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Gold and US sectoral stocks during COVID-19 pandemic

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ABSTRACT

In this study, we examine the hedging relationship between gold and US sectoral stocks during the COVID-19 pandemic. We employ a multivariate volatility framework, which accounts for salient features of the series in the computation of optimal weights and optimal hedging ratios. We find evidence of hedging effectiveness between gold and sectoral stocks, albeit with lower performance, during the pandemic. Overall, including gold in a stock portfolio could provide a valuable asset class that can improve the risk-adjusted performance of stocks during the COVID-19 pandemic. In addition, we find that the estimated portfolio weights and hedge ratios are sensitive to structural breaks, and ignoring the breaks can lead to overestimation of the hedging effectiveness of gold for US sectoral stocks. Since the analysis involves sectoral stock data, we believe that any investor in the US stock market that seeks to maximize risk-adjusted returns is likely to find the results useful when making investment decisions during the pandemic.

1. Introduction

The literature on the response of financial markets, including the stock market, to the COVID-19 pandemic is fast growing, owing to its grave consequences. Several studies have examined the impact of the pandemic on financial markets (see for example, Ali et al., 2020; Al-Awadhi et al., 2020; Baig et al., 2020; Haroon and Rizvi, 2020a,b; He et al., 2020; Li et al., 2020; Narayan et al., 2020a,b; Mishra et al., 2020; Phan and Narayan, 2020; Prabheesh et al., 2020; Salisu and Akanni, 2020; Salisu et al., 2020a,b; Salisu and Sikiru, 2020; Salisu and Vo, 2020; Sharma, 2020; Zhang et al., 2020; Sikiru and Salisu, 2021; among others)[1] and the evidence suggests a negative impact; consequently, the need to hedge against the risk associated with the pandemic becomes crucial.[2] This is the motivation for our study. In response to this challenge, we consider gold to be a potential asset that can serve as a good hedge for stocks against the pandemic risk. The pioneering studies on the gold-stocks nexus (see for instance, McDonald and Solnik, 1977; Sherman, 1982; Jaffe, 1989; Chua et al., 1990) indeed support the inclusion of gold in the equities portfolio for the benefits of portfolio

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[1] In additions, there is a growing body of empirical literature showing the adverse effect of the current pandemic on other financial assets such as energy market including oil market (see, Iyke, 2020a; Narayan, 2020a; Devpura and Narayan, 2020; Polemis and Soursou, 2020; Salisu and Adediran, 2020; Salisu et al., 2020a,b; Qin et al., 2020), foreign exchange market (see Iyke, 2020b; Narayan, 2020b,c; Narayan et al., 2020a,b), and cryptocurrencies (Conlon and McGee, 2020; Corbet et al., 2020).

[2] We do acknowledge that studies on hedging in the literature are huge, however, we do not intend to review them here as this may distract us from the main objective of this study.

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diversification and downside risk management.[3],[4] This continues to be emphasised in the recent literature with pieces of evidence of negative or low correlation of gold in the investment portfolio containing stocks (see for example, Joy, 2011; Reboredo, 2013; Beckmann et al., 2015; Bredin et al., 2015). This strand of the literature also finds support in the conceptual arguments, which suggest stock market hedging qualities of gold when its return is shown to be negative or uncorrelated with the stocks prices (or returns) (see Baur and Lucey, 2010; Baur and McDermott, 2010; Zagaglia and Marzo, 2013).[5] In the class of traditional hedging assets, Shahzad et al. (2020), while not particularly considering the COVID-19 pandemic, have shown that gold offers more effective hedging benefits for G7 stock indices.

During pandemics, the search for alternative, safe assets is more critical than it is during tranquil periods, given the associated high uncertainties and the need to minimize downside investment risks (see Reboredo and Ugolini, 2017; Godil et al., 2020). The second motivation for situating the study in the context of the COVID-19 pandemic is hinged on previous incidences that have shown that stock market fundamentals were influenced by the SARS & Ebola Virus pandemics (see Chen et al., 2009; Ichev and Marinč, 2018). The third comes on the heels of the negative impacts of the COVID-19 pandemic on the global stock indices[6] and the US in particular (see Akhtaruzzaman et al., 2020; Ji et al., 2020; Shehzad et al., 2020 for relevant statistics showing that the major US indices (the DJIA and S&P 500) dropped by around 30 % and the stock market hit four historic circuit breakers during this period). The fourth motivation is against the backdrop of the literature, which suggests that the ability of gold to function as a justifiable hedge may be constrained during crises when the stock market volatility is exceptionally high,[7] which is currently observed to be the case as a result of the COVID-19 pandemic (see Hood and Malik, 2013; Baumöhl and Lyócsa, 2017; Shehzad et al., 2020).

This study focuses on the US sectoral stocks due to the pre-eminent posture of the US in the global economy and its highly developed financial market which attracts international investors to seek solace during periods of high market volatility (see for instance, Forbes, 2010; Gau and Wu, 2017; Yunus, 2020). This is theoretically argued in the International Capital Asset Pricing Model (I-CAPM), which allows investors to move their investments across national boundaries in search of international portfolio diversification in response to crises in one or more domestic markets (Guesmi and Nguyen, 2014; Adewuyi et al., 2019). Further, the sectoral analysis of stocks is important in the search for diversification benefits because of information transmission and diffusion of policy decisions across different classes of assets and markets (see Ciner et al., 2013; Baumöhl and Lyócsa, 2017). Further motivation for sectoral analysis emanates from the arguments of Haroon and Rizvi (2020b) in their sectoral analysis of effects of panic news on stocks, where they observe that aggregation hinders heterogeneous profiling of stock market fundamentals. Hence, sectoral analysis may reveal that the different sectors behave differently to the hedging behaviour of gold (see Akhtaruzzaman et al., 2020).[8]

In line with the extant literature on hedging, we construct a multivariate generalized autoregressive conditional heteroscedastic (MGARCH), which allows for time-variation in the analysis of hedging relationship (see for example, Arouri and Nguyen, 2010; Arouri et al., 2011a,b, 2012; Salisu and Mobolaji, 2013; Salisu and Oloko, 2015). Since there are alternative variants of the MGARCH model, we conduct relevant preliminary tests to determine the appropriate model. In addition to the outcome of these tests, the chosen methodology tends to offer superior hedging effectiveness performance relative to other competing models such as Vector Autoregressive model and its variants (see Lypny and Powalla, 1998; Lee et al., 2005; Sultan and Hasan, 2008; Yang and Lai, 2009).

Next to this background, we offer some preliminary analyses in Section 2 to determine the appropriate model for analyses; In Section 3, we evaluate the relative hedging effectiveness of gold for stock in order to mitigate the risk associated with the COVID-19 pandemic, while Section 4 concludes the paper.

2. Methodology

2.1. Data and pre-tests

In line with our study objectives, our data for sectoral stocks for the US and gold prices cover the period January 02, 2019 to July 27, 2020. The sample period is partitioned into three: (i) full sample, (ii) pre-COVID, and (ii) post-COVID. The pre-COVID sample covers the period before the emergence of COVID-19, that is, between January and December, 2019; while the COVID sample covers the period since the outbreak of the COVID-19 pandemic, starting from January 2020. The full sample on the other hand combines both the pre- COVID and during COVID samples.

