



How green screening influences risk transmission among stock-bond indices: Insight into the dependence structure

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ABSTRACT

Green characteristics are pivotal to risk transmission. We use environmental, social and governance (ESG) monetized accounting to measure green screening of stock-bond indices, and decompose risk transmission into comovement, contagion and hedging effects via a patched dependence structure model. Mechanisms through which green screening impacts three types of risk transmission effects are elucidated. Results indicate that high level of green screening is associated with significantly reduced comovement and contagion effects while hedging effects. Market sentiment factors such as interest rates, economic policy uncertainty and consumer confidence are identified as crucial channels. These results are further tested to be robust.

1. Introduction

Over the last decade, global challenges arising from climate change and energy crises have led to a growing trend of sustainable investment and changes in asset allocation and risk management, prompting the focus on green portfolios that favor stocks and bonds with enhanced environmental, social and government (ESG) attributes. Sustainable investors are increasingly focused on whether increased green screening in diversified portfolios leads to more effective risk diversification. Green portfolios, favoring stocks and bonds with higher green characteristics, may enhance diversification benefits by improving risk management, compliance and innovation (Chopra and Mehta, 2023; Nguyen et al., 2021; Su et al., 2023), thereby offering a hedging effect. However, stringent green screening may incur costs by diminishing portfolio diversification due to information asymmetry and investor biases (Avramov et al., 2022; Briere and Ramelli, 2021; Shi and Wang, 2023), exhibiting a contagion effect. Despite evidence that green bonds can act as a hedge against other assets, the influence of portfolio green screening on cross-asset risk transmission remains deeply unexplored Arif et al. (2021); Broadstock and Cheng (2019); Dutta et al. (2021); Pham and Luu Duc Huynh (2020); Pham and Nguyen (2022); Wan et al. (2024). Inspired by Ciciretti et al. (2017), who highlight the importance of both risk and preference effects in explaining asset return variations across different greenness, we propose that green screening can have multifaceted effects on cross-asset risk transmission, and portfolio managers should carefully assess the nonlinear influence of green screening on the dependence to balance hedging and contagion effects.

Risk transmission among traditional stock-bond indices are the result of nonlinear changes in multiple risk effects Bekaert et al.

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(2014); Yousaf et al. (2022). Especially during extreme markets, both a “flight-to-quality” hedging effect (Allard et al., 2020; Dimic et al., 2016; Nguyen et al., 2021; Sarwar, 2023; Su et al., 2023) and a “co-risk exposure” contagion effect may occur Arif et al. (2021); Dutta et al. (2021); Nguyen et al. (2021); Wan et al. (2024). Although nonlinear Granger causality and vector autoregressive models are used to capture dynamic nonlinear correlations (Asgharian et al., 2016; Broadstock and Cheng, 2019; Fang et al., 2018; Nguyen et al., 2021; Pham, 2021), a singular correlation coefficient cannot differentiate comovement, contagion and hedging effects Artzner et al. (1999); Cherubini and Mulinacci (2014); Cheung (2009); Dai et al. (2020); Dhaene et al. (2002); Sass and Thös (2021); Zhang and Duan (2013); Zheng et al. (2023, 2022). The patched bivariate Fréchet (PBF) copulas constructed by Zheng et al. (2011) decompose the dependence structure to identify contagion and hedging effects and thus clarify how these effects differ from the comovement effect measured using traditional Spearman coefficients. Using a uniform PBF copula framework, in this study, we aim to decompose the dependence structure between green stock-bond indices to measure comovement, contagion and hedging effects simultaneously.

We introduce a novel approach by employing environmental, social, and governance (ESG) monetized accounting to evaluate green screening by stock-bond indices, offering an advanced analytical perspective. Commonly, green characteristics are assessed using ESG ratings and long-short ESG strategies Papathanasiou and Koutsokostas (2024); Qian and Yu (2024). However, the limited breadth and depth of ESG market products in emerging markets and the discrepancies in ESG ratings cause these methods to be subjective and incompatible Li et al. (2024); Luo and Farag (2024); Wang et al. (2024); Zou et al. (2023). Unlike ESG ratings, ESG monetized accounting based on natural and social capital valuations reflects the actual value of ESG practices, circumvents subjective bias to some extent and can be used to objectively evaluate a company’s social impact. Drawing on Pástor et al. (2021)’s definition of social impact, we use ESG monetized accounting as a proxy for a firm’s social impact and divide this by the firm’s operating capital to measure its ESG characteristics. Finally, we use the green screening level of stock-bond indices to refer to a ranking based on the percentage of green characteristics within an index, i.e., the higher the green characteristics of a particular index, the higher its green screening level.

With this paper, we make three key contributions. First, we evaluate comovement, contagion and hedging effects among stock-bond indices within a cohesive decomposition framework, revealing that the impact of green screening on risk transmission among stock-bonds involves multiple effects, which supports the perspective of Ciciretti et al. (2017). Second, we provide empirical evidence that during market downturns, higher green screening reduces comovement and contagion while enhancing hedging effects, supporting green investments as a risk mitigation strategy. Finally, we use ESG monetized accounting to assess indices, bridging financial incompatibility and ESG ratings, enhancing sustainable investment strategies in emerging markets and promoting ESG principles in finance.

The structure of this paper is as follows: Section 2 introduces the models and data; Section 3 presents the main empirical results and discusses robustness; and Section 4 presents our conclusions.

2. Models and data

For each stock index i and bond index j at time t , we calculate the log return as $S_{i,t} = \ln(P_{i,t}^s) - \ln(P_{i,t-1}^s)$ and $B_{j,t} = \ln(P_{j,t}^b) - \ln(P_{j,t-1}^b)$ respectively. Given quantile $q \in (0, 1)$, the local market condition is $A_{i,j,t|q}$ if $A_{i,j,t|q} = \{(S_{i,t}, B_{j,t}) | F_i(S_{i,t}) \leq q, G_j(B_{j,t}) \leq q\}$, where F_i and G_j represent the probability distributions of the log returns $S_{i,t}$ and $B_{j,t}$. Within the united framework of the dependence structure, we aim to study the impact of green screening on the comovement, contagion and hedging effects of stock-bond indices $(S_{i,t}, B_{j,t})$ under the lower-tail market conditions.

