The sentiment divides: How do individual and institutional investors shape green bond market performance?

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Abstract: This study identifies and analyses the impact of individual and institutional investors' sentiment on the green bond market performance across China, Japan, the United States (U.S.), and the European Union (EU), covering the period from January 3, 2022, to December 31, 2024. We conduct our research by applying exponential general autoregressive conditional heteroscedasticity (EGARCH), quantile-on-quantile (QQ), and GARCH-mixed data sampling (MIDAS) regression techniques. Our empirical results reveal the significant role of both domestic and foreign investors' sentiment in enhancing the performance of the green bond market. However, the effects are asymmetric and vary across countries and different quantiles of green bond returns, as well as sentiment indicators. Our research findings contribute to the growing body of literature on sustainable and behavioural finance. It also offers valuable policy implications and investment strategies to green bond regulators and investors across countries.

Keywords: green bond market performance; individual investor sentiment; institutional investor sentiment

1.0 Introduction

The question of whether and how investor sentiment impacts green bonds has garnered increasing attention in recent literature. Early studies by (Pham & Huynh, 2020; Piñeiro-Chousa et al., 2021, 2022) were among the first to explore this relationship, documenting a positive and significant influence of sentiment on green bond returns. These findings have opened a research avenue examining the broader effects of investor sentiment on green bond market performance,

including its impact on returns (Pham & Cepni, 2022; Wu & Liu, 2023), volatility (Bouteska et al., 2024; Uckun-Ozkan, 2024), premiums (Fu et al., 2024), and spillovers (Le et al., 2025; Man et al., 2024; Su et al., 2024).

A review of the literature reveals that investor sentiment is captured through various proxies, ranging from direct measures to indirect indicators. However, a critical gap remains regarding whether these findings hold when distinguishing between different investor groups, namely, individual and institutional investors. It is widely acknowledged that these groups differ significantly in terms of size, sophistication, and trading behaviour (Griffin et al., 2003; Lakonishok & Edwin, 1990; Schmeling, 2007). Institutional investors tend to be contrarian in nature (Griffin et al., 2003), driven by two key factors. First, they possess superior access to information, greater resources, and more time for in-depth analysis (Gao et al., 2021; Nofsinger & Sias, 1999). Second, they are generally more sophisticated and less prone to misestimating return variances (Schmeling, 2007; Wang, 2018). Consequently, existing research recognises the distinction between institutional and individual investor sentiment, with the former often viewed as more rational (Verma & Verma, 2008). Specifically, institutional sentiment is frequently associated with 'smart money', while individual sentiment is linked to 'noise trader risk' (Schmeling, 2007). This leads us to our first research question: What are the differential effects of institutional and individual investor sentiments on the performance of the green bond market?

Due to shifts in hedging demand (Dean et al., 2010; Pham, 2021) and increasing capital flow liberalisation, investors are constructing international portfolios considerably. This implies that investors from one country may actively participate in foreign markets (Le et al., 2025). Suppose investor sentiment plays a role in domestic markets. In that case, it is pertinent to ask whether this influence extends to foreign markets where these investors hold assets, particularly in leading international markets. The strategy of international diversification among individual and institutional investors leads us to our second research question: To what extent do sentiments of individual and institutional investors affect the performance of the foreign green bond market?

To address these two research questions, our study is based on the context of four major international green bond markets, including China, Japan, the U.S., and the EU, over the period from January 3, 2022, to December 31, 2024. The research proceeds in two stages. First, we utilise proxies of individual and institutional investors' sentiment provided by Sentix to examine their

respective impacts on green bond returns. Second, we examine whether the sentiment of individual and institutional investors from one country has a measurable impact on the performance of another green bond market. To obtain empirical evidence, we first employ the E-GARCH model to estimate the overall impact of investor sentiment on the performance of green bond markets. After that, we use QQ regression to produce surface plots to explore if the effects are consistent with different distribution levels of green bond returns and sentiment indicators. We also apply the GARCH-MIDAS model to address the frequency mismatch between the returns and sentiment indicators.

Unlike previous studies, the innovative contributions of this research primarily encompass the following aspects. First, despite nearly two decades since their inception by the European Investment Bank, green bonds still account for only about four per cent of the global debt market, with uneven growth across countries (Torvanger et al., 2021). Notably, green bond markets are supply-driven rather than demand-driven (Barua & Chiesa, 2019), exacerbating developmental disparities. While prior research has focused extensively on issuer-side factors, investor-side dynamics, particularly sentiment, receive less attention. (Barua & Chiesa, 2019; Wu & Liu, 2023) argue that the core of supply-demand imbalances in green bond markets lies in investor choices shaped by sentiment. Conceptualised initially as investor expectations (Zweig, 1973), sentiment has evolved into a key psychological factor influencing investment decisions (Pham & Huynh, 2020; Piñeiro-Chousa et al., 2021; Wu & Liu, 2023). Our research contributes to the fields of sustainable and behavioural finance by digging directly into the demand-side of the green bond market-investors' sentiment. Second, while existing studies emphasise the role of general investor sentiment in asset valuation, few differentiate between institutional and individual sentiment or explore their distinct effects on green bonds. Given their divergent trading behaviours, understanding their respective impacts is crucial to green bond regulators and investors. Our study pioneers this investigation by analysing how these two sentiment types influence green bond performance. Third, unlike previous research that focuses primarily on domestic markets, our study incorporates the sentiment of both local and foreign individual and institutional investors, offering a more nuanced and comprehensive understanding of sentiment dynamics in global sustainable finance. Finally, we employ the state-of-the-art QQ model to clarify the varied impact of investor sentiment on the performance of the green bond market across different quantiles of green bond returns and sentiment indices. Unlike previous studies that performed standard quantile regression, which reports the varied relationship between variables based on different quantiles of the

dependent variable, a QQ estimation reveals an association at different levels of both the dependent and independent variables. As a result, it provides more objective findings on the role of investor sentiment in enhancing the performance of the green bond market.

The remainder of the paper is as follows: In Section 2, we discuss relevant literature. Section 3 introduces theoretical background and proposes research hypotheses. Section 4 details the data, their sources, and the methods used to test the models. Results and their discussions appear in Sections 5, 6, and 7. Section 8 concludes the study with a summary of the findings and their implications for future studies.

2.0 Literature Review

In exploring the influence of investor sentiment on green bond performance, (Piñeiro-Chousa et al., 2021, 2022) were among the first to empirically assess this relationship, utilising Twitter data as a proxy for investor sentiment. Their findings reveal a statistically significant and positive correlation between sentiment and green bond returns. Similarly, (Fu et al., 2024) demonstrate that sentiment derived from text mining techniques contributes to a widening of yield spreads between green and conventional bonds, thereby increasing volatility in the green bond market. (Bouteska et al., 2024) further corroborates the role of sentiment in driving fluctuations in green bond prices. Beyond sentiment, investor attention has also been employed as a predictive factor in this context. Studies by (Gao et al., 2023; Pham & Cepni, 2022; Pham & Huynh, 2020) utilise the Google Search Volume Index and Baidu Index to measure investor attention, finding that these indicators significantly forecast both returns and volatility in green bond markets. Recent research has also extended the analysis to the spillover effects between green bonds and other financial markets, with investor sentiment playing a central role. (Wu & Liu, 2023) examine sentiment-driven spillovers across various green finance sectors, including clean energy, transportation, building, clean water, ESG stocks, green bonds, and carbon markets, using Google search data as a proxy for sentiment. Their results suggest that investor sentiment intensifies dynamic inter-market linkages. (Gao & Liu, 2024) adopt the U.S. VIX index as an indirect sentiment measure to analyse time- and frequency-domain spillovers between rare earths and other markets such as oil, clean energy, gold, base metals, ESG assets, and green bonds. Their findings position green bonds as net receivers of shocks, with investor sentiment emerging as a key driver of market connectedness. (Man et al., 2024) investigate risk spillovers among green bonds, fossil fuels, new energy, equities, and traditional bonds in China,

incorporating macroeconomic sentiment indicators based on the framework of (Baker & Wurgler, 2006). Their study reveals time-varying, asymmetric, and heterogeneous spillover patterns, with investor sentiment having a significant influence on inter-market dynamics. (Le et al., 2025) expand this line of inquiry by employing a comprehensive set of direct and indirect sentiment proxies to assess their impact on return contagion across twelve major green bond markets, including China, Japan, Canada, the United States, Australia, New Zealand, the EU, the UK, Switzerland, Denmark, Norway, and Sweden. Their results indicate that sentiment effects are significant but vary across markets.

Despite the growing body of literature, several gaps remain in this research branch. First, while existing studies underscore the importance of investor sentiment in green bond performance, they largely overlook the differentiated roles of individual versus institutional investor sentiment. Given the contrasting behavioural tendencies of these investor groups, this omission raises questions about the consistency of sentiment effects across market segments. Second, the influence of cross-border sentiment remains underexplored. Most studies focus on the domestic sentiment impacts, with limited attention, aside from (Le et al., 2025), on how investor sentiment originating in one country may affect green bond performance in foreign markets. Lastly, given that the overall impact of investor sentiment on the performance of the green bond market is evident, it remains underexplored whether this effect varies across green bond markets and different levels of bond returns, along with sentiment.

3.0 Theoretical background and hypothesis development

This study is grounded in the principles of behavioural finance to examine the influence of investor sentiment on the performance of the green bond market. Traditional financial theories, such as those proposed by (Simon, 1955) and supported by (Prosad et al., 2015), assume that investors behave with full rationality, making decisions based solely on objective information and utility maximisation. However, behavioural finance challenges this assumption by incorporating psychological and emotional factors into financial decision-making (Pompian, 2011; Sewell, 2010). It posits that investors are not perfectly rational but are instead influenced by sentiment, cognitive biases, and heuristics (Statman, 1999).

A central framework within behavioural finance is prospect theory, introduced by (Tversky & Kahneman, 1979), which departs from the classical expected utility theory (Bernoulli, 1738). The

prospect theory suggests that individuals evaluate outcomes relative to a reference point and exhibit loss aversion, resulting in systematic deviations from rational behaviour under uncertainty. This theory provides a foundation for understanding how investor sentiment, particularly in volatile or uncertain market conditions, affects asset pricing.

In addition to prospect theory, the concept of socially responsible investment (SRI) and the theory of planned behaviour developed by (Ajzen, 1985) further support the theoretical framework of this study. While SRI lacks a universally accepted definition, it is commonly understood as an investment approach that integrates environmental and social considerations into financial analysis (Anastasia, 2003). Prior research (Adam & Shauki, 2014; Paetzold & Timo, 2014) highlights that investor intention is a key determinant of SRI decisions, aligning with the core premise of the theory of planned behaviour. This theory posits that individual actions are guided by behavioural intentions, which reflect the level of effort and commitment an individual is willing to invest in a particular behaviour.

Together, these theoretical perspectives provide a comprehensive framework for understanding the psychological and motivational drivers underlying investor behaviour in green bond markets. They suggest that sentiment, rather than purely financial considerations, plays a significant role in shaping investment decisions in environmentally focused financial instruments.

Although the behavioural finance literature documents the significant role of investor sentiment in asset pricing, it also reveals contrarian tendencies among individual and institutional investors (Griffin et al., 2003), recognising the existence of distinct sentiment patterns across these groups (Verma & Soydemir, 2006). Individual investors are often influenced by fads and fashion (Nofsinger & Sias, 1999), whereas institutional investors are typically informed traders (Puckett & Yan, 2011) and less prone to misestimating return variances (Wang, 2018). These differences are driven by two key factors: (1) individual investors face limited access to cohesive and fundamental information (Nofsinger & Sias, 1999), and (2) institutional investors benefit from pooled resources and time for intensive analysis. Consequently, individual and institutional investor sentiment serve as proxies for noise trader risk and smart money, respectively (Schmeling, 2007), with institutional sentiment generally outperforming individual sentiment in predicting asset prices (Gao et al., 2021).

Based on this analysis, we propose the following hypothesis:

H1: There is an impact of sentiment of domestic individual and institutional investors on green bond index returns, with the latter yielding a greater effect.

Sentiment is not limited to investor groups within a single market—it also extends across international financial markets. (Baker et al., 2012) identifies two primary channels of cross-country sentiment contagion: (1) optimistic investors in one country may invest in another, and (2) pessimistic investors may reallocate risky assets globally. (Hudson & Green, 2015) confirms this phenomenon by demonstrating that U.S. investor sentiment has a significant predictive value for UK equity returns. With increasing hedging demand and capital liberalisation, investors are more engaged in international diversification (Le et al., 2025), accessing diverse sources of information and using sentiment from one market to infer price changes in others (Lin & Ito, 1994; Mervyn & Sushil, 1990).

Empirical evidence further supports the role of foreign investor sentiment in domestic asset valuation. For example, (Pham & Huynh, 2020; Piñeiro-Chousa et al., 2021) use global sentiment measures to assess green bond performance in the EU, U.S, and China. (Gao & Liu, 2024) employ the U.S. VIX to analyse global financial market spillovers, while (Fernandes et al., 2016) examine the influence of EU investor sentiment on Portugal's debt market.

Based on this analysis, we propose the following hypotheses to test how the sentiment of foreign individual and institutional investors affects green bond market performance:

H2: There is an impact of sentiment of foreign individual and institutional investors on green bond index returns, with the latter yielding a greater effect.

4.0 Research design

The research design section introduces variables and econometric models to test the hypotheses presented above.

