PORTFOLIO DIVERSIFICATION DURING COVID-19 OUTBREAK: IS GOLD A HEDGE AND A SAFE-HAVEN ASSET?

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Abstract

Price changes on all international financial and commodity markets have shown a significant correlation. The correlation dependence increased due to macroeconomic changes that led to cyclical economic trends caused by the COVID-19 pandemic. In the new economic circumstances, there has been a change in investment strategy of individual and institutional investors. The investment portfolios have increased in demand related to the purchase of gold, seen as a safe-haven asset, which has led to significant growth in aggregate demand on the international precious metals market. This paper deals with a dynamic conditional correlation (DCC) between the investment in gold as an asset and the movement of major world market indices. We used cryptocurrency (bitcoin) volatility as an independent variable in the model. We tested its correlation to the other major market indices and gold as a safe-haven asset. Related to a proposed model based on GARCH DCC and the Generalised Reduced Gradient (GDR) algorithm, we set up the Hedging Effectiveness (HE) index and an optimally weighted investment portfolio.

Keywords: COVID-19, gold, market indices, bitcoin, portfolio diversification, hedging, safe-haven asset

JEL Classification: G15, G20, G21, G23

1. Introduction

The COVID-19 pandemic, which was declared in March 2020, brought uncertainty and panic, leading to a slowdown in all economic activities and an increase in price volatility on financial and commodity markets. Okorie and Lin (2021) stated a visible decline in the financial performance of companies in all economies and sectors, reflecting on the dynamics

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of the capital market. At the same time, official statistics show a continuous increase in the numbers of cases and deaths globally, on a daily level. The COVID-19 pandemic, as a global health crisis with significant economic consequences, is believed to surpass the 2008 financial crisis (Park and Shin, 2020; Agosto *et al.*, 2020; Zaremba *et al.*, 2020).

Following that, there was a change in the investment activities of both individual and institutional investors. The activities were related to diversification of current and potential investment portfolios. Application of adequate diversification should lead to a reduction of all types of financial risks. The new structuring of the investment portfolio required an asset that could replace one or a certain number of financial assets and have divergent market movements to reduce losses and the degree of risk at the portfolio level. An asset suitable for these activities is gold, often referred to as investing in a safe haven.

The use of gold as a safe-haven asset is not new. This precious metal has played a significant investment role in previous financial crises, such as the global financial crisis in 2008. The growth of aggregate demand for precious metals, specifically gold, has conditioned significant price fluctuations of this precious metal. The first major peak in the gold price growth occurred at the beginning of 2020, when the price per troy ounce was over 1,560 US dollars, a 21% increase compared to the same period in 2019. These changes in the price of gold and other precious metals on the LBMA market have led to an expansion of investors' interest in using gold as an asset to diversify their portfolios. As the pandemic continued, the price of gold at the end of June 2020 rose to around 1,800 US dollars per troy ounce, which is an increase of 15% compared to the beginning of 2020, or an increase of 40% compared to the beginning of 2019. Related to negative cyclical economic trends on the international financial markets, we should expect that the growth trend of gold as a safe-haven asset will continue during 2021.

We set up the research question as follows: "Can gold be used as a safe haven or investment alternative for individual and institutional investors in the creation of an optimal investment portfolio?" In this paper, the impact of gold as a new asset is set to provide investors with information about the necessary level of diversification and hedging of certain financial positions.

Based on the research question, the subject of this study is the formation of an investment portfolio in a crisis and increased volatility on the financial markets. The paper analyses the need to diversify the investment portfolio to expand returns and reduce market risks. The main goal of the research is to justify the use of gold as a safe-haven asset and hedging instrument to diversify and optimize the combined investment portfolio (stocks and cryptocurrencies), especially at a time characterized by unusual activities caused by negative cyclical economic trends and the COVID-19 pandemic.

Despite creating research that allows investors to form an optimal investment portfolio with gold as a safe-haven asset, the model has several limitations. They are related to the unknown duration of exceptional economic circumstances and the total limited amount of gold on the market, which, due to increased aggregate demand, quickly leads to a significant increase in the price of these assets, as well as in the value of the bitcoin cryptocurrency market. After the cessation of the recessionary economic flow on a global level, observed in the mid-term, it is realistic to expect a decline in the value of gold. Due to the decrease in the value of gold, these real assets may give way to other traditional forms of financial assets that are well known to investors as hedging instruments on the international financial market. Because of these tendencies, the elemental limitation of the model based on gold as a safe-haven property or hedging instrument, together with the bitcoin cryptocurrency, refers to a lengthy period.

The paper has the following structure. After the Introduction, Section 2 presents a literature review with the latest scientific analysis based on the main subject and goal of research. Section 3 presents the research methodology. Empirical analysis and discussion of main results follow in Section 4, where results of the proposed model obtained by implementing multivariate regression analysis are presented in the first part, and portfolio diversification and results of the construction of an optimally weighted investment portfolio are presented in the second part. Section 5 makes some concluding remarks.

2. Literature Review

Economic theory has differing views on gold as a safe haven. Baur and Lucey (2010) believe that gold can be used in hedging activities versus the average group of shares in case of extreme market circumstances, as well as safe-haven assets in the short term. Their analysis claims that gold is a hedge against stocks on average and a safe haven in extreme stock market conditions. Their empirical results show that gold is a safe haven for stocks but not for bonds on any market. The authors state that gold as a safe-haven asset could be used for a limited time, and investors can lose money if holding gold for more than 15 trading days after an extreme negative price shock on the LBMA market.

In another research, the same authors used a descriptive and econometric analysis for the 30 years from 1979 to 2009 (Baur and McDermott, 2010). They found that gold is both a hedge and a safe haven for major European stock markets and the US but not for Australia, Canada, Japan and large emerging markets, such as the BRIC counties. Gold can be used as a stabilizing force for the financial system by reducing losses in extreme negative market shocks.