2.1. Measurements of comovement, contagion and hedging effects

In line with much of the literature, we estimate the comovement effect between each pair of stock-bond indices $(S_{i,t}, B_{j,t})$ using the local Spearman coefficient $\hat{\rho}_{i,j,t|q}$ at quantile q according to Durante et al. (2014), as shown in Equation (1):

$$\hat{\rho}_{i,j,t|q} = \frac{\text{Cov}(\hat{F}_{i|q}(S_{i,t}) | \hat{F}_i(S_{i,t}) \leq q, \hat{G}_{j|q}(B_{j,t}) | \hat{G}_j(B_{j,t}) \leq q)}{\hat{\sigma}_{i|q}^s \times \hat{\sigma}_{j|q}^b}, \quad (1)$$

where $\hat{F}_i$, $\hat{G}_j$, $\hat{F}_{i|q}$ and $\hat{G}_{j|q}$ represent the empirical and local empirical cumulative distribution functions respectively.

By decomposing the dependence structure using the PBF copula, as shown in Equation (2), Zheng et al. (2023, 2022, 2011) demonstrated that the local Spearman coefficient quantifies the net dependence remaining after the impacts of the local comonotonic and counter-monotonic structure are offset:

$$\hat{C}_{i,j,t}(u, v) = \sum P(A_{i,j,t|q}) [\hat{\alpha}_{i,j,t|q} M(u, v) + \hat{\gamma}_{i,j,t|q} W(u, v) + (1 - \hat{\alpha}_{i,j,t|q} - \hat{\gamma}_{i,j,t|q}) \Pi(u, v)], \quad (2)$$

where $M(u, v) = \min(u, v)$ and $W(u, v) = \max(u + v - 1, 0)$ are respectively the Fréchet upper and lower bounds of any copula functions and thus represent the comonotonic (maximal) and counter-monotonic (minimal) dependence structures. $\Pi(u, v) = uv$ represents the independent structure. The estimated local comonotonic coefficient $\hat{\alpha}_{i,j,t|q}$ and counter-monotonic coefficient $\hat{\gamma}_{i,j,t|q}$ measure the contagion and hedging effects in the lower tail region $A_{i,j,t|q}$, respectively.

2.2. Measurements of green screening

For each time t , Pástor et al. (2021) provided that firm i with positive green characteristics $g_{i,t} > 0$ produces a positive social impact $SI_{i,t} > 0$ in addition to its financial payoffs, and defined the social impact $SI_{i,t}$ as $SI_{i,t} \equiv g_{i,t}K_{i,t}$, where $K_{i,t}$ represents the operating capital of firm i at time t .¹ Thus, we calculate firm i 's green characteristic as follows:

$$g_{i,t} = SI_{i,t} / K_{i,t}. \quad (3)$$

To suitably match the financial data, we measure $SI_{i,t}$ for firm i using its ESG monetized net worth² according to the OneESG database³, which provides a clear financial perspective on a firm's ESG actions by considering its natural and social capital valuation. Then, the green characteristics of the stock index ($gs_{i,t}$) and bond index ($gb_{j,t}$) are obtained by weighting the market value proportions of their components' social impacts. To examine the impact of green screening on stock-bond indices' comovement, contagion and hedging effects, we regard an index's green screening level as high if its $gs_{i,t}$ (or $gb_{j,t}$) is high and measure green screening as $gs_rank_{j,t}$ for the stock index as shown in Equation (4):

$$gs_rank_{i,t} = 1 - \left(\frac{rank(gs_{i,t}) - 1}{len(gs_{i,t})} \right), \quad (4)$$

where, for each time t , $rank(\cdot)$ orders the stock indices by their green characteristics in descending order, and $len(\cdot)$ indicates the number of indices ranked. Green screening, as calculated using Equation (4), follows a positive monotonicity, i.e., a higher level of green characteristics corresponds to a higher level of green screening. Green screening $gb_rank_{i,t}$ of bond indices follows a similar calculation.

2.3. Impact of green screening on comovement, contagion and hedging effects

The domains of the local Spearman, comonotonic and counter-monotonic coefficients are restricted to the range $[-1, 1]$; therefore, to avoid model specification errors (Li et al., 2014; Wälti, 2011), we perform the following monotonic transformations:

$$p_{i,j,t} = \ln\left(\frac{1 + \rho_{i,j,t}}{1 - \rho_{i,j,t}}\right), \quad w_{i,j,t} = \ln\left(\frac{1 + \alpha_{i,j,t}}{1 - \alpha_{i,j,t}}\right), \quad y_{i,j,t} = \ln\left(\frac{1 + \gamma_{i,j,t}}{1 - \gamma_{i,j,t}}\right). \quad (5)$$

To investigate whether green screening affects the comovement, contagion and hedging effects among stock-bond indices, let $p_{i,j,t}$, $w_{i,j,t}$, $y_{i,j,t}$ in Equation (5) be the dependent variable $Y_{i,j,t|q}$, and let the level of stock-bond indices' green screening, $g_{i,j,t} = gs_rank_{i,t} \times gb_rank_{j,t}$, be the core explanatory variable. We set the basic regression model as in Equation (6):

$$Y_{i,j,t|q} = \beta_0 + \beta_1 g_{i,j,t} + \beta_2 X_{i,j,t} + \mu_{i,j} + \nu_t + \varepsilon_{i,j,t}, \quad (6)$$

where $X_{i,j,t}$ represents the control variables from three channels commonly mentioned in the literature: macroeconomics, market sentiment and market trading (see Table 1 for details).

According to the signaling hypothesis and stakeholder theory, green bonds can mitigate risk volatility and enhance liquidity by reducing information asymmetry and increasing agent preferences, thus providing hedging and diversified returns for other risk assets (Arif et al. (2022); Chopra and Mehta (2023); Flammer (2021)). Thus, we further explore the channel mechanism by which green screening influences comovement, contagion and hedging effects among stock-bond indices, as shown in Equation (7):

$$Y_{i,j,t|q} = \beta_0 + \beta_1 g_{i,j,t} + \beta_2 X_{i,j,t} + \beta_3 g_{i,j,t} \times X_{i,j,t} + \mu_{i,j} + \nu_t + \varepsilon_{i,j,t}. \quad (7)$$

¹ Different proxy variables are used to measure the operating capital of firms within stock-bond indices, which comprise financial and non-financial entities with distinct asset-liability structures. For non-financial companies, operating capital is defined as the current assets minus current liabilities; for financial companies, operating capital is substituted by the net assets or net interest income.

