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Dependence Structure between Green Bond Market and Asian Stock Markets: Evidence from India, China and Pakistan

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A B S T R A C T

The purpose of the underlying study is to investigate the dependence structure between the selected Asian Stock Market (Pakistan, India, and China) and Green Bonds Market. For this purpose time, a series of daily data of closing prices of all the markets were obtained from 2014 to 2021. Further, the Bivariate copula approach has been used for analyzing the data. The findings of the study reveal that there is a dependence between log returns of three Asian stock markets (Pakistan, China, and India) and the green bond market as the best fit copula is t-student. The student-t copula work portrays the dependence between arbitrary variables on the two tails. Although this study contributes to the literature by analyzing more countries in the future shall further add to the literature by adding a regional perspective. Lastly, the findings of the study shall aid the investors in portfolio making, risk management, and policymakers as well.

Keywords: Green bond, copula, dependence, Pakistan, China, India

1. INTRODUCTION

Green bonds are among the most innovative and important innovations in the sustainable finance's field during the last decade. Green debt is one of the latest components of the global financial markets that are attracting market participants' interest. The green bond is a one-of-a-kind financial product that is classified based on how the issuer intends to use the proceeds. The gains by issuing green bonds are utilized to support climate change adaptation and mitigation, environmental pollution prevention, natural resource conservation, and control, etc. (Broadstock & Louis T.W., 2019). For more research, several kinds of literature such as energy finance, and climate finance, have covered this topic and green finance, among the center of attention is the tremendous growth of green bonds (Zhang, 2018).

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There has only been little research done to determine the dependence structure between the green bond market and other financial markets, which leads to the research gap. Because of the relevance of a climate-resilient economy, finance literature must investigate the volatility dynamics, dependence structure, co-movement, and price spillover of green bonds, which are one of the most important and visible innovations in the field of sustainable finance. Ejaz (2021) conducted a study on the volatility dynamics, market risk of the global green bond, co-movement dynamics, and their impact on portfolio diversification. Reboredo (2018) concentrated in his research on the dependence structure between the green bond market and other financial markets, which are stock markets, energy markets, treasury-fixed income markets, and corporate markets, as well as the consequences of these reliance price spillovers and green bond diversification benefits. This is the first study to look into the green bond's co-movement dynamics with other financial markets.

In terms of volatility, the green bond market is not separate from other financial markets. As a result, investors have used green bonds to earn a profit on their investments while also contributing to the climate-resilient economy's development. The bond, stock, energy, and green bond markets on the other hand respond differently to the arrival of new information. For example, the black and green markets are sensitive to changes in multiple macroeconomic factors such as changes in the financial market's returns and volatility, economic activity, and economic policy uncertainty on daily basis (Ejaz, 2021). This divergent response to the arrival of new information by the green bond market results in the study of dependence structure, risk estimation, portfolio diversification, and volatility.

Investors use several financial tools for global diversification, such as global conventional bonds, stocks, Islamic bonds, and stocks, commodities, currencies, precious metals, etc. As a result, institutional and individual investors in their portfolios use green bonds to develop a climate-resilient economy as a financial tool (Reboredo & Ugolini, 2020). Investors' interests are shifting toward environmentally friendly investments as a means of global diversification (Dutta et al., 2020).

The copula technique is a relatively new approach that has yet to be widely used.

This technique helps in risk management therefore; it could be valuable in the banking industry. The copula approach is used to determine the pattern of reliance, which aids in understating the market movements. For managing the risk, this technique is also very helpful. For this reason, we can say that the copula technique is very beneficial for policymakers and investors. They can create a very effective risk management model with the help of the copula technique to avoid future risks.

The core objective of this study is to improve investors' understanding of how green bonds interact with other main asset classes. The dependence structure shows how a change in the green bond returns affects the stock returns of Asian countries either positively or negatively. It helps in deciding whether select the opposite direction or continue moving forward in the same direction. If the study proves that, there is a dependency, policymakers will make decisions/policies based on the findings of this research.

1.1. Research questions

Following are the research questions,

1. What is the dependence structure between the Nifty 50 and s & p green bond index?
2. What is the dependence structure between KSE-100 and the s & p green bond index?
3. What is the dependence structure between the Shanghai composite and the s & p green bond index?

