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Risk spillovers between the S&P500, green bonds, real estate, oil market, and dollar index June 2022

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Abstract

One of the main concepts in finance is portfolio diversification and optimization. Typically, investors use the risk and return approach to diversify their portfolios. However, risk spillovers and market connectivity should also be considered when making investment decisions, especially during times of crisis. The TVP-VAR approach is used in this study to analyze risk spillovers and connectivity between the S&P 500 index, green bond, real estate, oil market, and dollar index in the USA from 2016 to July 2022. The TVP-VAR model is a time-varying model that may consider current political and economic circumstances. As a result, investors can choose wisely when it comes to their portfolios. According to comparisons with other markets, the S&P 500 index and the real estate market are the two most significant sources of volatility in the system. In fact, they not only transmit greater volatility, but they also take it in more. After 2020, there will likely be a significant increase in the volatility of the real estate market and the S&P 500 index due to the COVID-19 epidemic. Additionally, as anticipated, other markets have an impact on the green bond market. It does not, however, transmit them.

Keywords: Risk Spillovers, S&P500 Index, Green Bond, Real Estate, Oil, Dollar Index

JEL codes: G01, G11, G17, G32

Introduction

Financial advances are making financial markets more dependent on one another in the modern era. The intricacy of spillover effects among financial markets has amplified due to integration. Sudden price fluctuations in a particular market can cause fluctuations in other markets, such as the exchange rate, stock, bond, real estate, and commodities (Maitra & Dawar, 2019).

The higher market uncertainty can persuade investors to use higher discount rates, which pave the way for decreased bond prices. An unanticipated surge in commodity prices can trigger production costs and damage corporate financial capacity. Therefore, equities and dividend returns will be lower. The spillover influence from the commodities market is expected to be transmitted to the stock market. Indeed, a downturn in the stock market will eventually affect the bond market, resulting in a more extensive impact on both markets, albeit with a time lag. When the spillover impact across all markets becomes so strong, it usually coincides with an economic or financial crisis. Commodities, currencies, bonds, and stock markets are fundamentally interconnected (Guo et al., 2020).

Oil-importing nations' production expenses go up when oil prices rise. Therefore, raising production costs could cause businesses to make less money and see a drop in return. Inflation is also significantly impacted by the fluctuation in oil prices (Cuado & De Gracia, 2005; Cuado et al., 2015), which causes consumers to reduce spending in other areas and reduces consumption (Narayan & Narayan, 2007; Leung, 2010). Many studies have shown that because crude oil is a significant energy source in the energy market, the price of crude oil can impact other markets. The relationship between oil and stock returns was studied by Jones and Kaul (1996), Sardosky (1999), Park and Ratti (2008), and Apergis and Miller (2009), among others. They concluded that crude oil prices impact the stock markets. Bonds help balance the risk of stocks in a portfolio because they are a generally less volatile asset class than stocks in terms of portfolio diversity. Therefore, several earlier research (Cappiello et al., 2006; Christiansen, 2010; Chuliá & Torro, 2008; Dean et al., 2010; Fleming et al., 1998; Steeley, 2006) explore the dynamic interaction between the equity and bond markets. One kind of bond is a green bond. According to Climate Bonds Market Intelligence, the market value for green bonds exceeded 517.4 billion USD in 2021. understanding the connection between green bonds and other markets enables investors to manage their portfolios more effectively. As world pollution rises, investing in environmentally beneficial financial assets is increasingly crucial. Green bonds are assets that can give investors long-term income. Therefore, it is essential to determine how green bonds affect other markets, like the stock market, commodities, and others (Kim et al., 2017). However, research on this subject is lacking because green bonds have lately seen considerable trading.

A measure of how the US dollar performs against a group of other currencies, such as the EUR, JPY, GBP, CAD, SEK, and CHF, is known as the US dollar index. This index serves as a reliable benchmark for the USD's value and a crucial indicator for commodities whose values are heavily influenced by the USD. The US Dollar Index reveals the dollar's strength or weakness and gauges the dollar's value on international currency exchange markets. American stock values, particularly those that are part of market indices, frequently rise with the demand for dollars. As more investors participate in American stocks or other markets, they must first buy US dollars in order to do so. As a result, the value of that index rises. The relationship between the strength of the BRICS exchange rate vs the dollar and the BRICS stock markets is supported by Naresh, Vasudevan, et al. (2018). In Zhang, Fan et al., the dollar index and oil relationship is also acknowledged. Recent crises have demonstrated the irrefutable importance of the real estate market to an economy and the need to consider how it relates to other economic factors, particularly the global financial crisis (GFC) brought on by the collapse of the subprime mortgage market in 2007. In other words, investing in real estate has advantages for diversity. However, spillover effects can lessen diversification's benefits, particularly during a crisis.

Considering the studies above, this study contributes to the existing literature in the following main ways:

1. An analysis of the connections and spillovers between the dollar index, the S&P 500 index, the bond market, the real estate market, the oil market, and the dollar index, which is not taken into account in other studies, this

approach uncovers the heterogeneity in the size and direction of spillover effects across different markets;

2. Because the method monitors volatility spillovers between various markets, financial institutions, investors, and policymakers will be able to decide to manage their portfolio's risks and returns and maximize their portfolio diversification more effectively, particularly during a crisis (such as COVID-19);
3. In addition to time-frequency domain analysis, the study employed asymmetric analysis and dynamic analysis.

