

# GREEN BOND VOLATILITY AND SPILLOVER TO THE EQUITY MARKET OF SOUTH ASIA

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**Abstract.** *This study aims at finding out the volatility and spillover of green bonds over equity markets of South Asia including three countries; China, India and Pakistan. For this purpose, sample dataset of daily closing price of stock returns of equity markets was collected from the stock exchange institutes of these three countries from time period of 2011 to 2019. Dataset of green bond market was obtained from official site of S&P global green bond index. Unit root test, LM test, Durbin Watson test, ARCH test and GJR-GARCH test was used as techniques for proving the hypothesis of this study. Findings show that green bond market is positively linked with the equity markets of these three countries. Moreover, no volatility exists in the green bond returns but there is an existence of volatility in green bond markets. ARCH effect exists in green bond market return series so spillover does not exist. As conclusion, both green bond market and equity market are not completely independent and there is an existence of informational spillover between these markets which can be helpful for investors against risk diversification. This study is also fruitful for policy makers, researchers and portfolio managers.*

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## Introduction

Environment change plays a significant role in the company's sustainability and it's a biggest challenge for the world. In the last decades, the new of financial derivate has been created, and known as "Green Finance", where the proceeds are provides benefits to climate and stop the changing in the environmental stated by Nylen (2021). Green bond is originated in developed countries and plays a significant role in developing bond market. The purpose of the green bond proceed is to making the financing environmentally friendly projects. Green bond is the

type of bonds that uplift sustainability and to help climate-related or different kinds of climate projects. Companies are progressively deposed towards to structuring a “a green image” which gives the real value to the firm. Green bonds proceed will be used to finance a green project which are lined up with the four segments of the green bond principal (GBP). It includes the utilize of proceeds, project evaluation and selection process, the proceed of management and last one is reporting. Green bond principal plays an important role in the growing of green bond market.

Green bond is used for the allocation of fund and it’s a positive impact on environment. In 2007, European investment bank issued the first green bond and then first green bond market is created. The next year World Bank adopted it. So the following 12 years, the green bond market developed fastly. In 2019, the total amount of green bond insurance is 257.7 billion US dollar and 51% is the market yearly growth. The market is dominated by the US and China but the expansion in 2019 was mainly driven by the European markets elaborated by Karesjoki (2020). In 2013, the first corporate bond was issued by electricite de France, and then the developing of corporate green bond market started. These are similar to conventional bonds, but the green bonds proceeds is uses for putting resources into projects that fulfil certain environmentally targets, that is beneficial for environment such as renewable energy, environmental friendly building or feasible transports. According to the climate bond initiative database, 95% proceeds of green bond devoted to assets or project or undertaking lined up with the climate bonds taxonomy showed by Nylen (2021). The overall features of bonds and research interest associated with bond market is its link with the stock markets are often analyzed by green bonds. The system by which volatility is moved between the equity and bond market plays a crucial role in risk management and portfolio composition. After examine the relationship between the bond and stock markets, it helps investors to sort out their portfolio tested by Park et al. (2020). It is well-understood thing that every investor comes into the business world to earn profit and it is the primary source of business as well.

Over the past few years, investors are more concerned about the environmental impacts of business. In the past few years, some studies are conducted on green finance to measure the volatility modeling of green bonds with the purpose to find out the volatility spillover between the green bond market and conventional bond market. The volatility modeling of green bond with overall conventional bond market provides the information that how conventional bond market will take part to the volatility of green bond market. Moreover, the results of study provide information that how much information spillover exists between the green bond market and the conventional bond market. The information spillover leads towards the cause-and-effect relationship between financial markets. The cause-and-effect relationship between the financial markets indicate that how efficiently one market responds to the information spillover. If one financial market responds to the knowledge spillover of the other financial market, then it indicates the presence of

co-movement within the data. So, co-movement between the financial markets that how these financial moves together, and investors will use these co-movement results to predict future returns based on the past prices to diversify their portfolio and maximize their returns (Ejaz, 2021).

The volatility of returns is an essential risk metric used in the financial decision making. Volatility and its dynamics are important in various finance applications such as asset allocation, risk management and derivation pricing. Karesjoki (2020) showed that the volatility behavior and dynamics of the green bond market is essential for participants in new market. In this research we first examine the market for green bond, then we analyze the volatility dynamics and spillover between the stock market and green bond markets in South Asian countries. Most the studies have conducted with the intention of the effect of interest rates on the stock prices of South Asian countries that it has a positive or negative effect on the equity market, however evidences were also mixed. Some studies identify the channels of transmission and some have tried to link them to financial and commercial channels. Further, in many studies the evidence of the impact of global interest rates on equity market was also mixed. Some researchers confirmed the positive impact as well as negative impact on the equity market.

Moreover, the green bond is a new financial instrument, due to the importance of climate it is the need of finance literature to explore the volatility dynamics of green bond because green bond is the significant innovation in the field of finance. Pham (2016) conducts the first study in order to understand the risk and return behavior of green bond market volatility and in this study volatility of green bond has been analyzed with the overall conventional bond market. A few studies have been conducted to find out the volatility modeling of the green bond that creates a gap in the body of knowledge. Studies specific to the South Asian countries are quite less researched, which are the big gap and a great motivation of the study that we are trying to examine the through advanced methodology. In this study we examine the price spillover between green bond market and equity market, and also find out the dynamics of green bond market with equity market in South Asian countries. Therefore, to fill the gap of finance literature the purpose of this research is to find out the volatility modeling and dependence structure of global green bond with equity market.