4.1. Research variables

The dependent variable in this study is the performance of the green bond market. In line with prior research (Le et al., 2025; Pham & Cepni, 2022; Pham & Huynh, 2020; Piñeiro-Chousa et al., 2021, 2022), we utilise the daily returns of green bond indices as a proxy for market performance. With the growing significance of green finance, several global green bond indices have emerged,

including the S&P Green Bond Index, Bloomberg Barclays MSCI Green Bond Index, and J.P. Morgan Emerging Markets Green Bond Index. Although these indices differ in terms of construction methodologies and inclusion criteria, they exhibit similar market dynamics and strong correlations (Reboredo, 2018; Reboredo & Ugolini, 2020). Therefore, we adopt green bond indices compiled by the Bloomberg database, which is consistent with the existing literature in this domain.

The independent variables are the investor sentiment index, specifically distinguishing between individual and institutional investor sentiment. To capture these sentiments, we utilise the Investor Sentiment Index (Sentix) survey data, provided by Sentix GmbH. This independent German research institute collects information on investors' preferences, assessments, and expectations regarding financial markets and macroeconomic trends. The Sentix index is constructed as a qualitative diffusion indicator, ranging from -100 (strongly deteriorating) to +100 (strongly improving), with zero representing a neutral stance, indicating unchanged expectations relative to current conditions.

This sentiment dataset is particularly well-suited to our research for three key reasons. First, the monthly surveys conducted by Sentix GmbH anonymously solicit investor views on short- and medium-term market directions across major regions, including the EU, the U.S, Asia (excluding Japan), and Japan. This provides a direct and timely measure of investor sentiment. Second, the survey methodology explicitly distinguishes between individual and institutional investors. To participate as an institutional investor, respondents must register using a verified institutional email address to ensure accurate classification and identification. This distinction aligns precisely with our objective of examining the differential effects of individual and institutional sentiment on the performance of the green bond market. Third, the Sentix sentiment indicators have been widely employed in previous empirical studies (e.g., Corredor et al., 2013; Debata et al., 2018; Gao et al., 2021; Schmeling, 2007; Wang et al., 2021).

Although Sentix provides regional sentiment data for Asia (excluding Japan), Japan, Eastern Europe, the EU, Latin America, and the U.S., green bond index data is not uniformly available across all these regions. To ensure consistency in data coverage, our analysis focuses on four markets: Asia (excluding Japan), Japan, the EU, and the U.S, with the Chinese green bond market serving as the representative for Asia (excluding Japan).

Regarding the study period, the availability of green bond index data varies across regions. While indices for China, the EU, and the U.S. were introduced earlier, Japan's green bond index data only became fully available from October 2021. To maintain consistency across all markets, we define our sample period as from January 3, 2022, to December 31, 2024. All green bond index data are sourced from the Bloomberg database and are available at a daily frequency, whereas investor sentiment data are provided on a monthly basis. To reconcile the difference in data frequency, we apply linear interpolation to the monthly Sentix sentiment data, following the methodology of (Bethke et al., 2017; Wang & Duxbury, 2021).

Table 1 provides an overview of variables used in our research for the four green bond markets mentioned.

Table 1: Research variable overview

Markets	Notations	Variables
China	regbcn	FTSE Chinese Green Bond Index Onshore CNY
	invicn	China's Individual investor sentiment index
	insticn	China's Institutional investor sentiment index
Japan	regbjp	Bloomberg Green Bond Index JPY
	invijp	Japan's Individual investor sentiment index
	instijp	Japan's Institutional investor sentiment index
The U. S	regbus	Bloomberg Green Bond Index USD
	invius	The U.S. Individual investor sentiment index
	instius	The U.S. Institutional investor sentiment index
EU	regbeu	Bloomberg Green Bond Index EUR
	invieu	EU's individual investor sentiment index
	instieu	EU's institutional investor sentiment index

4.2. Research models

To empirically investigate our research questions, we employ a multi-method approach that comprises two econometric models. First, we apply the Exponential Generalized Autoregressive Conditional Heteroskedasticity (E-GARCH) model to examine the influence of investor sentiment on green bond returns. After that, we utilise the Quantile-on-Quantile (QQ) regression technique to explore how the effects of explanatory variables vary across different quantiles of both dependent

and independent variables. Each model is estimated separately for each green bond market and sentiment indicator.

4.2.1. E-GARCH model

To assess the impact of investor sentiment and sentiment contagion on green bond market performance, we employ the EGARCH model developed by (Nelson, 1991). This model is widely recognised in financial econometrics for its ability to capture volatility asymmetries and conditional heteroscedasticity more effectively than other GARCH-family models, such as GARCH and GJR-GARCH (Hadad & Kedar-Levy, 2024; Wang et al., 2022; Wang & Duxbury, 2021).

Given that sentiment spillovers may exhibit conditional heteroscedasticity (Wu & Liu, 2023), the EGARCH framework is particularly suitable. It accommodates asymmetric effects and allows for modelling both mean and volatility spillovers (Hadad & Kedar-Levy, 2024; Skintzi & Refenes, 2006).

The EGARCH model specification is as follows, with the daily return of green bond indices as the dependent variable:

$$regb_t = \mu_t + \varepsilon_t \quad (6)$$

Where $regb$ is the daily return of the green bond index for each market. Following existing literature, the daily returns of green bonds are measured by the first natural log difference: $regb_t = \ln(P_t) - \ln(P_{t-1})$, where P is the closing price of the green bond index. μ is a constant term and ε is an error term. The conditional variance model is:

$$log(\sigma_t^2) = \omega + \alpha\left[\frac{|\varepsilon_{t-1}|}{\sigma_{t-1}} - \frac{\sqrt{2}}{\pi}\right] + \beta(\frac{\varepsilon_{t-1}}{\sigma_{t-1}}) + \gamma log(\sigma_{t-1}^2) + \delta_t sent_t \qquad (6)$$

Where σ_t^2 is the conditional variance of the daily return. *sent* is either individual investor sentiment, institutional investor sentiment (measured by the natural logarithm of sentiment index), or sentiment contagion. ω, α, β are constant, symmetric, and asymmetric effects of the general autoregressive model. γ captures the conditional volatility's persistence. δ presents our matter of interest by reflecting on the impact of investor sentiment or sentiment contagion on the returns of green bonds.

Following (Anderson & Burnham, 2004; Wang & Duxbury, 2021), we report the log-likelihood function (LLF) and Akaike's Information Criterion (AIC) for each regression.

4.2.2. QQ model

To gain deeper insights into how investor sentiment and sentiment contagion affect green bond returns across different distributional segments, we apply the Quantile-on-Quantile (QQ) regression method developed by (Sim & Zhou, 2015). This technique extends the standard quantile regression framework introduced by (Koenker & Bassett, 1978) by incorporating non-parametric estimation.

The QQ model is well-suited for our research for two main reasons. First, unlike traditional quantile regression, which estimates the effect of an independent variable across quantiles of the dependent variable, the QQ approach evaluates the relationship across quantiles of both variables (Sun et al., 2023), offering a more nuanced understanding of their interaction (Chang et al., 2020). Second, the QQ model effectively captures full dependence structures—including tail behaviour and structural breaks—that are often overlooked in standard quantile models (Sim & Zhou, 2015; Sun et al., 2023).

The basic model is:

$$regb_t = \beta^{\theta}(sent_t) + u_t^{\theta} \quad (7)$$

Where $regb$ is the daily green bond return. $sent$ is either individual investor sentiment, institutional investor sentiment, or sentiment contagion. θ is the θth of the quantile based on the conditional distribution of return. u_t^{θ} is the quantile error term. $\beta^{\theta}(\bullet)$ is the slope of the relationship between green bond return and sentiment.

To measure the impact of the θth quantile of the return on the τth quantile of the sentiment, proxied by $sent^{\tau}$, β^{θ} can be linearised by the first-order Taylor rule as:

$$\beta^{\theta}(sent_t) \approx \beta^{\theta}(sent^{\tau}) + \beta^{\theta'}(sent^{\tau})(sent_t - sent^{\tau}) \quad (8)$$

Where $\beta^{\theta'}$ is the partial derivative of $\beta^{\theta}(sent^{\tau})$ and $\beta^{\theta'}(sent^{\tau})$ in terms of θ and τ.

Equation (8) can be rewritten as:

$$\beta^{\theta}(sent_t) \approx \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(sent_t - sent^{\tau}) \quad (9)$$

By changing equation (9) in equation (7), we obtain the last equation to examine the impact of investor sentiment or sentiment contagion on daily green bond return.

$$regb_t \approx \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(sent_t - sent^{\tau}) + u_t^{\theta} \quad (10)$$

Where $\beta_0(\theta,\tau) + \beta_1(\theta,\tau)(sent_t - sent^{\tau})$ is the conditional quantile of the green bond return. Following (Sim & Zhou, 2015), we set the bandwidth parameter h=0.05.

5.0 Empirical findings

In this section, we present the empirical findings of our research, which begin with the descriptive statistics of the research variables. Next, we report the results of the impact of individual and institutional investor sentiment on domestic green bond returns. Finally, we provide the results of the role of individual and institutional investor sentiment in the performance of foreign green bond markets.

5.1. Descriptive statistics

Table 2 presents the summary statistics for green bond returns and investor sentiment indices across the selected markets. The four green bond markets include Asia (excluding Japan with China-*cn*- as a representative), Japan (*jp*), European Union (*eu*), and the United States (*us*).

Table 2: Descriptive statistics of investor sentiment and green bond indices

Variable	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	ADF Test
regbcn	0.0144	0.0547	-0.0839	7.1661	566.44***	-24.734***
regbjp	-0.0279	0.3869	0.3754	4.2248	67.262***	-26.370***
regbus	-0.0251	0.5854	0.2447	4.3961	71.308***	-24.866***
regbeu	-0.0166	0.3886	0.3330	3.9656	44.845***	-26.315***
invicn	0.9389	1.9264	-0.8189	2.1225	112.49***	-3.4385**
invijp	-0.1311	1.9655	-0.1099	1.4493	79.926***	-1.8642**
invius	-0.4091	1.9374	0.1990	1.5076	77.731***	-1.8892**
invieu	-2.2024	1.4762	1.7646	5.4163	596.11***	-3.3077***
insticn	0.9203	1.8102	-0.5885	1.9346	82.1323***	-2.1696**
instijp	0.4224	1.8552	-0.4804	1.7919	77.6323***	-1.7241**
instius	-1.8413	1.7238	1.3504	3.5049	245.97***	-2.2811**
instieu	-1.5684	2.1921	1.0029	2.5192	138.64***	-2.2883**

Notes: This table presents descriptive statistics for variables used in the research across four green bond markets. All variables are defined in Table 1.

The data reveal that average returns in green bond markets are relatively low over the sample period, with China being the only market to exhibit a positive mean return. The skewness values for most markets are positive, except for China, indicating right-skewed distributions. Furthermore, the kurtosis values for all markets exceed the benchmark value of 3, suggesting the presence of fat tails in return distributions.

Regarding investor sentiment indices, the average values are predominantly negative, reflecting a generally pessimistic outlook among investors during the research period. These sentiment indicators also display higher volatility, as measured by standard deviation, compared to green bond returns. The distributional characteristics of sentiment indices show left skewness and relatively thin tails, as evidenced by their skewness and kurtosis statistics.

The results of the Jarque-Bera and Augmented Dickey-Fuller (ADF) tests are statistically significant for all variables, indicating that the data deviate from normality and exhibit stationarity.

5.2. The impact of domestic investor sentiment on green bond performance

The E-GARCH estimation results, showing how domestic individual and institutional investor sentiment impact green bond returns in the four markets, are presented in Table 3.

Table 3: Impact of domestic investor sentiment on green bond performance

Markets	Individual investor sentiment				Institutional investor sentiment			
	Constant	Coefficients	LLF	AIC	Constant	Coefficients	LLF	AIC
China	1.1867***	0.1332***	-2435.9	6.2609	1.2221***	0.2352***	-2444.3	6.2826
	(0.0466)	(0.0224)			(0.0487)	(0.0234)		
Japan	-3.1190***	0.2845*	-4036.7	10.361	-2.895***	0.3875***	-4049.8	10.394
	(0.2783)	(0.1671)			(0.3770)	(0.1122)		
U. S	-2.448***	-0.4496***	-4335.3	11.125	-3.7032***	-0.4278*	-4335.8	11.126
	(0.5279)	(0.0913)			(0.6619)	(0.2399)		
EU	5.9682***	2.5443***	-3992.0	10.064	-0.9375**	0.5123***	-4049.6	10.393
	(0.8061)	(0.3581)			(0.4477)	(0.1886)		

Notes: This table reports the impact of individual and institutional sentiment of a country on its green bond return. *, **, and *** denote 10%, 5%, and 1% significance levels respectively.

Overall, the slope coefficients reported in Table 3 are all statistically significant, indicating that the investor sentiment of both individuals and institutions plays a crucial role in explaining the performance of these green bond markets. The findings also reveal the varied impact of sentiment of different investor groups on green bond index returns in China, Japan, the U.S and the EU.

Specifically, the sentiment of institutional investors in China and Japan has a greater impact on their green bond returns than that of individual investors, as reflected by the magnitude of their coefficients. Meanwhile, the sentiment of individual investors dominates the performance of the EU's green bond market compared to that of institutional investors. In the details, a one per cent increase in the natural logarithm of the individual investors' sentiment index leads to a 2.5 per cent rise in its green bond index return. In comparison, the institutional investors' sentiment index is associated with only 0.5 per cent of the bond return. Interestingly, among these four green bond markets, the U.S. shows the opposite pattern, where its green bond index return has a negative relationship with the sentiment of different investor groups. The coefficients are -0.44 and -0.43 for the individual and institutional investor sentiment indices, indicating that their effects on the U.S. green bond market performance are relatively equal.

