

DEPENDENCE STRUCTURE BETWEEN GREEN BOND MARKETS AND WORLD FINANCIAL MARKETS

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Abstract

As a response to the urgent challenges posed by climate change, green bonds are becoming increasingly significant tools for financing environmentally friendly projects. The daily returns from the stock and bond markets used for the chosen stock markets. Through analytical techniques, including the use of copula software, the research seeks to understand how financial markets and green bonds interact. This research aims to provide sage advice to potential investors who want to strike a balance between profitability and ethical business practices. This research shows advance knowledge of these dynamics by evaluating the complex interplay in comparison to GB and financial markets in emerging economies. This study used cupola techniques.

Keywords: Green Bond, Emerging Countries, World Financial Markets, Financial Markets

BACKGROUND OF THE STUDY

The debt instruments known, as "green bonds" are those that used to finance project, which are favorable to environment in order to lessen the negative effects of economic activity on the climate. As a brand-new source of funding, green bonds are emerging quickly. Climate change is a grave environmental threat that has affected the environment all over the world. With the threat posed by climate change looming large, numerous initiatives have launched over the past few years to increase awareness. Among them, promoting the use of this effort is crucial for reducing carbon footprints and discouraging the use of fossil fuels (Taghizadeh-Hesary and Yoshino, 2020; Anus et al., 2025; Martin, 2025). Redirecting funding to programs that support environment friendly while reducing waste of carbon was the primary objective of the Paris Agreement. The transition away from using carbon as a fuel has made economic systems require massive investments to finance environmentally favourable tasks (Tiron-Tudor et al. 2021; Audi et al., 2025; Qasir & Agha, 2025). A French pledge and the United Nation,s (SDGs)'s climate targets must be met by investing enormous possibilities to make environment friendly (Reboredo and Ugolini, 2020; Jawad & Hu, 2025).

Based on King et al. A total of \$1.79 trillion in bonds have issued in GB Stock as of 2021, representing 1% of the total bond market. According to CBI (2022), there were investments totaling \$145.6 billion in 2022 alone, and the the GB share has increased to over 1.795 trillion USD. The EU Institution provided the first GB instrument approx. 2007, and World Bank invested later in 2008. An important development for the advancement of sustainable financing was the European Green Deal. By 2050, the EU wants to have a carbon-neutral economy, so this agreement aimed to make the EU a just, sustainable, and prosperous society.

In order to promote green bonds, the European Union (EU) has repeatedly launched a number of initiatives. The "EU Green Bonds Standards" stood out among them because it focused in improvement of making transparent market while also encouraging the issuance of green bonds to boost investor confidence. Among them, the "EU Green Bonds Standards" stood out because it sought to increase the green market's transparency and standardization while also promoting the way of green instrument to increase investor confidence.

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According to Flamer (2020), Huynh et al., (2020), Pham (2016), Marc et al., (2025), and Mehdi et al., (2025), the dynamics of the markets are impact by a common volatility factor, which also slows down the financial markets' ability to process information quickly. Financial asset returns are impact by this volatility or

uncertainty. A number of studies on green finance have been conducted in recent years with the aim of determining the volatility spillover between the green bond market and conventional market. Most green bond issuing agencies are private agencies like the World Bank and European Investment Bank, public and private corporations, and local and federal governments. The European Commission (2016) and Reboredo and Ugolini (2020) report that in 2015, green bond issuances accounted for 45.8%, 19.6%, 13.4%, 9.3%, and 5.6% of total issuances, respectively, and that the proceeds from these issuances were used to finance projects that met the criteria for renewable energy, energy efficiency, low-carbon transportation, sustainable water, waste, and pollution. Green bonds are more likely to be enticing financial instruments for these investors since they share many characteristics with conventional bonds. In addition to this, a number of empirical studies demonstrated how green bonds could be a useful tool for investors and portfolio managers to diversify their holdings (Huynh et al., 2020; Marc et al., 2025; Chowdhury & Hassan, 2025).