The literature research, data collection, processing, and descriptive statistics are discussed in Sections 2 and 3, respectively; Sections 4 and 5 are devoted to the methodology and the findings. Finally, section 6 renders a conclusion.

Literature Review

Extensive empirical studies have addressed relationships and Connectedness between various markets. For example, Wen, Zhang, et al. (2019) examine the dynamic effects of financial factors on oil prices based on a TVP-VAR model and show that the USA dollar index affects oil prices. Using TVP-VAR, Zhang, Chen et al. (2021) demonstrate that during the COVID-19 pandemic, there were dynamic spillovers between energy and stock markets. Sarwar, Tiwari, et al. (2020) analyze the spillover between oil and Asian stock markets using the bivariate BEKK-GARCH model in their study and accept this spillover from oil to stock markets and vice versa. Furthermore, the global financial crisis does not affect the mentioned market relationships. The acceptance and transmission of the volatility between the oil and USA stock markets are tested by Wen, Wang et al. (2019). They use a multivariate quantile model called the VAR for the VaR approach. They also analyzed the spillover of oil and the US stock market before and after the 2008 global financial crisis and concluded that the spillover was significantly higher after this event. Shahzad, Mensi, et al. (2018) analyze the Connectedness between oil and Islamic stock markets and find asymmetric down- and upside-risk spillovers from oil to the Islamic stock markets and vice versa. Besides, the spillover mentioned above has been more substantial since the financial crisis. Khalfaoui, Sarwar, et al. (2019) split the oil importing and oil exporting countries and suggested that there would be a difference in the volatility of spillover of oil importing and oil exporting countries. The evidence shows that oil-importing countries' stock markets are more affected by lagged oil price shocks. This article used symmetric and asymmetric versions of DCC and cDCC models. Xu, Ma et al. (2019) test the relationship between the volatility of stock markets such as the S&P 500 index, the Shanghai Stock Market composite index, and the oil market. They accepted the relationship of negative volatility between oil and stock markets using the asymmetric generalized dynamic conditional correlation (AG-DCC) model. Rao, Gupta, et al. (2022) test the Connectedness between the S&P500 stock market and oil and Green Bonds markets. Finding the Connectedness between the markets uses the TVP-VAR and Quantile regression model, and the results reveal a considerable degree of interconnectivity across assets from pre- to post-COVID periods. Xiao, Hu et al(۲۰۱۹) .examine the relationship between the volatility of the oil market and the Chinese stock market using a quantile regression approach and find that the risk of the oil market influences the Chinese stock market. Pham and Nguyen (2022) study the effect of the stock and oil market volatility and policy uncertainty on green bonds. By defining three uncertainty indexes, they conclude that, in low uncertainty, the relationship between uncertainty and the green bond is weaker when the uncertainty is low. Park, Park, et al. (2020) is another research that examines the effect of stock and Green Bonds markets. They conclude that these two markets have spillover between each other, but they have no response to adverse shocks. Elsayed, Naifar, et al. (2022) use a multivariate wavelet technique and dynamic Connectedness to study the connection between green bonds and financial markets. They combine Ensemble Empirical Mode Decomposition (EEMD) with Diebold and Yilmaz's (2012) spillover concept. According to the data, investing across multiple markets can provide short-term diversification benefits. The findings of the static connectedness framework explain why the volatility in the green bond market is received more frequently than it is sent. According to Reboredo et al.'s (2020) analysis of the interconnectedness of green bonds and asset classes in Europe and the United States, Treasury, green, green, and corporate bonds are tightly connected in the short- and long-term. Naeem, Conlon, et al. (2022) examine the relationships between green bonds and traditional assets, such as commodities, stocks, and bonds, from 2008 to 2020 using a quantile-connectedness approach and find higher total time-varying risk spillovers during extremely high volatility periods than those with average and low volatility.

Gabauer and Gupta (2020) test the real estate and macroeconomics uncertainties using the TVP-VAR method and find that uncertainties are connected to the real estate market. Samitas, Papathanasiou, et al. (2022) use the TVP-VAR model to investigate volatility spillover between multiple markets, oil, and real estate. They conclude that oil diffuses volatilities to the real estate markets. The Diebold Yilmaz (DY) (2012) approach in the time domain and the Barunk-Kehlk (2018) methodology in the frequency domain are used by Tiwari, André et al. (2020) to examine the strength and time variation of spillovers between returns on residential real estate, real estate investment trusts (REITs), stocks, and bonds in the United States. They came to the conclusion that REITs and equities experience spillovers in both directions substantially more frequently than REITs and housing. Nazlioglu, Gormus, et al. (2016) examine the relationship and spillover of oil market volatility and six REIT groups. They use a model that augments the Toda-Yamamoto method with a Fourier approximation. Also, they found that their test showed bi-directional volatility transmission between the oil market and all REITs. Zhang, Fan, et al. (2008), and Lizardo and Mollick (2010) use the monetary approach to test the relationship between us dollar and oil price. Uddin, Tiwari, et al. (2013) investigate the relationship between oil and exchange rate using wavelet analysis within the time-frequency space. Adekoya and Oliyide (2021) examine the effect of the COVID-19 pandemic on the interconnectedness between markets. They use TVP-VAR in the commodity market and find that the US dollar is one of the markets that receive shocks from others.

