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Research article

Hedging with financial innovations in the Asia-Pacific markets during the COVID-19 pandemic: the role of precious metals

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Abstract: In this study, we exploit the information contained in financial innovations in precious metals for hedging the risks associated with the Asia-Pacific equities during the current pandemic. We measure financial innovations as exchange traded funds (ETFs) for gold, silver, platinum and palladium which contrast with investment in the physical precious metals since the former tracks well the prices of the latter and as well provides cost-effective alternative to invest in the markets without storage costs. Based on the optimal portfolio weights and optimal hedge ratios, we find that gold offers the best hedge (followed by silver, platinum, and palladium) against the risk associated with the Asia-Pacific equities during the COVID-19 pandemic albeit with a lower hedging effectiveness during the pandemic. Overall, including gold ETFs in an Asia-Pacific equity portfolio would provide both a valuable portfolio combination that could improve the risk-adjusted performance of the market in addition to serving as an effective hedge for equity-related risks.

Keywords: financial innovation; hedge; precious metals; ETFs; Asia Pacific equity market

JEL Codes: C58, F21, G10, G15

1. Introduction

In this paper, we investigate whether financial innovations in precious metals can be exploited to deliver hedging effectiveness for pandemic-induced risks in the Asia-Pacific market during the COVID-19 pandemic. We seek protection against the pandemic-induced uncertainty in financial innovations captured as exchange traded funds in precious metals in line with similar evidences on financial innovations in commodities to hedge market risks (Sukcharoen et al., 2015; Arunanondchai et al., 2019; Latunde et al., 2020), however, we differ from these studies as our analyses also accommodate the COVID-19 effects by partitioning our data sample into the pre-COVID-19 and COVID-19 samples. We rely on the Exchange traded funds (ETFs hereafter) as our choice of financial innovations since they constitute innovative investment funds that allow for cost-effective hedging benefits through passive investments in baskets of assets rather than trading in the actual indexes containing the physical assets (Marszk and Lechman, 2018; Naeem et al., 2020; Ozdurak and Ulusoy, 2020; Sakarya and Ekinci, 2020). In addition to being cost-effective alternatives to trading in physical assets, these investment options track well the performances of the underlying assets composed in the ETF indexes with negligible tracking errors (extensive discussions on the nature, origin and features of ETFs as financial innovations can be found in Gao (2001), Haslem (2003), Hehn (2005), Harper et al. (2006), Ferri (2009), Tari (2010), Chelley-Steeley and Park (2011), Charupat and Miu (2013), Lechman and Marszk (2015), and Dannhauser (2017), among others).

We attempt two contributions to the growing literature on pandemic-financial markets nexus bothering on the choice of proxy for financial innovation and Asia-Pacific financial markets. The first contribution seeks to explore financial innovations in precious metals for risk hedging purposes particularly during the COVID-19 pandemic. This effort allows us to contribute to two sub-literature: one, those that limit the search for alternative instruments to mutual funds, cryptocurrency, Islamic bonds, etc. (Balcilar et al., 2016; Reboredo and Naifar, 2017; Maghyereh et al., 2018; Selmi et al., 2018; Olson et al., 2019; Shahzad et al., 2019; Okorie and Lin, 2020; Urom et al., 2020) and two, those that restrict the hedging role to physical precious metals (Beckmann et al., 2018; Junttila et al., 2018; Salisu et al., 2019; Huynh, 2020) both of which do not consider the COVID-19 effects.[1] Thus, we consider the hedging potential of an array of precious metals as alternative options to equities that seem to more vulnerable to the current pandemic (Baker et al., 2020; Salisu and Vo, 2020; Salisu et al., 2020; OECD, 2020; Li et al., 2020; Salisu and Sikiru, 2020; Sharma, 2020). We prefer financial innovations in precious metals because they offer flexible and cost-effective means to invest in precious metals (which are themselves established safe assets) without concerns about storage costs (Kraft, 2012; Leung and Ward, 2015; Kaur and Singh, 2020). We also build on the existing evidences from Lau et al. (2017) and Cheng et al. (2018) that financial innovations in the gold market can replace physical gold to hedge oil and currency market risks. Going forward, we probe whether same can be