In further research related to gold as a safe haven, Baur and McDermott (2016) stated that gold is a noted safe-haven asset but risky compared to other safe-haven assets such as risk-free US government bonds. Under the market conditions related to a global financial crisis in 2008, the US dollar took the role of the safe-haven currency and overlaid the effect of gold as a safe haven.

Baur and Smales (2020) investigated the connection between geopolitical risk and precious metals as hedging instruments. Precious metals can be used as a hedge against geopolitical risk. On the other side, stocks and bonds respond negatively to geopolitical risk. Authors found that only gold and silver have visible safe-haven properties.

Shahzad *et al.* (2019a), Raza *et al.* (2018), indicated that the gold market is less sensitive to bond market innovations and more responsive to stock market innovations. They found otherwise that gold does not act as a safe haven for the stock and bond markets.

Ciner *et al*. (2013) analysed how gold acts as a safe-haven asset against the US dollar and GB pound between January 1990 and June 2010. These authors investigated the dynamic correlations between oil, gold, currency, bond and stock markets in the US and the UK. They stated that the bond market plays its traditional role as a hedge for the equity market. However, in conditions of extreme price movements, when exchange rates drop significantly, gold acts as a safe haven. Gold is also seen as a safe haven when changing the exchange rate of different currencies, emphasizing its monetary role and the role of hedging against currency risks at the portfolio level (Ciner *et al.,* 2013).

Reboredo (2013) stresses the need to use a mixed approach to the gold-currency portfolio, which shows the positive effect of diversification and risk reduction. In his study of gold as a safe haven or a hedge for the US dollar, the author examined the period between January 2000 and September 2012 and found positive and significant average dependence between gold and the US dollar depreciation. The author stated that gold could hedge against the US dollar rate movement. In this research, the authors prove symmetrical tail dependence between gold and the US dollar exchange rates, which indicates that gold can act as a safe haven against extreme US dollar rate movement. Regarding risk management, gold showed significant downside risk reduction if investors used gold in currency portfolio risk management. The hedging effectiveness index shows a high level at the portfolio level containing gold and main financial assets (Akhtaruzzaman *et al.,* 2020a; 2020b).

Under altered market circumstances, a need to re-evaluate existing known safe-haven assets such as gold, cryptocurrencies, exchange rates and commodities emerges, showing that of all known safe-haven assets, gold retains a leading role (Ji, 2020). The use of cryptocurrencies as safe-haven assets may vary over time and depend on different movements on the financial market, which has not been confirmed (Shahzad *et al*., 2019b). They researched bitcoin (BTC), gold and commodities as safe-haven assets on a sample period spanning from 19 July 2010 to 22 February 2018. Their analysis focused on leading market indices in the USA, China and other developed and emerging economies. The main results show that BTC, gold and the commodity index can be considered weak safe-haven assets in some cases. This is the expected result, considering the extremely high volatility of cryptocurrencies even in stable financial circumstances.

Naeem *et al*. (2020) indicated that BTC, as the leading cryptocurrency, shows hedging potential for the noncyclical industries, but gold is still a superior hedging instrument compared to BTC. Gold is an excellent and stable diversifier for industry portfolios and has higher safe-haven and hedging potential over cryptocurrencies.

In one of the latest studies, Shahzad *et al.* (2020) compared gold and BTC for G7 stock markets between 20 July 2010 and 31 December 2018. They found that gold is a safe-haven and hedge asset for several G7 stock indices instead of BTC, which has minor hedge potential. The main results indicate that gold and BTC have substantial dissimilarities regarding safe-haven or hedge abilities for the stock markets of the G7 countries. However, BTC provides profit opportunities for investors and has very high volatility, which is not acceptable for most investors on medium and long-term investments. This aggressive growth in the price of cryptocurrencies, especially BTC, is potentially interesting for investors in extraordinary market conditions, such as current conditions related to the COVID-19 pandemic.

As for volatility of cryptocurrencies from 25 July 2016 to 1 April 2020, Shahzad *et al.* (2021) indicated various spillover patterns in volatility regimes during COVID-19. Authors found more intense spillovers across all cryptocurrencies in the high volatility regime during the COVID-19 period.

Another group of authors investigated the impact of the COVID-19 pandemic on different market indices and the possibilities of a hedge on the financial market to mitigate the bleak effects caused by the pandemic. Akhtaruzzaman *et al.* (2020a; 2020b) researched how financial contagion occurs through financial and nonfinancial firms between China and G7 countries. The empirical results of their study show a significant increase in dynamic conditional correlation (DCC) between observed firms during the COVID-19 period. Also, optimal hedge ratios have increased significantly in most cases during the pandemic.

Zhang *et al*. (2020) found significant impacts on the global market, increases in volatility and global stock market reactions during the COVID-19 pandemic. They stated that counties are not working together to cope with these challenges, and there are a visible different national strategies of implementing adequate macroeconomic policy. As to the impact of unprecedented market conditions on emerging stock markets, Salisu *et al*. (2020) evaluated the stock return predictability of 24 emerging market stocks. These authors found that emerging market stocks are more vulnerable to uncertainty of pandemics and epidemics than developed market stocks. Salisu *et al.* (2021) stated that developed stock markets offer a better hedge against pandemics and epidemics. Under the COVID-19 pandemic, it is vital to evaluate the role of gold as a hedge or safe-haven asset.

