Sentiment-Driven Risk Contagion: An Emotionally Enhanced TENET Analysis of China's Stock Market

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Abstract. This study investigates how investor sentiment magnifies inter-industry risk spillovers across 18 industrial sectors in the Chinese stock market. We propose a sentiment-enhanced framework that integrates the ΔCoVaR approach with the tail-event driven network (TENET) model to construct a directed, weighted risk contagion network. Utilizing weekly data from 2015 to 2024—a period encompassing multiple systemic crises—our empirical analysis yields four key findings. First, incorporating investor sentiment universally improves the model's explanatory power for tail risk spillovers, with capital-intensive sectors such as Mining and Real Estate exhibiting the highest sensitivity. Second, we identify a robust bilateral feedback loop between investor sentiment and sectoral risk, driving a self-reinforcing cycle of financial instability. Third, among various transmission mechanisms, the capital flow channel exerts the dominant moderating effect, transforming highly liquid sectors into critical risk-transmission hubs. Finally, this sentiment-driven amplification is highly asymmetric, spiking dramatically during extreme market events such as the 2015 stock market crash and the COVID-19 pandemic. These findings provide actionable empirical evidence for policymakers to design sentiment-integrated early-warning systems and targeted macro-prudential interventions to mitigate systemic risk.

Keywords: Systemic Risk, Investor Sentiment, TENET Model, ΔcoVaR, Emotional Enhancement, Risk Contagion, China's Stock Market

1 Introduction

In today's highly interconnected global financial markets, the complex linkages among industrial sectors have become a "double-edged sword." On the one hand, deep industrial integration optimizes the efficiency of capital allocation; on the other hand, it establishes hidden channels for the rapid cross-market contagion of systemic risks. In recent years, the global economy has experienced multiple shocks, including the COVID-19 pandemic, geopolitical conflicts, and drastic shifts in macroeconomic policies. Studies have shown that upstream and downstream linkages in supply chains can amplify the transmission capacity of risks under extreme external shock[1]. Meanwhile, the cross-market correlation network between different financial markets and real

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economy sectors allows localized volatility to generate significant global spillover effects[2]. As China's capital market continues to deepen, exploring the asymmetric contagion mechanisms of cross-industry tail risks in the Chinese stock market under the superposition of multiple crises is of urgent practical significance for preventing systemic financial risks[3].

Traditional financial theories, typically based on the rational expectation hypothesis, posit that asset prices primarily reflect macroeconomic and fundamental information. However, behavioral finance indicates that investor sentiment, as a systematic irrational factor deviating from fundamentals, often acts as a "catalyst" for risk contagion during market turmoil[4]. Particularly in the Chinese stock market, which is characterized by a high proportion of retail investors and pronounced "herding effects," the rapid flow of capital across sectors can easily trigger cross-industry stock price co-movements[5]. Recent empirical studies further demonstrate that noise trading and expectation biases driven by sentiment not only directly elevate the idiosyncratic volatility of specific sectors but also significantly exacerbate systemic risk spillovers[6].

Regarding risk measurement methodologies, the ΔcoVaR approach effectively quantifies the tail risk contribution of a single institution or sector to the overall system during crises[7]. To further identify directional contagion characteristics in high-dimensional networks, the Tail Event Driven Network (TENET) model has been widely applied[8]. By utilizing penalized quantile regression, this model exhibits exceptional capability in capturing non-linear dependencies under extreme market conditions. Frontier research in recent years confirms that the improved TENET approach possesses significant advantages in measuring currency tail risk networks[9] and evaluating economic policy uncertainty spillovers[10]. However, existing high-dimensional network measurements mostly focus on objective trading or macroeconomic fundamental data. Few studies have deeply integrated "investor sentiment" as an independent core driving variable into the TENET network topology. In particular, there is a lack of systematic quantitative exploration of the "Emotional Enhancement Effect" across different industrial chain channels under multiple continuous crises.

To bridge these research gaps, this study proposes an innovative "Emotional Enhancement Strategy" aimed at profoundly analyzing the non-linear amplifying effect of investor sentiment on cross-industry risk spillovers in the Chinese stock market. Utilizing weekly data from 18 industrial sectors in the Chinese stock market from 2015 to 2024, this paper constructs a sector-specific investor sentiment index and integrates it into the ΔCoVaR and TENET frameworks to construct a sentiment-enhanced, directed, and weighted risk spillover network. The core contributions of this study are as follows: First, it confirms that investor sentiment universally enhances the model's explanatory power for sectoral tail risk contagion, especially in highly sensitive sectors such as Mining and Real Estate. Second, it reveals a significant bilateral causal feedback loop between investor sentiment and tail risk. Third, it identifies the primary transmission channels of risk contagion, highlighting the dominant moderating role of capital flows and verifies the highly asymmetric and event-driven characteristics of the sentiment amplification effect during extreme crises (e.g., the 2015 stock market crash and the COVID-19 pandemic).

