an important impact on the trend of the A-share market.

2) At A significant level of 1%, the net buying of northbound funds (Lnnf) becomes the Granger cause of A-share market volatility (Vola). This shows that the flow of northbound funds can affect

the volatility of the A-share market to A certain extent, bringing new challenges and opportunities for market stability.

3) In addition, the volatility of the A-share market has also been found to be the Granger reason for the return rate. Further impulse response analysis and variance decomposition diagram are needed to further explore and verify the strength and direction of the above effects.

These new findings not only reveal the important role of northbound funds in the A-share market, but also provide A new perspective and basis for understanding market dynamics.

Table 6 Granger test results

Null hypothesis	Chi-square statistics	Degree of freedom	p-value
Return is not Lnnf's Granger causality	33.69762	2	0.0000
Vola is not Lnnf's Granger causality	14.89918	2	0.0006
Vola and Return are not Lnnf Granger at the same time	54.39336	4	0.0000
Lnnf is not the Granger causality of Return	17.53663	2	0.0002
Vola is not Granger causality of Return	2.221161	2	0.3294
Lnnf and Vola are not Granger causality of Return simultaneously	19.60651	4	0.0006
Lnnf is not Vola's Granger causality	0.934014	2	0.6269
Return is not Vola's Granger causality	12.55243	2	0.0019
The difference between Lnnf and Return is Granger causality of Vola	18.58204	4	0.0009

(4) Impulse response

As shown in Figure 5, the following conclusions can be drawn:

1) When A positive impact is given to the amount of northbound funds bought (Lnnf), the A-share market Return (Return) shows a significant positive impact within 1-9 lag periods, and then the impact gradually weakens to zero, and the impact reaches a peak in the second lag period. This paper believes that this phenomenon may be caused by two main factors: First, the herding effect. According to the past literature review, many scholars believe that the opening of the mainland stock Connect has introduced foreign funds, which has intensified the herding effect of the A-share market. This paper argues that the flow of northbound funds reflects the expectations of foreign investors on the future trend of the A-share market, and domestic investors often regard it as A bellwether of market sentiment, which leads to a large number of "follow the trend" investment behaviors. Second, with the deepening internationalization of A-shares, their price trend is more susceptible to international factors (for example, during the COVID-19 pandemic in 2020, A-shares once became A haven for global capital). Overseas mature investors have more advantages in obtaining international information and conducting analytical research, and can more keenly find the "valuation depression" in the A-share market.

2) After giving A positive shock to the A-share market Return rate, the shock will change into small positive feedback with a lag of 3 days, and continue until the 9th day, during which the positive feedback will gradually weaken to zero. This shows that when the A-share market rises, northbound funds will first adopt A catch-up strategy, then sell, and finally end their investment actions by buying slowly.

3) In addition, when the amount of northbound funds bought (Lnnf) is given A positive impact, the volatility of the A-share market first shows a slight upward trend within 1 to 2 lag periods, and then turns to continuous negative feedback in the medium and long term. This suggests that the inflow of northbound funds will stimulate investor sentiment in the short term, leading to higher volatility. Over the medium term, however, increased northbound inflows from value-focused investments have helped smooth out stock market volatility. It is worth noting that the net inflow of northbound funds

showed large positive feedback when the lag was 1 day, then fell to negative on the lag of 2 days, and changed to smaller positive feedback once again when the lag of 3 days, and gradually weakened to zero until the 9th day. This dynamic change once again confirms the investment strategy taken by northbound funds when the A-share market rises: first chase up, then sell, and finally buy slowly.