The green bond market with regards of volatility is neither separate from the equity markets and not from the other bond markets. So that's why the green bond is utilized by the financiers to make extra money in terms of profit on their assets beside with the growth of the weather volatile economy explored by Huynh et al. (2020). Though this emerging market is an opportunity for the financiers for their investments that are valuable for ecologically and also for economy. According to the World Bank that green bond is an economical tool which is used for increase

wealth in terms of environmental related ventures insisted by Pham (2016). The answer to the other market like bond market, equity market is different as related to the green bond market because it's a complex in many aspects of macroeconomics factors like alteration in the returns, volatility and uncertainty in the financial strategy and actions in the daily routine pointed by Broadstock and Cheng (2019). Among the green bond and equity markets it points out the learning of volatility modeling, risk assessment and co-movement. Green bond is not as much different from the other conventional bonds but the major purpose of the green bond is to give advantages to the environmental project.

This research aims to analyze the effect of green bond market on the equity markets of South Asia. This study identifies that if there is any spillover, volatility or price fluctuation in one market (Green bond market), can either affect the other market (Equity market). This study will also examine that either there is positive or negative correlation. Green bond market is the new and flourished market, this current study will also check whether it is good to invest in green bond market or not. The current research is conducted on day-to-day closing values of the S&P green bond index and the stock market data. The dealing size in the fixed income market is smaller than the stock market that's why the daily data have to be enough. This study observes spillover and volatility for the long period of time. In this study we will study the co-movement among the green bond market and equity market. Between green bond market and the equity market there is a feebly co-movement. In regards of green bond market, the advantageous modification for the financiers in the equity market. If there is high price spillover in equity market than it has an insignificant impact on the green bond prices analyzed by Reboredo & Ugolini (2020). If there is volatility in one market because of the volatility in another markets than the abnormality of volatility spillover occurs which studied by Gulfranz (2021). The main purpose of this study is to analyze the volatility in the green bond and spillovers to the equity markets of the South Asia.

### **Research Questions**

- Does spillover exist from green bond market to the Pakistani equity market?
- Does spillover exist from green bond market to the Chinese equity market?
- Does spillover exist from green bond market to the India equity market?

### **Significance of the Study**

This study examined the green bond usefulness to fund climate change costs and green bond market volatility. Global annual issuance of green bonds has risen each year since 2017-2019 record of \$266.1 bn. Various multi-national institutions and record of sixty-seven nations have originated green bonds (Climate Bond Initiative, 2020). There are positive effects of issuing green corporate bond on environmental and financial performance. It increases long-term green investment as well as green innovations. Different studies showed that prices of green bonds moved independently with stock market and changed

in energy prices. MSCI green bond index of global Barclays states that treasury bond market is integrated with green bond market. But further information that owing to price changes in treasury market, sizeable spillover impacts are received by green bond market. So, it transmit negligible reverse effects exhibited by Reboredo and Ugolini (2019). It is also represented by MSCI world index that stock market is weakly connected with green bond market and green bond market is independent of any price change in energy market and transmits minor price spillover effects.

Green bonds act like a specific asset class which is connected with currency exchange rates and treasury bonds but in case of other kind of assets, green bonds also offers some diversification opportunities. So, through this investors interest could also rise in green bonds. It will give the opportunity to issuers to extend their long term green investors base. It also favors more flows to projects of low-carbon. The ability of green bonds to finance low-carbon investments as an alternative source has been attracting the interest of investors across Asia and all over the world stated by Azhgaliyeva et al. (2020). Green bonds explosively global growth has also attracted the attention scholars. Several scholars have started studying the standards and definitions, pricing & issuance of green bonds. They have also begun to study risks & returns associated with green bonds. However green bond as an innovational finance tool is gaining popularity among many countries. Another reason of their popularity is that they are issued only for green energy projects and projects of environmental energy to reduce the effects of climate change & pollution control coined by Zhou & Cui (2019). Green bond is fixed income product. It offers opportunity to investors to take part in financing green projects. Green bonds help countries to adapt the plans of climate change. Therefore example of an innovative fixed income product is green bond that could raise specific amount of capital. This specific amount of capital is used in financing the fight against change in climate. Due to standard financial characteristics of green bonds, they have become very effective. Green bonds dedications to environmental issues make them desirable for various investors which have specific environmental strategies and institutional investors which are basically interested for climate oriented investments.

Green Bonds as an emerging concern over environmental protection catches the eyes of various institutions and investors. Joint dependent dynamics of green bonds and explored volatility help to understand the risk nature of green bonds and their effect on the financial environment. It fulfills the environmental concern along with wealth maximization objective of individuals. Therefore, the conclusion of the study enhances the investor's knowledge regarding how green bonds integrate with other major asset classes. Green bonds hedging properties along with aforementioned financial instruments will assist and motivate investors for their portfolio diversification and restructuring with aiming of

returns maximization on the given required risk of a portfolio. This is because green bond index perform outstandingly to hedge the market volatility even in the crisis period and is the most effective hedge for carbon futures showed by Ejaz (2021). If we understand the interdependence of green bond market performance and investor attention, it is found useful for policy in promoting environment friendly finance proved by Pham and Huynh (2020). Green bonds are considered to be sustainable and stable because they are used to fund those social projects which are long term. Example of long term projects is wind and solar energy facilities and they requires large amount of funding. So raising funds through large bond market for long period of time might be an appropriate choice. Stable investment for investor is considered to be green bonds that give long term income. Now green bonds are issuing for social purposes that is why political and social demand for green bonds is increasing. Thus, without burdening the portfolio of investors Green bond allows them to execute their green initiatives. Green bonds are easy to incorporate in to the portfolios because method of issuing green bonds is similar to the method of issuing traditional green bonds. On the other hand due to variable interest payments of traditional eco-friendly bonds, they are difficult to incorporate in to the portfolio (Park et al., 2020).