² ESG monetized accounting quantifies corporate ESG practices differently than traditional ESG ratings. The environmental and social factors are valued in natural and social capital terms, while governance factors are scored by experts. The final assessment assigns a non-financial value to corporate ESG via a cost-earnings method, with the results denominated in CNY. We also neutralize corporate-level ESG monetized accounting to mitigate the effects of industry and market value variability (Wei et al., 2022).

³ The OneESG database is developed by GoldenBee (Beijing) Management Consulting Co., Ltd., which is a member of the Sustainable Development (ESG) Professional Committee of the China Listed Companies Association. The company established the OneESG digital technology platform in 2021, pioneering the method of monetizing ESG factors and it has developed the OneESG database, which has conducted ESG value accounting for all A-share listed companies and mainland companies listed in Hong Kong since 2017.

Table 1
Descriptions and measurements of control variables⁴.

Variable	Descriptions	Data
IPR_t	Macroeconomics Channel Growth of industrial production, mentioned in CHEN et al. (2022)	NBSPRC website
$InflaR_t$	Consumer price index, mentioned in Campbell et al. (2014); Asgharian et al. (2016)	
$IntereR_t$	Market Sentiment Channel Inter-bank lending rates, mentioned in Pericoli (2020)	Wind database
EPU_t	Economic policy uncertainty, mentioned in Pham and Nguyen (2022); Wang et al. (2022)	Economic Policy Uncertainty website
CCI_t	Consumer confidence index, mentioned in Fang et al. (2018)	OCED website
$SysR_{i,j,t}$	Market Trading Channel Multiple of betas: $\beta_{i,t}^{Stock} \times \beta_{j,t}^{Bond}$, mentioned in Sarwar (2023)	Wind database
$CoissuR_{i,j,t}$	$\frac{Co - issuer_{i,j,t}}{issuer_{i,t}^{Stock}} \times \frac{Co - issuer_{j,t}}{issuer_{j,t}^{Bond}}$, mentioned in Wang and Jiang (2023)	
$SIA_{i,t}$	$\frac{Trading Volume_{i,t}^{stock}}{Trading Volume_{all the market,t}^{stock}}$, mentioned in Yang et al. (2017)	
$SIL_{i,t}$	$Turnover_{i,t}^{stock}$, mentioned in Connolly et al. (2005)	

⁴ Calculated by policy-related economic uncertainty articles in the South China Morning Post, Hong Kong's leading English-language newspaper.

2.4. Data

We select 28 green-themed stock-bond indices in the Chinese market (for abbreviations, see Tables A.1 and A.2 in the Appendix) and obtain their 28,697 daily closing prices⁵ from the Wind database and ESG monetized accountings for 8 semiannual periods from the OneESG database. The sample period is from June 30, 2018 to December 31, 2022⁶. Throughout this period, we obtain the local comovement effects $\hat{\rho}_{i,j|q}$, contagion effects $\hat{\alpha}_{i,j|q}$ and hedging effects $\hat{\gamma}_{i,j|q}$ using Equations (1) and (2). Table 2 presents the statistical characteristics of the three effects and green screening among stock-bond indices when $q = 0.37, 0.33, 0.30$.⁷ The data indicate that the mean of the comovement effect $\hat{\rho}$ is comparable to the mean differences in the contagion effect $\hat{\alpha}$ and hedging effect $\hat{\gamma}$ among stock-bond indices with varying levels of green screening. Higher skewness of $\hat{\gamma}$ suggests a preference for safety over returns during market downturns. The mean level of green screening is 0.55 for both the stock-bond indices, indicating that the screening criteria used by most of the index samples contain a moderate level of greenness and no notable distinction in performance.

Regarding the influence of green screening on the three types of effects among stock-bond indices, Fig. 1 displays heat-maps at different market quantiles ($q = 0.37, 0.33, 0.30$). The horizontal and vertical axes represent stock-bond indices, respectively, and both are arranged from the lowest to highest level of green screening, from left to right and bottom to top, respectively. The strength of the three effects is indicated by color: a darker color signifies a stronger effect. We find that in the upper right corner, the heat-maps for ρ and α show darker colors, while that of γ shows lighter colors, indicating that green screening could have multifaceted effects on stock-bond indices and result in lower contagion and higher hedging effects with a higher level of green screening. When comparing the upper-left (i.e., bond indices with a higher level of green screening) and lower-right areas (i.e., stock indices with a higher level of green screening) in each heat-map, bond indices with a higher level of green screening appear to lead to lower comovement and contagion effects than stock indices with a higher level of green screening. As the market gradually becomes depressed, the local comovement, contagion and hedging effects among stock-bond indices tend to strengthen. Compared with other regions, when both stock-bond indices exhibit higher levels of green screening (i.e., the top-left area of the heat map), the local comovement and contagion effects show smaller increases, while the hedging effect shows a larger increase, suggesting that green screening by stock-bond indices may improve risk mitigation outcomes.

Furthermore, we estimate $\hat{\rho}_{i,j,t|q}$, $\hat{\alpha}_{i,j,t|q}$ and $\hat{\gamma}_{i,j,t|q}$ using a one-year window with a six-month rolling step to observe the dynamic trends of the three effects. For each time t , take $q = 0.33$ for example, we use the sample mean of green screening to cutoff the whole samples into high and low green screening subgroups and calculate their average risk transmissions. Fig. 2 illustrates the comparative means of the comovement, contagion and hedging effects across the high and low subgroups. Fig. 2 (a) shows that the comovement effects are strongly correlated with the net contagion and hedging effects, while Fig. 2 (b)–(d) show that risk transmission varies distinctly with the level of green screening. In most cases, a higher level of green screening is correlated with a weaker comovement

⁵ Since the issuance dates of each index vary, the index with the latest issuance date only has 332 trading days, while the earliest issued index has data for 1,097 trading days. The total number of daily closing prices is the sum of the number of daily closing prices for each index, specifically, $1097 \times 23 + 934 \times 3 + 332 \times 2 = 28697$.