2. Literature Review

According to portfolio theory, most investors are risk-averse and choose low-risk investments, but the key assumption is that risk and return are interconnected. Emerging economy investors have different attitudes about returns and risks; they avoid high-risk investments and stocks with a high level of volatility. On the other hand, Increased transparency and duty in the using and managing proceeds, provides another tool for risk management; Modification in policies for example carbon levies, which might rout turn-into stranded assets, can help green bonds reduce risks related to climate change in the portfolio. Instead, a green bond invests in climate-friendly assets that have a lower credit risk over time, such as green buildings and renewable energy (Kahagalle & Jones, 2021).

Portfolio diversification theory shows how risk-averse investors are and how they want to avoid risk as much as possible. This theory established a framework for investors to reduce risk. This theory states that if two portfolios provide the same return, investors will choose the .one with the lowest risk.

The Efficient Market Theory, published (Fama, 1970), provides a theoretical basis for this study. It is based on the assumption that capital markets are efficient and securities reflect all available information. Prices of securities adjust in response to new information, according to the efficient market theory.

As a result, according to this theory, information prices adjust in response to the introduction of new information, and information spills over from one market to another, leading to price adjustments based on the arrival of new information. As a result, there is a spillover of information among the market green bond and other financial markets, leading to price adjustments based on new information.

Linh & Nguyen (2022) examined the impact of economic policy and financial market uncertainty on the green bond market. Nguye et al (2022) highlighted the current positive impact, hurdles, associated regulations, and market participants' expectations for the development of green bonds. Benlagha & Hemrit (2021) used a copula mixture to show symmetric dependence in a power crisis. During market collapses, Hussain & Li (2021) used copulas to estimate the dependency pattern between oil and other commodities. Copulas are useful instruments for modeling dependency patterns, according to the major findings of these studies. Nguyen & Bhatti (2012) study the interdependence of six worldwide stock exchanges.

2.1. Karachi Stock Exchange-100 Index

The KSE-100 is a benchmark stock index that compares prices on Pakistan Stock Exchange (PSX) across times. The index was first introduced in November 1991 with a base of 1000 points. To determine the representatives' companies for computing the index, firms that have the highest market capitalization are chosen. The firm that has the largest market capitalization in every sector is also admitted for ensuring complete market representation. The Karachi stock exchange-100 index is a free float index since 2012. The KSE-100 experienced record-breaking growth on Dec 26, 2007, with 14,814

points. Furthermore, in 2008 the 7.4% increase made KSE-100 the best performer among big emerging markets. from 2011-2012, KSE was regarded as the best emerging market with up to 40-50% returns in Asia. The stock market reached an all-time high of 49,969 points in January 2017. On February 26, 2020, the first case of covid was recorded in Pakistan, the impact of covid on KSE-100 was a decline of 62%.

2.2. National Stock Exchange Fifty (Nifty 50)

The Nifty 50 is the major stock market index in India representing the weighted average of the largest 50 Indian companies that are listed on the NSE. Nifty 50 is one of the two main stock markets that are used in India. The Nifty 50 has grown to become India's largest single financial product that has an ecosystem that includes exchange-traded options and exchange-traded funds both onshore and offshore at NSE. The Nifty 50 is the most actively traded contract in the world. It is a free float market index. The index was created on a whole market capitalization at first. The computation of the index was updated to a free float methodology on June 26, 2009. The base value of Nifty 50 is 1000.

2.3. SSE Composite Index

This index is also known as the SSE index which is a stock market index for all the stocks including A shares and B shares that are being traded at the shanghai stock exchange. The Paasche weighted composite price index formula is used to calculate SSE indices. This signifies that the calculation of the index is based on a base period on a certain base day. The SSE Composite index's base day is dec19, 1990 with the base period consisting of the total market capitalization of all stocks of that particular day. The base value of the SSE composite index is 100. On July 15, 1991, the index was launched.

2.4. S&P Green Bond Index

S & p green bond index is termed a market-weighted index that attempts to trace the global green bond market. This ground-breaking index adheres to strict criteria to add only those specific bonds whose gains are used to fund environmentally beneficial projects. Only green bonds that meet a stringent set of criteria, for example being designated as "green" by the climate bond initiative (CBI), having a debt rating that aligned with its credit quality, and bonds having a minimum par value are acceptable for

inclusion.

