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Time-Varying Systemic Financial Risk in China: Evidence from a Factor-Augmented TVP-VAR Model

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Abstract: *This article has made a time-changed system finance risk index (SRI) for China inside a factor-increased TVP-VAR frame. By making use of a data set which holds 38 macro-financial indicators, five hidden risk factors are extracted by means of principal component analysis, and therefore the model is estimated with the employment of Bayesian methods across the time period 2005-2025.The experiment outcome indicates that the index which we built can effectively catch big events of financial pressure, hence including the global financial crisis, hence the 2015 stock market turbulence, and hence the COVID-19 strike. In the factors that have been found out, the risk from outside part gets more and more noticeable as time goes by, this reflects that China's contact with world financial situation becomes bigger and bigger. In addition, the relative weight of different risk origins shows obvious difference, thus it indicates that the framework of system risk changes continuously without stop. On the whole, the research results give new understandings about the changeable character of system risk in rising economies and thus emphasize the significance of bringing time change into risk measuring frameworks. The results also provide useful inspirations for the formulation of macroprudential policies that have the goal of advancing financial stability.*

Keywords: *Systemic financial risk; TVP-VAR; Factor model; China; Macro-financial variables*

1. Introduction

Systemic finance risk has drawn ever more attention from policy makers and research workers, especially in developing economies that go through fast financial change. Along with financial markets getting higher integration and complication, channels of risk transmission have become larger, hence making systemic risk have more difficulty in being found and handled[1]. Under this background, the making of effective tools to monitor and measure systemic risk has already become an important question in academic research and policy practice two aspects.

China gives a especially significant instance for researching the movement rules of systematic financial risk. As the world's second-biggest economy, China in the past twenty years has undergone comparatively obvious financial expansion and structural transformation. The fast expansion of credit, changes in asset prices, and growing contact with global financial markets have together caused a more complicated risk environment. Every one of these factors acts on the others and changes as time passes, hence traditional indices therefore have difficulty getting the full picture of systemic risk. Past researches have put focus on the significance of carrying out supervision on system-level risk in rising markets which have the feature of rapid financial growth[2].

Although the academic circle has made quite big progress in related research, the current methods used for measuring systemic risk still have a number of shortcomings. Market-oriented index indicators, for example CoVaR and SRISK, depend greatly on financial asset prices, and can perhaps not sufficiently reflect risks existing in bank-led financial systems[3]. In the meantime, composite index numbers which are built from macro-financial variables often hold the assumption of fixed weights, hence they ignore the possibility that the importance of different risk sources changes along with time. Therefore, these kinds of methods are not able to capture the dynamic developing process of system risk.

For solving these restrictions, this paper has constructed a time-changing system financial risk index under a factor-expanded TVP-VAR frame. Through the combination of information from a large group of macro-financial variables with a flexible time-changed model structure, the method that we put forward makes both risk transmission mechanisms and factor contributions change along with the time.

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When we put this framework together with current methods that have been already used, it can give a more overall and moving description of systemic risk.

This present article has three main contributions to the existing academic publications. First, this research builds a dynamic system risk index which can catch the time change in both risk degree and factor importance. Second, it has included a wide group of macro-financial variables, hence it promotes the information foundation for risk measurement. Third, this article gives new experiment-based proof about the changing origin of systematic risk in China, and hence provides policy-related viewpoints for macro-prudential management in developing countries.

2. Literature Review

The literature on systemic financial risk has developed along several main strands.

One important research direction focuses on measures which are based on market, for instance CoVaR and SRISK, these assess the contribution which single institutions give to the entire systemic risk. Adrian along with Brunnermeier (2016) put forward the CoVaR framework, and after that Acharya et al. (2017) proposed SRISK to act as an indicator for capital shortage when systemic pressure is present. Although these methods already obtain very wide utilization, they rely extremely greatly on market-related data, hence they are not able to sufficiently reflect the risks which exist in financial systems that are controlled by banking actions.

Another school of thought puts emphasis on the function of interconnection and spillover influences among different markets. Through making use of the methodologies that are based on VAR, Diebold and Yilmaz (2014) have built a connectedness framework that can implement quantification upon risk transmission that lies between financial variables[4]. Though this method provides helpful perspectives for the building of financial links, it generally assumes a time-constant system, which hence may limit its ability to capture structural changes.