The sectoral stocks are captured using the Standard and Poor's (S&P) 500 sectoral stock indices, which consist of eleven primary stock sectors: Basic Materials, Consumer discretionary, Consumer staples, Energy, Financials, Health care, Industrials, Information Technology, Real estate, Telecommunication, and Utilities. Each of the indices measures the performance of the stocks of US firms in

[3] See relevant theoretical justification in the Capital Asset Pricing Models (Tobin, 1958; Markowitz, 1959; Ross, 1976).

[4] A review of relevant studies on the gold-stocks hedging relationship is well documented in Shahzad et al. (2020).

[5] In addition to gold serving stock market hedging purposes, gold aids policy makers in their efforts at financial stability by keeping gold reserves to defend the domestic currency (see Mensi et al., 2015).

[6] A recent paper by Al-Awadhi et al. (2020) on the Chinese stock market shows that growth in COVID-19 reported cases and deaths negatively affects stock returns of companies.

[7] Other justification is that increased speculation in gold during this period could destroy its hedging power (see Baur and Glover, 2012).

[8] Generally, studies have shown that the response of sectoral stocks to macroeconomic fundamentals or risks may differ (see Bampinas and Panagiotidis, 2016; Rooyen and Jones, 2019) and therefore, using the aggregate stocks will not only undermine this salient attribute of sectoral sectors but may also lead to wrong conclusions about the response of stocks to the hedging potential of gold market.

Table 1
Descriptive statistics for gold and stock returns.

	Mean			Standard Deviation		
Sectoral stock returns	Full sample	Pre-Covid	During-Covid	Full sample	Pre-Covid	During-Covid
Consumer discretionary	0.0918	0.0890	0.0882	1.7241	0.9093	2.6094
Consumer staples	0.0528	0.0873	−0.0019	1.4503	0.6796	2.2434
Energy	−0.1063	0.0212	−0.3384	2.8996	1.2072	4.5564
Financials	0.0005	0.0991	−0.1804	2.3220	0.9703	3.6471
Health care	0.0564	0.0737	0.0250	1.6013	0.8424	2.4263
Industrials	0.0285	0.0929	−0.0978	2.0488	0.9875	3.1504
Information technology	0.1386	0.1560	0.0966	2.0860	1.1394	3.1316
Materials	0.0532	0.0770	0.0203	1.9733	0.9869	3.0186
Real estate	0.0380	0.0979	−0.0581	2.0663	0.7844	3.2834
Telecom services	0.0764	0.1023	0.0221	1.6805	0.9684	2.4888
Utilities	0.0347	0.0871	−0.0479	1.9727	0.7186	3.1472
S&P 500	0.0647	0.1006	−0.0040	1.7706	0.7878	2.7615
Gold	0.0941	0.0563	0.1593	1.0381	0.7092	1.4508

Note: The stock returns series for the different sectors are used in the computation of the descriptive analyses.

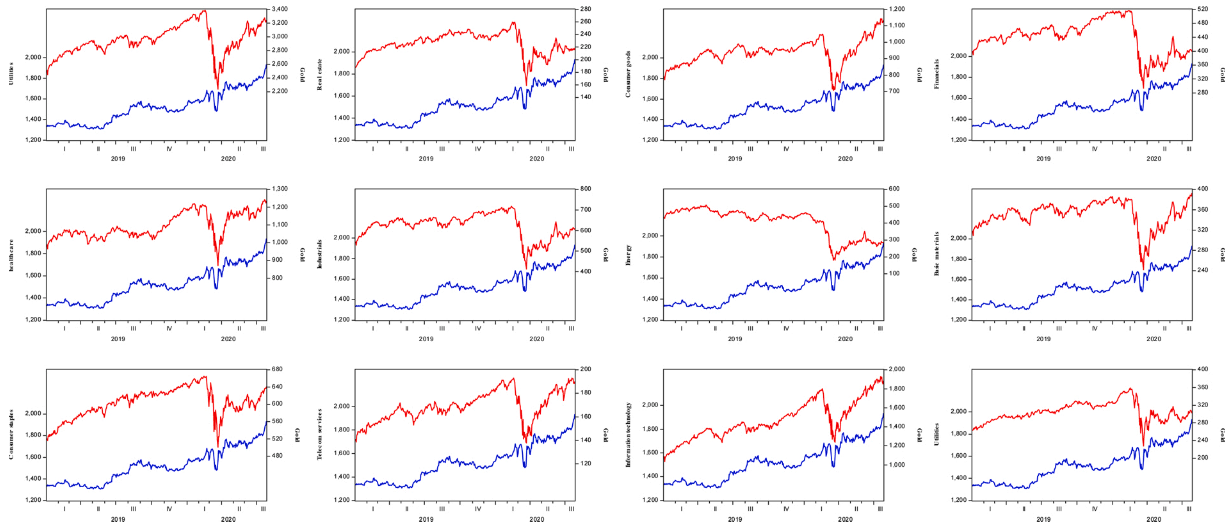

Fig. 1. Co-movements between gold and sectoral stock indices.

each of the sectors under consideration. In addition to the sectoral classification, we also include the overall S&P500 index to evaluate the hedging effectiveness of gold on the overall equity. Daily data on the sectoral stock series are freely downloadable from the www.investing.com online database, while data on gold prices is obtained from the Federal Economic Reserve Database (https://fred.stlouisfed.org/series). Start and end periods are January 02, 2019 and July 17, 2020[9] respectively.

The descriptive statistics (mean and standard deviation) for the considered series and their returns[10] are summarized in Table 1. While the mean values are positive for virtually all the sectors with the exception of energy sector over the full sample, however, they are only positive for the non-essential consumer goods and services (i.e. consumer discretionary), health care, materials, and technology sectors during the covid-19 period. By implication, the average returns in the four latter sectors suggest improved performance during the COVID-19 period, while the remaining seven sectors, including the tourism sector on the average experienced decline in their stock performance since the outbreak of the pandemic.

In addition, the standard deviation, which depicts how volatile the stock return series are, shows that the oil & gas sector stocks returns exhibit more volatility than all other sectors while both the health care and telecommunication sectors have the least standard deviation values, and thus less volatile stock returns. Additionally, we offer some graphical evaluation of the co-movements between gold and each of the sectoral stock indices (see Fig. 1) and they show evidence of a shift in their trends after the outbreak of the pandemic. This further validates the need to conduct distinct analyses for the pandemic period in order to fully understand its peculiarities relative to the period before it and possible hedging options to mitigate its adverse effects on the stock markets.

[9] This is the most recent coverage at the time of preparing the first draft of this article.

[10] All the data are transformed to returns series in the main analysis as a way of ensuring stationarity of the series

Table 2
Conditional Heteroscedasticity, Autocorrelation and Asymmetry Tests (Full sample)[a].