Considering the studies mentioned above, there is much research in the risk spillover area. However, there is a systematic need for more scarce to incorporate fundamental macroeconomic variables such as the dollar index (which is directly connected to interest rate) and financial markets and analyze risk spillover between them. Secondly, Numerous studies have employed several models, including ARMA, ARIMA, ARCH-LM and GARCH, EGARCH, and multivariate GARCH, to describe and quantify the spillover and connection between markets. The models above seldom adequately assess quantification spillovers (Asadi et al., 2022; Bouri et al., 2021).

We adopt the Diebold and Yilmaz (2012) (DY) approach, which employs Time-Varying Parameter Vector Auto Regressions (TVP-VAR), in this work to accomplish more precise calculations, unlike the DY based on the VAR system, which is impacted by the window size. The rolling window method does not allow us to achieve the results in the first window, which would result in the loss of observations, especially given that the window size is not insignificant in the VAR approach. This is another difference between the DY based on the VAR system and the DY based on TVP-VAR. Additionally, the rolling window's outlier is sensitive, which makes discoveries less likely to be corroborated as the window first accepts or rejects an outlier in the VAR system. The most recent advantage of the TVP-VAR is the ability to calculate efficient adjustments for parameter changes (Bouri et al., 2021).

Data

The S&P 500, Green Bonds, Dollar Index, Real Estate Index, and WTI Oil market's daily data from 2016 through June 2022 is used in this study. This sample includes significant political and economic events. The information is downloaded from https://fred.stlouisfed.org. The study's input, which uses this data set, offers significant findings about the connections between the S&P 500 index, Green Bonds, Dollar Index, Real Estate Index, and WTI Oil market.

This information may be affected by political and economic factors that affect the commodities and financial markets, such as changes in the energy market, the trade war between the United States and China, and the conflict between Russia and Ukraine.

We compute the returns series (r_t) by comparing the data with the first differences for each series using a natural logarithm in order to do data analysis and graphical displays.

$$r_t=100*[\Delta\log(P_t)] \qquad (1)$$

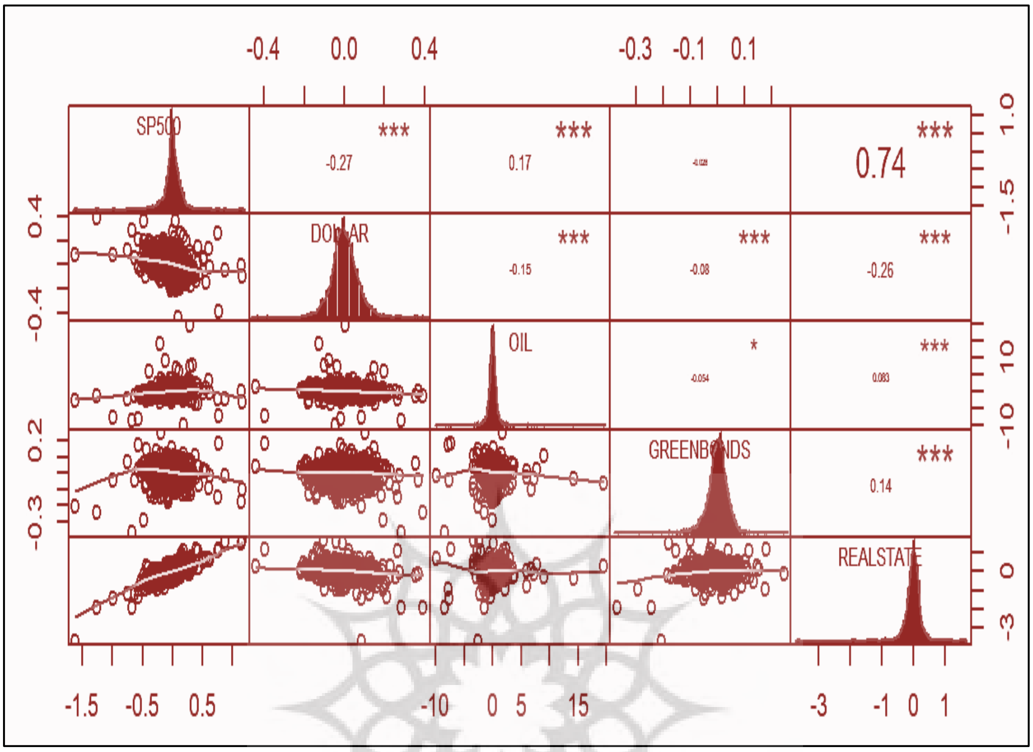
The unit root tests and descriptive statistics for all return series are displayed in Exhibit 1. As shown, every market has a mean return that is either positive or zero. Regarding volatility, the oil market is the most volatile, while green bonds are the least volatile. Additionally, skewness analysis reveals that all of the variables are asymmetrical. The kurtosis values show that all returns have fat tails and a leptokurtic distribution. The Jarque-Bera (JB) test demonstrates that non-normality distribution exists in all return series.

Using the Elliott, Rothenberg, and Stock (ERS) unit root test is advantageous because a series of returns have the leptokurtic distribution combined with jumps and structural breaks.