Green bond price is alike conventional bond when issuer and duration of the bond is same. Investors do not take lower returns of green bonds. Nowadays even investors get low return by integrating green bonds into the portfolio; they are willing to diversify their investments by having green bonds in portfolios. Environmental risk is decreased by issuing and investing in green bond which is quite beneficial. The cost of obtaining attention and resources for environmental degradation is expected to be reduced by green bonds. It is stated by U.S municipal bond market that Green bonds are traded at higher yield but at low price. They found that conventional bonds are given preference over green bonds summed up by Nylen (2021). Apart from investment and investors, this study opens a new direction for policymakers to devising strategies to develop the climate-resilient economy with mutual benefits (Ejaz, 2021).

## **2. Literature Review**

With the passage of time the financiers are initiating to diversify their portfolios. The financiers begin to start the diversification of global investments in 1960s and 1970s. According to Gilmore and McManus (2002), initially the US financiers earned profit through diversification. Phylaktis and Ravazzolo (2005) also explored the relationship of capital markets in growing economies through inference of the global diversification and foreign portfolio diversification. Liu (2016) identified that increase in the portfolio diversification of corporate bond market, and he also explored that this part of financial portfolio diversification was unnoticed. This study also revealed that the resulted portfolio reduced the straggle variance and increased the risk in the portfolio for

US financiers. Additionally, this study added that regardless of GFC 2008 bond market, the returns and work well than the financial market. Guesmi et al. (2019) identified hedging strategies depends on the commodities prices, upcoming financial markets, crypto currencies with less portfolio risk. In this study they used the GARCH models and recommends that DCC-GJR-GARCH model is best model for studying volatility. This study also emphasized that the role crypto currency in the risk profile of portfolio is too less. Result of the study that the use of upcoming financial markets, crypto currencies and prices of commodities build diversified portfolio which decrease the whole portfolio risk than the portfolio of only commodities and equities.

Jin et al. (2020) researched on the linkage among the carbon market with green bond, VIX, commodity and energy index. In this used various hedging ratio methods like DCC-APGARCH, DCC-TGARCH and DCC-GJR GARCH. The outcomes of the study are that throughout the volatile phase the dynamic hedging ratios worked well as compared to the OLS and these procedures is record the volatility spillover and also the dynamic correlation among the markets. The empirical results of the study are that the results of the green bond are more refined from hedging ratio with the carbon market as compared to other markets. Also declared that the green bond have a good hedging choice with carbon in futures. Saeed et al. (2020) claimed that the absence of indication related to the hedging skills of green bonds. But the linkage between the clean energy and black energy are time consuming. In this study they used the GARCH model to discover the dynamic conditional correlation and they used hedging ratio. The outcomes show that for the portfolio diversification they have to use the dynamic hedging ratios. The study also shows that the clean energy tools work well as compared to the green bond in portfolio optimization.

### **Market Efficiency Theory**

Fama (1970) suggested that the basic function of the capital market is the allocation of possession to the whole economy capital stock market. The best market is those markets where the charges are shown all the info existing in the market. In the efficient market the firms have ranges of demands in the manufacturing investments and the financiers must be sure that the charges must show the all data regarding to the product and which is not the overrated or underrated stocks in the market so that's why this market is known as the efficient market. Fama (1970) defined the purpose of the efficiency of this market. In this market there are three conditions. First one is the weak condition in which there is only reach to those materials which are related to the old values and earnings. The second one is the semi strong, in which the data is regarding to the community information and the final one is the strong in which the data is related to the community and secretive. All of the three conditions define that

the how the data obtainable to financiers. The strong condition covers the data regarding to the weak and also semi strong condition just like the old and ancient information, community data and the secretive data. At that time only the strong type have the authority to right of the personal secretive data related to the business and might be this information is related to the valuing of shares.

### **Empirical Review**

According to Pham and Huynh (2020) studied that the connection among investors and their response towards the green bond market and also the performance of the green bond market. They used a daily data of the green bond index and realize that the investors should have to invest in the green market and found that this link is being fluctuating with the passage of time. The outcomes of the study are that the investors have to invest money in this new advanced and rapidly developing green bond market. The results also highlight that the proper and suitable info leads to the maintainable investments. This study is carried on by the changed indices of the green bond market like the S&P green bond market and the S&P green bond select index. In this the S&P is shows the most common and the comprehensive green bond market while the second one shows the special and selected green bond market. In this the stock market indexes of the China are exemplified by the conventional bonds of the China and the stock market indexes of the US are exemplified by the conventional bonds of the US. In this the time is taken of the 10 years from 2010 to 2019. The outcomes of this study shows that the there is a high volatility seen in the green bond market as related to the conventional bond markets. In the first years there is also some leverage effects seen in the green bond market. The volatility spillover also exists between the both green market of the China and the US and there is also the co movement occurs among these two markets. Volatility is much tenacious in the comprehensive as compared to the selected green bond market. The outcome of the study emphasizes that due to the volatility the green bond market is much self-determining market as compared to the conventional bond markets.

