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# The Study of Relation Among Green Bonds and Other Financial Assets: A Systematic Literature Review

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**Abstract:** The purpose of this study is to provide a literature review of green bonds and their relation with other financial assets. Most of the research that has been conducted has focused on the spillover transmission from the financial asset market to the green bond market. The method used to select and analyze the results of journal reviews is Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The journals used in this study are Scopus-indexed journals, which are searched using the keywords green bond, cointegration, transmission, and spillover. The result indicates that green bonds can be used as an alternative in diversifying portfolio instruments. Based on previous studies, it was found that there was spillover transmission from the financial asset market to the green bond market. This indicates that volatility in the financial market will spill over and affect the green bond market. This study can be used as a strategy for making investment decisions, especially in building investment portfolios.

**Keywords:** green bonds, PRISMA, spillover, spillover transmission, volatility transmission.

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## INTRODUCTION

The countries' economic growth of the world is seen as one of the goals and the macroeconomic indicators. This economic growth shows a country's prosperity level. However, economic growth emerges an unnoticed impact on the survival on earth. The increase of Greenhouse Gas Emissions (GGE) in the earth's atmosphere has persisted, as a result of the development of technology and industry, which has caused global warming (Nordhaus, 2018). Global warming has resulted in the earth's climate change and affected the occurrence of natural disasters, crop failure, and hunger. The issue of global warming does not only affect the ecosystem and environmental damage, yet it potentially impacts economic disruption and financial stability. Financial analysts state that if global warming is not resolved and the global temperature rises rapidly, the world's economic growth will decrease to 80%. In contradict, if the world's temperature is able to be decreased by less than 2° Celsius,

global economic growth will decline by approximately 4%. Based on Koh (2018), building the infrastructure in order to resolve global warming, is needed funding of about USD 92 trillion.

Green financing is a financial innovation that has banking funding, microcredit, insurance and investment, either from the public sector, private or franchise, that is used to fund the green project and to reduce the impact of global climate change (Cui et al., 2020; Zhang et al., 2022). In other words, green financing is funding for sustainable building projects and relates to the environment and policy of sustainable economic development. Green bond, green index, and environmental insurance are some samples of green financing (Gilchrist et al., 2021). Green Bond is an investment that has a purpose in line with Sustainable Development Goals (SDG) and qualified the Sustainable and Responsible Investing (SRI). The green bond is issued for the purpose of funding projects related to environmental preservation, anticipating global climate change and developing renewable energy (Pham & Huynh, 2020; Banga, 2019).

The environmental bond was first published in 2007 by the European Investment Bank (EIB), known as Climate Awareness Bond. The aim of the publication was to have funding collection in order to look for renewal energy, the value of the bonds reached EUR 600 million. In 2008, World Bank via International Bank for Reconstruction and Development (IBRD) for the first time published green bond, with a publication value of around USD 440 million. The world's banking foundations that also published Green Bond were The African Development Bank (AfDB) in 2013, The International Finance Corporation (IFC) in 2010, Asian Development Bank (ADB), European Bank for Reconstruction and Development (EBRD), and Nordic Investment Bank (NIB) (World Bank, 2015). The publication of green bond was subject to standards and procedures applied globally, namely the Green Bond Principles (GBP), which was published by International Capital Market Association (ICMA) on January 2014 and by the Climate Bonds Standard (CBS) (Reboredo, 2018).

Currently, the green bond is traded at the world stock exchanges, such as Europe, China, Singapore, the U.S., and South America, and in the last two years was traded at the Shenzen stock exchange, Bombay, and Indonesia. Besides the multilateral and government financial foundations, companies get involved in green bond issuance. Companies that issued the green bond are those whose commitment to environmental preservation, can be seen from the increase in the improvement of environmental performance as well as the financial performance at the publishing companies (Flammer, 2021).