Table 1. Descriptive statistics of return series

	SP500	DOLLAR	OIL	GREEN BONDS	REAL ESTATE
Mean	0.005	0.002	0.033	0.000	0.001
X	(0.175)	(0.266)	(0.183)	(0.903)	(0.842)
Variance	0.022***	0.005***	1.127***	0.002***	0.064***
Skewness	-0.925***	0.165***	4.277***	-1.057***	-2.014***
X.1	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)
Kurtosis	18.506***	3.497***	93.385***	8.365***	31.866***
X.2	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
JB	26805.709***	955.979***	681257.182***	5768.344***	79954.130***
X.3	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ERS	-17.625***	-17.188***	-17.859***	-15.230***	-17.977***
X.4	(0.0000)	(0.000)	(0.0000)	(0.000)	(0.000)
Q.20.	273.294***	19.596***	120.665***	77.056***	117.473***
X.5	(0.000)	(0.021)	(0.000)	(0.000)	(0.000)
Q2.20.	2244.499***	167.271***	543.100***	769.366***	1044.937***
X.6	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Kendall	SP500	DOLLAR	OIL	GREEN BONDS	REAL ESTATE
SP500	1.000***	-0.156***	0.162***	-0.101***	0.414***
DOLLAR	-0.156***	1.000***	-0.167***	0.000	-0.131***
OIL	0.162***	-0.167***	1.000***	-0.082***	0.049***
GREEN BONDS	-0.101***	0.000	-0.082***	1.000***	0.049***
REAL ESTATE	0.414***	-0.131***	0.049***	0.049***	1.000***
Source: Results of study					

The results of the pairwise correlations are shown in Exhibit 2. None of the indicators are normally distributed, as seen by this graph. That suggests a strong correlation (0.74) between the S&P 500 and real estate. Additionally, there is a weak inverse relationship between the S&P 500 and oil.



Source: Results of study

Figure 1. Pairwise correlations of the return series

Research Methodology

Numerous models are available to describe the interconnectedness between factors in various marketplaces. The DY model offers a fresh method for determining the connections between marketplaces. This method was chosen primarily because it provides a better indicator of market connectivity in a dynamic environment where market parameters change over time. This model has the following benefits:

1) Unaffected by anomalous data.

2) Selecting the rolling window's size at random is unnecessary.

3) No information is missing.

4) This technique can also

The non-dynamic approach of the TVP-VAR based on the Bayesian Information Criterion (BIC) has been applied to create an index for measuring the Connectedness between the markets.

$$V_t = \beta_t V_{t-1} + \gamma_t , \quad \gamma_t \sim \mathrm{N}(0, D_t) \tag{2}$$

$$\mathrm{vec}(B_t) = \mathrm{vec}(B_{t-1}) + \mu_t , \mu_t \sim \mathrm{N}(0, P_t) \tag{3}$$

In the above equations, Vectors of V_t, V_(t-1), and γ_t are K×1 dimensional. Other elements are β_t and D_t, which are typical of K×K dimensional matrices in Eq. (2). Next equation is the equation (3), vec (B_t) and μ_t depict vectors, which are k^2×1 dimensions; yet, P_t is a matrix with a distinguishing characteristic of k^2×k^2 dimension.

Following the steps above, we measure the H-step ahead (scaled) Generalized Forecast Error Variance Decomposition (GFEVD), which demonstrates the variable ordering's invariability—the exact opposite of the orthogonal Forecast Error Variance Decomposition—and which is used to calculate the forecast error variance. The Wold representation theorem serves as the foundation of this version, which converts the calculated TVP-VAR method to a TVP-VMA process using the equality below:

$$V_t = \sum_{i=1}^{p} B_{it} \; V_{t-i} + \gamma_t = \sum_{j=0}^{\infty} S_{jt} \; \gamma_{t-j} \tag{4}$$

Subsequently, in order to achieve a degree of unity in every row, the use of (scaled) GFEVD is required. In order to achieve this, we must normalize the (unscaled) GFEVD together with _(ij,t)f. To be clear, _(ij,t)f (H) informs us of the forecast error variance share of the asset j that is subject to i. Utilizing the pairwise directed connection from j to i is essential in this process. The intended equation is:

$$\sigma_{ij,t}^{f}(\mathrm{H}) = \frac{D_{ii,t}^{-1} \sum_{t=1}^{H-1} (l' S_t l_j)^2}{\sum_{j=1}^{k} \sum_{t=1}^{H-1} l_i D_t S_t' l_i} \tag{5}$$

$$\sigma_{ij,t}^{f\prime}(\mathrm{H}) = \frac{\sigma_{ij,t}^{f}(H)}{\sum_{j=1}^{k} \sigma_{ij,t}^{f}(H)} \tag{6}$$

A selected vector will closely correspond to unity on the ith position and zero otherwise, provided that $\sum_{j=1}^{k} \sigma_{ij,t}^{f\prime}(H) = 1$, $\sum_{i,j=1}^{k} \sigma_{ij,t}^{f\prime}(H)$ k, together with l_i.

In accordance with the GFEVD, extracting spillover calculations via the DY is straightforward, and this equation is identifiable as follows:

$$TO_{jt} = \sum_{i=1,i\neq j}^{k} \sigma_{ij,t}^{f'} (H) \quad (7)$$

$$FROM_{jt} = \sum_{i=1,i\neq j}^{k} \sigma_{ji,t}^{f'} (H) \quad (8)$$

$$NET_{jt} = TO_{jt} - FROM_{jt} \quad (9)$$

$$TCI_{t} = k^{-1} \sum_{j=1}^{k} TO_{jt} = k^{-1} \sum_{j=1}^{k} FROM_{jt} \quad (10)$$

$$NPDC_{ij,t} = \sigma_{ij,t}^{f'} (H) - \sigma_{ji,t}^{f'} (H) \quad (11)$$

We can partially realize a total directional connection to others using Eq. (7) by combining the effects of a shock by variable j on the sum of all other variables. The combined influence of all alternative assets on variable j is then explained by Eq. (8). We can see more clearly from Eq. (9) if a variable is a net giver, receiver, or neither. Eq. (10) determines if a system's interconnections and market risk are high or low. If this index is low, several variables do not depend on one another. As a result, a shock to one variable does not depend on other variables, resulting in minimal market risk. Eq. (11) ultimately offers net pairwise directional connectivity, signaling the extent to which variable i impacts variable j and vice versa. Thus, if NPDC is positive and the effects of i on j are inverse, we can infer from this index that variable j impacts asset i.

