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The Risk Spillover Effect of China's Financial Market and Real Economy——Based on Network Correlation Analysis

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Abstract

Financial security is crucial for the development of the Chinese economy owing to the complex interconnections between the financial market and the real economy. This study employs the generalized variance decomposition method to construct a two-way risk spillover model between China's financial market and the real economy. It investigates the two-way risk spillover trans- 4 mission and risk hedging in different markets when facing external shocks over the past four years. Firstly, following external shocks, both the overall market's total risk spillover and individual markets' risk spillover exhibit different characteristics and effects across various periods. Secondly, convertible bonds in the bond market, along with the securities lending, margin trading and short selling in the stock market, are identified as key channels for cross-market financial transmission. This study underscores the importance of coordinated economic growth and financial risk management, thereby enhancing our understanding of the relationship between China's financial markets and the real economy.

Keywords: risk spillover, real economy, financial markets, financial security, transmission chan-nels

1. Introduction

The Communist Party of China (CPC) pointed out in its report to the Twentieth National Congress that it would "insist on focusing its economic development efforts on the real economy" and "prevent the transmission of risks across institutions, markets and borders" (People's Republic of China., 2022). This means that China will focus on preventing systemic financial risks while developing the real economy.

Systemic risk can originate from within or outside the financial system, or can result from the interconnectedness of specific financial institutions and markets with the real economy (Chakrabarty, K. C., 2012). In 2011, the International Monetary Fund (IMF) and the Bank for International Settlements (BIS) defined systemic financial risk as the risk of disruption to financial services, which could lead to severe adverse impacts on the real economy as a result of partial or complete damage to the financial system (National Health Commission, 2022). (Li, 2021) argued that owing to the intricate interconnections between various industries within the real economy and different markets within the financial industry, risks may spill over from financial markets to the real economy or vice versa. Consequently, researchers have focused on the risk relationships between financial markets and the real economy.

As the world's second-largest economy as of August 2024, China's economic de- velopment and the stability of its financial system have become crucial contributors to global economic stability. Fang et al. (2021) proposed that over the past three decades years of rapid economic development in China, the relationship between the financial sector and the real economy has become increasingly intertwined (Fang et al., 2021). Domestically, the sudden outbreak of the COVID-19 pandemic in December 2019 prompted the Chinese government to implement various policies to provide financial support to the real economy (People's Bank of China., 2020). This further strengthened the interconnectedness between China's domestic financial market and the real economic sectors. Internationally, the Rus-sia–Ukraine conflict in February 2022 led to global economic fluctuations, which heightened the uncertainty and risks between China's financial sector and the real economy. Therefore, exploring the cross-market spillover and feedback effects of financial risks in recent years are crucial for preventing and mitigating major financial risks and realizing sustainable economic development.

This study uses the Chinese market as a case study to examine the impacts of external events, such as the abrupt onset of the COVID-19 pandemic and the Russia–Ukraine conflict, on the financial and real sectors. This investigation addresses three main questions: (i) What are the dynamic changes in the characteristics of risk spillover across markets and how are risks hedged after these events? What are the risk-transmission channels between various key financial mar-kets and the real economy? Exploring these questions can effectively assist regulatory authorities in preventing and resolving systemic financial risks, thereby helping to achieve stable economic growth.

This study contributes to the literature by examining the stabilizing roles of diverse Chinese markets during recent external shocks, expanding the scope of empirical cases. It provides a nuanced understanding of individual market contributions to economic stability and risk hedging within China's unique context. Furthermore, by investigating the internal risk-transmission mechanisms within key financial markets, this research offers a more granular perspective for regulators, highlighting the importance of focusing on specific financial market activities for effective systemic risk management.

Firstly, this study examines the bidirectional risk spillovers and hedging effects between the real economy and the financial market under external shocks, and assesses the stabilizing functions of each market across different time periods. Secondly, it identifies key financial markets based on the intensity and volatility of spillovers. Thirdly, by catego- rizing these key financial markets according to business types, the study investigates the transmission channels of risk spillovers and the feedback mechanisms between financial activities and the real economy (see Figure 1). Finally, it conducts sensitivity analyses, robustness tests, and comparative evaluations against existing studies.

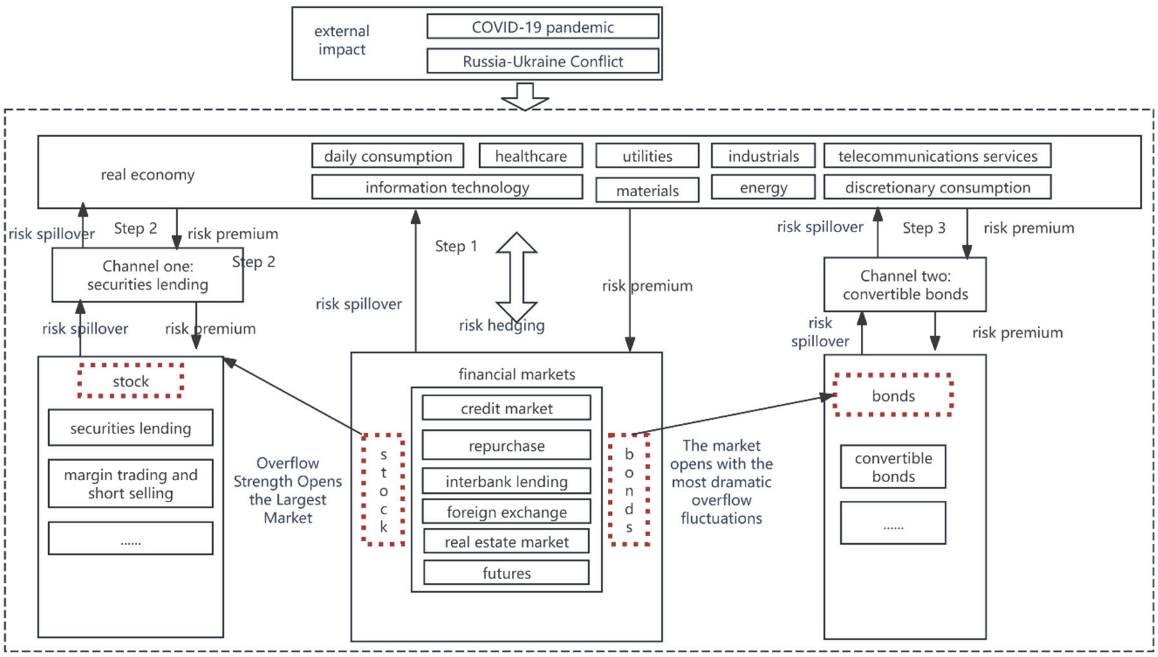


Figure 1. Framework of research

This paper is organized as follows: Section 2 offers a comprehensive literature review. Section 3 details the model specification and data selection. Section 4 analyzes market spillover effects. Finally, Section 5 presents the conclusions and policy recommendations.

2. Literature Review

Systemic risk is a complex issue that has garnered significant attention from academia and industry in recent years. Following the 2008 financial crisis, awareness of systemic risk has deepened. (Fang, 2023) identified three stages in the evolution of systemic risk: (1) risk shocks, which trigger systemic financial risk; (2) cross-contagion within financial markets, acting as an "amplifier" of systemic risk; and (3) the cross-transmission between financial markets and the real economy, serving as a "diffuser" of systemic risk, as the final link leading to systemic risk. Understanding how risks spread between financial markets and the real economy is thus crucial.

Most studies on risk spillover between the financial sector and the real economy focus on analyzing interconnections and risk spillover scenarios (Pacelli et al., 2022; Gao et al, 2021; Fang et al., 2021).

In terms of relevance (Li et al., 2019) constructed a systemic risk spillover network among Chinese industries from 2002 to 2017, identifying the overall interconnectedness of the financial network and the sector characteristics. Their empirical analysis revealed complex network properties in Chinese financial institutions, such as small world phe- nomena and scale free characteristics. Their empirical analysis revealed complex network properties in Chinese financial institutions, such as small world phenomena and scale free characteristics (Hu et al., 2023) quantitatively analyzed the continuous impulse impact of major crises on the level of bidirectional risk spillovers by using a smoothed local projection model, pointing out that the real economy has a strong net risk spillover characteristic, has a high level of risk correlation with the four major financial markets, and has an important position in the network. However, in recent years, studies have focused more on the cross-market spillover and transmission of risks between financial markets and the real economy.

In terms of risk spillovers, (Ma & Hu, 2021) constructed an extreme risk network among financial entities to examine factors influencing risk spillover levels within the financial sector. From the perspective of extreme risk spillovers, their research highlighted nonlinear characteristics in systemic financial risk transmission across sectors during external shocks from 2013 to April 2020. (Pacelli et al., 2022) identified asymmetric effects of extreme risk spillovers from financial markets to the real economy. They examined the bidirectional spillover effects among financial markets, key financial submarkets, and real sectors post external events occurring over the past three years. Moreover, they explored cross-market transmission mechanisms of these risks (Bai & Wang, 2024) found that exogenous events often trigger financial markets to become the primary channels for risk transmission, while the real economy acts as a risk convergence and absorption point. This dynamic can form multiple risk spillover loops, amplifying risks between financial markets and the real economy.

Regarding cross-market transmission of risks, the literature has extensively inves- tigated the transmission of risk across sectors following sudden risk events (Bilio, 2012; Fink, 2015; Abuzayed, 2021; Wang, 2022; Yang, 2020). For instance, (Rizan et al., 2022) examined how macro variables spread through specific transmission channels among different sectors within a country, while (Zhang et al., 2020) explored the cross sector transmission of tail risk networks. However, there is a lack of exploration into the transmission mechanisms or channels that are specifically based on financial activities and instrument types within the financial sector. To quantify and measure the process of risk transmission more accurately, scholars have proposed many quantitative models in recent years.

In terms of risk metrics, some studies have employed quantitative methods, such as LASSO quantile regression (Hautsch et al., 2015), and TENET (Härdle et al., 2016) to measure risk. In recent years, metrics based on the financial network perspective have become important research tools. Various scholars (Fang et al., 2021); (Hu et al., 2023); (Bai & Wang, 2024)) have utilized financial market data to construct risk networks and employed complex network analysis techniques to quantify cross-market risk transmission and systemic risk levels. For instance, (Diebold & Yılmaz, 2014) introduced the con-cept of complex networks and developed a generalized variance decomposition model to address limitations in existing risk network construction methods related to the inadequate characterization of risk spillover intensity and direction. (Pericoli & Yilmaz, 2024) analyzed volatility spillovers across the global stock, bond, foreign exchange, and commodity mar- kets from 2007 to 2022 using the Diebold Yilmaz connectedness methodology, and found that stocks are the asset class that generated the highest level of volatility connectedness to others, followed by bonds and foreign exchange. Commodities are the asset class that receives the most connectedness from other asset classes.

Compared with other major economies, China’s risk spillover effect shows unique characteristics. For example, among the largest economies, the United States is identified as the main contributor of risk spillovers and China is an important recipient (Bai et al., 2019). During the COVID-19 pandemic, risk spillovers from China to other BRICS countries have increased, while its stock market remains resilient to external shocks (Cheng et al., 2021). In Asia, China shows a strong risk spillover effect, especially during the financial crisis event (Zhao & Park, 2024). Globally, the United States is a key spreader and receiver of risk spillovers, with strong economic risk correlation with other major economies (Bai et al., 2019).