⁶ The inaugural green bond indices in China were established in April 2016. Annually, firms publish their final ESG data in April, and OneESG completes the ESG monetized accounting by June. Our sample period is therefore extended to the end of 2022 to align with these reporting timelines. We also exclude indices with name changes or mergers, as well as those lacking ESG monetized accounting data.

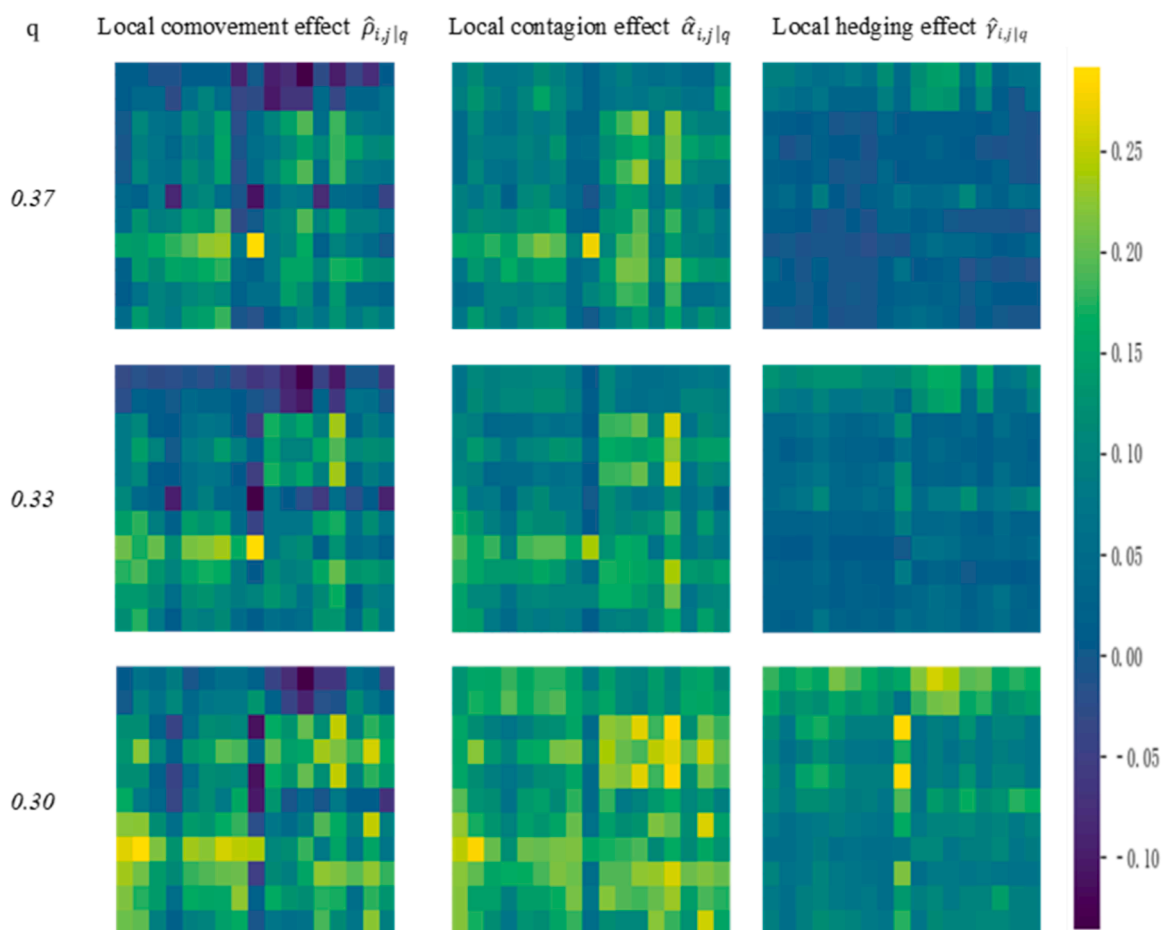
⁷ Given the constrained sample size of stock-bond index during extreme market conditions and the semi-parametric nature of dependence structure decomposition models, this paper opts for $q=1/3$ to mitigate sample estimation errors in panel regression. Subsequent robustness tests will assess the impact of minor parameter variations on the core findings.

Table 2

Descriptive statistics of risk transmission and green screening among stock-bond indices.

	Obs	Mean	SD	Min	Median	Max	SK	K
$\hat{\rho}_{ij 0.33}$	921	0.09	0.13	-0.43	0.09	0.44	-0.10	3.07
$\hat{\alpha}_{ij 0.33}$	921	0.11	0.09	0.00	0.10	0.45	0.88	3.55
$\hat{\gamma}_{ij 0.33}$	921	0.04	0.05	0.00	0.02	0.44	2.00	8.79
$\hat{\rho}_{ij 0.37}$	921	0.08	0.11	-0.39	0.09	0.44	0.01	3.16
$\hat{\alpha}_{ij 0.37}$	921	0.11	0.11	0.00	0.10	0.45	0.94	3.98
$\hat{\gamma}_{ij 0.37}$	921	0.03	0.04	0.00	0.16	0.46	2.02	8.85
$\hat{\rho}_{ij 0.30}$	921	0.08	0.14	-0.44	0.08	0.43	-0.19	2.92
$\hat{\alpha}_{ij 0.30}$	921	0.11	0.09	0.00	0.10	0.40	0.71	2.83
$\hat{\gamma}_{ij 0.30}$	921	0.05	0.06	0.00	0.17	0.40	1.87	7.15
<i>gs_rank</i>	921	0.54	0.29	0.06	0.53	1.00	0.00	1.79
<i>gb_rank</i>	921	0.56	0.29	0.09	0.56	1.00	-0.04	1.72
<i>gs_rank * gb_rank</i>	921	0.30	0.24	0.01	0.23	1.00	0.90	2.95

Note: Here we perform a dependence structure decomposition every half year, resulting in 921 valid sets of $(\hat{\rho}_{ij|q}, \hat{\alpha}_{ij|q}, \hat{\gamma}_{ij|q})$.