Results

Information on spillovers between the S&P 500 index, bond market (green bonds), real estate market, oil market, and dollar index is provided in Exhibit 3. The findings indicate that this system's primary transmitters and drivers are the S&P500 and real estate, with 42.52% and 34.6%, respectively. The following transmitters are the dollar index, oil, and green bonds. For another example, the Dollar Index contributes 19.04% of shocks to this system, whereas oil contributes 13.42%. These outcomes mirror those of Balcilar, Ozdemir, and colleagues. They confirm that volatility in the S&P 500 and the oil market transfers to other markets.

The exhibit's "from" column points to the conclusion that the S&P500 index has the highest level of sensitivity, at 35.63%. The real estate market is following, receiving 32.48% shocks from other sectors. The S&P500 index receives 8.53% of its volatility shocks from the Dollar index, 6.01% from oil, 4.05% from green bonds, and 23.93% from the real estate market, according to an analysis of the spillovers between the variables. These findings are consistent with the investigations that follow. Xu, Ma et al. confirmed the volatility spillover between the S&P 500 and the oil market. In Park Park et al., it is acknowledged that there is a spillover between the S&P500 stock market and the market for green bonds. In Tiwari, André et al., the relationship between real estate and stock markets, such as the S&P500 stock market, has been examined and found to be valid.

A high percentage was also produced by the Total Connectedness Index (TCI), which suggests that simultaneous losses in the S&P 500 index, bond market, real estate market, oil market, and dollar index are likely.

Table 2. Estimates of spillovers between the S&P500 index, bonds market, real estate market, oil market, and the dollar index

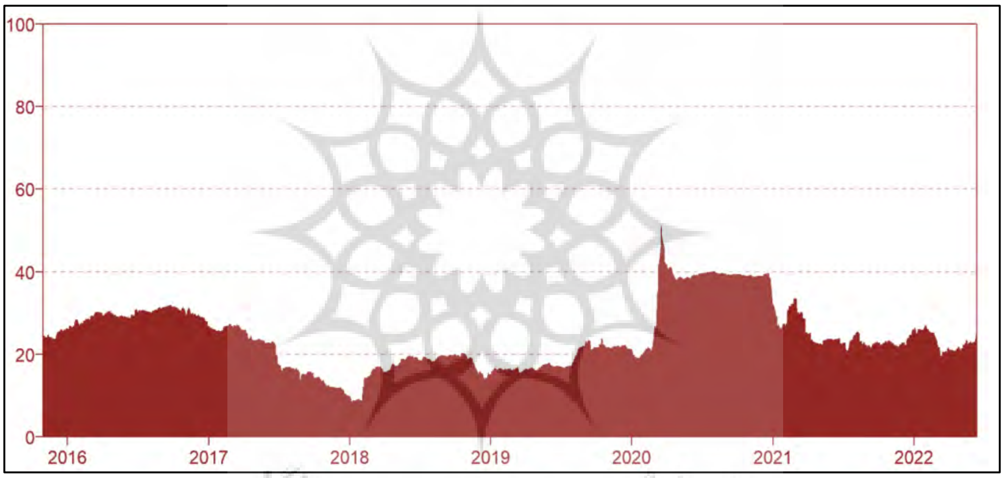
	SP500	DOLLAR	OIL	GREEN BONDS	REAL ESTATE	FROM
SP500	63.37	5.97	4.57	2.69	22.4	35.63
DOLLAR	8.53	77.5	4.5	3.24	6.22	22.5
OIL	6.01	4.25	85.58	1.99	2.17	14.42
GREENBONDS	4.05	4.58	2.66	84.92	3.8	15.08
REAL ESTATE	23.93	4.25	1.69	2.61	67.52	32.48
TO	42.52	19.04	13.42	10.54	34.6	120.12
NET	6.89	-3.47	-1	-4.54	2.12	TCI = 24.02
Source: Results of study						

Notes: The results are presented based on a 20-step-ahead generalized forecast error variance decomposition and a TVP-VAR model with a lag length of order one (BIC).

It can be concluded from Figure 2, which depicts dynamic total connectivity, that changes in economic, political, and even health conditions can have an impact on dynamic total Connectedness. This exhibit indicates that the index ranges between 10% and 50%. It is clear that chaotic situations magnify worries, and as a result, the index fluctuates somewhat. The index grew steadily from 2016 to 2017 with the Brexit referendum. On the other hand, early in 2016, the oil price, which dominates the energy market, dropped to $26.19 a barrel. The index experienced a downward slope after this year due to the US adopting a contractionary monetary policy.