One another group of researches constructs macro-financial indexes on the foundation of a big range of economic and financial indicators. Take as one example, the study by Cardarelli and other joint workers (2011) have done development of financial stress indexes through using numerous macro-financial variables[5]. However, the vast majority of these indexes use fixed weight schemes, which hence are not able to consider the changing significance of various risk sources.

According to these literature roads, this paper puts together factor picking and a TVP-VAR frame to build a time-changing systemic risk index which holds both dynamic mutual actions and changed factor contributions.

3. Methodology

3.1 Factor Extraction

For the purpose of summing up information that comes from a great number of macro-financial index items, this research firstly extracts one group of latent risk factors through the use of principal component analysis (PCA). The motivation of utilizing PCA lies in that numerous macro-financial variables possess very high correlation, and directly putting all of them into a multivariate time-series model will bring about serious dimension problems and multicollinearity. Through cutting down the original variable group to a smaller amount of common elements, PCA lets people hold the main change inside the data, at the same time it promotes the handle easiness of the experience-type analysis.

To speak concretely, the complete data package holds 38 macro-financial indexes that cover credit situations, finance marketplaces, the foreign sector, interest levels, and finance operation situations. These variables are carried out standardization processing before factor extraction, therefore in order to eliminate scale influences and thus make them have comparability. PCA is next used for handling the standardized data set, and the principal components that are obtained are explained as hidden risk factors which sum up the shared changes of the original indexes.

The quantity of factors that are kept is fixed on the basis of both information standards and the ratio of variance that gets explained. According to this method, five hidden factors are obtained to carry out the analysis that follows next. This selection manifests a equilibrium that lies between model simpleness and information holding. From one aspect, keeping too little factors can leave out important variation

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sources in the data; on the other hand, if we keep too many factors, it can bring down the interpretability of the model, and thus weaken the aim which dimension reduction has. Therefore, the factors that have been extracted act as condensed descriptions of the main origins of systematic risk within China's financial system.

3.2 TVP-VAR Model

After the extraction of factors, a model which is named time-varying parameter vector autoregression (TVP-VAR) is utilized by us to depict the dynamic connection relations among the latent risk factors. When put in comparison with the standard VAR model, the TVP-VAR framework is more suited for analyzing systemic financial risk, for the reason that it lets model coefficients and volatility processes undergo change along with time. This character property is especially important under the situation of financial systems, where passing mechanisms are not unchanging but can have change because of rule adjustments, whole economy changes, or big outer impacts.

In this frame, each extracted factor is regarded as an internal variable, and the mutual influences between factors are got via a system of self-regression equations. In difference from the traditional fixed-parameter setting, the coefficient values in the TVP-VAR model change with time following stochastic processes, which are usually modeled as random walks. In the meanwhile, the variances of the shocks are also permitted to change, thus it becomes possible to capture time periods that have increased uncertainty and volatility. By this method, the model is able to depict not merely the average relations between risk factors, but also the altered strength and direction of these relations in different time periods.

The utilization of a TVP-VAR model is driven by the circumstance that systemic risk possesses an intrinsically dynamic nature. For instance, risks that are connected with credit may hold the dominant position in one time period, while risks coming from outside or from the market may thus get a higher degree of importance in another period. A model with fixed parameters would force invariable connections across the entire sample, and hence may hence hide key structural alterations. As a comparison, the TVP-VAR framework can give a flexible method to catch changing connecting relations and moving transmission rules in the financial system. This modeling method has been broadly utilized in macroeconomic and finance researches for recognizing time-changing influences and structural unstableness (Primiceri, 2005)[6].

3.3 Systemic Risk Index

According to the picked-out factors and the calculated TVP-VAR model, this article builds a systemic risk index (SRI) to measure the whole level of systemic financial risk in China. This index is by definition a weighted gathering together of the hidden factors:

$$SRI_t = \sum_{i=1}^{K} w_{i,t} F_{i,t}$$

where$F_{i,t}$denotes the standardized value of factor i at time t and $w_{i,t}$represents the corresponding time-varying weight. The employment of time-changing weights is of significance because the contribution of each risk factor to systematic risk can not very possibly keep unchanging through time. Instead, the degree of importance of each different factor can therefore change along with macroeconomic conditions, financial cycles, and also external disturbances.

In this study, the weights are derived from impulse response information obtained from the TVP-VAR model. Intuitively, a factor that generates a stronger system-wide response is assigned a larger weight in the construction of the index. This approach ensures that the SRI reflects not only the presence of different risk sources, but also their relative systemic importance at each point in time. As a result, the proposed index is able to capture both the level and the composition of systemic risk in a dynamic manner.