**Fig. 1.** Heat-maps of three effects among stock-bond indices with sorted green screening.

Note: the right bar shows the sizes of three types of risk transmission among stock-bond indices

effect and stronger hedging effect, while the trend of the impact of green screening on the contagion effect is more unstable.

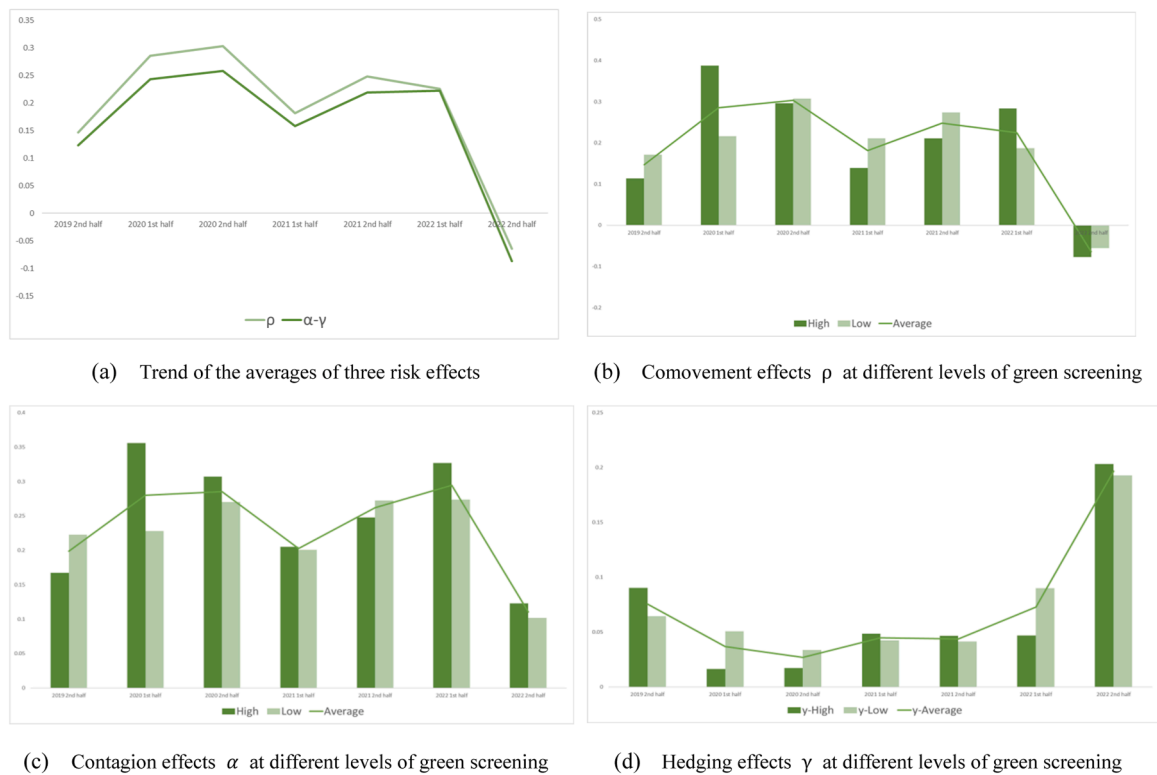


Fig. 2. Average levels of risk transmission among stock-bond indices at different levels of green screening.

3. Empirical results

3.1. Basic regressions

Table 3 displays the results of a basic regression analysis with individual fixed effects, shown in Equation (6), when $q = 0.33$. After controlling for macroeconomic, market sentiment and trading factors, it shows that green screening among stock-bond indices significantly affects risk transmission in the framework of dependence structure. Specifically, green screening reduces the local comovement and contagion effects between indices while enhancing the hedging effects, which are aligned with the “flight-to-quality” and “safe-haven” phenomena associated with green bonds (see further discussions in Asgharian et al. (2016), Arif et al. (2022) and Chopra and Mehta (2023)).

3.2. Robustness analysis

To test the robustness of our baseline regression results, we substitute variables and address sample selection bias. Robustness results are listed in Table 4. In the baseline regression, we replace the dependent variable, which was initially estimated using PBF copulas when $q = 0.33$, with variables corresponding to the less extreme ($q = 0.37$) and more extreme quantile ($q = 0.30$), and our results remain robust. We then address potential biases arising from the inconsistent issuance dates of Chinese green stock-bond indices by excluding such indices from the regression; again, the results confirm the robustness of our findings. These tests collectively demonstrate that our results are broadly reflective of the general reducing effect of green screening on risk transmission, which is independent of specific variables or sample choices.

3.3. Mechanism analysis

In emerging capital markets, green assets and investments are more susceptible to factors such as market sentiment (Asgharian et al., 2016; Píñero-Chousa et al., 2021; Guo et al., 2023). We select the inter-bank lending rate, consumer confidence index and economic policy uncertainty as proxies for sentiment indicators originating from the market, agents and government, respectively. We then investigate the role of market sentiment in the impact of green screening on the dependence structure among stock-bond indices by Equation (7). The interaction and main effects are presented in Table 5. We find that the benefits of green screening in terms of reducing comovement and contagion effects and enhancing hedging effects among stock-bond indices are contingent on favorable market liquidity conditions and consumer sentiment. Increases in the inter-bank lending rate and consumer confidence can amplify the

Table 3Basic regression of green screening on risk transmission among stock-bond indices when $q = 0.33$.

	p	w	y
$\mathcal{G}_{i,j,t}$	-0.18*** (-3.89)	-0.08** (-2.36)	0.07*** (3.86)
SysR	0.21*** (6.66)	0.14*** (6.25)	-0.07*** (-5.69)
Co issuer	-6.20*** (-2.88)	-3.55** (-2.25)	3.41*** (4.03)
SIA	-0.14 (-0.24)	-0.43 (-0.96)	-0.05 (-0.20)
SIL	0.22*** (7.89)	0.16*** (7.62)	-0.05*** (-4.28)
IPR	-0.63*** (-3.56)	-0.42*** (-3.26)	0.29*** (4.19)
InflaR	-9.01*** (-4.83)	-4.28*** (-3.13)	4.47*** (6.1)
IntereR	-0.11** (-1.99)	-0.05 (-1.22)	0.01 (0.52)
EPU	0.27* (1.85)	0.29*** (2.68)	0.07 (1.23)
CCI	13.71*** (3.83)	5.51** (2.1)	-5.13*** (-3.65)
Constant	-28.99*** (-4.00)	-12.35** (-2.33)	10.36*** (3.64)
Obs	921	921	921
adj.R ²	0.33	0.24	0.36

Note: The t -statistics are shown in parentheses. *, ** and *** represent significance at the 10%, 5% and 1% levels, respectively.

