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DISCUSSION PAPER SERIES

IZA DP No. 14888

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ABSTRACT

A Survey of Hedge and Safe Havens Assets against G-7 Stock Markets before and during the COVID-19 Pandemic

We propose a new Sharpe ratio index obtained from return and volatility spillover indices to individual assets from the whole financial system. We use our new approach to shed light on a new perspective on a hot topic examining the safe-haven assets after Covid-19. To do that, we compare both hedge and safe-haven properties of gold, Bitcoin, and crude oil against G-7 stock markets by using daily return and volatility data from September 2013 to October 2021. Our empirical findings show that the hedging effectiveness of gold, Bitcoin, and crude oil varies overtime before the Covid-19 pandemic. Furthermore, according to our analysis results, only Bitcoin acts as a safe haven against G-7 stock markets during most of the Covid-19 pandemic time.

JEL Classification: C58, G10

Keywords: sharpe ratio, safe haven, hedge, spillover effect, G-7 countries

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1. Introduction

In economics & finance literature, a spillover is defined as a scenario in which a shock in one economy or region spreads and impacts others through, for example, price fluctuations. Researchers have been increasingly interested in this notion following the 2008 global economic crisis because it was intriguing how a problem in the US housing market spread to the global financial industry. In accordance with the analysis objectives, these scholars have utilized the return, volatility, or both return/volatility spillover effects in their studies. On the economic side, one would like to quantify and observe such spillovers since it may provide *early warning systems* for emerging crises and track the evolution of existing crises (Diebold and Yilmaz, 2012). However, one would like to develop superior portfolio strategies when incorporating spillover effects among invested assets (Al-Yahyaee and Kang, 2018) on the financial side. The spillover effects among financial assets may bring valuable knowledge for financial applications such as option pricing, value at risk, portfolio optimization, and optimal hedging (Awartani and Maghyereh, 2013; Kumar, 2013).

Various studies such as Awartani and Maghyereh (2013), Fasanya *et al*. (2020), Balcilar *et al*. (2021), and Tiwari *et al*. (2021) use return and volatility spillover impacts among different financial assets to make financial inferences across markets. Although these studies offer significant contributions to the finance literature, handling the return and volatility spillover effects separately among assets implies a significant shortcoming in examining the time-changing characteristics of investment instruments in portfolios. Balcilar et al. (2021), for example, attempt to explain the safe-haven features of gold and oil relative to the S&P500 index by evaluating the return and volatility spillovers among gold, oil, and S&P500 as a whole. Other studies have also ignored this phenomenon, resulting in deficiency as well. This study closes a significant gap in the literature by examining the return and volatility spillover effects in the context of the well-known reward-risk approach, the Sharpe ratio. The Sharpe ratio is widely used to help portfolio investors understand the return of an investment compared to its risk.

During the early days of the COVID-19 pandemic, financial markets worldwide plummeted to all-time lows, resulting in enormous losses for traditional investors. For example, the S&P 500

dropped 7.6 percent, the FTSE 100 lost 7.7 percent, the TSX Composite Index fell more than 10%, and the FTSE MIB, CAC 40, and DAX also tanked on March 9, 2020. Panic and decline continued in the world stock market, where circuit breakers were activated several times in the following days. In addition to the stock markets crash, there was a severe decrease in the world economic growth and, accordingly, in the price of oil. Contrary to expectations, the current pandemic's protracted duration prompted traditional stock investors to seek alternative safe-haven assets to preserve their portfolios or earn positive returns (Hong et al., 2021). Market participants should be aware of market spillovers as well as the dynamic relationship between some of the world's most important financial markets (Li and Meng, 2021). Considering the G-7 stock market cap, we provide crucial insights for equities investors and regulators in the G-7 and other countries to implement diversification/hedging strategies of gold and Bitcoin during market turmoil.

This paper fills substantial gaps in the literature and introduces a novel approach to such research, arguing that investors should consider the spillover impact for asset selection in their portfolios during both calm and crisis periods. Following Diebold and Yilmaz (2012), we use a generalized vector autoregressive framework to calculate daily Diebold and Yilmaz (DY) return and volatility spillover indices and generate a new indicator (*Spillover Sharpe Ratio*) to take into account these indices together by utilizing the spirit of the Sharpe ratio. We then use our method in a substantive empirical analysis across G-7 stock, oil, gold, and Bitcoin markets over seven years, including the ongoing Covid-19 pandemic crisis. In a nutshell, this study yields the following primary findings: (1) the hedging effectiveness of oil, gold, and Bitcoin against G-7 markets varies overtime before the Covid-19 pandemic outbreak, (2) It is interesting to note that only Bitcoin acts as a safe-haven against the G-7 stock markets during the most of Covid-19 pandemic period.

We proceed as follows. Section 2 reviews the background and related studies. Section 3 outlines our analytical approach and reasoning for unifying return and volatility spillover indices under the Sharpe ratio. Section 4 describes our data and presents our substantive findings. Section 5 discusses our empirical findings with relevant publications, and Section 6 concludes the paper.

2. Literature review and our motivation

Our study is mainly related to literature, which attempts to understand spillover effects of various financial assets on portfolio diversification. Balcilar et al. (2021), for example, investigate the return and volatility spillover effects of the S&P 500, crude oil, and gold in order to explore their safe-haven and portfolio diversification properties. Further, Tian and Hamori (2016) use a time-varying structural vector autoregression model with stochastic volatility to investigate the cross-market financial shocks transmission mechanism on the foreign exchange, equities, bond, and commodity markets in the United States. They advise investors to monitor risk-spillovers closely among financial assets and to diversify their portfolios during times of extreme events. Furthermore, Kumar (2013) investigates the return and volatility spillovers between exchange rates and stock prices in India, Brazil, and South Africa. He provides evidence that the stock markets play a relatively more crucial role than foreign exchange markets regarding both return and volatility spillover. Liow (2015) investigates the conditional volatility and correlation spillover among G7 countries to focus on portfolio diversification and volatility forecasting using the DY spillover index. As we mentioned above, the most important weakness of such studies is not connecting between return and volatility spillovers in the context of risk (fear) and return (reward). Because of this reason, these studies provide only a partial picture of the behavior of financial assets within a portfolio. Our primary motivation is filling such gaps in the finance literature.

There has been a resurgence of academic and professional interest in researching different financial assets' hedging and safe-haven ability against market crashes following the Great Recession. This interest has shifted mostly away from traditional safe-haven investments (such as gold and government bonds) and toward Bitcoin, dubbed the *"digital gold"* of the new era after the Covid-19 outbreak. Academic finance has shown a strong interest in Bitcoin's hedging, diversification, and safe-haven properties. Goodell and Goutte (2021) provide evidence to support a positive relationship between Bitcoin and levels of COVID-19 related fatalities. These studies attempted to justify Bitcoin's advantage over gold in portfolio diversification because of the epidemic's tremendous volatility in worldwide financial markets. As a result, investors are turning to alternative assets such as Bitcoin to lower the risk of their portfolios (Chkili *et al*., 2021).

According to Conlon and McGee (2020), Bitcoin was neither a safe-haven nor a hedge against the severe bearish market in the S&P500 caused by the COVID-19 pandemic. Moreover, Hasan et al. (2021) examine the safe-haven role of twelve assets against the US stock market and discover that the Islamic stock index and Tether are safe-havens during the COVID-19 pandemic. Moreover, Marina et al. (2021) point out the possibility of using Bitcoin and Ethereum as a safe-haven instrument for the S&P 500 index. They report that both Bitcoin and Ethereum act as a safe-haven asset against the US stock market during extreme stock market plunges in the short term. Using asymmetric and frequency connectedness measures, Qarni and Gulzar (2021) find that Bitcoin provides significant portfolio diversification benefits for major foreign exchange portfolios. Rubbany et al. (2021a, b) also give thought to the short and long-term safe-haven properties of cryptocurrencies during the pandemic period. They find supporting evidence of safe-haven features of new digital golds in several spots and future markets.

Our study is also related to academic interest, which compares the hedging/safe-haven properties of gold and Bitcoin against risky assets during periods of market turmoil. Various studies have evaluated gold and Bitcoin's safe-haven properties together during the COVID-19. For instance, against the major world stock indices and currencies, Chemkha et al. (2021) show the efficacy of Bitcoin and gold as hedging assets in lowering the risk of international portfolios. Their empirical findings also suggest that gold is a weak safe-haven for the assets under consideration, but Bitcoin cannot provide shelter owing to its heightened volatility during the COVID-19 pandemic. Using the wavelet approach, Shehzad et al. (2021) compared the safe-haven properties of gold in contrast to Bitcoin. Overall, they discover that gold investments outperform Bitcoin investments during most of the COVID-19 period. Furthermore, Kristoufek (2020) analyzes Bitcoin and gold and supports the claim that Bitcoin does not protect risky assets, whereas gold is the apparent winner in this race. Naeem et al. (2021) indicate that cryptocurrencies, bonds, and gold are average hedges against both conventional and Islamic equities; nevertheless, these are not "safe-havens" during COVID-19. Last but not least, Kumar (2020) compares the safe-haven properties of gold and Bitcoin to stock markets (NSE50, DJIA, SSE, and CAC40) and indicates that both gold and Bitcoin act as a safe-haven during Covid-19.

3. Methodology

The empirical methods used in this study are described in this section. First, we discuss the spillover index methodology of Diebold and Yilmaz (2009, 2012) to examine both return and volatility spillover indices used for obtaining the Sharpe Ratio in G-7 countries. Second, we go through Sharpe Ratio and its usage for portfolio selection in the financial markets and how we formalize the Sharpe ratio by using the spillover index.