Ji *et al*. (2020) studied the period between August and December 2019 and the period between December 2019 and March 2020, stating that in these two periods during the COVID-19 pandemic, gold and other commodities such as soybeans remain robust as safe-haven assets. Besides previous analyses, Akhtaruzzaman *et al.* (2021) analysed the role of gold as a hedge or safe haven in two phases. Phase I covered the period from 31 December 2019 to 16 March 2020 and Phase II between 17 March and 24 April 2020. These authors emphasize that gold used as safe haven for stock markets during Phase I kept its safe-haven role during Phase II. However, if we looked at optimal weights of gold in S&P 500, Euro Stoxx 600, Nikkei 225 and WTI crude oil portfolio, the impact increased significantly during Phase II, which suggests that investors have used gold as a safe haven during the crisis. It is also crucial to evaluate the role of gold as a safe haven with other commodities such as crude oil or real estate.

In analyses of hedging the oil price risk with gold, Salisu *et al.* (2021) used an asymmetric VARMA-GARCH model with daily frequencies data in the period between January 2016 and August 2020. Empirical results of their study find gold as a significant safe haven against oil price risks. Optimal portfolio and hedging ratios confirmed results from this research, and authors proved the hedging effectiveness of other precious metals such as silver, platinum and palladium. Based on these results, investors and portfolio managers can use gold and other precious metals to diversify an investment portfolio and to minimize the risk associated with volatility or market risk in general.

Finally, the investors' preferences vary over time. One group of investors may weigh more profits on their portfolio, and another may choose variance or skewness over return. Regarding these, different investors have been chosen during the current pandemic period. In their research, Ashfaq *et al.* (2021) set up a model of multiple-objective optimization. They used a polynomial goal programming model and analysed the market indices of BRIC counties from January 2010 to December 2016. Findings from their research show different investment patterns for potential investors in BRIC counties. As leading counties in the BRIC group, investments in India and China advise investors to invest in stocks on the Indian financial market and look at portfolio returns on the Chinese financial market.

Qur'anitasari *et al.* (2021) determine the stocks of the LQ-45 index, which form a portfolio based on a single index model, analysed using the Sharpe, Treynor and Jensen ratio in measuring portfolio performance. The regression analysis shows that the Sharpe method is most appropriate for measuring portfolio performance. The authors suggest further research, and we can use other models in the formation of portfolios (Sortino ratio and Information ratio).

3. Research Methodology

In this paper, we used a statistical model based on GARCH DCC, a dynamic condition correlation based on stock variables at the level of the investment portfolio, gold as a hedging and safe-haven asset and BTC cryptocurrency as a hedging instrument. We used descriptive statistic methodology to describe the rudimentary features of the study data. For the descriptive statistic methodology, we used a sample period for the price of dominant market indices, including price data for gold and BTC between March 2020 and May 2021.

This paper proposes a multivariate generalized autoregressive conditional heteroscedasticity (GARCH) correlation model, used to describe an approach to estimating volatility on financial markets, which is set up by the proposed model (Engle, 2001). The proposed model should allow the projection and analysis of volatility changes over time. Multivariate correlation analysis was applied based on the period from March 2020 to May 2021 with the impact of different variables on an investment portfolio. The first reason for applying the GARCH multivariate model is that asset pricing depends on the covariance of assets in the portfolio. In this regard, it is principal to analyse all these price movements at the portfolio level. Secondly, financial market volatility has a common trend that is closed during the observation period. The implementation of multivariate analysis and some other assets in the analysis should enable the creation of more relevant empirical models. The use of a multivariate model such as GARCH DCC ensures a better application of portfolio selection at the level of individual and institutional investors.

Assuming that we have a return defined as α_t, and n assets with the expected value 0 and the covariance matrix $\mathbf{H}_t$, then the GARCH DCC model can be expressed as:

$$r_t = \mu_t + \alpha_t \,, \tag{1}$$

$$\alpha_t = \mathbf{H}_\mathbf{t}^{1/2} z_t \,, \tag{2}$$

where $\boldsymbol{r}_t$ $(n \times 1)$ is the vector of log-returns of n assets at the time t, $\boldsymbol{\alpha}_t$ $(n \times 1)$ is the vector of mean-corrected returns of n assets at the time t, $\boldsymbol{\mu}_t$ $(n \times 1)$ is the vector of the expected value of the conditional r_t, $\mathbf{H}_t$ $(n \times n)$ is the matrix of conditional variance α_t at the time t, $\mathbf{H}_\mathbf{t}^{1/2}$ is the obtained Cholesky factorisation of H_t, z_t $(n \times 1)$ is the vector of *iid* errors such that $E\,[z_t] = 0$ and $E\,[z_t z_t^T] = 1$ (Orskaug, 2009).

In the further design of the multivariate GARCH model, we used a model based on conditional variance and correlations. The conditional covariance matrix can be decomposed into conditional standard deviations and a correlation matrix as:

$$\mathbf{H}_t = D_t R_t D_t , \tag{3}$$

where $\mathbf{H}_t$ ($n \times n$) is the conditional covariance matrix, $\mathbf{D}_t$ ($n \times n$) is the diagonal matrix of the conditional standard deviation of $\boldsymbol{\alpha}_t$ at the time t, $\mathbf{R}_t$ ($n \times n$) is the conditional correlation matrix of $\boldsymbol{\alpha}_t$ at the time t.

$$D_t = diag\left(H_{11,t}^{\frac{1}{2}} \cdots H_{nn,t}^{\frac{1}{2}} \right), \tag{4}$$

$$R_t = diag\left(q_{1,t}^{-\frac{1}{2}}, \ldots\ q_{n,t}^{-\frac{1}{2}} \right) Q_t\, diag\left(q_{1,t}^{-\frac{1}{2}}, \ldots\ q_{n,t}^{-\frac{1}{2}} \right). \tag{5}$$