2.5. Dependence

The linear correlation coefficient is the most well-known degree of dependency among two arbitrary variables and within the circular world, is the normal degree. It isn't suitable for non-circular distributions and it isn't invariant under non-linear changes that are increasing entirely. Kendell's tau and spearman rho are the best options for degree dependence for non-elliptical distributions. The non–linear transformation does not influence these two coefficients which describe the degree of few monotonic dependences (Shafique et al., 2021).

2.6. Hypotheses Statements

H_1: *There is a dependence between the Nifty 50 and the green bond index.*

H_2: *There is a dependence between KSE-100 and the green bond index.*

H_3: *There is a dependence between the Shanghai composite and green bond index.*

3. RESEARCH METHODOLOGY

3.1. Data

Selection of Sample

To measure the reliance structure of the green bond market and Asian stock markets the secondary data of three Asian stock market indices, China, India, and Pakistan are used. The data is available at (Investing.com, 2021). For the secondary data of green bonds is extracted from (S & P Dow Jones indices, 2021). S& P Green bond index is the pioneering index that represents the global bonds data. It serves to track the global green bond market (Kochetygova and Jauhari 2014). Further, the selection of countries is based on keeping in view the neighboring countries of Pakistan especially India and China to understand the situation in these countries in comparison to Pakistan.

Table 1. Indices Details

Serial number	Indices	Time span
1	Nifty 50	24 January 2014 to 24 December 2021
2	Karachi 100	24 January 2014 to 24 December 2021
3	Shanghai composite	24 January 2014 to 24 December 2021
4	S & P Green bond index	24 January 2014 to 24 December 2021

Note: table 1 presents the detail of Asian stock market indices and green bond index and also the period from which the data is used for analysis.

Measurement of Variables

As the underlying study is based on time series data where closing prices of stocks and green bonds were used for taking the log returns of these prices. The green bond prices and stocks prices were converted into returns by the following formula,

(Current price-previous price)/previous price

3.2. Copula

Many studies on risk management issues have found that using the copula function to demonstrate related multivariate series is an effective strategy because a multivariate joint distribution can be built effectively from marginal distributions thus allowing selection of the construction of appropriate copula to examine the dependence pattern among variables. (Shafique et al., 2021). Copula-based models offer a lot of flexibility when it comes to displaying multivariate distributions. This allows the researcher to control the peripheral conveyance models independently of the dependence structure that connects them to form a mutual conveyance. (Raza et al., 2021).

The copula can examine joint dissemination between variables by converting the minor conveyance into minor distribution. Hence, any aggregate circulation can be converted into minimal dispersion. The equation for this process can be composed as follows:

$$F(F1 \dots . . F_K : O_1 \dots \dots \dots O_{K,dc}) = C(F(X_1, O_1) \dots F(X_1, O_K): \quad (1)$$

Equation (1) $X_1 \dots \dots X_K$ represents the uncertain factors of joint appropriation F and C is used to exhibit copula work. For copula, boundaries δ_C are being used and the minimal circulation boundaries are addressed by $O_1 \dots O_k$

By using the bivariate copula technique, the research aims to capture the dependency structure. It is accepted in the bivariate copula approach that all joint conveyance is differentiable. Joint bivariate conveyance can be composed as follows:

$$(X_1, X_2, \theta_1, \theta_2, \delta_C) = \vartheta^2(F_1(X_1; \theta_1), F_2(X_2; \theta_2); \delta_{C/\vartheta} X_{1.\vartheta} X_2 \quad (2)$$

$$f(X_1, X_2, \theta_1, \theta_2, \delta_C) = C(F_1(X_1; \theta_1), F_2(X_2, \theta_2); \delta_C). \Pi_{(k=1)}^2 f k(x_{(k)} \delta_C) \quad (3)$$

if $C(u_1, u_2; \delta_C = \vartheta^2 C(u_1, u_2, \delta_{c/\vartheta}) u_{1.\vartheta} u_2$

