Cross-Border Credit Risk Spillover: A Mechanism Investigation Based on Dynamic High-Dimensional Network Analysis[‡]

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Abstract

This paper examines offshore-to-onshore credit risk contagion in China's real estate bond market, exploiting the 2021 default of Evergrande's U.S. dollar-denominated offshore bonds as an exogenous shock. Using a difference-in-differences design that compares onshore RMB bonds issued by firms with and without prior offshore USD bond exposure, we find a statistically and economically significant widening of onshore credit spreads among USD-exposed issuers following the default. Mechanism tests reveal that the effect operates primarily through credit rating downgrades and a contraction in secondary-market liquidity. We further construct a high-dimensional spillover network and document a pronounced shift in network topology: offshore USD bonds migrate to the center of the spillover system and serve as the primary conduit of cross-market risk transmission. Our findings highlight the importance of monitoring offshore financing exposure in credit risk assessment and call for stronger cross-market supervisory coordination and liquidity backstops during stress episodes.

Keywords: Credit Risk; Offshore USD Bonds; Cross-Border Risk Spillover; Network Analysis.

JEL Classification: G12, G15.

1 Introduction

Capital market liberalization integrates emerging economies with global capital flows, reshaping domestic financing conditions. While financial openness reduces financing costs and improves capital allocation efficiency, it also heightens exposure to external shocks and amplifies cross-border risk propagation. Greater integration between offshore and onshore markets raises the possibility that foreign credit shocks directly influence domestic credit pricing. Understanding this transmission mechanism is therefore critical for designing macro-prudential frameworks capable of mitigating spillovers from external credit disturbances to local lending conditions.

China offers a unique laboratory for examining this issue. Over the past decade, bond market liberalization has progressed rapidly through initiatives such as Bond Connect and Swap Connect, strengthening linkages between domestic and international investors. The offshore U.S. dollar-denominated bond market for Chinese sovereign and corporate issuers plays a key role in the dual liberalization of China's bond market and contributes to the diversification of bond products and market structure (Chang and Zhang, 2020). Using firm-level data from China and Malaysia, Pan and Wu (2022) show that following the 2008 financial crisis, cross-border bond issuance—particularly in U.S. dollars—has become an important financing channel in major emerging economies. Meanwhile, U.S. dollar-denominated offshore bonds issued by Chinese firms, commonly referred to as offshore USD bonds, have grown substantially as an external financing channel. The real estate sector has been the dominant issuer in this market. For property developers facing tightening domestic credit conditions, offshore USD bonds offered an important source of funding diversification. At the same time, offshore issuance exposed firms to exchange rate fluctuations, global liquidity cycles, refinancing risk, and cross-border regulatory uncertainty—raising the possibility that offshore financing exposure influences the pricing of firms' onshore debt.

The 2021 default of Evergrande, a major Chinese real estate developer, on its offshore USD-denominated bonds provides a natural experiment to study the onshore-offshore risk transmission channel. As one of the largest property developers and a prominent issuer in the offshore

USD bond market, Evergrande's default constituted a systemic credit shock rather than an isolated firm-specific event. In its aftermath, offshore financing conditions tightened sharply, risk sentiment deteriorated, and rating downgrades spread across the sector. Importantly, the shock was not confined to offshore markets: credit spreads on onshore RMB bonds issued by property developers widened markedly, suggesting cross-market contagion. This episode raises a central question: does exposure to offshore USD bond financing amplify onshore credit risk pricing following a major offshore default?

This paper investigates offshore-to-onshore credit risk contagion in China's real estate bond market. We ask whether firms with offshore USD bond exposure are priced differently—specifically, whether they experience a significantly larger increase in onshore RMB bond credit spreads following the Evergrande default. Following Gilchrist et al. (2024), we employ a difference-in-differences (DID) framework that compares RMB bonds issued by firms with prior offshore USD bond exposure to those without such exposure, before and after the default. This design isolates the incremental effect of offshore exposure on domestic credit spreads, controlling for common time effects and bond-level heterogeneity.

We find that USD-exposed firms exhibit systematically higher onshore RMB credit spreads following the Evergrande default relative to non-exposed firms. This result provides direct evidence that offshore credit shocks transmit into the domestic bond market within an integrated financial system. We examine two transmission channels: the deterioration of credit quality among exposed issuers and the contraction of secondary-market liquidity. These channels capture information transmission and market-based propagation, respectively, enabling us to disentangle how offshore credit shocks are impounded into domestic bond pricing. Our findings contribute to the literature on cross-border risk transmission in emerging economies (Asriyan, 2021; Kim and Shin, 2021): as offshore markets increasingly serve as conduits for global financial conditions, secondary-market liquidity frictions—interacting with financial constraints—generate mispricing and amplify asset price volatility.

We complement the regression analysis with a high-dimensional spillover network approach to characterize how the structure and direction of risk transmission evolve around the default event. After the shock, offshore USD bonds emerge as the central hub of the spillover net-

work, and the dominant direction of risk flow reverses—from onshore-to-offshore to offshore-to-domestic. RMB bonds issued by cross-border-exposed firms become more tightly connected to offshore bonds, whereas bonds of non-exposed firms migrate to the network periphery. This analysis extends the growing literature on spillover connectedness in bond markets (Diebold and Yılmaz, 2014; Jia et al., 2025; Ren et al., 2025) by documenting a structural transformation of the risk propagation network in a cross-border setting.

The remainder of the article is organized as follows. Section 2 reviews relevant literature and proposes the hypotheses. Section 3 summarizes our data and measures. Section 4 outlines the research design. Section 5 presents the empirical results, while Section 6 discusses the risk transmission structures via high-dimensional network analysis. Section 7 concludes.

2 Literature Review and Hypothesis Development

Corporate defaults affect not only individual issuers but also the credit pricing of related securities through information and behavioral channels. Default events raise market uncertainty, heighten investor risk aversion, and reduce market liquidity, thereby widening spreads on other bonds. Rating downgrades following defaults convey adverse credit information and elevate risk premia, constituting an important propagation mechanism.

Cross-market transmission of credit risk is well documented in the literature. Such transmission intensifies in integrated financial systems where investors and pricing mechanisms span borders (Baruník and Křehlík, 2018; Diebold and Yılmaz, 2014). Yang et al. (2021) document that policy shocks transmit across Asia-Pacific regions primarily through trade linkages and financial interconnections, with effects significantly amplified during crises. Wu et al. (2024) show that offshore default risk contagion raises financing costs and credit spreads for industry peers. Within the Asian context, risk spillovers across equity and bond markets are particularly pronounced during stress periods, as shocks in one market amplify risk premia in others (Wang et al., 2024). Contagion channels include liquidity, supply chains, investor sentiment, and asset prices (Ma and He, 2021); these channels can also influence non-defaulting firms' earnings management incentives (Ning et al., 2020). Cheng et al. (2022) show that the COVID-19 out-

break significantly strengthened global stock market volatility linkages.

The 2021 default of China Evergrande's USD-denominated offshore bonds constitutes a systemic offshore credit shock. As one of the largest issuers in the Chinese USD bond market, Evergrande's default signaled a sharp deterioration in sectoral credit fundamentals and prompted international investors to reassess solvency and refinancing risk across the real estate sector. In integrated bond markets, pricing mechanisms and investor bases partially overlap across offshore and onshore segments. Offshore default shocks can therefore alter global investors' assessment of sectoral creditworthiness, affecting pricing benchmarks and risk premia in onshore markets. Through portfolio rebalancing, funding constraints, and information updating, offshore risk repricing may transmit to RMB bond spreads, particularly for firms directly exposed to offshore USD liabilities—reflecting a sector-wide repricing of default and liquidity risk across integrated market segments.

Hypothesis 1: Onshore RMB bonds issued by firms with offshore USD bond exposure exhibit higher credit risk due to cross-border risk spillover after Evergrande's default.