	Conditional Heteroscedasticity and Autocorrelation						Asymmetry and CCC					Model Choice
	ARCH LM (5)	ARCH LM (10)	LB(5)	LB(10)	LB^2(5)	LB^2(10)	Sign bias	Negative bias	Positive bias	Joint bias	E-S test	
Gold	13.22***	10.14***	4.70 (0.32)	23.25***	93.48***	209.9***	0.890	0.574	0.232	0.840		
	(0.00)	(0.00)		(0.01)	(0.00)	(0.00)	(0.374)	(0.566)	(0.817)	(0.840)	0.003	Asymmetric
SP500	26.83***	17.25***	17.66***	73.10***	193.3***	362.7***	2.438**	0.472	0.446	9.418**	(0.998)	CCC
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.015)	(0.638)	(0.656)	(0.024)		
Consumer discretionary	32.25***	23.85***	19.07***	64.05***	160.5***	248.6***	2.268**	0.571	0.271	7.784*	0.043	Asymmetric
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.024)	(0.568)	(0.786)	(0.051)	(0.979)	CCC
Consumer staples	28.04***	23.03***	23.37***	73.88***	217.8***	418.5***	0.706	0.820	0.909	4.459	3.184	Symmetric
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.481)	(0.413)	(0.364)	(0.216)	(0.204)	CCC
Energy	16.10***	11.59***	12.32**	64.36***	108.8***	189.2***	1.284	1.035	0.750	7.965**	1.711	Symmetric
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.200)	(0.301)	(0.454)	(0.047)	(0.425)	CCC
Financials	27.84***	15.03***	21.78***	75.12***	262.9***	433.3***	1.485	0.422	0.362	5.295	2.366	Symmetric
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.139)	(0.673)	(0.717)	(0.151)	(0.306)	CCC
Health care	36.40***	25.11***	18.17***	76.06***	265.6***	539.0***	1.694*	0.162	0.166	4.678	5.997*	Asymmetric
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.091)	(0.871)	(0.868)	(0.197)	(0.050)	DCC
Industrials	35.45***	22.61***	20.19***	75.78***	264.0***	477.7***	1.117	0.062	0.183	2.221	4.196	Symmetric
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.245)	(0.950)	(0.855)	(0.528)	(0.123)	CCC
Information technology	19.06***	13.90***	5.24 (0.26)	49.25***	142.6***	282.3***	2.869***	0.843	0.084	10.68**	0.002	Asymmetric
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.004)	(0.400)	(0.933)	(0.014)	(0.999)	CCC
Materials	26.47***	16.39***	21.48***	75.22***	204.6***	368.0***	1.472	0.401	0.109	4.298	1.518	Symmetric
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.142)	(0.689)	(0.913)	(0.231)	(0.468)	CCC
Real estate	29.58***	16.18***	36.96***	70.71***	205.1***	328.3***	2.483**	0.202	0.834	7.057*	2.703	Asymmetric
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.014)	(0.840)	(0.405)	(0.070)	(0.259)	CCC
Telecom services	18.0***	11.11***	6.64 (0.16)	43.39***	134.2***	217.6***	3.131***	0.923	0.499	11.57***	0.106	Asymmetric
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.002)	(0.357)	(0.618)	(0.009)	(0.949)	CCC
Utilities	75.40***	48.57***	42.15***	97.26***	496.6***	819.4***	2.412**	0.066	0.206	9.076**	0.140	Asymmetric
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.016)	(0.948)	(0.837)	(0.028)	(0.933)	CCC

Note: The ARCH LM tests refer to the Engle (1982) test for conditional heteroscedasticity while the LB and LB^2 imply the Ljung-Box tests for autocorrelations involving the standardized residuals in levels and squared standardized residuals respectively. The null hypothesis for the ARCH LM test is that the series has no ARCH effects (that is, it is not volatile) while LB test for null hypothesis is that the series is not serially correlated; ES test denotes the Engle-Sheppard constant conditional correlation (CCC) χ^2_2 test; the computed probability values are in parentheses.

[a] The results of these pre-tests for pre-covid and covid samples are not reported here for want of space but could be provided upon request.

Table 3
Structural breaks and dates.

	Full sample		Pre-Covid		During-Covid	
	BN	BD	BN	BD	BN	BD
Gold	1	23/03/2020	2	30/05/2019 02/08/2019	0	
S&P 500	1	24/03/2020	0		2	3/05/2020 4/06/2020
Consumer discretionary	1	24/03/2020	1	29/07/2019	1	24/02/2020
Consumer staples	1	24/02/2020	1	31/07/2019	1	05/03/2020
Energy	1	19/03/2020	0		1	19/03/2020
Financials	1	05/03/2020	1	29/07/2019	1	05/03/2020
Health care	1	24/03/2020	2	09/10/2019 04/06/2019	1	24/03/2020
Industrials	2	24/03/2020 27/12/2019	0		1	05/03/2020
Information technology	0		0		1	24/02/2020
Materials	1	24/03/2020	0		2	05/03/2020 06/04/2020
Real estate	1	24/03/2020	1	25/10/2019	1	09/03/2020
Telecom services	1	21/02/2020	0		1	24/02/2020
Utilities	1	09/03/2020	0		1	09/03/2020

Notes: The table reports the number of structural breaks and their dates. BN indicates the number of identified breaks, while BD is the break date.

As a precondition in standard empirical research, we conduct some pre-tests to validate our choice of multivariate volatility model, on the one hand and whether to allow for constant or dynamic correlation as well as asymmetric effect in the model, on the other hand. These tests include the serial correlation, which is carried out using the Ljung-Box Q-statistics and the conditional heteroscedasticity using the ARCH-LM test. In addition, we evaluate whether asymmetric effects exist, as well as the constant conditional correlation tests. The asymmetry test is carried out using the Engle and Ng sign and bias tests, while the Engle-Sheppard test is used to evaluate the presence or otherwise, of constant conditional correlation (CCC). The results are summarised in Table 2. The ARCH-LM tests indicate the rejection of the null hypothesis of no ARCH effects for all the series under consideration, implying that the stock returns exhibit conditional heteroscedasticity; hence, capturing such effects is essential when modelling their returns. Complimentarily, the Ljung-Box tests also confirm the presence of serial correlation in the return series for all the sectors and therefore the inclusion of lagged terms of the return series in the mean and variance equations (as demonstrated in the immediate section) is justified.

The Engle-Ng sign and joint sign bias tests which evaluate whether there is evidence of significant asymmetric effects in the relationship between gold and sectoral stock returns are also summarised in Table 2. Both tests confirm significant asymmetric effect for the overall US stocks using the S&P 500 index. In addition, six sectors of the eleven sectoral categorisation reveal evidence of statistically significant asymmetric effects. These sectors are: consumer discretionary, health care, information technology, real estate, telecommunication services, and utilities. On the other hand, the five other sectors (consumer staples, energy, financials, industrials and materials) exhibit symmetric effects. The Engle-Sheppard test is not significant across all the sectors except health care and by implication, the assumption of constant conditional correlations between each of the sectoral stocks and gold stock is valid. On the other hand, the health care stock returns exhibit a dynamic conditional correlation with gold stock returns and same is captured in the estimation process. For easy reference, the choice of model in line with the foregoing pre-tests is summarised in the last column of Table 2.