3.1 Spillover index

This study uses the Diebold and Yilmaz (DY) index to calculate the Sharpe ratio based on a forecast error variance decomposition from vector autoregressions (VARs). Following Diebold and Yilmaz (2012), we assume a covariance stationary VAR as:

$$x_t = \Phi_1 x_{t-1} + \Phi_2 x_{t-2} + \cdots + \Phi_p x_{t-p} + \varepsilon_t \tag{1}$$

where x_t is the *Nx1* vector endogenous return and volatility variables, $(\Phi_1, \ldots, \Phi_p)$ are *NxN* autoregressive coefficient matrices and $\varepsilon_t \sim iid(0, \Sigma)$ is a vector of error terms assumed to be serially uncorrelated. Since the VAR process is assumed to be covariance stationary, the moving average (MA) representation can be written as:

$$x_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i} \tag{2}$$

where A_i is the $N \times N$ coefficient matrices which can be obtained recursively as $A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + \cdots + \Phi_p A_{i-p}$, and A_0 is the $N \times N$ identity matrix and $A_i = 0$ for i<0 . Then, the forecast error variance decompositions of each variable can be computed to evaluate the fraction of the *H*-step-ahead forecast error variance in forecasting x_i for each $i = 1,2, \ldots, N$ which occurs due to the shocks to x_j, $\forall_{j \neq i}$ by utilizing this MA representation. Hence, we can obtain the *H*-step ahead GFEVDs as follows:

$$\theta_{ij}(H) = \frac{r_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)^2} \tag{3}$$

where Σ designates the variance matrix of the vector of errors ε, r_{jj} is the standard deviation of ε for the jth equation, and e_i is the selection vector that takes the value of 1 on the i-the element and

zero otherwise. Our approach does not rely on Cholesky factor identification of VAR; therefore, the variance decomposition findings are unaffected by order of variables[2]. Since the sum of the own- and cross-variable variance contribution shares is not equal to one under the generalized decomposition (i.e. $\sum_{j=1}^{N} \theta_{ij}(H) \neq 1$), each entry of the variance decomposition matrix is needed to normalize by its row sum as follows:

$$\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{j=1}^{N} \theta_{ij}(H)} \tag{4}$$

with $\sum_{j=1}^{N} \tilde{\theta}_{ij}(H) = 1$ and $\sum_{i,j=1}^{N} \tilde{\theta}_{ij}(H) = N$ by construction.

This allows us to compute the total spillover index as:

$$S(H) = 100\ x\ \frac{1}{N} \sum_{i,j=1\ i \neq j}^{N} \tilde{\theta}_{ij}(H) \tag{5}$$

The total spillover index measures the contribution of spillovers of return or volatility shocks across all assets or markets to the total forecast error variance. In addition to the total spillover index, we can also calculate the directional spillovers received by market *i* from all other markets *j*, $i \neq j$, and the directional spillovers transmitted by market *i* to all other markets *j*, $i \neq j$. The directional spillovers received by market *i* from other markets can be defined as:

$$S_{N,i\leftarrow.}(H) = 100\ x\ \frac{1}{N} \sum_{j=1\ i \neq j}^{N} \tilde{\theta}_{ij}(H) \tag{6}$$

Similarly, the directional spillovers transmitted by market *i* to other markets can be defined as:

$$S_{N,i\rightarrow.}(H) = 100\ x\ \frac{1}{N} \sum_{j=1\ i \neq j}^{N} \tilde{\theta}_{ji}(H) \tag{7}$$

Finally, we compute the net volatility spillovers from one market to all other markets by subtracting Eq. (7) from Eq. (6):

$$S_{N,i}(H) = S_{N,i\rightarrow.}(H) - S_{N,i\leftarrow.}(H) \tag{8}$$

This study uses directional return and volatility spillovers transmitted by market i to other markets described in Eq. (7) to calculate a kind of Sharpe ratio from using return and volatility spillover indices.

[2] See Diebold and Yilmaz (2012), for further discussion.

3.2. Sharpe ratio and its application to our research

One of the most frequent metrics of portfolio performance is the Sharpe ratio. It was developed and extended by William Sharpe (1966, 1994) to analyze and forecast the performance of mutual funds. The Sharpe ratio is made up of two parts. The realized return is the numerator, while the standard deviation is the denominator. As a result, large returns can be traded for a smaller standard deviation, potentially improving the quotient. This trade-off indicates that a manager might achieve a very low Sharpe ratio even with an indisputably winning approach. In the literature, some influential studies such as Yilmaz (2010), Zhang Wang (2014), Ahmad *et al*. (2018), Koutmos (2018), Fasanya and Akinbowale (2019), Balcilar *et al*. (2020, 2021), and Geng *et al*. (2021) calculate the return and volatility spillovers together to unveil the degree of contagion among various financial markets. With this, they aim to provide specific recommendations regarding the corresponding markets by evaluating return and volatility spillover results.

In this study, we develop an approach to take into account both return spillover (reward) and volatility spillover (fear) together by utilizing the spirit of the Sharpe ratio. We take the return and volatility directional spillover index from other markets to target market *i* as described in Eq. (7). Accordingly, as the return spillover from the whole financial system to the market *i* rise, the numerator in Eq. (9) also increases, resulting in a reward for market *i* investors. On the other hand, as the volatility spillover from the whole financial system to the market *i* rises, the denominator in Eq. (9) also rises, increasing market *i* investors' fear in the market. Hence, a reward-risk performance ratio ($SoSR$) is defined as a ratio between a reward measure ($S^{R}_{N,i\rightarrow.}$) and a risk measure ($S^{V}_{N,i\rightarrow.}$).

$$SoSR = \frac{S^{R}_{N,i\rightarrow.}}{S^{V}_{N,i\rightarrow.}} \tag{9}$$

Based on Roy's (1952) inspirational idea, Sharpe (1966) introduced the well-known Sharpe Ratio for managing mutual funds. Subsequently, studies (i.e. Farinelli *et al*. 2008; Zakamouline and Koekebakker, 2009; Darolles and Gourieroux, 2010; Theron and Van Vuuren, 2018; Wang *et al*., 2020; Li *et al*., 2021) regarding constructing portfolios based on optimal ass*et al*location have

literally exploded. However, the purpose of this study is not to determine the appropriate weight for a portfolio. Our objective is to investigate the situations where return and volatility spillovers may be summed up in one index (*Spillover Sharpe Ratio*). As a result, we have an outstanding opportunity to examine safe and risky investments by calculating the spillover Sharpe Ratio for each G-7 country, separately.

4. Data and descriptive statistics

In this study, we use daily oil price (BRENT), gold price, Bitcoin (BTC) price, and each G-7 countries' stock market prices (S&P 500, Nikkei, DAX-30, FTSE-100, CAC-40, MIB, and TSX). We convert all stock market price indices, except S&P 500, into US dollars. Therefore, all variables are in US dollars. All data are obtained from the Datastream database, except the Bitcoin price which is collected from the https://coinmarketcap.com. We employ seven different VAR models for each G-7 country, and each VAR model has four variables: stock market, oil, gold, and Bitcoin. To utilize the longest span available, we do not use the same time-span for each country. Moreover, since the trading days of financial markets under consideration are not the same[3], we eliminate excess oil, gold, and Bitcoin observations. To sum up, the number of daily observations for the US is 1578, for Japan 1483, for Germany 1555, for the UK 1552, for France 1567, for Italy 1560, and for Canada it is 1553.

In this paper, we calculate the daily returns by dividing the first differences to its previous price as $r_{it} = \frac{P_{it}^{close} - P_{i(t-1)}^{close}}{P_{i(t-1)}^{close}}$ where P_{it} is the closed price level of the corresponding market *i* in a given period t. Moreover, the daily volatility series is calculated using the daily opening, closing, high, and low prices described by Garman and Klass (1980). The daily volatility is determined in the first stage as follows:

$$\tilde{\sigma}_{it}^2 = \frac{1}{2}[ln\ ln\left(P_{it}^{high}\right) - ln\ ln\left(P_{it}^{low}\right)]^2 - [2\ ln\ ln\ (2) - 1][ln\ ln\left(P_{it}^{close}\right) - ln\ ln\left(P_{it}^{open}\right)]^2$$

[3] One of the most distinctive features of cryptocurrency trading is that it is available 24 hours a day, seven days a week. When we compare the trading days of stock market to oil and gold market, stock market is traded fewer days during the year compared to other markets. Hence, we reduce the observations based on stock market data in G-7 countries.

where P_{it}^{open} P_{it}^{high}, P_{it}^{low}, P_{it}^{close} represent the open, the maximum, the minimum, and the close price of market *i* on day *t*, respectively.

Figure 1 shows the time series plots of the series used in the estimation. As indicated in the graph, the stock market prices of advanced economies have been on an upward trend since 2013, albeit their slopes have varied. Furthermore, the synchronous movement of related stock market prices demonstrates strong evidence of international spillovers among these markets. After the Covid-19 pandemic broke out in early 2020, nearly all stock values plummeted. Except for the FTSE-100, stock values returned and exceeded their previous highs, owing to central banks' adoption of an expansionary monetary policy to mitigate the economic impact of Covid-19. Crude oil prices have declined since the outbreak due to decreased global activity but have begun to rebound as the virus's effects have waned. Moreover, the price of gold began to rise sharply after 2019 and broke the all-time high in August 2020, and it fluctuates at $1800 nowadays. Bitcoin, which is extremely volatile compared to other financial markets, continued its upward trajectory in April 2021, breaking its previous high of $63000.