Credit risk contagion operates through identifiable channels rather than mechanical comovement. We focus on two principal mechanisms: the credit quality channel and the liquidity channel. Credit ratings signal issuer quality to the market, strengthening market discipline and playing a central role in corporate bond pricing by conveying changes in default probabilities (He and Jin, 2010). Rating downgrades increase required spreads by signaling deteriorating creditworthiness, and following a large default event, rating agencies may reassess firms with similar credit profiles, triggering clustered downgrades that further widen spreads (Hu et al., 2023). Credit-risk contagion can thereby depress the rating standing of an entire sector, consistent with evidence that default shocks raise spread volatility through downgrade transmission (Billio et al., 2012).

Market liquidity is a second key determinant of credit spreads. Credit defaults dampen both market-wide and asset-specific liquidity, as reflected in wider bid-ask spreads and lower trading volumes (Cai et al., 2015; Bao et al., 2011; Dick-Nielsen et al., 2012). Offshore default shocks can trigger risk aversion and reduce investor risk appetite, tightening liquidity in related bond markets. This contraction may transmit to the onshore market through integrated investor

behavior, raising the liquidity premium demanded on onshore RMB bonds.

Hypothesis 2: The Evergrande USD bond default risk spills over to the onshore RMB bond market via deteriorating credit conditions and liquidity tightening.

3 Data & Variables

3.1 Data

Because our analysis focuses on offshore-to-onshore credit risk contagion following the Evergrande default, the sample is restricted to real estate firms. We obtain onshore RMB bond issuance and trading data from Wind Information Co. (WIND), a leading Chinese financial data provider, and download offshore USD bond information—including issuance details, trading yields, and default status—from Bloomberg. We then manually match offshore USD bonds to domestic real estate firms based on issuer names, equity relationships, and bond-issuer identifiers. For example, RiseSun Real Estate Development Co., Greenland Holdings Corporation, and Jinke Property Group each issued both onshore and offshore bonds simultaneously; Country Garden Real Estate Group Co. is a wholly owned subsidiary of Country Garden Holdings Company Limited.

To calculate credit spreads, we extract the yield to maturity of China Government Bonds (CGB) from the China Central Depository & Clearing Co. Ltd (CCDC),[1] and U.S. Treasury yields from the Federal Reserve Bank of St. Louis. Firm-level financial statements (e.g., total assets, leverage, and operating revenue) are obtained from CSMAR, while key financial indicators such as return on equity and liquidity ratios are drawn from Wind. The main sample spans June 3, 2005, to September 30, 2025, at weekly frequency. The offshore USD bond sample, used only in the spillover network analysis, runs from January 3, 2020, to November 24, 2023. Bonds with missing observations are excluded. The final sample comprises 834 bonds issued by 298 real estate firms: 789 issued by domestic firms and 45 issued overseas or by overseas subsidiaries, yielding 90,375 bond-week observations for onshore RMB bonds and 4,907 for

[1] ChinaBond: https://yield.chinabond.com.cn/cbweb-mn/indices/single_index_query?locale=zh_CN

offshore USD bonds.

3.2 Variable Construction

We measure credit risk using bond trading yield spreads (*Spread*) as the dependent variable (Collin-Dufresn et al., 2001; Gao et al., 2026; Longstaff et al., 2005). For onshore RMB bonds, *Spread* is the yield difference between the weekly trading yield-to-maturity (YTM) and that of Chinese government bonds of the same maturity.[2] We compute the analogous measure for offshore USD bonds by subtracting U.S. Treasury yields.

Evergrande defaulted on its offshore USD bond on December 3, 2021.[3] We define $Shock_t = 1$ for observations after the fourth quarter of 2021 and zero otherwise. We define $US_bond_{ic} = 1$ if the domestic real estate firm had issued offshore USD bonds prior to the fourth quarter of 2021, and zero otherwise. The interaction term $US_bond_{ic} \times Shock_t$ captures the differential change in onshore credit spreads for USD-exposed issuers following the Evergrande default.

Following Gao et al. (2026), Geng and Pan (2024), Huang and Guo (2021), Saunders et al. (2025), and He et al. (2026), we include three sets of control variables. Bond-level controls comprise maturity (Term), issuance amount (Amount), embedded option rights (Right), guarantee status (Guarantee), issuance credit rating (Rating), bid-ask spread (BidAsk), and trading volume (Volume). Firm-level controls include return on equity (*ROE*), leverage (*Leverage*), current ratio (*Liquidity*), asset turnover (*Asset Turnover*), and the number of actual trading days (*Days*). Macro controls are the RMB/USD exchange rate and the real GDP growth rate (Δ*lnGDP*) (Dai and Sun, 2011). All variable definitions are summarized in Table 1.

Table 2 reports summary statistics. The average bond trading spread is 0.963%, ranging from -1.043% to 6.865%. Among the sample firms, 32.5% had issued offshore USD bonds prior to Evergrande's default.

[2] We interpolate the full yield curve using the YTMs of government bonds of 1, 2, 3, 5, 7, and 10 years.

[3] See: https://finance.caixin.com/2021-12-03/101813522.html (*In Chinese*).

4 Research Design

This section describes the empirical design. We begin with the baseline DID specification, followed by the transmission mechanism tests, and conclude with the high-dimensional spillover network model.

4.1 Baseline Model

To identify offshore-to-onshore credit risk contagion, we implement a DID framework using the 2021 Evergrande offshore USD bond default as an exogenous credit shock:

$$\begin{aligned} Spread_{ict} = \beta_0 + \beta_1 \times Shock_t + \beta_2 \times US_bond_{ic} + \beta_3 \times US_bond_{ic} \times Shock_t \\ + \sum_k \gamma_k \times X_{ict}^k + \mu_c + \lambda_t + \varepsilon_{ict} \end{aligned} \tag{1}$$

where $Spread_{ict}$ denotes the trading credit spread of bond i issued by firm c in week t. The coefficient β_3 captures the incremental change in onshore credit spreads for USD-exposed issuers following the Evergrande default relative to non-exposed issuers. A positive and significant β_3 indicates credit risk spillover from the offshore USD market to the domestic RMB bond market. X_{ict}^k denotes the aforementioned control variables; μ_c and λ_t are firm and time fixed effects, respectively. We use heteroskedasticity-robust standard errors throughout.

4.2 Transmission Mechanisms

To identify the channels through which offshore credit risk transmits to the domestic market, we estimate the following triple-difference specification:

$$\begin{aligned} M_{ict} = \beta_0 + \beta_1 \times Shock_t + \beta_2 \times US_bond_{ic} + \beta_3 \times US_bond_{ic} \times Shock_t \\ + \beta_4 \times US_bond_{ic} \times Shock_t \times Default_Amount_{ct} \\ + \sum_k \gamma_k \times X_{ict}^k + \mu_c + \lambda_t + \varepsilon_{ict} \\ M_{ict} \in \{\Delta Rating_{ict}, \quad BidAsk_{ict}, \quad Volume_{ict}\} \end{aligned} \tag{2}$$

where $\Delta Rating_{ict}$ captures rating adjustments of onshore RMB real estate bonds after the Evergrande default—defined as the January 2022 rating score minus the issuance rating score—reflecting industry- and market-level contagion effects. $BidAsk_{ict}$ and $Volume_{ict}$ measure bid-ask spreads and trading volume, respectively, capturing offshore default effects on domestic bond market liquidity. The triple interaction $US_bond_{ic} \times Shock_t \times Default_Amount_{ct}$, where $Default_Amount_{ct}$ counts a firm's offshore USD bond defaults at time t, tests whether greater offshore default exposure amplifies contagion in the domestic market.

4.3 High-Dimensional Risk Spillover Network

While the DID framework identifies average treatment effects, it does not capture the structural topology of cross-market risk propagation. We therefore complement the analysis with a high-dimensional spillover network approach to characterize system-wide risk transmission across offshore and onshore bond segments, focusing on the window from September 6, 2021, to March 6, 2022.