Lastly, we account for structural breaks in the volatility analysis to enhance the model precision. A number of studies have suggested the need to account for structural breaks in addition to controlling for volatility when dealing with high frequency series such as those used in this paper (see Narayan and Liu, 2011, 2015; Salisu et al., 2016; Salisu and Adeleke, 2016). The assumption that GARCH processes are stationary may cause problems during periods where structural breaks are present, which can render the GARCH assumptions invalid (Babikir et al., 2012). Besides, failure to account for such breaks has grim consequences, and can particularly lead to sizeable upward biases in the degree of persistence in estimated GARCH models.[11] The effects of ignoring structural breaks have been found to affect the optimal weights, hedge ratios and hedge effectiveness (see Babikir et al., 2012; Mongi and Dhouha, 2016). Therefore, we account for structural breaks by following a three-step procedure. First, we determine the presence of structural breaks in each of the series using the Bai and Perron (2003) multiple break tests. The number of breaks and break dates for each of the series is summarized in Table 3 for full sample, pre-covid sample and covid sample. The second step requires regressing each of the sectoral stocks and gold return series on dummy variables constructed for the identified break dummies, that is, $r_{it} = \theta + \sum_{j=1}^{N} \tau_j D_{jit} + \upsilon_{it}$ where $D_j = 1$ for each j and zero otherwise, where j is the number of breaks up to N. In the third step, we determine the break-adjusted returns (r_{it}^d) which is estimated as $r_{it}^d = r_{it} - \left(\widehat{\theta} + \sum_{j=1}^{N} \widehat{\tau}_j D_{jit}\right)$ or simply $r_{it}^d = \widehat{\upsilon}_{it}$. The estimated break-adjusted return series (r_{it}^d) is thereafter used in the returns and volatility modelling as discussed in the next section.

[11] For robustness purposes, we estimated the appropriate model VARMA GARCH model for each of the US sectoral stock returns while ignoring structural breaks. The estimated optimal portfolio weights and hedge ratios are provided in the appendix section (Tables A1 and A2). We find that ignoring structural breaks may over-estimate the optimal weights and hedging effectiveness of gold for US stocks.

3. The model and results

3.1. The model

One of the prominent instruments for modelling interdependencies among financial time series with and without asymmetric shock effects in the empirical literature is the VARMA–GARCH[12] model (see Salisu and Mobolaji, 2013; Salisu and Oloko, 2015; Caporale et al., 2017). We employ the VARMA-CCC-GARCH model and the DCC variant model (Ling and McAleer, 2003), following the results of the preliminary tests discussed in the preceding section. The preference for the model lies in its ability to capture both the symmetric and asymmetric effects that could exist in the asset returns, which structurally the CCC[13] model, including its dynamic variant (the DCC model), may not capture (McAleer et al., 2009).[14] The mean equations for the gold and stock series are respectively given as:

$$r_t^G = \phi^G + \delta^G r_{t-1}^G + \lambda^{S^*} r_{t-1}^{S^*} + \varepsilon_t^G \tag{1}$$

$$r_t^{S^*} = \phi^{S^*} + \delta^{S^*} r_{t-1}^{S^*} + \lambda^G r_{t-1}^G + \varepsilon_t^{S^*} \tag{2}$$

where r_t^G and $r_t^{S^*}$ are return series, with G and S^* denoting gold and sectoral stocks, respectively. The parameter ϕ denotes the constant term and δ is for the lagged own-return series and λ denotes the coefficient on the lagged cross-returns and measures cross-return spillovers between the two markets; ε_t is for the identically distributed errors while the superscripts.

The volatility and shock spillover effects between gold and sectoral stock returns are computed using the conditional variance equations and they are specified in Eqs. (3) and (4) respectively for gold and stock returns respectively:

$$h_t^G = c^G + \alpha_1^G\left(\varepsilon_{t-1}^G\right)^2 + \alpha_2^{S^*}\left(\varepsilon_{t-1}^{S^*}\right)^2 + \beta_1^G\left(h_{t-1}^G\right) + \beta_1^{S^*}\left(h_{t-1}^{S^*}\right) \tag{3}$$

$$h_t^{S^*} = c^{S^*} + \alpha_1^{S^*}\left(\varepsilon_{t-1}^{S^*}\right)^2 + \alpha_2^G\left(\varepsilon_{t-1}^G\right)^2 + \beta_1^{S^*}\left(h_{t-1}^{S^*}\right) + \beta_2^G\left(h_{t-1}^G\right) \tag{4}$$

where the shock and volatility spillover effects between the gold and stock return series are measured respectively as α_2 and β_2 where the superscripts are used to identify the series in question. Eqs. [3] and [4] are the symmetric version of the model and both demonstrate that the conditional variance for each sector is dependent on its immediate past values and own innovations as well as immediate past conditional variance and innovations from the other sector[15] . The conditional covariance on the other hand is given as:

$$h_t^{GS^*} = \rho^{GS^*} \times \sqrt{h_t^G} \times \sqrt{h_t^{S^*}} \tag{5}$$

where ρ^{GS^*} is the conditional constant correlations. The conditional variance and convariance estimates are crucial for the computation of the optimal weights and hedge ratios. The optimal portfolio weight (OPW) establishes the proportion of an asset pair that could form an investment portfolio to ensure optimality. For example, the significant volatility spillover between gold returns and any of the sectoral stock returns is an indication that investment in both assets is volatile and susceptible to risk and uncertainty. To circumvent or reduce such risks, investors need to engage in hedging, by investing in future contract while not jeopardising their expected returns. In line with the works of Kroner and Ng (1998); Arouri et al. (2011b); Salisu and Mobolaji (2013) and Salisu and Oloko (2015), the optimal portfolio weight of holding the two assets in an investment portfolio is constructed using the conditional variance and covariance estimates as given in Eqs. [3], [4] and [2] and it could be expressed as:

$$\varpi_{GS^*,t} = \frac{h_t^G - h_t^{GS^*}}{h_t^{S^*} - 2h_t^{GS^*} + h_t^G} \tag{6}$$

and,

$$\varpi_{GS^*,t} = \begin{cases} 0, & \text{if}\, \varpi_{GS^*,t} < 0 \\ \varpi_{GS^*,t}, & \text{if } 0 < \varpi_{GS^*,t} \le 1 \\ 1, & \text{if}\, \varpi_{GS^*,t} > 1 \end{cases} \tag{7}$$

where $\varpi_{GS^*,t}$ denotes the weight of gold asset in a one-dollar gold/stock combination in an investment portfolio at time t. The term $h_t^{GS^*}$ is the conditional covariance between the gold and stock returns at time t. Consequently, the optimal weight of the gold stocks in the

[12] VARMA-GARCH denotes Vector Autoregressive Moving Average-Generalized Autoregressive Conditional Heteroscedasticity.

[13] CCC demotes Constant Conditional Correlations

[14] Ling and McAleer (2003) provide the estimation procedure, including the structural and statistical properties of the model which covers both the necessary and sufficient conditions. Returns, shoch and volatility spillovers are evaluated using conditional mean and conditional variance equations specified within a bivariate framework (see also Salisu and Oloko, 2015).

[15] The asymmetric version of the model includes own asymmetric effects as part of the independent variables in Eqs. [3] and [4] and this is given as $\gamma^G \varepsilon_{t-1}^2 I_{t-1}^G$ and $\gamma^{S^*} \varepsilon_{t-1}^2 I_{t-1}^{S^*}$ for gold and stock conditional variance equations, respectively.

Table 4
Optimal portfolio weights between gold and stocks returns (after SB).

	Full sample	Pre-Covid	During-Covid
S&P 500	0.2755	0.3953	0.2864
Consumer discretionary	0.2919	0.4475	0.1835
Consumer staples	0.4109	0.6441	0.4746
Energy	0.1489	0.5026	0.1161
Financials	0.3037	0.4727	0.3678
Health care	0.3186	0.4346	0.6330
Industrials	0.3241	0.3842	0.1889
Information technology	0.2507	0.4484	0.2136
Materials	0.2373	0.2394	0.4484
Real estate	0.2723	0.5363	0.1794
Telecom services	0.3095	0.3958	0.2025
Utilities	0.3759	0.5239	0.2915

Notes: The table reports average optimal portfolio weights in a gold-stock asset portfolio.