The descriptive statistics of the return series are presented in Table 1[4]. Compared to the G-7 stock market, oil, and gold, the mean, median, and standard deviation of Bitcoin return are the highest, confirming the basic principle of the risk-reward trade-off in the finance. Moreover, all return distributions are concentrated on the right side (negatively skewed), indicating a greater probability of loss when investing in such markets. Interestingly, the loss probability of Bitcoin is lower than MIB, TSX, and crude oil market. Kurtosis refers to the whole tails, whereas skewness refers to the asymmetry of the tail distribution. The kurtosis values of the associated returns are more than 3, as shown in the table, implying that the likelihood of extreme returns for all assets is quite high. Oil and MIB are the two assets that are most likely to give the greatest returns to investors.

[4] We agglomerate ten markets and eliminate the un-match observations to compare the daily returns of each market more accurately in the same period. After elimination, 1582 observations remained. The statistical results belong to these return series.

Figure 1 Time series plots of the series used in the estimation

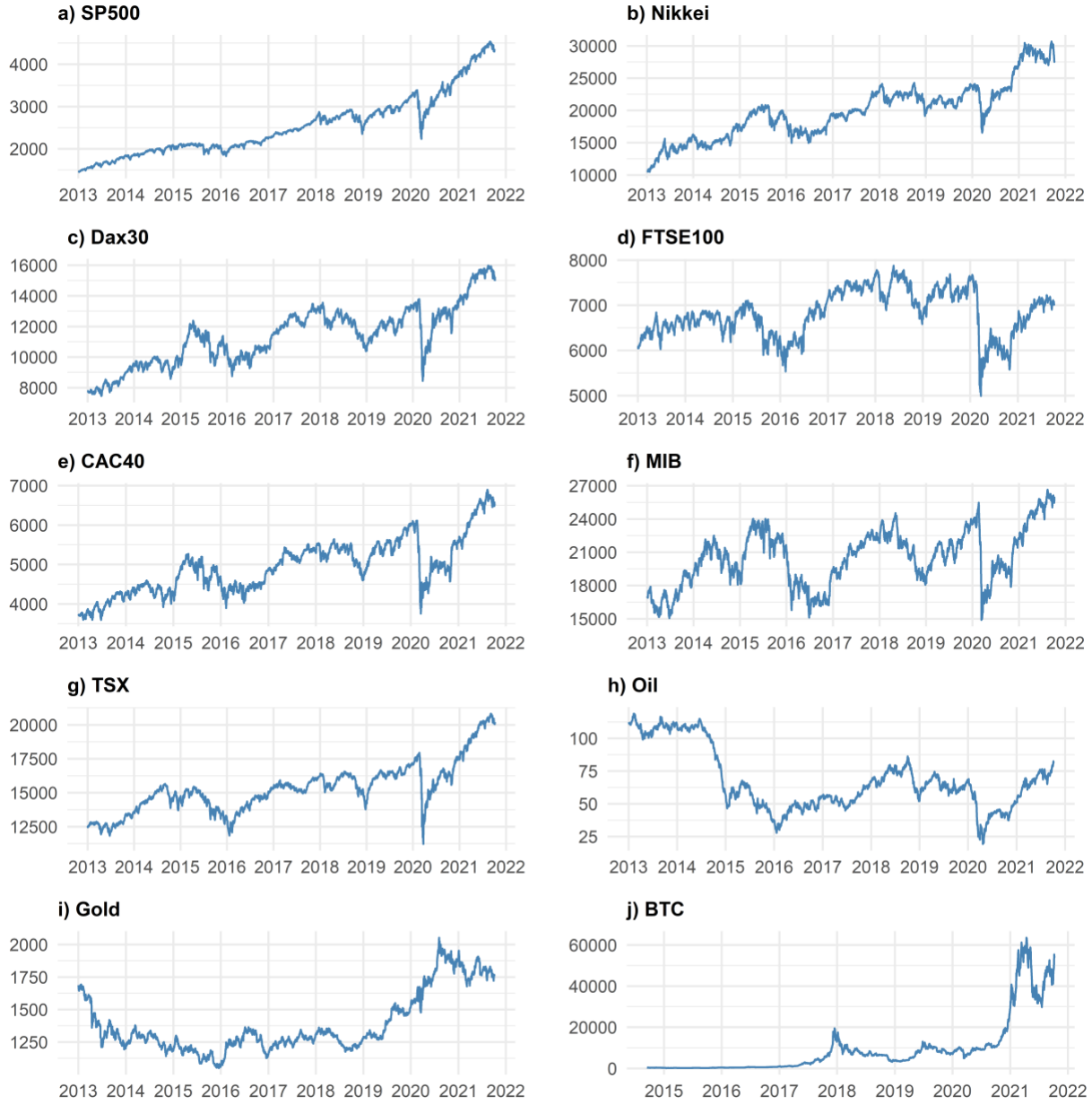


Table 1 Descriptive statistics

	N	Mean	Median	S.D.	Min	Max	Skewness	Kurtosis
SP500	1582	-0.013	-0.004	0.932	-8.839	5.791	-0.683	13.367
Nikkei	1582	0.015	0.042	0.873	-5.879	5.342	-0.437	9.435
Dax30	1582	-0.016	0.036	0.953	-7.392	4.842	-0.278	6.936
FTSE100	1582	-0.003	0.049	1.073	-11.512	8.666	-1.001	17.422
CAC40	1582	-0.003	0.030	0.919	-7.853	5.774	-0.362	9.004
MIB	1582	-0.047	0.016	1.313	-17.000	5.900	-2.474	31.19
TSX	1582	-0.027	0.009	0.723	-8.453	5.405	-1.100	21.979
Oil	1582	-0.018	0.077	2.706	-27.955	18.615	-1.042	21.891
Gold	1582	0.008	0.000	0.835	-5.448	5.153	-0.168	10.232
Bitcoin	1582	0.132	0.194	4.277	-46.501	22.690	-1.032	15.565

5. Empirical results and robustness check

Empirical results

Figures 2-8 illustrate the time-varying spillover Sharpe ratio (*SoSR*) values[5], defined as the ratio of return spillover to volatility spillover emanating from the whole financial system in G-7 countries. Investors frequently use the Sharpe ratio to compare portfolios relative to their peers; unfortunately, it is not possible to make a definite judgment about the value that the Sharpe ratio should take. However, Sharpe ratios greater than 1.00 are typically seen as "good," implying that the portfolio provides excess returns concerning its volatility[6]. Therefore, one might prefer financial assets which have a greater Sharpe ratio regardless of their value. Following this practical use, we assess financial market performance in G-7 countries according to their values before and during the Covid-19 Pandemic. To show and compare financial market performance better, we add red dashed lines in the horizontal axis at some specified positions (1, 2, and 3) in Figures 2-8. As the *SoSR* takes a larger value, we suggest that the market *i* (for instance) offers excess returns relative to its volatility since market *i* takes more return spillover than volatility spillover from the financial system. Hence, we have an excellent opportunity to compare nontrivial markets before and during a pandemic by utilizing our new approach.

[5] We use 250 trading days as a rolling-window size in accordance with the Sharpe ratio approach. Practically, financial analysts use one-year daily observation when they calculate the Sharpe ratio. We also shorten and enlengthen this rolling window size for robustness, but the results do not change significantly. These results are available from the authors upon request.

[6] https://www.investopedia.com/terms/s/sharperatio.asp

Figure 2 illustrates the estimated results of the *SoSR* of S&P500, oil, gold, and Bitcoin in the US market. By our definition, the higher the *SoSR* value of a financial asset, the higher the return for its investor's risk. It is interesting to note that the SoSR values of all financial assets except Bitcoin remain under one after the Covid-19 outbreak. Among the other three financial assets, Bitcoin is a strong safe-haven in this subperiod, and this condition is also valid for other G-7 countries. Even before Covid-19, the Bitcoin investors benefited more return compared to the risk they took. After 2018, gold went to the safe investment zone in the US market, but it could not keep this status for a long period. Furthermore, the empirical data suggest that Bitcoin's *SoSR* exceeds one in several sub-periods because of its massive price spike. The stock market investors in the US feel safe themselves, especially from 2018 to 2019. Moreover, the *SoSR* of the G-7 stock mark*et al*so takes higher values during the same time interval. It is difficult to say that the oil market in the US shows the characteristics of a hedge or a safe-haven before its pre-Covid-19 leap.