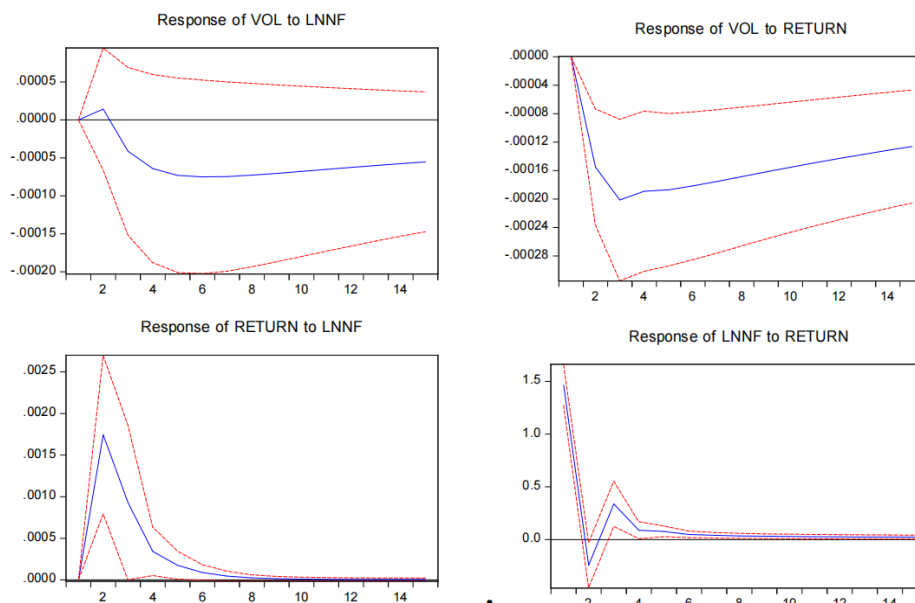


Figure. 5 Impulse response

(5) Variance decomposition

By analyzing the variance decomposition results of each variable in the second stage, we can draw the following conclusions:

1) In the decomposition of factors affecting the amount of northbound capital purchase, similar to the first phase, the contribution rate of the first phase is as high as 100%. From the second phase, the contribution of A-share market return rate is about 3.6%, which is slightly enhanced compared with the first phase, but overall, the proportion is still relatively low.

2) As for the variance decomposition of A-share market return rate, its own contribution rate is stable at about 73% from the first to the 15th period. The contribution rate of northbound capital inflows is about 26.5%. According to the information sorted out above, after 2019, the daily turnover of northbound funds accounted for 10%-15% of the total turnover of A-shares. By comparison, we can reconfirm that northbound fund play the role of "leader" in the A-share market, and its influence exceeds the proportion of its investment in the A-share market.

3) Finally, regarding the variance decomposition of A-share market volatility, about 99% of the contribution rate comes from the A-share market itself, while the influence of northbound funds on it is only about 1%. This shows that the northbound capital flow has A relatively weak impact on the volatility of the A-share market.

2.3.3 Summary of empirical research on the impact of northbound capital flows on A-share market

This paper first discusses the differentiated impact of northbound funds in different development stages of A-share market. Specifically, in the initial penetration phase of northbound funds (covering 2017 to the first half of 2018):

There is no Granger causality between northbound capital flow and A-share market yield and volatility. On the contrary, the return rate of the A-share market can be used to explain the Granger reason of the net purchase amount of northbound funds, and accompanied by short-term negative impulse response effect. This phenomenon reveals that when the mainland stock Connect mechanism was first established, foreign investors still had A shallow understanding of the A-share market, and

their investment strategy tended to be long-term value investment, holding the expected psychology of the investment target, and often adopted the reverse operation strategy of "buy low and sell high".

Then, entering the expansion phase of northbound funds (from the second half of 2018 to 2021), the situation took a significant turn:

With the inclusion of A-shares in the MSCI index and the expansion of the mainland stock Connect quota, the scale of northbound capital inflows into the A-share market has increased significantly, and the international influence of A-shares has also been significantly enhanced. The empirical results show that, quite different from the initial stage, Granger causality is established between the return rate of A-share market and the net purchase amount of northbound funds, and the flow of northbound funds has A significant impact on the volatility of the A-share market. In addition, the net buying of northbound funds showed A positive impulse response on the A-share market yield from 1 to 9 days, and its impact accounted for about 26.5% in the variance decomposition, far exceeding its daily turnover in the A-share market of 10% to 15%. This shows that northbound funds have assumed the role of "leader" in the A-share market, becoming A key indicator of market sentiment. With their profound investment experience, keen ability to capture information and strong research and analysis ability, foreign investors have led the investment trend of some A-share investors, produced an obvious herd effect, and then exerted A profound impact on the A-share market with A daily capital volume of 10 billion yuan.