While the aforementioned studies have contributed to the analysis of extreme risk estimation and factors affecting it, some areas still need improvement. First, when examin- ing research events, earlier studies often rely on events from the distant past. Majority of scholars (Hu et al., 2023; Tang J et al., 2024) have neglected the significant disrup- tions affecting various global domains, including politics, economics, and public health, when studying risk events over the past four years. The repercussions of these events are exceptionally far reaching and destructive. Conversely, crises in the Chinese market in the past decade have primarily had local effects, although they also caused large risk shocks. These crises include "cash crunch" in China's money market in 2010, 2013 and 2016, the stock market crash in China's stock market in 2015, and the default of AAA rated state owned enterprise bonds such as Brilliance Bond, Yongcheng Coal Bond and Unigeng Bond in 2020. Although these events also caused large risk shocks, the crises have resulted in primarily local effects. Second, regarding the research process, more scholars (Abuzayed et al., 2021; Rizan et al., 2022; Zhang et al., 2020) have studied risk spillovers across markets. Studies on the role of different markets in overall economic stability following a risk shock are scant. Third, regarding influencing factors, few studies have explored the mechanism of transmission between the key financial markets and the underlying real economy. Instead, various scholars have focused on one or several financial markets and concluded that the stock market or bond market were important risk spillover markets. For instance, (Deng & Xie, 2020) found that the stock market and the real estate market were enhanced by the spillover effect of cyclical fluctuations in other financial submarkets in recent years. (Li et al., 2021) found that the money market was the center of the risk spillover network when the financial crisis occurred. (Hu et al., 2023) found that in the events after the 2008 financial crisis, the money market often had a high level of network importance, the risk spillover level in the bond market was relatively large, and the risk spillover level in the foreign exchange market was relatively high. However, the current literature is yet to identify the businesses that account for the main risk factors in key financial markets.

This study contributes to the literature primarily as follows:

First, in the face of the shock of external emergencies in the past four years, explore the role played by various markets in the overall stabilization of economic growth. It expands the boundary of research cases.

Second, this study explores how China's different markets contribute to economic stability and risk hedging amid cross-market spillovers. The findings allow for a more comprehensive understanding of the influence of various markets on the economy. In the face of external shocks, the impact and measures taken by countries around the world are different, but the reaction of the Chinese market and the measures taken by the Chinese government are still of reference significance.

Third, the study investigates by "opening up" the key financial markets discovered to explore the risk-transmission mechanism between the core business of key financial markets and the real economy. The literature (Billio et al., 2012; Fink and Schuler, 2015; Rizan et al., 2022; Lai and Hu, 2021) has few explorations on risk-transmission mechanisms based on internal business within financial markets. Building on and expanding the literature on cross-market risk transmission mechanisms, this study seeks to provide regulators with a more comprehensive perspective. Specifically, regulators should not only focus on the relationships between various financial and real sectors but also prioritize specific financial markets within key sectors. Given the global availability of these financial services, this study aims to assist regulators worldwide in addressing the challenges of risk transmission across markets and fostering the stability and sustainable development of financial systems.

3. Model Specification and Data Selection

3.1 The Definition and Measurement of Generalized Variance Decomposition

Diebold and Yılmaz's (2014) approach to connectedness is based on assessing shares of forecast error variation in various locations (firms, markets, tries, etc.) due to shocks arising elsewhere. This method combines the vector autoregressive (VAR) variance decomposition theory with the network topology theory, constructs the weighted directed network through the VAR variance decomposition results, and then measures the connectivity and systemic risk among markets. Through this method, it is possible to capture the different strengths of different connections as well as the time variability of connectivity. When the correlation of each market increases due to an external shock, its measured Diebold and Yılmaz (DY) spillover index will increase synchronously.

The generalized variance decomposition model aligns with the systemic risk for two (Fang & Shao, 2022). Therefore, this study employs generalized variance decomposition by (Diebold & Yılmaz, 2014) to analyze the spillover and feedback effects between financial markets in real sectors.

Vector autoregressive model (VAR) process: $X_t = \mu + \Phi_1 X_{t-1} + \ldots + \Phi_p X_{t-p} + \varepsilon_t$, where, $Xt = (x_{1,t}, \ldots, x_{N,t})$ is an

N-dimensional column vector, $x_{i,t}$ representing the financial pressure of market i in period t; μ is the $N \times 1$ dimensional column vector, Φ_i is the $N \times N$ dimension matrix, $\varepsilon \sim (0, \Sigma)$.

Under the generalized variance decomposition, the proportion of the h-step forecast error variance of x_i explained by x_j is $(\theta_H)_{ij}$:

$$(\theta_H)_{ij} = \frac{\sigma_{ij}^{-1} \sum_{h=0}^{H-1} \left(e_i' \Psi_h \sum e_j\right)^2}{\sum_{h=0}^{H-1} \left(e' \Psi_h \sum \Psi_h' e_i\right)}, H = 1, 2, 3, \ldots \quad (1)$$

Since $\Sigma_{i=1}^{N}$ $(\theta_H)_{ij}$ $\neq 1$under generalized variance decomposition, $(\theta_H)_{ij}$ is generally normalized to:

$$(\tilde{\theta}_H)_{ij} = \frac{(\theta_H)_{ij}}{\sum_{j=1}^{N} (\theta_H)_{ij}}, H = 1, 2, 3 \ldots \quad (2)$$

Here, $(\tilde{\theta}_H)_{ij}$ can measure the level of spillover from market j to market i in the forecast period H, and $\tilde{\theta}_H$ can help us identify the structure of financial stress spillover among multiple submarkets.

The total spillover index measures the level of total spillover from financial stress:

$$S(H) = \frac{\sum_{j,i=1, j\neq i}^{N} (\tilde{\theta}_H)_{ij}}{\sum_{j,i=1}^{N} (\tilde{\theta}_H)_{ij}} \times 100 = \frac{\sum_{j,i=1, j\neq i}^{N} (\tilde{\theta}_H)_{ij}}{N} \times 100 \quad (3)$$

Directional spillover indices $S_i \cdot (H)$ and $S_{\cdot i}(H)$ measure the level of spillover from market i to other markets and spillover to other markets respectively:

$$S_i \cdot (H) = \sum_{j=1, j\neq i}^{N} (\tilde{\theta}_H)_{ij} \times 100, S_{\cdot i}(H) = \sum_{j=1, j\neq i}^{N} (\tilde{\theta}_H)_{ji} \times 100 \quad (4)$$

VAR models may also fail to adequately capture spillovers at different frequencies, ignoring differences between short-and long-run spillovers. Finally, VAR variance decomposition mainly focuses on the variance decomposition of forecast errors, rather than directly measuring the causal relationship between variables.

3.2 Sample and Data Description

The primary dependent variables are obtained based on representations of the real economy and financial market volatility and within the study's framework established in this study. For the measurement index of the real economy, Hu et al. (2023) selected the year-on-year growth rate of industrial added value to reflect the development of the real economy. Although this index is the commonly used index to comprehensively measure a country's economic development, it only has a monthly frequency. It cannot reflect the changes in risks in a timely manner, nor can it measure the risks of different real industries. Thus, it cannot be applied to the problems proposed in this study. As an alternative, a large number of scholars, such as (Li et al., 2019; Bai & Wang, 2024; Hu, 2021) adopted the real industry index, which selects representative enterprises in various fields and covers the real industry comprehensively, so it can reflect the basic performance of the industry. This study selecting Wind industry indices to investigate the systemic risk spillover effects among different markets in the real economy. The Wind index's primary industry classification includes nine non-financial industry indices: namely consumer staples market (CSM), commodity market (COM), utilities market (UM), industrials market (IM), energy market (EM), information technology market (ITM), health-care market(HM), telecommunications services market (TCSM), and consumer discretionary market (CDM). Regarding financial markets, the analysis framework is synthesized from existing literature practices (Yang, 2020; Deng and Xie, 2020; Sun and Jiang, 2022; Li. 2021; Guo and Du, 2014; Peng and Zhu, 2019) and the analysis framework primarily encompasses stock market(ESM), interbank lending market (ILM), repurchase market (RM), bonds market (BM), futures market (FM), foreign exchange market (FEM) and real estate market market (REM), constituting a total of seven financial markets. Based on the literature (Yang, 2020; Fang et al., 2021; Li et al., 2021), the following indicators are selected: The CSI 300 Index for the stock market; the seven-day weighted average interbank offered rate for the interbank lending market; the seven-day repurchase rate for the repo market; the ChinaBond Composite Index for the bond market; the Nanhua Comprehensive Index for the futures market; the spot exchange rate of the US dollar to Chinese renminbi (RMB) for the foreign exchange market and the Shenwan Industry Index for the real estate market.

To explore the bidirectional spillover effects and transmission mechanisms of internal submarkets in the stock market on the real economy, this study refers to relevant literature (China Securities Regulatory Commission, 2015; Shanghai Stock Exchange, 2018; Shanghai Stock Exchange, 2020; China Securities Regulatory Commission, 2020). The stock market is divided into four submarkets based on different methods and stock trading characteristics: stock pledge repo (SPR), margin trading and securities lending (MTSL), securities lending (SEL), and agreed repurchase securities (ARS). From theWind database, the selection is based on the trading volume of the stock pledge repo, the trading volume of margin trading and securities lending, the end-of-period balance of securities lending, and the repurchase trading volume of agreed repurchase securities.

To further explore the impact of different types of bonds on real industries after the outbreak of the pandemic, this study selects 13 first-class bond indexes of Chinese bond companies, namely local government bond index (LGB), import and export bond index (IEB), national development bond index (NDB), Chinese government bonds index (CGB), financial bond index (FB), China Railway bond index (CRB), corporate bond index (COB), credit bond index (CB), real estate bond index (REB), green bond index (GB), convertible bond index (CONB), and agricultural development bond index (ADB). All the data are sourced from theWind database (www.wind.com.cn).

(Ouyang & Zhou, 2022) divided risk elements into procyclical risk, credit risk, price risk, and liquidity risk. The indicators can measure the cross-market price risk contagion and liquidity risk between the financial market and the real economy, and the credit risk contagion between the bond market and the real economy. The sample period spans from January 1, 2017, to December 27, 2022. This study employs the logarithmic return series of each variable and subsequently estimates the corresponding volatility series using the GARCH (1,1) model. The descriptive statistics are shown in Table 1. As (Chao et al., 2017) indicated, this model provides a straightfor- ward economic interpretation and accurately captures fluctuations in financial asset prices. Regarding skewness and kurtosis, the volatility series is characterized by a right-skewed distribution with "sharp peaks and thick tails". Finally, the result of the Augmented Dickey- Fuller (ADF) smoothness test confirms that the original hypothesis (existence of unit root) is rejected for each series at a 1% significance level. This indicates that the volatility series is stable and suitable for the VAR model (Li et al., 2021).

4. Comprehensive Analysis of the Market Spillover Effects

The following analysis is based on four aspects. First, we examine the dynamic spillover effects and roles played in both the overall market and individual markets when affected by external events. Second, we test different market risk hedging mechanisms. Third, we investigate the bidirectional risk spillover effects and transmission mechanisms within stock submarkets in key financial markets. Fourth, we explore the risk bidirectional spillover effects and transmission mechanisms within bond submarkets in key financial markets.

4.1 Analysis of the Spillover Effects Between the Chinese Financial Market and the Real Economy

4.1.1 Overall Market Spillover Effect Analysis

Considering the literature (Li et al., 2022) on static analysis, there exists a possibility of overlooking the fluctuation overflow at different times after external events impact; therefore, a deeper analysis of its relevant characteristics is imperative. Drawing on established methodologies (Diebold & Yılmaz, 2014; Fang et al., 2021), this study employs a rolling window approach with a 200-day window and a 10-day rolling step to estimate volatility spillovers. Based on these estimates, a corresponding index time series is constructed to capture the temporal dynamics and structural characteristics of cross-market interactions. Furthermore, a comprehensive analysis is conducted, as illustrated in Figure 2. To test the sensitivity of the index to the choice of VAR lag order, the methodology of Diebold and Yılmaz (2014) is applied, with lag orders set at one, three, and five. The findings indicate that the index exhibits consistent dynamic patterns and is largely robust to variations in lag specification.