Dispersion work, at that point X_1, and X_{215} the outcomes of Copula capacities and the two-minor distributions $F_1(X_1;\vartheta_1)$ and $F_2(X_2;\vartheta_2)$. The log probability can be written as,

$$\log f\,(X_1,X_2,\theta_1,\theta_2,\delta_C) = \log C\,(F_1(X_1;\theta_1),F_2(X_2,\theta_2);\delta_C) + \sum_{(k=1)}^{2}\log f_{(k)(xk;\delta_C)} \quad (4)$$

$$L(\theta_1,\theta_2,\delta_C) = L_C(\delta_C) + \sum_{(k=1)}^{2} L_K(\theta_K)$$

The log probability of X_K and copula is depicted by L_C $and L_K$

The boundaries of the copula are determined by using deduction elements of the edges. The derivation elements of the edges are asymptotically usually circulated and provide consistency. This technique is generally utilized by an analyst to determine copula boundaries. For anticipating copula boundaries, the international financial management (IFM) system BIC uses two venture measures.

For assessment purposes, the greatest log probability is used to measure the boundaries of marginal distribution in the first stage. This process can be composed as,

$$\theta_1 = arg\max\sum_{(t=1)}^{T}\log f_1(x_{1,t;O_2}) \quad (5)$$

$$\theta_2 = arg\max\sum_{(t=1)}^{T}\log f_2(x_{2,t;O_2}) \quad (6)$$

For deciding the copula boundaries, in the second step we apply the boundaries which are already determined in the principal stage:

$$\delta_C = arg\max\sum_{(t=1)}^{T}\log C(\mu_{1,t;\delta_C}) \quad (7)$$

The best copula, which illustrates the example of dependence structure is picked after examining the copula boundaries. Although for model choice several experts have used different choice measures. The Akaike data model procedure is applied in this examination. For interpretation purposes, the copula which contains base Akaike information criterion (AIC) regard is preferred. Akaike information criterion can be characterized as:

$$AIC = -2(log - liklihood + K) \quad (8)$$

3.3. Bivariate copulas

Because of asymmetric behavior in monetary information, determining the dependence pattern between arbitrary factors is an uncertain cycle. To avoid this complexity, this study applies the bivariate copula methodology to determine the dependence structure among irregular factors. (Raza et al., 2021)

3.4. Copula Families

Two common copula families include the elliptical copula and the Archimedean copula family. The elliptical copula family contains the gaussian and student t copula, on the other hand, the Archimedean copula family contains Gumbel, Clayton, and frank copula. The elliptical copula is used to depict the symmetric dependence on the two tails on the other hand Archimedean copula is used to depict the lower and upper dependence among irregular factors. (Raza et al., 2021) The two copula families are discussed below,

3.5. Gaussian copula

Gaussian copula communicates the reliance pattern of multivariate normal distribution, i.e., normal marginal disseminations are paired with gaussian copula to generate a multivariate normal distribution. (Shafique et al., 2021). The Gaussian copula is a unit cube distribution that is calculated using the likelihood of fundamental change from a standard multivariate appropriation. (Raza et al, 2021). It can be written mathematically as follows,

$$C^{Gauss}(u) = \phi P \phi^{-1}(u_1), \ldots\ldots \phi^{-1}(u_d) \quad (9)$$

$$C_{(u,v)} = \int_{-\infty}^{\theta-1(u)} \int_{-\infty}^{\theta-1(u)} \frac{1}{2\pi.\sqrt{1-\delta^2}} \frac{x^2-2\delta xy+y^2}{\exp\{-2(1-\delta^2)\}dx.dy} \quad (10)$$

3.6. Student-t copula

The straight coefficient of the relationship is discussed by a student-t copula and the opportunity level is less than 30. In comparison to the Gumbel copula, the student-t copula has more tails. The student-t copula work portrays the dependence between arbitrary variables on the two tails. (Raza et al., 2021). Furthermore, if the gaussian copula does not fit the data well but the student-t copula does, the student-t copula captures the reliance inside the tails precisely, whereas the gaussian copula does not. (Shafique et al., 2021). Numerically, student-t copula can be shown as follows,

$$C_{(u,v,s)} = \int_{-\infty}^{t_u^{-1}(u)} \int_{-\infty}^{t_v^{-1}(v)} \frac{1}{2\pi.\sqrt{1-\delta^2}} \frac{x^2-2\delta xy+y^2}{\{\ -2(1-\delta^2\}-(v+2)/2dx.dy} \quad (11)$$