As standardised residuals, we can express $u_{i,t}$ as:

$$u_{i,t} = \alpha_{i,t} / \sqrt{H_{ii,t}} \tag{6}$$

$\mathbf{R}_t$ is the conditional correlation matrix of the standardized disturbance ϵ_t. The conditional correlation matrix is symmetric. The standardized disturbance can be presented as:

$$\epsilon_t\, D_t^{-1} \alpha_t \sim N\left(0, R_t\right). \tag{7}$$

$\mathbf{R}_t$ can be decomposed into:

$$R_t = Q_t'^{-1} Q_t Q_t'^{-1}. \tag{8}$$

Q_t' is a diagonal matrix with the square root of the diagonal elements of $\mathbf{Q}_t$. Further, $\mathbf{Q}_t$ must be positive definite to ensure $\mathbf{R}_t$ to be positive definite.

$$Q_t' = (q_{ii,t}') = \sqrt{q_{ii,t}} \ . \tag{9}$$

The return in the DCC model between gold and underlying market indices can be shown as:

$$r_{ii,t} = q_{ii,t} / \sqrt{q_{ii,t} q_{jj,t}} \ , \tag{10}$$

$$i, j = 1, 2, \ldots, n, \ and\, i \neq j, \tag{11}$$

where $r_{ii,t}$ represents the conditional correlation between the return of gold and the return of each stock index pair.

Research has shown that the Hedging Effectiveness (HE) index for a portfolio composed of gold and other major assets improves the portfolio's performance in terms of adjustment with financial and market risks during crisis and non-crisis periods (Rossi and Zucca, 2002).

Before setting up, the HE index should define how the optimal portfolio, which is described with gold and other market indices of this investment portfolio, evolves during the COVID-19 pandemic. It is necessary to calculate the optimal weight of gold in a proposed investment portfolio (Kroner and Ng, 1998). The optimal weight at the time *t* can be expressed as:

$$w_t^{i/gold} = \frac{h_t^i - h_t^{i/gold}}{h_t^i - 2h_t^{i/gold} + h_t^{gold}} , \tag{12}$$

where h_t^i and h_t^{gold} are conditional volatility of S&P500, NIKKEI 225, STOXX 600, SSE Composite Index, SZSE Component Index and BTC, and $h_t^{i/gold}$ represents the covariance between gold and proposed market indices at the the time *t*. Following this assumption, the optimal hedge ratio $\beta_t^{i/gold}$ is calculated as (Kroner and Sultan, 1993):

$$\beta_t^{i/gold} = \frac{h_t^{i/gold}}{h_t^{gold}} , \tag{13}$$

Following the construction of an optimal investment portfolio, the HE index can be expressed by comparing the variance of hedged and unhedged portfolios. HE index can be calculated as (Chang *et al*., 2011):

$$HE = \frac{var_{unhedged} - var_{hedged}}{var_{unhedged}} , \tag{14}$$

where var_{hedged} and $var_{unhedged}$ is the variance of the hedged/unhedged portfolio return. The variance for the hedged investment portfolio can be calculated as:

$$var\left(r_{h,t}|I_{t-1}\right) - 2\beta_{1,t} cov\left(r_{gold,t}|I_{t-1}\right) + \beta_{i,t}^2 \left(r_{i,t}|I_{t-1}\right) . \tag{15}$$

In this part, we have established all the necessary theoretical grounds for the upcoming analysis based on the proposed model, defined the research question related to gold as a safe haven or investment alternative for an investment portfolio, and statistical analysis used for portfolio diversification.

The second stage of the analysis is related to proving the research question. The research question based on the proposed model is as follows: "Can gold be used as a safe haven or investment alternative for individual and institutional investors in the creation of an optimal investment portfolio?" To prove the proposed research question, it was necessary to set up dependent and independent model variables. Gold was used as a dependent model variable. A group of independent variables was used with the dependent variable. The further model development represents the influence of each of these independent variables on the dependent variable with the implementation of multivariate regression correlation analysis. The independent model variables represent the trading values shown through a composite index of major global financial indices such as S&P 500, NIKKEI 225, STOXX 600, SSE Composite Index, SZSE Component Index, and trading values and volatility of the BTC cryptocurrency.

For all model variables, we used data from March 2020 to May 2021, a period of the COVID-19 pandemic, and consequently a direct impact on real and financial sector developments and the emergence of global economic contraction trends. The analysis includes an independent variable of the model that follows the trading indices of one of the first and most well-known cryptocurrencies, the BTC, to show whether this independent variable has a significant economic movement that can be an alternative for investors, with investments in traditional stocks on financial markets or gold as a safe-haven asset and dependent model variable.

4. Results and Discussion

In this section, we present the results of the proposed model obtained by means of the implementation of multivariate regression, portfolio diversification and discussion related to achieved results. We used multivariate regression as a method to measure the degree to which more than one independent variable and more than one dependent variable are linearly related. To implement the multivariate regression analysis, we analyse trading data for leading trading indices, gold as an asset with possibilities to use as a safe-haven or hedge asset, and the bitcoin as a major cryptocurrency that can be used as a hedge asset. The observed period covered extraordinary market conditions caused by the COVID-19 pandemic.

4.1 Multivariate regression analysis and results

To implement the proposed model, based on multivariate regression analysis, we used trading value data shown in Table 1 for the period related to the COVID-19 pandemic, representing dependent and independent model variables. Multivariate regression analysis uses the least-square method. Based on the given data from Table 1, it was possible to conduct a linear analysis, minimizing the sum of the squares of errors following the values of the predicted model variables.