After 2018, the index surged up in tandem with significant occurrences like the US-China trade war, the imposition of sanctions on nations that export energy, such as Iran and Venezuela, and a decline in energy prices. Due to the Covid-19 epidemic, there was more uncertainty in the financial and commodity markets in 2019. Mao and Zhang, demonstrate that the volatility of Chinese stock markets in 2020 and the backdrop of COVID-19 spills over to US stock markets, which may be one of the causes of the high volatility experienced by the S&P500 market in 2020.

Following immunization, the outlook for the global economy was upbeat, but in 2022, the war between Russia and Ukraine raised doubts once more. The US imposed severe sanctions on Russia, devastatingly impacting the markets for food and energy.



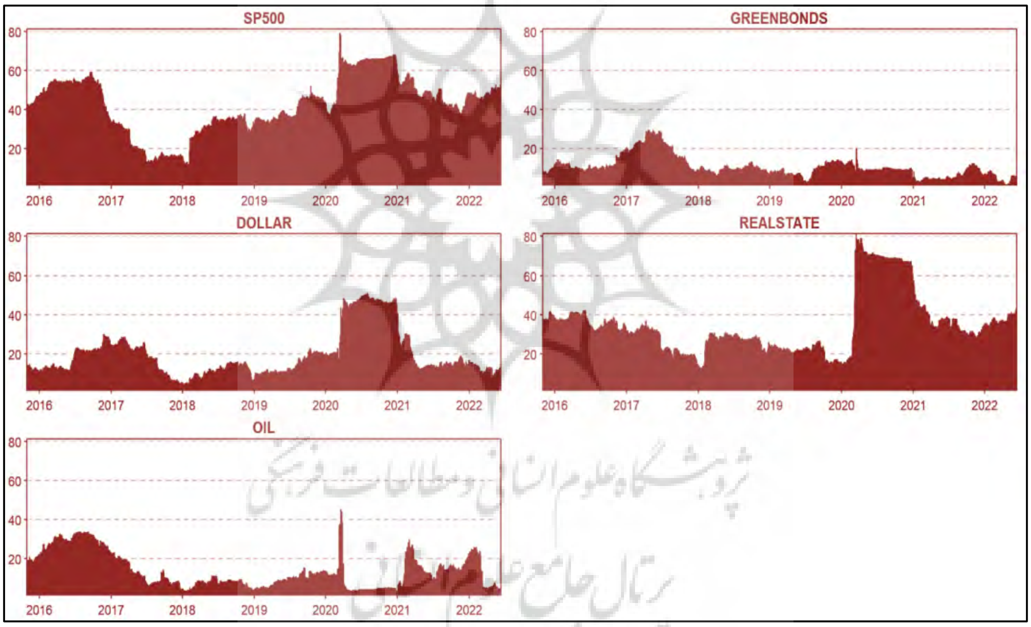
Source: Results of study

Figure 2. Dynamic total spillover based on the DY-TVP-VAR

A more thorough explanation of volatility spillovers across the markets for the S&P 500, green bonds, the dollar index, real estate, and WTI oil is given in Figure 3. The illustration suggests that the S&P500 causes others to experience high volatility shocks.

Real estate follows as the next most significant transmitter in this network. After 2020, real estate will significantly impact other markets' volatility shocks, which also applies to the S&P 500. When looking at the S&P 500, its shocks declined after 2017 but later reversed to the most significant values. These ups and downs are related to US trade policies and President Trump's trade bluster. During the Covid-19 pandemic crisis, the S&P 500 and real estate prices are at their highest levels. The COVID-19 issue substantially damaged the real estate market in 2020. As a result of health issues and instructions to stay at home, fewer buyers were looking for homes, and fewer sellers were ready to offer their properties or open their homes to outsiders during a pandemic.

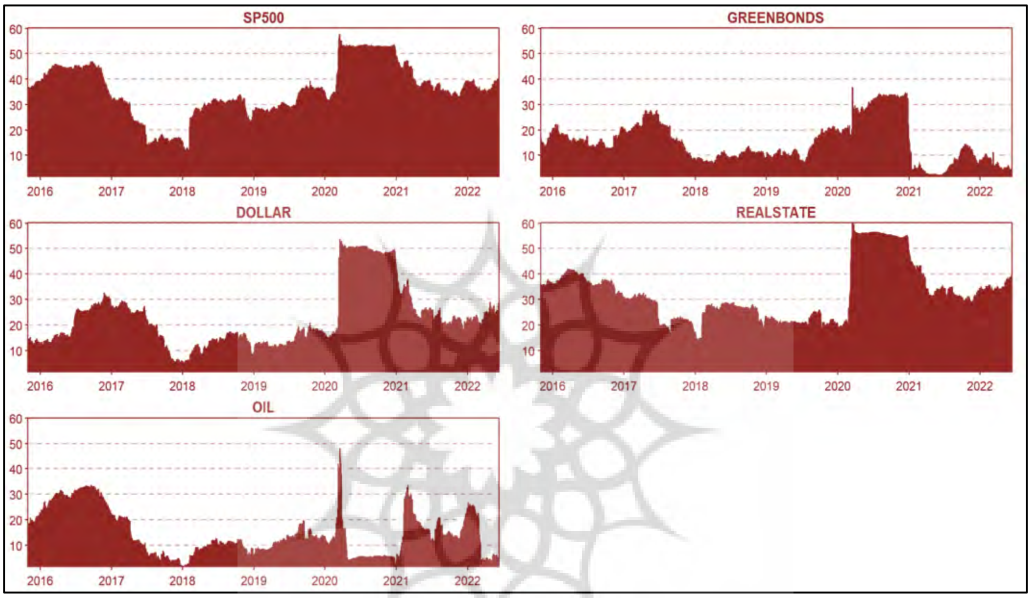
It is also clear that, due to their lower risk compared to other markets, green bonds have a lower network spillover of volatility, which validates the most miniature transmission of green bond volatility to other markets. The COVID-19 pandemic wiped off the world's oil demand, which fell astoundingly in the second quarter of 2020 when lockdowns and other pandemic-related restrictions were enacted. Countries as a whole abruptly stopped flying and driving.