Compared with traditional composite indices based on fixed weighting schemes, the SRI constructed here is more flexible and better suited to the analysis of evolving financial risk structures. It provides a synthetic measure of systemic financial conditions while preserving information on how underlying risk contributions shift across time.

3.4 Estimation

The parameters of the TVP-VAR model are estimated using Bayesian Markov Chain Monte Carlo

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(MCMC) methods. Bayesian estimation is particularly suitable in this context because the TVP-VAR model contains a large number of time-varying parameters, making classical estimation difficult and potentially unstable. By incorporating prior information and drawing from posterior distributions, the Bayesian approach improves estimation efficiency and helps ensure stable inference in high-dimensional settings.

The MCMC procedure is used to obtain posterior estimates of the time-varying coefficients and stochastic volatilities. Through iterative sampling, this method generates the full posterior distribution of the model parameters rather than only point estimates. This is useful because it allows uncertainty in the estimation process to be taken into account more explicitly. In empirical applications involving financial time series, where volatility clustering and structural change are common, Bayesian MCMC methods are particularly advantageous.

Overall, the combination of PCA, TVP-VAR, and Bayesian estimation provides a coherent framework for measuring systemic financial risk. PCA reduces dimensionality and extracts the main latent sources of risk, the TVP-VAR model captures changing interactions among these sources, and Bayesian MCMC estimation ensures that the model can be implemented in a stable and flexible way. Together, these methods form the basis for constructing a time-varying systemic risk index that is capable of reflecting the evolving nature of China's financial system.

4. Data

This study is based on a comprehensive dataset consisting of 38 macro-financial variables that capture different dimensions of China's financial system. These variables are selected to reflect key aspects of systemic risk, including credit conditions, financial markets, the external sector, interest rates, and fiscal indicators. By incorporating a broad range of variables, the dataset aims to provide a comprehensive representation of the macro-financial environment and the multiple sources of systemic risk.

In terms of data sources, the variables are collected from widely used and reliable databases, including CEIC, Wind, and official statistical releases from government institutions. These sources are commonly employed in empirical macro-financial research and are generally considered to provide high-quality and consistent data. The sample period spans from 2005 to 2025 at a monthly frequency, which allows the analysis to capture both long-term structural trends and short-term fluctuations in financial conditions. The relatively long sample period also covers several major economic and financial events, making it suitable for studying the dynamics of systemic risk.

Given that the selected variables are measured in different units and may exhibit different levels of volatility, all series are transformed into a standardized form prior to analysis. Specifically, each variable is normalized to have zero mean and unit variance. This standardization process helps eliminate scale differences across variables and ensures that no single indicator dominates the factor extraction process due to its magnitude. In addition, standardization facilitates the interpretation of the extracted factors and improves the stability of subsequent model estimation.

Furthermore, the inclusion of variables from multiple sectors allows the dataset to capture the interaction between domestic and external sources of risk. For example, credit-related variables reflect the role of financial intermediation, while market-based indicators capture asset price movements and volatility. External sector variables provide information on exchange rates, trade dynamics, and capital flows, and fiscal indicators help account for government-related influences on financial stability. The combination of these dimensions makes it possible to analyze systemic risk from a more integrated perspective.

Overall, the dataset provides a solid empirical foundation for the construction of the systemic risk index. Its broad coverage, reliable sources, and consistent preprocessing ensure that the subsequent analysis is both comprehensive and robust. This also enhances the credibility of the empirical results and supports the validity of the conclusions drawn in this study.

5. Empirical Results

5.1 Systemic Risk Dynamics

As illustrated in Figure 1, the estimated systemic risk index (SRI) exhibits pronounced fluctuations over time and closely tracks major financial and economic events. This pattern suggests that the

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constructed index is able to capture the evolution of systemic risk in a dynamic and timely manner.

In particular, several periods of sharp increases in the index correspond to well-known episodes of financial stress. The index rises significantly during the global financial crisis, reflecting the spillover effects of international financial turmoil on China's economy. A similar surge can be observed during the 2015 stock market turbulence, when rapid asset price declines and market instability led to heightened financial risk. More recently, the COVID-19 shock is also associated with a noticeable increase in the index, indicating the substantial impact of global economic disruptions on domestic financial conditions.

These observations demonstrate that the proposed SRI has strong crisis identification ability. The close alignment between peaks in the index and major economic shocks further supports the validity of the measurement framework. In addition, the index does not only react to extreme crisis events, but also captures intermediate fluctuations, suggesting that it reflects both abrupt shocks and gradual changes in financial conditions.