Elastic-Net VAR Framework. Let Y denote a $T \times N$-dimensional vector of bond credit spreads. We estimate a p-order VAR:

$$Y_t = \sum_{k=1}^{p} \phi_k Y_{t-k} + \varepsilon_t, \quad t = 1, 2, \ldots, T \tag{3}$$

We set $p = 5$. To address high-dimensionality, we incorporate elastic-net shrinkage (Gross and Siklos, 2020; Huber and Feldkircher, 2019):

$$\hat{\phi} = \arg\min \left\{ \sum_{t=1}^{T} \left(Y_{it} - \sum_{k=1}^{p} \phi_{k,i} Y_{it-k} \right)^2 + \delta \sum_{k=1}^{p} \left[(1-\alpha)|\phi_{k,i}| + \alpha |\phi_{k,i}|^2 \right] \right\} \tag{4}$$

where δ controls overall penalty intensity and α governs the Lasso–Ridge trade-off. The estimated parameters yield the error variance-covariance matrix $\hat{\Sigma}$.

Generalized Forecast Error Variance Decomposition. Following Diebold and Yılmaz (2014) and Arouri et al. (2025), we compute the H-step-ahead generalized forecast error vari-

ance decomposition ($H = 10$). The directional risk spillover from bond i to bond j is:

$$C_{i\to j}^{H} = \frac{\sigma_{ii}^{-1} \sum_{h=0}^{H-1} \left(e_j' A_h \hat{\Sigma} e_i \right)^2}{\sum_{h=0}^{H-1} \left(e_j A_h \hat{\Sigma} A_h' e_j \right)^2} \tag{5}$$

where σ_{ii} is the i-th diagonal element of $\hat{\Sigma}$, e_i is an N-dimensional selection vector, and A_h is the moving-average coefficient matrix. We row-normalize to ensure comparability across bonds.

Spillover Network Measures. The **Total Spillover Index** is $S_H = \frac{\sum_{i\neq j} C_{i\to j}^{H}}{n}$. **Directional Spillovers** are $To_i = \sum_{j\neq i} C_{i\to j}^{H}$ and $From_i = \sum_{j\neq i} C_{j\to i}^{H}$. The **Net Spillover** is $Net_i = From_i - To_i$: a positive value indicates bond i is a net risk transmitter; negative indicates a net receiver.

Group-Level Spillovers. We aggregate to three groups: (1) offshore USD bonds; (2) onshore RMB bonds of USD-exposed firms (treatment group); (3) onshore RMB bonds of non-exposed firms (control group):

$$GI_{a\to b} = \sum_{i\in a} \sum_{j\in b} C_{i\to j}^{H} \tag{6}$$

where a and b denote different groups. This framework allows us to assess whether offshore USD bonds become central transmitters of credit risk following the Evergrande shock, thereby structurally validating the contagion mechanism identified in the DID analysis.

5 Onshore-Offshore Risk Exposure Analysis

This section presents the empirical results. We begin with the baseline estimates, proceed to robustness checks addressing potential selection bias via PSM and entropy balancing as well as an alternative dependent variable, and conclude with mechanism tests and heterogeneity analysis.

5.1 Baseline Regression

Table 3 reports the baseline DID estimates. Column (1) includes no controls or fixed effects; columns (2)–(4) progressively add controls and fixed effects. The preferred specification in column (4)—which includes issuer and time fixed effects—shows that the coefficient on $US_bond \times Shock$ is 1.6457 and significant at the 1% level. This estimate implies that investors demand a 1.6457 percentage point higher credit spread from USD-exposed issuers after the Evergrande default relative to non-exposed issuers, providing evidence of offshore-to-onshore credit risk transfer.

Three mechanisms plausibly explain this widening. First, cross-border signal transmission may have amplified risk perceptions: the Evergrande default weakened international investor confidence in China's real estate sector, and adverse sentiment spilled over into the domestic bond market, leading investors to demand higher premia from USD-exposed firms. Second, liquidity pressures intensified—tightening offshore financing conditions constrained funding access for USD bond issuers, forcing them toward domestic markets and raising refinancing costs. Third, heightened risk aversion triggered precautionary selling, price declines, and spread widening in the short run.

The coefficient on US_bond is positive and significant at the 1% level in columns (2) and (3), indicating that USD-exposed firms carry structurally higher domestic credit spreads even before the shock—consistent with investors pricing in pre-existing cross-border market risk. The positive and significant coefficient on $Shock$ confirms that average credit spreads rose across the real estate sector following the Evergrande default, reflecting a broader deterioration in market conditions.

Turning to control variables, bond maturity (Term) is negatively associated with credit spreads, consistent with shorter-maturity bonds commanding higher spreads due to heightened refinancing pressure and near-term rollover risk. Issuance size (Amount) is positively associated with credit spreads, plausibly reflecting investor concerns about repayment capacity for large-scale debt obligations. Bonds with embedded options (Right) carry lower spreads, consistent with the view that contractual flexibility reduces perceived risk (Wanfa et al., 2022).

The positive and significant coefficient on Guarantee may reflect adverse selection or uncertainty about underlying asset quality. Credit rating scores (Rating) are negatively associated with credit spreads in the within-issuer specification, consistent with the coding convention in which lower scores denote higher quality. Financial indicators—ROE, liquidity ratio, and asset turnover—are negatively associated with spreads, indicating that financially stronger firms face lower financing costs (Fan, 2025), consistent with trade-off theory.

5.2 Robustness Analysis

We subject the baseline estimates to several robustness checks. First, we conduct an event study to validate the parallel-trends assumption and trace the dynamic treatment effect. Using the third quarter of 2021 as the reference period, Figure 1 shows that the interaction-term coefficients fluctuate around zero with non-significant confidence intervals before the default—consistent with parallel pre-trends. After the default, the coefficients rise sharply and remain elevated, indicating a persistent widening of credit spreads for treated bonds relative to the control group.

Second, to address potential selection bias, we employ PSM with 1:2 nearest-neighbor matching and entropy balancing. We compute propensity scores from a logit regression on the control variables. Table 4 shows that standardized biases for all covariates fall below 20% after matching, and Figures 2–3 confirm substantially improved covariate balance. Columns (1) and (2) of Table 5 report DID estimates on the PSM-matched and entropy-balanced samples, respectively; the interaction coefficient remains positive and significant at the 1% level in both cases.

Third, we replace the secondary-market credit spread with the primary-market issuance spread as an alternative dependent variable. Column (3) of Table 5 shows that the interaction coefficient retains its sign and significance, confirming that the Evergrande default also raised primary-market financing costs for USD-exposed issuers. The smaller coefficient magnitude relative to secondary-market estimates is consistent with primary markets adjusting more gradually to credit shocks than the faster-moving secondary market.

5.3 Mechanism Investigation

The baseline results establish that USD-exposed firms experienced significantly wider onshore credit spreads following the Evergrande default. Table 6 reports the mechanism estimates from equation (2), with columns (1)–(3) using $\Delta Rating$, $BidAsk$, and $Volume$ as dependent variables, respectively.

Credit quality channel. Column (1) shows that $US_bond \times Shock$ is positive and significant at the 1% level, indicating that the Evergrande default triggered broad credit rating deterioration among offshore-exposed issuers. The triple interaction $US_bond \times Shock \times Default_Amount$ is also positive and significant at the 1% level: the greater the volume of subsequent offshore defaults, the larger the rating downgrade for a firm's onshore bonds. This pattern is consistent with clustered default contagion in the offshore market propagating to domestic credit ratings and, in turn, to secondary-market spreads.

Liquidity channel. Columns (2) and (3) show that $US_bond \times Shock$ significantly widens bid-ask spreads and reduces trading volumes, indicating that offshore exposure deteriorates domestic bond liquidity. The triple interaction is also significantly positive for bid-ask spreads, confirming that liquidity conditions worsen further as the count of offshore USD bond defaults accumulates.