Along with the growth of the green bond market, lots of research about green bond have been done. With the various background of knowledge, the researchers do research with stream research in Finance, Marketing, Strategic Management, Economics, and Business. The most researched topic related to green bond is the relationship between green bond and other financial instruments, the topic of greenium or green premium phenomena is at the second position followed by the green bond topic from the supply sides, green bond and stock reaction, the green bond market performance analysis and other topics excluded those classifications (Cortellini & Panetta, 2021).

Greenium is a very developed topic to be researched. Greenium is an application of investors' taste theory, in which the investors who invest their funding in the green bond are the ones who have a taste for environmental preservation and not only for interests (Baker et al., 2018). Greenium or green premium is shown by the investors' willingness to buy a green bond with a high price even though it promises a lower yield compared to the conventional bond (Partridge & Medda, 2018). The presence of greenium or green premium encourages companies to issue green bond (Hsueh, 2019). Greenium is found in the primary market (Agliardi & Agliardi, 2021)

or the secondary market (Alessi et al., 2021; Immel et al., 2021; Zerbib, 2019; Bachelet et al., 2019; Febi et al., 2018; Hachenberg & Schiereck, 2018; Baker et al., 2018; Karpf & Mandel, 2017). Greenium which is found in the primary market shows green bond investors' motivation that contributed to environmentally friendly projects. Otherwise, greenium which is found in the secondary market will put pressure on the primary market. Besides that, greenium at the secondary market becomes the indicator of what the market bears.

The relationship between the green bond market and other financial markets becomes another subject of research. The knowledge about mutual movement between the green bond price and the important asset price is known by the investors, especially to arrange the investment portfolio and diversification assets. There is a strong correlation between the green bond market and the treasury bond market and the corporate bond market, while green bond has a weak co-movement with high yield bond, the stock market and the energy market (Reboredo 2018). Green bond price has a strong correlation with the currency market and the fixed-income investment market (Reboredo & Ugolini 2019). This research is supported by further research which stated that there is a strong correlation between the green bond market, treasury market and corporate bond especially markets in the U.S. and European Union (Reboredo et al., 2020). The results state that green bond can become the hedging tool and portfolio arranging instruments. The correlation between the green bond market and the black bond market (conventional bond) is affected by macroeconomic factors such as volatility in the financial markets, economic policy uncertainty, the condition in the business world, oil prices, and market sentiments (Broadstock & Cheng 2019). Changes in the world oil prices will also trigger changes in the green bond market and vice versa. World oil prices have only predictive power in bullish market conditions, in the bearish market, the green bond prices can be the hedging tool for world oil prices. Besides that, geopolitical risk (the country's political upheaval, terrorism issues, and geopolitical pressure) has predictive value on green bond price changes (Lee et al. 2020). There is a strong correlation between carbon futures return and green bond return, this can be interpreted as green bond ability of green bond as a hedging tool for carbon futures (Jin et al. 2020). A long position in carbon futures can be hedged with a short position in green bond. Green bond can be a diversification of assets both in the medium and long term for stock investors. Green bond has diversification potential and becomes safe haven instruments (Arif et al. 2021). It is because the green bond has a neutral relationship with the commodity market and financial market. The fluctuation in the U.S. dollar exchange rates affect the relationship between return green bond and return conventional bond, in which the increase of dollar exchange rates will increase the correlation between green bonds and conventional bonds. In contradiction, if there is a decline in the U.S. dollar exchange rates, it will impact the decreasing correlation between green bond and the energy market and stock markets. This means that green bond can be used as a hedging tool for the value of the assets in the energy market and stock markets, during turbulent times (Kocaarslan 2021).

The research with a systematic literature review about green bond had been done before, among others: the study of literature by Cheong & Choi (2020) revealed three major research topics related to green bond such as pricing green bond, the effect of green bond issuance on company value and the effect of green bond issuance on the economy and the environment. Meanwhile, research by Liaw (2020), focused on the study of greenium, both in the primary market and the secondary market. In addition, from this study, it can be concluded that the results of this research showed that the differences in results were influenced by the matching method and the data used. Similar to the previous research, research by MacAskill (2021) conducted literature reviews on

research that focused on green premium or greenium, which was the difference between the yield and price of the green bond and conventional bond. Cortellini & Panetta (2021) compiled a review of green bond literature by discussing it from a more complete aspect by including the topic of market reaction to the issuance of the green bond, green bond from its supply side, green bond and market performance analysis, in addition to the former topics, namely greenium. This study literature also reviews green bonds and their relationship with other financial investment instruments. Recent research about green bond has found that there is a correlation between the issuance of environmentally friendly funding and the company value (Gilchrist et al., 2021). Ntsama et al. (2021) conducted a literature review on green bond with the background in countries that categorized low and middle-income countries.