Table 5
Optimal hedge ratios between gold and stocks returns (after SB).

	Full sample	Pre-Covid	During-Covid
S&P 500	−0.3204	−0.2480	−0.0064
Consumer discretionary	−0.3333	−0.2285	−0.2141
Consumer staples	0.0357	0.0081	0.0987
Energy	−0.4417	0.1287	0.0130
Financials	−0.3817	−0.3297	−0.0830
Health care	0.1011	−0.2398	−0.2057
Industrials	−0.2287	−0.3344	−0.1065
Information technology	−0.3457	−0.2032	−0.1708
Materials	−0.2315	−0.2317	0.0174
Real estate	0.1597	0.1409	−0.0048
Telecom services	−0.2524	−0.2431	−0.1506
Utilities	0.1881	0.1886	0.1779

Notes: The table reports average optimal hedge ratios in a gold-stock asset portfolio.

two assets class considered can be evaluated using $1 - \varpi_{GS^*,t}$.

In addition, we construct the optimal hedge ratio (OHR) following Kroner and Sultan (1993), who accordingly considered a portfolio of two assets and concluded that the risk of the investment portfolio is minimised if a long position of one dollar in stocks can be hedged by a short position of α_t dollars in the gold stock. The formulation of the OHR between gold and stock returns is defined as:

$$\alpha_{GS^*,t} = \frac{h_t^{GS^*}}{h_t^{G}} \tag{8}$$

where $\alpha_{GS^*,t}$ is the optimal hedge ratio between gold and each of the sectoral sectors. The estimated results are discussed in the next section. However, given our objective of evaluating the hedging effectiveness of the sector stocks, we only report results for the optimal portfolio weights and hedge ratios between gold and stock returns.[16]

3.2. Results

Our objective is to evaluate the effectiveness of gold as a hedge or safe haven for US sectoral stocks, particularly during pandemics. It has been well established in the literature that gold is an effective diversifier for financial assets including common stocks. In line with the proposition of Kumar (2014), the risk in taking a long position in stock assets can be offset by taking a short position in an alternative asset such as gold. The optimal portfolio weights and hedge ratios are summarised in Tables 4 and 5 respectively. Both the portfolio weights and hedge ratios are obtained using the estimates of the conditional variance and covariance from the estimation of the main model. The estimated optimal portfolio weights show positive portfolio weights of gold assets in a portfolio combination of gold and stock assets. For example, the estimated results show that for the overall US stocks (S&P 500), the optimal portfolio weight is 0.2755, however for the sub-samples, we find that in a unit of gold-stock portfolio, the proportion of gold to be held in such portfolio combination is about 39.53 % before the outbreak of COVID-19 but declined to about 28.6 % afterwards (during the pandemic).

[16] The results of VARMA-GARCH models are not reported here for want of space but could be made available upon request.

Table 6
Optimal portfolio weights and hedge ratios.

	Epidemic period		Pandemic period	
	OPW	OHR	OPW	OHR
S&P 500	0.1636	−0.7724	0.4967	0.0973
Consumer discretionary	0.2670	−0.7154	0.4585	0.0567
Consumer staples	0.2042	−0.1449	0.4412	0.1127
Energy	0.1170	−0.9861	0.0912	0.0359
Financials	0.1191	−0.9468	0.2029	−0.0801
Health care	0.2384	−0.4640	0.4466	0.1628
Industrials	0.1378	0.0333	0.2472	0.0088
Information technology	0.2417	−0.8446	0.4289	0.0729
Materials	0.2142	−0.2223	0.3578	0.2656
Real estate	0.1732	−0.0571	0.2868	−0.0076
Telecom services	0.5393	−0.3055	0.6108	0.0538
Utilities	0.1467	0.5493	0.2314	0.2416

Notes: OPW indicates average optimal portfolio weights, while OHR denotes the optimal hedge ratios in a gold-stock asset portfolio. Endemic period denotes the periods before the COVID-19 was declared as a global pandemic by the WHO, while pandemic period is the period after the declaration.

The results for the sectoral stocks are comparable to the overall stocks as they show decline in the optimal weights across all the sectors considered. The optimal portfolio weights during-COVID period are less than the pre-COVID era (see Table 4). However, the OPW differs across sectors for the three sample periods considered, supporting the arguments that different sectors behave differently to the gold hedging (see Akhtaruzzaman et al., 2020). For example, while 37 % of gold/stock portfolio should be invested in financial stocks during-COVID period, the energy sector should attract just about 12 %. The remaining 63 % and 88 % of the portfolio are expected to be invested in gold for the financial and energy sectors respectively. While the results show that gold has continued to perform its traditional role as a safe haven against decline in US stocks (see also Baur and Lucey, 2010), the decline in the optimal portfolio weights may not be unconnected with the increase in stock market volatilities brought about as a result of the pandemic which could have eroded investors' confidence, and increased uncertainties (Justin, 2020). These uncertainties in the market environment may have further left investors unsure how to respond to the unprecedented shocks and delay in their investment rebalancing options to curtail the risks associated with volatile markets.

Similar to our findings, Baur and Lucey (2010) empirically establish that during extreme stock market conditions such as the 2007/2008 global financial crisis and in volatile periods such as during war, gold market still acts as a safe haven for equities. In addition, Ciner et al. (2013) using time rolling regressions to investigate time-varying safe-haven relations, also find the safe-haven status of gold versus US equities between 1990 and 2010 to range between 18 % and 89 %, with the average value at 59 %.

The optimal hedge ratios in a gold - US stock portfolio combination are summarised in Table 5. The estimated hedge ratios show negative values between gold returns and US stock returns, both at aggregate and sectoral levels. As established in Baur and Lucey (2010), the negative correlation between two assets within a given portfolio indicates hedging. However, as similar to the optimal portfolio weight results discussed above, the optimal hedge ratios also show that the hedging effectiveness of gold for stocks declined (in absolute term) during the COVID-19 period across all the sectors considered relative to those obtained for the pre-covid sample. These findings corroborate the similar diminishing effectiveness of gold against US stocks reported in Kumar (2014) and Shrydeh et al. (2019). For instance, Kumar (2014) finds that a stock-gold portfolio provides better diversification benefits than holding just stock portfolios. On the other hand, Shrydeh et al. (2019) suggest that gold hedging effectiveness against US stocks tends to diminish during a crisis era. Besides, a hedge may sometimes not retain the property of minimizing losses in periods of market turbulence since it may exhibit a positive correlation with another asset during such periods.

4. Robustness

As a robustness check, we extend the empirical analyses by evaluating the hedging effectiveness of gold for the US sectoral stocks before and after the declaration of COVID-19 as a global pandemic. The World Health Organisation (WHO) declared COVID-19 a pandemic on March 11, 2020, following its alarming spread and severity across countries (WHO, 2020). Addressing the media in his opening remarks, the WHO Director-General emphasised one of the implications of declaring the virus as a pandemic is that it can stoke up fear and panic[17] . Therefore, we categorized the COVID-19 sample period into epidemic and pandemic periods. The estimated optimal portfolio weights and optimal hedge ratios are summarised in Table 6.