3.7. Gumbel copulas

Gumbel copula generated by Clayton. Gumbel copula is an imbalanced Archimedean copula that shows more dependence on the negative tail instead of a positive tail. (Raza et al., 2021). Mathematically, Gumbel copula can be shown as,

$$C_C(u,v;\delta) = \exp\{-(-1\ n\ u)^2 + [(-1\ n\ v)\delta\ ]\}, \delta\epsilon(1,\infty) \quad (12)$$

If the distribution of two irregular factors follows the Gumbel copula, then there is a strong probability that two variables are increasing at the same time. (Shafique et al., 2021).

3.8. Clayton Copulas

Clayton proposed the Clayton copula, which is depicted as an asymmetric Archimedean copula. In general, Clayton copula shows tail dependence on the positive tail rather than the negative tail. (Raza et al., 2021). Numerically, Clayton copula can be shown as,

$$C_C(u,v;\delta) = \max\left\{\left(u^{-\delta} + v^{-\delta} - 1\right)\frac{-1}{\delta}, 0\right\}, \delta \in [-1,\infty]\{0\} \quad (13)$$

3.9. Frank Copulas

The frank copula, also known as an interchangeable copula, is a copula used to show the co-dependency between arbitrary factors. The numerical structure of frank copula can be composed as follows:

$$C_\theta^{Fr}(u_1 \dots\dots\dots u_k) = \frac{1}{-\theta} \frac{\Pi_i(\exp(-\theta u_1)-1)}{\log(1+\exp(-\theta)-1)} \quad (14)$$

In the case that we undertake the $\theta = 0$ then for the association of copula the cutoff is used. All the above-mentioned copula capacities capture the dependence structure ranging from low to higher dependence that can be on lower or upper tail or positive or negative tail dependence.

3.10. Spearman's correlation and Kendell tau's

Correlation is a type of analysis that measures the strength and direction among variables. The power can be in the range of +1 and -1. If the value is near +1, then

between the variables there is a perfect positive relationship on the other hand if the value is near -1 then among the variables, there is a perfect negative relationship. To measure the relationship among variables, in this study spearman and Kendal tau correlation tests are used. Kendell tau correlation is regarded as a non-parametric test that is utilized for determining the strength of reliance of variables on the other hand the spearman rank correlation is used to determine the degree of relationship among variables. (Raza et al., 2021).

4. RESULTS AND ANALYSIS

4.1. Descriptive statistics

Table 1.Descriptive Statistics

	Nifty 50	Karachi100	Shanghai composite	S & P Green bond index
Minimum	-0.1298046	-0.0932671	-0.0959402	-2.381e-02
1st quartile	-0.0044761	-0.0049365	-0.0048781	-1.601e-03
Median	0.0006859	0.0003013	0.0006502	7.325e-05
Mean	0.0005438	0.0002981	0.0003683	5.019e-05
3rd quartile	0.0062038	0.0061214	0.0060575	1.740e-03
Maximum	0.0662475	0.0479539	0.0799507	2.033e-02
Standard deviation	0.01108191	0.01103583	0.01373345	0.003060601
Skewness	-1.192444	-0.6583243	-0.9114372	-0.5000792

Note Table 2 display the descriptive statistics of Asian stock market indices (Pakistan, India, and China) and the green bond market. Descriptive statistics show the values of Skewness, standard deviation, median, mean, minimum value, and maximum value. Histograms of log returns of the green bond market and Asian stock market indices are also given. (See Appendix)

4.2. Dependence structure between the Indian stock market and green bond market

Table 2. Dependence structure between Nifty 50 and green bond index

Copula	Initial parameter	Final Parameter	Log-likelihood	AIC	BIC	Tail dependence	
						Lower	Upper
Gaussian	0.07586151	0.02844	0.8276 (df= 1)	0.3447131	5.980983	0	0