A study by Diebold and Yilmaz (2008) investigated the relationship among asset return volatility and the macro-economics. They work on the largest data of the 40 countries from 1960 to onwards. The results are that there is a solid relationship in the volatility in the stock market and the macro-economic essentials. Hyun et al. (2020) are firstly not discovered any major indication of the revenue of the green bonds. When these bonds are licensed by another party then they discover the revenue premium of the green bonds. They signify that if we produce the worldwide the same and general green bonds then it will increase the value of the green bonds and also enhance the growth of these green bond markets. The outcomes of the study are that we found the much greater returns of the stock market for the issuance of general green bond market. Banga (2019) studied the adjustment of green bond market for decrease the risk in the

developing countries. The outcomes are that the increase in the green bond market in the developing and the developed countries are because of the investors because they invest money in this. Moreover, the green bond market is growing and emerging market in the developing nations and the obstacles in the advancement in the green bond market are absence of the suitable management for green bond market in the developing nations are problem of least size and the great contract prices. For the solution of this problem the study recommends effectual usage of domestic banks as works for management of native green bond market. For this purpose the local government also plays major play in the issuance of green bond.

Reboredo and Ugolini (2020) investigated in study that there is a price relationship among the green bond market and financial market. They use a VAR model in their study and show the straight and unplanned transfer of financial transmissions through the market. The result of the research tells that the green bond market is strictly linked with the fixed market. Due to the price spillovers from the fixed income markets and then they transfer the opposite effects. On the other hand it also suggests that the green bond market have feebly relationship with the stock and corporate bond markets. Tang and Zhang (2020) also studied about the green bond market from the year 2008 to 2017 and suggest that the stock market reacts positively towards the green bond market. This study also express that the liquidity in the stock market get developed after the green bond market and it also enhance the organizational ownership. But this study does not discover any indication of a constantly significant premium that means that the revenues from the stock market are not operate by the less value of the stock. Zerbib (2017) studied an identical ways relating the green bond market with the alike conventional bond market with the same bond features. On this the reduction rate of 0.08% on the green bond market. He discovers the lesser markup cost on the Europe at only the 0.02%. The characteristics of the study are the negative premium to the extra response and the payments of these green bonds in the market. He also discovers that in the response of the equity markets to the green bond market the geographical dissimilarities also matters. In the market of Europe there is a fewer positive average return in the stock market as compared to the worldwide average. According to Nylen (2021) suggestion that how the green bond market affects the prices of business's stock prices. The main purpose of the study that in the European market the stock market prices responds positively to the green bond market.

Alonso-Conde and Rojo-Suárez (2020) studied that due to the volatility spillover in the equity and green bond market it approves that there is uneven or unbalance volatility in the green bond market. As compared to the equity market the volatility of the green bond market is liable to the affirmative yield. Hou et al. (2019) investigated the study of volatility spillover of Chinese fuel, oil and

stock market. They apply the time variation DCC GARCH model. The research observed that different pattern exists in volatility spillover due to some structural breaks and this will be more useful for risk management. Christiansen (2010) analyzed the volatility spillover by used bivariate GARCH model. This spillover effect checks in the England and United States. This showed that each market's unpredictability is more affected by its own instability than by that of the other market. These past investigations showed that the questionable outcomes relying upon the area, sample periods and financial items stated by Park et al. (2020). According to Nguyen (2020) since the dispatch of green bond its market has developed with tremendous yearly rate which implies that it is significantly more imperative to comprehend the instruments of the market. Since that few earlier studies have focused on the volatility and liquidity risk of the green bond markets. For instance, Pham (2016) was one of the principal studies to analyze the volatility behavior happened on the green bond market. This examination is utilizing information from 2010 to 2015 from S&P green bond file between and tracked down some fascinating outcomes. Utilizing the multivariate GARCH model, study finds that the green bond market has huge volatility clustering as contrasted with ordinary bonds. In simple word, green bonds are not more volatile than ordinary bonds but if market sees high volatility of the green bond cost in the past, it is probably going to proceed soon. This finding gives some data of the green bond advertises and is essential to consider while examining the green security markets and their conduct whether members are investors or issuers.

Yang and Zhou (2017) examined the volatility spillover between international markets and they used the VAR model in different international markets instead of imposing a previous limitations. Flammer (2020) investigated the issuance of green corporate bond effect on financial markets. It results shows that the issuance of green corporate bond has positive effect on environmental and financial performance. It also rises the green long term investments and innovation. Past research also reflects that volatility dynamics affect the current conditional variance and covariance. Results showed that previous volatility effect the current variance. Empirical results proposed that those occasions that influence the volatility structure of financial instruments had significant impact on investors' portfolios. Reboredo and Ugolini (2020) added new evidence in the green bond market. They find the receives sizeable spillover impacts from value changes in the treasury market and sends negligible opposite effects. So find that the green bond market is interconnected to the money market of USD. At the point when changes in the USD transmitting impressive spillover to the green bond market, and changes in the green bond market passing on negligible spillover to the USD exchange rate. We additionally affirm that there is two-path spillover between the corporate debt market and the green bond market. According to the MSCI World Index the green bond market is weakly associated with the equity market. Overall, outcomes shows that the green bond market

essential for the growth of the treasury market. It is affected by the development of the USD exchange rate and shows low mix with the high return corporate bond and energy markets.