Figure 2 Time-varying spillover Sharpe ratio results approach for the US

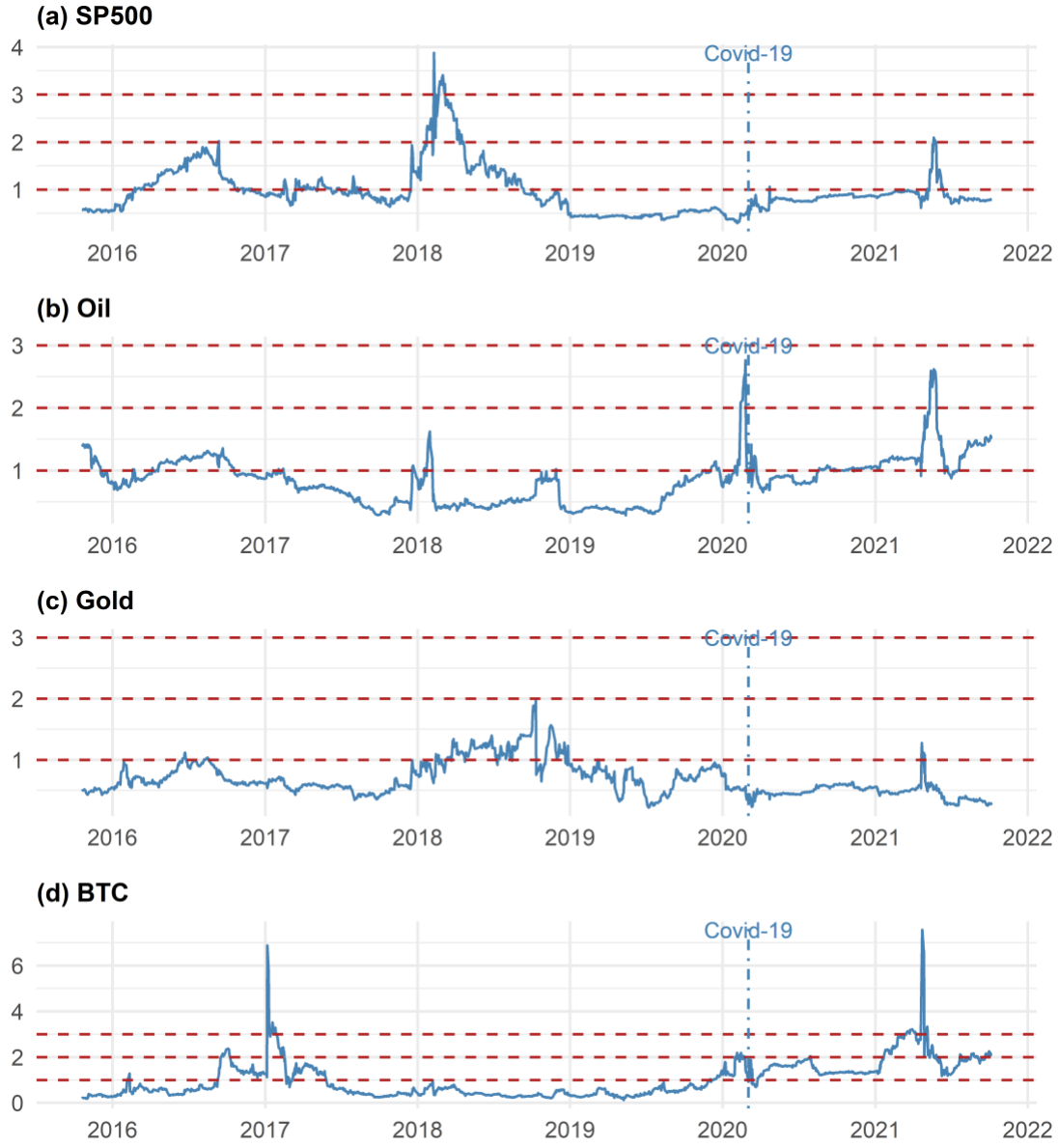


Figure 3 shows the *SoSR* results for Nikkei and the other three assets considered in this study. In Japan, the oil is not a safe-haven asset and cannot hedge against risk among other assets during the whole analysis period. However, gold acts as a hedge against downside risk in the Japanese stock market before the Covid-19 outbreak in some sub-period. On the other side, the *SoSR* of gold remains below one during this pandemic period like other G-7 countries. Bitcoin has generated higher rewards from the financial system based on the risk it takes between 2016 and 2018. The

SoSR of Bitcoin climbs to eight in this sub-period. Nevertheless, Bitcoin is unable to maintain this performance after the epidemic.

Figure 3 Time-varying spillover Sharpe ratio results approach for Japan

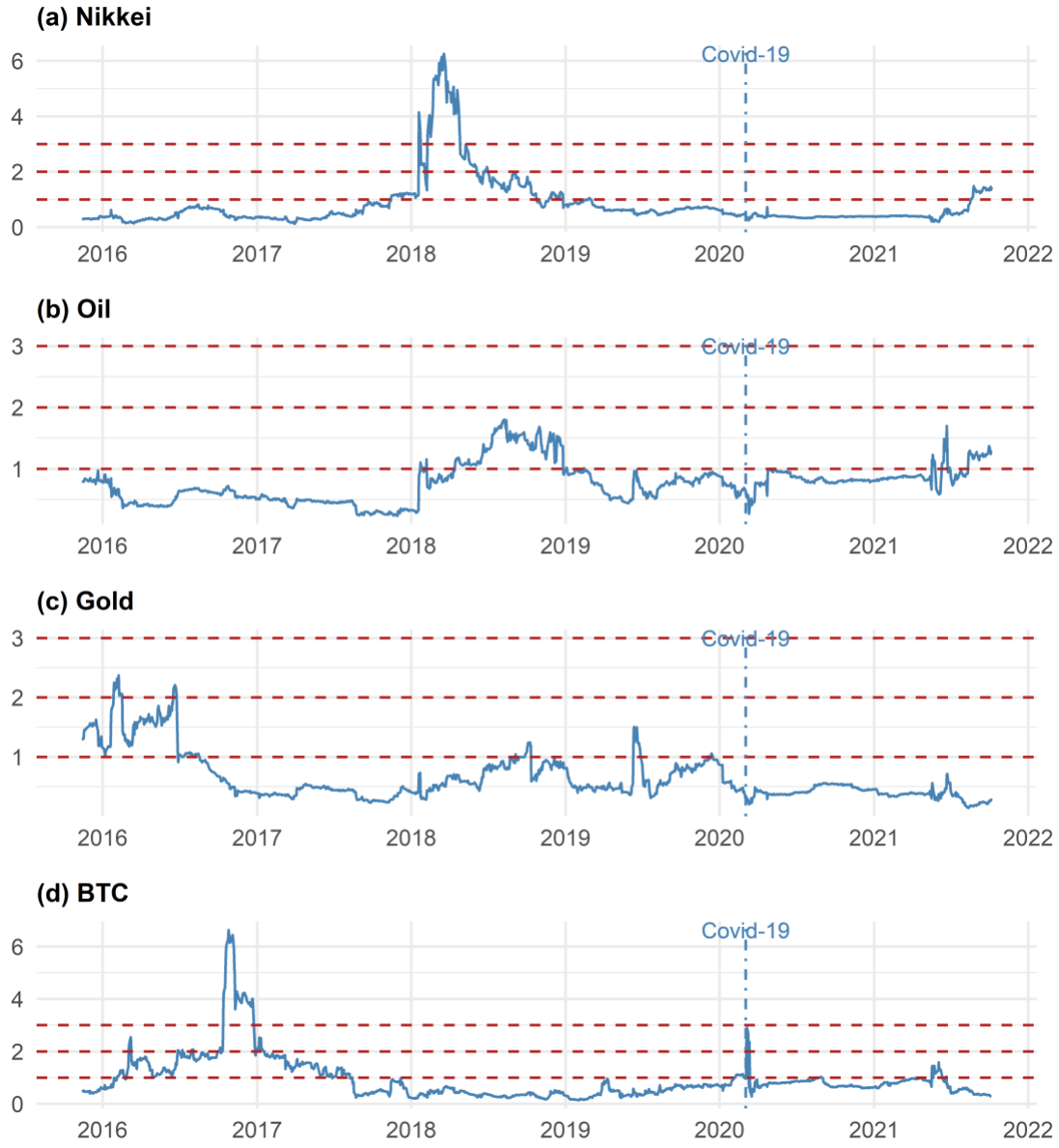


Figure 4 illustrates the time-varying *SoSR* values of each asset in the German market. The first notable thing is that the DAX index can be used as a hedge from 2016-2017and to the 2018-2019 sub-period, but it cannot provide its safe-haven properties during the Covid-19 distress. The hedging role of gold and oil in the German financial market is decisive in some sub-periods before the health crisis, but the safe-haven properties of these financial assets are not observed during the

Covid-19 period. On the other side, the Bitcoin shows a strong safe-haven property against DAX compared to its peers. Unlike other G-7 countries, we do not observe any jump in the *SoSR* value of Bitcoin during the pre-covid period, illustrating its incapability of hedge property in the German financial market.