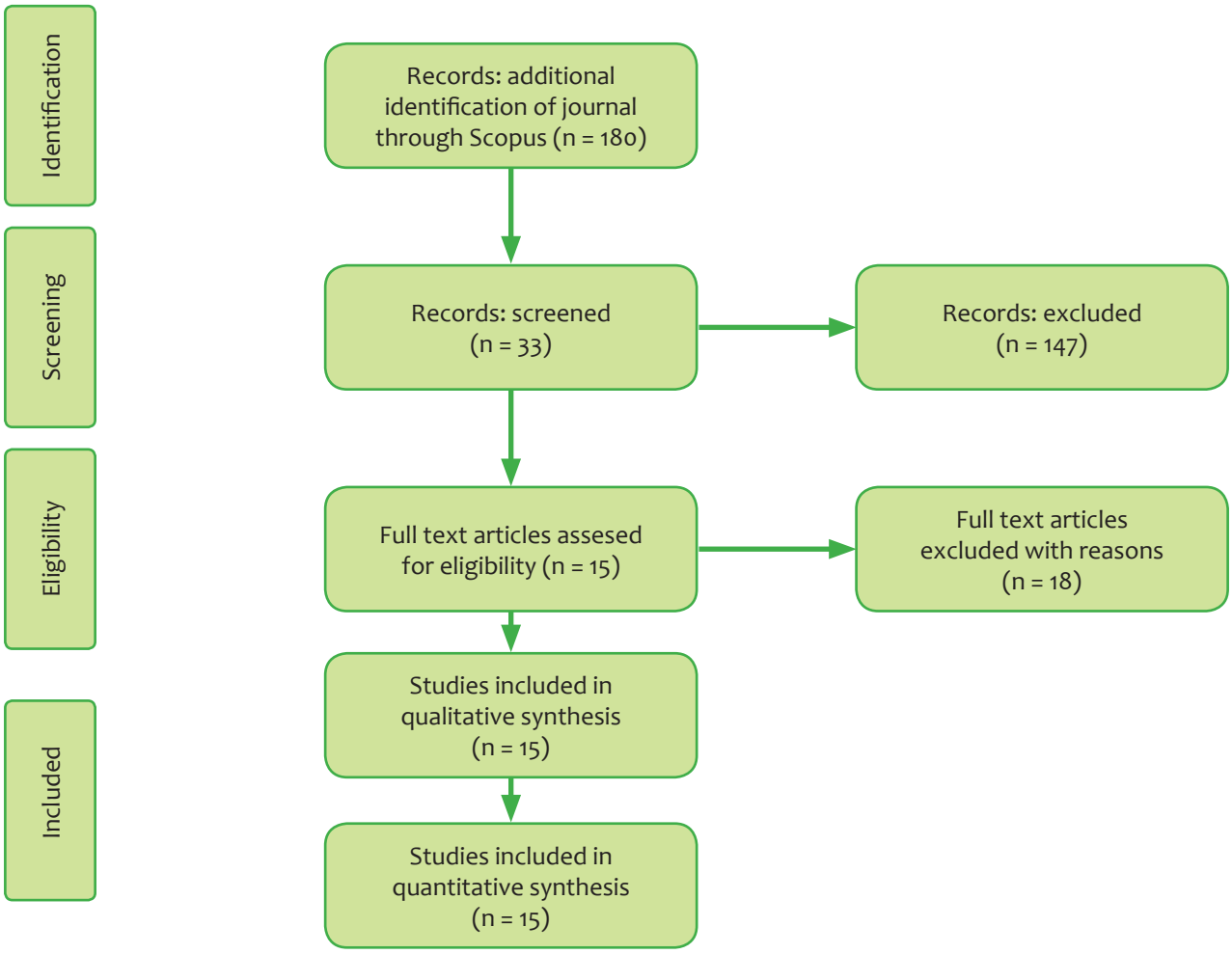
The research aims to develop a state-of-the-art topic of green bond with the main focus on the relationship between green bond and other financial assets and other determination factors. For portfolio managers and investors, the higher the diversification of investment instruments, the closer to achieving the goals of the investment strategy. Therefore, it is important to comprehend market connectivity among countries, co-movement, cointegration, spillover and contagion between markets and financial assets. The research stages are carried out through a review of the previous studies by using the keyword spillover, transmission spillover, volatility transmission, and the that are close. The finding will become the input for further research.