Given the significant impact of sentiment from different investor groups on the four green bond markets, we further identify this impact on the varied distribution levels of both green bond returns and sentiment using a QQ regression surface plot. Figures 1 to 4 report the QQ regression findings on this relationship in China, Japan, the U.S., and the EU, respectively.

Figure 1: Surface plot of QQ estimates on China's investor sentiment and its green bond market performance

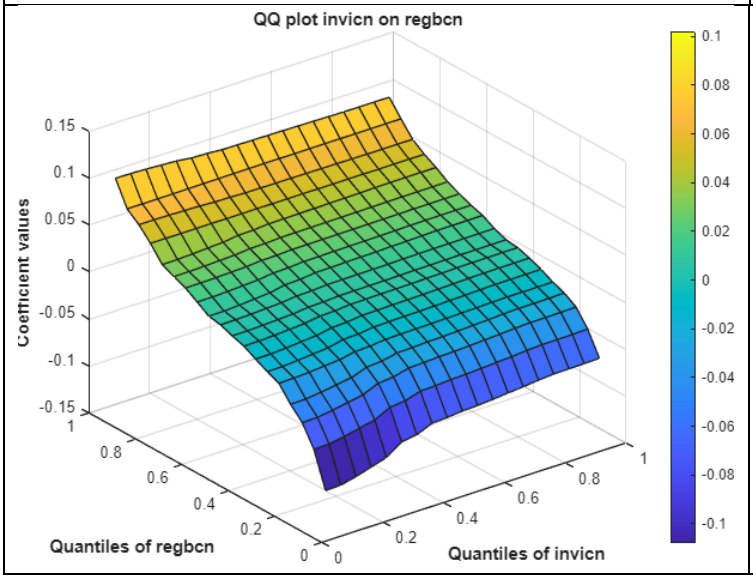
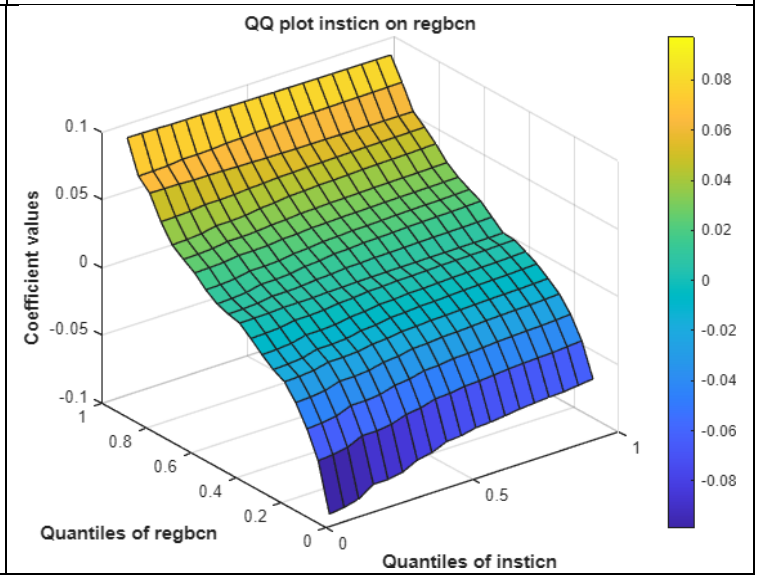
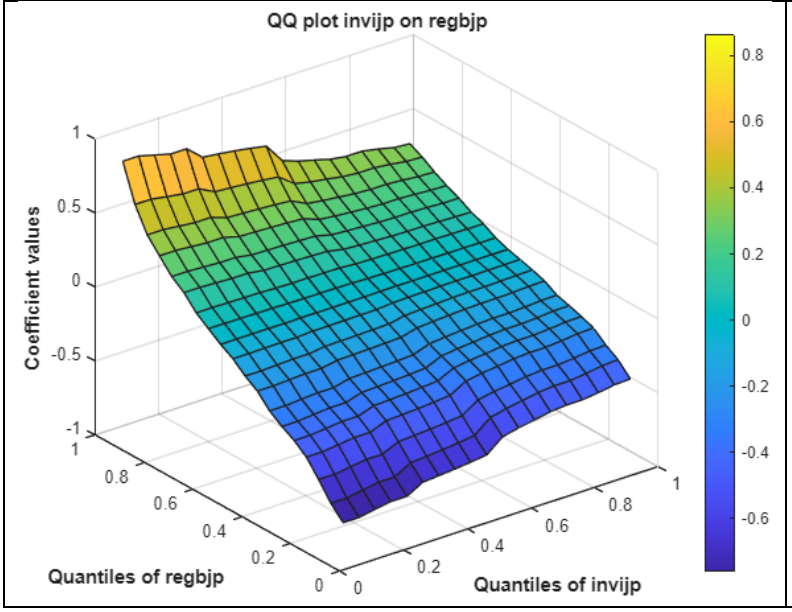
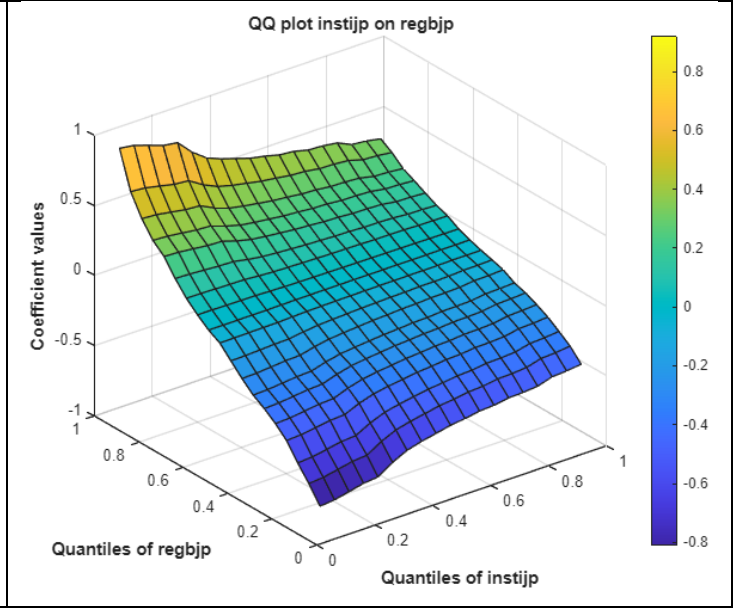
China's individual investor sentiment on its green bond return	China's institutional investor sentiment on its green bond return
	

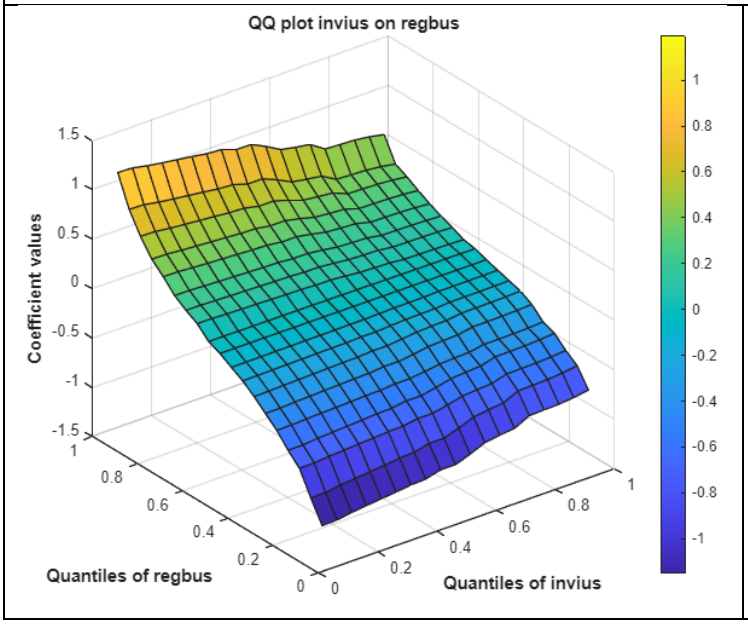
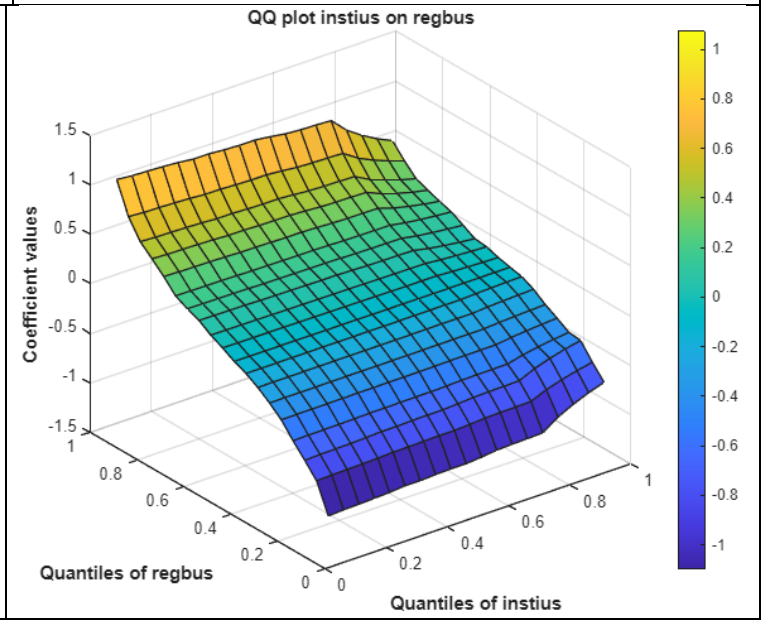
Figure 1 illustrates the varied effects of sentiment among individual and institutional investors on the performance of the Chinese green bond market across quantiles of dependent and independent variables. The positive effects of investor sentiment focus on the medium and upper quantiles of green bond returns (0.55-0.95), while the negative impacts are centred on the lower quantiles of the returns (0.2-0.5). Interestingly, the highest coefficients of association are between 0.05% and 0.09%, which are primarily located in the upper quantile of the bond (0.8-0.95).

Figure 2: Surface plot of QQ estimates on Japan's investor sentiment and its green bond market performance

Japan's individual investor sentiment on its green bond return	Japan's institutional investor sentiment on its green bond return
	

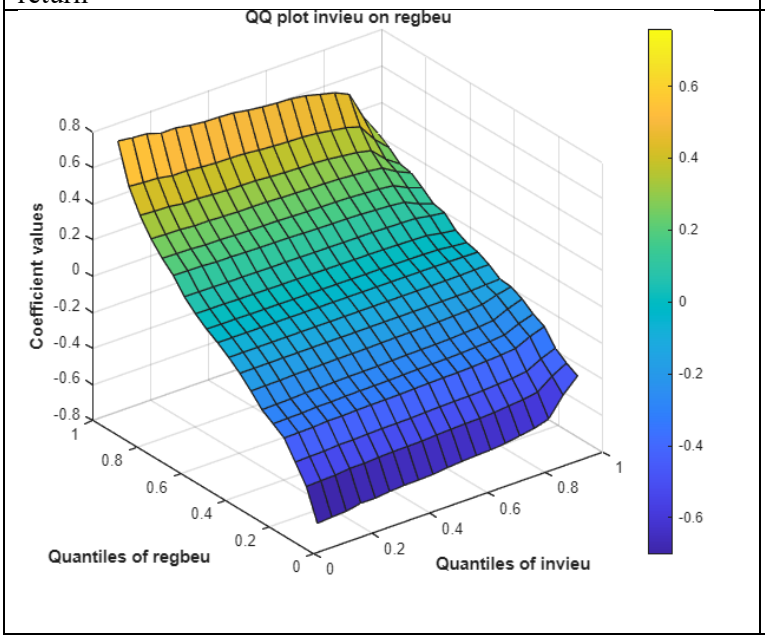
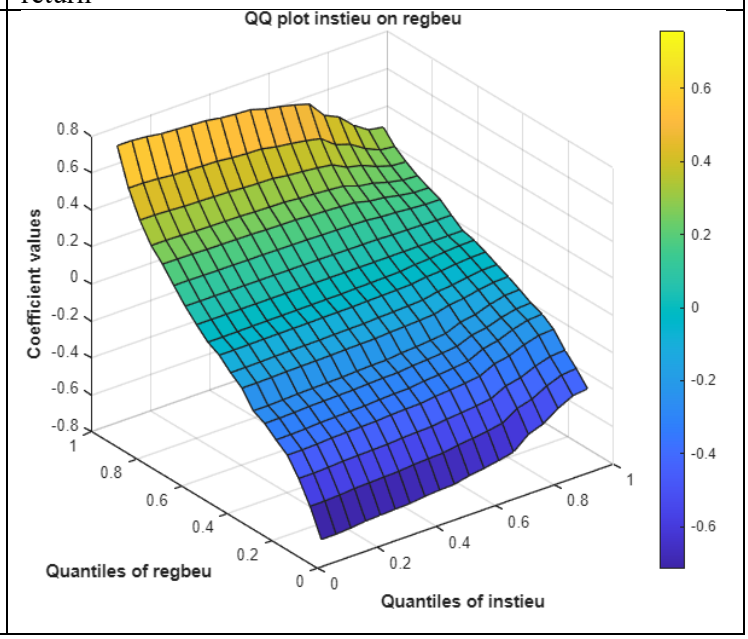
From QQ surface plots of Japan in Figure 2, we can observe the same pattern as in China, where the positive impact of investor sentiment on green bond returns is concentrated in the medium and upper quantiles of the returns, while adverse effects are observed in the lower quantiles (0.2-0.5). It is noteworthy that the most impact of the sentiment on Japanese green bond market performance (reflected by the highest coefficients (0.6%-0.8%) is central to the upper quantiles of the bond returns (0.8-0.95) and lower quantiles of both individual and institutional investor sentiment indices (0.1- 0.4).