2 Theoretical Analysis and Research Hypotheses

2.1 The Mechanism of Investor Sentiment on Risk Spillovers

Theoretical financial models traditionally assume rational expectations, where asset prices reflect fundamental values[11].However, behavioral finance suggests that investor sentiment—defined as a systematic deviation from rationality—plays a pivotal role in market dynamics[4]. In a multi-sector financial system, investor sentiment affects risk spillovers through two primary channels:

- The Cognitive Bias Channel: When investors hold overly optimistic or pessimistic views about a specific sector (e.g., Real Estate or Technology), their trading behavior becomes decoupled from economic fundamentals. This noise trading increases idiosyncratic volatility[12], which can then propagate to interconnected sectors through cross-industry arbitrage or liquidity rebalancing[6].
- The Herd Behavior Channel: During periods of high market uncertainty, investors tend to follow the "market mood" rather than private information[13]. This collective behavior leads to synchronized price movements across different industries, effectively increasing the density and intensity of the risk spillover network[5].

2.2 The Logic of the Emotional Enhancement Effect

The "Emotional Enhancement" strategy proposed in this study is based on the premise that risk is not a static link between sectors but a dynamic process moderated by market psychology. We define this as the "Sentiment-Risk Feedback Loop."In this framework, a negative shock in one industry triggers a decline in investor sentiment, leading to panic selling. This drop in sentiment, in turn, increases the marginal contribution of that industry to systemic risk (ΔCoVaR). By integrating sentiment variables into the TENET model, we "enhance" the baseline risk network, allowing it to capture the additional variance in risk transmission that traditional fundamental-based models fail to explain.

2.3 Research Hypotheses

Based on the aforementioned theoretical framework, we propose the following hypotheses:

- **Hypothesis 1 (H1): The Sentiment Enhancement and Sectoral Heterogeneity.** The integration of investor sentiment significantly improves the model's ability to capture inter-industry tail risk spillovers. Furthermore, this enhancement effect is heterogeneous, being more pronounced in capital-intensive and cyclical sectors (e.g., Mining and Real Estate).
- **Hypothesis 2 (H2): The Bilateral Feedback Loop.** There exists a significant bilateral causal relationship between investor sentiment and sectoral risk spillovers,

forming a self-reinforcing cycle of financial instability rather than a unidirectional shock.

- **Hypothesis 3 (H3): The Moderating Role of Contagion Channels.** Sentiment-driven risk contagion is structurally moderated by specific transmission channels rather than just static topological links. Specifically, the capital flow channel exerts a more prominent moderating effect on risk spillovers than the industrial chain connection, transforming capital-intensive sectors into key transmission hubs.
- **Hypothesis 4 (H4): Dynamic Asymmetry under Extreme Shocks.** The emotional enhancement effect is dynamically asymmetric, with sentiment playing a significantly larger amplifying role during extreme market downturns or "black swan" events compared to normal market conditions.

3 Research Methodology

To quantify the risk spillover effects and the magnifying role of investor sentiment, this study employs a multi-stage econometric framework combining the ΔCoVaR approach with the Tail Event Driven Network (TENET) model.

3.1 Individual Tail Risk Measurement:The ΔCoVaR Approach

Following Adrian and Brunnermeier (2016)[7], we define the Value-at-Risk (VaR) of an industry i at the q -quantile as:

$$P(R_i \leq VaR_{q,i}) = q \tag{1}$$

To capture the risk spillover from industry i to the entire financial system, we utilize the Conditional Value-at-Risk (CoVaR). The $CoVaR_{q,system|i}$ represents the VaR of the system conditional on industry i being in a state of distress (i.e., its return is at its q -quantile):

$$P(R_{system} \leq CoVaR_{q,system|i} \mid R_i = VaR_{q,i}) = q \tag{2}$$

The marginal risk contribution of industry i to the system, denoted as $\Delta CoVaR_{q,i}$, is calculated as the difference between the CoVaR under distress and the CoVaR under the median state:

$$\Delta CoVaR_{q,i} = CoVaR_{q,system|i} - CoVaR_{q,system|i,median} \tag{3}$$

3.2 High-Dimensional Risk Network:

The TENET ModelTo identify the directional and non-linear risk transmission channels, we adopt the TENET framework proposed by Härdle et al. (2016)[8]. Unlike traditional linear models, TENET utilizes penalized quantile regression to select the most significant risk drivers in a high-dimensional setting. For each industry i, the tail risk is modeled as a function of other industries' states and macro-state variables:

$$R_{i,t} = \alpha_i + \sum_{j \neq i} \hat{\beta}_{i,j} \widehat{VaR}_{j,t} + \gamma_i M_{t-1} + \varepsilon_{i,t} \tag{4}$$