Nazlioglu et al. (2015) studied the volatility transmission between the Islamic and conventional equity markets. It is based on fact that Islamic equity market reached the market capitalization of 1.6 trillion dollars in 2013. Study explored the pre and post GFC 2008 volatility spill over dynamic between the, Asian, European and US conventional and Islamic equity markets along with the US Monetary policy, oil prices, VIX and US economic uncertainty index by using GARCH. Empirical results of study showed a transformation of risk between different markets. Volatility structure found short-run in first phase and long run in second phase and similar transmission pattern of volatility has been observed. Further study found Islamic equity market was more affected from risk factor (VIX) then the oil prices and US economic policy uncertainty index. According to Zhou and Cui (2019), the Green bonds are a financial instrument that has been promoted in the worldwide green finance field. The issuance of green bonds has seen explosive growth in the worldwide in the year 2013. China's green bond market has gained incredible development in the worldwide. They used Chinese listed companies as a research object and check the impact of green bond issuance on companies, including the effect of the declaration of green bond issuance on organizations, stock prices, financial performance and corporate social responsibility (CSR). These results indicate that declarations of green bonds issuance have a positive effect not just on organization's stock costs, organization's profitability, and operational performance, but also on innovation capacity, and can improve organization CSR's. Overall, outcomes show that the issuance of green bonds positive effects on organizations, promotes CSR and value creation, and helps to attract investors.

Park et al. (2020) examined the green bond market properties to check the existence of asymmetric volatility in bond green bonds. They used S&P 500 equity market index and S&P green bond index to explore the asymmetric volatility and find out the relationship of green bond and equity market. Results shows that the volatility exists in green bonds and react like conventional equity market but in less intensity. Both markets have some conditional variance spillover effect with greater impact of positive news on returns. Green bond market growing fastly, financial analyses conducted on green market in previous researches. Green bond volatility analyzed by Pham (2016), in which with the help of using GARCH model and S&P used by traditional bond markets. GARCH model shows that in the traditional bond market investors, green bonds don't gave the diversification effects and Reboredo and Ugolini (2020) also uses this model. The relation between green bonds markets and other financial instruments is crucial. It is depend on green bonds relationship with the stock and

energy commodity markets. The relation between Stock and bond markets has been considered. Yet, no relationship happens to depict the association between the two business sectors. The relationship between British short and long-term bonds and stocks shows that the profits in the two business sectors are adversely corresponded and it is analyzed by Steeley (2006). In descending order of countries issuing green bonds is USA, China, France, Germany, Spain, Canada, India, and Brazil. If we talk about development banks EIB, World Bank, and K&W are on the top three positions of green bond issuer. To meet the targets of financing the climate plans, the green bond issuance is increasing in banks and corporate sectors. It is the objective of climate bonds to increase green financing upto \$ 1trillion.

Jebran et al. 2017 also investigated the volatility and co-movement between Islamic and conventional equity market. GARCH and EGARCH model were applied to investigate the volatility spillover between Islamic and conventional equity market. Study found the volatility spillover which was bidirectional between Islamic equity market and conventional equity market. Furthermore study found that there is little opportunity for domestic investors to diversify their portfolio by adding Islamic equity. Naifar (2018) explored the impact of volatility on sukuk bond. DCC GARCH model was applied in study to explore correlation between change in commodity prices and sukuk bond. Negative correlation was shown between sukuk bond returns and commodity prices in result. The study also investigated that for ideal allocation of portfolio the understanding of volatility dynamics correlation is very important. Akkoc and Civcir (2019) investigated the relation between prices of oil, gold and Turkish stock index. They explored impact of change in prices of commodities on stock market return of turkey of developing economies. To investigate the dynamic spillover, SVAR DCC GARCH model was applied utilizing oil and gold international prices and equity index of Turkey (BIST). To describe SVAR model boot strap causality test was applied which is used to report nonstandard error distribution. The results described time varying co relation spillover from oil and gold to stock index of Turkey (BIST). Results showed that due to high volatility gold cannot be used as save heaven in portfolio and it has great impact on Turkish stock index than oil. Nylen (2021) investigated that green bond market is the small portion of bond market. It was also explored that stock index has both positive and negative impact on green bonds. The basic purpose of study was to examine the effect of green bond announcement toward stock prices of companies. OLS regression model was applied to measure the variables. Green bond which are issued by nonfinancial firms from 2013 to 2020 in Europe were collected for research purpose. The results of the study showed that there is negative announcement impact of green bonds. The result obtained from OLS regression showed positive results for S&P credit rating of company, callable green bonds and green bond issued in Europe.

## Hypothesis Statements

H<sub>1</sub>: There is a spillover between green bond market and Chinese financial market.

H<sub>2</sub>: There is a spillover between green bond market and Pakistan financial market.

H<sub>3</sub>: There is a spillover between green bond market and Indian financial market.