The OPW results confirm the main estimation results using the COVID-19 sample. The analysis using the post-pandemic declaration data further supports our main findings that gold provides a safe-haven against declining stock performance, although the performance is mixed across different sectors. Besides, the optimal hedge ratios support the main estimation that gold provides effective hedge for

[17] See the WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. Available at WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. Accessed February 06, 2020.

US stocks during the epidemic period. However, the performance diminishes in the pandemic period as previously noted. Overall, the results provide supportive evidence of gold effectiveness as a suitable hedge for US stocks, although the magnitude and unprecedented nature of COVID-19 reveal a reduction in the hedging performance between the epidemic and pandemic periods.

5. Conclusion

The main objective of this study is to examine the portfolio designs and hedging effectiveness in gold and US aggregate and sectoral stocks, especially with the outbreak of COVID-19. In the paper, both the symmetric and asymmetric versions of the VARMA-CCC-GARCH model, determined based on formal pre-tests, are used to estimate the conditional variance and covariances required for the hedging analysis. We evaluate the impact of the COVID-19 pandemic, partitioning the full data into the pre-covid and covid samples. We also test and account for structural breaks, a presence of which could lead to sizeable upward biases in the degree of persistence in estimated GARCH models and the overestimation of the portfolio weights and hedging effectiveness. Overall, our results suggest that including gold in a stock portfolio could provide a valuable asset class that can improve stock risk-adjusted-performance. Our findings further suggest that the shocks associated with the unprecedented emergence of COVID-19 may have increased investors' uncertainties in responding to market shocks, leading to delay in their investment rebalancing options. This is reflected with the declining optimal portfolio weights and hedge ratios in the crisis period, with further empirical support in the robustness check, wherein we partitioned the COVID-19 sample into epidemic and pandemic samples. Finally, we believe that our findings will have a far-reaching impact, given the fact that we utilize sectoral stock data covering virtually all the sectors of the US economy. Therefore, any investor in the US stock market seeking to maximize risk-adjusted returns is likely to find the results useful when making investment decisions during the pandemic. Future studies that extend our analysis to other precious metals will further enrich the literature on the subject.

Author contributions

Afees A. Salisu: Conceptualization, Methodology, Formal Analysis, Software, Writing - Original Draft, Reviewing & Editing.
Xuan Vinh Vo: Conceptualization, Data curation, Results validation, Reviewing & Editing, Funding acquisition, Project administration.
Brian Lucey: Conceptualization, Results validation, Reviewing & Editing, Supervision, Project administration.

Declaration of Competing Interest

The authors declare that there are no conflicts of interest.

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Appendix A

Table A1
Optimal portfolio weights between gold and stocks returns (before SB).

	Full sample	Pre-Covid	Post-Covid
S&P 500	0.3698	0.5037	0.2947
Consumer discretionary	0.3181	0.4662	0.1894
Consumer staples	0.5505	0.5322	0.4948
Energy	0.1972	0.1953	0.1034
Financials	0.3512	0.4441	0.3739
Health care	0.4156	0.4379	0.3902
Industrials	0.3640	0.3789	0.2565
Information technology	0.2208	0.4417	0.2082
Materials	0.3163	0.5136	0.3525
Real estate	0.4307	0.5388	0.2075
Telecom services	0.3397	0.3793	0.3286
Utilities	0.3458	0.5267	0.3032

Notes: The table reports average optimal portfolio weights in a gold-stock asset portfolio.

Table A2
Optimal hedge ratios between gold and stocks returns (before SB).

	Full sample	Pre-Covid	Post-Covid
S&P 500	−0.2518	−0.1526	−0.0768
Consumer discretionary	−0.3080	−0.2171	−0.1944
Consumer staples	0.0213	0.0223	0.0899
Energy	−0.3873	−0.5693	−0.0406
Financials	−0.3174	−0.3609	−0.0959
Health care	−0.0753	−0.2399	0.1428
Industrials	−0.2333	−0.3279	−0.1639
Information technology	−0.3089	−0.2185	−0.1220
Materials	−0.1656	−0.1592	0.0474
Real estate	0.1247	0.1692	−0.0192
Telecom services	−0.2317	−0.2224	−0.0500
Utilities	0.2035	0.1855	0.2088

Notes: The table reports average optimal hedge ratios in a gold-stock asset portfolio.

References

Adewuyi, A.O., Awodumi, O.B., Abodunde, T.T., 2019. Analysing the gold-stock nexus using VARMA-BEKK-AGARCH and Quantile regression models: new evidence from South Africa and Nigeria. Resour. Policy 61, 348–362.

Akhtaruzzaman, M., Boubaker, S., Sensoy, A., 2020. Financial contagion during COVID–19 crisis. Finance Res. Lett. https://doi.org/10.1016/j.frl.2020.101604.

Al-Awadhi, A.M., Alsaifi, K., Al-Awadhi, A., Alhammadi, S., 2020. Death and contagious infectious diseases: impact of the COVID-19 virus on stock market returns. J. Behav. Exp. Finance 27, 100326. https://doi.org/10.1016/j.jbef.2020.100326.

Ali, M., Alam, N., Rizvi, S.A.R., 2020. Coronavirus (COVID-19)—an epidemic or pandemic for financial markets. J. Behav. Exp. Finance 27, 100341. https://doi.org/10.1016/j.jbef.2020.100341.

Arouri, M.E.H., Nguyen, D.K., 2010. Oil prices, stock markets and portfolio investment: evidence from sector analysis in Europe over the last decade. Energy Policy 38 (8), 4528–4539.

Arouri, M.E.H., Jouini, J., Nguyen, D.K., 2011a. Volatility spillovers between oil prices and stock sector returns: implications for portfolio management. J. Int. Money Finance 30 (7), 1387–1405.

Arouri, M.E.H., Lahiani, A., Nguyen, D.K., 2011b. Return and volatility transmission between world oil prices and stock markets of the GCC countries. Econ. Model. 28 (4), 1815–1825.

Arouri, M.E.H., Jouini, J., Nguyen, D.K., 2012. On the impacts of oil price fluctuations on European equity markets: volatility spillover and hedging effectiveness. Energy Econ. 34 (2), 611–617.

Babikir, A., Gupta, R., Mwabutwa, C., Owusu-Sekyere, E., 2012. Structural breaks and GARCH models of stock return volatility: the case of South Africa. Econ. Model. 29 (6), 2435–2443.

Bai, J., Perron, P., 2003. Computation and analysis of multiple structural change models. J. Appl. Econom. 18 (1), 1–22.

Baig, A.S., Butt, H.A., Haroon, O., Rizvi, S.A.R., 2020. Deaths, panic, lockdowns and US equity markets: the case of COVID-19 pandemic. Finance Res. Lett. 38, 101701 https://doi.org/10.1016/j.frl.2020.101701.

Bampinas, G., Panagiotidis, T., 2016. Hedging inflation with individual US stocks: a long-run portfolio analysis. North Am. J. Econ. Finance 37, 374–392.

Baumöhl, E., Lyócsa, Š., 2017. Directional predictability from stock market sector indices to gold: a cross-quantilogram analysis. Finance Res. Lett. 23, 152–164.

Baur, D.G., Glover, K.J., 2012. The destruction of a safe haven asset? Appl. Finance Lett. 1 (1), 8–15.

Baur, D.G., Lucey, B.M., 2010. Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. Finance Rev. 45 (2), 217–229.