Owing to the inclusion of multiple external events during the sample period, this study categorizes the experimental timeline into three phases, presented in Table 2. This delineation is based on the *White Paper on China's Response to the COVID-19 Pandemic* (People's Bank of China, 2020b) and the timing of the Russia–Ukraine conflict. The COVID-19 outbreak is identified as the emergency phase, from December 27, 2019, to January 19, 2020, according to the National Health Commission's (NHC) announcements. Subsequently, owing to China's reclassification of the COVID-19 as a "Class B" infectious disease in December 2022 (Chakrabarty, 2012), the period from January 19, 2020, to December 27, 2022, is defined as the pandemic prevention and control phase.

Table 1. Descriptive statistics of the real sector and financial market volatility

	Variable	Mean	Standard deviation	Minimum	Maximum	Skewness	Kurtosis	ADF test
Financial markets	Stock market	0.18	0.06	0.08	0.45	1.03	1.00	-5.428***
	Interbank borrowing market	1.38	0.37	0.84	3.73	1.54	4.10	-5.667***
	Repurchase market	0.54	0.22	0.34	1.83	2.30	6.58	-7.118***
	Bond market	0.01	0.00	0.01	0.05	5.45	46.73	-16.096***
	Futures market	0.16	0.04	0.10	0.30	0.84	0.82	-3.658***
	Foreign exchange market	0.03	0.01	0.02	0.09	1.68	3.44	-3.912***
	Real estate market	0.24	0.07	0.11	0.54	1.11	0.96	-5.751***
	Energy market	0.23	0.08	0.12	0.55	1.31	1.69	-5.111***
	Commodity market	0.23	0.05	0.17	0.53	1.90	5.21	-8.858***
Real sector	Industrial market	0.21	0.04	0.15	0.51	2.14	6.80	-8.914***
	Consumer discretionary	0.20	0.06	0.10	0.52	1.33	2.18	-5.665***
	Consumer staples	0.23	0.07	0.12	0.47	0.88	0.52	-5.358***
	Healthcare	0.23	0.06	0.11	0.46	0.37	-0.16	-5.114***
	Information technology	0.27	0.06	0.17	0.49	1.05	1.04	-3.960***
	Telecommunications	0.24	0.09	0.12	0.65	1.09	1.13	-4.923***
	Utilities	0.17	0.06	0.09	0.45	1.36	2.40	-5.358***

*** indicates significance at the 1% level.

Table 2. Crisis event occurrence and event phases

Crisis events	**Event phases**		**Specific dates**
COVID-19 pandemic	Pre-pandemic		January 1, 2017–December 27, 2019
	Post-pandemic	Pandemic outbreak	December 27, 2019–January 19, 2020
		Pandemic control	January 19, 2020–December 27, 2022
Russia–Ukraine conflict	Post-Russia–Ukraine conflict		February 15, 2022–Today

Figure 2 shows that the overall overflow index experienced a sharp increase in January 2020, remained relatively high and stable from February to August 2020, rapidly declined from August 2020 to February 2022, and gradually increased after February 2022. During the pandemic outbreak phase, characterized by a significant surge in the overall spillover index in January 2020, both the financial sector and the real economy were affected to varying degrees.

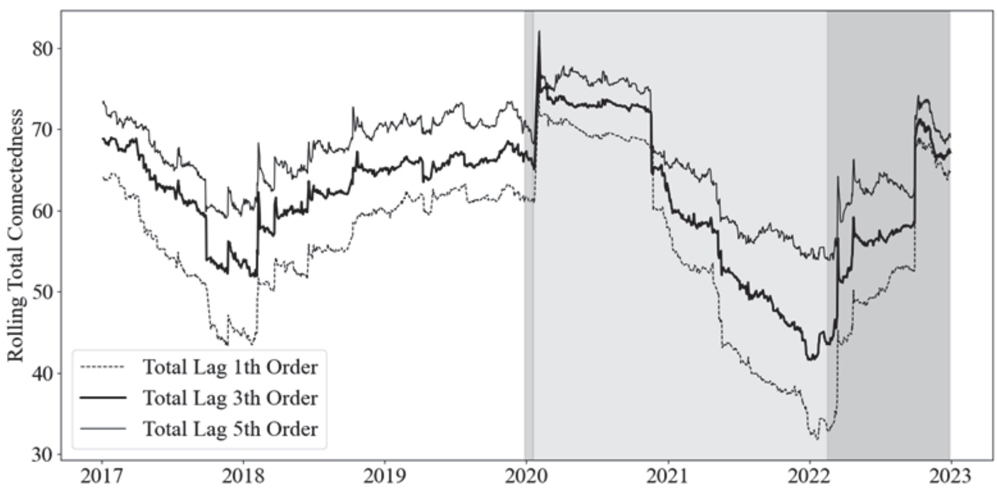


Figure 2. Dynamic changes of the overall spill index (January 1, 2017 to December 27, 2022)

The COVID-19 prevention and control phase (Figure 2) can be classified into two main periods. First, from February 2020 to December 2021, following the sudden outbreak of the pandemic, the Chinese government proactively initiated comprehensive efforts in epidemic prevention and control, responding to the crisis by implementing a series of robust measures. Consequently, this successfully curtailed the spread of the virus, maintained social stability, and mitigated the negative impact of the pandemic. This is specifically reflected in the overall high and stable trend of the total spillover index from February to August 2020, followed by a rapid decline from August 2020 to December 2021, indicating the effectiveness of the policies enacted by the Chinese government in response to the pandemic.

Second, from January 2022 to October 2022, as the nationwide epidemic prevention and control entered the new normal phase (People's Bank of China, 2020b; Liu, 2020), China succeeded in obtaining mass participation in medical assistance efforts and the large-scale provision of essential supplies. Simultaneously, owing to the "emergency brake" applied to the national economy, a noticeable economic downturn persisted, which negatively affected the macroeconomic demand and supply (Hu, 2021). While the government attempted to alleviate adverse effects through various policies, the negative impacts gradually increased, making it challenging for these policies to provide effective relief by 2022.

The global economic uncertainty generated during the outbreak phase of the Russia–Ukraine conflict had adverse external effects on the Chinese economy, as evidenced by the gradual increase in the total spillover index after February 2022. This indicates that the negative impact of the "emergency brake" on the national economy diminished through policy adjustments.

4.1.2 Analysis of the Single Market Spillover Effect

Owing to the presence of both positive and negative cross-market risk transmissions in the overall spillover index, and to better examine the volatility patterns and functional roles of different markets following the outbreak of the COVID-19 pandemic, we further decompose the total index. This allows us to identify the directional flow of risks from various financial markets and sectors to others, as illustrated in Figure 3. We analyze four distinct time intervals following the occurrence of external events. During the pandemic outbreak phase, both the financial sector and the real economy were affected to varying degrees. Trends during the pandemic prevention and control phase can be divided into three main parts (Figure 3).

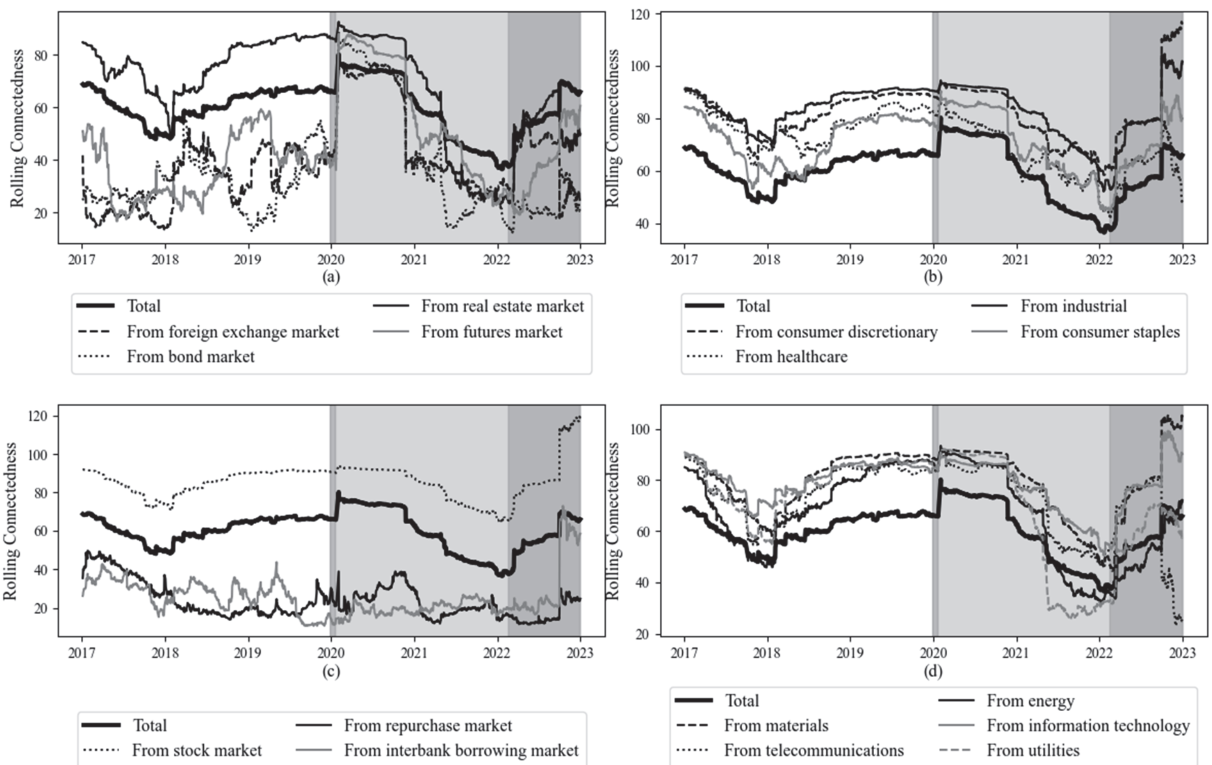


Figure 3. Dynamic changes in the market spillover index across various markets (January 1, 2017 to December 27, 2022). (a, c) compare the volatility of risk spillovers in various financial markets with the total spillover index; (b, d) compare the volatility of risk spillover in various entity industries with the total spillover index

The first section covers the period from February 2020 to August 2020. Figure 3 shows that: (1) all the real sectors consistently maintained a high level of risk spillover above the total spillover index. This indicates that China's real sector is exposed to significant systemic risk. When impacted by external events, risks are transmitted through the "real sector–finance–real sector" mechanism (Hu, 2021). As shown in Figure 3, after the outbreak of the epidemic, the risk in the real sector surged. Despite two years of risk mitigation, it escalated again following the Russia–Ukraine conflict. Various financial markets, including real estate, stocks, bonds, and futures, consistently maintained a high-risk spillover status above the total spillover index. This is because the real estate and stock markets are the most active investment markets in China, attracting the widest range of investor participation. Their fluctuations directly reflect investor expectations of the financial market and the real economy, often becoming the starting point for systemic risk transmission caused by external shocks. Due to the bidirectional risk spillover relationship between the stock, bond, and futures markets, investors allocate assets between these markets based on their risk preferences, resulting in a high correlation between markets (Zhang, 2024).

(2) Interbank lending and repurchase markets fluctuated below the total spillover index, maintaining a relatively low-risk spillover status. This is because China's current financial system mitigates liquidity risk impacts through the creation of interbank lending and repurchase markets, and manages interest rate and exchange rate risks by participating in derivative markets (Fang, 2023). At the beginning of 2020, the People's Bank of China, along with relevant departments, issued the *Notice on Further Strengthening Financial Support for the Prevention and Control of Novel Coronavirus Pneumonia Epidemic* (People's Bank of China, 2020a), which proposed 30 measures covering areas such as monetary credit and financial services. During this period, the pandemic significantly impacted real sectors, with financial markets critically supporting pandemic prevention, economic recovery, and stability maintenance. Figure 3 shows that the interbank lending and repurchase markets fluctuated violently during the pandemic, gradually stabilized, and then the risk increased.