## Methodology

### Research Design

Research design basically explains about the structure of the study. Research design examines the study purpose and also explains about the sources of data. The research design entails the procedure used for the purpose of collecting, measuring and the analysis of the data. This research study is quantitative in nature and has used secondary data (Time series) for the purpose of analyzing the research question proposed in it. E views 8 software is used for the analysis of data.

### Type of investigation

This research study attempted to investigate the spillover among cross markets that includes green bond market and financial markets. The study is uni-directional that is, it shall attempt to find out the spillover from the green bond market to financial market. The nature of the study is explanatory.

### Data

The underlying study has used time series data and daily average closing price of three financial markets (Pakistan, India and China). The data for these three financial markets was obtained from PSX for Pakistan, BSX for India, and Shanghai Stock Exchange for China. Also, the daily average closing prices of green bond markets have been used for the study. Data of green bond market was obtained from [www.spglobal.com](http://www.spglobal.com). The duration of the data has been December 30, 2011 to December 30th 2019.

### Variables of Study

#### Stock returns

Daily closing prices were obtained for all the four markets including green bond market and three financial markets of Pakistan, India and China. Further, the returns were calculated from these closing prices. The formula for the return calculation is as follow:

$$= \text{Return } c \text{ Return}(-1) \quad (1)$$

## Model Specification & Estimation

The study aims to investigate the spillover from the green bond market to the financial markets selected for the purpose of the study. For this purpose, GJR Garch methodology was used.

### Measurement Of Daily Market Returns (Mean Equation)

The mean equation used for the purpose of the study is as follows:

$$R_t = \mu + \lambda_i R_t - 1 + \varepsilon_t \quad (2)$$

### Modelling GJR Garch (Variance Equation)

GJR GARCH model has been proposed by Glosten-Jagannathan-Runkle is often by numerous studies to investigate the spillover among the markets. The model assumes to measure the conditional heteroscedasticity through the following equation by considering a return time series:

$$r_t = \mu + \varepsilon_t \quad (3)$$

Where  $\mu$  is the expected return and  $\varepsilon_t$  is a zero-mean white noise. Despite of being serially uncorrelated, the series  $\varepsilon_t$  does not need to be serially independent. For instance, it can present conditional heteroskedasticity. The Glosten-Jagannathan-Runkle GARCH (GJR-GARCH) model assumes a specific parametric form for this conditional heteroskedasticity. More specifically, we say that  $\varepsilon_t = \sigma_t Z_t$ , where  $Z_t$  is standard gaussian and:

$$\sigma_t^2 = \omega + (\alpha + \gamma_{t-1}) \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \quad (4)$$

## Data Analysis

For the purpose of data analysis EViews 8 has been used. The following procedure has been adopted to test the above-described model on the data collected for the purpose of this study.

### Unit Root Test

In a time, series data, the component root experiment is being used to examine the stationarity. Unless the data is horizontal the mean as well as discrepancy are continuous.

### LM Test

In such a regression model, the Breusch–Godfrey habitual regression LM exam is a measure of autocorrelation throughout the mistakes. It renders use of residuals from either the system becoming regarded in a logistic regression, but from those was deduced an exam stat. There's no serial connection of every attempt up in p.

### ARCH (1,0)

Return equation was estimated through OLS. The next step was to check the ARCH Effect within the series selected for the purpose of the study. Each series was tested for ARCH test. The ARCH Test was executed through heteroscedasticity test. In order to check the volatility spillover, volatility spillover series shall be created.

### GJR-GARCH (1,1)

Finally, GJR-GARCH method was applied to find out the spillover from the green bond market to the financial markets.

## Results & Discussion

### Unit Root Test

Table 1: *Unit Root Test (China)*

	<b>t-Statistic</b>	<b>Prob.*</b>
Augmented Dickey-Fuller test statistic	-36.738	0.000

Table 2: *Unit Root Test (Green Bonds)*

	<b>t-Statistic</b>	<b>Prob.*</b>
Augmented Dickey-Fuller test statistic	-40.809	0.000

Table 3: *Unit Root Test (India)*

	<b>t-Statistic</b>	<b>Prob.*</b>
Augmented Dickey-Fuller test statistic	-34.884	0.000

Table 4: *Unit Root Test (Pakistan)*

	<b>t-Statistic</b>	<b>Prob.*</b>
Augmented Dickey-Fuller test statistic	-35.744	0.000

First of all, we have to see null hypothesis of unit root test which is there is a unit rule it means that the time series is non-stationarity, so if the p-value is less than 0.05, we will reject this null hypothesis, so this is the result of unit root test and we know that the rule of thumb is that if the p-value is less than 0.05, we reject null hypothesis and null hypothesis says that the time series is non-stationarity. It means that there is a trend after seeing the p-values, we can conclude that the data series of green bond markets and financial markets is stationary at level.

**Autocorrelation**Table 5: *Autocorrelation*

Serial Name	Durbin Watson Stats
Green Bonds	1.9984
Pakistan	1.9974
India	1.9996
China	2.0016

**Heteroscedasticity Test (ARCH Test)**Table 6: *ARCH Test for Green Bonds Market*

F-statistic	6.6163	Prob. F (1,1489)	0.0102
Obs*R-squared	6.5958	Prob. Chi-Square (1)	0.0102

As the p-value is less than 0.05, it suggests that the ARCH effect exists in the green bond market return series. Further, it shows that further analysis can be executed in order to check spillover.