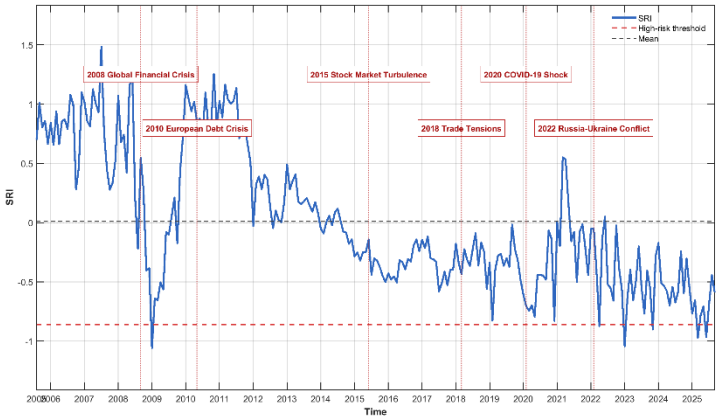

Figure 1. Time-varying systemic risk index (SRI).

5.2 Factor Contributions

Figure 2 reports the time-varying contributions of different risk factors to the overall systemic risk index. The results reveal substantial variation in the importance of these factors across different periods, highlighting the dynamic nature of systemic risk.

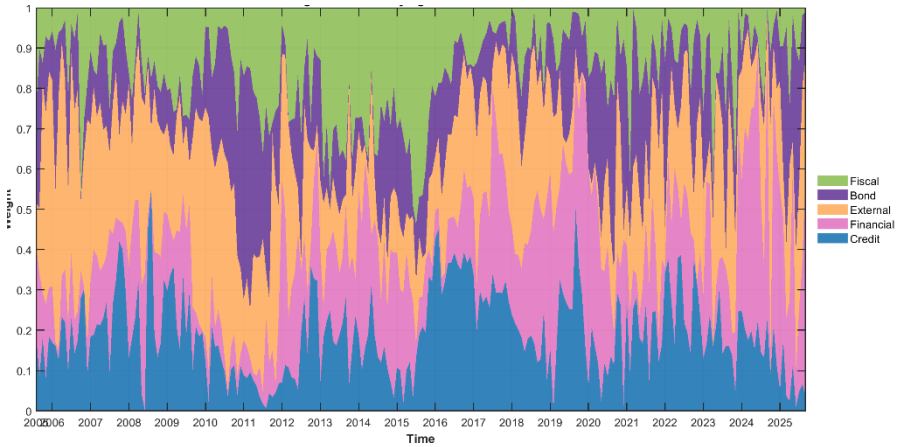

Figure 2. Time-varying Factor Contributions.

In the earlier stage of the sample period, credit-related risks play a dominant role. This finding is consistent with the rapid expansion of credit in China's financial system, particularly during periods of economic stimulus and financial deepening. The increasing reliance on credit as a driver of economic growth during this period is likely to have amplified the contribution of credit-related factors to systemic risk.

In contrast, the importance of external sector risk increases markedly in more recent years. This shift reflects China's growing integration into the global financial system, as well as its increased exposure to international capital flows, exchange rate movements, and global economic cycles. As external

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conditions become more influential, shocks originating outside the domestic economy are more likely to affect financial stability.

In addition, financial market risk exhibits considerable fluctuations over time, especially during periods of asset price volatility. Episodes such as stock market corrections or rapid changes in housing prices are associated with noticeable increases in the contribution of financial factors. This suggests that market-based risks remain an important channel through which systemic instability can emerge.

Overall, these findings indicate that systemic risk in China is not driven by a single source, but rather by the interaction of multiple factors whose relative importance evolves over time. The time-varying contribution structure provides additional insights beyond the aggregate index and helps identify the underlying drivers of systemic risk.

5.3 Time-Varying Effects

The estimation results from the TVP-VAR model further confirm the presence of significant time variation in the relationships among risk factors. The coefficients associated with different factors change across periods, indicating that the transmission mechanisms of systemic risk are not constant.

This time-varying behavior reflects the ongoing structural transformation of China's financial system. Changes in financial regulation, shifts in economic policy, and evolving market conditions can all alter the way in which different risk factors interact. For example, the relative influence of credit expansion, external shocks, and market volatility may differ depending on the macroeconomic environment.