From the research results of the two stages, the positioning of foreign investors in the A-share market and the influence of northbound funds on the A-share market have changed significantly. In the early stage of development, foreign investors are more like traditional value investors in the A-share market, preferring blue chip stocks and investing according to market trends, with limited impact on the broader market. However, in the expansion stage, northbound funds are known as "smart capital", and their investment style is more flexible and changeable, which intensifies the herding effect in the market and significantly enhances the influence of the A-share market. When the net buying of northbound funds increases, it will have A short-term positive boost to the A-share market yield and have a certain calming effect on volatility.

This paper believes that the core reason for this change is that the increase of the mainland stock connect quota in May 2018 and the inclusion of A-shares in the MSCI index in June led to A significant increase in the proportion of northbound capital turnover in A-share trading, and the internationalization level of the A-share market has also significantly improved. Looking to the future, as China's capital market continues to open to the outside world, the impact of capital inflows from foreign investors on the A-share market will continue to deepen. Therefore, we should make full use of the investment experience and technology of foreign investors to stabilize the domestic stock market and reduce financial risks. At the same time, it is also necessary to reasonably control the pace of opening to the outside world, strengthen investor education, and prevent the A-share market from being excessive intervention by foreign funds.

3. Conclusions and policy recommendations

3.1. Conclusion

Based on the key events of the A-share market's inclusion in the MSCI index and the adjustment of the mainland stock Connect quota between May and June 2018, this paper divides the development process of northbound funds into two stages: the first stage is the growth period from January 2017 to May 2018, and the second stage is the growth period from June 2018 to November 2021. Through comparative analysis of the effects of northbound capital flows on the return rate and volatility of China's stock market in these two stages, we draw the following conclusions:

1) The impact of northbound funds on the A-share market shows the characteristics of dynamic evolution. In the growth stage, our research reveals that compared with the significant impact of A-share market yield on northbound fund flows (which is represented by A gradually weakening negative impulse response within 0-5 days), northbound fund flows themselves have no significant

impact on the return rate and volatility of A-share market. This may be due to the fact that at this stage, foreign investors' cognition of the A-share market is still shallow, and their investment strategies are more focused on long-term value investment and tend to operate inversely according to market fluctuations. However, after entering the growth period, northbound capital flows have had A significant impact on both the yield and volatility of the A-share market, which may be related to the inclusion of A-shares in the MSCI index and the increase of the mainland stock Connect quota attracting more foreign capital inflows, thus significantly enhancing its market influence.

2) In recent years, northbound funds have been praised as "smart money", which has a certain rationality. In the growth period, A Granger causality relationship was established between the A-share market yield and the northbound net purchase amount, and the northbound net purchase had A positive impulse response of 1-9 days to the A-share market yield. The variance decomposition results show that the influence of northbound funds accounts for about 26.5%, far exceeding the proportion of 10-15% of its daily turnover. Therefore, investors can regard the daily net purchase of northbound funds as an important reference indicator of market sentiment.

3) In the growth period, northbound funds also have Granger effects on the volatility of the A-share market. The impulse response results show that there is positive feedback in the short term (1-2 lag periods), and continuous negative feedback in the medium and long term. This may be due to the inflow of northbound funds stirring investor sentiment in the short term, resulting in higher volatility; In the medium term, as the inflow of value investment increases, it helps to stabilize the volatility of the stock market. However, from the results of variance decomposition, the contribution of northbound funds to volatility is relatively small, about 1%.