Table 4

Robustness of basic regression with replacement of dependent variables and exclusion of sampling selection bias.

	Variable substitution ($q = 0.37$)			Variable substitution ($q = 0.30$)			Exclusion of sample selection bias		
	p	w	y	p	w	y	p	w	y
$\mathcal{G}_{i,j,t}$	-0.17*** (-3.67)	-0.78** (-2.38)	0.06*** (3.77)	-0.22*** (-4.57)	-0.08** (-2.29)	0.09*** (4.07)	-0.19*** (-3.8)	-0.08** (-2.25)	0.09*** (4.57)
SysR	0.17*** (5.32)	0.10*** (4.65)	-0.04*** (-3.65)	0.26*** (8.16)	0.18*** (7.78)	-0.09*** (-6.13)	-0.13 (1.48)	-0.07 (-1.16)	0.02 (0.54)
Co issuer	-5.13** (-2.41)	-2.78* (-1.82)	1.58** (2.08)	-6.64*** (-3.01)	-1.21 (-0.79)	3.72*** (3.57)	-5.69*** (-2.49)	-3.19* (-1.90)	3.45*** (3.95)
SIA	-0.35* (-0.57)	-0.14 (-0.33)	0.16 (0.75)	-1.37** (-2.19)	-1.33*** (-3.05)	0.16 (0.53)	-0.16 (-0.24)	-1.04** (-2.17)	-0.10 (-0.38)
SIL	0.26*** (9.52)	0.19*** (9.60)	-0.08*** (-7.75)	0.20*** (7.02)	0.13*** (6.65)	-0.02 (-1.53)	0.12*** (4.31)	0.08*** (3.58)	-0.02** (-2.26)
IPR	0.71*** (-4.11)	-0.65*** (-5.24)	0.27*** (4.32)	-0.59*** (-3.30)	-0.35*** (-2.77)	0.22*** (2.59)	0.50** (2.30)	0.36** (2.26)	0.05 (-0.63)
InflaR	3.20* (1.73)	3.76*** (2.84)	1.38** (2.10)	-17.01*** (-8.90)	-10.38*** (-7.79)	7.74*** (8.58)	12.60** (2.27)	6.52 (1.59)	-3.27 (-1.54)
IntereR	-0.04 (-0.85)	-0.02 (-0.51)	-0.02 (-1.13)	-0.31*** (-5.71)	-0.20*** (-5.27)	0.07*** (2.69)	0.61*** (3.18)	0.31** (2.21)	-0.26*** (-3.57)
EPU	0.28* (1.94)	0.35*** (3.32)	-0.03* (-0.49)	0.32** (2.14)	0.31*** (2.88)	0.18** (2.51)	3.17*** (3.83)	1.74** (2.85)	-0.10*** (-3.02)
CCI	0.62 (0.18)	-1.71 (-0.67)	-1.60 (-1.26)	31.87*** (8.68)	19.45*** (7.6)	-10.96*** (-6.33)	26.16*** (6.96)	15.96*** (5.77)	-8.32*** (-5.79)
Constant	-3.19 (-0.45)	1.66 (0.32)	3.75 (1.47)	-64.79*** (8.72)	-39.73*** (-7.67)	21.44*** (6.11)	-62.45*** (-7.10)	-37.25*** (-5.75)	19.92*** (5.91)
Obs	921	921	921	921	921	921	648	648	648
adj.R ²	0.24	0.22	0.27	0.42	0.33	0.38	0.40	0.25	0.50

Note: The t -statistics are shown in parentheses. *, ** and *** represent significance at the 10%, 5% and 1% levels, respectively.

appeal of green assets, which are perceived to offer better risk adjustment than other assets during times of economic contraction. Conversely, high policy uncertainty can negate these advantages, as it introduces volatility that investors may prefer to avoid, particularly when committing to long-term sustainable projects (see [Tables A.3 and A.4](#) in Appendix for the robustness of mechanism analysis with $q=0.30$ and $q=0.37$). This finding underscores the importance of a stable macroeconomic environment for green finance growth and efficacy and the need for policymakers to foster certainty and liquidity in financial markets to support the development of green investments.

Table 5

Market-sensitive channel of the impact of green screening on risk transmission among stock-bond indices.

	p			w			y		
$g_{i,j,t}$	-0.18*** (-4.02)	-0.19*** (-4.09)	-0.18*** (-4.03)	-0.08** (-2.48)	-0.08** (-2.46)	-0.08** (-2.48)	0.07*** (3.96)	0.07*** (3.95)	0.07*** (3.99)
IntereR	0.02 (0.25)	-0.10** (-1.98)	-0.12** (-2.29)	0.04 (-0.93)	-0.05 (-1.21)	-0.06 (-1.49)	-0.03 (-1.12)	0.01 (0.5)	0.02 (0.79)
EPU	0.12*** (4.07)	-0.23 (-1.21)	0.31** (2.09)	0.28*** (2.61)	0.07 (0.52)	0.31*** (2.9)	0.08 (1.31)	0.17** (2.27)	0.06 (1.03)
CCI	-0.14*** (-4.10)	13.20*** (3.72)	24.19*** (5.54)	6.60** (2.53)	5.29** (2.02)	12.53*** (3.91)	-5.60*** (-3.98)	-5.03*** (-3.58)	-8.98*** (-5.22)
IntereR $\times$ $g_{i,j,t}$	-0.17*** (-3.82)			-0.09*** (-3.85)			0.04*** (3.05)		
EPU $\times$ $g_{i,j,t}$		0.12*** (4.07)			0.05** (2.36)			-0.02** (-2.06)	
CCI $\times$ $g_{i,j,t}$			-0.14*** (-4.10)			-0.09*** (-3.74)			0.05*** (3.82)
Constant	-49.94*** (-5.67)	-26.49*** (-3.68)	-49.94*** (-5.67)	-14.58*** (-2.76)	-11.28** (-2.12)	-26.37*** (-4.08)	11.32*** (3.97)	9.86*** (3.46)	18.05*** (5.21)
Obs	921	921	921	921	921	921	921	921	921
adj. R2	0.34	0.34	0.34	0.25	0.24	0.28	0.37	0.37	0.38

Note: The t-statistics are shown in parentheses. *, ** and *** represent significance at the 10%, 5% and 1% levels, respectively.