Figure 4 Time-varying spillover Sharpe ratio results approach for Germany

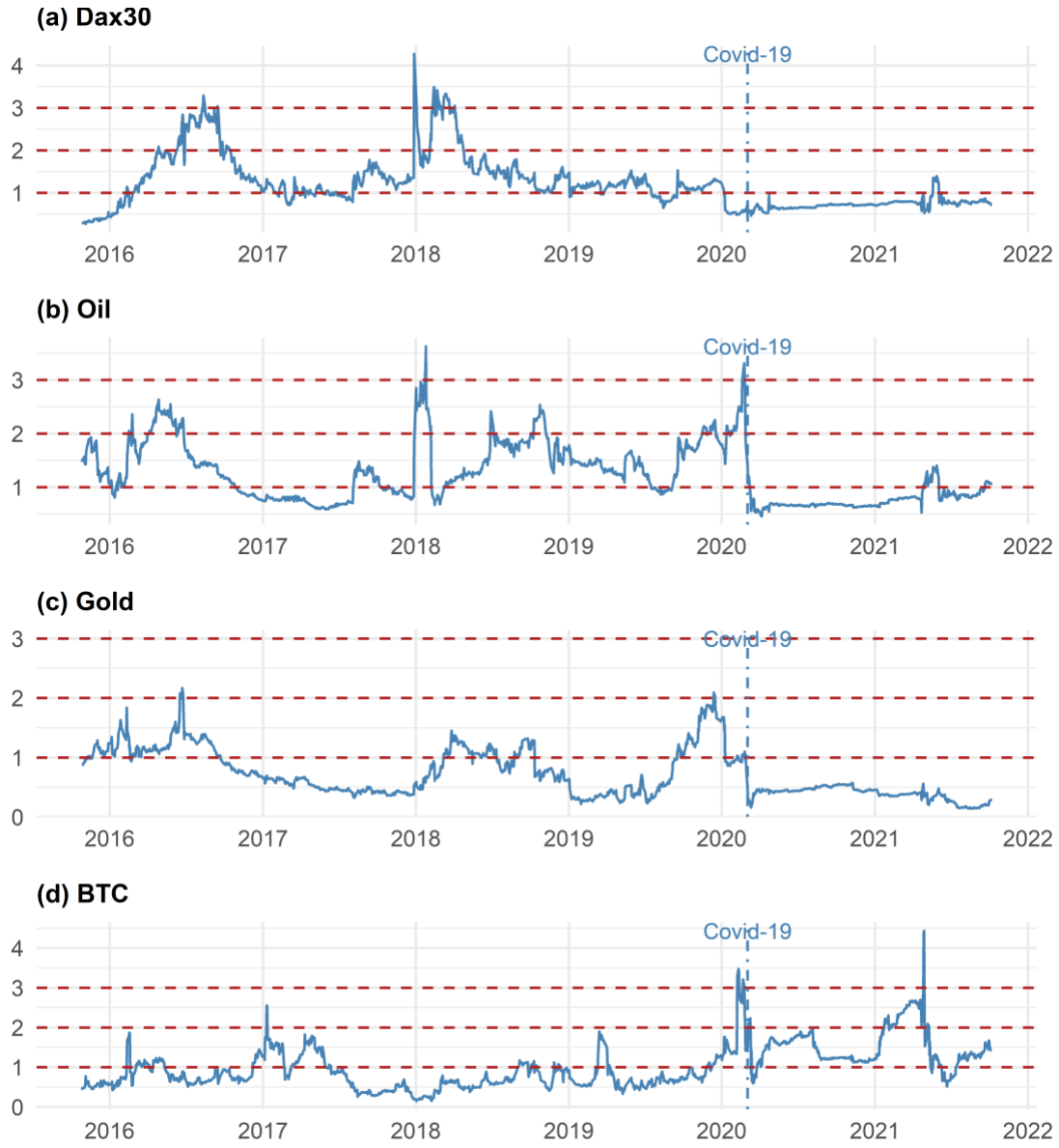
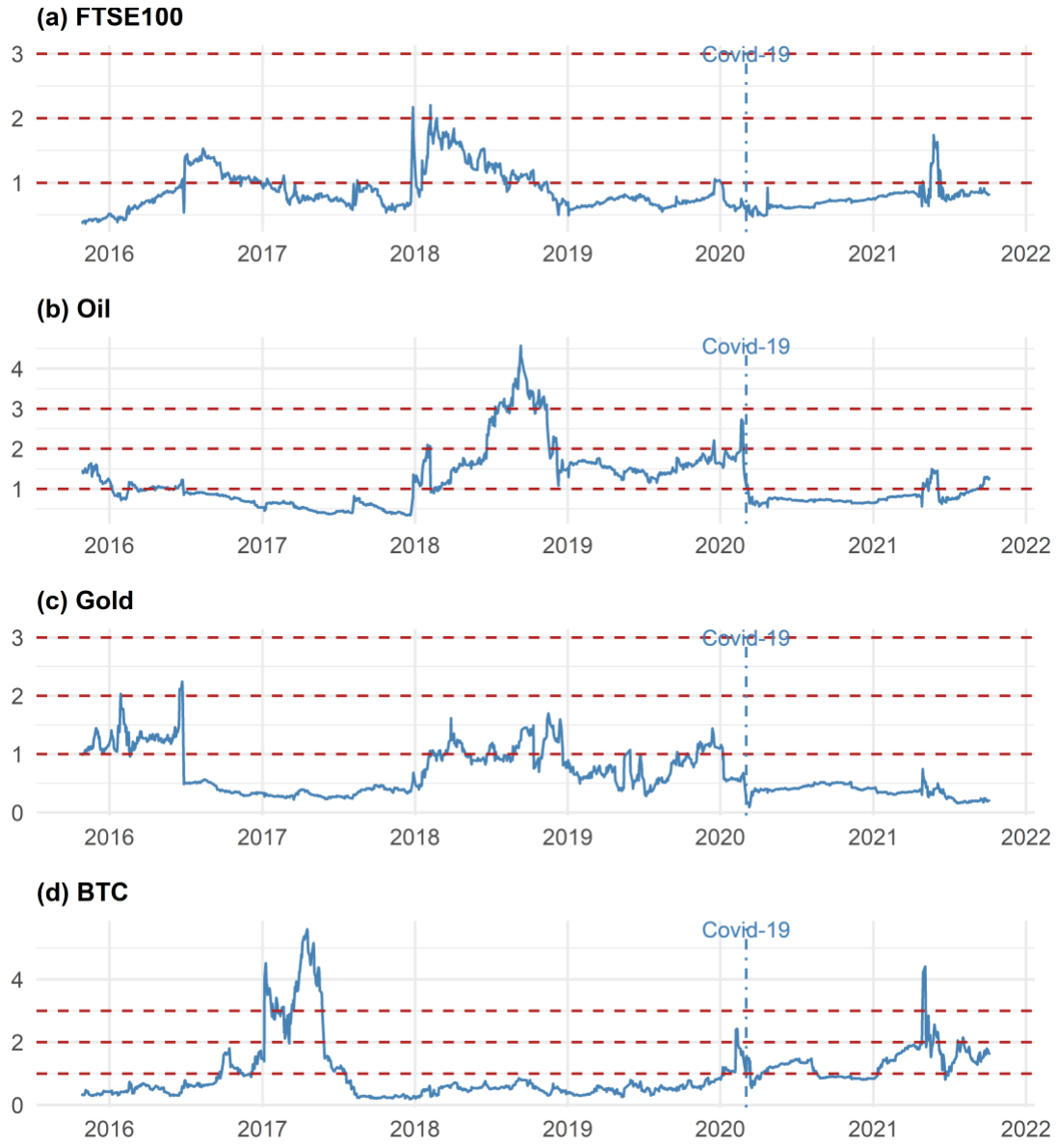


Figure 5 presents the time-varying Sharpe ratio results for the UK market. As seen in the figure, the balance of return and volatility spillovers from the financial system favors stock market investors in the UK between mid-2016-2017 and 2018-2019 subperiods. We see the same situation

for crude oil investors after mid-2018, but it lost its hedging role during the COVID-19 pandemic. We may argue that gold is in a similar position in the UK financial market in the corresponding periods. Furthermore, the Bitcoin serves as a hedging asset for one year (i.e., from mid-2016 to mid-2017) and as a safe-haven for the UK market at times of covid stress.

Figure 5 Time-varying spillover Sharpe ratio results approach for the UK



We calculate the *SoSR* for CAC 40 and other critical financial assets for the French market, as documented in Figure 6. The empirical findings prove that the financial investors in France find

CAC 40 and oil are less risky than gold and Bitcoin at the beginning of the analysis period. However, these assets lose their hedging property, and the gold takes this role from 2018 to the Covid-19 outbreak. Like other G-7 countries, the Bitcoin lost its less risky but high return character after the Covid-19 pandemic bursts, but it gained this property again as time passed during stressful times.