The second section covers the period from August 2020 to December 2021. As depicted in Figure 3, the risk spillover indices of all real sectors declined rapidly: (1) The energy and utility sectors experienced the most significant decline, from 85% to 33%, while the other real sectors decreased to approximately 50%. (2) The risk spillover indices of the various financial sectors remained stable, with some showing an increasing trend, including the interbank lending, repurchase and bond markets. This suggests that during this period, the real sectors played a stabilizing role in the economy.

The third section covers the period from January 2022 to October 2022. As illustrated in Figure 3, the risk spillover indices of both the financial and real sectors show varying degrees of increase. This indicates that owing to the pandemic's continued expenditures on prevention and control due to the pandemic and the increasing international uncertainties, the risk management capabilities of the financial and real sectors have been weakened, making it challenging to effectively offset risk spillovers through internal transmission and mitigation mechanisms. Prolonged uncertainty has heightened risk aversion among investors and consumers, increasing market volatility and amplifying risk spillovers. The overall rise in the risk spillover index for both the financial and real sectors reflects the heightened demands on risk management capabilities in a complex and volatile economic environment.

In the post phase of the outbreak of the Russia–Ukraine conflict, as depicted in Figure 3, risk premium indices for various industries increased in varying degrees. Specifically, all real sectors exhibited a rising trend in risk, with the financial sector witnessing an increased risk in the foreign exchange market, futures market, and real estate sector. This can be attributed to the heightened challenges in maintaining the stability of the RMB during the Russia–Ukraine conflict, coupled with turbulence in commodity markets and restricted international trade. During this phase, the bond, credit, interbank lending, and repo markets exhibited declining risk trends, effectively serving as stabilizing factors for the economy.

This study segments key financial markets to analyze the risk transmission mechanisms of various financial markets to the real economy more accurately. Bidirectional risk spillovers are ranked based on their intensity and the degree of risk volatility during external shocks, with the stock market showing the highest net risk spillover intensity (Table 3). Considering the degree of risk spillover volatility, the bond market exhibits the most pronounced volatility. The bond market connects the creditor's rights and debts between finance and real sectors. By June 2024, the total market value of China's stock market exceeded \$10 trillion, while the total size of China's bond market exceeded \$22 trillion, both ranking second in the world. Due to its large scale, its risk spillover impacts other financial markets in China, the real economy, and other countries in the world. Despite the Chinese government's implementation of various financial policies to support the real economy (China Securities Regulatory Commission, 2020; PRC, 2022), financial institutions, prioritizing the health of their own balance sheets, are compelled to tighten credit in response to emergencies. This results in insufficient capital for real enterprises and an increased risk of debt default (Hu, 2024). Consequently, as shown in Table 4, the volatility of the bond market is the highest at each stage. Given these empirical findings, we conduct a detailed analysis of the Chinese stock and bond markets.

4.1.3 Testing of Risk Hedging Mechanisms

As seen in Figure 4, when the epidemic broke out, the risk of both the financial industry and the real industry rose sharply, after which the risk spillover of the real industry gradually rose and the risk spillover of the financial industry gradually declined, indicating that at this time, China's various financial initiatives (People's Bank of China, 2020a; China Securities Regulatory Commission, 2020) have made the financial industry become the stabilizer of the economy. With the outbreak of the Russian–Ukrainian conflict, the financial sector showed an increasing trend of risk spillovers, and the real sector showed a high level of risk volatility, indicating that the role of financial instruments as a stabilizer was weakening in the face of both internal and external shocks.

Table 5 reveals a single upward trend in the financial sector and real sector during the pandemic. It also reveals that the real sector was most volatile during the pandemic control period, while the financial sector was more stable, which further confirms that the financial sector had assumed the role of a stabilizer at the time.

Table 3. Ranking of cumulative risk net spillover intensity in China's financial markets (January 1, 2017 to December 27, 2022)

	Pre-pandemic				Post-pandemic				Post-Russia–Ukraine conflict			
Industry	Overflow	Overflow return	Netoverflow	Ranking	Overflow	Overflow return	Net overflow	Ranking	Overflow	Overflow return	Net overflow	Ranking
Stock market	136.59	84.1	120.69	1	150.99	80.45	131.44	1	126.99	85.82	112.81	1
Real estate market	98.58	77.38	75.96	2	90.94	61.7	52.64	2	92.29	74.58	66.87	2
Bond market	94.48	17.85	12.33	3	82.23	40.66	22.89	5	85.93	61.28	47.21	5
Interbank lending market	89.8	18.1	7.89	4	93.12	15.46	8.58	6	95.31	58.75	54.06	4
Futures market	84.21	22.31	6.52	5	85.67	50.12	35.79	4	77.49	66.23	11.54	6
Foreign exchange market	87.54	18.72	6.26	6	85.11	21.9	36.79	3	103.41	63.11	66.51	3
Repurchase market	92.24	12.4	4.72	7	98.58	7.81	6.38	7	86.20	54.70	7.42	7

Table 4. Ranking of risk volatility intensity (variance)

	Pre-pandemic	Post-pandemic	Post-Russia–Ukraine conflict	Ranking
Bond market	180.85	403.30	24.95	1
Futures market	84.02	310.69	14.10	2
Real estate market	47.85	304.02	23.92	3
Foreign exchange market	80.87	153.65	31.00	4
Stock market	25.31	62.03	11.18	5
Interbank lending market	70.19	60.96	16.88	6
Repurchase market	106.59	52.00	43.06	7

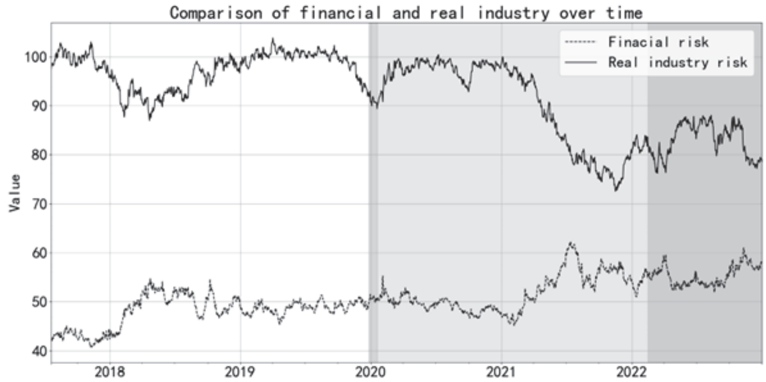


Figure 4. Risk hedging diagram

Table 5. Risk hedging table (January 1, 2017 to October 31, 2022)

	Pre-pandemic		Pandemic outbreak		Pandemic control		Post-Russia–Ukraine Conflict	
	Financial	Real industry	Financial	Real industry	Financial	Real industry	Financial	Real industry
Mean	48.08	97.39	50.59	91.04	52.87	88.30	54.73	83.85
Standard deviation	3.18	3.70	0.41	0.77	3.72	8.26	1.61	3.10
Minimum	40.75	86.93	49.78	89.37	45.16	72.52	51.93	76.22
Maximum	54.84	103.84	51.50	92.98	62.18	100.40	59.64	88.04

4.2 Analysis of Stock Market Segments Spillover Effects and Transmission Mechanisms

4.2.1 Analysis of Stock Market Segments Spillover Effects To further investigate the bidirectional spillover effects and transmission mechanisms of internal submarkets within the stock market in the real economy, we calculate the risk spillover of four submarkets: stock pledge repo, margin trading and short selling (MTSS), securities lending (SEL), and agreed repurchase securities, and construct a risk network diagram, as illustrated in Figures 5–7. Based on Figures 5–7, we calculate the weighted outdegree (spillover) and weighted indegree (spillover return); the results are presented in Table 6. In Table 6, values greater than 0.01 are retained, while values lower than 0.01 are indicated with a backslash. By comparing Figures 5–7 and Table 6, it becomes evident that there are significant characteristics in the risk spillover and spillover return effects between the stock market segments and real sectors before and after the pandemic.

Table 6. Weighted outdegree (spillover) and weighted indegree (spillback) of stock submarkets at various stages in the real sector

Financial market	Pre-pandemic nodal outdegree	Post-pandemic nodal outdegree	Node outdegree after the Russia-Ukraine Conflict	Pre-epidemic node in-degree	Post-pandemic node in-degree	In-degree of nodes after the Russia-Ukraine conflict
Securities lending	0.28	1.59	0.68	0.07	2.46	1.88
Margin trading and short selling	¥	¥	¥	1.58	0.88	0.90

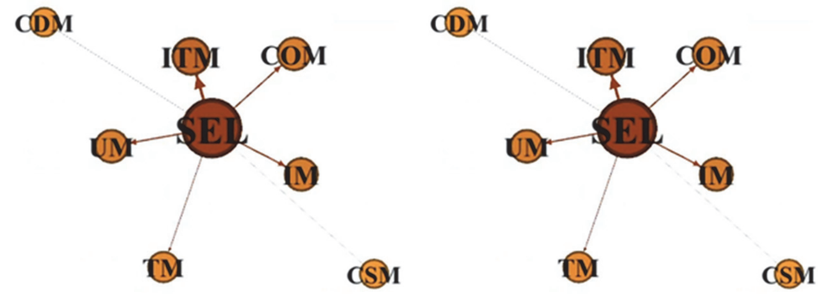


Figure 5. Risk spillover diagram (left) and spillover reversal diagram (right) between submarkets of the stock market and real industries before the pandemic.

The submarket spillover network of the stock market indicates that SEL and MTSS are the key nodes between networks. It can be seen from Figure 5-7 that when impacted by external events, the risk spillover from the short-selling market to the real economy increases, while the risk spillover from the real economy to the securities margin trading market decreases.

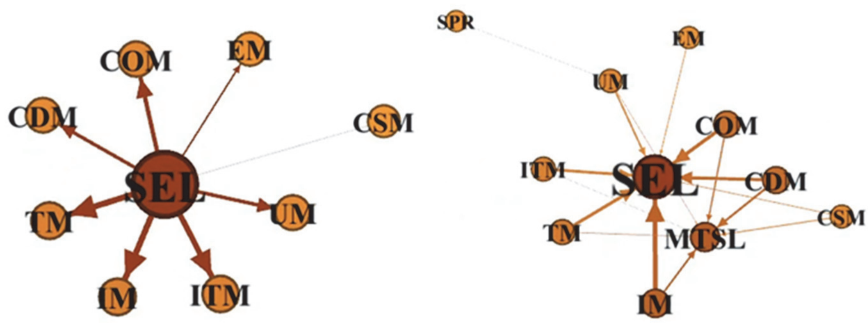


Figure 6. Risk spillover diagram between submarkets in the stock market and real industries after the pandemic (left) and spillover reversal diagram (right).

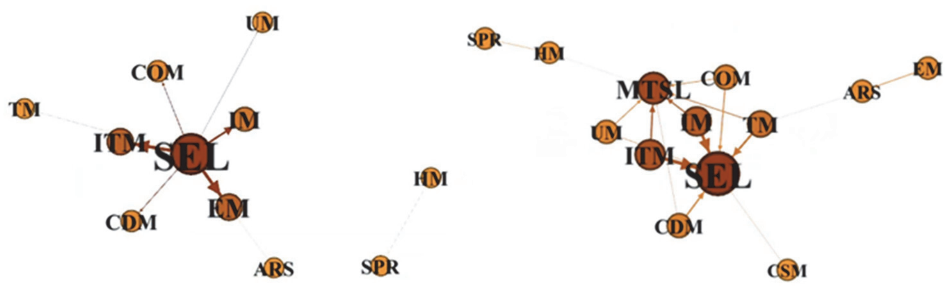


Figure 7. Risk spillover diagrams between stock market segments and real sectors after the Russia–Ukraine conflict (left) and reverse spillover diagram (right).