Figure 3: Surface plot of QQ estimates on the U.S. investor sentiment and its green bond market performance

The U.S. individual investor sentiment on its green bond return	The U.S. institutional investor sentiment on its green bond return
	

The QQ plots for the U.S. market reveal consistent findings with the average negative impact of investor sentiment, as reported by the E-GARCH estimation, on individuals and institutions. Specifically, the surface plots in Figure 3 show that the negative effects of sentiment on its green bond market performance are most pronounced in both the lower (0.2-0.5) and medium (0.5-0.65) quantiles of the bond returns. For the impact of individual investor sentiment on green bond performance, most of the highest coefficients (0.8%-1 %) are present in the upper quantiles (0.8-0.95) of the bond returns and the lower quantiles (0.2-0.5) of the sentiment index. Meanwhile, institutional investors focus on the upper quantiles of the bond return, as well as both lower (0.2-0.5) and medium (0.5-0.75) quantiles of the respective sentiment index.

Figure 4: Surface plot of QQ estimates on the EU's investor sentiment and its green bond market performance

The EU's individual investor sentiment on its green bond return	The EU's institutional investor sentiment on its green bond return
	

The varied impacts of individual and institutional investor sentiment on the EU's green bond market performance are reported by QQ surface plots in Figure 4. They show that the prevalence of positive effects is concentrated in both the medium and upper quantiles (0.5-0.95) of the green bond returns. Additionally, the highest coefficients of the estimation are associated with the upper quantiles of green bond returns, and from lower to medium quantiles of investor sentiment.

5.3. The impact of foreign investor sentiment on green bond performance

The existing literature on the nexus between investor sentiment and green bond market performance primarily focuses on the domestic market, overlooking the impact of foreign investor sentiment on local green bond markets. This research bridges the gap by examining whether the sentiment of individual and institutional investors affects foreign green bond markets. The methodology remains consistent with the previous section, utilising both E-GARCH and QQ surface plot estimation.

5.3.1. Impact of foreign individual and institutional investors' sentiment on the China green bond market

The effect of Japanese, U.S., and European investor sentiment on the performance of the Chinese green bond market, as estimated using the E-GARCH model, is reported in Table 4.

Table 4: Impact of foreign individual and institutional investors' sentiment on the China green bond market

From	Individual investor sentiment				Institutional investor sentiment			
	Constant	Coefficients	LLF	AIC	Constant	Coefficients	LLF	AIC
Japan	1.3991***	0.1666***	-2438.8	6.2683	1.2855***	0.1373***	-2438.6	6.2679
	(0.0507)	(0.0083)			(0.0432)	(0.0079)		
U. S	1.2718***	0.2025***	-2430.3	6.2466	1.5829***	0.2119***	-2435.7	6.2604
	(0.0410)	(0.0162)			(0.0350)	(0.0096)		
EU	1.6903***	0.2135***	-2436.1	6.26147	1.6538***	0.1428***	-2442.4	6.2776
	(0.0799)	(0.0212)			(0.0725)	(0.0301)		

Notes: This table reports the impact of individual and institutional sentiment of foreign countries on the Chinese green bond return. *** denotes 1% significance level.

The results in Table 4 show the positive and significant effects of foreign individual and institutional investor sentiment on China's green bond index return. Regarding foreign individual investor sentiment, those from Western countries have a greater impact on Chinese bond returns than those from Japan, as reflected by higher coefficients. Accordingly, a 1 per cent increase in the sentiment index of U.S. and EU individual investors is associated with a more than 0.2 per cent rise in Chinese green bond returns, while that for Japan is 0.16 per cent. The sentiment of U.S. institutional investors also has the most significant impact on the Chinese bond, with an estimated coefficient of 0.21, compared to those of Japan and the EU.

The surface plot using QQ regression on this relationship is shown in Figure 5.

Figure 5: Surface plot of QQ estimates on foreign investor sentiment and Chinese green bond market performance

Figure 5.a: Japan's individual and institutional investor sentiment on Chinese green bond

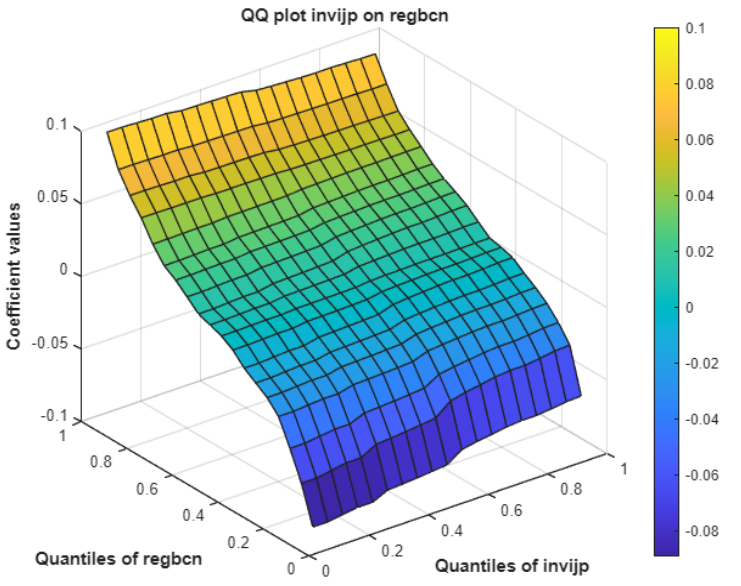
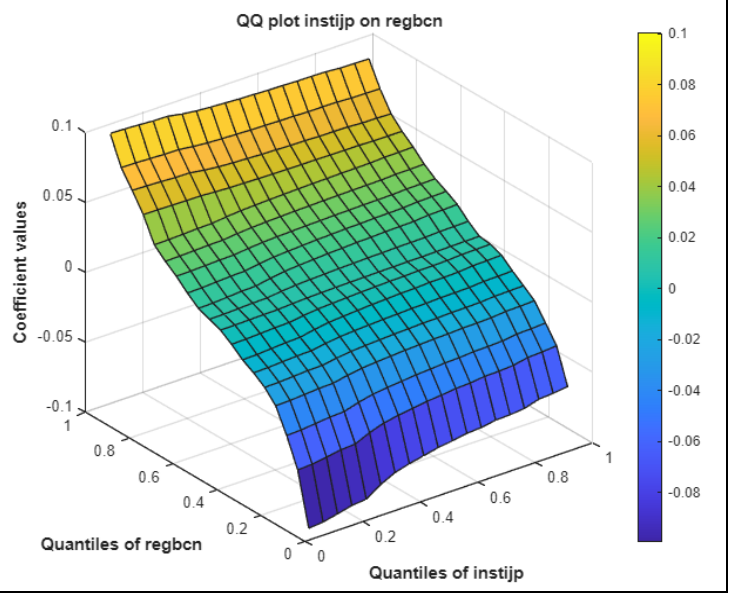
Japan's individual investor sentiment on the Chinese green bond return	Japan's institutional investor sentiment on the Chinese green bond return
	

Figure 5.b: The U.S individual and institutional investor sentiment on Chinese green bond

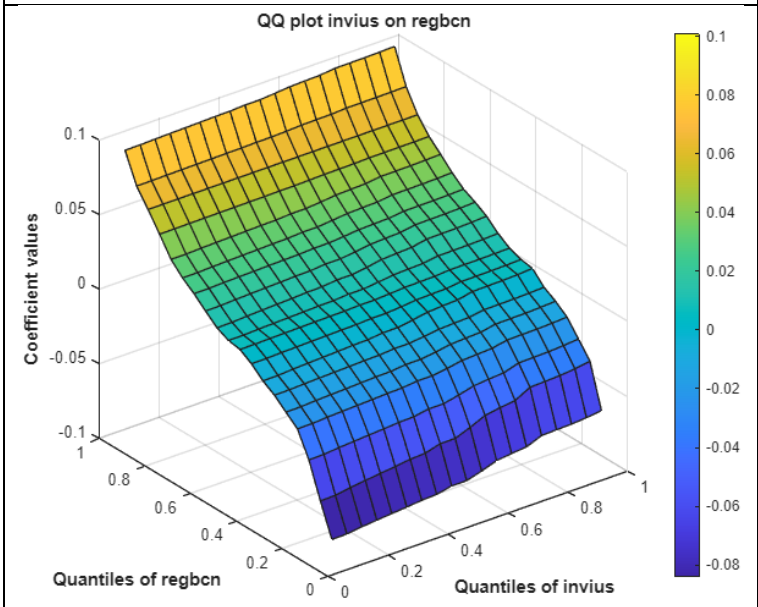
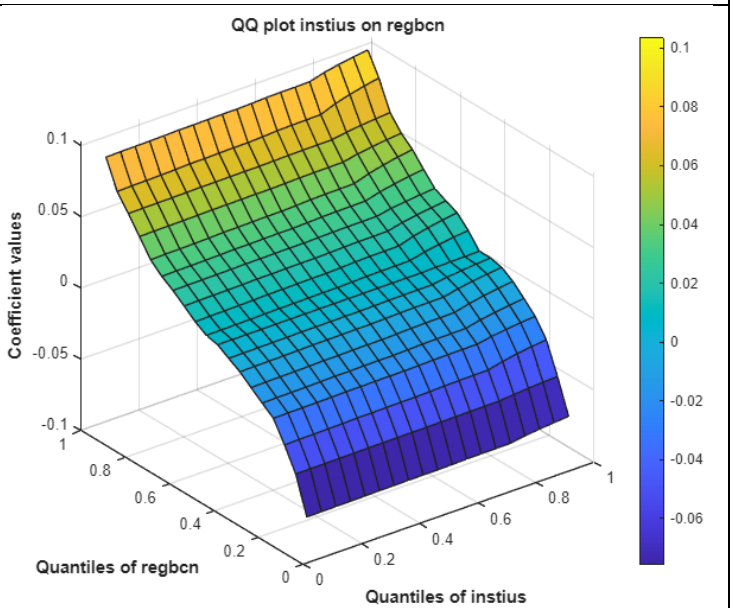
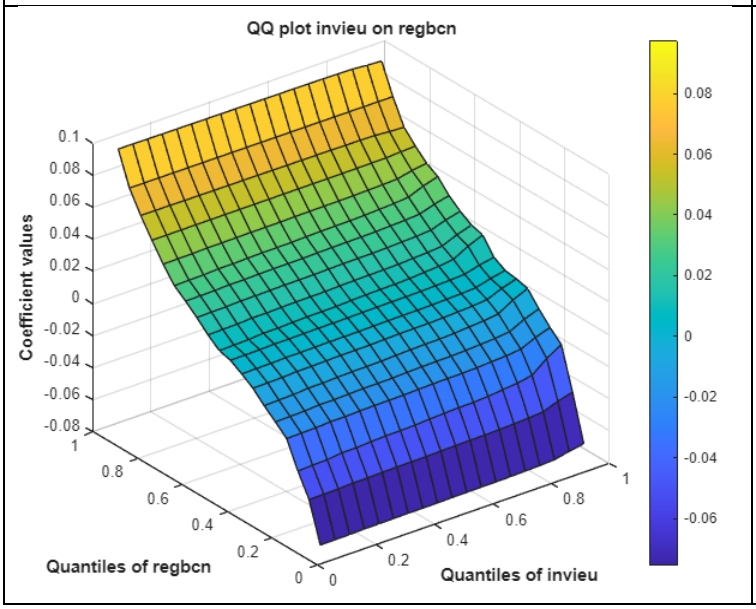
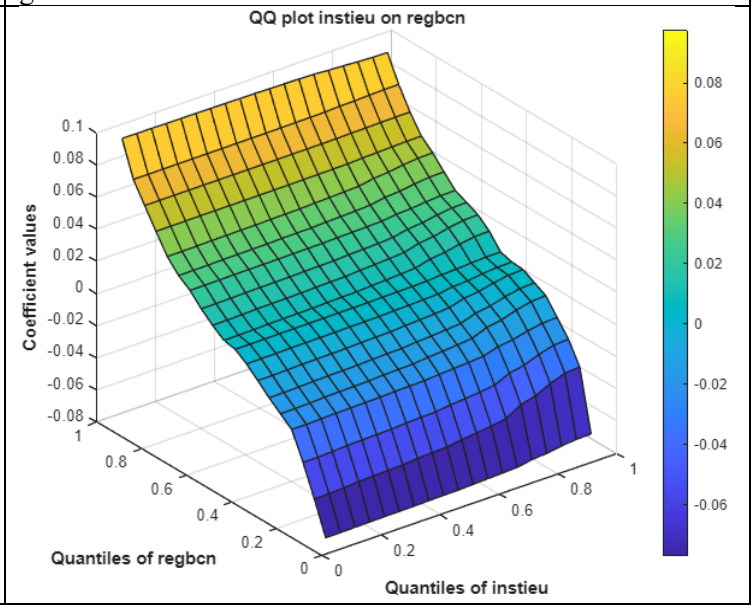
The U.S individual investor sentiment on the Chinese green bond return	The U.S institutional investor sentiment on the Chinese green bond return
	

Figure 5.c: The EU's individual and institutional investor sentiment on Chinese green bond

The EU's individual investor sentiment on the Chinese green bond return	The EU's institutional investor sentiment on the Chinese green bond return
	

The surface plots in Figures 5a, b, and c further validate our findings using the E-GARCH model, which highlights the role of sentiment among foreign individual and institutional investors in boosting the returns of Chinese green bonds. Specifically, these plots show the dominance of positive relationships between variables, with most positive coefficients concentrated in the medium (0.5-0.7) and upper (0.75-0.95) quantiles of the green bond returns. Interestingly, the highest values of slope coefficients are concentrated in the upper quantiles of bond returns and spread across all quantiles of foreign investor sentiment.