## METHODS

The data used in this study are articles published in reputable Scopus indexed journals. Data was downloaded from Scopus Elsevier database using keywords: green bond, spillover and transmission. The method used to compile a systematic literature review (SLR) in this research uses the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method (Selçuk, 2019). A systematic literature review is a review conducted to formulate research questions using a systematic method to identify, select and critically assess relevant research. Then, collecting related literature for the analysis (Moher, 2009). The aim of using the PRISMA method is to assist the writer to improve their analysis of literature studies and meta-analysis (Figure 1). PRISMA provides directions for compiling a literature review which contains 27 checklist items related to the topics discussed and stages that should be taken in preparing the SLR. These stages are: identification, screening, eligibility, and included, and are carried out at the moment of sample selection. Referring to the research purposes, the focus of the research is on searching the green bond journal with topics of spillover between the green bond market and other financial markets.

The first step in determining the literature related to green bond topics is by downloading them through the Scopus Elsevier database. The selected published articles are English articles published in Scopus-indexed journals. The journal publication period is from 2018 to 2022. Articles are searched using the keywords green bond, volatility, transmission and spillover. Then, the criteria are narrowed down to only using research articles and subject areas including economics, econometrics, and finance, so that a total of 180 articles are obtained.

The next step is screening the selected articles via their abstracts. The articles which do not contain the keyword green bond are then eliminated. Based on the screening, 147 articles are issued and 33 articles are obtained. The next step is to select only those articles that discuss volatility spillover and price spillover so that the final result obtains 15 eligible articles for further in-depth review.




Source: A Guide for Systematic Reviews: PRISMA (Selçuk, 2019)

**Figure 1 PRISMA Method**

## RESULTS AND DISCUSSION

International trade is a factor in the transmission of financial system instability (shock) between countries. The crisis that occurs in one country within a certain period of time can spread to countries that become a trading partner. Spillover and contagion are defined as shock transmission mechanisms from one country to another, spillover is a transmission mechanism both in good conditions (good time) or in a bad condition (bad time). A different thing to contagion happens in a bad condition (bad time), such as the crisis due to the currency exchange rates in Mexico in 1994, the crisis in Asia in 1997, the subprime in the U.S in 2008, the currency crisis in 2018 (Rigobon, 2019). Based on (Engle, 1990) spillover emerges whenever there is a shock to returns and volatility in one market spreads to other markets. The difference is that return spillover is a transmission of returns between financial markets, while volatility spillover is a transmission of volatility between financial markets Nguyen & Le (2021).