Taken together, these results demonstrate that the Evergrande default propagated to the onshore RMB market through two reinforcing channels—rating deterioration and liquidity contraction—each of which contributed to higher domestic credit spreads.

5.4 Heterogeneity Analysis

We examine whether the contagion effect varies across bond and issuer characteristics by splitting the sample along four dimensions: guarantee status, credit rating, asset size, and bond maturity. For each partition, we estimate both a triple-interaction regression on the full sample and subsample regressions, using Fisher's combination test—with p-values from 100 bootstrap replications—to compare coefficients across groups.

Table 7 reports the results. *Panel A: Guarantee and credit rating.* The triple interac-

tion $US_bond \times Shock \times Guarantee$ in column (1) is positive but not statistically significant ($t = 1.11$). However, the subsample estimates in columns (2) and (3) show a significantly larger contagion effect for guaranteed bonds than for non-guaranteed bonds (p-suest < 0.001). In China's real estate sector, guarantors are typically affiliated upstream or downstream firms, or parent/subsidiary companies; when industry credit conditions deteriorate broadly, these guarantee networks can amplify risk propagation. For credit ratings, the triple interaction in column (4) is large and highly significant, and subsample estimates in columns (5) and (6) confirm that the contagion effect is concentrated among low-grade issuers—consistent with tighter refinancing constraints and lower resilience to sector-wide credit shocks.

Panel B: Asset size and bond maturity. The triple interaction $US_bond \times Shock \times Small$ in column (7) is positive and significant, and subsample estimates in columns (8) and (9) confirm that smaller firms experience significantly larger spread increases. Large firms benefit from diversified asset bases, stronger collateral, and greater financial flexibility. For bond maturity, the triple-interaction terms in column (10) show that the shock effect increases with maturity: the coefficients on $US_bond \times Shock \times Medium$ and $US_bond \times Shock \times Long$ are both positive and significant, while the short-maturity subsample effect in column (11) is not statistically significant ($t = 1.18$). Long-term bonds carry structurally lower liquidity, leading investors to demand higher liquidity premia during periods of elevated uncertainty; they also embed greater cumulative default risk, prompting further spread compensation as credit events accumulate.

6 Risk Spillover Network Analysis

To complement the regression evidence, we construct a high-dimensional risk spillover network using machine learning techniques and augment the sample with weekly credit spreads of offshore USD bonds over the window from September 6, 2021, to March 6, 2022. We classify bonds into three groups: (1) onshore RMB bonds issued by firms without offshore USD bond issuance (control group); (2) onshore RMB bonds issued by firms that had issued offshore USD bonds prior to the default (treatment group); and (3) offshore USD bonds issued by domestic real estate firms and their subsidiaries. This classification enables a systematic analysis of spillover

characteristics and transmission flows across market segments.

6.1 Risk Spillover Intensity Across Bond Groups

Figure 4 reports the total spillover indices across the three bond groups before (red bars) and after (green bars) the Evergrande default. The patterns are strikingly differentiated. For the control group of non-exposed onshore RMB bonds, the index declines from 82.19% to 79.10%, indicating reduced interconnectedness after the shock. For the treatment group of USD-exposed onshore RMB bonds, the index rises modestly from 81.47% to 82.59%. Most strikingly, the offshore USD bond index surges from 87.84% to 94.86%, reflecting a sharp intensification of spillover activity.

These patterns corroborate the liquidity-channel evidence in Table 6. Following the default, offshore USD bonds emerge as the dominant source of systemic risk spillovers as markets reprice Chinese real estate credit risk. This heightened uncertainty propagates to the onshore RMB bonds of USD-exposed firms, whose spillover intensity rises in tandem—highlighting a strong cross-market linkage within the same issuer group. The simultaneous decline in spillover intensity among non-exposed bonds serves as a natural placebo, confirming that the contagion is concentrated among firms with direct offshore credit exposure.

6.2 Evolution of Network Structure

Figures 5 and 6 display the full risk spillover network before and after the default, respectively. Red nodes are non-exposed onshore RMB bonds (control group), green nodes are USD-exposed onshore RMB bonds (treatment group), and blue nodes are offshore USD bonds. Node size is proportional to a bond's total spillover index; edge thickness reflects pairwise spillover magnitude.

Before the shock (Figure 5), the network is relatively balanced, with no discernible structural hierarchy across the three groups. After the shock (Figure 6), a distinct core–periphery structure emerges. Offshore USD bonds (blue nodes) migrate to the network center and become the dominant hub of risk transmission, with markedly increased connectivity and edge

weight. USD-exposed onshore bonds (green nodes) form dense, high-weight connections with these offshore bonds, reflecting intensified cross-border linkage. Non-exposed onshore bonds (red nodes) shift to the periphery, with declining connectivity—mirroring the reduction in their spillover index documented in Figure 4.

6.3 Cross-Border Risk Transmission Patterns

Figure 7 quantifies the directional spillover flows between onshore and offshore markets. Blue (orange) bars denote pre- (post-) default indices; solid (hatched) bars denote onshore-to-offshore (offshore-to-onshore) spillovers.

Before the shock, the average onshore-to-offshore spillover is 0.0081 versus an offshore-to-onshore spillover of 0.0048, indicating that domestic fundamentals drive the dominant direction of cross-border risk transmission. After the shock, this pattern reverses sharply: onshore-to-offshore spillover collapses to 0.0002, while offshore-to-onshore spillover rises to 0.0188—nearly four times the pre-shock level. The Evergrande default thus transferred pricing power to the offshore USD bond market, which became the primary driver of onshore RMB bond credit risk, marking a structural transformation in cross-border contagion dynamics.

7 Conclusion

This paper provides evidence on offshore-to-onshore credit risk contagion in China's real estate bond market, using the 2021 Evergrande offshore USD bond default as an exogenous shock. Our DID estimates show that USD-exposed firms experience a 1.65 percentage point increase in onshore RMB credit spreads relative to non-exposed issuers. This spread widening operates through two reinforcing channels: rating downgrades that convey deteriorating credit quality and liquidity contraction reflected in wider bid-ask spreads and lower trading volumes. High-dimensional spillover network analysis reveals a structural transformation: offshore USD bonds migrate from the network periphery to its center, the dominant direction of risk transmission reverses from onshore-to-offshore to offshore-to-domestic, and non-exposed bonds retreat to the periphery.

These findings carry broader implications. Financial integration amplifies vulnerability to cross-border credit risk transmission, and during stress episodes, offshore markets can become dominant sources of systemic spillovers. Regulators should strengthen surveillance of offshore debt exposure, currency mismatches, and refinancing concentration, and develop early-warning systems to detect the build-up of systemic vulnerability. Enhanced coordination between offshore and onshore regulatory regimes—supported by liquidity buffers and appropriate disclosure requirements—is critical for containing cross-border contagion. Future research could evaluate the effectiveness of specific policy interventions, such as central bank liquidity facilities and regulatory forbearance, in mitigating such episodes.