Table 1: Data on trading value of dependent and independent model variables

M/Y	Gold	S&P 500	NIKKEI 225	STOXX 600	SSE Composite Index	SZSE Component Index	BTC
03/2020	1,592.85	2,584.59	18,917.01	320.06	2,750.30	1,665.93	6,412.50
04/2020	1,681.48	2,912.43	20,193.69	340.03	2,880.08	1,763.36	8,629.00
05/2020	1,716.04	3,044.31	21,877.89	350.36	2,852.35	1,786.51	9,454.80
06/2020	1,733.13	3,100.29	22,288.14	360.34	2,984.67	1,975.52	9,135.40
07/2020	1,842.06	3,271.12	21,710.00	356.33	3,310.01	2,256.87	11,333.40
08/2020	1,969.87	3,500.31	23,139.76	366.51	3,395.68	2,295.49	11,644.20
09/2020	1,922.85	3,363.00	23,185.12	361.09	3,218.05	2,149.54	10,776.10
10/2020	1,901.40	3,269.96	22,977.13	342.36	3,224.53	2,198.07	13,797.30
11/2020	1,866.50	3,621.63	26,433.62	389.36	3,391.76	2,249.66	19,698.10
12/2020	1,854.88	3,756.07	27,444.17	399.03	3,473.07	2,329.37	28,949.40
01/2021	1,868.33	3,714.24	27,663.39	395.85	3,483.07	2,335.05	33,108.10
02/2021	1,811.09	3,811.15	28,966.01	404.99	3,509.08	2,293.69	45,164.00
03/2021	1,719.89	3,972.89	29,178.80	429.60	3,441.91	2,217.62	58,763.70
04/2021	1,760.24	4,181.17	28,812.63	437.40	3,446.86	2,298.93	57,720.30
05/2021	1,867.50	4,173.85	28,084.47	443.76	3,529.01	2,324.27	45,011.70

Source: Yahoo Finance – Trading Data

Table 2 presented statistical analysis related to the research question based on the implementation of multivariate regression analysis. In the analysed model, seven variables were set, one of which is dependent, and the other six are independent variables. As a dependent variable, gold was used as a safe-haven asset, with the other six remaining market indices tracking movements on the most important international financial markets. The model variables presented in Table 2 are denoted as β_1 to β_6, and based on the formula for multivariate regression analysis given in the following form:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots \beta_6 x_6 + \varepsilon \ . \tag{16}$$

Variables from β_1 to β_6 represent independent model parameters and ε is the error term. For the independent model, each variable was calculated with standard error, with a 95% confidence interval.

In further analysis of the effects of the dependent variable, presented in the proposed model based on the movement of the price of gold as a safe-haven asset, it was necessary to conduct portfolio diversification. The modern portfolio theory (MPT), first presented by Harry Markowitz (1952), analysed portfolio diversification. Table 2 shows the return value for the dependent and independent variables for the proposed model.

Table 2: Monthly return values for dependent and independent variables

	Return						
M/Y	**Gold**	**S&P 500**	**NIKKEI 225**	**STOXX 600**	**SSE Composite Index**	**SZSE Component Index**	**BTC**
04/2020	5.56	12.68	6.75	6.24	4.72	5.85	34.57
05/2020	2.06	4.53	8.34	3.04	−0.96	1.31	9.57
06/2020	1.00	1.84	1.88	2.85	4.64	10.58	−3.38
07/2020	6.29	5.51	−2.59	−1.11	10.90	14.24	24.06
08/2020	6.94	7.01	6.59	2.86	2.59	1.71	2.74
09/2020	−2.39	−3.92	0.20	−1.48	−5.23	−6.36	−7.46
10/2020	−1.12	−2.77	−0.90	−5.19	0.20	2.26	28.04
11/2020	−1.84	10.75	15.04	13.73	5.19	2.35	42.77
12/2020	−0.62	3.71	3.82	2.48	2.40	3.54	46.97
01/2021	0.73	−1.11	0.80	−0.80	0.29	0.24	14.37
02/2021	−3.06	2.61	4.71	2.31	0.75	−1.77	36.41
03/2021	−5.04	4.24	0.73	6.08	−1.91	−3.32	30.11
04/2021	2.35	5.24	−1.25	1.82	0.14	3.67	−1.78
05/2021	6.09	−0.18	−2.53	1.45	2.38	1.10	−22.02

Source: Own calculations

Based on the setting of the regression model in which gold is a dependent variable, two variables were obtained as statistically significant independent variables, namely the SZSE Component Index and the BTC (see Table 3).

Table 3: Regression model statistics

Analysis of variance (Gold):					
Source	**DF**	**Sum of squares**	**Mean squares**	**F**	**Pr > F**
Model	2	108.710	54.355	41.220	< **0.0001**
Error	10	13.186	1.319	–	–
Corrected total	12	121.896	–	–	–

Sum of squares analysis (Gold):					
Source	**DF**	**Sum of squares**	**Mean squares**	**F**	**Pr > F**
S&P 500	0	0.000	–	–	–
NIKKEI 225	0	0.000	–	–	–
STOXX 600	0	0.000	–	–	–
SSE Composite Index	0	0.000	–	–	–
SZSE Component Index	1	47.000	47.000	35.643	**0.000**
BTC	1	61.709	61.709	46.798	< **0.0001**

Model parameters (Gold):						
Source	**Value**	**Standard error**	***t***	**Pr > |*t*|**	**Lower bound (95%)**	**Upper bound (95%)**
Intercept	1.207	0.432	2.794	**0.019**	0.245	2.169
S&P 500	0.000	0.000	–	–	–	–
NIKKEI 225	0.000	0.000	–	–	–	–
STOXX 600	0.000	0.000	–	–	–	–
SSE Composite Index	0.000	0.000	–	–	–	–
SZSE Component Index	**0.633**	0.105	6.040	**0.000**	0.399	0.866

Table 3 (Continuation)

Standardized coefficients (Gold):						
Source	**Value**	**Standard error**	***t***	**Pr > |*t*|**	**Lower bound (95%)**	**Upper bound (95%)**
S&P 500	0.000	0.000	–	–	–	–
NIKKEI 225	0.000	0.000	–	–	–	–
STOXX 600	0.000	0.000	–	–	–	–
SSE Composite Index	0.000	0.000	–	–	–	–
SZSE Component Index	**0.628**	0.104	6.040	**0.000**	0.396	0.860
BTC	**–0.712**	0.104	–6.841	**< 0.0001**	–0.943	–0.480

Source: Own calculations

All necessary econometric tests were performed to verify the obtained model: autocorrelation – Durbin-Watson test, multicollinearity – VIF and TOL, heteroscedasticity – Breusch-Pagan and White test. The test results are shown in Table 4.