Baur, D.G., McDermott, T.K., 2010. Is gold a safe haven? International evidence. J. Bank. Finance 34 (8), 1886–1898.

Beckmann, J., Berger, T., Czudaj, R., 2015. Does gold act as a hedge or a safe haven for stocks? A smooth transition approach. Econ. Model. 48, 16–24.

Bredin, D., Conlon, T., Potì, V., 2015. Does gold glitter in the long-run? Gold as a hedge and safe haven across time and investment horizon. Int. Rev. Financ. Anal. 41, 320–328.

Caporale, G.M., Spagnolo, F., Spagnolo, N., 2017. Macro news and commodity returns. Int. J. Finance Econ. 22 (1), 68–80.

Chen, C.D., Chen, C.C., Tang, W.W., Huang, B.Y., 2009. The positive and negative impacts of the SARS outbreak: a case of the Taiwan industries. J. Dev. Areas 43 (1), 281–293.

Chua, J.H., Sick, G., Woodward, R.S., 1990. Diversifying with gold stocks. Financ. Anal. J. 46 (4), 76–79.

Ciner, C., Gurdgiev, C., Lucey, B.M., 2013. Hedges and safe havens: an examination of stocks, bonds, gold, oil and exchange rates. Int. Rev. Financ. Anal. 29, 202–211.

Conlon, T., McGee, R., 2020. Safe haven or risky hazard? Bitcoin during the COVID-19 bear market. Finance Res. Lett. 35, 101607. https://doi.org/10.1016/j.frl.2020.101607.

Corbet, S., Larkin, C., Lucey, B., 2020. The contagion effects of the COVID-19 pandemic: evidence from gold and cryptocurrencies. Finance Res. Lett. 35, 101554. https://doi.org/10.1016/j.frl.2020.101554.

Devpura, N., Narayan, P.K., 2020. Hourly oil price volatility: the role of COVID-19. Energy Res. Lett. 1 (2), 13683. https://doi.org/10.46557/001c.13683.

Engle, R.F., 1982. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. Econometrica: J. Econom. Soc. 987–1007.

Forbes, K., 2010. Why do foreigners invest in the United States? J. Int. Econ. 80, 3–21.

Gau, Y.F., Wu, Z.X., 2017. Macroeconomic announcements and price discovery in the foreign exchange market. J. Int. Money Finance 79, 232–254.

Godil, D.I., Sarwat, S., Sharif, A., Jermsittiparsert, K., 2020. How oil prices, gold prices, uncertainty and risk impact Islamic and conventional stocks? Empirical evidence from QARDL technique. Resour. Policy 66, 101638. https://doi.org/10.1016/j.resourpol.2020.101638.

Guesmi, K., Nguyen, K., 2014. International CAPM and regional integration factors: evidence from some European emerging countries. Appl. Econ. 46 (11), 1279–1290.

Haroon, O., Rizvi, S.A.R., 2020a. Flatten the curve and stock market liquidity—an Inquiry into emerging economies. Emerg. Mark. Finance Trade 56 (10), 2151–2161. https://doi.org/10.1080/1540496X.2020.1784716.

Haroon, O., Rizvi, S.A.R., 2020b. COVID-19: media coverage and financial markets behaviour – a sectoral inquiry. J. Behav. Exp. Finance 27, 100343. https://doi.org/10.1016/j.jbef.2020.100343.

He, P., Sun, Y., Zhang, Y., Li, T., 2020. COVID–19's impact on stock prices across different sectors — an event study based on the Chinese stock market. Emerg. Mark. Finance Trade 56 (10), 2198–2212.

Hood, M., Malik, F., 2013. Is gold the best hedge and a safe-haven under changing stock market volatility? Rev. Financ. Econ. 22, 47–52.

Ichev, R., Marinč, M., 2018. Stock prices and geographic proximity of information: evidence from the Ebola outbreak. Int. Rev. Financ. Anal. 56, 153–166.

Iyke, B., 2020a. COVID-19: the reaction of US oil and gas producers to the pandemic. Energy Res. Lett. 1 (2), 13912. https://doi.org/10.46557/001c.13912.

Iyke, B.N., 2020b. The disease outbreak channel of exchange rate return predictability: evidence from COVID-19. Emerg. Mark. Finance Trade 56 (10), 2277–2297. https://doi.org/10.1080/1540496X.2020.1784718.