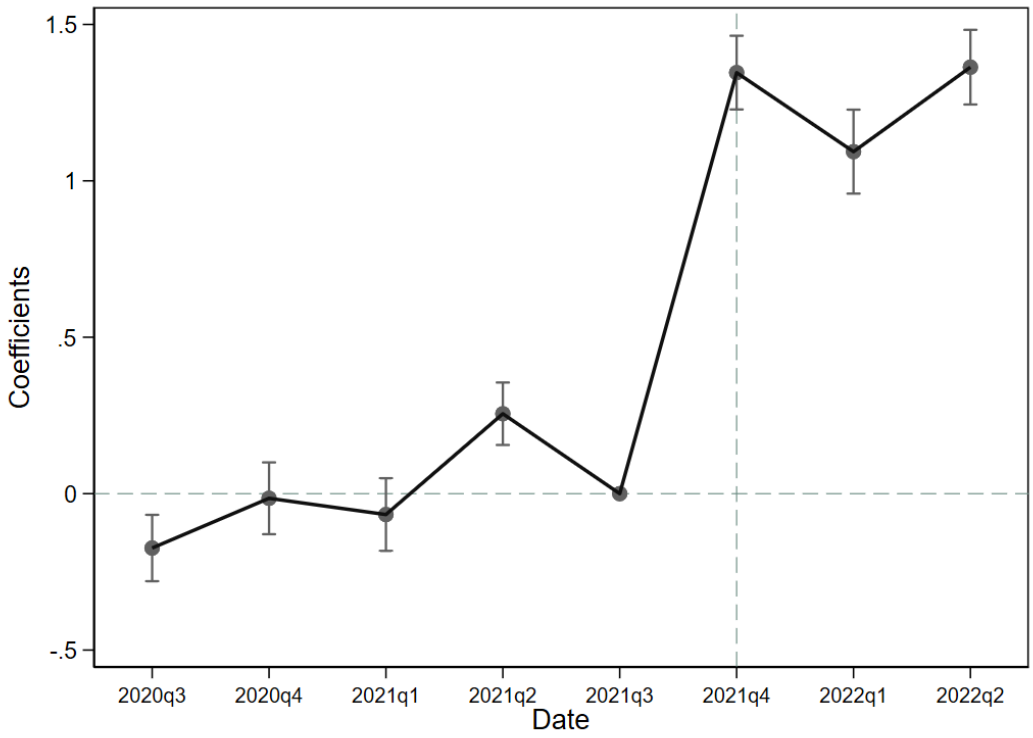


Figure 1: Event Study for Dynamic Treatment Effect. This figure employs the event-study approach to test the parallel trend assumption in the pre-shock period and analyze the dynamic treatment effects after the shock. Taking the third quarter of 2021 as the benchmark period, the figure reports the dynamic evolution of the interaction term coefficients.

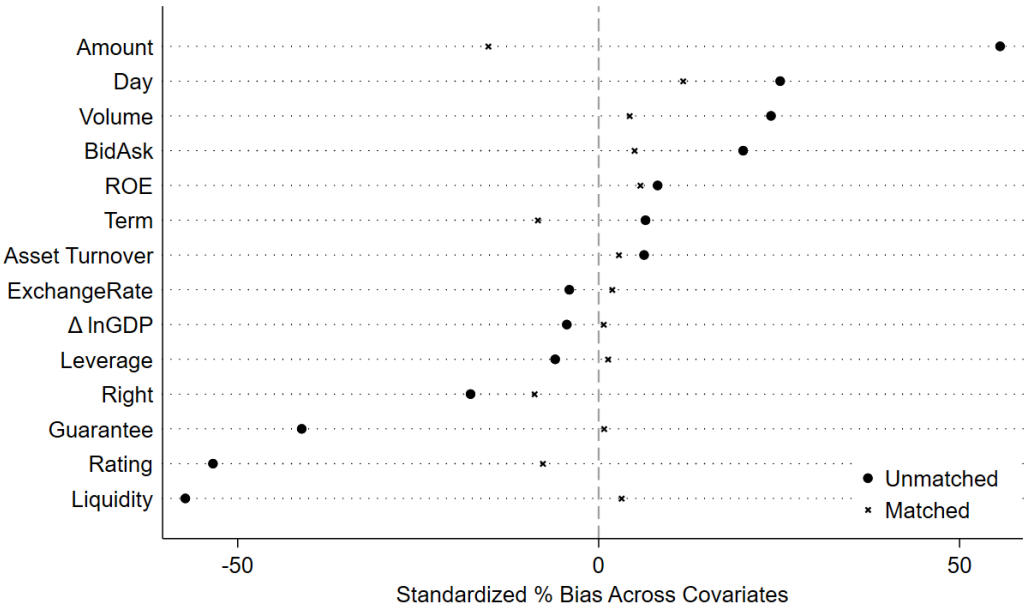


Figure 2: PSM Balancing Test. This figure presents the standardized percentage bias across the covariates before and after matching in the PSM-DID analysis. The horizontal axis shows the standardized % bias, and the vertical axis lists the covariates. The black dots represent the standardized bias in the unmatched sample, while the black crosses represent the standardized bias in the matched sample. The vertical dashed line at zero indicates no bias.

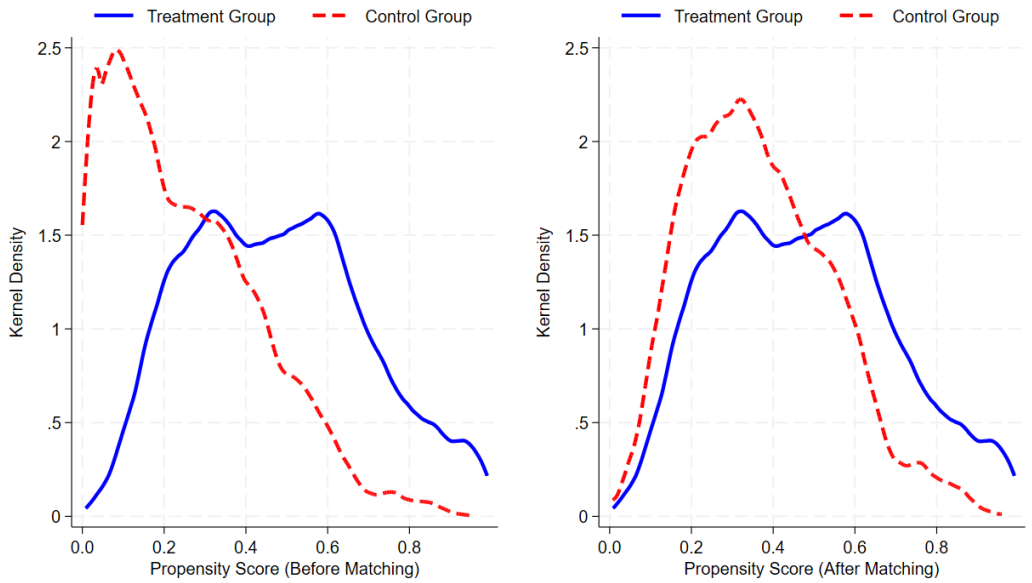


Figure 3: PSM Kernel Density Plot. This figure presents the kernel density distribution of propensity scores for the treatment and control groups before and after propensity score matching (PSM). The left panel shows the distribution before matching, while the right panel shows the distribution after matching. The horizontal axis represents the propensity score, and the vertical axis represents the kernel density. The solid blue line denotes the treatment group, and the dashed red line denotes the control group.