Figure 6 Time-varying spillover Sharpe ratio results approach for France

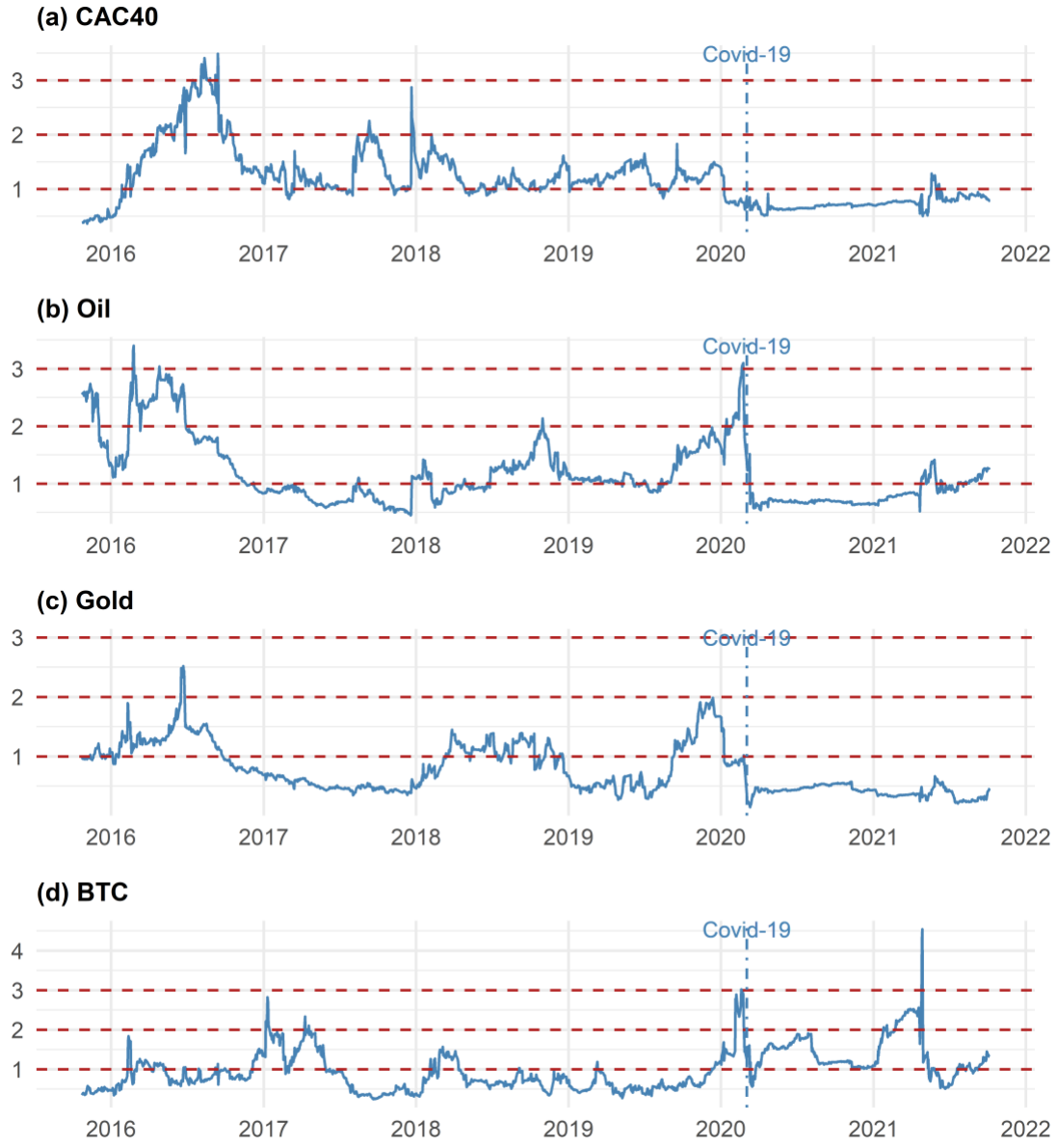
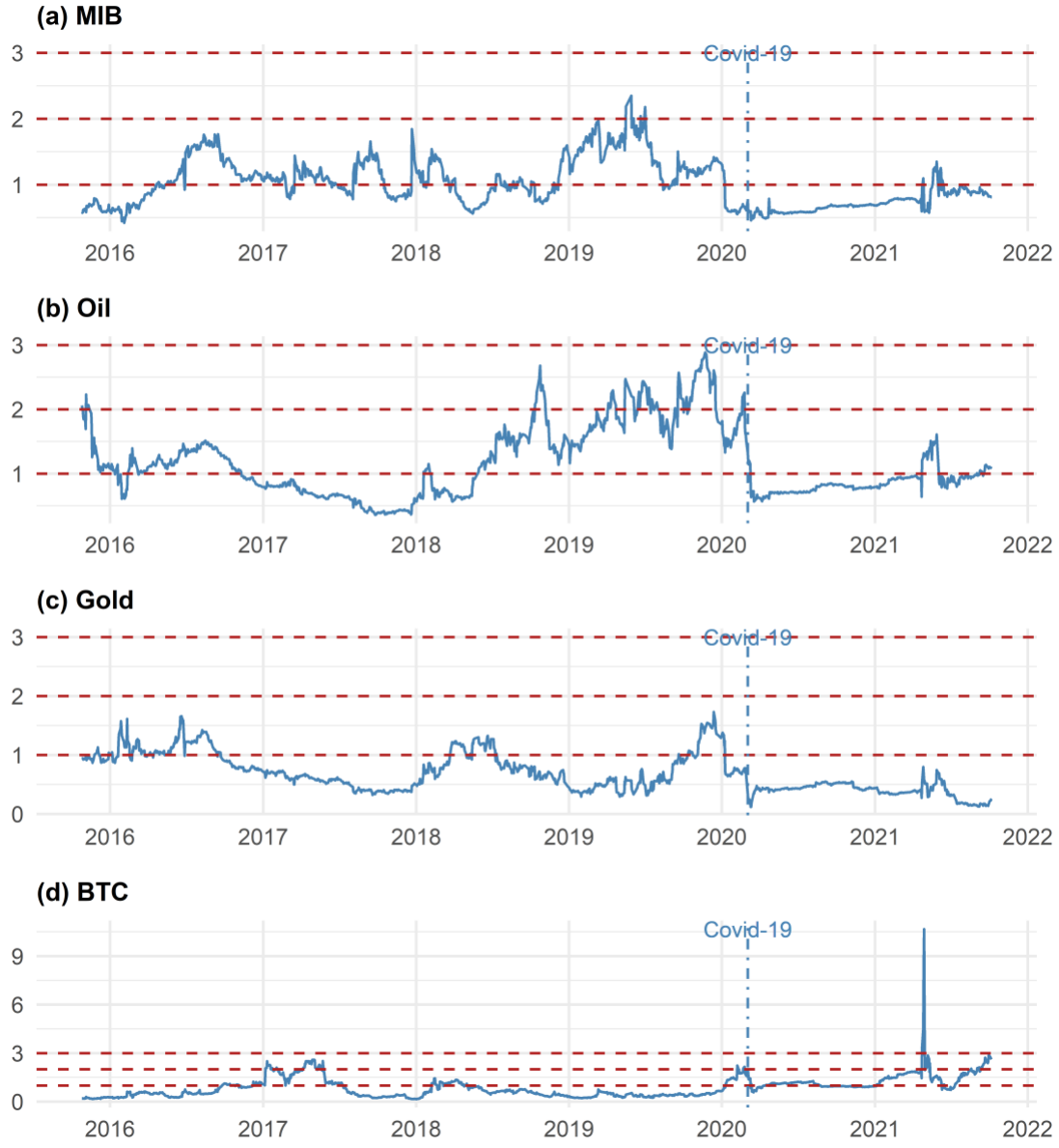


Figure 7 depicts the time-varying *SoSR* values for Italy before and after the Covid-19 pandemic. SoSRs of MIB and crude oil fluctuate around one until 2019. Before crashing at the Covid-19

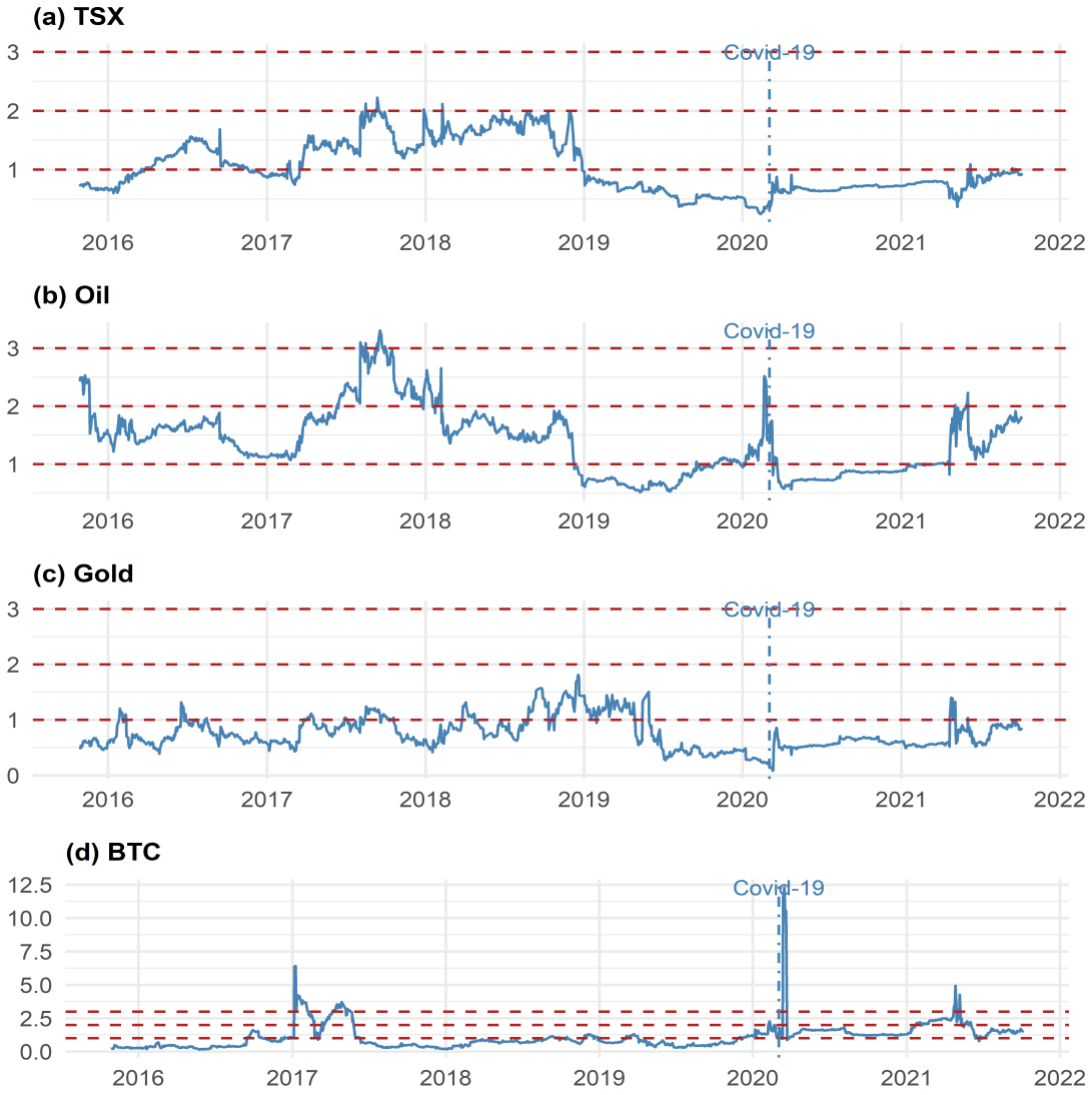
outbreak, MIB and oil started to increase and act as hedging assets. Moreover, gold, on the other hand, serves as a hedging role after 2019 to the Covid-19 outbreak time. Like other G-7 countries, Bitcoin has emerged as a safe-haven asset among other assets during a post-covid era. The *SoSR* value of Bitcoin in the Canadian and Italian financial markets soared beyond ten relatively quickly. As can be seen, the return-risk value of Bitcoin in a fictitious portfolio consisting of these four financial assets has soared to unbelievable proportions in favor of return.

Figure 7 Time-varying spillover Sharpe ratio results approach for Italy



Lastly, we compute a rolling estimation of *SoSR* of related assets for Canada, as shown in Figure 8. The empirical findings provide evidence that oil and gold are a hedge in some sub-periods, but none of them take a safe-haven role during the recent outbreak of Covid-19. The financial assets except for Bitcoin under consideration cannot exceed two during the analysis period. However, even if in a concise period, the *SoSR* value of Bitcoin surpasses ten just before Covid-19 pandemic outbursts.