Table 4: Results of econometric tests

Durbin-Watson test:	
U	**2.006**
***p*-value**	**0.473**
alpha	0.050
H_0: The residuals are not autocorrelated	
Breusch-Pagan test:	
LM (Observed value)	2.573
LM (Critical value)	5.991
DF	2.000
***p*-value (2-tailed)**	**0.276**
alpha	0.050
White test:	
LM (Observed value)	4.346
LM (Critical value)	11.070
DF	5.000
***p*-value (2-tailed)**	**0.501**
alpha	0.050
H_0: The residuals are homoscedastic	

Table 4 (Continuation)

Multicollinearity statistics:			
Statistic	**Gold**	**SZSE Component Index**	**BTC**
R^2	0.520	0.433	0.298
Tolerance	**0.480**	**0.567**	**0.702**
VIF	**2.082**	**1.765**	**1.424**
Test conclusion: Predictors are moderately correlated			

Source: Own calculations

The obtained results of the DW test in Table 4 indicate that the risk of rejecting the null hypothesis that the residuals are not autocorrelated is a *p*-value greater than 0.05. We can say that the analysis is statistically significant, and there is no pronounced autocorrelation.

In further analysis of the model variable multicollinearity, the Variance Inflation Factor (VIF) value was calculated. Table 4 also shows the values of R^2, which gives the static value of the variance proportions. Results from Table 4 show the lowest level of multicollinearity in the independent variable BTC. This result is somewhat expected because it is a cryptocurrency with very high volatility. The tolerance for all model variables is at a statistically significant level. The VIF values also indicate the lowest level of collinearity between gold as a dependent variable and BTC as an independent model variable.

Homoscedasticity/heteroscedasticity testing of model residuals was performed using the Breusch-Pagan and White tests. The obtained results at the level of 0.05 are satisfactory: −0.276 and 0.501. The conclusion is to accept H_0 – the residuals are homoscedastic.

4.2 Portfolio diversification model and results

As with the previously conducted analysis, the observed time covers the period of the COVID-19 pandemic from March 2020 to May 2021. The portfolio diversification analysis includes the analysis of the investment portfolio for gold as a safe-haven asset, five major financial indices, namely S&P 500, NIKKEI 225, STOXX 600, SSE Composite Index and SZSE Component Index, and the value of trading BTC as a cryptocurrency.

In the further analysis of portfolio diversification, we used statistical elements to calculate diversification, such as average monthly return, monthly variance, annual return and annual variance. It was necessary to divide the returns of market indices by the number of months in the period to determine the average monthly return. Based on nineteen span studies following a monthly effect in stock returns, Ariel (1987) stated that all the markets' cumulative advances occurred around the first half of the month. The second half did not contribute to the cumulative gain. The author concludes that there has been a small monthly effect in stock return. Rozeff and Kinney (1976) used monthly returns on stocks to evaluate seasonality on the fluctuation of a capital market. These studies were implemented in standard economic conditions and cannot be used in the contractionary stage of an economy, such as the current pandemic situation. We used monthly returns to calculate the variance-covariance matrix and, based on these results, to have sufficient data for portfolio diversification and construction of an optimally weighted investment portfolio.

The following formula can express monthly returns:

$$R_t = \frac{P_t}{P_{t-1}} - 1, \tag{17}$$

where R_t represents monthly returns P_t and P_{t-1}, P_t and P_{t-1} the prices of the assets at the moment t and $t-1$, respectively. The second statistic was the monthly variance value. The variance formula calculates the difference between a forecast and the actual result. The variance can be expressed as a percentage.

In our calculation for the portfolio diversification, we assume that the risk-free rate on 3M US Treasury Bills on 20 February 2020 is 1.55%, and calculate this risk-free rate based on annual returns data in Table 7. In that case, we can calculate expected returns, risk, Sharpe ratio, Treynor ratio and Jensen's alpha.

The expected return presents the amount of profit or loss an investor can expect to receive on an investment. Merton (1980) expressed that the expected return model explicitly reflects the dependence of the market returns on the interest rate but fails to account for changes in the level of market risk. To calculate an equally and optimally weighted investment portfolio, the expected return is calculated by multiplying potential outcomes by the odds of their occurrence and then totalling these results. The formula for the expected return is as follows:

$$E|R| = \sum_{i=1}^{n} R_i P_i \,, \tag{18}$$

where $E|R|$ is expected return, R_i return in the scenario *i, P_i* the probability of the return R_i in the scenario *i,* and n represent several scenarios.

The risk in Table 7 represents the market risk of all assets in the proposed investment portfolio. Finally, the Sharpe ratio calculation is used to understand the return of an investment compared to its risk (Sharpe, 1994). The Sharpe ratio is the average return earned over the risk-free rate per unit of volatility or total risk and can be calculated with the following formula:

$$Sharpe\,Ratio = \frac{R_p - R_f}{\sigma_p}\ , \tag{19}$$

where R_p is the return of the portfolio, R_f is the risk-free rate, and σ_p represents the standard deviation of the portfolio excess return.