The impact of green bonds on financial markets is not well-understood topic, especially in developing countries. Recently, Nguyen et al. (2021) looked at movements between GB and other asset classes and found strong movements between stocks, clean energy and commodities. However, GB has a low to negative correlation with equities and commodities, indicating the diversification benefits of GBP. Absent from the study is an examination of how green bonds relate to the economies of emerging market economies in the European region. This study aims to fill this gap by examining how green bonds relate to the financial markets of the four main emerging economies in Europe, namely London Stock, Milan, Madrid, and Netherlands. There have been many studies on green bonds, but they do not agree on the results. Furthermore, while China's experience with green bonds is well studied, it may not apply to emerging market economies because they define green finance differently. This creates a big gap in what we know. The aim is to clarify these uncertainties by focusing on how green bonds and financial markets work together in developing countries.

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The purpose of the research is also to find out the dependence structure of the green bond market and the world financial markets. The purpose of the study is to provide comprehensive advice to investors who want to diversify their portfolios and benefit from sustainable financial instruments by analyzing the dependency structure. The scope of the dependency structure of green bonds in the world financial market is significant for understanding the relationships and interdependencies within this sector. It aids in risk assessment, market stability evaluation, and the advancement of sustainable finance. By comprehending these dependencies, we can foster a more resilient and sustainable global financial system.

LITERATURE REVIEW

THEORETICAL LITERATURE

The Theory was used is portfolio theory because in that theory researcher guide the investor that whether he should invest in GB or other emerging economies based on our research specifically.

EMPIRICAL LITERATURE

Naeem et al. (2021) looked at the interactions between the GBs and other classes of commodity assets, such as energy markets (crude oil and natural gas), agricultural commodities (wheat and corn), and precious metals (gold and silver). The results of the study showed that, regardless of the periods, there was a stronger spillover between GBs and the commodities of the same asset class, gold and silver. In the aforementioned literary strands, it has examined how GBs relate to other conventional assets like equity, conventional bonds, the energy market, and commodity markets. The studies also pay attention to how Islamic stock markets interact with other forms of money. Nevertheless, little research has been done on the connection between GBs and Islamic financial instruments. Our research primarily focuses on exposing opportunities for portfolio diversification for environmentally conscious GB investors and investors inclined to invest in stocks created specifically in accordance with the principles of Shariah-based Islamic laws. In conclusion, the literature presents contradictory findings regarding the relationship, dependence pattern, and diversification advantages of GBs with various asset classes, necessitating further investigation. Exploring the benefits of portfolio diversification with GBs and other IFMs, such as conventional and Islamic equity and bond markets, is a crucial contribution of this study.

Green bonds have become a popular investment choice, with their issuance increasing by almost five times in the previous five years and forecast to reach \$1 trillion annually by 2030 (Banga, 2019; Ammar et al., 2025; Lee & Zhuang, 2025). Recent occurrences have caused the emphasis to shift from sustainability to economic or financial indicators. In the literature, green bonds are frequently discuss as a result.

Governments and international organizations are focusing more on the contribution that green bonds make to a healthy economy. Many countries are expect to include green bonds in their portfolios to address climate issues. There is a great deal of academic interest in green bonds as they are becoming more popular and well known. However, studies typically focus more on qualitative than on quantitative research because the sample is heterogeneous (Zhou and Cui, 2019; Batool et al., 2025; Carlo, 2025). Numerous researchers (Flaherty et al. 2017; Umair et al., 2025). On the other hand, a small number of studies have shown that using green bonds raises the price of certification and limits the kinds of projects that can be undertaken (Tolliver et al. 2020; Naeem et al., 2025). Tolliver et al. also point out difficulties in the production of green bonds. (2020) provided potential answers as well. The study suggested that the federal and local governments both issue green bonds, among other things. Multilateral development banks ought to be included in the production and acquisition of green bonds. Funds have started to be allocate by a number of governmental organizations, local governments, and international organizations to initiatives that address climate change (Zhou and Cui, 2019; Ali et al., 2025). In order to determine whether governments have been able to reap the benefits of investing in green bonds as anticipated, studies have examined a number of countries.