Source: Results of study

Figure 3. Time-variations of volatility spillovers amid a market S&P500, Green Bonds, Dollar Index, Real Estate Index, and WTI Oil market

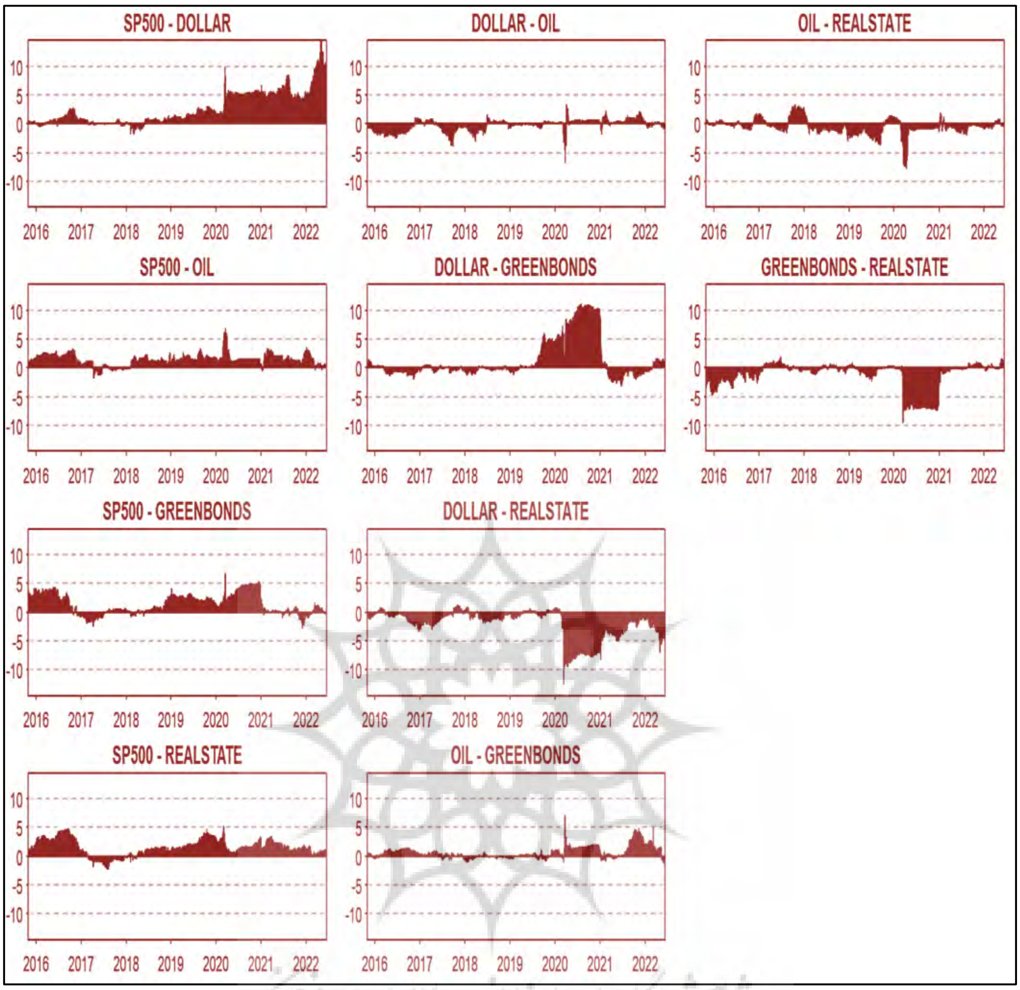
Taking Figure 4 into consideration, the S&P500 is the market that receives the most significant volatility from other markets, especially when things are turbulent. This issue hints at the S&P 500's reliance on other markets. This implies that because of the importance of this market to the US economy, particularly in times of crisis, authorities should closely monitor it. It is important to note that while the network receives a low degree of volatility from the green bond market, it receives a high amount from other markets. Except for oil, all markets saw high levels of volatility between 2020 and 2021. After 2021, risk-taking declined in all markets, but the bond market had the most significant decline. Comparing the oil market to other markets, it displayed a different tendency. It received low volatility from the market between 2020 and 2021, but it experienced a surge after that.