5.3.2. Impact of foreign individual and institutional investors' sentiment on the Japan green bond market

The E-GARCH estimation of how the sentiment of foreign individual and institutional investors affects Japan's green bond market performance is shown in Table 5.

Table 5: Impact of foreign individual and institutional investors' sentiment on the Japan green bond market

From	Individual investor sentiment				Institutional investor sentiment			
	Constant	Coefficients	LLF	AIC	Constant	Coefficients	LLF	AIC
China	-4.6256***	0.8561***	-4037.9	10.363	-2.5974***	-0.0133	-4037.2	10.3617
	(0.6032)	(0.2673)			(0.3337)	(0.1789)		
U. S	-2.7564***	-0.0497	-4037.1	10.361	-2.8984***	-0.0241	-3933.1	10.095
	(0.2070)	(0.0607)			(1.0520)	(0.4457)		
EU	-2.8002**	0.0642	-3933.5	10.096	-2.3139***	0.1921	-4037.8	10.363
	(1.2273)	(0.5103)			(0.2508)	(0.1187)		

Notes: This table reports the impact of individual and institutional sentiment of foreign countries on Japanese green bond return. ***, and ** denote 1%, and 5% significance levels respectively.

As revealed by the estimated parameters in Table 5, only the Chinese individual investor sentiment yields a positive and significant impact on Japanese green bond returns. Other sentiment indicators show nonsignificant and mild effects on its bond returns. These results indicate the relatively high independence of Japanese green bond market performance, which is only affected by the sentiment of its neighbours' individual investors.

The varied impacts of sentiment of foreign individual and institutional investors on the Japanese green bond market across different quantiles of bond returns and sentiment indices are reported in Figure 6.

Figure 6: Surface plot of QQ estimates on foreign investor sentiment and Japanese green bond market performance

Figure 6. a: China's individual and institutional investor sentiment on Japanese green bond

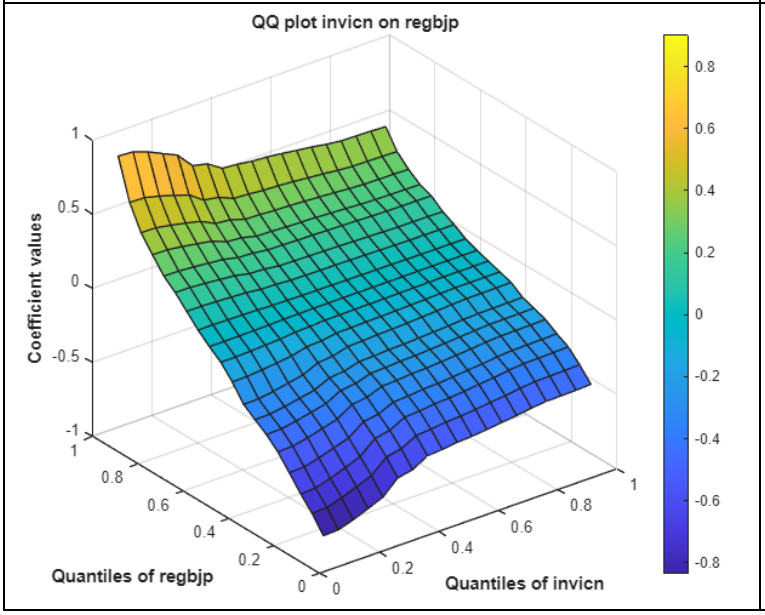
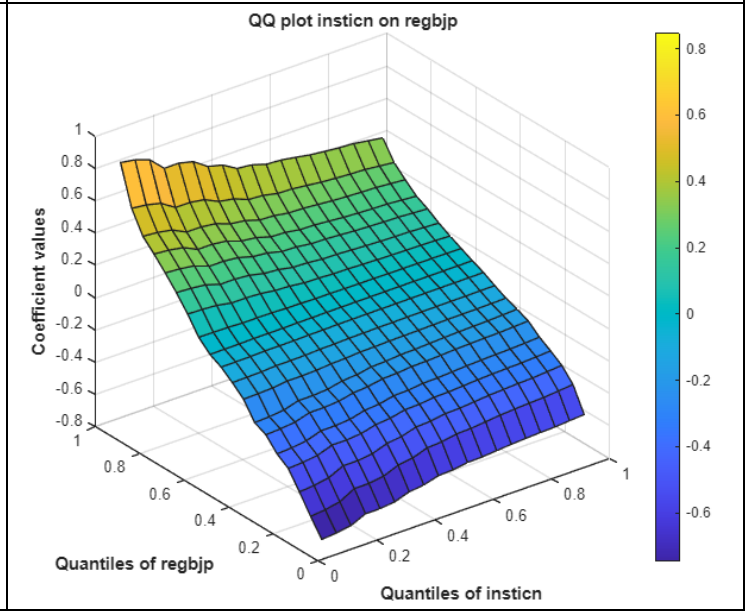
China's individual investor sentiment on the Japanese green bond return	China's institutional investor sentiment on Japanese green bond returns
	

Figure 6.b: The U.S individual and institutional investor sentiment on Japanese green bond

The U.S individual investor sentiment on the Japanese green bond return	The U.S institutional investor sentiment on the Japanese green bond return

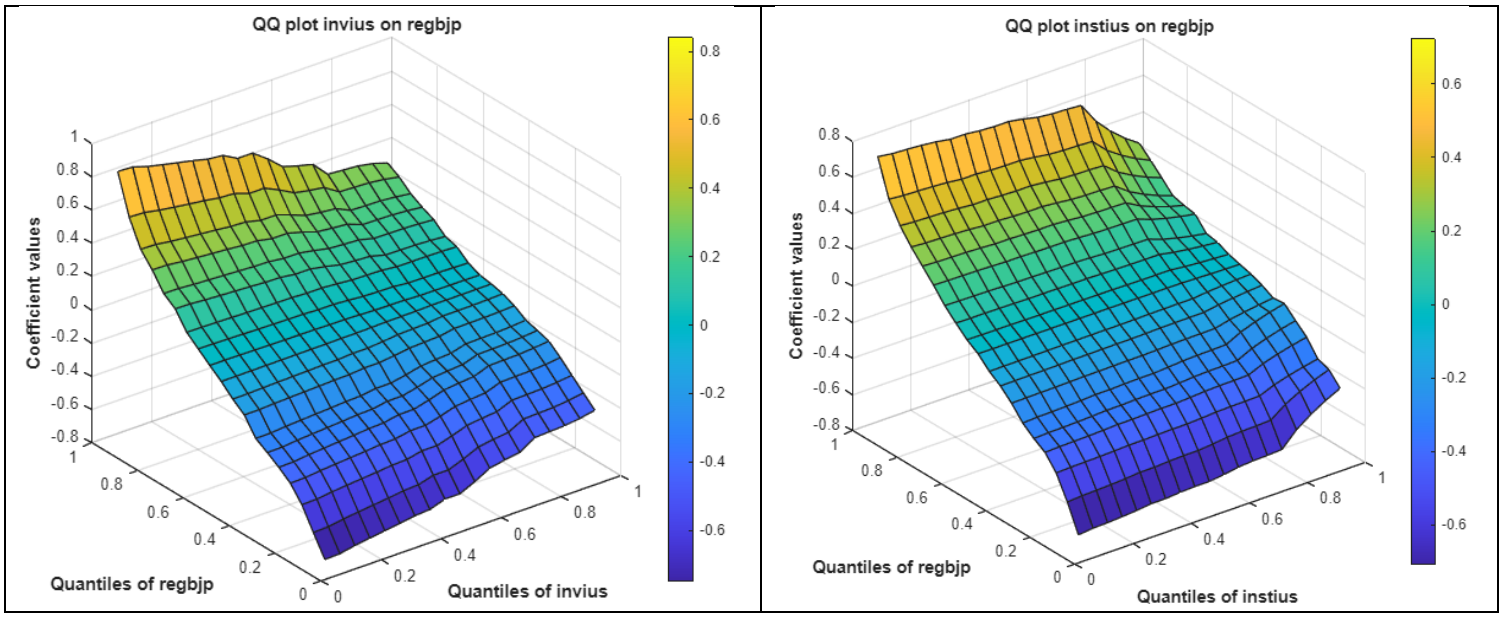
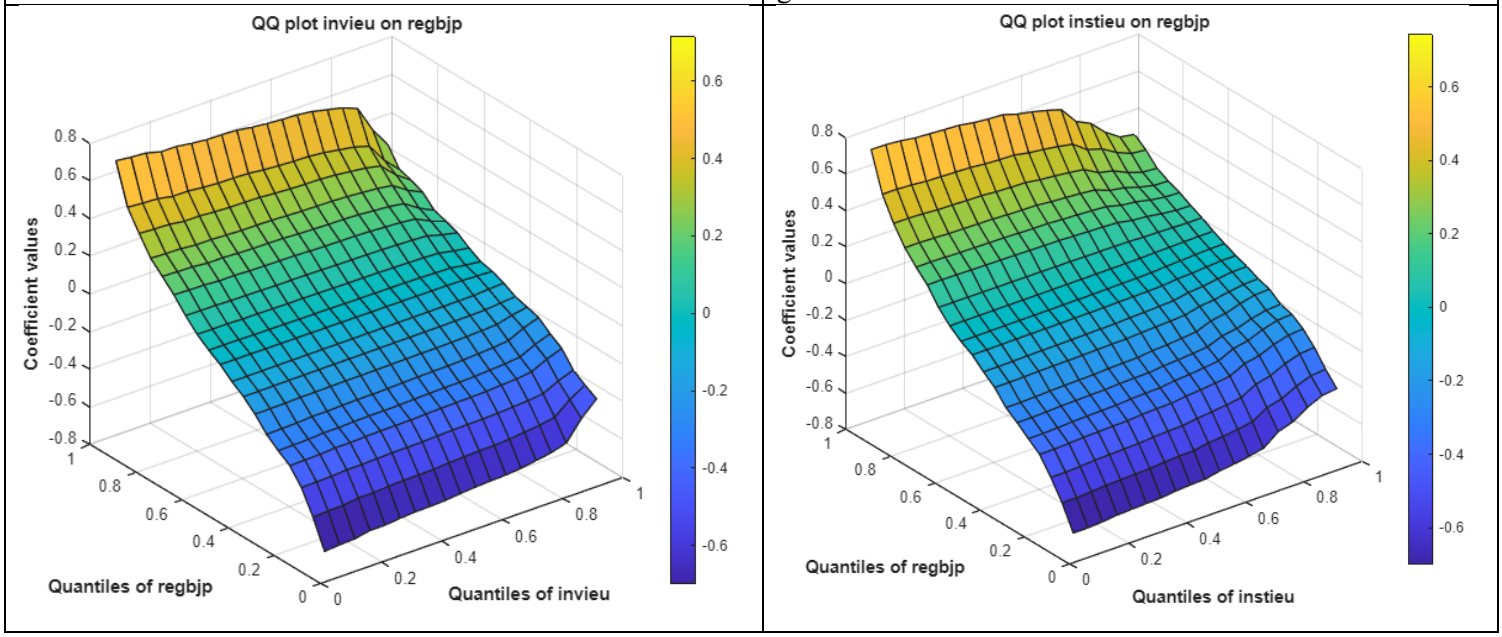


Figure 6.c: The EU's individual and institutional investor sentiment on Japanese green bond

The EU's individual investor sentiment on the Japanese green bond return	The EU's institutional investor sentiment on the Japanese green bond return



From Figures 6a, b, and c, we can see that the positive relationship between foreign investor sentiment and Japanese green bond returns is primarily observed in the upper quantiles of the bond returns. Unlike the pattern observed in the Chinese market, where the highest coefficients are concentrated in the upper quantiles of bond returns and spread across quantiles of foreign investor

sentiment, those in the Japanese market are concentrated in the upper quantiles of green bond returns but in the lower quantiles of sentiment.

5.3.3. Impact of foreign individual and institutional investors' sentiment on the U. S green bond market

Table 6 below presents the regression results from the E-GARCH model on the association between the investor sentiment of foreign individuals and institutions and the performance of the U.S. green bond market.

Table 6: Impact of foreign individual and institutional investors' sentiment on the U.S green bond market

From	Individual investor sentiment				Institutional investor sentiment			
	Constant	Coefficients	LLF	AIC	Constant	Coefficients	LLF	AIC
China	-3.4915***	1.5446***	-4336.3	11.127	0.3494	3.2236**	-4298.1	11.0295
	(0.3809)	(0.2224)			(0.3202)	(1.310)		
Japan	-1.6691***	0.8612***	-4332.4	11.117	-1.1328***	0.7921***	-4334.1	11.121
	(0.2574)	(0.1174)			(0.2343)	(0.2044)		
EU	-0.2410*	2.1024*	-4230.0	10.857	0.1357*	0.3610***	-4334.1	11.122
	(0.1249)	(1.1021)			(0.0807)	(0.1195)		

Notes: This table reports the impact of individual and institutional sentiment of foreign countries on the U.S green bond return. *, **, and *** denote 10%, 5%, and 1% significance levels respectively.