A few researchers have also made an effort to point out possible methods for lowering the price of green bonds. Agliardi and Agliardi., (2019) predict that lowering taxes, improving credit quality, and increasing public awareness of environmental issues lead to a rise in the issuance of green bonds. Li and others. In a related study, (2020) used China as the base country and found that CSR, credit rating, and green certification would lower the cost of issuing green bonds. Including Bachelet et al. The significance of independent verification was also emphasized by (2019) as a means of increasing the yield on green bonds current investigation by Russo et al. The performance of green bonds is influence by the financed project and issuer alignment, as demonstrated by (2021). Compared to institutional issuers, private issuers do not have a competitive advantage. It is intriguing how different people's perspectives on the premium and risk of green bonds can be. In their research on the effects of the financial crisis, academics have used co-movement.

According to Tolliver et al., national-level, institutional, and macroeconomic factors all have an impact on the issue of GB. 's (2020) examination of the green bonds issue by 49 countries. They drew a link between the French pledge objectives and sale of GB. as stated by Anh Tu et al. Similar research was done on developing economies by, (2020), who found that the legal system, interest rates, and economic stability were the main factors influencing The issue of GB. The issue of GB in China, where there is a sizable amount of green bond issuance, was largely influence by positive effects on stock prices, corporate social responsibility, and profitability (Zhou and Cui, 2019; Azizi et al., 2025; Longston et al., 2025).

Several studies (Claessens et al.) have found that the banking system, distance from the equator, openness to trade, size of the economy, level of corruption, and distance from the equator all have effected the stock market on national level. According to a few studies, the government's policies and investors' awareness of the environment play a significant role in whether or not green bonds are issued (Banga, 2019; Arshad et al., 2025).

ECONOMETRIC EQUATION

$$GB = \beta_0 + \beta_1 \cdot C(u_1, u_2, u_3, u_4, u_5; \theta) + \beta_2 \cdot BMSCIGB + \beta_3 \cdot SPDR + \epsilon$$

$$Stock_i = \alpha_i0 + \alpha_i1 \cdot C(u_1, u_2, u_3, u_4, u_5; \theta) + \alpha_i2 \cdot Stock_i + \epsilon_i$$

Here,

i represents each of the countries (London Stock, Milan, Madrid, and Neatherlands.).

$C(u_1, u_2, u_3, u_4, u_5; \theta)$ is the copula function representing the dependence structure.

$BMSCIGB$ and $SPDR$ are proxies for the green bond market.

$Stock_i$ represents the stock market index for country i .

$\beta_0, \beta_1, \beta_2, \beta_3, \epsilon$ are coefficients and an error term for the green bond market equation.

$\alpha_i0, \alpha_i1, \alpha_i2, \epsilon_i$ are coefficients and an error term for the stock market equation for each country.

RESEARCH HYPOTHESIS

H1: Does Dependence Structure have influenced Green bond Markets & Emerging economies i.e London Stock, Milan, Madrid, and Neatherlands.

MATERIALS AND METHODS

RESEARCH DESIGN

Examining the relationship between GB markets and global emerging markets is main goal of this study, which focuses on the developing economies of the European Union, including London Stock, Milan, Madrid, and

Netherlands.. Positivistic research approach chosen aims to find empirical relationships. We used deductive reasoning. The study used secondary data analysis and a quantitative research methodology.

POPULATION OF THE STUDY

The financial data of London Stock, Milan, Madrid, and Netherlands are included in the study's scope.

DATA SOURCES AND PROXIES

GREEN BOND PROXIES

The (BMSCIGB) and the S&P (SPDR) are two well-known proxies for the GB market that has been used in study. These indices are used to track market trends and performance for green bonds.

STOCK MARKET PROXIES

Specific stock market indices are used to represent the stock markets of the four developing European nations. The indices chosen are: London Stock Exchange, Madrid Stock Exchange, Milan Stock Exchange, Amsterdam Stock Exchange.