Where: $\widehat{VaR}_{j,t}$ represents the estimated risk state of industry j. M_{t-1} is a vector of lagged macro-state variables (e.g., market volatility, interest rates). $\hat{\beta}_{i,j}$ determines the adjacency matrix of the risk network, where a non-zero coefficient signifies a directed risk spillover from industry j to industry i.

3.3 The Emotional Enhancement Strategy

The core contribution of this study is the integration of Investor Sentiment ($Sent_{k,t}$) into the TENET framework to create an "Enhanced Risk Network." We construct a composite sentiment index for each industry using proxies such as turnover rates and detrended trading volume.The "Emotionally Enhanced" TENET model is specified as:

$$R_{i,t} = \alpha_i + \sum_{j \neq i} \beta_{i,j} \widehat{VaR}j,t + \sum k\delta_{i,k} Sent_{k,t} + \gamma_i M_{t-1} + \varepsilon_{i,t} \tag{5}$$

By introducing the sentiment vector $Sent_{k,t}$, the model captures two distinct effects:Direct Sentiment Impact: The coefficient δ measures how local or market-wide sentiment directly triggers tail events in industry i.Amplification Effect: By comparing the adjacency matrix $\beta_{i,j}$ in this enhanced model with the baseline model, we can quantify how much of the inter-industry connection is actually driven or moderated by emotional fluctuations. This allows us to filter out "fundamental" risk spillovers and focus on "sentiment-driven" contagion.

4 Data and Variables

4.1 Sample Selection and Data Sources

This study utilizes weekly data from the Chinese stock market, specifically covering 18 primary industry sectors from January 1, 2015, to December 30, 2024. This extensive 10-year period yields 520 weekly observations per sector and intentionally encompasses multiple systemic shocks, including the 2015 stock market crash, the 2018 US-China trade friction, the COVID-19 pandemic, and recent geopolitical conflicts. All original trading, financial, and macroeconomic data are obtained from the WIND, CSMAR, and iFinD databases.

4.2 Variable Construction

Investor Sentiment Index ($Sent$): To accurately capture the irrational emotional fluctuations of market participants, we construct an industry-specific composite sentiment index. Following established behavioral finance literature, we employ Principal Component Analysis (PCA) to extract the common factor from four industry-level trading proxies: turnover rate (IT), trading volume (TV), return rate (RR), and price amplitude (AM).

Macro-state Variables (M_{t-1}): To control for overarching economic conditions and systemic risks that may simultaneously drive multi-sector distress, we incorporate a set of lagged macroeconomic variables. These include GDP growth, the Consumer Price Index (CPI), RMB/USD exchange rate volatility (RE), M2 money supply growth, and the market panic index (VIX).

Industry Control Variables: Furthermore, to isolate the pure risk spillover effects, we control for fundamental industry characteristics, including market capitalization (MC), leverage (Lev), return on equity (ROE), gross margin (GM), and accounts receivable turnover (ART).

5 Empirical Results and Analysis

5.1 Model Performance and Sectoral Sensitivity

To evaluate the effectiveness of the emotional enhancement strategy, we compare the baseline TENET model with our sentiment-integrated TENET model. The empirical results(as shown in **Table 1**) demonstrate that incorporating investor sentiment universally improves the explanatory power (R2) for tail risk spillovers across the 18 sectors.

Table 1. Incremental Explanatory Power of the Emotionally Enhanced Model Across Selected Sectors

Sector	Baseline R2	Enhanced R2	ΔR2	Sentiment Coef.
Accommodation & Catering	0	0.436	0.436	0.303***
Mining	0	0.282	0.282	0.192***
Real Estate	0	0.27	0.27	0.151***
Construction	0	0.241	0.241	0.140***
Manufacturing	0	0.147	0.147	0.194***
Information Technology	0	0.094	0.094	0.106***

*** indicates significance at the 1% level.

Notably, the sentiment sensitivity is highly heterogeneous. Sectors deeply intertwined with economic cycles and capital intensity, specifically Mining and Real Estate, exhibit the highest sensitivity to sentiment shocks. This indicates that irrational emotional fluctuations disproportionately amplify the tail risks in these foundational industries. These empirical results robustly support Hypothesis 1 (H1), confirming both the universal explanatory enhancement of investor sentiment and its distinct heterogeneous impact across different industrial sectors.