Combined with the in-depth analysis of the operation status of northbound funds in Chapter 2 and the empirical research results in Chapter 3, we can explain the reasons for the impact of northbound funds on the A-share market trend from the following dimensions:

From the perspective of holding style, northbound funds mainly invest in high-quality industry leading blue-chip stocks, which not only have an important impact on the trend of the industry, but also an important weight of the A-share index. Due to the low proportion of outstanding shares in the total share capital of these stocks, the annual turnover of northbound funds on these weighted stocks accounts for more than 20% of the total turnover of the stock, so the northbound funds can use the leverage amplification effect of weighted stocks to have A significant impact on the trend of the entire A-share market.

From the emotional side, the flow of northbound funds reflects the expectations of foreign investors for the future trend of the A-share market, becoming the "leader" in the A-share market. With its rich investment experience, keen information capture ability and strong analytical research ability, northbound funds have become the "investment vane" of some A-share investors, and have produced A significant herd effect. The scale of tens of billions of funds every day makes northbound funds have an important impact on the A-share market.

From the market perspective, between June 2018 and 2021, the internationalization process of the A-share market has accelerated, while the uncertainty of the international economic situation has also intensified. This makes the A-share market more susceptible to changes in overseas markets. For example, during the COVID-19 pandemic in 2020, the A-share market briefly became A haven for global capital. Overseas mature investors have more advantages in international information acquisition and analysis and research, and they are more accurate in judging the "low valuation time point" of A-shares. These factors have combined to make northbound funds play an increasingly important role in the A-share market.

3.2. Policy Recommendations

Empirical research shows that northbound capital flows have had A significant impact on the trend of the A-share market in recent years. Although the participation of foreign funds has played A positive role in the allocation efficiency and market effectiveness of China's capital market, it also poses a challenge to the stability of the A-share market, affects the asset pricing mechanism, and may

exacerbate the investment risks of small and medium-sized investors. Therefore, while deepening the opening of China's capital market to the outside world, this paper puts forward the following strategic suggestions in view of potential problems:

First and foremost, it is particularly important to improve the Shanghai-Shenzhen-Hong Kong stock connect mechanism. At present, when foreign investors invest in A-shares through the Shanghai-Shenzhen-Hong Kong Stock Connect, they use Hong Kong central clearing agent as the account name, which brings challenges to the traceability and supervision of China's regulatory system. In order to protect the rights and interests of small and medium-sized A-share investors and effectively resist the risks that may be brought by overseas speculative funds, it is proposed to introduce the see-through account system into the Shanghai-Shenzhen-Hong Kong Stock Connect mechanism. At the same time, regulators in the mainland and Hong Kong should deepen information exchange and cooperation, closely monitor abnormal movements of stock prices and funds, build a more rigorous regulatory framework, and improve information transparency.

Second, better investor education is crucial. With the continuous improvement of the degree of capital market liberalization, the complexity and harmfulness of financial risks also increase. In view of the current situation that the A-share market is dominated by retail investors, relevant departments in China should increase investor education and strengthen risk warning. The market risks caused by large-scale inflow and outflow of foreign funds should be popularized to small and medium-sized investors, and they should be guided to avoid blindly following the trend and advocate the concept of rational investment and value investment.

Finally, it is also necessary to strengthen the foreign investment qualification examination and standardize the account opening process. In order to evade regulation, some domestic speculators took advantage of Hong Kong's low financing costs to carry out high leverage operations, opened accounts in Hong Kong, and used the Shanghai and Shenzhen Stock Connect to buy A-shares. This behavior was called "fake foreign investment", which seriously disrupted the order of the stock market and went against the original intention of the Shanghai, Shenzhen and Hong Kong Stock Connect. Although this part of the transaction amount accounts for a relatively small proportion of northbound funds, it still needs to be attached great importance. Chinese authorities have introduced policies to clean up Shanghai-Shenzhen stock Connect accounts opened by mainland investors in Hong Kong, and strengthen the examination of account opening qualifications. These measures can prevent the breeding of financial risks in the process of expanding the opening up of the capital market at the source, shut out speculators, protect the interests of small and medium-sized domestic investors to the maximum extent, and promote the steady operation and sustainable development of the Shanghai-Shenzhen-Hong Kong Stock Connect.

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