First, The SEL market exhibited pronounced shifts in risk spillover and reversal dynamics following the abrupt onset of the COVID-19 pandemic and the subsequent Russia-Ukraine conflict. Specifically, concerning risk spillover, the restricted access of SEL transactions to securities firms effectively positioned them as potent short-selling instruments for institutional investors. The introduction of SEL expanded the strategic toolkit of these investors, enabling them to engage in targeted short-selling of individual securities for profit, coupled with simultaneous short positions in stock index futures. This diversified approach allowed for hedging market risks and the potential generation of alpha. However, this increased utilization of short-selling mechanisms, while offering enhanced profit potential for institutional investors, simultaneously amplified the potential for risk spillovers into the broader real economy. Conversely, concerning risk reversal, the performance of the real economy exerted a direct and significant influence on investor sentiment and market behavior. The “sudden stop” experienced by the real economy in the wake of the pandemic triggered liquidity constraints, prompting listed companies to leverage stock pledging as a financing mechanism. This, in turn, precipitated an increase in risk reversal from the real economy back into the SEL market.

Second, following the sudden outbreak of the pandemic and the Russia–Ukraine conflict, risk premiums in the MTSS market diminished for the real sector. Similarly, owing to the abrupt onset of the pandemic, the real sector encountered a shortage of funds; consequently, listed companies channeled available capital into production and operations, resulting in a reduction in risk premium in the MTSS market for the real sector. With lower interest rates, convertible bonds enable other controlling shareholders in the real sector to raise funds rapidly, thus diminishing their willingness to manage real business entities. Simultaneously, the excessive issuance of such bonds can result in listed companies lacking actual controlling shareholders, thereby amplifying risks within the real sector.

4.2.2 Analysis of Submarket Transmission Mechanisms in the Stock Market

To validate the rationality of the critical nodes, this section investigates the mechanism of risk transmission between the financial market and real sectors from the perspective of critical nodes in the network. Based on the quantitative evidence of the relationship between critical node volatility and various real sectors, this study uses annual samples to analyze the correlation coefficients between stock market segments and various real sectors. Owing to the existence of both positive and negative correlations between various real sectors, which leads to the cumulative offsetting of positive and negative correlations, the correlation coefficients can be calculated as follows:

$$\mathrm{corr}_{ii} = \sum_{\xi} \left| \mathrm{corr}_{ii,\xi} \right| \tag{5}$$

Here, ii represents any market within the stock or bond submarkets, ξ any specific industry entity, and corr the correlation coefficient.

$$\mathrm{corr}_{\mathrm{normalize}} = \frac{\mathrm{corr}_{\mathrm{ii}} - corr_{\mathrm{min}}}{corr_{\mathrm{max}} - corr_{\mathrm{min}}} \tag{6}$$

$\mathrm{corr}_{\mathrm{normalize}}$ is a normalization of$\mathrm{corr}_{\mathrm{ii}}$.$\mathrm{corr}_{\mathrm{min}}$ is the minimum of $\mathrm{corr}_{\mathrm{ii}}$, $\mathrm{corr}_{\mathrm{max}}$ is the maximum of $\mathrm{corr}_{\mathrm{ii}}$.

Table 7 shows the correlation coefficients after normalization [0,1], revealing that the correlation coefficients of SEL and MTSS are significantly higher than those of other submar- kets. This indicates that, among stock submarkets, the primary channels for cross-market risk transmission rely on SEL and MT. Therefore, these two markets warrant significant attention from regulatory authorities. In July 2024, the China Securities Regulatory Commission (CSRC) approved the suspension of short selling and short selling business in accordance with the law to further strengthen the countercyclical adjustment of short selling (CSRC, 2024). Whether the short-selling market is permanently suspended or resumed after adjustment needs to be carefully considered.

Table 7. Correlation between the stock market and its submarkets and various industry sectors

Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Ranking**
Securities lending	1.000	1.000	1.000	1.000	1.000	1.000	1
margin trading and short-selling market	0.345	0.000	0.082	0.469	0.359	0.518	2
Pledged repo	0.000	0.090	0.204	0.000	0.458	0.000	3
Repurchase agreements (repos)	0.113	0.094	0.000	0.027	0.000	0.067	4

4.3 Analysis of Bond Market Segments Spillover Effects and Transmission Mechanisms

4.3.1 Analysis of Submarket Spillover Effects in the Bond Market

To further explore the impact of different bond types on the real sector in the bond market after the pandemic outbreak, we calculate the risk spillover within the bond marketto the real sector. We construct a risk network diagram, as shown in Figures 8-10. Subse- quently, we calculate the weighted outdegree (spillover) and weighted indegree (feedback); the results are presented in Table 8. By comparing Figures 8–10 and Table 8, we observe the important characteristics of risk spillover and feedback effects between the submarkets of the bond market and the real sector before and after the pandemic.

Table 8. Interconnectedness (spillover) and interconnectivity (feedback) between the bond submarket and the real sector before and after the pandemic

Financial markets	Pre-pandemic node outdegree	Post-pandemic node outdegree	Post-Russia–Ukraine conflict node outdegree	Pre-pandemic node indegree	Post-pandemic node indegree	Post-Russia–Ukraine conflict node indegree
Convertible bonds	1.03	3.93	3.19	1.71	3.14	2.76
Credit bonds	¥	0.13	0.04	¥	¥	0.06
Government bonds	¥	0.46	0.05	¥	¥	0.01
Corporate bonds	0.01	0.19	0.04	¥	¥	0.01
Railway bonds	¥	0.36	¥	¥	¥	0.42
Exchangetraded green bonds	0.01	0.24	0.02	¥	0.01	0.03
Local government bonds	¥	0.12	0.08	¥	0.01	0.03
Corporate bonds	¥	0.28	0.07	0.11	0.67	0.17

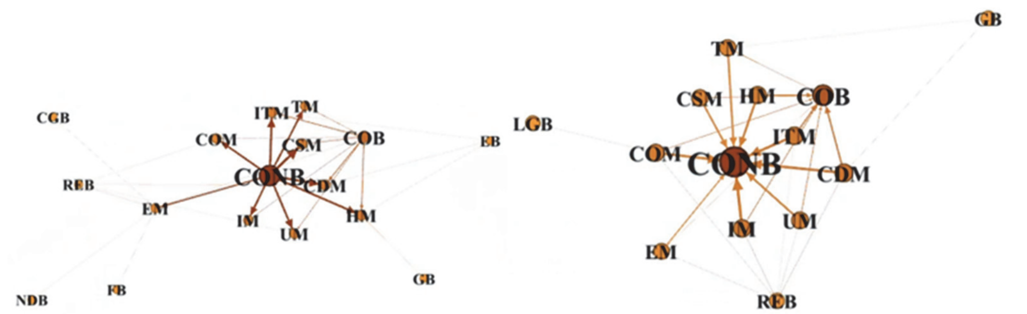


Figure 8. Risk spillover diagram (left) and spillback diagram (right) between the bond market and the real economy before the pandemic

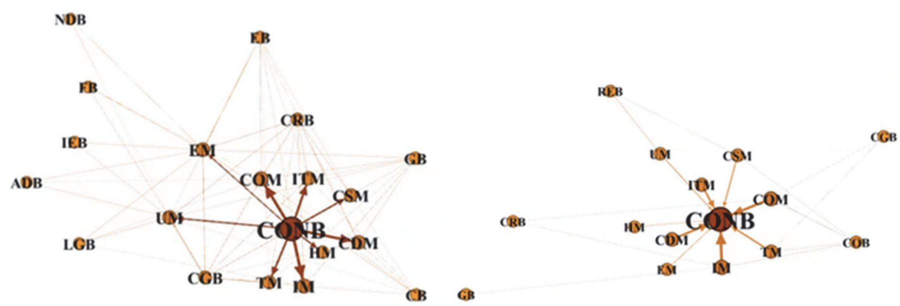


Figure 9. Risk spillover diagram (left) and backflow diagram (right) between the bond submarket and real industries after the pandemic

Firstly, the imbalance in risk transmission from the bond submarket to the real economy is evident, as the bond submarket exhibits a higher level of risk spillover to the real economy than the reverse effect. According to debt deflation theory, the process of the economy shifting from prosperity to recession is characterized by monetary tightening and excessive debt as core factors that trigger financial crises (Liu, 2020). The sudden outbreak of the pandemic subjected the national economy to an "emergency brake," resulting in insufficient external demand and operational difficulties for debt-issuing enterprises. As the emergency brake was applied nationwide, the collective decline of asset prices occurred when a large number of enterprises simultaneously sold their assets. Through the interac- tion between the real economy and financial institutions, the situation led to decreasing money deposits and reduced currency circulation velocity. According to Xinhua News Agency, the central bank injected 1.2 trillion RMB into the Chinese economy during the pandemic to ensure liquidity supply (People's Bank of China, 2020a). This action prevented a deflationary scenario and allowed the economy to survive the pandemic outbreak.

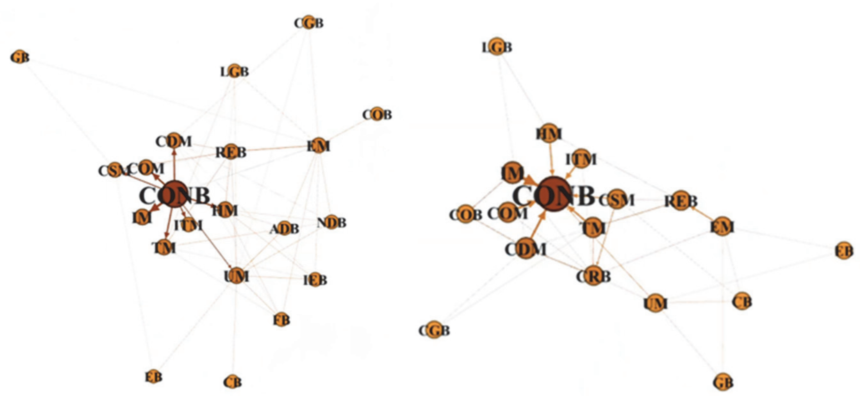


Figure 10. Risk spillover diagram (left) and spillover reversion diagram (right) between the bond market and the real sector after the Russia–Ukraine conflict

Second, convertible bonds exhibit the highest risk spillover and spillover effect on the real sector. Owing to their convertibility into stocks, convertible bonds possess the dual characteristics of debt and equity, leading to a linkage effect with the stock market regarding the risk spillover into the real sector. With lower interest rates, convertible bonds enable other controlling shareholders in the real sector to raise funds rapidly, thus diminishing their willingness to manage real business entities. Simultaneously, the excessive issuance of such bonds can result in listed companies lacking actual controlling shareholders, thereby amplifying risks within the real sector.

Third, encountering unexpected external events, credit bonds, government bonds, corporate bonds, railway bonds, green bonds on stock exchanges, local government bonds, corporate bonds, and real estate bonds all exhibited significant volatility in terms of the risk spillover effect on the real sector. According toWind data, the bond market experienced frequent defaults after 2020. Bond market defaults can affect liquidity, leading to liquidity risk. Although the People's Bank of China increased the money supply to alleviate the liquidity crises, numerous bond defaults reflect deep seated issues in the current Chinese bond market.