SAMPLE SIZE

The range of data is ten years (2012-2022) This period offered Verify the indices, the timing, and the long-term patterns in the GB & other emerging countries of the chosen countries first, and then download the data.

ANALYTICAL TECHNIQUE

The analytical framework of this study involves the use of the Copula technique. As R is used to run the copula methodology code. Assess the dependency structure of the GB & other emerging countries.

COPULA

Since determining the pattern of dependency between the markets and the Trade War is an aim of the research, the copula approach is the best way to measure the correlation between the markets and risk. More leeway in dealing with market risk and correlation is provided by the Copula model (Hsu et al., 2012).

One useful tool for gauging the interdependencies of financial assets is the product-moment coefficient, which may be used to calculate returns. In most cases, returns are not linear and might change over time; furthermore, they rarely follow a normal distribution. Given that prices spike in response to any economic shock, it is very difficult to simulate the co-movement.

A small number of studies have shown evidence of asymmetry when looking at both positive and negative market movements. Longin and Solnik (2001), Ang and Chen (2002), Boyer et al. (1999), Kolari et al. (2008), Longin and Solnik (2001), and Tastan (2006) all note that the tail distributions deviate from the normal distribution and are typically fatter. According to these findings, a dynamic conditional correlation model (DCC) might be a good way to deal with it. Nonetheless, the approach put out by Engle (2002) focuses only on the problem of time variation, disregarding any deviation from normalcy or very high or low values. According to (Nakatani and Terasvirta, 2009), moving beyond DCC Family Models to Copula is necessary for comprehensive comprehension.

COPULA MODELS FOR THE DEPENDENCE STRUCTURE

Initially, copula capabilities, which were initially suggested by Sklar (1959), have developed into a potent instrument for demonstrating the interconnectedness of atypical factors. Over the last two decades, there has been a significant growth in the use of copula capabilities. Several research has used copula capacity to ascertain the dependency structure in financial data, with encouraging results. The copula is a mechanism that links a three-dimensional overall transport capacity to its one-dimensional boundaries; it is separate from other types of distribution activities that illustrate the model's interdependence and may be characterized in this manner. Sklar (1959) suggests that by converting the minor conveyance into a uniform distribution, it is possible to analyze the collective dispersion across components in a copula structure. Thus, it is feasible to transform any collective circulation into the least amount of dispersion. The following text presents the formulation of the equation for this cycle.

$$F(F_1, \dots, F_K; O_1, \dots, O_{K,d_c}) = C(F(X_1, O_1), \dots, F(X_1, O_K); \delta_c) \dots \dots \dots 1$$

The use of F and C to illustrate copula work is exemplified by $X_1 \dots X_k$, which represents atypical elements of collective appropriation. $O_1 \dots O_K$ are used to denote the lower limits of circulation, whereas δ_c is employed to represent the boundaries of copulas.

The research used the bivariate copula approach to ascertain the dependent structure. The assumption is made that all joint conveyances are differentiable. The sequential delivery of two items may be expressed as

$$(X_1, X_2, \theta_1, \theta_2, \delta_c) = \vartheta^2(F_1(X_1; \theta_1), F_2(X_2; \theta_2); \delta_c / \vartheta X_1, \vartheta X_2) \dots \dots \dots 2$$

$$f(X_1, X_2, \theta_1, \theta_2, \delta_c) = C(F_1(X_1, \theta_1), F_2(X_2, \theta_2); \delta_c) \cdot \prod_{k=1}^2 f_k(x_{(k)}; \delta_c) \dots \dots \dots 3$$

if $C(u_1, u_2; \delta_c) = \vartheta^2 C(u_1, u_2, \delta_c) / \vartheta u_1, \vartheta u_2$ at that point dispersion work X_1 and X_{2IS} the result of copula capacities and the two-minor distributions $F_1(X_1; \theta_1)$ and $F_2(X_2; \theta_2)$. the log probability can be written as

$$\log f(X_1, X_2; \theta_1, \theta_2, \delta_c) = \log C(f_1(X_1, \theta_1), f_2(X_2, \theta_2); \delta_c) + \sum_{k=1}^2 \log f_k(x_k; \delta_c) \dots\dots\dots 4$$

$$L(\theta_1, \theta_2, \delta_c) = L_C(\delta_c) + \sum_{k=1}^2 l_k(\theta_k) \dots\dots\dots 5$$

L_K and L_C depict the log-probability capacity of the copula and X_K .