Jaffe, J.F., 1989. Gold and gold stocks as investments for institutional portfolios. Financ. Anal. J. 45 (2), 53–59.
Ji, Q., Zhang, D., Zhao, Y., 2020. Searching for safe-haven assets during the COVID-19 pandemic. Int. Rev. Financ. Anal. 71, 101526. https://doi.org/10.1016/j.irfa.2020.101526.
Joy, M., 2011. Gold and the US dollar: hedge or haven? Finance Res. Lett. 8, 120–131.
Justin, H., 2020. Rebalancing Amid COVID-19: Turning Volatility Into Opportunity | Parametric Portfolio. https://www.parametricportfolio.com/blog/turning-volatility-into-opportunity.
Kroner, K.F., Ng, V.K., 1998. Modeling asymmetric comovements of asset returns. Rev. Financ. Stud. 11 (4), 817–844.
Kroner, K.F., Sultan, J., 1993. Time-varying distributions and dynamic hedging with foreign currency futures. J. Financ. Quant. Anal. 535–551.
Kumar, D., 2014. Return and volatility transmission between gold and stock sectors: application of portfolio management and hedging effectiveness. IIMB Manag. Rev. 26 (1), 5–16.
Lee, M., Chiou, J.-S., Wu, P.-S., Chen, C.-D., 2005. Hedging with S&P500 and E-mini S&P500 stock index futures. J. Stat. Manag. Syst. 8 (2), 275–294.
Li, Y., Liang, C., Ma, F., Wang, J., 2020. The role of the IDEMV in predicting European stock market volatility during the COVID-19 pandemic. Finance Res. Lett. 36 https://doi.org/10.1016/j.frl.2020.101749.
Ling, S., McAleer, M., 2003. Asymptotic theory for a vector ARMA-GARCH model. Econ. Theory 280–310.
Lypny, G., Powalla, M., 1998. The hedging effectiveness of DAX futures. Eur. J. Finance 4 (4), 345–355.
Markowitz, H., 1959. Portfolio Selection, Efficent Diversification of Investments. J. Wiley & Sons, New York.
McAleer, M., Hoti, S., Chan, F., 2009. Structure and asymptotic theory for multivariate asymmetric conditional volatility. Econom. Rev. 28 (5), 422–440.
McDonald, J.G., Solnik, B.H., 1977. Valuation and strategy for gold stocks. J. Portf. Manage. 3, 29–33.
Mensi, W., Hammoudeh, S., Reboredo, J.C., Nguyen, D.K., 2015. Are Sharia stocks, gold and US Treasury hedges and/or safe havens for the oil-based GCC markets? Emerg. Mark. Rev. 24, 101–121.
Mishra, A.K., Rath, B.N., Dash, A.K., 2020. Does the Indian financial market nosedive because of the COVID-19 outbreak, in comparison to after demonetisation and the GST? Emerg. Mark. Finance Trade 56 (10), 2162–2180.
Mongi, A., Dhouha, H.A., 2016. Do structural breaks affect portfolio designs and hedging strategies? International evidence from stock-commodity markets linkages. Int. J. Econ. Financ. Issues 6 (1), 252–270.
Narayan, P.K., 2020a. Oil price news and COVID-19—is there any connection? Energy Res. Lett. 1 (1), 13176. https://doi.org/10.46557/001c.13176.
Narayan, P.K., 2020b. Did bubble activity intensify during COVID-19? Asian Econ. Lett. 1 (2) https://doi.org/10.46557/001c.17654.
Narayan, P.K., 2020c. Has COVID-19 changed exchange rate resistance to shocks? Asian Econ. Lett. 1 (1) https://doi.org/10.46557/001c.17389.
Narayan, P.K., Liu, R., 2011. Are shocks to commodity prices persistent? Appl. Energy 88 (1), 409–416.
Narayan, P.K., Liu, R., 2015. A unit root model for trending time-series energy variables. Energy Econ. 50, 391–402.
Narayan, P.K., Devpura, N., Wang, H., 2020a. Japanese currency and stock market — what happened during the COVID-19 pandemic? Econ. Anal. Policy 68, 191–198.
Narayan, P.K., Phan, D.H.B., Liu, G., 2020b. COVID-19 lockdowns, stimulus packages, travel bans, and stock returns. Financ. Res. Lett. 101732. https://doi.org/10.1016/j.frl.2020.101732.
Phan, D.H.B., Narayan, P.K., 2020. Country responses and the reaction of the stock market to COVID-19 — a Preliminary Exposition. Emerg. Mark. Finance Trade 56 (10), 2138–2150.
Polemis, M., Soursou, S., 2020. Assessing the impact of the COVID-19 pandemic on the greek energy firms: an event study analysis. Energy Res. Lett. 1 (3) https://doi.org/10.46557/001c.17238.
Prabheesh, K.P., Padhan, R., Garg, B., 2020. COVID-19 and the oil price—stock market nexus: evidence from net oil-importing countries. Energy Res. Lett. 1 (2), 13745. https://doi.org/10.46557/001c.13745.
Qin, M., Zhang, Y.-C., Su, C.-W., 2020. The essential role of pandemics: a fresh insight into the oil market. Energy Res. Lett. 1 (1) https://doi.org/10.46557/001c.13166.
Reboredo, J.C., 2013. Is gold a safe-haven or a hedge for the US dollar? Implications for risk management. J. Bank. Finance 37, 2665–2676.
Reboredo, J.C., Ugolini, A., 2017. Quantile causality between gold commodity and gold stock prices. Resour. Policy 53, 56–63.
Rooyen, J.H., Jones, D.L., 2019. The inflation-hedging ability of individual shares: evidence from the Johannesburg Stock Exchange (JSE). Invest. Anal. J. 48 (1), 58–73.
Ross, S.A., 1976. The arbitrage theory of capital asset pricing. J. Econ. Theory 13 (3), 341–360.
Salisu, A.A., Adediran, I.A., 2020. Uncertainty due to infectious diseases and energy market volatility. Energy Res. Lett. 1 (2), 14185. https://doi.org/10.46557/001c.14185.
Salisu, A.A., Adeleke, A.I., 2016. Further application of Narayan and Liu (2015) unit root model for trending time series. Econ. Model. 55, 305–314.
Salisu, A.A., Akanni, L.O., 2020. Constructing a global fear index for COVID-19 pandemic. Emerg. Mark. Finance Trade 56 (10), 2213–2230.
Salisu, A.A., Mobolaji, H., 2013. Modeling returns and volatility transmission between oil price and US–Nigeria exchange rate. Energy Econ. 39, 169–176.
Salisu, A.A., Oloko, T.F., 2015. Modeling oil price–US stock nexus: a VARMA–BEKK–AGARCH approach. Energy Econ. 50, 1–12.
Salisu, A.A., Sikiru, A.A., 2020. Pandemics and the Asia-Pacific islamic stocks. Asian Econ. Lett. 1 (1) https://doi.org/10.46557/001c.17413.
Salisu, A.A., Vo, X.V., 2020. Predicting stock returns in the presence of COVID-19 pandemic: the role of health news. Int. Rev. Financ. Anal. 71, 101546. https://doi.org/10.1016/j.irfa.2020.101546.
Salisu, A.A., Ndako, U.B., Oloko, T.F., Akanni, L.O., 2016. Unit root modeling for trending stock market series. Borsa Istanbul Rev. 16 (2), 82–91. https://doi.org/10.1016/j.bir.2016.05.001.
Salisu, A.A., Ebuh, G.U., Usman, N., 2020a. Revisiting oil-stock nexus during COVID-19 pandemic: some preliminary results. Int. Rev. Econ. Finance 69, 280–294.
Salisu, Afees A., Vo, Xuan Vinh, Lawal, Adedoyin, 2020b. Hedging oil price risk with gold during COVID-19 pandemic. Resour. Policy 101897. https://doi.org/10.1016/j.resourpol.2020.101897.
Shahzad, S.J.H., Bouri, E., Roubaud, D., Kristoufek, L., 2020. Safe haven, hedge and diversification for G7 stock markets: gold versus bitcoin. Econ. Model. 87, 212–224.
Sharma, S.S., 2020. A note on the asian market volatility during the COVID-19 pandemic. Asian Econ. Lett. 1 (2) https://doi.org/10.46557/001c.17661.
Shehzad, K., Xiaoxing, L., Kazouz, H., 2020. COVID-19's disasters are perilous than Global Financial Crisis: a rumor or fact? Financ. Res. Lett. 36, 101669. https://doi.org/10.1016/j.frl.2020.101669.
Sherman, E.J., 1982. Gold: a conservative, prudent diversifier. J. Portf. Manage. 8 (3), 21–27.
Shrydeh, N., Shahateet, M., Mohammad, S., Sumadi, M., 2019. The hedging effectiveness of gold against US stocks in a post-financial crisis era. Cogent Econ. Financ. 7 (1), 1698268. https://doi.org/10.1080/23322039.2019.1698268.
Sikiru, A.A., Salisu, A.A., 2021. Hedging against risks associated with travel and tourism stocks during COVID-19 pandemic: the role of gold. Int. J. Financ. Econ. https://doi.org/10.1002/ijfe.2513 in press.
Sultan, J., Hasan, M.S., 2008. The effectiveness of dynamic hedging: evidence from selected European stock index futures. Eur. J. Finance 14 (6), 469–488.
Tobin, J., 1958. Liquidity preference as behavior towards risk. Rev. Econ. Stud. 25 (2), 65–86.
WHO, 2020. WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 -. 11 March 2020. Available at WHO Director-General's opening remarks at the media briefing on COVID-19 -. 11 March 2020. Accessed February 06, 2020.
Yang, M.J., Lai, Y.C., 2009. An out-of-sample comparative analysis of hedging performance of stock index futures: dynamic versus static hedging. Appl. Financ. Econ. 19, 1059–1072.
Yunus, N., 2020. Time-varying linkages among gold, stocks, bonds and real estate. Q. Rev. Econ. Financ. 77, 165–185.
Zagaglia, P., Marzo, M., 2013. Gold and the U.S. dollar: tales from the turmoil. Quant. Finance 13 (4), 571–582.
Zhang, D., Hu, M., Ji, Q., 2020. Financial markets under the global pandemic of COVID-19. Financ. Res. Lett. 101528. https://doi.org/10.1016/j.frl.2020.101528.