An Associative Analysis Method to Estimate Impact between Financial Market Risk and Macroeconomic Risk

Jinjia Tu*
Department of Economic, McMaster University, Hamilton, Canada
* Corresponding author: tarrencetu@gmail.com

Abstract. The intertwining and close correlation between financial market risk and macroeconomic risk have been a focal point of academic research. By constructing financial stress index and macroeconomic risk index, and employing the Time-Varying Parameter Vector Autoregression (TVP-VAR) model, this study analyzes the complex dynamic interactions between financial market risk and macroeconomic risk. The results indicate a bidirectional and intersecting relationship between financial market risk and macroeconomic risk. Financial market risk exerts a relatively significant impact on macroeconomic risk, and its accumulation exacerbates the downward pressure on the macroeconomy, while its alleviation does not promptly lead to economic prosperity. Moreover, there exists a significant time-varying correlation between financial market risk and macroeconomic risk, with macroeconomic risk continuously augmenting its promoting effect on financial market risk.

Keywords: big data, associative analysis, financial market risk, macroeconomic risk, autoregression model.

1. Introduction

Since the 1990s, with the continuous advancement of financial globalization and liberalization, along with the deepening diversification of financial markets, the fragility of financial systems has increased, leading to frequent financial crises. As a result, financial risk has become a focal point of concern for regulatory authorities and scholars [1]. The size of financial risk is closely related to the changing macroeconomic conditions [2]. Currently, China's economic growth has notably slowed down, and the downward pressure on the economy has intensified. The ongoing process of financial globalization and the introduction of innovative financial products have contributed to a decline in financial system stability, resulting in the accumulation of financial risks. This situation hampers the sustainable and healthy development of China's finance and economy, posing more severe challenges to macroeconomic regulation and financial supervision [3].

From the existing literature, numerous studies have shown that financial stress leads to macroeconomic risk, thus focusing on exploring the unidirectional impact of the aggregation and release of financial risks on the macroeconomy [4]. However, these studies often overlook the impact of macroeconomic risks on financial risks, and there is still no definitive conclusion regarding the characteristics of the interactive behavior between financial market risk and macroeconomic risk[5]. Additionally, due to the broad and encompassing nature of the concepts of financial risk and macroeconomic risk, current research often measures these risks using financial sub-markets or single economic variables to explore the mechanisms of their mutual influence. However, there is relatively limited research that investigates the complex interactive behavior between financial risks and macroeconomic risks from a holistic perspective.

Therefore, this study builds upon existing research and considers the complexity of financial risk, macroeconomic risk, and their interactive behavior [6]. It attempts to construct financial stress index and macroeconomic risk index and adopts the Time-Varying Parameter Vector Autoregression (TVP-VAR) model to systematically analyze the dynamic interactions between financial risk and macroeconomic risk from a time-varying perspective [7-8]. The innovation and contribution of this study mainly lie in the following aspects: (1) Constructing financial stress index and macroeconomic risk index from a systematic, comprehensive, and scientific perspective to avoid the limitations of research content and depth based on single variables; (2) Breaking through the traditional linear and
normal theoretical research framework by combining complexity financial theories with econometric methods. This approach fully considers the complex, nonlinear, and dynamic interdependence structure between financial risk and macroeconomic risk, exploring the characteristics of their complex time-varying behavior to provide valuable supplementary insights into the study of their intricate interactive behavior.


Financial risk refers to the possibility of significant fluctuations in the financial system due to external shocks or changes in internal structures, leading to potential losses. The currency market, bond market, foreign exchange market, and stock market are vital components of the financial market and important sources of financial risk [9]. Credit risk, liquidity risk, and market risk in financial sub-markets can transmit internally within the financial system, causing issues such as reduced liquidity, increased funding costs, and decreased asset returns, thereby impacting the stability of the financial system and reflected in changes in relevant financial market indicators. Given the complex factors affecting financial risk, such as banking system collapses, bursting of asset bubbles, currency market volatility, and fluctuations in the foreign exchange market, the conventional approach of focusing only on measuring financial risk in specific sub-markets is evidently inadequate. In this context, the concept of the financial stress index has emerged. It was initially selected 11 indicators from four sub-markets: banks, bonds, foreign exchange, and stocks, to construct Canada's financial stress index [10].