[1] Several evidences exist on the adverse impacts of the pandemic on financial markets: stock markets (Baker et al., 2020; Salisu and Vo, 2020; Salisu et al., 2020; OECD, 2020; Li et al., 2020; Salisu and Sikiru, 2020; Sharma, 2020; Salisu et al., 2021), oil market (Iyke, 2020a; Narayan, 2020a; Devpura and Narayan, 2020; Qin et al., 2020; Salisu and Adediran, 2020; Salisu and Obiora, 2021), foreign exchange market (Iyke, 2020b; Narayan, 2020b and c; Narayan et al., 2020), and cryptocurrencies (Conlon and McGee, 2020; Corbet et al., 2020; Salisu and Ogbonna, 2021).

shown for precious metals in general including gold, silver, platinum and palladium against pandemic-induced risks.

On the second contribution, our choice of Asia-Pacific financial markets is hinged on a number of justifications. One, the region is labelled as the region of the current pandemic and therefore inherent fear seems to have accentuated the economic consequences of the COVID-19 pandemic in the region (Salisu and Akanni, 2020; Salisu and Vo, 2020). For instance, during the early days of the pandemic, Salisu and Vo (2020) report contractions in the stock markets of Australia, South Korea, Hong Kong and China similar to occurrences in the United States, a major worst-hit country by the pandemic. Two, the Asia Pacific countries are highly connected through trade and financial flows, hence, the pandemic shocks are expected to reverberate through the region, thus make hedging against such uncertainties even more desirable. Three, evidences on past crises show that spillovers have deepened interactions among the Asia-Pacific stock markets (Kim, 2005 for evidence on the 1997 Asian crisis and Liu, 2014; Hengchao and Hamid, 2015; Lin, 2015; Chow, 2017; Ahmed and Huo, 2019 for evidences on the global financial crisis which further show increasing roles of China, Japan and the US in the region).

In the empirical analysis, we employ the Multivariate Generalized Autoregressive Conditional Heteroscedastic (M-GARCH) framework to examine the hedging effectiveness of financial innovations. The choice of this modelling technique is informed by the preliminary tests of the data as well as evidence in the extant literature showing its fitness for capturing conditional heteroscedasticity and serial correlation in the data (Arouri and Nguyen, 2010; Arouri et al., 2011; Salisu and Mobolaji, 2013; Salisu and Oloko, 2015; Salisu et al., 2020; Sikiru and Salisu, 2021). The suitability of the MGARCH model further lies in accommodating time-variation as well as volatility in the hedging analysis relative to competing models such as Vector Autoregressive model and its variants (Lypny and Powalla, 1998; Lee et al., 2005; Yang and Lai, 2009).

The highlights from this study show that investment in financial innovations in gold market presents optimal portfolio hedging alternative and provide premium for Asia Pacific investors. However, the impact of the financial crisis induced by the COVID-19 pandemic shrinks the hedging performance when compared with the period before it. Following this background, we offer some preliminary analyses in Section 2 to guide the choice of the model. In Section 3, we render the modelling framework and implements same in Section 4 with detailed discussion of findings. We conclude the paper in Section 5 with relevant policy implications.

2. Data description and preliminary analysis

Our empirical analysis is based on equities for 13 Asia-Pacific countries as well as the region aggregate, and 4 prominent precious metals ETFs. The regional aggregate is the iShares Core MSCI Pacific ETF which objective is to track the investment composition of the Pacific region large, mid and small capitalization equities. In a similar vein, the country specific equities are also selected from the MSCI family because of their characteristics of tracking investment results of equity market index for each of the countries under consideration. Besides, the funds generally invest at least 90% of assets in the securities of the underlying market index and in depositary receipts representing securities in the underlying index. The daily ETF series are collected for the periods between May 2015 and October 2020 from Yahoo Finance database (www.finance.yahoo.com). To evaluate the impacts of the COVID-19 outbreak as discussed in the introduction, the data sample is divided into three sub-samples, full, before and during the outbreak of COVID-19 pandemic.