The Treynor ratio is a kind of addition to the calculated Sharpe ratio. Compared to the Sharpe ratio, which includes total risk, the Treynor ratio uses a beta coefficient or systemic risk (Treynor, 1965). The Treynor ratio can be displayed as:

$$Treynor\,ratio = \frac{Return\ on\ the\ portfolio - Risk\ free\ rate}{Beta\ of\ the\ porfolio} = \frac{R_p - R_f}{B_p}\ . \tag{20}$$

The beta coefficient as a measure of systemic risk of assets included in the portfolio is obtained through the following formula:

$$\beta = \frac{covariance\left(R_e, R_m\right)}{variance\left(R_m\right)}, \tag{21}$$

where R_e is securities return and R_m is market return.

Jensen's alpha can be used to rank a portfolio by investors. The higher value of Jensen's alpha speaks in favour of a better-optimized portfolio (Jansen, 1968). Jensen's alpha is obtained based on the following formula:

$$Jensen's\,\alpha = R_p - \left(R_f + \beta_p\left(R_m - R_f\right)\right)\ , \tag{22}$$

where R_p is portfolio return, R_m is market return, R_f represents the risk-free rate (3M T-Bills), and β_p is the beta of the portfolio.

This section is related to constructing an optimal investment portfolio based on the implementation of investors' portfolio diversification. An optimal investment portfolio is based on different investment strategies by individual or institutional investors in the current market situation reflected with uncertainty and unprecedented market conditions. Table 5 presents statistics for portfolio diversification by using calculations of average monthly return, average monthly variance, annual return, annual variance and the beta coefficient.

Table 5: Statistics for portfolio diversification

Statistics							
	Gold	**S&P 500**	**NIKKEI 225**	**STOXX 600**	**SSE Composite Index**	**SZSE Component Index**	**BTC**
Average monthly return	1.21	3.58	2.97	2.45	1.86	2.53	16.78
Monthly variance	14.76	22.36	24.48	19.52	14.74	27.42	441.84
Annual return	14.52	42.99	35.64	29.38	22.36	30.35	201.40
Annual variance	177.16	268.27	293.81	234.27	176.94	329.08	5,302.06
Beta (β)	0.26	1.00	1.00	1.00	1.00	1.00	2.10

Source: Own calculations

Table 5 calculates the beta coefficient values for all model variables. The beta coefficient gold value and BTC were calculated using formula (21). The beta coefficients values were used in further analysis in connection with a diversified optimal investment portfolio. The beta values for gold and BTC were obtained using the base value of the market index S&P500, which has a value of 1.00, the benchmark value for market indices.

Continuing portfolio diversification analysis in Table 6, we calculated the excess return for the dependent and independent variables of the proposed model. Excess return is identified by subtracting the return of one investment from the total percentage achieved in another investment. For calculating portfolio excess return, we used multiple returns to get excess returns as a difference in an investment over a risk-free rate.

The results of the diversified investment portfolio are presented in Table 7. The first results are related to an equally weighted portfolio in which investors on an equal basis weigh each single asset investment in a portfolio. In the second portfolio, we have an optimally weighted portfolio that represents the best-diversified investment portfolio with trading assets such as bonds and stocks from main international financial markets and gold as a safe-haven asset and BTC as a hedging instrument.

Table 6: Excess returns for dependent and independent variables

Excess returns							
M/Y	**Gold**	**S&P 500**	**NIKKEI 225**	**STOXX 600**	**SSE Composite Index**	**SZSE Component Index**	**BTC**
03/2020	–	–	–	–	–	–	–
04/2020	4.35	9.10	3.78	3.79	2.86	3.32	17.78
05/2020	0.85	0.95	5.37	0.59	–2.83	–1.22	–7.21
06/2020	–0.21	–1.74	–1.09	0.40	2.78	8.05	–20.16
07/2020	5.07	1.93	–5.56	–3.56	9.04	11.71	7.28
08/2020	5.73	3.42	3.62	0.41	0.73	–0.82	–14.04
09/2020	–3.60	–7.51	–2.77	–3.93	–7.09	–8.89	–24.24
10/2020	–2.33	–6.35	–3.87	–7.64	–1.66	–0.27	11.25
11/2020	–3.05	7.17	12.07	11.28	3.32	–0.18	25.98
12/2020	–1.83	0.13	0.85	0.04	0.53	1.01	30.18
01/2021	–0.49	–4.70	–2.17	–3.25	–1.58	–2.29	–2.42
02/2021	–4.27	–0.97	1.74	–0.14	–1.12	–4.30	19.63
03/2021	–6.25	0.66	–2.24	3.63	–3.78	–5.85	13.33
04/2021	1.14	1.66	–4.23	–0.63	–1.72	1.14	–18.56
05/2021	4.88	–3.76	–5.50	–0.99	0.52	–1.43	–38.80

Source: Own calculations

If we assume an equally diversified investment portfolio in which each asset takes 15% of the portfolio, for the first six assets, and 10% investment in the BTC cryptocurrency, we should expect returns of this investment portfolio to be 46.43, with a market risk of 13.76, and a Sharpe ratio for this investment portfolio of 3.26. In the proposed investment portfolio, and assumed equally distributed investment, except investment in BTC, which has significant volatility, it can be assumed that rational investors will value BTC assets with 10% of their investment portfolio value. The second part of Table 7 presents the results of portfolio diversification after implementing modern portfolio theory, and these results show an optimally weighted portfolio. The optimally weighted portfolio is calculated using the generalised reduced gradient (GRG), based on an applied algorithm for the nonlinear programming method. Generalised gradient methodology sees the gradient or slope of the objective function as the input of variables measuring the changes of different investment assets in an investment portfolio. We can use two methods for constrained optimization. One is deterministic, the other is stochastic. Based on these approximations, GRG methods and the sequential quadratic programming methods represent the best deterministic local optimization methods. Alrabadi (2016) used the mean-variance optimization framework of Markowitz (Markowitz, 1952) on a portfolio consisting of 30 stocks from different sectors over the period between 2009 and 2013. He also used the GRG nonlinear algorithm to derive the optimally weighted portfolio that maximizes return or minimizes risk. Other authors, such as Li and Chan (2018), investigated the optimum portfolio of REIT (Real Estate Investment Trust) price return of Asia-Pacific, North America and a global portfolio, which included Asia-Pacific and North America countries, using the nonlinear generalised gradient methods.