The higher coefficients shown in Table 6, compared to other green bond markets, suggest that foreign investor sentiment indicators have a greater impact on the performance of the U.S. green bond market. Regarding the sentiment of foreign individual investors, those from the EU have the most significant impact, with a 1 per cent increase in the sentiment index linked to a 2.1 per cent rise in the U.S. green bond index return, followed by China with a 1.5 per cent increase. In the context of institutional investor sentiment, that of China has the greatest impact, with a 1 per cent rise in its institutional investor sentiment being associated with up to a 3.2 per cent improvement in the U.S. green bond market performance.

Figure 7 presents the surface plots used by the QQ model to clarify further the relationship between the dependent and independent variables at different distribution levels.

Figure 7: Surface plot of QQ estimates on foreign investor sentiment and the U.S green bond market performance

Figure 7. a: China's individual and institutional investor sentiment on the U.S green bond

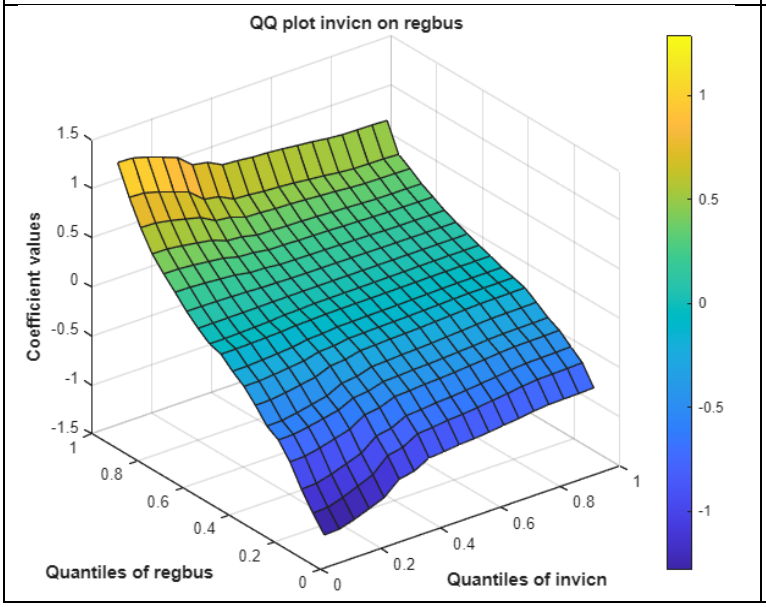
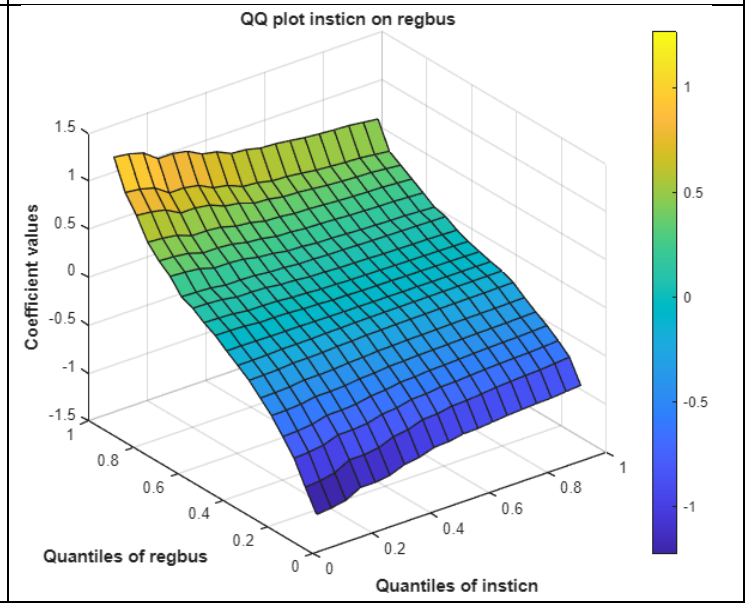
China's individual investor sentiment on the U.S green bond return	China's institutional investor sentiment on the U.S green bond return
	

Figure 7.b: Japan's individual and institutional investor sentiment on the U.S green bond

Japan's individual investor sentiment on the U.S green bond return	Japan's institutional investor sentiment on the U.S green bond return

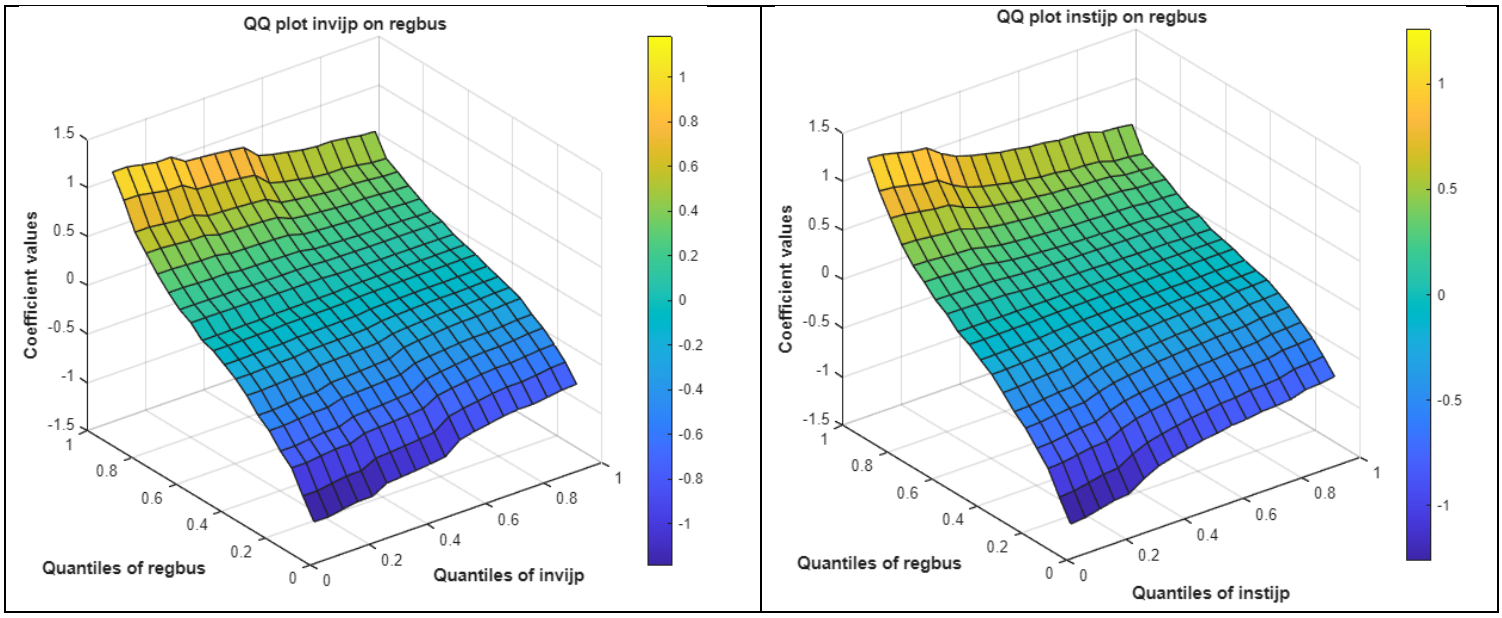
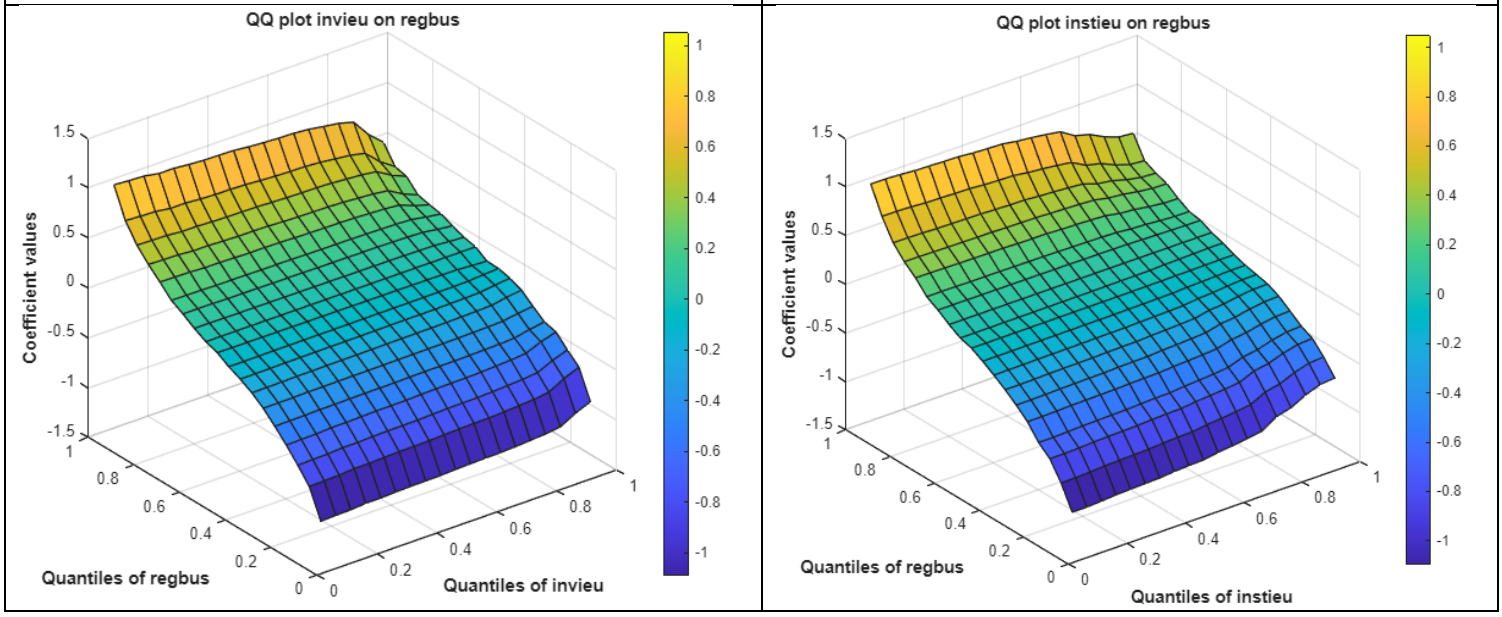


Figure 7.c: The EU's individual and institutional investor sentiment on the U.S green bond

The EU's individual investor sentiment on the U.S green bond return	The EU's institutional investor sentiment on the U.S green bond return



Figures 7. a, b, and c indicate diversified effects of foreign investor sentiment on the U.S green bond return. Specifically, the positive impact of this association is observed in the medium and upper quantiles of the bond returns, spread across the quantiles of the sentiment index of foreign

individual and institutional investors. Like the Japanese green bond market, in the U.S market, the highest coefficients are central to the upper quantiles of the bond returns and lower quantiles of the investor sentiment.

5.3.4. Impact of foreign individual and institutional investors' sentiment on the EU green bond market

Table 7 presents the estimated coefficients from an E-GARCH regression on the effects of sentiment indices and foreign individual and institutional investors on the performance of the EU green bond market.

Table 7: Impact of foreign individual and institutional investors' sentiment on the EU green bond market

From	Individual investor sentiment				Institutional investor sentiment			
	Constant	Coefficients	LLF	AIC	Constant	Coefficients	LLF	AIC
China	-3.2835***	1.2376***	-4049.6	10.393	-9.8016***	0.3817**	-4065.8	10.437
	(0.6189)	(0.2356)			(1.0951)	(0.1905)		
Japan	-1.7495***	0.7760***	-4049.0	10.392	-2.0212***	0.6261***	-4049.1	10.392
	(0.2483)	(0.1693)			(0.3471)	(0.2083)		
U. S	-2.3957***	0.4623**	-4049.9	10.394	2.8399**	0.9517**	-3927.2	10.079
	(0.2794)	(0.2039)			(1.2252)	(0.4788)		

Notes: This table reports the impact of individual and institutional sentiment of foreign countries on the European green bond return. ** and *** denote 1% and 5% significance levels, respectively.

The slope coefficients in Table 7 indicate that the sentiment of Chinese individual investors has a significant impact on the returns of green bonds in the EU. Accordingly, a 1 per cent increase in the sentiment index of Chinese individual investors raises the EU green bond returns by 1.23 per cent, followed by that of Japan with 0.77 per cent. Regarding foreign institutional investor sentiment, that of the U.S. has the most significant effect on the EU green bond market performance, increasing the return by 0.97 per cent for every 1 per cent rise in the sentiment index of U.S. institutional investors.

To clarify this nexus at different quantiles of foreign sentiment indices and the EU green bond market returns, we provide the surface plots using QQ regression in Figure 8.