T student	0.07586151	0.01319 (df= 5.77364)	26.88 (df= 2)	-49.76632	-38.49378	0.03814383	0.03814383
Gumbel	1.006829	1.035	6.545 (df= 1)	-11.09024	-5.453969	0.00000000	0.04633436
Clayton	0.01365785	0.05952	3.94 (df= 1)7	-5.893535	-0.2572649	8.757343e-06	0.000000e+00
Frank	N. A	0.06554	0.1181 (df= 1)	1.763841	7.400111	0	0
Note: This table presents the estimates of different copula parameters, which include initial and final parameter, log-likelihood, Akaike information criterion (AIC), and Bayesian information criterion (BIC) as well as tail dependence between Nifty 50 and S & P green bond index.							

To measure the dependence between the green bond market and the Indian stock market, a copula with the lowest AIC is selected. T-student is the best-fitted copula because it has the lowest value of AIC -49.76632 as shown in table 3. The fat tiredness of the dependence pattern is measured by t student copula. The fat tail dependence between two return series is indicated by the degree of freedom 5.77364 of the t- student copula.

According to the results, the upper and lower tail dependence are identical. This outcome specifies that there is a dependence structure that exists between the Indian stock market and green bond market and both market moves in the same direction. If the performance of one market increases, it will increase the performance of other markets as well and vice versa.

4.3. Dependence Structure between Pakistan Stock Market and Green Bond Market.

Table 3. Estimates of Dependence Pattern among Karchi100 and S&P Green Bond Index:

Copula	Initial parameter	Final Parameter	LOG-LIKELIHOOD	AIC	BIC	Tail dependence	
						Lower	Upper
Gaussian	0.05900611	0.02484	0.6314(df=1)	0.7372524	6.373522	0	0
T student	0.05900611	0.01911(df = 13.92916	5.618(df=2)	-7.235619	4.03692	0.001790306	0.001790306
Gumbel	1.009935	1.024	2.927(df=1)	-3.853503	1.782767	0.00000000	0.03222878

Clayton	0.01987063	0.03004	1.033(df=1)	-0.0660924	5.570177	9.528578e-11	0.000000e+00
Frank	N. A	0.0893	0.225(df=1)	1.550023	7.186293	0	0

Note: This table presents the estimates of different copula parameters, which include initial and final parameter, log-likelihood, Akaike information criterion (AIC), and Bayesian information criterion (BIC) as well as tail dependence between Nifty 50 and S & P green bond index.

Table 4 shows that t-student is the best-fitted copula to measure the dependence of the Pakistan stock market and green bond market because it has a minimum AIC value of -7.235619. As per the outcomes, both upper and lower tail dependence are identical which implies that returns of the Pakistan stock market and green bond market move with the same frequency. The fat tail dependence between the Pakistan stock market and green bond is indicated by the value of the degree of freedom 13.92916 of the t-student copula.

4.4. Dependence Structure between China Stock Market and green bond market

Table 4.Estimates of Dependence Pattern among Shanghai composite and S & P Green Bond Index

Copula	Initial Parameter	Financial parameter	Log-likelihood	AIC	BIC	Tail dependence	
						Lower	Upper
Gaussian	0.001363978	0.0143	0.2091 (df=1)	1.581766	7.218036	0	0
T student	0.001363978	0.01874(df=10.73290)	8.461 (df=2)	-12.92137	-1.648827	0.005824761	0.005824761
Gumbel	1.014355	1.015	0.8809 (df=1)	0.2381284	5.874398	0.0000000	0.0203854
Clayton	0.02871038	Assumptions violated	Assumptions violated	Assumptions violated	Assumptions violated	Assumptions violated	Assumptions violated
Frank	N.A	0.127	0.454 (df=1)	1.092085	6.728355	0	0

Note: This table presents the estimates of different copula parameters, which include initial and final parameter, log-likelihood, Akaike information criterion (AIC), and Bayesian information criterion (BIC) as well as tail dependence between Nifty 50 and S & P green bond index.

The data in table 5 present that the t-student copula shows the minimum AIC value of -12.92137 which is by the standard of goodness fit model. Fat tailedness in data is

measured by student t copula. In table 5 the symmetric behavior of the Shanghai composite and s & p green bond index is indicated by student t copula. The results also disclosed that between the right and left tails, the data is equally distributed. This indicates that the dependence pattern exists between these two markets. The assumptions of Clayton copula are violated hence it could not calculate the value of the final parameter and due to which the value of AIC is not calculated.