2.1.1. Currency Market

The currency market plays a dominant role in China's financial system as it is the primary provider of market liquidity for fund circulation and allocation. The risk pressure in the currency market directly affects the stability of the financial market. In this study, the TED spread and the weighted average interest rate of the interbank 7-day repo are chosen to reflect the risk in the currency market. The TED spread represents the difference between the 3-month interbank lending rate and the risk-free rate, reflecting liquidity conditions [11]. A larger TED spread indicates higher risk premiums among interbank lending, greater liquidity risk, and increased financial stress in the currency market. The TED spread in this study is calculated as the difference between the 3-month weighted average interbank lending rate in Shanghai and the 3-month government bond yield. The weighted average interest rate of the interbank 7-day repo reflects short-term funding demand. A higher value indicates faster circulation of bank funds and higher financial stress. Therefore, the 7-day weighted average interest rate of interbank repo is chosen as one of the representative variables for the currency market.

2.1.2. Stock Market

The stock market is the most crucial component of China's financial market and a primary investment and financing channel for the country's economic development. In recent years, abnormal fluctuations in stock prices have been the main cause of increased financial stress and turmoil in the entire financial system. The return rate and volatility of stocks are selected in this study to reflect the risk in the stock market. A higher stock market return rate indicates more profits from stock investments and a more active capital market. Conversely, a decline in stock market returns indicates increased market pressure. Thus, the monthly return rate of the Shanghai Composite Index is chosen as one of the representative variables for the stock market. Stock market volatility reflects the market's ability to handle pressure. Greater stock market volatility indicates higher uncertainty, and, as a result, more significant market pressure. This study calculates the stock volatility using a GARCH (1,1) model applied to monthly stock returns.
2.1.3. Bond Market

As one of the two major financing subjects in China, the stability of the bond market is critical to ensure smooth financing channels. In recent years, China's social financing scale has been continuously increasing, and the scale of bond financing has been expanding gradually, making the bond market a vital and inseparable part of the financial system. On the contrary, negative term spreads indicate that the market prefers long-term government bonds, indicating higher risk aversion and increased financial stress. In this study, the difference between the 10-year government bond yield and the 1-year government bond yield represents the term spread. Corporate bond spreads are essential indicators reflecting market risk appetite and liquidity preference. When market risk aversion declines and liquidity tighten, investors tend to buy safer and more liquid government bonds and avoid corporate bonds, leading to an increase in spreads. Conversely, when market risk appetite is high, and liquidity is sufficient, corporate bond spreads are usually lower. This study uses the difference between the 1-year AAA-rated corporate bond yield and the 1-year government bond yield to represent corporate bond spreads.

2.1.4. Foreign Exchange Market

In the context of economic globalization, the connection between China's economy and the global economy has become increasingly close. As a link between international financial markets, the foreign exchange market plays an increasingly important role in supporting foreign trade, capital market development, and national financial stability. However, along with the deepening integration of the economy, the financial risks arising from foreign exchange market pressures have also been increasing. Therefore, this study selects exchange rate volatility and foreign exchange reserve growth rate to represent the risk situation in the foreign exchange market. A small exchange rate volatility indicates a stable foreign exchange market, with less impact on the financial system's volatility. Conversely, significant fluctuations in the exchange rate can affect the circulation of domestic currency in the international market, influence international investors' expectations of the currency value, and lead to capital outflows, resulting in increased financial pressure. The growth rate of foreign exchange reserves is a crucial indicator reflecting a country's international payment capacity and its ability to control the stability of its currency. Although excessive foreign exchange reserves can bring high opportunity costs and hinder the implementation of monetary policy, a small scale of foreign exchange reserves significantly increases financial pressure and may even lead to financial risk. This study calculates the foreign exchange reserve growth rate as the difference between the foreign exchange reserves of the current month and the previous month, divided by the foreign exchange reserves of the previous month.