4. Conclusions

This study focuses on 28 green stock-bond indices in Chinese market from 2018 to 2022. Using a unified dependence structure framework, we illustrate the multifaceted impacts of green screening among stock-bond indices on their comovement, contagion and hedging effects in market downturns and also the underlying mechanisms. For the first time, we use the ESG monetized accounting, which is based on natural and social capital accounting, to measure the green screening of stock-bond indices. Our empirical results indicate that during extreme market conditions, a high level of green screening significantly increases hedging effects among stock-bond indices while reducing comovement and contagion effects. We also highlight the significant impacts of market sentiment on the effect of green screening.

Our findings enhance the understanding of sustainable investment in China's capital markets. Investors can benefit from better green asset allocation and re-balancing strategies by green screening of stock-bond indices, while policymakers should focus on improving policy stability and disclosure quality to support green finance growth. We admit that the current study has several limitations: for example, the impacts of ESG rating discrepancies and ESG uncertainty on the hedging effect of green screening warrant further investigation in the future.

CRedit authorship contribution statement

Zhijie Pan: Writing – review & editing, Software, Methodology, Formal analysis. **Yanting Zheng:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Dandan Xu:** Validation, Project administration, Investigation, Conceptualization. **Ting Wang:** Writing – review & editing, Supervision, Project administration, Investigation.

Data availability

Data will be made available on request.

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Appendix

Table A.1

Basic information on green stock and bond indicators

Stock indices in China			
No.	Abbreviation	Name of Indices	Component Selection
1	CSI300	CSI 300	Top 300 stocks by size & liquidity in SH & SZ markets
2	CSI500	CSI 500	500 small-cap stocks in SH & SZ markets
3	Lowcar	Mainland Low Carbon Eco	Stocks in low carbon economy themes
4	GInvest	CSI Green Investment	Stocks with high green revenue, no env. risks
5	GLead	CSI 300 Green Leading	Top 100 green CSI 300, excluding high-pollution, energy-intensive, overcapacity sectors
6	GQual	CSI Green Industry Quality	100 green industry stocks with high profit, sustainability, cash flow, & growth potential
7	ESGL	CSI Green Value ESG 100	Top 100 CSI 300 with highest ESG scores by IIGF of CUFE
8	300ESG	CSI 300 ESG Benchmark	CSI 300, excluding bottom 20% by industry ESG scores
9	300ESGL	CSI 300 ESG Leading	Top 100 CSI 300 by ESG scores
10	300ESGV	CSI 300 ESG Value	Top 100 CSI 300 with high ESG, low valuation
11	ESG120	CSI ESG 120 Strategy	Top 120 CSI 300 with high composite scores, excluding low ESG scores
12	500ESG	CSI 500 ESG Benchmark	CSI 500, excluding bottom 20% by industry ESG scores
13	500ESGL	CSI 500 ESG Leading	Top 150 CSI 500 by ESG scores
14	500ESGV	CSI 500 ESG Value	Top 150 CSI 500 with high ESG, low valuation
15	GEco	CSI Green Ecology	Stocks in green ecology themes
16	300Car	CSI 300 Carbon Neutral	CSI 300, excluding < B-rated by CSI ESG, adjusting weights via CSI carbon eval
17	300ESGG	CSI ESG 300 Growth Selection	CSI 300 with high growth, profitability; excluding significant ESG score decrease
Bond indices in China			
No.	Abbreviation	Name of Indices	Component Selection
1	ZZGB	ChinaBond Green Bond	Green bonds on SH or SZ exchanges, interbank, excluding ABS, private placements, equity-linked
2	ZZGABS	ChinaBond Green ABS	Green ABS on SH or SZ exchanges, interbank
3	TraGB	Exchange Green Bond	Green bonds on SH & SZ exchanges, excluding ABS, private placements, equity-linked
4	TraGBAAA	Exchange Green Bond AAA	AAA-rated green bonds on SH & SZ exchanges, excluding ABS, private placements, equity-linked
5	TraHGB	Exchange High Grade Green Bond	Green bonds $\geq$ AA+-rated on SH & SZ exchanges, excluding ABS, private placements, equity-linked
6	TraGABS	Exchange Green ABS	Green ABS on SH and SZ exchanges
7	SZGB	SH Green Bond	Green bonds on SH exchange, excluding ABS, private placements, and equity-linked products
8	SZGFB	SH Green Corporate Bond	Green corporate bonds on SH exchange, excluding private placements and equity-linked products
9	SZGBAAA	SH Green Bond AAA	AAA-rated green bonds on SH exchange, excluding ABS, private placements, and equity-linked products
10	SZHGB	SH High Grade Green Bond	Green bonds $\geq$ AA+-rated on SH exchange, excluding ABS, private placements, and equity-linked products
11	SZGEB	SH Green Corporate Bond Index	Green corporate bonds on SH exchange, excluding ABS, private placements, and equity-linked products