The green bond is an innovation in the field of financial investment, which differs from bond in general, green bond is issued to obtain funding for projects which generate sustainable benefits and is environmentally friendly (Daszyńska-Żygadło et al., 2018). According to World Bank (2015), projects that are funded by the green bond are those that support efforts to develop a lower carbon energy transition and support efforts to reduce world climate change. Meanwhile, Green Bond Principles (GBP) outlines the categories of projects that meet the requirements for green bond funding including renewable energy, energy efficiency, green building, sustainable waste management, sustainable land use, clean transportation, and adaptation to the climate change on earth. Differing from the conventional bond, the green bond is required to have the green bond label. The green bond label is a tool to monitor the consistency of green bond proceed usage, from its issuance time to maturity. From the monitoring result, the investors are able to get information related to the use of green bond funds and the positive impact of the use of funds that suits what is expected. As the investment offers fixed income, the green bond has lower risk compared to investment in other financial assets such as stocks. Otherwise, it does not mean that green bond has no higher return promises. The increasing volume of green bond issuance from various types of issuers shows an increase in green bond risk and this also shows an increase in returns. Besides that, more and more countries are issuing green bond using their own currency, and the funds obtained are used to finance projects that promise attractive levels of income (World Bank, 2015). For the investors, the diversity mentioned above makes the green bond a profitable instrument in the preparation of investment portfolios along with other types of financial assets.

Even though the green bond market is relatively new compared to the conventional bond in general, if there is financial system instability or shock in the green bond market, it will "overflow" or spillover occur to the conventional bond market. There is evidence indicating that there is a volatility spillover between the green bond and the conventional bond market. Both the green bond market has a label that does not have a positive correlation with the conventional bond market (Pham, 2016). If in the former articles, the detection of volatility spillover is carried out using univariate generalized autoregressive heteroskedasticity (GARCH), then in another research using multivariate GARCH it is found that there is a positive correlation between the green bond market and the conventional bond market at different time periods (Daszyńska-Żygadło et al., 2018). However, this correlation is not directly proportional to the ability of a green bond to make changes to a conventional bond. The size of a green bond is smaller compared to conventional bonds is the main reason.

Using the static and dynamic copula function to analyze the dependency structure between the green bond market and treasury market, corporate bond market, stock market and energy market, the results show that green bond receive spillover effects from the price changes that occur in the corporate bond market and treasury fixed income. It means the green bond global market will move together (co-movement) with the fixed-income asset market (in this research, treasury fixed-income market and corporate bond) (Reboredo, 2018). Green bond does not have a diversification effect on the fixed-income asset market. The finding results in the co-movement between the green bond global market and the energy market and the stock market is detected to be very weak. By adding several variables, that is high yield corporate bond, and currency market, besides other variables that have been studied in the former research, further research is carried out to examine the transmission of the changes in price in the green bond global market. Differing from the previous research, this research uses Structural Vector Autoregression Model (VAR) that is believed to be able to capture transmission direct or indirect when a shock occurs in the financial market. This research, the result shows that there is a strong correlation between the currency market and the green bond market, in which fluctuation occurs in the financial market and will transmit price spillover to the green bond market (Reboredo & Ugolini 2019).

Macroeconomic factors are sensitive to the relationship between green bond and conventional bond. The macroeconomic variables refer to include stability in financial markets, the uncertainty of economic policy (economic uncertainty), economic/business activities, world oil prices, and green bond market sentiment (Broadstock & Cheng, 2019). This research uses Dynamic Conditional Correlation (DCC) to examine the relationship between green bond and macroeconomic factors. Besides being affected by the changes in other assets, green bond prices also are influenced by factors that are indicators of world macroeconomics. Fluctuations that occur in world oil prices have an impact on the volatility in a green bond market, therefore any changes in oil prices will affect price spillover in the green bond market and vice versa. Examining for the co-integration this research uses the Quantile Auto-Regressive (GAR) and the causality relationship between variables is examined using the Grange-Causality in Quantile Test. This condition mainly occurs during the bearish condition. Investors are able to diversify their portfolios in bullish market conditions. Different things are found in geopolitical risk which is only a factor that influences the volatility of green bond prices, or only has a relationship that influences in one direction (Lee et al., 2020).

Using the green bond market data in America and Europe, the green bond market tends to have a strong co-movement with the treasury market and corporate bonds, both in the American and European markets on several time scale measurements. In contrast, there is weak co-movement between the green bond market and the high-yield corporate bond market, stock market and energy stock market (Reboredo et al. 2020). This research uses Multivariate Vector Auto-Regressive (MVAR) to examine the dynamic correlation between the green bond market and financial asset market instruments.