**GARCH Test (GJR Test)**Table 7: *Spillover green bonds to Pakistan*

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-4.69E-05	0.0003	-0.1391	0.8894
GREEN_BONDS(-1)	-0.0553	0.0803	-0.6897	0.4904
Variance Equation				
C	1.89E-05	1.21E-05	1.5658	0.1174
RESID(-1) <sup>2</sup>	0.1500	0.0941	1.5948	0.1107
GARCH(-1)	0.6000	0.2337	2.5673	0.0103
VSOP	0.0000	6.33E-06	0.0000	1.0000

The mean equation of table 7 shows that no volatility exists in the green bond returns whereas the variance equation that explains the error term shows that volatility exist as p-value is less than 0.05, the beta coefficient of GARCH (-1) shows that 60% volatility exists in the green bond market. However, spillover does not exist because the p-value is greater than 0.05.

**Table 8:** *Spillover green bonds to India*

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-4.69E-05	0.0003	-0.1391	0.8894
GREEN_BONDS(-1)	-0.0553	0.0802	-0.6897	0.4904
Variance Equation				
C	1.89E-05	1.21E-05	1.5677	0.1170
RESID(-1) <sup>2</sup>	0.1500	0.0942	1.5931	0.1111
GARCH(-1)	0.6000	0.2336	2.5681	0.0102
VSOI	0.0000	6.70E-06	0.0000	1.0000

The mean equation of table 8 shows that no volatility exists in the green bond returns whereas the variance equation that explains the error term shows that volatility exist as p-value is less than 0.05, the beta coefficient of GARCH (-1) shows that 60% volatility exists in the green bond market. However, spillover does not exist because the p-value is greater than 0.05.

Table 9: *Spillover Green Bonds to China*

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-4.69E-05	0.0003	-0.1391	0.8894
GREEN_BONDS(-1)	-0.0553	0.0802	-0.6897	0.4904
Variance Equation				
C	1.89E-05	1.21E-05	1.5677	0.1170
RESID(-1)^2	0.1500	0.0942	1.5931	0.1111
GARCH(-1)	0.6000	0.2336	2.5681	0.0102
VSOC	0.0000	6.70E-06	0.0000	1.0000

The mean equation of table 9 shows that no volatility exists in the green bond returns whereas the variance equation that explains the error term shows that volatility exist as p-value is less than 0.05, the beta coefficient of GARCH (-1) shows that 60% volatility exists in the green bond market. However, spillover does not exist because the p-value is greater than 0.05.

**Conclusions & Limitations**

The main purpose of this research is to find the impact of green bond market on the stock market of South Asian countries especially Pakistan, India, and China. This research also provides insight into the volatility of green bond market prices on the stock market of these countries. The relation among green bond market and stock markets of these countries are also examined during this research. We also investigate the spillover among cross markets that include green bond market and financial markets in this research. This research study is quantitative in nature and has used secondary data (time-series) and the daily average closing price of three financial markets (Pakistan, India, and China). The data for these three financial markets were obtained from PSX for Pakistan, BSX for India, and Shanghai Stock Exchange for China) For the purpose of data analysis, EViews 8 has been used. In this research, we used methodologies such as Unit Root Test, LM Test, ARCH (1, 0), GARCH (1, 1), and GJR-GARCH (1, 1) to find out the spillover in stock markets of Pakistan, India, and China. We concluded that the ARCH effect exists in the green market return series.

For green bond market of Pakistan, no volatility exists in the green bond returns whereas the variance equation that explains the error term shows that volatility exists as p-value is less than 0.05, the beta coefficient of GARCH (-1) shows that 60% volatility exists in the green bond market. However, spillover does not exist

because the p-value is greater than 0.05. In China, no volatility exists in the green bond returns whereas the variance equation that explains the error term shows that volatility exists as p-value is less than 0.05, the beta coefficient of GARCH (-1) shows that 60% volatility exists in the green bond market. However, spillover does not exist because the p-value is greater than 0.05. In India spillover does not exist because the p-value is greater than 0.05.

After concluding all these findings, study recommends to all the market players including policymakers, investors, and portfolio managers to keep a sharp eye on the arising information in different stock markets. Some most important recommendations of this study are as given below. The overall results of this research strongly recommend to the markets players including traders, investors, portfolio managers as well as research analysts to have the strongest hold on the fluctuation of green bond market as it is positively linked with Pakistan Stock Exchange, BSX for India, and Shanghai Stock Exchange for China.

Green bond and equity markets are not completely independent and information spillover exists between markets that have implications for risk diversification. Researcher and investor can use this research study as a pre-work study before working on the spillover volatility of any country. Investors of stock markets can use our findings as a role model in the process of investments as well as risk management as the volatilities are found more influenced than returns. For policymakers and investors, it is very necessary to keep cunning eyes on market performance to avoid risk. There are time-varying conditional correlations in the stock market which indicates decision-makers should consider the dynamic nature of correlation for portfolio restructuring and optimal hedging. This research study is limited only to the Pakistan, India, and China stock exchange markets.