Table A.2

Descriptive statistics of log-returns for stock-bond indices in China

	Mean	SD	Min	Median	Max	SK	K
CSI300	0.00	1.25	-7.88	-0.03	5.95	-0.21	6.00
CSI500	0.01	1.33	-8.68	0.04	5.59	-0.68	7.15
Lowcar	0.03	1.74	-6.47	-0.01	7.17	0.10	4.31
GInvest	0.02	1.67	-9.39	0.02	6.28	-0.27	5.16
GLead	0.00	1.20	-7.78	-0.01	6.66	-0.16	6.21
GQual	0.03	1.58	-9.55	0.01	5.79	-0.27	5.10
ESGL	0.00	1.24	-8.08	-0.02	6.17	-0.21	6.27
300ESG	0.02	1.22	-7.80	-0.01	6.01	-0.23	6.33
300ESGL	0.01	1.24	-7.81	0.00	6.14	-0.21	6.17
300ESGV	0.01	1.21	-8.13	-0.03	6.60	-0.13	6.85
ESG120	0.02	1.19	-7.64	-0.01	5.79	-0.25	6.25
500ESG	0.01	1.21	-8.65	0.08	4.22	-0.92	7.83
500ESGL	0.01	1.20	-8.48	0.05	4.64	-0.87	7.87
500ESGV	0.01	1.19	-8.47	0.03	4.72	-0.81	7.67
GEco	0.05	1.71	-7.42	0.03	7.45	0.04	4.59
300Car	-0.06	1.17	-5.10	-0.12	4.59	-0.06	4.26
300ESGG	-0.10	1.22	-5.46	-0.15	4.50	0.12	4.60
ZZGB	0.02	0.04	-0.25	0.02	0.38	0.28	19.79
ZZGABS	0.01	0.03	-0.19	0.02	0.15	-1.18	9.43
TraGB	0.02	0.05	-0.35	0.03	0.56	0.10	18.09
TraGBAAA	0.02	0.05	-0.33	0.02	0.55	0.41	21.00

(continued on next page)

Table A.2 (continued)

	Mean	SD	Min	Median	Max	SK	K
TraHGB	0.02	0.05	-0.34	0.02	0.55	0.15	20.68
TraGABS	0.02	0.04	-0.21	0.02	0.16	-1.22	9.09
SZGB	0.02	0.05	-0.35	0.02	0.56	0.04	17.40
SZGFB	0.02	0.05	-0.27	0.02	0.48	0.36	13.40
SZGBAAA	0.02	0.05	-0.32	0.02	0.55	0.21	16.19
SZHGB	0.02	0.05	-0.34	0.03	0.57	0.18	17.31
SZGEB	0.02	0.06	-0.40	0.03	0.63	0.03	17.68

Table A.3

Robustness of mechanism analysis results with replacement of dependent variables

Variable substitution ($q = 0.37$)									
	p			w			y		
$g_{i,j,t}$	-0.17*** (-3.74)	-0.18*** (-3.99)	-0.17*** (-3.74)	-0.08** (-2.46)	-0.09*** (-2.60)	-0.08** (-2.46)	0.06*** (3.85)	0.06*** (3.93)	0.06*** (3.85)
IntereR	0.03 (0.4)	-0.04 (-0.82)	-0.06 (-1.00)	0.04 (0.94)	-0.02 (-0.48)	-0.03 (-0.70)	-0.05** (-2.29)	-0.02 (-1.16)	-0.02 (-0.94)
EPU	0.28* (1.89)	-0.42** (-2.23)	0.30** (2.05)	0.34*** (3.26)	-0.05 (-0.39)	0.36*** (3.48)	-0.02 (-0.43)	0.13* (1.87)	-0.03 (-0.63)
CCI	1.46 (0.41)	-0.10 (-0.03)	6.03 (1.38)	-0.98 (-0.39)	-2.12 (-0.85)	3.45 (1.11)	-1.95 (-1.54)	-1.4 (-1.15)	-4.00** (-2.57)
IntereR* $g_{i,j,t}$	-0.07** (-2.19)			-0.06*** (-2.66)			0.03** (2.56)		
EPU* $g_{i,j,t}$		0.17*** (5.77)			0.10*** (4.56)			-0.04*** (-3.46)	
CCI* $g_{i,j,t}$			-0.07** (-2.12)			-0.07*** (-2.83)			0.03*** (2.64)
Constant	-4.92 (-0.68)	0.27 (0.04)	-13.99 (-1.59)	0.15 (0.03)	3.6 (0.71)	-8.7 (-1.38)	4.47* (1.75)	3.00 (1.18)	8.55*** (2.73)
Obs	921	921	921	921	921	921	921	921	921
adj.R2	0.25	0.27	0.25	0.22	0.24	0.23	0.27	0.28	0.27

Table A.4

Robustness of mechanism analysis results with replacement of dependent variables⁸

Variable substitution ($q = 0.30$)									
	p			w			y		
$g_{i,j,t}$	-0.23*** (-4.90)	-0.23*** (-4.90)	0.23*** (4.91)	-0.09*** (-2.75)	-0.09*** (-2.71)	-0.09*** (-2.75)	0.09*** (3.45)	0.08*** (3.12)	0.09*** (3.58)
IntereR	-0.21*** (-3.34)	-0.31*** (-5.95)	-0.33*** (-6.23)	-0.11*** (-2.50)	-0.20*** (-5.41)	-0.21*** (-5.74)	0.06* (1.68)	0.08*** (2.60)	0.08*** (2.78)
EPU	0.36** (2.46)	0.02 (0.10)	0.40*** (2.72)	0.35*** (3.39)	0.19*** (1.37)	0.38*** (3.67)	0.21** (2.62)	0.35*** (3.34)	0.20** (2.56)
CCI	32.30*** (-2.50)	30.69*** (2.78)	40.84*** (9.25)	20.45*** (8.02)	19.23*** (7.50)	27.06*** (8.63)	-9.83*** (-4.84)	-8.70*** (-4.40)	-12.98*** (-5.46)
IntereR* $g_{i,j,t}$	-0.11*** (3.32)			-0.09*** (-4.05)			0.03* (1.66)		
EPU* $g_{i,j,t}$		0.09*** (2.78)			0.04* (1.93)			-0.03* (-1.88)	
CCI* $g_{i,j,t}$			-0.13*** (-3.78)			-0.10*** (-4.16)			0.05*** (2.87)
Constant	-65.57*** (-9.05)	-61.54*** (-8.45)	-82.82*** (-9.32)	-41.97*** (-8.12)	-38.84*** (-7.48)	-55.08*** (-8.72)	19.09*** (4.43)	16.39*** (4.09)	25.35*** (5.28)
Obs	884	884	884	866	866	866	736	736	736
adj.R2	0.42	0.41	0.42	0.33	0.32	0.33	0.36	0.35	0.36

Note: The t-statistics are shown in parentheses. *, ** and *** represent significance at the 10 %, 5 % and 1 % levels, respectively.

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⁸ Due to errors introduced by perturbations to the quantile q , we apply a bilateral 1% truncation to all variables.

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