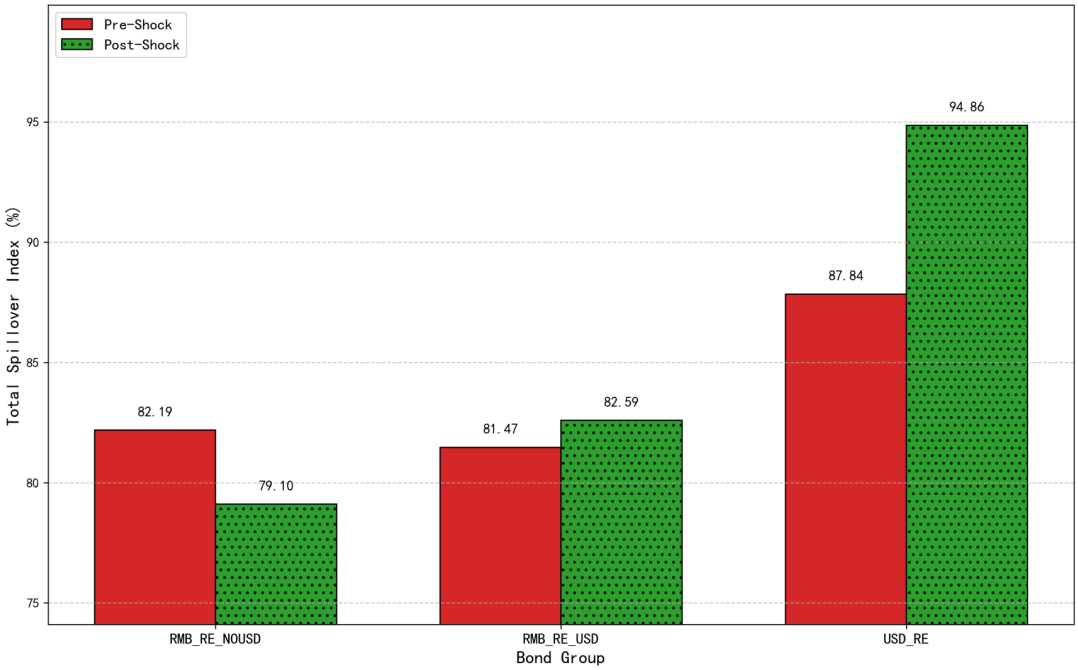


Figure 4: Comparison of Aggregate Risk Spillover Indices Across Different Bond Groups. This figure presents the total risk spillover indices (measured in percentage) for three distinct bond groups before and after the Evergrande default: The left panel (RMB_RE_NOUSD) refers to domestic bonds issued by real estate firms that did not issue offshore USD bonds; the middle panel (RMB_RE_USD) refers to domestic bonds issued by real estate firms that issued offshore USD bonds; the right panel (USD_RE) refers to the offshore USD bonds issued by the real estate firms. Red bars denote pre-shock indices; green dotted bars denote post-shock indices.

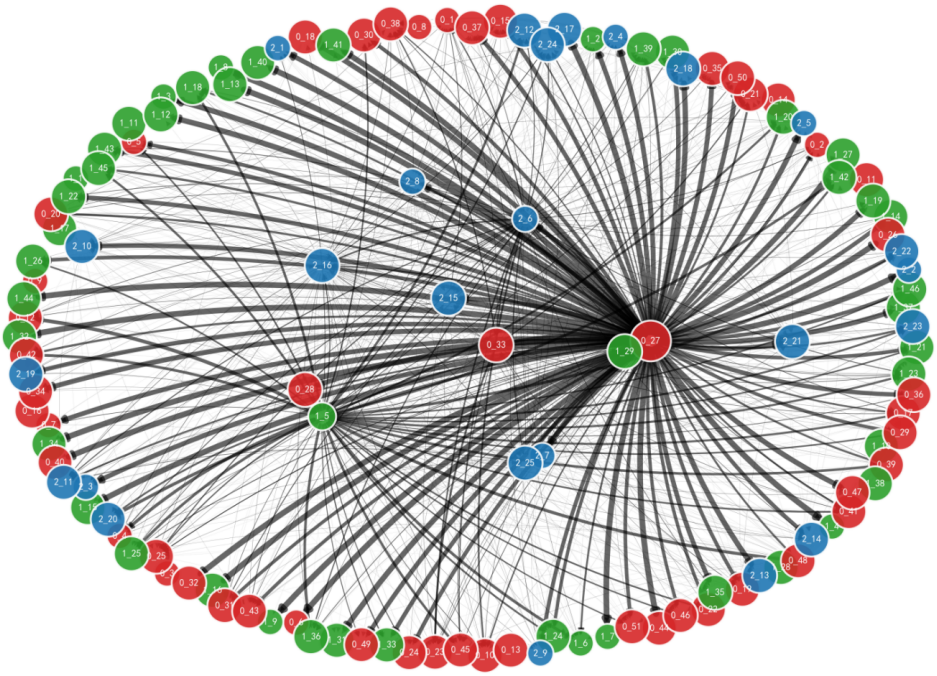


Figure 5: Pre-Event Network Analysis. This figure depicts the bond risk spillover network before the Evergrande default in December 2021. Red nodes ("0_") correspond to non-exposed onshore RMB bonds; green nodes ("1_") correspond to USD-exposed onshore RMB bonds; blue nodes ("2_") correspond to offshore USD bonds. Node size is proportional to the total spillover index; edge thickness reflects pairwise spillover magnitude.

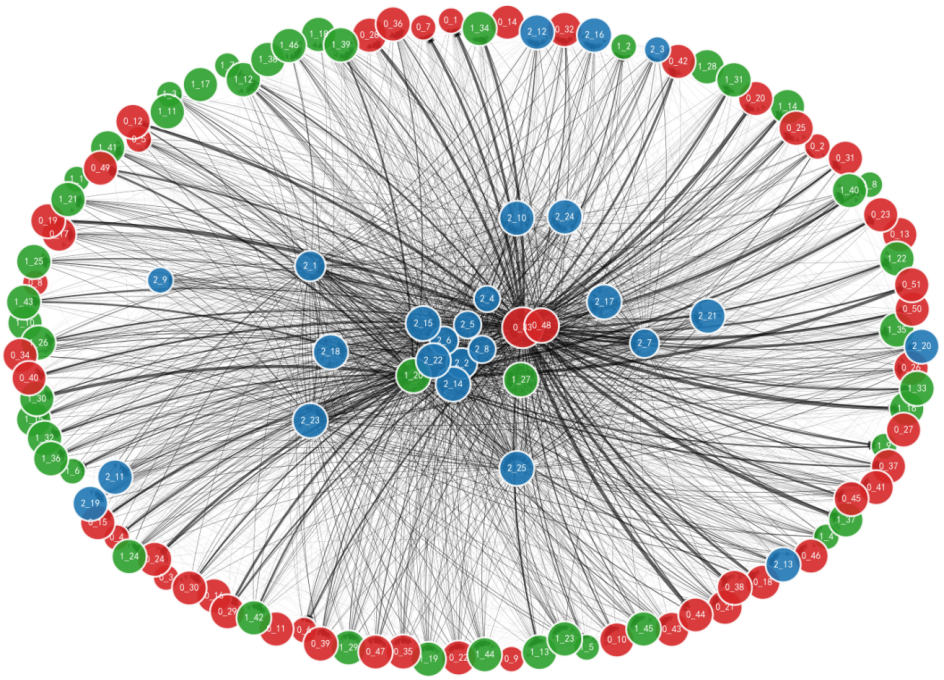


Figure 6: Post-Event Network Analysis. This figure depicts the bond risk spillover network after the Evergrande default in December 2021. Node colors and sizes follow the same convention as Figure 5. Edge thickness reflects pairwise spillover magnitude.