5.2 The Bilateral Feedback Loop Mechanism

Beyond unidirectional impacts, our analysis uncovers a robust bilateral feedback loop between investor sentiment and sectoral risk spillovers. To empirically validate this mechanism, we conducted linear Granger causality tests(as shown in **Table 2**) between the composite sentiment index and the risk spillover intensity across all 18 industrial sectors. The empirical results reveal that the p-values for both directional hypotheses—Sentiment Granger-causing Risk and Risk Granger-causing Sentiment—are universally 0.000, indicating strong statistical significance at the 1% level.

Table 2. Linear Granger Causality Tests Between Investor Sentiment and Sectoral Risk Spillovers

Sector	Sentiment → Risk (p-value)	Risk → Sentiment (p-value)	Causality Direction
Mining	0.000***	0.000***	Bidirectional
Real Estate	0.000***	0.000***	Bidirectional
Financials	0.000***	0.000***	Bidirectional
Business Services	0.000***	0.001***	Bidirectional
Manufacturing	0.000***	0.000***	Bidirectional
Accommodation & Catering	0.000***	0.000***	Bidirectional

*** indicates significance at the 1% level.

From an economic perspective, this dual causality underscores a severe contagion mechanism. When systemic risk elevates, it induces market-wide panic, thereby severely depressing investor sentiment. Conversely, this pessimistic sentiment further exacerbates liquidity constraints and triggers fire sales, initiating a new wave of cross-industry risk contagion. Ultimately, this self-reinforcing cycle acts as a critical amplifier, effectively transforming localized sectoral distress into broad systemic financial crises. This strong statistical evidence of dual causality validates Hypothesis 2 (H2), verifying that risk and sentiment operate in a dangerous, self-reinforcing feedback loop.

5.3 Moderating Effects of Contagion Channels

To uncover the underlying transmission mechanisms of sentiment-driven risk contagion, we empirically examine the moderating effects of three distinct channels: industrial chain connectivity, capital flow, and sentiment transmission.

The regression results (as shown in **Table 3**) indicate that while all three channels significantly facilitate risk contagion, the capital flow channel displays the most prominent moderating effect. Rather than relying solely on static topological connections, our empirical evidence proves that industries with higher capital mobility act as central hubs in the system. They effectively absorb sentiment shocks and efficiently transmit these amplified risks to peripheral sectors.

Table 3. Moderating Effects of Contagion Channels on Sentiment-Driven Risk Spillovers

Sector	Baseline R^2	Enhanced R^2	ΔR^2	Industrial Chain (Interaction Coef.)	Capital Flow (Interaction Coef.)
Mining	0.12	0.212	0.091	-0.015***	-0.015***
Real Estate	0.137	0.164	0.027	-0.008***	-0.008***
Construction	0.085	0.11	0.025	-0.008***	-0.008***
Agriculture	0.118	0.155	0.038	-0.007***	-0.007***
Utilities	0.159	0.194	0.034	-0.008***	-0.008***
Business Services	0.071	0.085	0.014	0.006***	0.006***

*** indicates significance at the 1% level. The negative coefficients in traditional cyclical sectors suggest that pessimistic sentiment significantly amplifies risk contagion through both industrial chain and capital flow channels.

Therefore, the regression outcomes confirm Hypothesis 3 (H3). They elucidate that the 'core-periphery' network is not randomly formed but structurally dictated by capital mobility, with the capital flow channel serving as the primary conduit for sentiment-amplified risks.

5.4 Dynamic Asymmetry under Extreme Shocks

To investigate the time-varying nature of the emotional enhancement effect, we conduct a rolling-window dynamic analysis covering multiple crisis periods(see **Fig. 1**). The results highlight a profound asymmetry: the amplifying effect of investor sentiment is significantly stronger during market downturns than during bullish periods. Specifically, the network density and the sentiment-driven spillover intensity spiked dramatically during the 2015 stock market crash and the outbreak of the COVID-19 pandemic. During these extreme market conditions, rational pricing mechanisms temporarily fail, and "sentiment contagion" dominates the inter-industry risk network. The observed dynamic spikes during the 2015 and COVID-19 crises directly verify Hypothesis 4 (H4), proving that the emotional enhancement effect is highly asymmetric and event-driven.