By using the edge deduction components produced by Joe et al. (1996), copula boundaries are created. The derivation components of the edges, which circulate asymptotically regularly, provide consistency. Typically, this is the method by which the analyst establishes the boundaries of the copula. The IFM methodology employs a dual-venture metric to forecast the attainment of copula boundaries.

The boundaries of the marginal distribution are determined during the first assessment phase by using the greatest log probability. Here is a method for assembling anything.

$$\theta_1 = \arg \max \sum_{t=1}^T \log f_1(x_{1,t}; \theta_1) \dots\dots\dots 6$$

$$\theta_2 = \arg \max \sum_{t=1}^T \log f_2(x_{2,t}; \theta_2) \dots\dots\dots 7$$

Secondly, we apply the boundaries which are determined in the first step to decide the copula boundaries.

$$\delta_c = \arg \max \sum_{t=1}^T \log C(\mu_{1,t}; \delta_c) \dots\dots\dots 8$$

The optimal copula, which exemplifies a dependent structure, is chosen after the assessment of copula boundaries. Various experts have used distinct choice metrics for model selection. The study employs the Akaike Information Criterion (AIC) approach for selection. To facilitate translation, we choose the copula, which has the fundamental AIC value. The following text provides a detailed account of AIC.

$$AIC = -2(\log\text{-likelihood} + K) \dots\dots\dots 9$$

Where K is utilized to signify the identification motivation behind the boundaries that are utilized in the model.

BIVARIATE COPULAS

The unexpected cycle arises from the asymmetrical nature of monetary information, which makes it difficult to determine the relationship structure between random components. To simplify this situation, this work uses the bivariate copula technique to establish the relationship between irregular components. Bivariate capacity consists of two categories of copulas: the elliptical copula, which quantifies symmetric dependence on both tails and the Archimedean copula, which represents the lower and higher tail dependence between arbitrary components. The elliptical copula and the student t-copula are instances of the former kind, while the Gumbel copula and Clayton copula are instances of the second category.

The following explanations outline several bivariate copulas that are constructed to ascertain the interrelationships between the crude petroleum market and the value markets in South Asia.

BIVARIATE GAUSSIAN COPULA

The Gaussian copula is represented by the "unit cube distribution". The chance of a fundamental change is calculated based on a multivariate typical distribution. The Gaussian copula may be mathematically represented as follows.

$$C^{Gauss}(u) = \Phi P \Phi^{-1}(u_1), \dots, \Phi^{-1}(u_d) \dots\dots\dots 10$$

$$C(u, v) = \int_{-\infty}^{\theta^{-1}(u)} \int_{-\infty}^{\theta^{-1}(v)} \frac{1}{2\pi\sqrt{1-\delta^2}} \exp\left\{-\frac{x^2 - 2\delta xy + y^2}{2(1-\delta^2)}\right\} dx dy \dots\dots\dots 11$$

BIVARIATE STUDENT T COPULA

It discusses the straight coefficient of relationship, and the level of opportunity is under 30. Student t copula has more in tails than Gumbel copula. This copula work shows the reliance between arbitrary variables on the two tails. It tends to be expounded as follows.

$$C^t(u, v; \delta) = \int_{-\infty}^{t_v^{-1}(u)} \int_{-\infty}^{t_v^{-1}(v)} \frac{1}{2\pi\sqrt{1-\delta^2}} \left\{ -\frac{x^2 - 2\delta xy + y^2}{2(1-\delta^2)} \right\} - (v+2)/2 dx dy \dots\dots\dots 12$$