4.3.2 Analysis of the Bond Market Segments Transmission Mechanism

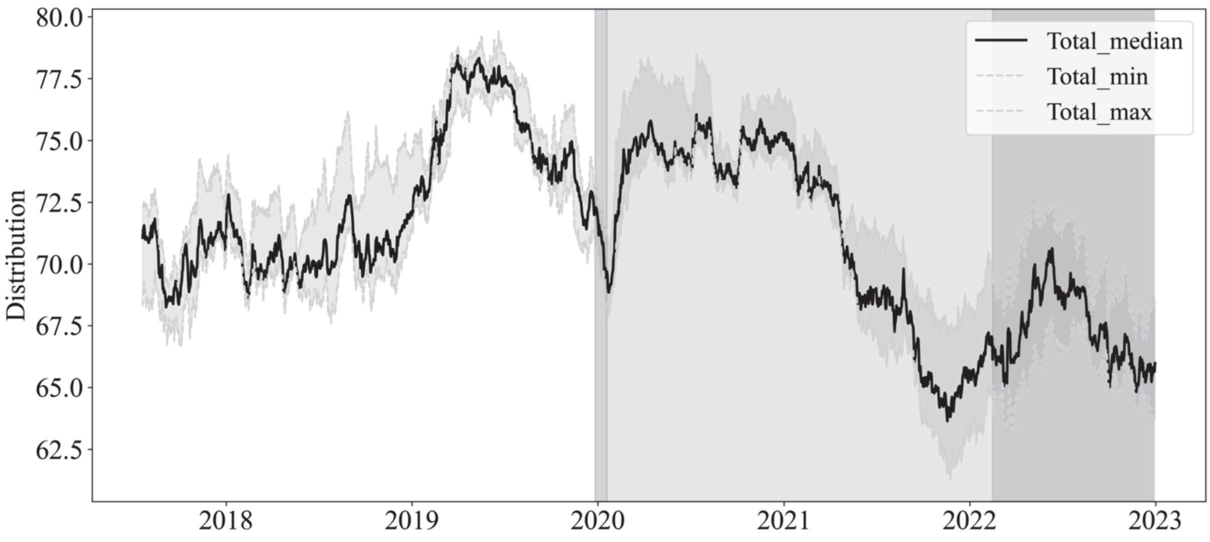
Table 9 shows the results for the correlation coefficients after normalization [0,1], The correlation coefficient on convertible bonds is significantly higher than that on other submar-kets. This suggests that convertible bonds' unique characteristics make them more sensitive to market fluctuations. When market risk increases, investors may convert convertible bonds into stocks to seek higher returns. Therefore, within the bond market segments, there exists substantial reliance on the convertible bond market for the transmission of risk across markets.

4.4 Sensitivity Analysis

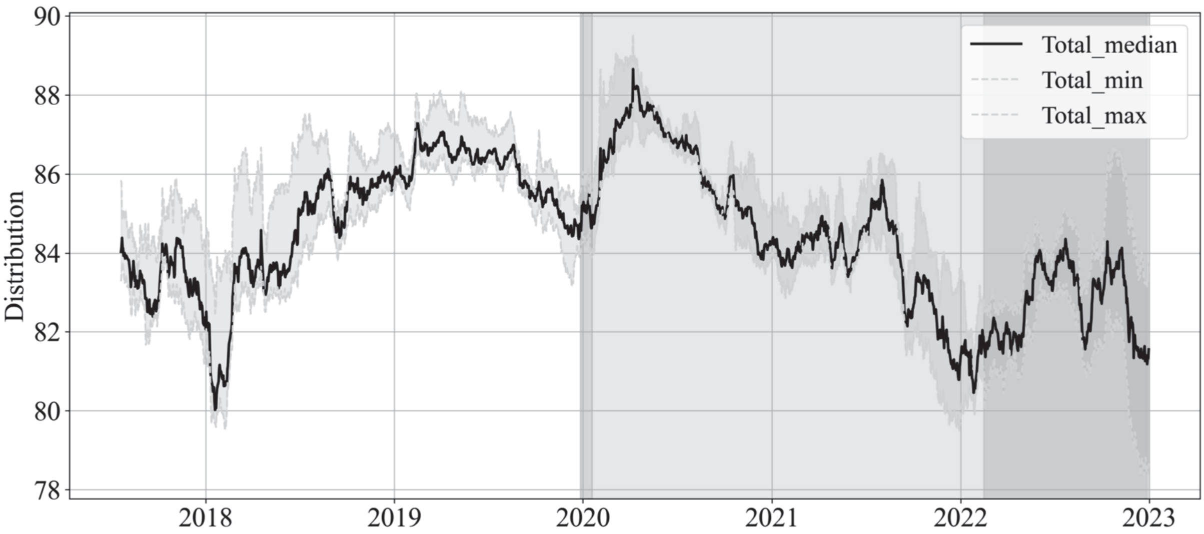
The temporal variation in skewness, as shown in Figure 11, may contain valuable information. During the pandemic outbreak period, both TSL and TBR showed a sharp right skew. With the pandemic control, TSL maintained a sharp right skew for about a year, and then began to weaken. From 2022, the left skew and right skew were equally sharp, indicating that the bilateral risks of the stock market and the real economy were experiencing severe fluctuations. Systemic risk increased, as China lifted epidemic control in December 2022, the left skew of TSL gradually weakened, and the risk spillover of bilateral risks between the stock market and the real economy weakened.

Table 9. Correlation between the bond market and its submarkets in various industry sectors

Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Ranking**
Convertible bonds	0.371	1.000	0.978	1.000	1.000	1.000	1
Government bonds	0.136	0.000	0.578	0.850	0.039	0.281	2
Corporate bonds	0.994	0.201	1.000	0.597	0.233	0.006	3
Credit bonds	1.000	0.166	0.890	0.564	0.217	0.000	4
Exchange green bonds	0.252	0.184	0.497	0.651	0.414	0.024	5
Local government bonds	0.471	0.192	0.380	0.657	0.018	0.014	6
Chinese railway bonds	0.000	0.184	0.000	0.782	0.000	0.054	7
Corporate bonds	0.594	0.938	0.303	0.000	0.328	0.040	8



(a)



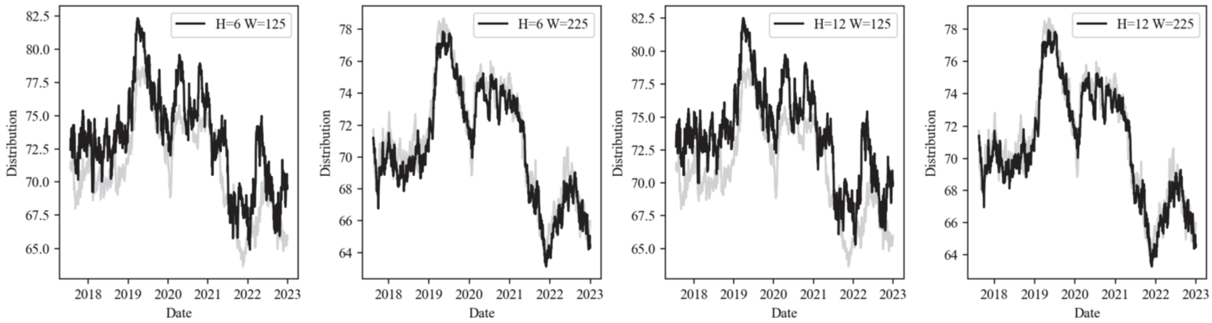
(b)

Figure 11. (a)Total sensitivity analysis of Stock submarkets and Real industries(TSL). (b) Total sensitivity analysis of Bond submarkets and Real industries(TBR).

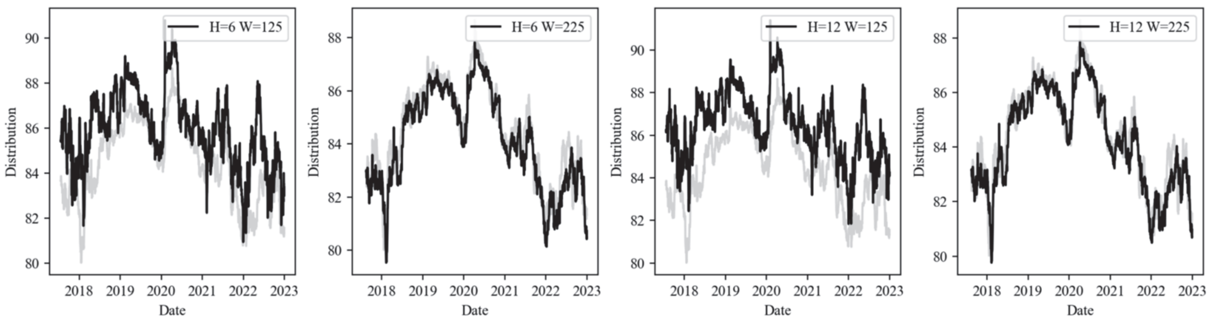
Different from TSL, with the pandemic control, TBR maintains a sharp right-skewness for a shorter time than TSL, and then there is no abnormality in both left-skewness and right-skewness. This is because the Russia-Ukraine conflict has directly affected the global energy market, especially the supply of natural gas and oil in Europe, and the rise in energy and commodity prices caused by the conflict has intensified the linkage effect between the bond market and the real economy. In addition, central banks around the world (especially the European Central Bank and the Federal Reserve) have adopted tight monetary policies, which not only has a direct impact on the real economy, but also makes the bond market interest rate rise and bond prices fall, further aggravating the bilateral risk spillover effect between the bond market and the real economy.

4.5 Robustness Assessment

To examine the robustness of this study's results to the choice of model parameters, the width of the risk spillover window is selected as 125, 225, and 200 for the equity submarket versus the real economy and the debt submarket versus the real economy, respectively. The prediction horizons considered are 6, 10, and 12 days, respectively. The results are presented in Figure 12, where the gray curve represents the benchmark parameters with H=10 and W=200.



(a) Robustness of total connectedness in stock market submarket



(b) Robustness of total connectedness in bond market submarket

Figure 12. (a) shows the overall spillover index of the stock market submarket and real industries under different parameters. (b) shows the overall spillover index of the bond market segments and real industries under different parameters

As observed in Figure 12, when W=125, the stock market submarket and the bond market submarket, regardless of H=6 or 12, the overall spillover index will be to the left compared with the benchmark model. Regardless of H=6 or 12, the overall spillover index remains consistent with the benchmark model. When H=6, the value of W is 225, which is more stable than W=125, and the results here remain consistent when H=12. This shows that for the stock market submarket, a larger window period can effectively improve the stability of the experiment, and the value of prediction horizons has little influence on the stability of the experiment.

When W=225, the total spillover indexes of the stock market submarket and the bond market segments show a small degree of right-skewness compared with the benchmark model, and when W=125, there is a greater degree of left-skewness. It indicates that the larger the window period is, the larger the accumulated total risk spillover index is, and the smaller the window period is, the smaller the accumulated total risk spillover index is.

The stock market submarket and the bond market segments keep the overall trend of the total risk spillover index consistent with the benchmark model when H andWare different, indicating that the total risk spillover index measured by the benchmark model is robust. It can accurately reflect the risk fluctuations of financial market and real economy.

Overall, the robustness tests in this study indicate that the dynamic behavior of the overall spillover index over a rolling sample window remains robust to the choice of alternative sample window lengths and forecast ranges in the VAR system.

5. Conclusions and Recommendations

Compared with existing studies, this paper reaches conclusions consistent with the established literature regarding risk imbalance. Additionally, it finds that China's real sector serves as an economic stabilizer when facing external catastrophic shocks. In terms of mining the key financial risk markets, this study extends previous research. It expands the stock market and bond market, which have been found to be the key risk markets in the existing literature, into the convertible bond market in the stock market and the convertible bond market in the bond market.

5.1 Conclusions

This study constructs multiple bidirectional risk spillover network models that explore the transmission of risks from their origin (multiple networks before external shocks) through bidirectional spillover processes (multiple networks after external shocks) to cross-market transmission mechanisms. We derive the following conclusions.

First, following catastrophic external shocks, the Chinese financial market provided robust support for crisis response and the early recovery of the real economy, thereby playing a stabilizing role in the economy. Subsequently, the interbank lending market, repurchase market and bond market within the financial industry exhibited an increasing trend of risk spillover. At this point, the stabilizing role in the economy shifted to the Chinese real sector. However, as these external shocks persisted over two years, both the Chinese financial and real sectors encountered challenges in effectively hedging against accumulating risks, according to paper research. The impact of these global external events extends beyond the Chinese market, influencing markets of other nations. Despite variations in industrial institutions and policies across countries to cope with shocks, the phenomenon and conclusions observed in the Chinese market may provide valuable lessons for markets in other countries.

Second, in terms of transmission mechanisms in key markets, the stock market primar- ily relies on two markets, namely the securities lending and margin trading markets, for cross-market risk transmission. Meanwhile, the bond market depends on the convertible bond market for cross-market risk transmission. The existence of similar markets in other countries means those countries may benefit from understanding these Chinese markets.