2.2. Construction of Macroeconomic Risk Measurement Index System

Macroeconomic risk refers to the likelihood of economic recession or uncertainty in the level of economic growth. In the review of literature, this study concludes that constructing a macroeconomic risk index is an effective method for systematically and comprehensively measuring macroeconomic risk, and reasonable selection of measurement indicators is the statistical foundation for constructing a macroeconomic risk index. Firstly, the economic foundation reflects the basic variables reflecting the macroeconomic situation. Economic growth rate not only reflects the overall economic development trend but also indicates the market size and development speed. Consumption, as the ultimate driving force of economic growth, plays a decisive role in the overall operation and effectiveness of the national economy. Investment, as a significant part of total social demand, is one of the most critical factors driving economic growth and plays a crucial role in balancing supply and demand, stabilizing the economy, and controlling fluctuations. Foreign trade is an essential component of a country's economy, and the degree of foreign trade dependence reflects the level of integration between a country and the global economy and the degree of cross-border resource allocation. Employment is the foundation of people's livelihood and an important reference variable for judging macroeconomic conditions and making regulatory policy decisions. The development
situation of a country's economy not only reflects the strength of past economic development but also indicates the potential for future development and market investors' confidence. The economic growth potential can provide a reference for economic development planners and economic market participants. Secondly, debt risk is also a critical factor affecting the stable operation of the macroeconomy. While borrowing brings vitality to economic development, issues such as asset bubbles, mismatched investment returns, and debt maturities will impact macroeconomic development. High debt brings high risk and has become a significant threat to economic stability. Finally, as one of the essential economic policies for macroeconomic regulation, monetary policy plays a crucial role in smoothing economic fluctuations, stabilizing prices, and promoting economic growth. Therefore, maintaining a stable currency value through sound monetary policy is always the most important and critical issue. Currently, the most authoritative macroeconomic risk index in China is the Economic Operation Risk Index in the "China Economic Operation Risk Research Report" published by China Lixin Risk Management Research Institute. This index includes six aspects: economic growth, price stability, full employment, international balance of payments, fiscal balance, and financial stability. Following the principles of systematic, measurable, and representative variable selection, relevant variables are adjusted, classified, and summarized from the three aspects of economic foundation, debt risk, and monetary operation to construct the macroeconomic risk index. The indicator system is shown in Table 1.

Table 1. Macroeconomic risk index construction

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Primary indicator</th>
<th>Secondary indicator</th>
<th>Description</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of Development</td>
<td>GDP Growth rate</td>
<td></td>
<td>Reflects the trend in the development of a country's economic power and its level of growth over time; the higher the level of growth, the less likely it is that economic risks will occur</td>
<td>Negative</td>
</tr>
<tr>
<td>Consumption</td>
<td>Consumption Retail Sales of Consumer Goods Cumulative growth rate of total</td>
<td></td>
<td>It is a composite indicator of the level of consumption of a country's population, with higher values indicating a growing economy and a lower likelihood of economic risk</td>
<td>Negative</td>
</tr>
<tr>
<td>Investment</td>
<td>Cumulative growth rate of investment in fixed assets</td>
<td></td>
<td>Indicators reflecting a country's domestic investment, which drives the economy and allows it to operate at a high and stable level of growth, thus reducing the likelihood of risks occurring</td>
<td>Negative</td>
</tr>
<tr>
<td>Import and Export</td>
<td>External trade dependence</td>
<td></td>
<td>The share of total exports and imports in GDP, reflecting a country's dependence on import and export trade, with higher values leading to higher debt-servicing difficulties, i.e., greater economic risk, in the short term</td>
<td>Positive</td>
</tr>
<tr>
<td>Employment</td>
<td>Per capita disposable income of employed urban residents Disposable income per urban resident</td>
<td></td>
<td>Disposable income per capita of urban residents can reflect the actual employment situation and the quality of employment, which in turn reflects a country's economic risk profile</td>
<td>Negative</td>
</tr>
<tr>
<td>Growth Potential</td>
<td>Tertiary output/GDP</td>
<td></td>
<td>Increased services output optimizes the industrial structure and thus promotes economic development and reduces the likelihood of risks</td>
<td>Negative</td>
</tr>
</tbody>
</table>
### Debt Risk
- **Size of debt**
- **Debt Ratio**: It is the ratio of the external debt balance to GDP, which indicates the size of the debt and also measures a country’s long-term debt-servicing capacity, with a high debt ratio indicating an excessive dependence on debt for economic development and an increased likelihood of economic risks.