Source: Results of study

Figure 4. Volatility spillovers from a market to S&P500, Green Bonds, Dollar Index, Real Estate Index, and WTI Oil market

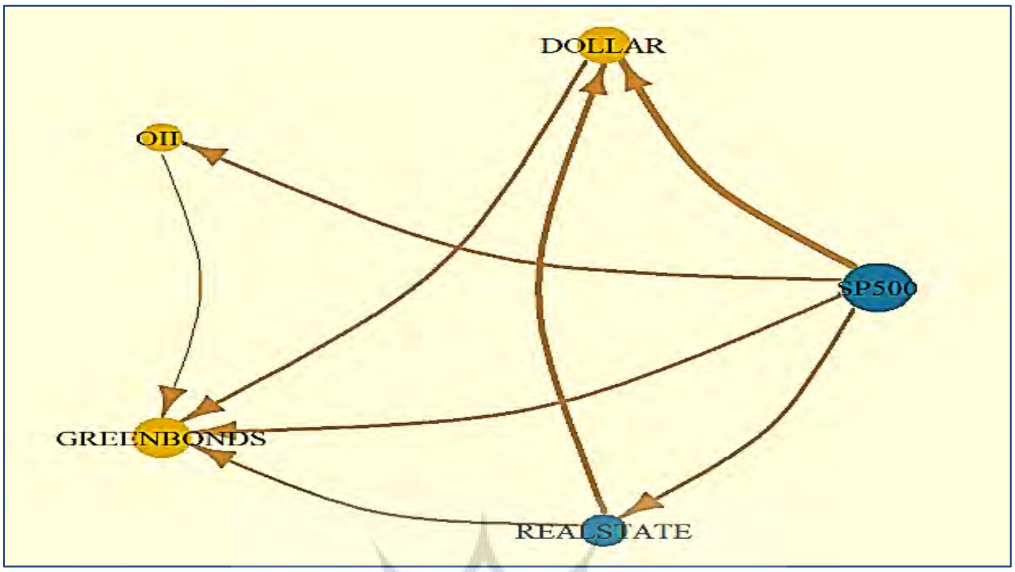
This study does a close examination that yields Figure 5 in order to analyze pairwise spillovers among the S&P500, Green Bonds, Dollar Index, Real Estate market, and WTI Oil market. This exhibit indicates that after 2020, the S&P500 and dollar index pairs will have substantial volatility. The relationship between the Dollar index and the oil market and the oil market and real estate, in contrast, is weak and negative. The relationships between pairs of (S&P-Oil), (S&P-Green bonds), (S&P-real estate), and (Oil-Green bonds) are typically weak but positive. Dollar-Green Bonds, Green Bonds-Real Estate, and Dollar Index-Real Estate are three pairs that, in 2020 and 2021, have high positive, negative, and harmful connections together. However, after 2021, they were less intense.



Source: Results of study

Figure 5. Pairwise spillovers based on the DY-TVP-VAR model

Figure 6 demonstrates the system's network connectivity between the S&P 500, Green Bonds, Dollar Index, Real Estate, and WTI Oil market. The bold arrows depict the strength of volatility spillovers between markets. According to this exhibit, the S&P 500 is a transmitter of volatility, while the green bond market is only a receiver. Other markets act as both transmitters and receivers of volatility spillover.



Source: Results of study

Figure 6. System network connectedness among S&P500, Green Bonds, Dollar Index, Real Estate Index and WTI Oil market

Discussion and Conclusion

Key Findings

The TVP-VAR model was used in this paper to quantify risk spillovers and connections between the S&P 500 index, bonds, real estate, oil, and dollar index from 2016 to July 2022. The findings indicate that, in comparison to other markets, the S&P500 index and the real estate market are two of the primary causes of volatility in the system. Compared to others, they not only transmit greater volatility but also take it in more. The S&P500 index level and real estate market volatility drastically rose after 2020, possibly related to the COVID-19 pandemic.

According to the net system of Connectedness, S&P500 risk spillover diffuses to all markets, and real estate receives risk spillover from the S&P500 and transmits it to the dollar index and green bonds. The oil market receives risk spillover from the S&P500 and transmits it to green bonds only. The green bond market is the only one that receives volatility from other markets. It is worth mentioning that the intensity of risk spillover between the S&P500 to dollar index and real estate to dollar index is high compared to others. On the contrary, volatility spillover intensity from the oil market to green bonds is less intense than others.

Recommendations

The results of this study can offer market players insightful information. Instead of the often utilized Mean-Variance model, the holistic view provided by the spillover and connectedness method allows investors to manage their portfolios’ risk more effectively.

Investors should not hold investments in the S&P 500 and the real estate market since there are clear connections between both. Green bonds can also be included in the portfolio as a hedging tool. According to the findings, the real estate market and S&P 500 volatility spillovers increased after 2020. Therefore, investors who study markets must take this into account. Under these circumstances, financial actors should continually modify their tactics in response to the political and economic environment in addition to quantizing non-static and other portfolios. As a result, portfolio managers and investors in various markets ought to create dynamic and alternative portfolios and periodically rebalance their portfolios in accordance with the market's conditions and volatility spillovers. Due to its significance in the spillover network, investors should keep an eye on S&P500 swings. As a result, they should take note of these index fluctuations while deciding on an investing strategy for the financial markets.

From policy policymakers' perspective, US officials should carefully examine The S&P500 index and its effects on other markets. Such as real estate and the dollar index, especially during a crisis. To illustrate, for example, monitoring the real estate market is an essential step towards reducing the adverse effects of high shock diffusion to the system, which is analyzed in this study, specifically during the crisis. Adjusting economic strategies to react against health crises, including the coronavirus, brought about the real estate market, and the S&P500 represented high oscillations.

Limitations and Future Research

Firstly, the focus of this study is on USA-selected markets. Future studies can investigate the spillover risks between other financial markets, asset classes, or stocks in a specific industry in other countries. Secondly, for comparison, it is worthwhile to apply the planar maximum filter graph method to determine the Connectedness between this study's variables and compare the results.

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