5.2 Policy Recommendations

The findings of this study yield critical insights for policymakers and practitioners seeking to foster a more resilient and sustainable financial ecosystem in China. First, the identified asymmetry in risk spillover and reversal between the financial sector and the real economy underscores the need for targeted interventions. To promote the robust and sus- tainable growth of the real economy, financial institutions should be incentivized to provide bespoke and appropriately scaled financing solutions, with a particular focus on strate- gically important sectors. Achieving this necessitates encouraging financial institutions to offer precisely targeted and calibrated financing services, particularly towards pivotal segments of the real economy. Concurrently, stringent controls must be implemented on the aggregate financing extended to high-risk sectors, preventing the transmission of risks from the real economy to the financial sector.

Second, Chinese regulatory bodies must proactively refine the regulatory framework governing securities lending, margin trading, and short-selling activities. This entails strengthening market infrastructure, streamlining operational efficiency, minimizing trans- action costs, and enhancing market liquidity to support the continued development of the real economy. Furthermore, regulators should augment oversight of market transparency to mitigate the potential for risks arising from information asymmetry. The prudent re- sumption of securities lending should be contingent upon prevailing market conditions and a comprehensive risk assessment.

Third, China should strategically manage the overall scale of its bond market and the composition of its constituent bond categories. Regulatory authorities should closely

monitor the size and growth rate of convertible bonds to avert excessive risk concentration and the potential for risk propagation within the broader market. Simultaneously, liquidity management practices in the bond market should be strengthened, alongside the enhance- ment of risk monitoring and assessment mechanisms to proactively address anomalous market fluctuations and mitigate risk transmission pathways.

Although this study refers to global external events, it only uses the data of Chinese markets, so the research conclusions have certain limitations.

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References

Abuzayed, B., Bouri, E., Al-Fayoumi, N., & Jalkh, N. (2021). Systemic risk spillover across global and country stock markets during the COVID-19 pandemic. *Economic Analysis and Policy, 71*, 180–197. https://doi.org/10.1016/j.eap.2021.04.010

Adekoya, O. B., & Oliyide, J. A. (2021). How COVID-19 drives connectedness among commodity and financial markets: Evidence from TVP-VAR and causality-in-quantiles techniques. *Resources Policy, 70*, Article 101898. https://doi.org/10.1016/j.resourpol.2020.101898

Bai, L., Zhang, X., Liu, Y., & Wang, Q. (2019). Economic risk contagion among major economies: New evidence from EPU spillover analysis in time and frequency domains. *Physica A: Statistical Mechanics and its Applications, 535*, Article 122431. https://doi.org/10.1016/j.physa.2019.122431

Bai, X., & Wang, X. L. (2024). Two-way risk spillovers between China's financial market and the real economy – Based on the perspective of exogenous event shocks. *Journal of Jilin College of Commerce and Industry, 40*(1), 94–103. https://kns.cnki.net/kcms2/article/abstract?v=5MjHqO3BiXURYMXRcCK1pCCWI1gBg8TJhe5Z0t6bPqd3eArdnH8ucDjaBv4D__WZOeLBTKW-ecwgJXJHZq5B5vyXkFv900KZNSsS7jMEecSngZHzwxn8Efckc1FbHyVc_EE3gw5IiBJYhxaiHVxb9L0qrT0-1V2ROgoRi8rDSOlXxsjeCSaXF7FHLLihjBmx-UPrEq36ENE=&uniplatform=NZKPT&language=CHS

Billio, M., Getmansky, M., Lo, A. W., & Pelizzon, L. (2012). Econometric measures of connectedness and systemic risk in the finance and insurance sectors. *Journal of Financial Economics, 104*(3), 535–559. https://doi.org/10.1016/j.jfineco.2011.12.010

Bosca, J. E., Domenech, R., Ferri, J., et al. (2021). The stabilizing effects of economic policies in Spain in times of COVID-19. *Applied Economic Analysis, 29*(85), 4–20. https://doi.org/10.1108/AEA-11-2020-0165

Chakrabarty, K. C. (2012). Systemic risk assessment – The cornerstone for the pursuit of financial stability. In *Inaugural at the International Seminar on Operationalizing Tools for Macro Financial Surveillance: Country Experiences*. Reserve Bank of India, Financial Stability Unit. https://rbidocs.rbi.org.in/rdocs/Bulletin/PDFs/01SPC090512.pdf

Chao, L., Junhui, X., & Wenwen, Z. (2017). Study on risk spillover effect of financial markets in China based on methods of spillover index and complex network. *Systems Engineering - Theory & Practice, 37*(12), 12–23. https://kns.cnki.net/kcms2/article/abstract?v=RyaFSLOYMk4Fz_VGG1fvYe9OTDsD4DtEqY-pZSHUuYz8WAwP0lYV6jIztjxW0Nuud1J3_Kt3ei6ORfIvrq2gH5F-bXXq8BL1kwWZ40SsY8Ef0QbICC_eg5FbpSM_Ic1dJRfZzfl2nAie2RAjwiu-CA==&uniplatform=NZKPT&language=CHS

Cheng, Y., Liu, J., Liu, J., & Sriboonchitta, S. (2021). Risk spillovers between China and other BRICS countries during COVID-19 pandemic: A CoVaR-copula approach. *IOP Conference Series: Earth and Environmental Science, 1978*(1), Article 012043. https://doi.org/10.1088/1742-6596/1978/1/012043

China Securities Regulatory Commission. (2015). *Notice of the CSRC on measures for the administration of financing and short selling business of securities companies*. http://w.csrc.gov.cn/csrc/c106256/c1653885/content.shtml

China Securities Regulatory Commission. (2020). *Provisional measures for the supervision and administration of margin trading and securities lending business*. http://www.csrc.gov.cn/csrc/c106256/c1653885/content.shtml

China Securities Regulatory Commission. (2024). *China Securities Regulatory Commission approved the suspension of short selling business in accordance with the law to further strengthen the counter-cyclical adjustment of short selling*. http://www.csrc.gov.cn/csrc/c100028/c7493852/content.shtml

Chiu, W. C., Peña, J. I., & Wang, C. W. (2015). Industry characteristics and financial risk contagion. *Journal of Banking & Finance, 50*, 411–427. https://doi.org/10.1016/j.jbankfin.2014.04.003

Deng, C., & Xie, J. (2020). The correlation dynamics and spillover effects among financial submarket cycle fluctuation in China. *Journal of Central South University (Social Sciences), 26*(2), 100–110. https://kns.cnki.net/kcms2/article/abstract?v=KqXyGY4RJv0yqk8pxXzOcLJcI9tnD1ww-DzR9fb5R230I0iLhWX8fUfft6SuCZh52chClvr1wzO0WoQsaJFxRpkR7GWqwzPlPHaFov0b_mc4NV-xBTMMgIkw-jAXLPzG5XaCnT2lXSxgJ7yYT3jIQQ0oRw1fPHZK&uniplatform=NZKPT

Diebold, F. X., & Yılmaz, K. (2014). On the network topology of variance decompositions: Measuring the connectedness of financial firms. *Journal of Econometrics, 182*(1), 119–134. https://doi.org/10.1016/j.jeconom.2014.04.012

Fang, Y., & Shao, Z. Q. (2022). Measurement of imported financial risk under major shocks. *Economic Science, 44*(2), 13–30. https://kns.cnki.net/kcms2/article/abstract?v=RyaFSLOYMk6rzLL3ltGL1I7C9g6-24RYN1FE-rmrAR40Yv_-ca1NG-Kn7-YlmBEIMvHIAwHM-sLX05aZM2I8VFlunV5FBcQofwWw27PPiCAylXfg89N0qt7s-dSaFNBdrAK3dMGLm0KPuWS94GlcCiw==&uniplatform=NZKPT&language=CHS

Fang, Y., & Wang, Y. R. (2023). Systemic financial risk: Theoretical mechanism, early warning system and dual-pillar policy framework. *Journal of Guizhou University (Social Sciences Edition), 41*(4), 92–99. https://doi.org/10.15958/j.cnki.gdxbshb.2023.04.11

Fang, Y., He, W. J., & Jin, Z. B. (2021). A study of risk spillovers between China's real economy and financial markets. *Journal of World Economy, 44*, 3–27. https://doi.org/10.19985/j.cnki.cassjwe.2021.08.002

Fink, F., & Schuler, Y. S. (2015). The transmission of US systemic financial stress: Evidence for emerging market economies. *Journal of International Money and Finance, 55*, 6–26. https://doi.org/10.1016/j.jimonfin.2015.02.019

Gao, Y., Li, Y., & Wang, Y. (2021). Risk spillover and network connectedness analysis of China's green bond and financial markets: Evidence from financial events of 2015–2020. *North American Journal of Economics and Finance, 57*, Article 101386. https://doi.org/10.1016/j.najef.2021.101386

Guo, H. B., & Du, J. M. (2014). Construction of China's financial stability conditions index. *Journal of Quantitative & Technical Economics, 5*, 100–116, 161. https://doi.org/10.13653/j.cnki.jqte.2014.05.007

Härdle, W. K., Wang, W., & Yu, L. (2016). TENET: Tail-event driven network risk. *Journal of Econometrics, 192*(2), 499–513. https://doi.org/10.1016/j.jeconom.2016.02.013

Hautsch, N., Schaumburg, J., & Schienle, M. (2015). Financial network systemic risk contributions. *Review of Finance, 19*(2), 685–738. https://doi.org/10.1093/rof/rfu010

He, G. (2022). The impact of stages of strikes by outbreak of large-scale epidemic on Chinese economy. *North China University of Technology Journal, 29*, 29–36. https://doi.org/10.26926/d.cnki.gbfgu.2022.000120

Hu, C. Y. (2021). *Two-way spillover effect of extreme risk between financial institutions and real industry in China: Based on the analysis of network association* [Master's thesis, Tianjin University of Finance and Economics]. https://kns.cnki.net/kcms2/article/abstract?v=FruxrO_GJXK8IUf3Q_P9f7zgRI_OLchqFlAQstpQNOxNRK7--TtXiIAZ01wUduggOI-IgH2wVMSoEDq67SECAjQ-jbLGEXT19_kaEX8zP5XXMFmxW91p4rf27t5FQuWpaX-9LZBsDgo2wUWN3YSEK7A==&uniplatform=NZKPT&language=CHS https://doi.org/10.27354/d.cnki.gtcjy.2021.000893

Hu, C. Y., & Ma, Y. M. (2024). The continuous impact of major events on the level of economic and financial risk spillover. *Finance & Trade Economics, 1*, 1–17. https://doi.org/10.19795/j.cnki.cn11-1166/f.20240712.007

Hu, C. Y., Ma, Y. M., & Ma, J. Y. (2023). Two-way tail risk spillovers between financial markets and real economy under major event shocks. *Research in Financial Economics, 38*(6), 3–19. https://kns.cnki.net/kcms2/article/abstract?v=5MjHqO3BiXXoAd1ed-SWFuRE1zajBfcFbp1pHpHh3FgFq92AisHjnjyrmfUc2zFZ6tNvLpUSny-ApIVl234vAmUZ4yT1gu-PDLUkCHhw9xyU4w9DkpZMxEBrLHgnwfLHHL6rruZqakn9Kk_MV7njRhhqLVzroiEKmQhIL46fl8bGUFqF7hlxhJxY4dy9KRtKWa85vxS2mG4=&uniplatform=NZKPT&language=CHS

Hu, C., & Ma, Y. (2022). The effect of strong financial supervision on extreme risk bidirectional spillover between financial institutions and real economy. *Studies of International Finance, 9*, 56–66. https://doi.org/10.16475/j.cnki.1006-1029.2022.09.007

Jiang, H., Ji, J. F., & Tang, S. F. (2021). Tail risk spillover network and systemic financial risk – A multi-angle empirical study based on TENET method. *Financial Regulation Research, 11*, 18–36. https://doi.org/10.13490/j.cnki.frr.2021.11.003

Jie, Y., & Xiang, Z. (2012). *Video object detection and tracking and its applications*. Shanghai Jiao Tong University Press. https://xueshu.baidu.com/usercenter/paper/show?paperid=b27435d7ec1f25ee2ca7b839f90126ff&site=xues

hu_se

Kewei, H., Yi, A., & Yuan, G. (2023). Financial fragility: Internal spillover and its impact on the real economy. *Credit Reference, 41*(6), 81–86. https://kns.cnki.net/kcms2/article/abstract?v=vdPasdvfHvuik31jA1h1Zi8JRqiE9WXB86b70Th2u0EYSMWefP2KIsjYzOSBpl4TM9g0rzrcmrd6p8PMy2NiMtrSLkcfuSHNBY8X--0Ea8Y_8yxvg1AV4Dyo-W3kGarpAOTWzCFpGU4=&uniplatform=NZKPT&flag=copy

Lai, Y., & Hu, Y. (2021). A study of systemic risk of global stock markets under COVID-19 based on complex financial networks. *Physica A: Statistical Mechanics and its Applications, 566*, Article 125613. https://doi.org/10.1016/j.physa.2020.125613

Li, S. W., Wang, H., & Liu, X. X. (2022). Systemic risk: Feedback effect between the financial system and the real economy. *Journal of Management Sciences in China, 25*(11), 25–42. https://doi.org/10.19920/j.cnki.jmsc.2022.11.002

Li, Z. (2021). *Measurement and prevention research on systemic financial risks in China*. China Financial Publishing Corporation.