### Solvency
- **Short-term external debt/foreign exchange reserves**: An indicator of a country's ability to service its debt quickly, whereby foreign exchange reserve assets can be drawn upon to service external debt when other means of payment are insufficient, and the likelihood of economic risk increases if the proportion is too high.

### Monetary Operations
- **Domestic (policy)**
- **M2/GDP**: Also known as the money supply expansion ratio, a significant increase in the money supply can not only create inflationary pressures but also lead to inefficiencies in monetary policy. Excessive ratios of this indicator may be a sign of financial deepening or a harbinger of increased economic risks.

- **Pertaining External or Foreign (affairs)**
- **Exchange Rate Fluctuations**: GARCH(1, 1) volatility of the real effective exchange rate index of the renminbi, an indicator of the external stability of a country's currency, where large fluctuations in the exchange rate can significantly exacerbate economic risks.

### 3. Research Methods and Models

Many studies have shown that financial risk and macroeconomic risk are two complex systems involving numerous elements, and the interactions between these elements tend to be complex. Moreover, the interaction between these two systems is characterized by complexity, dynamics, non-linearity, and non-stationarity, which implies that traditional single and linear methods cannot fully reveal the complex interactions between the two systems. The Time-Varying Parameter Vector Autoregressive (TVP-VAR) model assumes that time-varying parameters follow a random walk process, enabling the capture of abrupt structural changes in complex systems' random fluctuations and analyzing the complex time-varying characteristics of interactions between the systems.

To further analyze the time-varying effects of the correlation between the financial stress index and the macroeconomic risk index, this study adopts the Time-Varying Parameter Vector Autoregressive (TVP-VAR) model to capture the influence relationship between the financial stress index and the macroeconomic risk index at different time points. Introducing time-varying coefficient matrices and covariance matrices into the Structural Vector Autoregressive (SVAR) model yields the specific form of the TVP-VAR model as follows: [The mathematical expression of the TVP-VAR model will be inserted here based on the specific equations used in the study].

\[
Y_t = X_t \beta_t + A_{t^{-1}} \sum_t \epsilon_t
\]

In this equation, \( t = s+1, \ldots, n \). Following the approach of Nakajima [64], this study sets all elements in matrix \( A_t \), except for 0 and 1, to be column vectors, denoted as \( at = (a_{21, t}, a_{31, t}, a_{31, t}, a_{41, t}, \ldots, a_{kk-1,t})' \). Additionally, let \( ht = (h_{1t}, h_{2t}, \ldots, h_{kt})' \), where \( h_{jt} = \log \sigma \) for \( j = 1, \ldots, k \), and \( t = s + 1, \ldots, n \). The assumption for the time-varying parameters in Equation (25) is that they follow a random walk, characterized as follows:
\[
\beta_{t+1} = \beta_t + \mu_{\beta_t}, \alpha_{t+1} = \alpha_t + \mu_{\alpha_t}, h_{t+1} = h_t + \mu_{ht}
\]  

(2)

Also

\[
\begin{bmatrix}
\epsilon_t \\
\mu_{\beta_t} \\
\mu_{\alpha_t} \\
\mu_{ht}
\end{bmatrix} \sim N \left( \begin{bmatrix}
I \\
0 \\
0 \\
0
\end{bmatrix}, \begin{bmatrix}
\sum_{\beta} & 0 & 0 & 0 \\
0 & \sum_{\alpha} & 0 & 0 \\
0 & 0 & \sum_{h} & 0 \\
0 & 0 & 0 & \sum_{h}
\end{bmatrix} \right)
\]

Figure 1. random walk

In which, \( t = s+1, \ldots, n; \beta_s+1 \sim N(\cdot, \sum_{\beta}0); \alpha_{s+1} \sim N(\mu_{\alpha0}, \sum_{\alpha}0); h_{s+1} \sim N(\mu_{h0}, \sum_{h}0) \) (Fig.1).