GUMBEL COPULAS

Gumbel copula is created by Clayton (1978). The Gumbel copula is an unbalanced Archimedean copula and shows more reliance on the negative tail as opposed to the positive tail. Gumbel copula numerically can be shown as

$$C_c(u, v; \delta) = \exp\left\{-\left[-\ln u\right]^2 + \left[-\ln v\right] \delta\right\}^{\frac{1}{\delta}}, \delta \in (1, \infty) \dots\dots\dots 13$$

CLAYTON COPULAS

"Clayton copula is proposed by Clayton (1978)". The Clayton copula is portrayed as an "asymmetric Archimedean copula", which generally shows the tail reliance on the positive tail instead of a negative tail. Condition for Clayton copula can be developed as

$$C_c(u, v; \delta) = \max\{(u^{-\delta} + v^{-\delta} - 1)^{-\frac{1}{\delta}}, 0\}, \delta \in [-1, \infty] \setminus \{0\} \dots\dots\dots 14$$

FRANK COPULAS

Frank copula is the copula that is utilized to display codependency between irregular factors. It is additionally called an interchangeable copula. It can accept a numerical structure as follows.

$$C_{\theta}^{Fr}(u_1, \dots, u_k) = \frac{1}{\theta} \log \left(1 + \frac{\prod_i (\exp(-\theta u_i) - 1)}{\exp(-\theta) - 1} \right) \quad 15$$

If θ is set to zero, then the cutoff is used for copula association. Each of the copula capabilities stated above represents a distinct reliance structure, varying in degree from minimal to significant. This dependence may occur in either the positive or negative extreme or even in the lower or upper extreme.

SPEARMAN CORRELATION

Correlation is a multi-method research that measures the degree and direction of correlations between variables. Your power level may range from one to one and a half. The variables exhibit a strong positive correlation when their value approaches 1, and they exhibit a strong negative correlation when their value approaches -1. This study employs two correlation tests to assess the relationships between variables. The Kendall and Spearman correlation tests are both non-parametric. The Kendall tau correlation is an instance of a non-parametric test used to evaluate the level of dependence between variables. However, the Spearman rank correlation is used to measure the degree of association between the variables.

Understanding the interplay between market efficiency and portfolio management is paramount for investors, risk managers, and financial analysts in a dynamic and ever-evolving financial landscape. This research study delves into this crucial intersection, employing copula analysis as a powerful statistical tool to uncover hidden dependencies between financial assets while considering the implications for market efficiency and portfolio optimization. The empirical analysis unveils the results of the copula analysis. It presents the chosen copula model, the estimated parameters, and the results of goodness-of-fit tests, offering insights into the dependence structure between financial assets. Importantly, it discusses how these findings relate to market efficiency, highlighting both confirmations and challenges to established market efficiency theories. The below table shows the summarized results from the above analysis. It shows the selection of appropriate distribution for the series used by the researcher for analysis. For each pair, the appropriate distribution has been mentioned. For example, for the Ourselves and Exchange War composite variable, the Clayton copula is chosen.

Clayton copula is portrayed by its capacity to catch positive reliance, particularly in the tail of the circulation. It is in many cases used to demonstrate circumstances where there is a propensity for outrageous qualities in the two factors to happen together. The Clayton copula is especially appropriate for portraying reliance structures in the monetary time series information. It further shows that outrageous qualities in a single variable are probably going to be related to outrageous qualities in the other series. Clayton Copula explicitly shows the strength and nature of positive tail reliance between the two series

DATA ANALYSIS AND DISCUSSION

DISCUSSION RELATED TO ANALYSIS

The economic significance of your analysis comparing Green Bonds with other stock companies (from the London, Madrid, Netherlands, and Milan stock exchanges) using various copula families is substantial. Here's a detailed breakdown of the insights and implications derived from your copula analysis and how they relate to the Green Bond market:

UNDERSTANDING GREEN BONDS

GREEN BONDS

Green bonds are fixed-income instruments designed to raise funds for projects that have positive environmental impacts. As such, their performance can be influenced by various factors, including market conditions, investor sentiment, and environmental policies.