These results highlight the importance of adopting a time-varying modeling framework when analyzing systemic risk. A fixed-parameter model would impose constant relationships over the entire sample period and may therefore fail to capture important structural changes. In contrast, the TVP-VAR approach provides a flexible tool for identifying evolving dynamics and offers a more accurate representation of the financial system.

Taken together, the empirical findings suggest that systemic risk in China is inherently dynamic, both in terms of its overall level and its underlying drivers. This reinforces the need for continuous monitoring and adaptive policy responses in order to effectively manage financial stability.

6. Robustness Checks

The robustness of the proposed index is further illustrated in Figure 3. As shown in Panel A, the systemic risk indices obtained under alternative lag specifications remain highly correlated with the baseline measure. This indicates that the overall dynamics of the index are not sensitive to the choice of lag length in the underlying model. In other words, varying the lag structure does not materially affect the measurement of systemic risk, suggesting that the baseline specification provides a stable representation of the data.

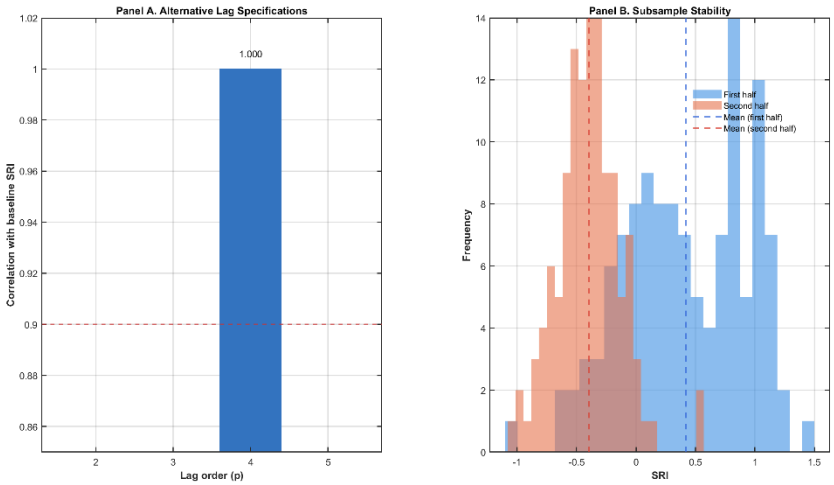

Figure 3. Robustness comparison under alternative specifications.

Panel B shows that the distributional properties of the index are broadly stable across subsamples. Although some differences in mean and dispersion can be observed between the first and second halves

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of the sample, the overall distributional patterns remain similar. This suggests that the statistical characteristics of the index are not driven by a specific period, but instead reflect persistent features of the financial system. Such stability is particularly important in the context of emerging economies, where structural changes may occur over time.

Taken together, the results in Figure 3 provide strong support for the reliability of the empirical findings. The consistency of the index across alternative specifications implies that the proposed methodology is robust to model choices and sample variations. This enhances confidence in the validity of the constructed systemic risk index and its ability to capture the underlying dynamics of financial risk.

7. Conclusion

This paper proposes a time-varying systemic financial risk index for China within a factor-augmented TVP-VAR framework. By integrating information from a broad set of macro-financial variables and allowing model parameters to evolve over time, the proposed approach provides a flexible tool for capturing the dynamic nature of systemic risk. The empirical results show that systemic risk exhibits substantial time variation and is shaped by multiple interacting factors.

A key finding of this study is the increasing importance of external sector risk in recent years. This pattern reflects China's growing integration into the global financial system and highlights the rising influence of international financial conditions on domestic financial stability. As external shocks become more relevant, fluctuations in exchange rates, global liquidity, and cross-border capital flows can play a more prominent role in shaping systemic risk.

These findings carry important implications for macroprudential policy. In particular, policymakers should take into account not only domestic sources of vulnerability, such as credit expansion and asset price fluctuations, but also external risk factors. A comprehensive policy framework that considers both internal and external dimensions is essential for maintaining financial stability in an increasingly open economy. This result is consistent with the existing literature emphasizing the time-varying nature of systemic financial risk.

More broadly, the proposed framework offers a practical and adaptable approach for monitoring systemic risk in emerging economies. Its ability to incorporate time variation and multiple sources of risk makes it suitable for application in other countries and financial systems with similar structural characteristics. Future research may further extend this framework by incorporating higher-frequency data, exploring nonlinear dynamics, or integrating network-based risk measures to provide a more comprehensive understanding of systemic risk.

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