Li, Z., Liu, Q., & Liang, Q. (2019). A study on forestalling China's systemic risk based on financial industry and real economy interacted network. *Statistical Research, 36*(2), 15–27. https://doi.org/10.19343/j.cnki.11-1302/c.2019.02.003

Li, Z., Yao, Y. Z., Tang, H. L., & Zhang, J. (2021). Extreme risk spillovers in the Chinese financial system: Based on the spillover index and spillover network. *South China Journal of Economics, 12*, 80–92. https://kns.cnki.net/kcms2/article/abstract?v=KqXyGY4RJv3DnxBqQDryN8gk3rPAhXvmXUYzvrzwVi4VQyzKLW2Xh9wHSfVsqdAl9lpnyhHAWIP8CuXENMqCx99XRL8MhYMJ2fU7La63-sNMVj7WSr1DgkUup3KoO0J54EItgSchvBuqIflVTyuZ-caCBjqG-I5ixpB7m-jYGwsc-LQhiJo-fC1ZT4872XOc&uniplatform=NZKPT&language=CHS

Liu, J. S. (2020). *China's bond default and systemic risks research* [Master's thesis, Central University of Finance and Economics]. https://kns.cnki.net/kcms2/article/abstract?v=nouGVBS_tgeuB_Vkm1OUHyQDVaWHxhBHV9a1ic9yvn09dcXBgFub8c0E10qsn8ZsjU_fp6gl0FuGbdvFQc_WnaXWD0T0h3lJ10P1rBtS5llSoPqmYC1yvSZPZP6DM45l-F5sEtW9lRWWqFOSMByKsw==&uniplatform=NZKPT&language=CHS

Liu, X. H. (2011). *Estimation of probability density for high-dimensional data based on Gaussian mixture models* [Doctoral dissertation, Institute of Automation, Chinese Academy of Sciences]. Wanfang Data. https://d.wanfangdata.com.cn/thesis/Y2035224

Ma, Y. M., & Hu, C. Y. (2021). The impact of fictitious-toward economy and strong financial supervision on the extreme risk connection between financial and entity industries. *Statistical Research, 38*(4), 74–88. https://doi.org/10.19343/j.cnki.11-1302/c.2021.04.006

National Health Commission. (2022). *Notice of the NHC on the issuance of the general plan for the implementation of class II management of novel coronavirus infections*. http://www.gov.cn/xinwen/2022-12/27/content_5733739.htm

Ouyang, Z. S., & Zhou, X. W. (2022). Spillover effect of systemic financial risk on macro economy: Based on quantile to quantile method. *Journal of Statistical Research, 39*(10), 68–83. https://kns.cnki.net/kcms2/article/abstract?v=KqXyGY4RJv1ErJ1gHmVoWoTNRlLWGoZ3ARceQrO08A-pIuYRmskJrZgv5-jbNvQ5G7gBKotwQhyqzA2RjODV0fNIh4meIQtFa4hgXeBtU5Rum_DOPNJ283v3cEN4XeNHmcNPLyu-1fiQcyEHdbjNxU4AjsMHWfaKrj_62jIVXxlmZTqPxFwlVvHuTxYP9erx&uniplatform=NZKPT&language=CHS

Pacelli, V., Miglietta, F., & Foglia, M. (2022). The extreme risk connectedness of the new financial system: European evidence. *International Review of Financial Analysis, 84*, Article 102408. https://doi.org/10.1016/j.irfa.2022.102408

Peng, H. F., & Zhu, Y. Z. (2019). Capital account liberalization, financial stability and economic growth. *Studies of International Finance, 2*, 5–14. https://doi.org/10.16475/j.cnki.1006-1029.2019.02.001

People's Bank of China. (2020a). *Notice PBC on further strengthening financial support for the prevention and control of novel coronavirus pneumonia epidemic*. http://www.gov.cn/zhengce/zhengceku/2020-

02/01/content_5473639.htm

People's Bank of China. (2020b). *Notice of the PRC on China's response to the COVID-19 pandemic*. http://www.gov.cn/xinwen/2020-06/07/content_5517737.htm

People's Republic of China. (2022a). *Hold high the great banner of socialism with Chinese characteristics uniting and striving for the comprehensive construction of a modernized socialist country – Report at the 20th National Congress of the Communist Party of China*. https://www.gov.cn/xinwen/2022-10/25/content_5721685.htm

People's Republic of China. (2022b, December 23). *Notice of the PRC on the financial support for the real economy continues to increase in strength*. *Economic Daily*. https://www.gov.cn/xinwen/2022-12/23/content_5733198.htm

Pericoli, M., & Yilmaz, K. (2024). Shocks and global asset market connectedness. In *Handbook of financial integration* (pp. 108–133). Edward Elgar Publishing. https://doi.org/10.4337/9781803926377.00012

Rizan, M., Salim, M. Z., Mukhtar, S., & Daly, K. (2022). Macroeconomics of systemic risk: Transmission channels and technical integration. *Risks, 10*(9), Article 174. https://doi.org/10.3390/risks10090174

Shanghai Stock Exchange. (2018). *Notice on the issuance of the 'stock pledge repo trading and registration settlement business measures (2018 revision)'*. http://www.sse.com.cn/services/tradingservice/stockrepo/business/c/c_20190118_4711978.shtml

Shanghai Stock Exchange. (2020). *Notice of the SHSE on regarding the release of Shanghai Stock Exchange securities trading business guide No. 3 – Repurchase agreement securities trading business*. http://www.sse.com.cn/lawandrules/guide/hyznlc/c/c_20201207_5274061.shtml

Sun, Y., & Jiang, C. H. (2022). China's financial real intermediary scale, intermediary quality and economic growth: Based on regional heterogeneity analysis. *Journal of Technical Economics & Management, 5*, 67–71. https://kns.cnki.net/kcms2/article/abstract?v=vdPasdvfHvvJ3Q5O_7ZdkcDR8NIZ2F-FMW9KGyCBUo5_n10Jr61DKCh6E1nnW293mikosBx2Cd58WOZjUWskxGQIeVVCXjaH_116jguzL6lVcuGLur6kGvsZ8BXoPuP7HUyF1B3RbOjt5gQ7obzt6g==&uniplatform=NZKPT&language=CHS

Tang, J., Ren, Z. Y., Chen, H. H., & Qiao, S. (2024). Multidimensional risk spillover among power, coal, and carbon markets: Empirical evidence from China. *Environmental Science and Pollution Research, 31*(1), 1244–1259. https://doi.org/10.1007/s11356-023-31099-y

Wang, Z., Gao, X., Huang, S., Sun, Q., Chen, Z., Tang, R., & Di, Z. (2022). Measuring systemic risk contribution of global stock markets: A dynamic tail risk network approach. *International Review of Financial Analysis, 84*, Article 102361. https://doi.org/10.1016/j.irfa.2022.102361

Yang, Z. H. (2020). The risk contagion relationship between the financial market and the macro economy: A mixed-frequency based empirical research. *Social Sciences in China, 12*, 160–180, 204. https://kns.cnki.net/kcms2/article/abstract?v=RyaFSLOYMk5zgjOV3V6nIwjDRK50MMmf6eDQ_gz0dqm2hBloGbhWjFDg0aSsE0oXqs6OttUIRnnmHZ_f5vQqZahwTJoyelXBXfl-0NhK7rsetVxR45Ux2aunJraT3a_U_XElxRLndX0knQYs1NfoTA==&uniplatform=NZKPT&language=CHS

Yu, J. X. (2024, April 9). Commercial banks should be good real economy "stabilizer". *Newspaper Title Unspecified, 006*. https://kns.cnki.net/kcms2/article/abstract?v=4wkQyjAcIEeR7wvj_thdISknqj4D5dY6faOQ5oxciVAyU3Sovz_bkXYq4GcvYjKfSq2pz0HuVGEJisEzYesMkT6DbdEOHbp7yCVfGKty4LON6H4G5emU3yNm08g9XFAATS1_QKuHb7GJtLgtQbCcn4cjYQHTwUDP51bdNnWtshwZgOzT6e0pm9h8aG0VlEPn7v7e5AE3Vw6wNLW2aoQBHF5ndqiWw6ys&uniplatform=NZKPT&language=CHS

Zeng, C., & Tang, S. (2023). The role of state-owned enterprises as economic stabilizers under COVID-19: From the perspective of supply chain support. *Economic Research, 58*, 78–96. https://kns.cnki.net/kcms2/article/abstract?v=4wkQyjAcIEflEsa1Beqe66CJRnUxDJRmqZpvpuVpGU375heCJrd1JLnswpBSXWypuQ8Ln5CH-Ch3dEhgiy0-LV6fOZJTrEdMcio2VwfxKwKgN0aeRIG_h6wAJYDvDcVxGMAjCjs3qiwreR3RyQPKCi2bwVA5T_ttCiBN4iOHTR_ht3FCQ9bU7l6_Hz-b71oP0_zdn61hjP2ZWdqWuchRBA==&uniplatform=NZKPT&language=CHS

Zhang, W. P., Zhuang, X. T., Wang, J., & Lu, Y. (2020). Connectedness and systemic risk spillovers analysis of Chinese sectors based on tail risk network. *North American Journal of Economics and Finance, 54*, Article

101248. https://doi.org/10.1016/j.najef.2020.101248

Zhang, Z. X., & Huang, Z. J. (2024). Systematic risk monitoring and risk spillover in capital market: From the perspective of financial stress index. *Securities Market Herald, 7*, 57–67, 79. https://kns.cnki.net/kcms2/article/abstract?v=O_Pen4SgC0BhSqit5LS3ohUL9eXugLsWu4jUMz98jf8yfgPdvkL93o3gP3p7XLAVoYyDRl-a0DfRqE11on4rd0zbEGfzrJZbpSb75fBMjZvYF2Tr6rdJSP25Dx6P1YlTYzzvZOJCqsAWHzjP85-sCBkT2q31zzc9TNyGe6wDLPX8n0j5Icc377LndoKROE0O&uniplatform=NZKPT&language=CHS

Zhao, M., & Park, H. (2024). Bidirectional risk spillovers between Chinese and Asian stock markets: A dynamic Copula-EVT-CoVaR approach. *Journal of Risk and Financial Management, 17*(3), Article 110. https://doi.org/10.3390/jrfm17030110