ANALYZING DEPENDENCIES WITH COPULA MODELS

Capturing Non-linear Relationships: By employing copula models (like T-Student, Gumbel, Clayton, and Gaussian), you can effectively capture the non-linear dependencies between the Green Bond returns and those of the other stock markets. This is crucial because financial returns often exhibit complex behaviors that standard correlation measures might miss.

TAIL DEPENDENCE INSIGHTS

T-Student Copula: The T-Student copula's ability to capture tail dependencies (as shown in your results) is particularly valuable in understanding how the returns of Green Bonds might co-move with equities during market downturns. For example, the lower tail dependence values suggest that during extreme negative market events, the returns of Green Bonds and equities may move together, highlighting potential risks.

GUMBEL AND CLAYTON COPULAS

These copulas help understand upper and lower tail dependencies, respectively. The Gumbel copula reflects the likelihood of simultaneous extreme positive returns, while the Clayton copula captures the risk of extreme

negative returns occurring together. This is particularly relevant for investors assessing how Green Bonds may perform during periods of market stress.

RISK MANAGEMENT AND PORTFOLIO DIVERSIFICATION

ENHANCED PORTFOLIO CONSTRUCTION

Investors in Green Bonds can use insights from your analysis to construct portfolios that include both Green Bonds and equities, optimizing risk-return profiles. For example, understanding how these assets correlate during stress scenarios can help in balancing exposure to systemic risks.

GB and LSE

	Initial Parameter	Final Parameter	Log Likelihood	AIC	BIC	Tail dependence lower	upper
Gaussia	0.175	0.1538	35.49	-68.989	-62.691	0	0
t student	0.175	0.175	1396.868	-2778.1	-2778.1	0.119966	0.119966
Gumbel	1.1308	1.131	-2.77	8.299	8.299	0	0.15533
Clayton	0.26179	0.2618	93.26	-178.2	-178.2	0.0708	0
Frank	NA	1.067	61.2581	-114.22	-114.2	0	0

GB and Madrid

	Initial Parameter	Final Parameter	Log Likelihood	AIC	BIC	Tail dependence lower	upper
Gaussia	-0.0278	-0.04	2.7	-3.4	2.89	0	0
t student	-0.0278	-0.0278	1396.868	-2789	-2778.1	0.699	0.699
Gumbel	0.97	NA	-2.7691E-0.6	8.29	8.29	NA	NA
Clayton	-0.057	-0.57	-0.9646	10.23	10.23	0	0
Frank	NA	-0.2159	2.56	3.12	3.17	0	0

GB and Nederland

	Initial Parameter	Final Parameter	Log Likelihood	AIC	BIC	Tail dependence lower	upper
Gaussia	-0.26	-0.496	442.8	-883.6	-877.3	0	0
t student	-0.26	0-0.4975	442.07	-880.1	-867.5	0.0097	0
Gumbel	0.73	0	-2.77	2.0	8.30	0	0
Clayton	-0.53	-0.1336	68.6	-135.2	-128.9	0	0
Frank	0	-3.426	492.4	-982.7	-976.4	0	0

GB and Milan

	Initial Parameter	Final Parameter	Log Likelihood	AIC	BIC	Tail dependence lower	upper
Gaussia	-0.1313	-0.1852	58.75	-115.5	-109.2	0	0
t student	-0.1313	-0.13	442.07	80.15	-867.55	0.0511	0.0511
Gumbel	0.8867	1.13	-2.7691	2.0	8.298	0.153	0
Clayton	-0.2265	-0.226	5.129	-8.26	-1.159	0	0
Frank	-0.1852	-1.029	60.959	-119.91	-113.62	0	0

HEDGING STRATEGIES

The data can inform hedging strategies for asset managers. If Green Bonds tend to exhibit tail dependence with equities during downturns, investors may consider hedging equity exposure with Green Bonds or vice versa.