Figure 8: Surface plot of QQ estimates on foreign investor sentiment and the EU green bond market performance

Figure 8. a: China's individual and institutional investor sentiment on the EU green bond

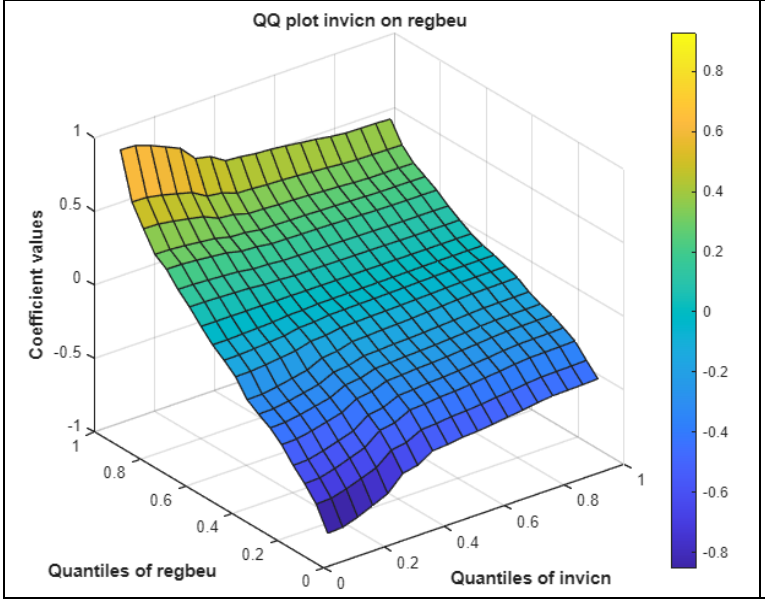
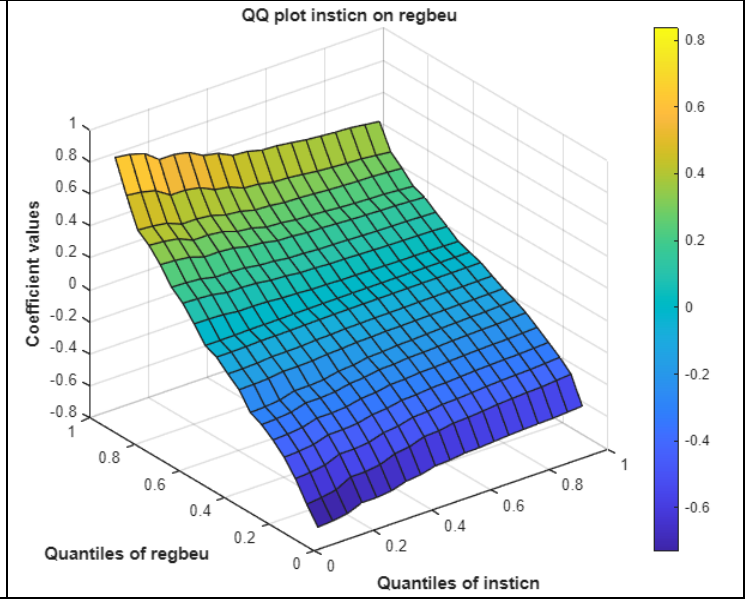
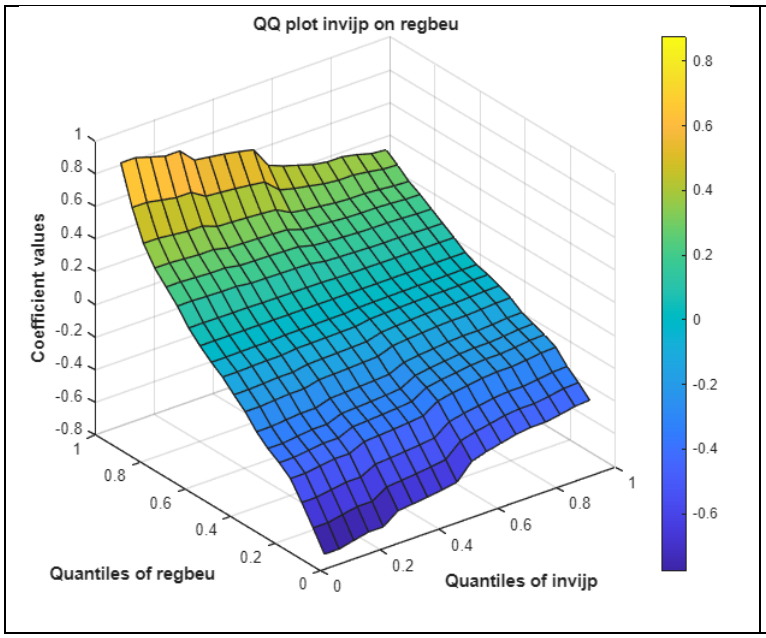
China's individual investor sentiment on the EU green bond return	China's institutional investor sentiment on the EU green bond return
	

Figure 8.b: Japan's individual and institutional investor sentiment on the EU green bond

Japan's individual investor sentiment on the EU green bond return	Japan's institutional investor sentiment on the EU green bond return



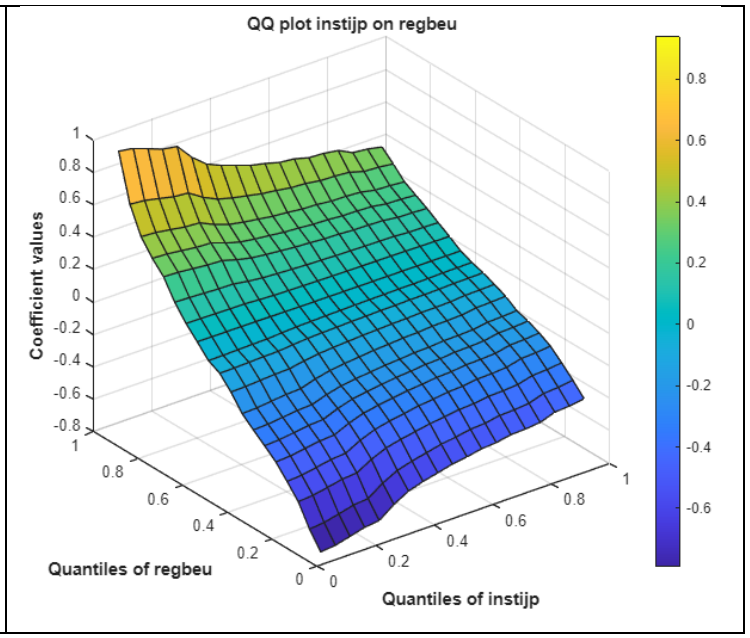
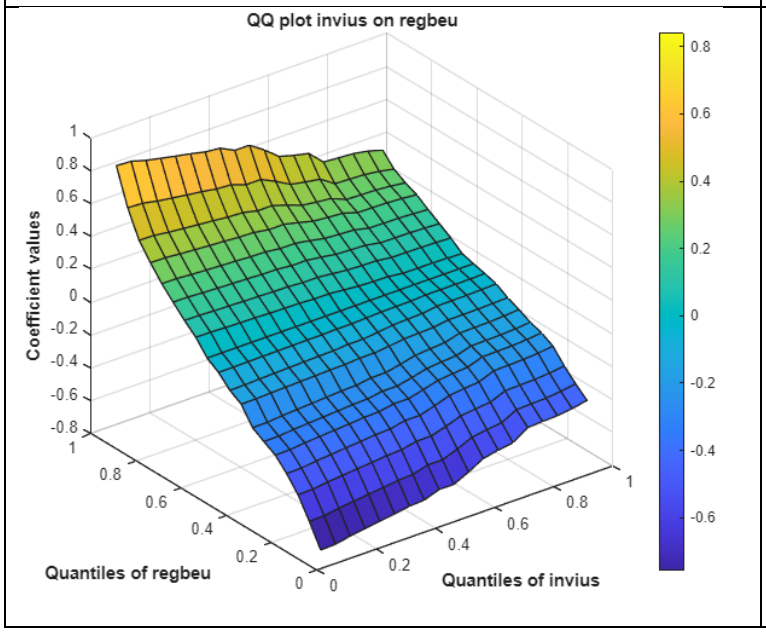
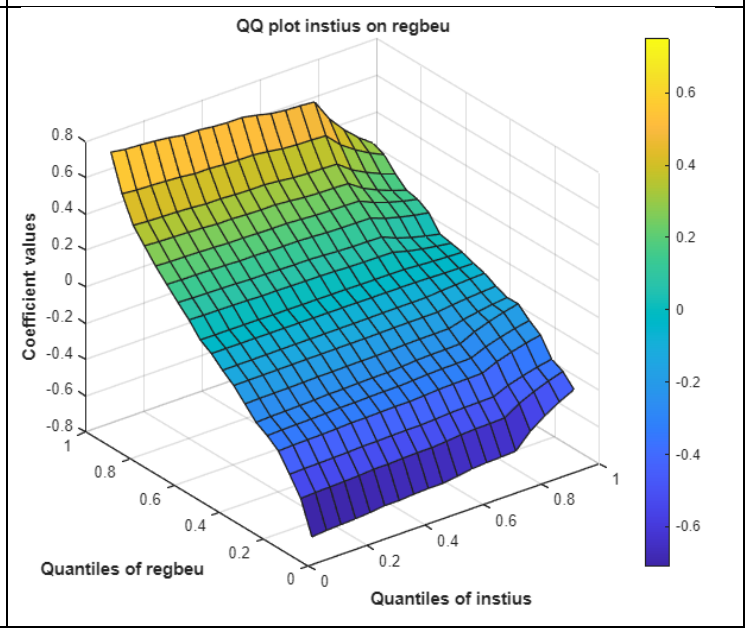


Figure 8.c: The U.S's individual and institutional investor sentiment on the EU green bond

The U.S individual investor sentiment on the EU green bond return	The U.S institutional investor sentiment on the EU green bond return





The QQ surface plots in Figure 8. a, b, and c show a similar pattern to the U.S green bond market. Accordingly, the positive impact of the sentiment of foreign individual and institutional investors on the EU green bond market performance lies in the medium and upper quantiles of the bond returns. Additionally, the highest coefficients of the relationship are concentrated in the upper

quantiles of the bond returns, but in the lower quantiles of the foreign investor sentiment indices. Additionally, the highest coefficients of the relationship are concentrated in the upper quantiles of the bond returns, but in a lower quantile of the foreign investor's sentiment indices.

6.0 Robustness check

In our research, there is a mismatch of data frequency between dependent and independent variables. Specifically, the data frequency of green bond return is daily while that of sentiment index is monthly. In previous empirical section, we apply linear interpolation to the monthly Sentix sentiment data, following the methodology of (Bethke et al., 2017; Wang & Duxbury, 2021). In this section, we employ the GARCH-MIDAS model as a robustness test to see if our research findings are still consistent.

The GARCH- MIDAS model developed by Engle et al., 2013 is widely used to address the common data frequency mismatch between variables. It is superior in smoothing out the genuine dynamics of our direct investor sentiment variable. Additionally, the mixed-frequency integration of this approach means that we do not need to interpolate our monthly data of sentiment index. The most significant importance of this integration is helping our research to restore the native essence of this data (Zheng et al., 2025). Notably, because it incorporates the GARCH component based on daily bond returns, and the MIDAS polynomial links macroeconomic variables to the long-term component (Engle et al., 2013). Therefore, it can capture both short-term and long-term volatility.

In the original GARCH- MIDAS mode, we have:

$$regb_{i,t} = \mu_i + \sqrt{m_{i,\tau} g_{i,t}} \times \zeta_{i,t} \quad (11)$$

Where $\zeta_{i,t} \mid \Omega_{t-1} \sim N(0,1)$ with Ω_{t-1} is the available information on day *i-1;* $g_{i,t}$ is the short-term component; $m_{i,t}$ is the long-term component; μ_t is unconditional mean. The short-term factor $g_{i,t}$ follows the GARCH (1,1) model as:

$$g_{i,t} = (1-\alpha_i-\beta_i) + \alpha_i \times \frac{(regb_{i-1,t}-\mu)^2}{m_{i,\tau}} + \beta_i g_{i-1,t} \quad (12)$$

Where α and β are ARCH and GARCH components, respectively, with $\alpha_i > 0$, $\beta_i > 0$, and $\alpha + \beta < 1$.

Regarding the long-term factor, $m_{i,t}$ it is a varying function of the exogenous variable, which is investor sentiment in our research as follows:

$$\log(m_{i,t}) = m_v + \theta_v \sum_{k=1}^{K_v} \varphi_k(w_v) sent_{t-k} \quad (13)$$

Where $\varphi_k(w_v)$ is the beta weights, defined as:

$$\varphi_k(w_v^i = \frac{(1-\frac{k}{K_1})^{w_v^i-1}}{\sum_{j=1}^{K_v}(1-\frac{j}{K_v})^{w_v^i-1}}, \forall k = 1,...,K_v \quad (14)$$

Again, we individually estimate the GARCH- MIDAS model for each market and investor sentiment measure. Following Engle et al., 2013, we set the lag order of the low frequency variable, Sentix index, to be 12 months (one year).

Tables 8 report the regression results from the GARCH-MIDAS estimation for domestic markets.