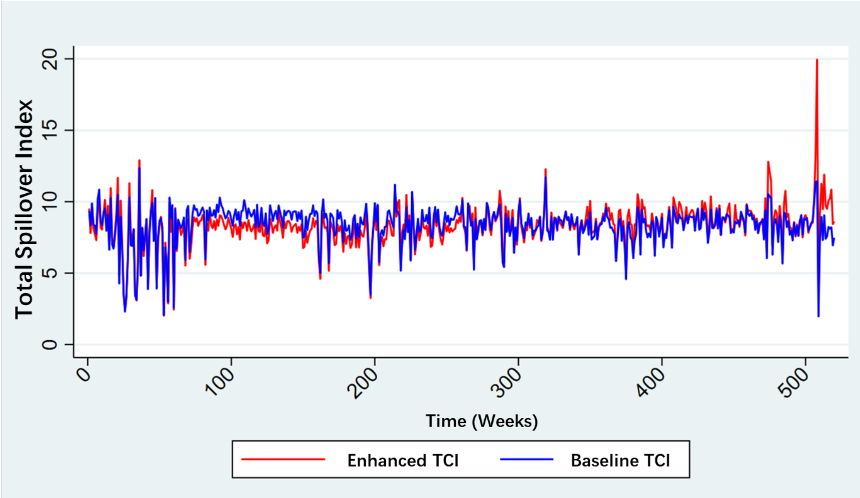

Fig. 1. Dynamic evolution of the overall inter-industry risk spillover level using a rolling-window analysis. The shaded areas (or vertical dashed lines) indicate extreme market crises, notably the 2015 stock market crash and the outbreak of the COVID-19 pandemic, during which the sentiment-driven spillover intensity spiked dramatically.

5.5 Synthesis of Empirical Results

The empirical evidence presented above constructs a comprehensive map of how investor sentiment redefines inter-industry risk contagion.

First, the significant predictive power of sentiment and the verified bilateral feedback loop establish sentiment as an endogenous risk amplifier.

Second, the identification of the capital flow channel's dominant role provides a structural explanation for how sentiment-amplified risks are transmitted through key sectoral hubs.

Finally, the dynamic asymmetry reveals that this sentiment-driven amplification is most lethal during crisis periods.

6 Robustness Check

To ensure the reliability of the "Emotional Enhancement Strategy," we conducted extensive robustness tests across three dimensions. First, we re-estimated the sentiment-enhanced TENET model using $q = 0.01$ (extreme distress) and $q = 0.10$ (moderate distress). The results show that the incremental R^2 contributed by sentiment remains remarkably stable, particularly for the Mining and Real Estate sectors, confirming the persistence of the emotional enhancement effect across different stress levels.

Second, we substituted the PCA-based composite sentiment index with individual proxies, such as detrended turnover rate and investor attention index. The rank of identified "risk hubs" (e.g., Financials and Real Estate) remained consistent, and the

Accommodation and Catering sector maintained its high path intensity (> 0.10) in triggering spillovers. Finally, we tested different lag lengths $p = 1, 2, 3$. The bilateral feedback loop remained statistically significant $p < 0.01$ across all specifications, with a one-day lag showing the highest information transmission efficiency.

7 Conclusion and Policy Implications

7.1 Conclusion

This study develops a sentiment-enhanced TENET model to investigate risk contagion in China's stock market. Key findings include:

- Sentiment as an Amplifier: Investor sentiment significantly improves the model's ability to capture tail risk spillovers across 18 industrial sectors.
- Mechanism of Interaction: A robust bilateral feedback loop exists between sentiment and risk, creating a self-reinforcing cycle during market distress.
- Dominance of Capital Flows: The capital flow channel is the primary pathway through which sentiment-driven shocks are transmitted, with high-liquidity sectors serving as critical hubs.
- Non-linear Dynamics: The sentiment-risk nexus is highly asymmetric, exhibiting dramatic intensity spikes during major market crashes.

7.2 Policy Implications

- Dynamic Sentiment Monitoring: Regulators should integrate real-time behavioral metrics into systemic risk dashboards to capture irrational volatility that traditional models miss.
- Liquidity-Based Intervention: Since capital flow is the dominant contagion channel, macro-prudential policies should focus on liquidity management in high-turnover sectors to prevent sentiment shocks from spreading.
- Stabilizing Market Expectations: Breaking the "sentiment-risk" loop requires enhanced information transparency and timely communication to prevent panic-driven fire sales during crises.

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