4. Empirical Analysis

4.1. Research on the time-varying correlation

Based on the previous analysis, it was found that the financial stress index and the macroeconomic risk index influence each other. The next question is whether this bidirectional influence relationship changes over time. To investigate this, the TVP-VAR model was employed, and three-time intervals (3 quarters lag, 6 quarters lag, and 12 quarters lag) were chosen to conduct equidistant impulse response analysis on the financial stress index and the macroeconomic risk index. This allowed for a further exploration of the time-varying characteristics of the correlation between the two sequences. Figure 5 illustrates the dynamic impulse responses of the financial stress index and the macroeconomic risk index. The three curves in Figure 5 exhibit a high degree of consistency, indicating the suitability and robustness of the TVP-VAR model's estimation results. Overall, the financial stress index and the macroeconomic risk index mutually influence each other, confirming the conclusions from the directional impact analysis. However, the degree and direction of influence vary at different stages, demonstrating apparent time-varying characteristics. This suggests that the levels of financial risk and macroeconomic risk are not constant and continuously change over time. Various factors, including domestic and international unexpected events, severe natural disasters, investors' psychological expectations for market development, and the direction of government support policies, contribute to the fluctuations of financial risk and macroeconomic risk. Lead to the cross-correlation between financial risk and macroeconomic risk also exhibits time-varying properties.

When giving the financial stress index a one-standard-deviation positive shock, the impulse response of the macroeconomic risk index is shown in Figure 5(a). Before the beginning of 2010, the impulse response is positive, indicating a positive impact of the financial stress index on the macroeconomic risk index during that time period. Between 2010 and 2014, the impulse responses alternate between positive and negative, suggesting that the influence of the financial stress index on the macroeconomic risk index is not significant during this period. Subsequently, all impulse responses become negative, indicating that the financial stress index has a dampening effect on the macroeconomic risk index, reaching its peak around early 2016. The gradual reduction of the promoting effect of the financial stress index on the macroeconomic risk index may be due to the realization of regulatory authorities about its substantial destructive power following the subprime mortgage crisis and the European debt crisis. As a result, they began to emphasize the identification, early warning, and control of financial risks, strengthening the ability to respond to financial crises. The impact of macroeconomic risk may also have a certain lag relative to the increase in financial risk. Therefore, around 2010, when the financial market experienced sudden shocks, the government took prompt and proactive regulatory measures to resolve and respond to avoid excessive market volatility, which decreased the positive promotion effect of financial risk on macroeconomic risk.
Subsequently, with the government's active actions, the functionality of the financial market improved, guiding the proper flow of market funds, enhancing the efficiency of capital allocation, and resulting in positive effects on employment, income distribution, social welfare, and associated demands. As a result, the promoting effect of financial risk on macroeconomic risk turned into a negative effect. After 2016, China's economic development entered a new normal, transitioning from high-speed growth to "stable growth." Coupled with the government's deepening "streamlining administration, delegating power, and improving regulation" reforms, aiming to build a service-oriented government, the government's interventions and regulations in the financial market became more scientifically-based. Consequently, the impact of financial risk on macroeconomic risk gradually weakened. It can be observed that the government's proactive actions in response to financial risk can avoid excessive market volatility, thereby reducing the impact of financial risk on macroeconomic risk. Therefore, when severe financial risks affect the macroeconomic, appropriate "market rescue" policies can effectively reduce macroeconomic risk. This requires regulatory authorities to accurately grasp the timing, direction, and strength of policy tool utilization to ensure the effectiveness and rationality of policy implementation.

Giving the macroeconomic risk index a one-standard-deviation positive shock, the impulse response of the financial stress index. It can be observed that the macroeconomic risk index has an overall positive impact on the financial stress index, and this impact increases over time. This indicates that the healthy development of the macroeconomy is the foundation of financial system development. The development of the financial system relies on the overall performance of the macroeconomy, and the level of financial system risk is inevitably influenced by the operating conditions and fluctuations of the macroeconomy. This leads to an increasing trend of positive correlation between financial risk and macroeconomic risk, resulting in "risk resonance." In recent years, China's economy has transitioned from high-speed growth to medium-high-speed growth. Factors such as reduced domestic market demand, slowed growth in consumer spending, decreased investment, shrinking export orders, and China-US trade frictions have significantly slowed down economic growth. The increasing number of potential risks in the macroeconomy has also heightened the impact of macroeconomic risk on financial risk. Therefore, the smooth operation of the macroeconomy is crucial in guarding against financial risk.