Table 8: Impact of domestic investor sentiment on green bond performance using GARCH-MIDAS

Markets	Individual investor sentiment			Institutional investor sentiment		
	Coefficients	LLF	AIC	Coefficients	LLF	AIC
China	0.4102*	-168.84	0.6706	0.3415***	-1036.1	2.9930
	(0.2340)			(0.0454)		
Japan	0.9337**	15.663	-0.064	0.2886***	309.33	-0.8421
	(0.3929)			(0.4543)		
U. S	-0.1765***	369.69	-1.3896	-0.1584*	539.31	-1.6303
	(0.0573)			(0.0916)		
EU	0.2576**	344.13	-0.9645	0.4767***	211.04	-0.7501
	(0.1192)			(0.1034)		

Table 9: Impact of foreign investor sentiment on Chinese green bond performance using GARCH-MIDAS

From	Individual investor sentiment			Institutional investor sentiment		
	Coefficients	LLF	AIC	Coefficients	LLF	AIC
Japan	0.6773***	-945.26	2.7324	0.1862*	-827.92	3.1989
	(0.0548)			(0.1088)		
U. S	0.2773***	-808.58	3.1248	1.4417***	-865.51	2.5036

	(0.0879)			(0.1894)		
EU	0.4298**	-793.85	3.0683	0.0907**	-1073.3	3.0970
	(0.1961)			(0.0505)		

Table 10: Impact of foreign investor sentiment on Japanese green bond performance using GARCH-MIDAS

From	Individual investor sentiment			Institutional investor sentiment		
	Coefficients	LLF	AIC	Coefficients	LLF	AIC
China	0.2703***	318.74	-0.8655	-0.6959	120.40	-0.4383
	(0.0496)			(0.5262)		
U. S	-0.1479	117.44	-0.4231	-0.1295	117.64	-0.4239
	(0.1003)			(0.1618)		
EU	0.2261	133.50	-0.4846	0.1688	144.16	-0.5255
	(0.1988)			(7.0824)		

Table 11: Impact of foreign investor sentiment on the U.S green bond performance using GARCH-MIDAS

From	Individual investor sentiment			Institutional investor sentiment		
	Coefficients	LLF	AIC	Coefficients	LLF	AIC
China	0.2057*	378.01	-1.4215	1.5470*	198.41	-1.2485
	(0.1249)			(0.8097)		
Japan	0.1675*	540.83	-1.6381	0.1315***	192.92	-1.2191
	(0.0881)			(0.0405)		
EU	0.1438***	192.58	-1.2235	0.1536***	190.65	-1.2042
	(0.0451)			(0.0466)		

Table 12: Impact of foreign investor sentiment on the EU green bond performance using GARCH-MIDAS

From	Individual investor sentiment			Institutional investor sentiment		
	Coefficients	LLF	AIC	Coefficients	LLF	AIC
China	0.1025*	42.119	-0.2018	0.0802*	43.307	-0.2029
	(0.4607)			(0.0736)		
Japan	0.0336*	198.03	-0.6273	0.0585*	212.44	-0.6714
	(0.1494)			(0.2703)		
The U.S.	0.0823*	269.28	-0.7526	0.0586*	193.72	-0.6131
	(0.0614)			(0.0502)		

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7.0 Results discussion

Based on the findings presented in the previous section, this section discusses our research results. We first provide a discussion about the role of sentiment of individual and institutional investors in

domestic green bond market performance, followed by this role in the foreign green bond market context.

7.1. The impact of domestic individual and institutional investors' sentiment on the green bond market

The coefficients estimated from the E-GARCH model, reported in Table 3, show a significant and varied impact of the sentiment of domestic individual and institutional investors on green bond markets across China, Japan, the U.S., and the EU.

It reveals that in Asian markets, the sentiment of institutional investors has a greater impact on the performance of the green bond market than that of individual investor sentiment. These findings are also consistent with previous literature highlighting the outperformance of institutional investors as compared to individual ones in predicting asset prices (Gao et al., 2021). In addition to the advantages of institutional investors in accessing larger pools of capital, better information, greater resources and more time for in-depth analysis, these findings can result from the fact that in China and Japan, governments strongly encourage institutional investors to engage more in green finance. Thus, their large trading volume in green bond markets may have a more significant impact on the performance of the green bond market than that of individual investors. Moreover, as these green bond markets are still in development, it is not easy for retail investors to trade green bonds like those in advanced green bond markets.

In contrast to the Asian green bond markets, the performance of the Western green bond market (including the U.S. and EU) is dominated by the sentiment of individual investors, particularly in the EU, with the coefficient of its individual investors' sentiment nearly five times higher than that of its institutional investors. These findings highlight the disparities in environmental awareness and the evolution of the green bond market. On the one hand, in countries like the U.S and the EU, people exhibit strong pro-environmental norms, which induce them to engage proactively in ethical investment strategies. On the other hand, the financial markets in these economies witness higher levels of development and integration; green financial products, such as green bonds, may be more accessible to retail investors than in Asian countries. As a result, their sentiment has a greater impact on the returns of green bonds.

It is noteworthy that among the four green bond markets, the U.S. reports a negative nexus between its green bond returns and the sentiment of both investor types. The negative relationship may reflect a behavioural dynamic in which increased optimism and sentimental alignment among investor groups lead to portfolio rebalancing, with investors reallocating funds from green bonds to assets perceived as offering higher returns or lower risk. This behaviour underscores the complexity of sentiment-driven investment decisions in mature and highly liquid markets, such as the U.S.

In our surface plots based on QQ regression in Figures 1-4, we find that the role of domestic individual and institutional investors' sentiment varies across different sentiment distribution levels and green bond indices in the four markets. Although the specific results are unique to the green bond market, we identify a similar pattern: the positive impact is central to the medium and upper quantiles of the bond returns, while being widely distributed across all quantiles of the investor sentiment. Interestingly, the greatest effects are concentrated in the upper quantiles of the bond returns, but in the lower quantiles of the sentiment indicators. This means that the most pronounced impact occurs when both types of investors are pessimistic (in lower sentiment quantiles), and green bonds offer good returns (in upper return quantiles). Two main reasons may explain this finding. On the one hand, at lower quantiles of the sentiment index, investors are already pessimistic about the performance of green bond markets. If the returns are high (reflected by upper quantiles of the bond returns), it creates a contrarian surprise effect on investors. Thus, this may trigger intense buying pressure, leading to significant price adjustments in the green bond markets, as investors perceive that they may be undervaluing these bonds. On the other hand, at the upper quantiles of green bond returns, the green bond markets are already performing well. Therefore, a signal of good market performance may induce investors to engage strongly in green bond investment, thereby magnifying the effects of investors' sentiment on the green bond market performance. These findings suggest a non-linear and asymmetric relationship between investor sentiment and the performance of the green bond market.

7.2. The impact of foreign individual and institutional investors' sentiment on the green bond market

The roles of sentiment of foreign individual and institutional investors in green bond returns vary across green bond markets, as reported in Tables 4-7. These effects also vary at different quantiles of both dependent and independent variables, as shown by the QQ surface plots in Figures 5-8. We

observe four patterns in the findings of the relationship between the sentiment of two investor groups and the green bond returns of China, Japan, the U.S., and the EU.

First, China's green bond market performance is the most impacted by the sentiment of Western investors, especially individual investors. These effects are nearly double those cast by the sentiment of its local individual and institutional investors. While the Chinese green bond market is relatively closed to foreign investors compared to developed financial markets, this finding may result from the fact that U.S. and EU investors majorly purchase Chinese green bonds, particularly those issued offshore. As a result, their sentiment drives cross-border demand and impacts the performance of their green bond market.

Second, Japan's green bond returns reveal the highest level of independence from foreign investor sentiment. It is significantly affected by the sentiment of Chinese individual investors, which is easily understandable because China's retail investors are numerous and it is the country's closest neighbour to Japan. Otherwise, neither the sentiment of the two investor groups yields a significant effect on Japanese green bond returns. This result may stem from the strongly domestic-oriented nature of the Japanese green bond market, where most green bond issuance and trading occur onshore in local currency. Moreover, its green bond market has low penetration among foreign investors, and domestic investors are dominant due to their long-term and conservative investment attitudes. Hence, it limits the sentiment spillover from foreign investors.

Third, as compared to other green bond markets, the U.S is the most affected by foreign individuals and institutional investors' sentiment, reflected by their higher estimated coefficients in the E-GARCH model. While the sentiment of its local investors has a negative impact on its green bond returns, the sentiment of all foreign investors plays a positive and significant role in boosting its green bond market performance, particularly the sentiment of EU individual investors and Chinese institutional investors. These findings also indicate a relatively high dependence of the U.S. green bond market's performance on the sentiment of foreign retail and institutional investors. However, the results are readily understandable because the U.S green bond market is highly developed and market-oriented. Thus, it attracts more foreign investors, whose sentiment has a significant impact on its market.

Fourth, in comparison with Asian green bond markets, those of Western countries, such as the U.S. and the EU, are significantly influenced by the sentiment of foreign investors, as reflected by the

higher values of the slope coefficients reported in Tables 4-7. These findings are also consistent with the fact that green bond markets of these economies are more efficiently operated; therefore, green financial tools like green bonds are easily accessible to both foreign individual and institutional investors. Furthermore, their green bond markets demonstrate a high level of integration, allowing for greater penetration by foreign investors. As a result, the sentiment of foreign investors can be transmitted to their bond returns.

8.0 Conclusion and implications

Although the existing literature sheds light on the impact of general investor sentiment on green bond market performance, how this effect is manifested in the context of sentiment division among different investor groups remains underexplored. The previous research also recognises the existence of distinct sentiment patterns across individual and institutional investors. Therefore, this study aims to identify and analyse the role of sentiment of individual and institutional investors in improving green bond market performance.

Due to the constraints imposed by data availability of investor sentiment indicators, we conduct our research in four green bond markets: China, Japan, the U.S., and the EU, for the period from January 3, 2022, to December 31, 2024. The aforementioned relationships are evaluated using the EGARCH model to estimate average effects and the QQ regression to capture the results, considering the distributional dynamics of both dependent and independent variables.

Our research findings are threefold. First, based on E-GARCH regression coefficients, we observe a significant impact of domestic investors' sentiment on boosting green bond returns across all markets, with institutional investor sentiment prevailing in Asian countries and individual investor sentiment in Western green bond markets. Our surface plots, drawn from the QQ model, reveal the varied impact of domestic investors' sentiment on green bond returns across quantiles of the bond return and sentiment indices. Importantly, the most potent effects are in the upper quantiles of the bond returns and lower quantities of sentiment. Second, in examining the role of foreign investors' sentiment in the performance of the green bond market, we obtain interesting results. On the one hand, the Asian green bond market's return, as proxied by the Chinese green bond index, is more influenced by the sentiment of Western countries' individual investors than that of its local investors. In contrast, Japan exhibits a high level of independence from foreign factors, except for the sentiment of Chinese individual investors. On the other hand, the performance of the Western green

bond market is more sensitive to the sentiment of both foreign individual and institutional investors, especially the U.S. Finally, although the QQ regression results report that the said effects vary across different distribution levels of variables, they share the same patterns with those in domestic concerns. Accordingly, the positive impact is central to the medium and upper quantiles of the bond return but spread across quantiles of the sentiment indicators. Notably, the most pronounced effects are concentrated in the upper quantiles of bond returns, but in the lower quantiles of both individual and institutional investors' sentiment. These findings suggest a non-linear and asymmetric relationship between investor sentiment and the performance of the green bond market.

Our research findings bring important policy implications to green bond market regulators. First, recognising the importance of investor sentiment in enhancing green bond market performance, policymakers should incorporate factors such as investors' psychology into frameworks for developing green bond markets and assessing market performance. Second, in Asian markets, including China and Japan, the sentiment of institutional investors yields a greater impact, while the sentiment of individual investors dominates in Western markets. Thus, green bond market regulators in different economies should have appropriate policies to attract investors and develop green finance instruments to achieve the most efficient operation of the green bond market. Third, understanding the significant role of sentiment among foreign individual and institutional investors adds another lens for regulators to develop their green bond markets. For instance, the return on Japanese green bonds is indifferent to the sentiment of foreign investors (except for that of Chinese individual investors); hence, the Japanese government may be satisfied with its stable green bond market, but with low penetration among foreign investors, which reduces the opportunity to increase trading volume and fund scale for its green projects. The U.S is another important example. Specifically, its green bond market performance is most affected by the sentiment of foreign investors, particularly that of Chinese institutional investors and EU individual investors. Therefore, the U.S government may achieve a more dynamic green bond market, but it also faces the risk transmissions from external factors like foreign investors, especially in turbulent periods. Therefore, when developing policy to enhance green bond markets, regulators should seriously consider the non-trivial aspect of foreign investor sentiment. Lastly, the association between investor sentiment and green bond market performance is non-linear and asymmetric, with the most potent effects observed in higher bond returns and lower sentiment indices. Hence, policymakers

should ensure a harmonised combination of green bond return and sentiment levels to avoid sudden and considerable adjustments in bond values.

Our results also offer valuable implications for green bond investors. First, although the sentiment of both investor groups has a significant impact on green bond performance, the effects vary for different types of investors. For instance, the sentiment of institutional investors has a greater impact on bond performance than that of individual investors. Therefore, to price a green bond, investors should consider the psychology of their counterparts. Second, among the four markets, the U.S. green bond market's performance has a negative relationship with investor sentiment, and the sentiment of the two investor groups shares a relatively equal impact. Thus, investors there may take an investment relocation into account when pricing U.S. green bonds. Third, in rebalancing green investment by forming an international portfolio, investors should consider the role of foreign investor sentiment to deliver optimal decision-making. For example, knowing that the Japanese green bond market is highly independent of external factors, investors can consider the green bond market as a stable source of diversification. Meanwhile, the U.S. green bond market is susceptible to the sentiment of foreign investors; therefore, investors should exercise caution when making green investments here, especially in uncertain times.

While this study offers meaningful insights and practical recommendations for green bond regulators and investors, it has limitations. First, although widely accepted proxies for individual and institutional investor sentiment are employed to construct sentiment contagion indicators, these measures may not fully capture the nuanced psychological and behavioural dimensions specific to socially responsible investing, such as green bonds. This underscores the need for future research to develop standardised sentiment metrics tailored to the context of green finance. Second, data availability imposes constraints on the analysis's temporal and geographic scope. For example, Japan's green bond index data is only available from October 2021 onward, limiting our ability to examine sentiment contagion effects during earlier periods of market stress, such as the COVID-19 pandemic. Additionally, the limited availability of sentiment data across investor groups restricts the inclusion of other regions or country-level analyses. As green bond markets evolve and data coverage improves, future studies will be better positioned to explore these dimensions in greater depth, thereby enriching the understanding of sentiment dynamics across diverse market environments.

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