MARKET BEHAVIOR ANALYSIS

INVESTMENT TRENDS

The analysis can highlight how the market for Green Bonds interacts with conventional equities. If certain stock markets exhibit high tail dependencies with Green Bonds, it could suggest that investors are increasingly viewing them as a safe haven during market volatility.

IMPACT OF ECONOMIC EVENTS

Understanding the relationships between Green Bonds and various stock markets can also inform how external economic factors (like changes in policy, interest rates, or global economic conditions) influence both markets. This is crucial for predicting future performance and investor behavior.

REGULATORY AND POLICY IMPLICATIONS

SUPPORT FOR SUSTAINABLE INVESTMENT

Policymakers may use these findings to encourage sustainable investments. If Green Bonds are found to have stable returns or low correlation with high-risk assets, they can promote their use as a stabilizing investment during turbulent market periods.

PROMOTING MARKET RESILIENCE

Insights from the copula analysis can help regulators understand how to foster a more resilient financial system by promoting the growth of Green Bonds, which can enhance sustainability while also providing stability in times of economic stress.

CONCLUSION

The economic significance of your copula analysis of Green Bonds in relation to major stock markets lies in its ability to provide valuable insights into the interdependencies and risk characteristics of these financial instruments. By understanding these dynamics, investors, asset managers, and policymakers can make informed decisions that enhance portfolio performance, promote sustainable finance, and contribute to overall market stability. This analysis positions Green Bonds not only as investment opportunities but also as crucial components of a sustainable financial ecosystem. The analysis of the dependence structures between green bond markets and various financial markets has revealed important insights that can inform investment strategies, regulatory frameworks, and market practices. The findings indicate varying degrees of dependence, with certain markets exhibiting countercyclical behavior relative to green bonds and a potential for joint extreme movements during periods of market stress.

Investors can benefit from incorporating green bonds into their portfolios as a means of diversification and risk management, particularly given their lower correlation with traditional assets during downturns. Policymakers are encouraged to create a more integrated and transparent market environment to foster confidence in green bonds and enhance their attractiveness to investors. Financial institutions should leverage advanced statistical models to assess risks accurately and develop innovative financial products that align with the growing demand for sustainable investments.

Overall, understanding the dependence structure of green bonds in relation to other financial markets not only enhances strategic decision-making but also contributes to the broader objective of promoting sustainable finance and investment practices. By taking these findings into account, stakeholders can better navigate the complexities of the financial landscape, ultimately supporting the transition to a more sustainable economy.

RECOMMENDATIONS

Based on the findings from the analysis of the dependence structure of green bond markets with other financial markets, here are some tailored recommendations for investors, policymakers, and financial institutions.

RECOMMENDATIONS FOR INVESTOR, DIVERSIFICATION STRATEGIES, PORTFOLIO DIVERSIFICATION

Incorporate green bonds into investment portfolios to enhance diversification, particularly if they exhibit low dependence with traditional financial markets (e.g., LSE, Madrid). This could help reduce overall portfolio risk during market downturns.

Given the presence of tail dependence, consider using green bonds as a hedge against extreme market events. They may provide stability during periods of high volatility in conventional markets.

DYNAMIC ASSET ALLOCATION, ADJUST ALLOCATIONS BASED ON MARKET CONDITIONS

Monitor the dependence structures over time and adjust allocations dynamically based on market conditions. For instance, increase exposure to green bonds during periods of high market stress when traditional assets may underperform.

FOCUS ON COPULA MODELS

UTILIZE ADVANCED STATISTICAL MODELS

Employ copula models (like t-student) in the analysis of dependence to better understand joint extreme movements. This can guide investment decisions in assessing risk and identifying potential opportunities

RECOMMENDATIONS FOR POLICYMAKERS

Encourage stronger linkages between green bond markets and traditional financial markets to enhance overall market stability and integration. This could involve regulatory frameworks that support cross-market investments.

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