In addition, the amplitude of the oscillations in the impulse response curve of the financial stress index to the macroeconomic risk index is larger than the amplitude of the oscillations in the impulse response curve of the macroeconomic risk index to the financial stress index. This further illustrates that the financial stress index has a greater impact on the macroeconomic risk index compared to the impact of the macroeconomic risk index on the financial stress index.

4.2. Robustness Test

The robustness of the results obtained from the nonlinear Granger causality test between the financial stress index (FSI) and the macroeconomic risk index (ERI) is examined. Table 4 presents the results of the nonlinear Granger causality test for both FSI and ERI series.

From Table 2, it can be observed that at the significance level of 10%, FSI is the nonlinear Granger cause of ERI, and vice versa, ERI is the nonlinear Granger cause of FSI. This indicates the existence of a bidirectional causal relationship between the financial stress index and the macroeconomic risk index, which is consistent with the conclusions drawn in this study. Therefore, the above conclusions are robust.

<table>
<thead>
<tr>
<th>Test hypothesis</th>
<th>Lag period</th>
<th>T-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSI is not a Granger cause of ERI</td>
<td>2</td>
<td>1.458</td>
<td>0.0724</td>
</tr>
<tr>
<td>ERI is not a Granger cause of FSI</td>
<td>2</td>
<td>2.106</td>
<td>0.0176</td>
</tr>
</tbody>
</table>

Note: The lag order was determined to be 2 by the AIC criterion.
5. Conclusion

This paper empirically analyzes the time-varying and complex interactive behavior between financial risk and macroeconomic risk by using TVP-VAR model, and obtains the following research conclusions.

By constructing TVP-VAR model for impulse response analysis, it is found that the correlation between financial stress index and macroeconomic risk index has significant time-varying characteristics; in the short term, the positive influence of macroeconomic risk on financial risk has been increasing, while the promotional effect of financial risk on macroeconomic risk has been gradually weakened from a positive to a negative influence.

Based on the above findings, this paper draws the following policy implications. First, since the accumulation of financial risks will aggravate the downturn of the macroeconomy, while the easing of financial risks may not necessarily bring economic prosperity in time, the supervisory authorities should "take precautionary measures", improve and innovate the financial supervisory system and supervisory tools, explore scientific and effective risk early warning models, and comprehensively monitor the dynamic changes of China's financial risks, so as to provide early warning and early warning of risks. Secondly, a stable financial environment is the key to the new economy, and it is important for the new economy to have a stable financial environment. Secondly, a stable financial environment is an important prerequisite and basic guarantee for optimizing and adjusting the economic structure and cultivating a new driving force for economic growth in the new period [67], given the conclusion that the financial stress index has a relatively greater impact on the macroeconomic risk index, we should focus on the correlation dynamics between financial risks and macroeconomic risks, and consider the following measures from the perspective of financial risk: to deepen the reform of the financial system, to prevent and resolve financial risks, and to create a stable and healthy financial development environment. We should further deepen the reform of the financial system to prevent and resolve financial risks and create a stable and healthy financial development environment, while focusing on the dynamics of the link between financial risks and macroeconomic risks, and consider mitigating the vulnerability of the macroeconomic from the perspective of reducing financial risks, so as to effectively bring into full play the booster effect of finance on economic growth and achieve the dual stability and coordinated development of the macroeconomic and the financial system. Thirdly, the direction of influence between financial risk and macroeconomic risk is two-way, and the macroeconomic risk index has a tendency to climb year by year, and its promotion effect on financial risk is also increasing, so the relevant departments should pay close attention to changes in the domestic and foreign economic situation, analyze the main factors that may trigger a surge in financial risk due to the impact of the macroeconomic situation on the financial market, and improve the risk monitoring system, and at the same time, dredge up the transmission channels of macroeconomic policies, and improve the financial system. At the same time, the transmission channels of macroeconomic policies should be unblocked, and the policy effect and implementation efficiency of macroeconomic control should be improved, so as to maintain a stable macroeconomic development situation and realize sustainable and healthy development of the economy. This paper explores the cross-correlated, asymmetric, directional and time-varying complex interaction between financial risks and macroeconomic risks, which has certain theoretical and practical significance, but the depth of research in this paper needs to be further strengthened, and the theories of the formation law and influence mechanism of the interaction between the two should be explored more in depth in the future research, so as to make the research system more complete.

References