Simultaneously, the green bond has the ability to anticipate fluctuations in the financial market. Along with the major financial markets and energy markets, the green bond market quickly responds the incoming information. The green bond market transmits shock to other markets in a short term. Similar to the previous research, there is a spillover effect, both on return and volatility, between the global green bond market and global treasury market, and the conventional bond market. However, the green bond market receives a low spillover effect, that even almost no existence with the stock market, renewable energy market, and the world oil market. It can be concluded that the green bond can be a portfolio instrument along with these asset instruments due to offering diversification privilege (Ferrer et al., 2021).

Volatility in the stock market affects volatility in the green bond market and vice versa (Park et al., 2020). Using Dynamic Conditional Correlation Generalized Auto Regressive Conditional Heteroskedasticity (DCC-GARCH), it can be said that there is volatility transmission or volatility spillover on the green bond market and the stock market, which are sensitive to positive return shocks. It is a positive response to financial instruments for environmentally friendly investments. Conversely, the negative shock that occurs in the green bond market does not spread to other markets. This shows that the transmission of volatility between the stock market and the green bond market is not asymmetric. Green bond has a strong correlation with carbon market futures, especially during the financial crisis. Using three dynamic hedging models (DCC-APGARCH, DCC-T-GARCH and DCC-GJR-GARCH), volatility transmission is found between the carbon futures market and the green bond market, besides that, it is summarized that the green bond index can be used as an effective and inexpensive hedging instrument for carbon risk. The green bond is the only instrument that has a positive hedging ratio value, so in this condition, a short position must be added to the portfolio. A positive hedging ratio value remains through crisis periods and shows green bond as the best hedging instrument (Jin et al., 2020).

In a high uncertainty condition, such as during the Covid-19 Pandemic, the green bond market is affected by economic policy uncertainty, capital market, and oil commodity market uncertainty (Pham & Nguyen, 2022).

The Markov Switching Dynamic regression (MSDR) method is used to analyze the effect of uncertainty on the green bond market. In contrast, in a low uncertainty condition, the green bond market only has less effect by uncertainties in economic policies, the stock market, and the petroleum commodity market. In this case, the uncertainty transmits the shock to the green bond.

Using the Diebold and Yolmaz models to measure the spillover effect that occurs on the green bond market during the Covid-19 Pandemic has found that there is risk spillover of the green bond global index to the sectoral green bond index. The financial sector green bond index is a sector that, in a bearish market condition, does not integrate with the green bond global index, so the financial sector green bond index is a safe haven for the green global index, especially during a turbulent condition such as during the Covid-19 Pandemic. The risk spillover that occurs between the green bond global market and the sectoral green bond price index is triggered by risk aversion, financial condition, and the Covid-19 Pandemic variables (Mensi et al., 2022). Markets that get spillover are more accurate in providing forecasts, yet the accuracy will decrease along with the volatility of the dynamic correlation. The green bond volatility is mostly driven by uncertainty in the fixed-income market, then followed by the currency market, the capital market, and green infrastructure activities, especially during the Covid-19 Pandemic (Liu, 2022).

The portfolio that includes green bond, stocks and energy assets have a potential for diversification compared to portfolios made up of green bond and conventional bond (Kocaarslan, 2021). Besides that, this research also reveals that fluctuation in the U.S Dollar exchange rate is an important factor that influences the correlation between green bond and conventional bond, as also other financial assets. The effort to seek renewable energy as the fossil fuel substitution by using funding from green investments that have an impact on the volatility of world oil prices. Meanwhile, geopolitical risk is the risk that comes from political upheaval, the threat of terrorism, and geopolitical pressure are the main factors that influence the business climate and also affect the financial market performance. From this research, it can be concluded that green bond can be used as a hedge, especially in bearish market conditions and investors can include them in the preparation of investment portfolios for diversification purposes. Nevertheless, this research is different from the research by Gao et al. (2021), where the green bond market in China has a low correlation with the forex market and the monetary market or shows that these two markets will not transmit risk spillover to the green bond market. Moreover, this research also can be concluded that the risk spillover transmission that occurs in the green bond market is not caused by the seasonal condition that occurs, with unexpected events like Covid-19 Pandemic and financial market conditions being the main factors driving the risk spillover transmission to the green bond market.