We render some descriptive statistics, which consist of the mean, maximum, minimum, standard deviation, skewness and kurtosis using the equity and commodity ETF return series. The daily returns are computed as the natural log of the ratio of two successive prices. The statistics are summarized in Table 1. The mean value of returns for the countries reveal positive values only for four of the countries, namely, Canada, Japan, South Korea and Taiwan and the rest return with negative average values. Bearing the differences in the average values, the distributions of the daily return series appear to have similar spread with the standard deviation values with Canada and Indonesia having the lowest and highest values respectively. Similarly, they have similar skewness features as all are negatively skewed and follow leptokurtic distribution (i.e. kurtosis value > 3). Among the precious metals' financial innovations, all except platinum display positive average returns in the period under investigation. Likewise, the trio (of gold, silver and palladium) except platinum are positively skewed. Hence, given the distributional differences, we may expect the precious metals ETFs to be negatively correlated with the equities ETFs in which case the former may be expected to provide the much needed hedging potentials.

Table 1. Summary statistics for returns.

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
Equities						
Asia-Pacific	0.0106	7.7375	−10.2400	1.4138	−1.0494	14.3524
Australia	−0.0060	9.4624	−16.5154	2.0758	−1.2490	15.1847
Canada	0.0017	12.0724	−10.8922	1.7155	−0.4178	13.7430
China	−0.0159	9.0894	−16.2070	2.1210	−1.1409	12.5391
Hong Kong	−0.0108	10.3173	−15.6309	1.8244	−1.2918	16.2689
India	−0.0068	11.3957	−23.7748	1.9855	−3.0689	38.5313
Indonesia	−0.0383	17.4787	−15.1530	2.4162	−0.0507	12.9931
Japan	0.0172	9.2567	−12.5994	1.4913	−1.0686	16.8304
South Korea	0.0224	11.6331	−14.7822	2.1096	−1.0187	12.3750
Malaysia	−0.0852	9.4849	−33.5131	2.0190	−6.5472	105.8972
Philippines	−0.0516	11.0056	−14.2494	1.9770	−1.2250	15.4561
Singapore	−0.0380	11.1393	−11.2970	1.7442	−0.7596	13.8548
Thailand	−0.0241	12.4843	−14.1983	1.9453	−1.3106	19.1074
Taiwan	0.0516	10.6735	−13.4176	1.8182	−1.3834	15.7240
Commodities						
Gold	0.0843	14.3416	−6.5206	1.3870	1.7025	21.3950
Silver	0.0729	13.9908	−13.2704	2.2498	0.1210	12.4236
Platinum	−0.0137	10.7941	−11.6726	1.9565	−0.0322	8.5674
Palladium	0.1722	28.4089	−15.1885	2.7989	1.2105	19.5042

We probe the foregoing further in the graphical analyses that follow the descriptive statistics. Figures 1a to 1d depict the graphs of the co-movements between the returns for precious metals and equities ETF for each of the countries in the Asia-Pacific region. The idea behind these graphs is that financial innovation in a market (precious metals markets, in the current case) can only hedge risks in another market if the returns on traded funds in both markets are negatively correlated (Baur and Lucey, 2010). The graphs (in Figures 1a to 1d), divided into four segments each for the individual precious metals' financial innovations, show evidence of a negative relationship between each of the precious metals and country's equities. These negative correlations are more pronounced in the segments for financial innovations in gold, silver and palladium, thereby corroborating the previous preliminary findings and therefore indicating that financial innovation in platinum may not possess strong hedging power to cover the Asia-Pacific stock market risks.

Next, we conduct formal pre-tests as discussed in the methodology section. The obtained estimates from the formal pre-tests are categorized into two and they are both crucial in the determination of the appropriate VARMA-GARCH model[2] as well as in the estimation of the optimal portfolio weights and hedging ratios between each of the considered equities and commodities ETFs. The first set of preliminary statistics is conducted to establish the appropriateness of the VARMA-GARCH model, and the two tests conducted include the serial correlation and autocorrelation tests. On the other hand, the asymmetric effect test and the constant conditional correlation tests are conducted to evaluate the presence of asymmetric effect, and the choice between constant and dynamic specification of the conditional correlations. The serial correlation test is conducted using Ljung-Box Q-statistics, while we employ the ARCH-LM test for the conditional heteroscedasticity tests. We evaluate the asymmetric effects using the Engle and Ng sign and bias tests while the Engle-Sheppard test is used to evaluate the constant conditional correlation (CCC). All the results are summarised in Tables 2 and 3.