Figure 8 Time-varying spillover Sharpe ratio results approach for Canada



Robustness check

Since we run so many rolling estimations, it would be cumbersome to employ similar robustness tests done by previous studies (See Diebold and Yilmaz, 2012; Balcilar et al., 2021). Instead, we employ full sample VAR models at different lags (1:4) and forecast periods (2:20) for each G-7 country data. Then, we make box plots for each variable from these calculations, as seen in Figures A.1 to A.7. Figures A.1 to A.7 show that the *SoSR* results do not take a far cry value when running these VAR models at different lags and forecast horizons. As a result, we can say that our results against various VAR lags and forecast horizons are robust, as demonstrated by the above robustness test with different window sizes.

6. Discussion

In the previous section, we attempt to put forth empirical findings and explain the different dynamics of oil, gold, and seven developed stock markets during the pre and post-covid periods. In this section, we compare our findings to those of earlier researches in the literature. Firstly, the main conclusion of our study is that only Bitcoin acts as a safe-haven among crude oil, gold against G-7 stock markets during the recent Covid-19 pandemic. The only time period that contradicts this finding is mid-2021, as can be seen from the figures. For example, the *SoSR* of oil climbs above two in the US. Indeed, this empirical result is consistent with some academic studies, such as Hasan *et al*. (2021), Mariana *et al*. (2021), Rubbaniy *et al*. (2021a,b), which show that Bitcoin acts as a safe-haven against some stock markets during the times of COVID-19. Our findings, however, contradict some studies in the literature. For example, Kristoufek (2020) employs time-varying quantile correlation analysis and discovers that the correlation between the S&P 500 and Bitcoin grows significantly during turbulent periods. However, gold outperforms Bitcoin in terms of portfolio and diversification usefulness. Evaluating the impact upon an S&P 500 portfolio diversified with an allocation to Bitcoin, Conlon and McGee (2020) find that the portfolio downside risk significantly increases.

As for gold, we find that gold served as a safe-haven asset just before 2020, but it started to lose its this property after that novel virus was first identified in the Chinese city of Wuhan in December 2019. Akhtaruzzaman *et al*. (2021) find that gold served as a safe-haven asset for stock markets from December 31, 2019–March 16, 2020, but it lost its safe-haven role from March 17−April 24, 2020. Our empirical data confirm their conclusions that gold loses its safe-haven features, but gold begins to lose its high-return low-risk property after January 2020. Our findings also provide evidence that the role of hedging effectiveness of gold change over the analysis period is in line with the work of Lucey and Li (2015), Li and Lucey (2017), Shahzad *et al*. (2019), Ji *et al*. (2020), Akhtaruzzaman *et al*. (2021). Further, we do not provide strong evidence to support the safe-haven properties of gold in developed markets during the Covid-19 stressful period.

By relying on the Sharpe ratio and genetic algorithm approach, Belhadj and Ben Hamad (2021) compare Bitcoin and gold's role and safe-haven properties against developed and emerging market indices during the COVID-19 crisis. In contrast to our findings, they discover that the gold acts as a safe-haven, but the Bitcoin does not show the same performance during the Covid-19. Furthermore, Kumar (2020) compares the safe-haven properties of gold and Bitcoin to various significant stock market indices (i.e., NSE50, DJIA, SSE, and CAC40) during the existing pandemic and discovers that both gold and Bitcoin display the safe-haven feature generally. Likewise, Chemkha et al. (2021) show that during the COVID-19 pandemic, gold is a weak safe-haven for the assets under consideration, whereas Bitcoin cannot provide protection owing to its increased volatility. Last but not least, Shehzad et al. investigates

This study is also related to the research topic, which looks into gold and Bitcoin's hedge and safe-haven properties in the crude oil market. Our empirical finding confirms that the SoRS value of crude oil has been below one from the beginning of Covid-19 to the middle of 2021, implying that the return spillover from the whole market to oil is less than the volatility spillover. As a result, throughout this period, we can claim that Bitcoin, whose *SoSR* value is typically more than one in the G-7 stock markets, also acts as a safe-haven for crude oil. Some studies agree with our empirical findings, but some do not. In contrast to our findings, Dutta *et al*. (2020) and Syuhada *et al*. (2021) show that Bitcoin cannot be used as a safe-haven amid turbulence such as the Covid-

19 outbreak, where gold can. Yousaf *et al*. (2021) find that gold is a powerful hedge and safe-haven for the oil market, but Bitcoin is a diversifier during the COVID-19 era.

7. Conclusion

This study fills significant gaps in the literature concerning the use of spillover effects in evaluating investment options. Aside from correlation analysis and studies in their various forms, it is common in theory that information spillover between assets plays a critical role in portfolio design (Zhang *et al*., 2021). To design better portfolio strategies, Mensi *et al*. (2018) recommend investors and speculators consider net spillover effects between assets. Accordingly, the rise in the spillover effects among financial assets during economic downturns requires investors to change the assets to diversify their portfolios and hedge market risk (Ji *et al*., 2020). Various studies such as Awartani and Maghyereh (2013), Fasanya *et al.* (2020), Balcilar *et al.* (2021), and Tiwari *et al.* (2021) use return and volatility spillover impacts among different financial assets to make financial inferences on certain economies. They do, however, concentrate on information spillovers between financial and non-financial assets, and they do not evaluate return and volatility spillover together. Hence, the impact of spillover among financial assets and their distribution on portfolio issues has not been well addressed in these studies.

This study fills this deficiency in the literature by establishing a link between spillover indices and financial concepts as hedge effectiveness and safe-haven in the scope of portfolio diversification. To do this, we use return and volatility spillover indices among financial markets and combine these two measures with the spirit of well-known risk assessment criteria, the Sharpe ratio. We base our approach on the following basic financial risk assessment criteria. As the financial asset earns a higher return while experiencing less volatility from the overall financial system, it can be put into a risk-free asset category based on its peers. Hence, we can say that this study is the first which attempts to combine return and volatility DY index to determine whether financial assets act as hedge effectiveness and safe-haven during financial calm or stressful times, respectively.

Our new approach uses daily data to investigate the hedge and safe-haven properties of common financial assets (i.e., gold, crude oil, and Bitcoin) with G-7 stock markets before and during Covid-

19 outbreaks. We believe that our research adds to the rapidly developing body of work on the financial consequences of COVID-19 and the continuing debate in the literature over whether Bitcoin or gold is a safe-haven investment. Firstly, our findings show that the hedging properties of crude oil, gold, and Bitcoin varies over time before the Covid-19 health crisis in G-7 economies. Put it differently; the empirical findings cannot conclude that any financial asset under consideration is predominantly a hedge against the G-7 stock market. Secondly, it is interesting to note that Bitcoin is the only asset that shows safe-haven properties against G-7 stock markets after the Covid-19 pandemic. In other words, the amount of return that Bitcoin receives from the financial system appears to be significantly greater than the amount of risk that it takes during the pandemic. On the other hand, this is not the case for gold and crude oil. In that regard, we can say that our empirical findings support studies that assert Bitcoin can be used as a safe-haven after Covid-19. But, our empirical findings provide the same evidence for neither gold nor crude oil.

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Appendix

Figure A.1 The robustness results for the US full sample analysis (lag=1:4, forecast period=2:20)

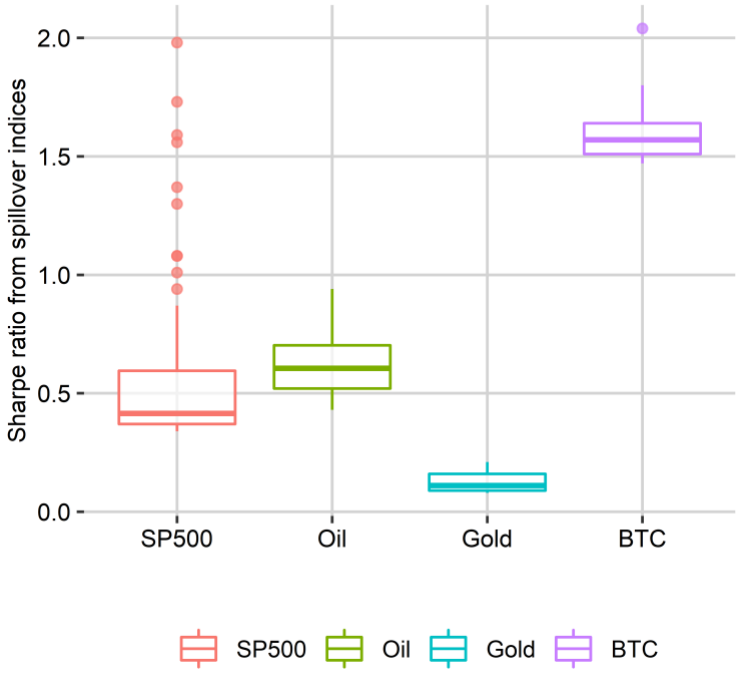

Figure A.2 The robustness results for Japan full sample analysis (lag=1:4, forecast period=2:20)