Research by Arif et al. (2021) shows that green bond is used as asset diversification for stock investors in the medium and long term. Furthermore, green bond as a hedging instrument and safe haven for investments in the financial market and commodity exchanges. During the financial crisis, especially those caused by the pandemic like what happened in 2020, the green bond is proven as a hedging and diversification instrument for long-term investment investors. Research shows that there is a decoupling of the green bond return index on returns on conventional assets results, in green bond returns having a weak connection with the conventional investment in stocks during the crisis, this shows that green bond can be used as hedging instruments for the stock investors. Green Bond – Spillover, Correlation, and Co-movement Matrix can be seen in Table 1

**Table 1 Green Bond – Spillover, Correlation, and Co-movement Matrix**

| Author | Variable | Observation Period | Method | Geographical Scope | Spillover & Correlation |
|---|---|---|---|---|---|
| Pham (2016) | GB Market, Conventional Bond Market | April 2010–April 2015 | Univariate GARCH | US | Volatility spillover between conventional bond & green bond |
| Daszyńska-Żygadło et al. (2018) | GB Market & Conventional Bond Market | 2014–2018 | Multivariate GARCH | US | GB has positive correlation with CB |
| Reboredo (2018) | GB Market, Corporate & Treasury Market, Stock & Energy Market | Oct 2014–Augt 2017 | Static & dynamic copula function, ARMA, TGARCH | US & EU | Treasury & Corporate Bond (strong); Stock & Energy (weak) |
| Reboredo (2019) | GB Market, Corporate High Yield, treasury bond market, stock market, energy commodities market | Until Feb 2022 | SVAR, Monte Carlo | US & EU | Treasury, USD currency, corporate bond market (high); stock, high yield, energy (weak) |
| Broadstock & Cheng (2019) | SPUSGRN, SPUSAGGT, MKT_RF, VIX, ADS, EPU, NEWS,_NEG, NEWS_POS, OIL | Nov 2008–July 2018 | Dynamic Conditional Correlation (DCC) | US | Correlation between GB & BB sensitive to macro economics factors |
| Lee et al. (2020) | GB Market, Oil price, geopolitical risk | Dec 2013–Jan 2019 | QAR unit root test, quantile cointegration tests, Granger causality | US | Oil market (weak); geopolitical risk impact to GBprice |
| Jin et al. (2020) | VIX Index, Commodity Index, Energy Index, GB Index | Dec 2008–Aug 2018 | DCC APGARCH, DCC TGARCH, DCC GUGARCH, OLS | Global | Carbon Market (strongest); GB as transmitter |
| Park et al. (2020) | Return SPX & Return GBS | Jan 2010–Jan 2020 | BEKK Model & DCC GARCH | Global | Volatility in stock market affect volatility in GB Market & VV (volatility spillover); negative news in stock market won't make shock in GB market & reverse |
| Reboredo (2020) | EU & US GB, Corporate & Treasury Market, High Yields Corporate Bond, Energy & Stock Market | Oct 2014–Dec 2018 | Ultivariate VAR & Wavel | US & EU | Trasury & Corporate Bond (strong); Stock, Energy & High Yield (weak) |
| Arif et al. (2021) | SPCOM, FTSE 100, DAXINDEX, MSWRLD, MSCI Europe, MSCI, USDXY | Pandemic Era | Cross quantilogram approach | US, EU, & Asia | SPCOM, FTSE100, DAXINDEX, MSWRLD (strong); commodity index & USD index (weak) |
| Ferrer et al. (2021) | GBI, treasury corporate bond, stock market, USD index, energy market, global crude oil market | Oct 2014–Dec 2018 | BK Methodology | Global | Treasury market corporate market (strong); currency market (medium); stock market, oil market (no spillover); renewable energy (weak) |