The results of the ARCH-LM tests indicate that the returns exhibit conditional heteroscedasticity with the hypothesis of no ARCH effects rejected. This outcome validates the choice of GARCH-based models to accommodate the presence of heteroskedasticity in the estimation process for the variables of interest. Similarly, the statistical significant estimates for both the correlogram Q-statistic and its squared version confirm the presence of serial correlation in all the return series under consideration, both at 5 and 10 lag orders. Thus, the consideration of a dynamic model like the VARMA-GARCH which accommodates dynamic effects both in the mean and variance equations is justified. Finally, the results of the Engle and Ng sign bias tests and Engle-Sheppard tests as summarized in Table 3 confirm mixed evidences for both symmetric and asymmetric effects between the equity ETF returns and precious metals ETF. For instance, the significant sign and joint bias results for Indonesia in the full sample and before COVID periods suggest that the effect of positive and negative shocks in the Indonesian equity stock ETF is significantly different confirming that the presence of asymmetry in the volatility process. On the other hand, Japan and Korea exhibit only positive bias respectively in the full sample and during COVID-19 periods. The results also show mixed evidence of constant and dynamic conditional correlations in the full-sample, pre-COVID and COVID-19 periods. Specifically, the equities for Australia, China, Hong Kong, Japan, Korea and Taiwan, all exhibit dynamic conditional correlations with the Palladium in the COVID-19 sample. This outcome further underscores the COVID effect in the behavior of financial markets as espoused in the emerging literature examining the connection between the pandemic and financial markets (Salisu et al., 2020; Sikiru and Salisu, 2021).

[2] The term VARMA-GARCH conventionally implies a multivariate GARCH model specified in the form of Vector (V) Autoregressive (AR) Moving Average (MA) form where both the ARCH and GARCH terms respectively mimic the AR and MA terms. For relevant applications of this methodology for hedging purpose, see Salisu and Oloko (2015a, b); Salisu et al. (2020); Sikiru and Salisu (2021), among others.

Table 2. Conditional heteroscedasticity and autocorrelation tests.