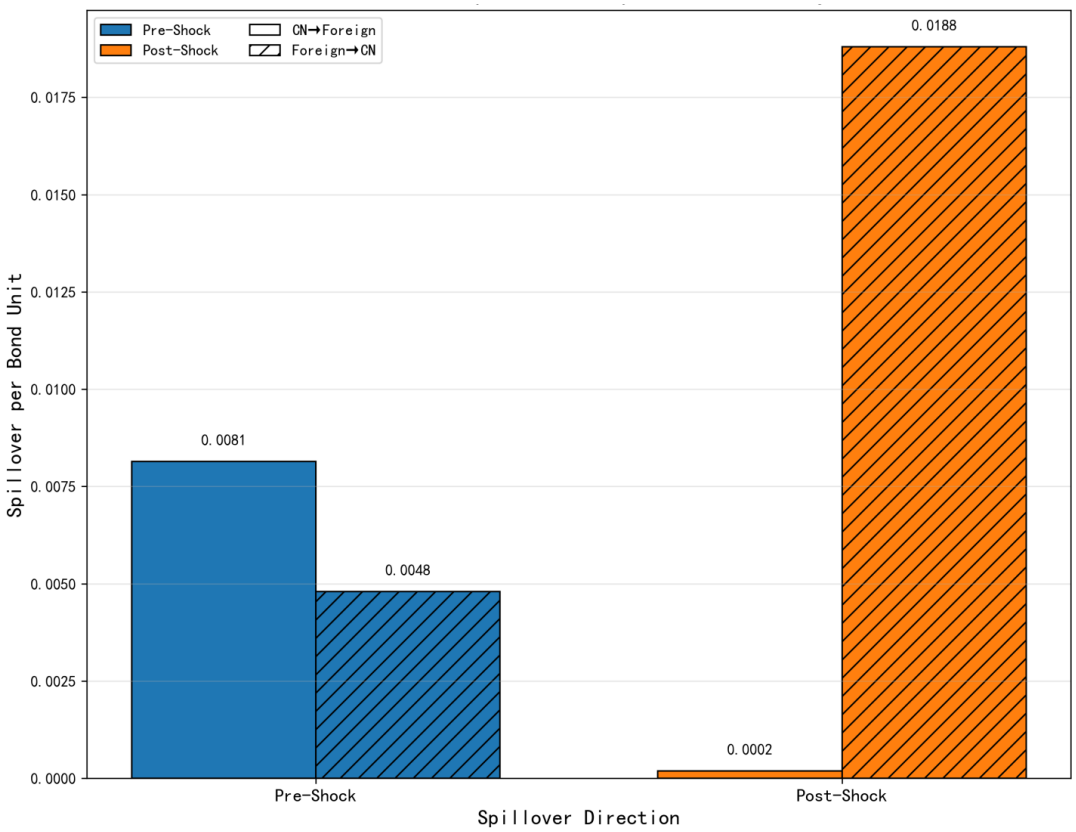


Figure 7: Onshore-Offshore Risk Spillover. Blue (orange) bars denote spillover indices before (after) the Evergrande default. Solid bars indicate onshore-to-offshore spillovers; diagonally hatched bars indicate offshore-to-onshore spillovers.

Table 1: Variable Definition

Variable Type	Variable Symbol	Definition
Dependent Variable	Spread	Weekly yield of RMB bonds minus treasury bonds yield (same maturity), natural logarithm processed.
Explanatory Variable	US_bond	1=firm issued US dollar bonds, 0=otherwise.
Control Variable	Term	Bond maturity (years, issue to maturity date).
	Amount	Bond issuance scale (100 million RMB).
	Right	1=bond has special rights, 0=otherwise.
	Guarantee	1=bond has guarantor, 0=otherwise.
	Rating	Issuance credit rating score (1=AAA,up to,12=CCC,lower=higher rating).
	BidAsk	Difference between weekly highest and lowest prices.
	ROE	Net profit / avg net assets (quarterly data).
	Leverage	Total liabilities / total assets (quarterly data).
	Liquidity	Current assets / current liabilities (quarterly data).
	Volume	Total weekly trading volume (measured in lots).
	Asset Turnover	Operating income / avg total assets (quarterly data).
	Day	Number of trading days in statistical period.
	ExchangeRate	RMB/USD closing price on trading day.
	ΔlnGDP	Real GDP growth rate.
Other variables	ΔRating	Post-shock bond credit rating score in January 2022 minus the corresponding issuance credit rating score.
	Default_Amount	The counts of firms' credit default of offshore USD bonds.
	Issuance Spread	Issuance yield of RMB bonds minus treasury bonds yield (same maturity), natural logarithm processed.

Table 2: Descriptive Statistics

This table reports the descriptive statistics of the main variables, including the number of observations (N), mean, standard deviation (SD), minimum (Min), median (P50), and maximum (Max). All continuous variables are winsorized at the 1% and 99% percentiles to alleviate the interference of extreme values. The sample period spans from June 3, 2005, to September 30, 2025.

Variable	N	Mean	SD	Min	P50	Max
Spread	90375	0.963	1.438	-1.043	0.779	6.865
US_bond	90375	0.325	0.468	0	0	1
Term	90375	4.854	1.528	2	5	10
Amount	90375	14.03	10.71	1	10	60
Right	89917	0.809	0.393	0	1	1
Guarantee	90375	0.314	0.464	0	0	1
Rating	80925	1.995	0.908	1	2	5
ROE	85979	1.507	9.337	-46.12	0.960	25.57
Leverage	82285	56.62	31.94	0	70.31	93.41
Liquidity	86291	1.426	0.997	0	1.499	5.043
Asset Turnover	86291	0.0830	0.0870	0	0.0590	0.392
BidAsk	90114	0.267	0.896	0	0.0550	6.582
Day	90375	62.94	147.2	0	7	903
Volume	90375	0.0510	0.192	0	0	1.333
ExchangeRate	90374	6.830	0.311	6.120	6.885	7.209
ΔlnGDP	90375	5.798	2.772	-6.900	5.900	18.70

Table 3: Baseline Difference-in-Differences Regression on Credit Spreads

This table reports the baseline regression results of the impact of US_bond×Shock on real estate firms' credit spreads. The dependent variable is Spread. The main independent variable is US_bond×Shock. Control variables include Term, Amount, Right, Guarantee, Rating, ROE, Leverage, Liquidity, Asset Turnover, BidAsk, Day, Volume, ExchangeRate, and ΔlnGDP. Column (1) shows the result without controls and fixed effects. Column (2) adds control variables. Column (3) controls for province and time fixed effects. Column (4) controls for issuer and time fixed effects. Robust standard errors are adjusted for heteroskedasticity. The t-statistics are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Dependent Variable: Spread			
	(1)	(2)	(3)	(4)
US_bond×Shock	1.6659***	1.3174***	1.1422***	1.6457***
	(65.13)	(50.46)	(45.10)	(68.06)
Shock	-0.6519***	-0.1804***	0.0009	-0.2720***
	(-58.71)	(-12.58)	(0.02)	(-7.15)
US_bond	0.0054	0.2514***	0.1344***	
	(0.82)	(33.83)	(17.56)	
Term		-0.1035***	-0.1054***	-0.0260***
		(-34.15)	(-35.20)	(-8.75)
Amount		-0.0006	-0.0034***	0.0059***
		(-1.74)	(-9.68)	(11.94)
Right		0.4600***	0.4999***	-0.0550***
		(42.89)	(48.82)	(-4.60)
Guarantee		-0.2436***	-0.2384***	0.0643***
		(-26.28)	(-26.62)	(5.05)
Rating		0.4093***	0.2887***	-0.1657***
		(70.69)	(45.24)	(-11.79)
ROE		-0.0306***	-0.0365***	-0.0214***
		(-39.98)	(-51.05)	(-35.82)
Leverage		0.0024***	0.0022***	0.0031***
		(11.35)	(10.59)	(15.61)
Liquidity		-0.3375***	-0.2695***	-0.1305***
		(-60.83)	(-54.20)	(-27.15)
Asset Turnover		0.6160***	0.4849***	-0.0030
		(11.19)	(8.63)	(-0.07)
BidAsk		0.2069***	0.1803***	0.1021***
		(30.84)	(29.44)	(20.10)
Day		0.0018***	0.0022***	0.0018***
		(43.54)	(50.37)	(41.09)
Volume		-0.2015***	-0.1559***	-0.1876***
		(-9.90)	(-7.79)	(-12.31)
ExchangeRate		-0.2805***	0.0803***	0.0929***
		(-15.27)	(3.24)	(4.95)
ΔlnGDP		-0.0166***	0.0053***	0.0032***
		(-13.66)	(4.02)	(2.67)
Constant	0.9850***	2.3064***	-0.1023	0.5000***
	(290.22)	(17.22)	(-0.59)	(3.71)
Observations	90,375	72,040	72,040	72,040
R-squared	0.122	0.403	0.487	0.747
Controls	NO	YES	YES	YES
Pro FE	NO	NO	YES	NO
Issuer FE	NO	NO	NO	YES
Time FE	NO	NO	YES	YES

Table 4: Covariate Balance Test for PSM

This table reports the covariate balance test results after propensity score matching (PSM). Variable denotes the name of each covariate; Match indicates whether the sample is unmatched or matched; Treated and Control represent the mean values of the treated group and the control group, respectively; %Bias refers to the percentage bias before and after matching; %Reduct represents the percentage reduction in bias after matching; t denotes the t-statistic for the mean difference between the treated and control groups; $p > |t|$ stands for the p-value of the t-test for mean equality; $V(T)/V(C)$ indicates the variance ratio of the treated group relative to the control group. U corresponds to the unmatched sample, and M corresponds to the matched sample based on 1:2 nearest neighbor matching. * marks a significant variance ratio at the 1% statistical level.