Table 7: Equally and optimally weighted portfolio

Equally weighted portfolio	
Gold	0.15
S&P 500	0.15
NIKKEI 225	0.15
STOXX 600	0.15
SSE Composite Index	0.15
SZSE Component Index	0.15
BTC	0.10
SUM	1.00
Expected returns	46.43
Risk	13.76
Sharpe ratio	3.26
Treynor ratio	44.92
Jensen's alpha	3.48

Table 7 (Continuaion)

Optimally weighted portfolio	
Gold	0.63
S&P 500	0.00
NIKKEI 225	0.00
STOXX 600	0.20
SSE Composite Index	0.00
SZSE Component Index	0.00
BTC	0.16
SUM	1.00
Expected returns	47.72
Risk	12.64
Sharpe ratio	3.65
Treynor ratio	65.98
Jensen's alpha	17.17

Source: Own calculations

After forming the optimal investment portfolio, the values of the beta coefficient for the portfolio with equal distribution and the optimal portfolio were calculated. For a portfolio with equal distribution, the value of the beta coefficient is obtained, which is approximately equal to 1.00, while the value of the beta coefficient for the optimal investment portfolio is approximately 0.70. This indicates that the diversified investment portfolio includes 70% of changes in the market benchmark, which, in extraordinary economic circumstances, reflects that the optimal portfolio should have a lower volatility level.

$$\beta_{port}EWP = \left(\beta_{GOLD} \times 0.15\right) + \left(\beta_{S\&P500} \times 0.15\right) + \left(\beta_{NIKKEI\,225} \times 0.15\right) + \left(\beta_{STOXX\,600} \times 0.15\right) + \left(\beta_{SSE} \times 0.15\right) + \left(\beta_{SZSE} \times 0.15\right) + \left(\beta_{BTC} \times 0.10\right) \tag{23}$$

$$\beta_{port}EWP = \left(0.260 \times 0.15\right) + \left(1.0 \times 0.15\right) + \left(1.0 \times 0.15\right) + \left(1.0 \times 0.15\right) + \left(1.0 \times 0.15\right) + \left(1.0 \times 0.15\right) + \left(2.0 \times 0.10\right) = 0.999 \approx 1.00 \tag{24}$$

$$\beta_{port}OWP = (\beta_{GOLD} \times 0.63) + (\beta_{STOXX\,600} \times 0.20) + (\beta_{BTC} \times 0.16) \tag{25}$$

$$\beta_{port}OWP = (0.260 \times 0.63) + (1.0 \times 0.20) + (2.1 \times 0.16) = 0.6998 \approx 0.70 \tag{26}$$

Based on the obtained values of the beta coefficient for the portfolio with equal distribution and optimal portfolio, the Treynor ratios were calculated. After calculating the Treynor ratios, Jensen's alpha was also calculated, which is also based on systemic risk.

In an optimally weighted portfolio, based on the proposed model and trading data for the given time, investors will invest 63% of their funds in gold as an asset, 20% in STOXX 600, and 16% in BTC. These proportions in an investment portfolio will lead to optimal results and the highest value of expected returns at 47.72, a lower value of the market risk at 12.64, the highest value of Sharpe ratio at 3.65, and a Treynor ratio of 65.98, and the highest value of Jensen's alpha at 17.17. These results indicate sustainable portfolios or investments. In addition to the Sharpe, Treynor and Jensen ratios, investors can then use other performance measurement methods for comparisons and investment decisions, such as the Sortino ratio, V2 ratio, Omega ratio, M2 (Modigliani-Modigliani) and Information ratio.

5. Conclusions

The study examined the research question based on the implementation of multivariate regression analysis and the use of gold as a safe-haven asset. The verified research question confirmed that gold as a safe haven could be adequately used as an asset that allows diversification of the investment portfolio of individual and institutional investors. Gold as a safe haven can be used both in crisis and in other non-crisis periods, when it can show its full monetary potential to protect against currency risks. Investors can predict and extrapolate future market trends based on the set model and create adequate portfolio selections. Investing in gold as a safe haven has affected both the monetary side to eliminate financial risks and the side of currency exchange and market movements to eliminate market and currency risks. Of course, due to excessive aggregate demand for these assets, their value continues to grow during the crisis, and it is necessary to determine the optimal volume of these assets at the portfolio level that allows the highest rate of return on investment depending on the value of risk (VaR). The proposed model, with gold as a dependent variable and six other independent variables, based on leading global composite trading indices, shows that gold can be a significant portion of an optimally weighed investment portfolio. Gold represents a considerable hedging instrument as well.

It is realistic to expect investors to be interested in diversifying their investment portfolios from 2020 and following in 2021 by including gold in their portfolios. Whether these activities will continue in 2021 largely depends on the effects of the measures taken at the level of national economies and the recovery of national economies and international markets, which should lead to stabilization and a larger volume of investment activities at the leading international stock exchanges.

In any case, using a robust GARCH DCC model, multivariate regression analysis and portfolio diversification based on MPT and GRG can help individual and industrial investors structure an efficient investment portfolio with minimal risk during a crisis. It can also help policymakers and regulators understand the effects and depth of the crisis on financial markets caused by the COVID-19 pandemic.

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