| Author | Variable | Observation Period | Method | Geographical Scope | Spillover & Correlation |
|---|---|---|---|---|---|
| Gao et al. (2021) | GB, stock market, traditional bond market, forex market, commodities market, monetary market | 8 April 2015–8 April 2020 | DCC GJRGARCH Model, Diebold Yilmaz, rolling time window method | China | 1) the strongest correlation are between GB & traditional bond, 2) the're significantly spillover between GB, stock & commodities market, 3) GB has low correlation between forex & monetary market, 4) Risk spillover are trigger by market condition & unexpected events |
| Kocaarslan (2021) | GB market, AB market, stock market, Energy index | Aug 2014–Oct 2019 | DCC GARCH, VAR Model | Global | Dynamic correction GB & CB (strong); Dynamic correlation GB & stock, energy (weak); USD fluctuation are the major impact to the correlation between GB & CB |
| Mensi et al. 2022) | GBI, GB Building, GB Utility, GB Finance, GB Industrial; citimacro risk index, US financial conditional index, covid-19 crisis | Panemic Era | Copula Modeling, CoVAR, Quantle Regression Approach (QRA) | Global | citimacro risk index impact the spillover between GB utility, GB Financial (high), GB Building (low), GB Industrial (No spillover); Financial condition impact spillover GB utility, GB Finance, GB Building, GB Industrial, Financial stress impact spillover GBI and sectoral GB |
| Liu (2022) | GB, CB, USD Currency market, Treasury market, Agregate Index, Oil index, natural gas index, VIX index, GB green building index | Panemic Era | Event study, DCC GARCH | US | GB & CB (strong) corporate bond, treasury index, high yield, green building index, currency index, renewable investment; no renewable (weak, no correlation) |
| Pham & Nguyen (2022) | SOGB, SPGB, GBUS, GBEU, VIX, OVX, USEPU | Panemic Era | Markov Switching Regression & TP-VAR | US & EU | The connection between GB and uncertainty is time varying and state dependent spesificaly during highly uncertainty like Pandemi |

Source: self-processed

## CONCLUSION

As an effort to reduce the effects of global warming in the long term, it can have an impact on the survival of mankind, it requires a joint commitment from all countries in the world. The effort to reduce global warming is started by reducing the substances of carbon gas emission in the earth's atmosphere by doing replacing the use of fossil energy with energy that is more environmentally friendly, reducing and processing domestic and industrial waste, building more environmentally friendly buildings, developing friendly transportation and many more. This effort needs a lot of funds. It is needed lots of funds to support the efforts mentioned above. One of the innovations in the budgeting field and funding is using a green bond. A green bond is a financial asset that promises a fixed income. Similar to a conventional bond, the green bond has maturity, coupon rate, rating, and others, the difference is that proceeds from the green bond are used only to fund projects that

have green qualifications. This qualification is marked by giving a green label to the projects being funded. The research related to green bond has been developed by many researchers by focusing on several phenomena which only be found in green bond, including greenium, the relationship between the green bond market and other financial asset markets, the supply side, market reactions, and other several topics. Much research has been conducted to seek the relationship between green bond and other financial assets, however, the research specifically on spillover volatility and financial asset prices still leaves a gap for further research. Most research shows that shock affects volatility and price changes in the financial market which is transmitted to the green bond market, or it can be concluded that the green bond market is correlated with the conventional bond and treasury bond markets. Nevertheless, it differs from the stock market, energy market, and oil commodity market. This shows that green bond is an instrument that can be used as a means of diversification and to form an investment portfolio when a shock occurs in other financial markets. Besides that, if an uncertain situation occurs such as during the Covid-19 pandemic, price changes and volatility that occurs will be transmitted to the green bond market in a short term. Further research relates to the relationship between the green bond market and the non-green bond market. In addition, research relates to the geopolitical conditions with a background of war between Russia and Ukraine and their impact on the green bond market is also interesting for further research. Other than that, the selection of the different methods to determine the presence of spillover and transmission can be additional empirical evidence regarding the chosen research topic.

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