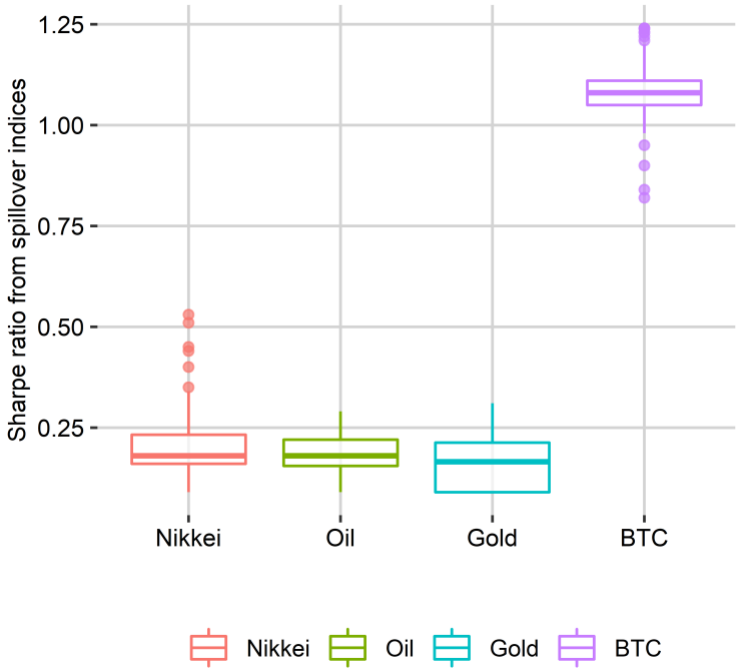

Figure A.3. The robustness results for Germany full sample analysis (lag=1:4, forecast period=2:20)

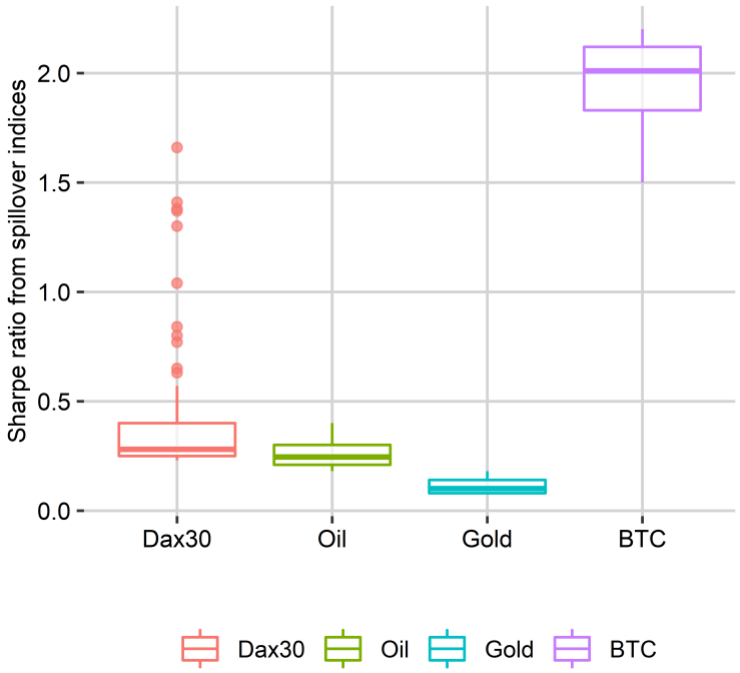

Figure A.4. The robustness results for the UK full sample analysis (lag=1:4, forecast period=2:20)

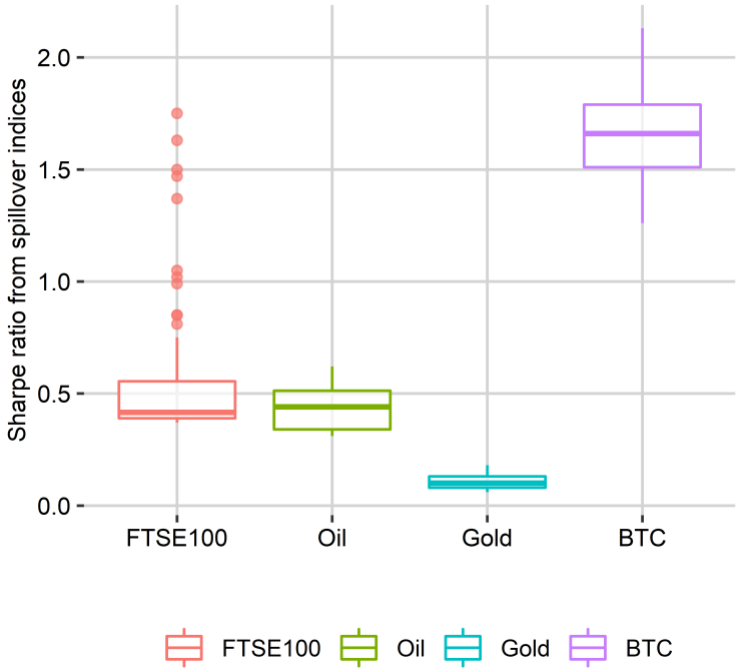

Figure A.5. The robustness results for France full sample analysis (lag=1:4, forecast period=2:20)

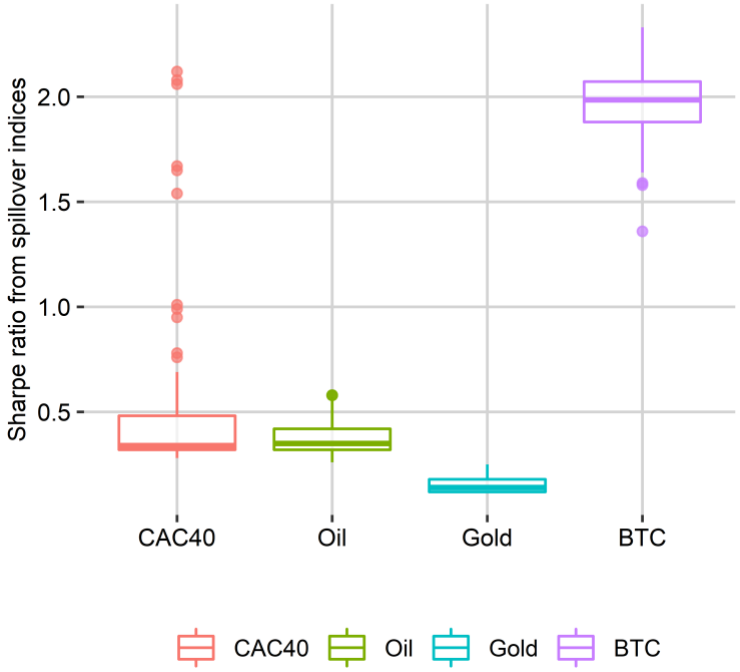

Figure A.6. The robustness results for Italy full sample analysis (lag=1:4, forecast period=2:20)

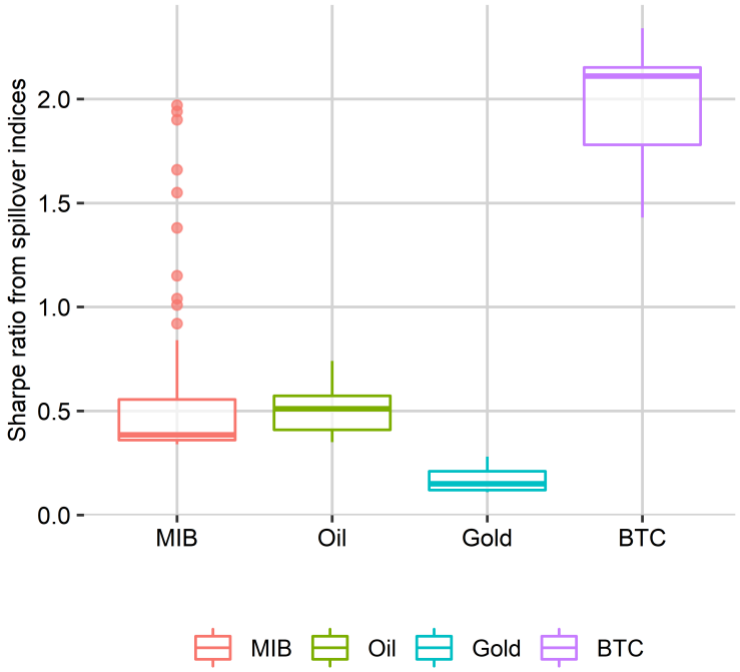
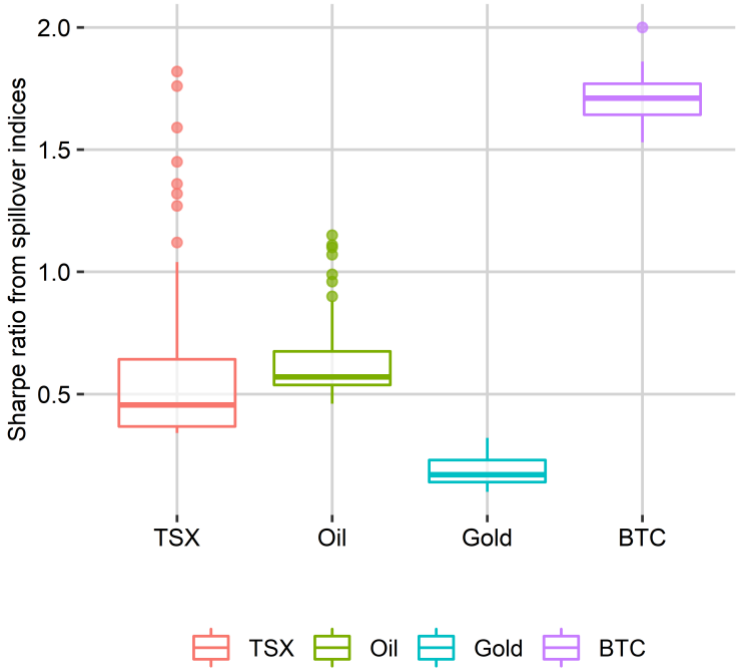
Figure A.7. The robustness results for Canada full sample analysis (lag=1:4, forecast period=2:20)