4.5. Spearman Correlation

Table 5. Estimates of Spearman Correlation

	Nifty 50	**Karachi100**	**Shanghai composite**	**S & p green bond index**
Nifty 50	1	-	-	0.07586151
Karachi100	-	1	-	0.05900611
Shanghai composite	-	-	1	0.001363978
S & P green bond index	0.07586151	0.05900611	0.001363978	1

Table 6 shows the result of the spearman correlation which indicates that there is no strong correlation between Asian stock markets and the green bond market, confirming our copula finding which reveals that there is a dependence structure between Asian stock markets and green bond market. The Spearman correlation value of the Indian stock market and the green bond market is 0.07 which means that there is dependence between them. The correlation value of Pakistan and the green bond market is 0.05 which also proves the dependence between them. Another finding reveals that there is a dependence between China stock market and the green bond market showing a correlation value of 0.001.

4.6. Kendell tau result

Table 6. Estimates of Kendell tau test

	Nifty 50	Karachi100	Shanghai composite	S & p green bond index
Nifty 50	1	-	-	0.006782606
Karachi100	-	1	-	0.009837576
Shanghai composite	-	-	1	0.01415203
S & p green bond index	0.006782606	0.009837576	0.01415203	1

5. DISCUSSION

Green bonds are gaining popularity in green finance due to their risk-reducing characteristics and attractiveness to institutional and socially conscious investors. When the green bonds are issued by an institution, an independent third party is hired to give a second party opinion to ensure that the issuer's overall objectives, policies, strategy, and use of proceeds are aligned with the principles of green bonds (Tolliver et al., 2021). The results of this study show there is a dependence between the green bond market and the Asian stock markets. According to the research conducted by Ejaz (2021), green bonds are less risky than oil, conventional, and Islamic equity. Research on the dependence structure between stock returns of developing and developed countries is conducted by (Shafique et al.,2021). The results of their study were also significant. The results of this study helped in understating the movements of various countries' stock markets which also assist the investors and policymakers in making their investment decision and developing a better risk model to control and quantify risk.

5.1. Policy Implications

Policymakers can use this method to make effective policies. Government authorities/policymakers might use this technique to monitor market activity and formulate policies to safeguard the interest of their country. To monitor the movement of international and local markets, investors can also use the copula technique and invest in the market which seems profitable for them. The findings of this study can be used by a fund manager and an investor to diversify risk by portfolio construction. Finally, the findings of this study are employed by government officials/policymakers in formulating policies for the legalization of green bonds in their country's stock exchanges. The regulatory authorities can also use the outcomes of this study to develop macro-stabilization strategies and for the management of risk. Based on the copula findings, it is recommended that investors should be careful while constructing their portfolios and relocating resources in their portfolios to use these stocks (assets) paired with green bonds.

5.2. Future Research Directions

It is recommended to future researchers take into consideration more Asian countries.

There are only a few studies on the green bond which leaves a research gap. A broader literature can be developed on green bonds to other stock markets. There are several other time-varying copulas, i.e., DVine, and t-DCC (Dynamic conditional correlation) that can be used for measuring the dependence structure. Future researchers can also check the dependence structure of green bonds within the bond market.

5.3. Limitations

The limitation of this study is the time for conducting the research. The main focus of this study is only on the stock market of the three Asian countries which are Pakistan, India, and China. There was only a limited amount of time to complete the research. In addition, the t-student copula model ignores changes in dependence structure caused by time variation. By employing time-varying copulas, the error can be fixed.

6. CONCLUSION

Based on copula fundings, it is concluded that there is dependence between Asian stock markets which are Pakistan, India, and China and the green bond market. The selection of the Asian countries was based on the same geographic region. The main aim of this study was to check whether there is a dependence between the green bond market and the Asian stock markets and whether changes in the green bond market can have an impact on Asian stock markets. To achieve the objective of this study and check the dependency copula technique was used with R and R studio software. The findings and results of the copula were very clear as it has different types and each type of copula represents different tail dependence.

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