## References

- Akkoc, U., & Civcir, I. (2019). Dynamic linkages between strategic commodities and stock market in Turkey: Evidence from SVAR-DCC-GARCH model. *Resources Policy*, 62, 231-239.
- Alonso-Conde, A. B., & Rojo-Suárez, J. (2020). On the effect of green bonds on the profitability and credit quality of project financing. *Sustainability*, 12(16), 6695.
- Azhgaliyeva, D., Kapoor, A., & Liu, Y. (2020). Green bonds for financing renewable energy and energy efficiency in South-East Asia: a review of policies. *Journal of Sustainable Finance & Investment*, 10(2), 113-140.
- Banga, J. (2019). The green bond market: a potential source of climate finance for developing countries. *Journal of Sustainable Finance & Investment*, 9(1), 17-32.

- Broadstock, D. C., & Cheng, L. T. (2019). Time-varying relation between black and green bond price benchmarks: Macroeconomic determinants for the first decade. *Finance Research Letters*, 29, 17-22.
- Christiansen, C. (2010). Decomposing European bond and equity volatility. *International Journal of Finance & Economics*, 15(2), 105-122.
- Diebold, F. X., & Yilmaz, K. (2008). *Macroeconomic Volatility and Stock Market Volatility Worldwide* (No. w14269). National Bureau of Economic Research.
- Ejaz, R. (2021). *Green Bond and International Financial Markets: Spillover, Co-Movement and Diversification* (Doctoral dissertation, Capital University).
- Fama, F. Eugene. (1970). Efficient capital markets: A review of theory and empirical work. *The Journal of Finance*, 25(2), 383-417.
- Flammer, C. (2020). Green bonds: effectiveness and implications for public policy. *Environmental and Energy Policy and the Economy*, 1(1), 95-128.
- Gilmore, C. G., & McManus, G. M. (2002). International portfolio diversification: US and Central European equity markets. *Emerging Markets Review*, 3(1), 69-83.
- Guesmi, K., Saadi, S., Abid, I., & Ftiti, Z. (2019). Portfolio diversification with virtual currency: Evidence from bitcoin. *International Review of Financial Analysis*, 63, 431-437.
- Gulfraz, N. (2021). *Bi-directional Mean and Volatility Spillover among Equity Markets* (Doctoral dissertation, Capital University).
- Hou, Y., Li, S., & Wen, F. (2019). Time-varying volatility spillover between Chinese fuel oil and stock index futures markets based on a DCC-GARCH model with a semi-nonparametric approach. *Energy Economics*, 83, 119-143.
- Huynh, T. L. D., Hille, E., & Nasir, M. A. (2020). Diversification in the age of the 4th industrial revolution: The role of artificial intelligence, green bonds and cryptocurrencies. *Technological Forecasting and Social Change*, 159, 120188.
- Hyun, S., Park, D., & Tian, S. (2020). The price of going green: the role of greenness in green bond markets. *Accounting & Finance*, 60(1), 73-95.
- Jebran, K., Chen, S., and Tauni, M. Z. (2017). Islamic and conventional equity index co-movement and volatility transmission: Evidence from Pakistan. *Future Business Journal*, 3(2), 98-106.
- Jin, J., Han, L., Wu, L., & Zeng, H. (2020). The hedging effect of green bonds on carbon market risk. *International Review of Financial Analysis*, 71, 101509.
- Karesjoki, R. (2020). Volatility analysis of the green bond market: clustering, leverage effects and spillovers from conventional bond markets.
- Liu, E. X. (2016). Portfolio diversification and international corporate bonds. *Journal of Financial and Quantitative Analysis*, 51(3), 959-983.

- Nazlioglu, S., Hammoudeh, S., & Gupta, R. (2015). Volatility transmission between Islamic and conventional equity markets: Evidence from causality-invariance test. *Applied Economics*, 47(46), 4996-5011.
- Nguyen, V. (2020). How implied volatilities in energy sector, crude oil and stock market affect the performance of green bond? Evidence from green bond market.
- Park, D.; Park, J.; Ryu, D. (2020). Volatility Spillovers between Equity and Green Bond Markets. *Sustainability* 2020, 12, 3722.
- Pham, L. (2016). Is it risky to go green? A volatility analysis of the green bond market. *Journal of Sustainable Finance & Investment*, 6(4), 263-291.
- Pham, L., & Huynh, T. L. D. (2020). How does investor attention influence the green bond market? *Finance Research Letters*, 35, 101533.
- Phylaktis, K., & Ravazzolo, F. (2005). Stock market linkages in emerging markets: implications for international portfolio diversification. *Journal of International Financial Markets, Institutions and Money*, 15(2), 91-106.
- Piñeiro-Chousa, J., López-Cabarcos, M. Á., Caby, J., & Šević, A. (2021). The influence of investor sentiment on the green bond market. *Technological Forecasting and Social Change*, 162, 120351.
- Reboredo, J. C., & Ugolini, A. (2020). Price connectedness between green bond and financial markets. *Economic Modelling*, 88, 25-38.
- Saeed, T., Bouri, E., & Tran, D. K. (2020). Hedging strategies of green assets against dirty energy assets. *Energies*, 13(12), 3141.
- Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance*, 61, 101427.
- Yang, Z., & Zhou, Y. (2017). Quantitative easing and volatility spillovers across countries and asset classes. *Management Science*, 63(2), 333-354.
- Zerbib, O. D. (2017). The Green Bond Premium. SSRN Working Paper.
- Zhou, X., & Cui, Y. (2019). Green bonds, corporate performance, and corporate social responsibility. *Sustainability*, 11(23), 6881.