Variable	Match	Treated	Control	%Bias	%Reduct	t	p> $\|t\|$	V(T)/V(C)
Term	U	4.9457	4.8466	6.5		8.42	0	1.44*
	M	4.9275	5.0564	-8.4	-38.1	-8.48	0	1.07*
Amount	U	19.427	13.119	55.6		73.45	0	1.77*
	M	18.902	20.639	-15.3	72.5	-13.35	0	0.60*
Right	U	0.75637	0.82809	-17.7		-22.78	0	
	M	0.76636	0.80231	-8.9	49.9	-9.36	0	
Guarantee	U	0.14907	0.31979	-41.1		-49.32	0	
	M	0.15107	0.14803	0.7	98.2	0.91	0.362	
Rating	U	1.7589	2.2251	-53.4		-66.54	0	0.93*
	M	1.7691	1.8366	-7.7	85.5	-8.67	0	1.12*
ROE	U	2.3364	1.4883	8.2		10.91	0	1.99*
	M	2.2991	1.7016	5.8	29.5	5.64	0	1.27*
Leverage	U	57.362	59.267	-6.0		-7.80	0	1.43*
	M	57.395	56.990	1.3	78.7	1.30	0.193	1.12*
Liquidity	U	1.0990	1.5997	-57.3		-67.71	0	0.48*
	M	1.1036	1.0760	3.2	94.5	4.21	0	1.03*
Asset Turnover	U	0.09215	0.08664	6.3		8.05	0	1.25*
	M	0.09227	0.08983	2.8	55.8	2.93	0.003	1.17*
BidAsk	U	0.42259	0.22045	20.0		27.18	0	2.41*
	M	0.40820	0.35823	4.9	75.3	4.65	0	1.10*
Day	U	84.184	48.146	25.1		32.87	0	1.57*
	M	76.343	59.601	11.7	53.5	13.13	0	1.10*
Volume	U	0.08735	0.03622	23.9		32.91	0	2.88*
	M	0.07964	0.07050	4.3	82.1	4.05	0	1.09*
ExchangeRate	U	6.8129	6.8248	-4.1		-5.03	0	0.86*
	M	6.8151	6.8096	1.9	54.2	2.02	0.044	0.91*
ΔlnGDP	U	5.6714	5.8048	-4.4		-5.67	0	1.30*
	M	5.6730	5.6525	0.7	84.6	0.71	0.479	1.15*

Table 5: Robustness Investigations

This table presents the robustness checks of the baseline regression results. Column (1) adopts 1:2 nearest neighbor matching, and Column (2) reports the estimation outcomes after entropy balancing treatment. Column (3) takes the issuance spread as the dependent variable. The t-statistics are provided in parentheses. Pro FE, Issuer FE, and Time FE refer to province fixed effects, issuer fixed effects, and time fixed effects, respectively. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Matching (1)	Balancing (2)	Alternative Measure (3)
US_bond×Shock	1.2010***	1.2130***	0.1556***
	(39.50)	(41.18)	(14.64)
Shock	-0.1452***	-0.0768*	-0.0379**
	(-2.75)	(-1.67)	(-2.12)
Constant	0.3324*	0.6307***	2.4119***
	(1.70)	(3.34)	(33.30)
Observations	38,167	72,040	72,040
R-squared	0.751	0.780	0.934
Controls	YES	YES	YES
Pro FE	YES	YES	YES
Issuer FE	YES	YES	YES
Time FE	YES	YES	YES

Table 6: Mechanism Investigation: Regression Analysis

This table reports the regression results of channel testing to explore the influencing mechanisms of three transmission channels, with the default quantity of Chinese USD bonds taken as the moderating variable. Column (1) takes ΔRating as the dependent variable, Column (2) takes BidAsk as the dependent variable, and Column (3) takes Volume as the dependent variable. The t-statistics are presented in parentheses. Pro FE, Issuer FE, and Time FE refer to province fixed effects, issuer fixed effects, and time fixed effects, respectively. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels.

	Dependent Variables		
	ΔRating (1)	BidAsk (2)	Volume (3)
US_bond×Shock ×Default_Amount	0.0008***	0.0048***	0.0001
	(8.09)	(9.59)	(1.50)
US_bond×Shock	0.1799***	0.0598**	-0.0213***
	(21.97)	(2.02)	(-3.97)
Constant	-1.6003***	0.9115***	0.0901***
	(-39.93)	(7.89)	(4.65)
Observations	67,591	81,399	81,514
R-squared	0.950	0.147	0.204
Controls	YES	YES	YES
Pro FE	YES	YES	YES
Issuer FE	YES	YES	YES
Time FE	YES	YES	YES

Table 7: Heterogeneity Analysis

This table reports heterogeneity analysis results. Panel A groups the full sample by guarantee type and bond credit rating. Specifically, columns (1)-(3) examine the difference in contagion effects between guaranteed and non-guaranteed bonds, while columns (4)-(6) compare the results for high-grade and low-grade bonds. Panel B groups the sample by corporate asset size and bond maturity. Columns (7)-(9) test the heterogeneity across large and small-sized issuers, and columns (10)-(13) explore the differential effects across bonds with short, medium, and long maturities. All regressions control for province, issuer, and time fixed effects, as well as a comprehensive set of bond-level and firm-level control variables. The t-statistics are presented in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A

	Guarantee			Bond Rating		
	Interaction (1)	Guarantee=1 (2)	Guarantee=0 (3)	Interaction (4)	High Grade (5)	Low Grade (6)
US_bond×Shock×Guarantee	0.0639					
	(1.11)					
US_bond×Shock×Low Rating				1.3981***		
				(55.29)		
US_bond×Shock		2.8855***	1.4173***		1.5309***	0.9918*
		(40.87)	(49.61)		(62.35)	(1.78)
Constant	0.5045***	1.0254***	0.0055	0.5582***	0.3717***	0.0312
	(3.74)	(4.73)	(0.03)	(4.01)	(2.61)	(0.10)
Observations	72,040	19,080	52,960	72,040	65,550	6,490
R-squared	0.747	0.788	0.766	0.735	0.747	0.796
P-suest		0.0000***			0.0000***	

Panel B

	Asset Size			Bond Maturity			
	Interaction (7)	Large (8)	Small (9)	Interaction (10)	Short (11)	Medium (12)	Long (13)
US_bond×Shock×Small	0.8622***						
	(32.57)						
US_bond×Shock×Medium				0.2350***			
				(4.20)			
US_bond×Shock×Long				0.4889***			
				(7.90)			
US_bond×Shock		0.9518***	2.5538***		0.8018	1.5804***	1.8413***
		(32.26)	(61.01)		(1.18)	(3.66)	(3.26)
Constant	2.1244***	0.0041	0.8100***	3.8022*	2.1859	-0.2439	
	(6.33)	(0.02)	(4.92)	(2.00)	(1.48)	(-0.45)	
Observations	72,040	37,877	34,163	59,469	13,462	37,478	8,528
R-squared	0.720	0.780	0.778	0.717	0.798	0.737	0.831
P-suest		0.0000***				0.0000***	
Controls	YES	YES	YES	YES	YES	YES	YES
Pro FE	YES	YES	YES	YES	YES	YES	YES
Issuer FE	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES

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