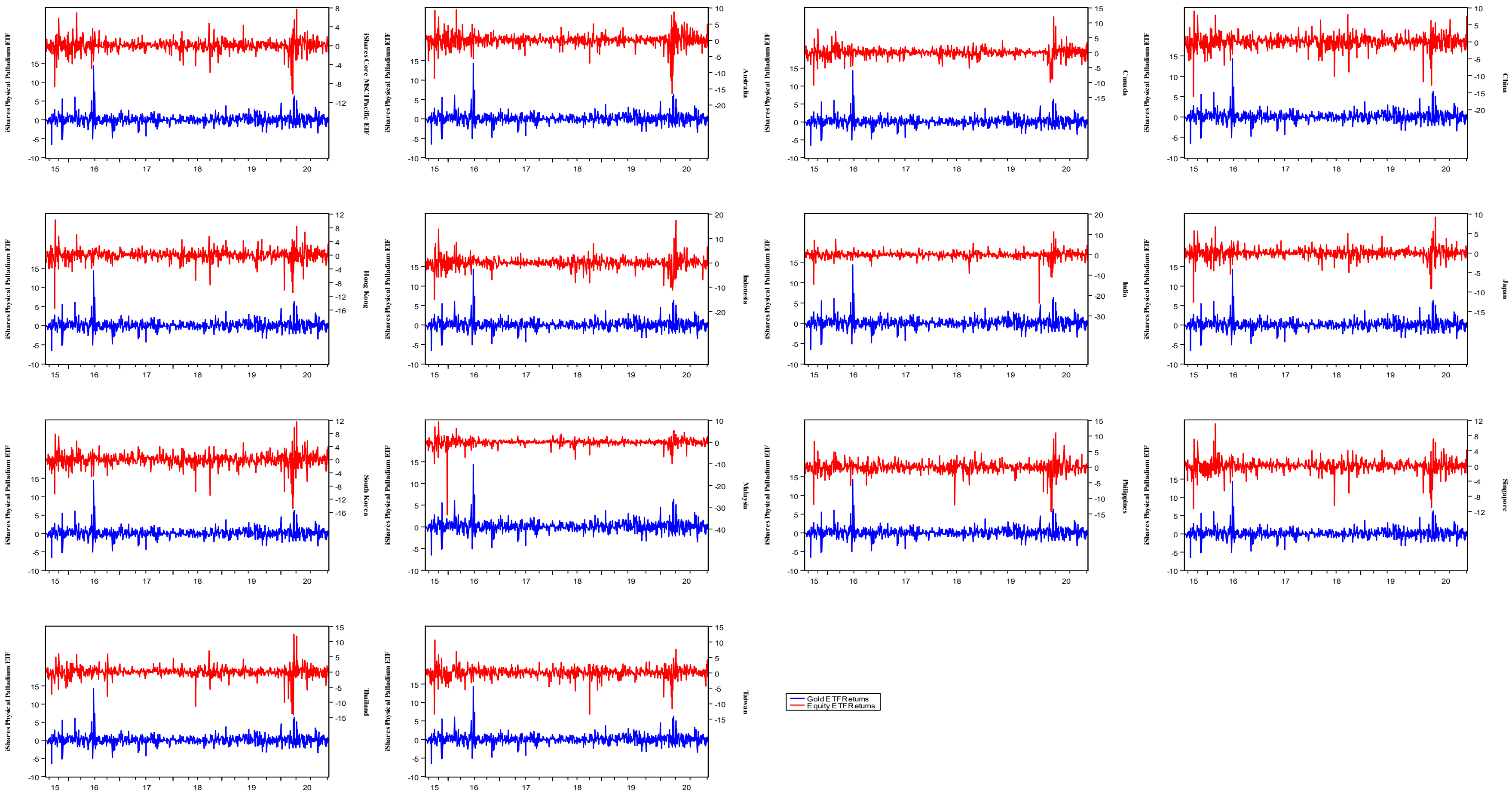
	Full sample						Before COVID-19						During COVID-19					
	ARCH$_5$	ARCH$_{10}$	LB$_5$	LB$_{10}$	LB$^2_5$	LB$^2_{10}$	ARCH$_5$	ARCH$_{10}$	LB$_5$	LB$_{10}$	LB$^2_5$	LB$^2_{10}$	ARCH$_5$	ARCH$_{10}$	LB$_5$	LB$_{10}$	LB$^2_5$	LB$^2_{10}$
Region	22.0^a	14.2^a	7.9^a	18.1^b	122.8^a	176.0^a	4.1^a	2.6^a	3.3	4.9	21.6^a	31.6^a	8.0^a	4.9^a	11.7^b	18.3^b	40.4^a	52.0^a
Australia	55.8^a	30.2^a	9.8^b	21.2^b	334.7^a	424.3^a	5.5^a	5.4^a	9.4^c	17.3^b	27.3^a	56.0^a	18.4^a	9.5^a	10.8^b	22.1^a	84.4^a	101.0^a
Canada	20.5^a	12.1^a	9.7^b	14.3	131.6^a	222.4^a	1.8	3.4^a	0.5	7.3	9.3	40.5^a	6.3^a	3.3^a	11.1^b	16.0^c	35.3^a	50.1^a
China	1.8	1.4	4.3	10.0	10.1^c	14.5	2.0^c	1.6	0.9	6.5	10.2^c	16.5^c	0.9	1.1	5.8	7.4	5.6	7.5
Hong Kong	3.4^a	2.5^a	4.5	9.1	19.6^a	28.7^a	5.0^a	2.9^a	1.5	4.0	23.7^a	27.9^a	1.6	2.0^b	3.3	7.8	9.6^c	14.4
India	1.6	0.9	11.9^b	20.8^b	9.0	10.8	0.1	0.1	1.9	5.5	0.3	0.4	16.3^a	9.5^a	8.1^c	18.9^b	78.0^a	104.9^a
Indonesia	20.9^a	12.4^a	3.6	6.9	156.0^a	262.2^a	4.5^a	4.2^a	0.4	8.3	25.2^a	53.2^a	4.4^a	2.6^a	3.0	9.2	34.7^a	53.8^a
Japan	7.8^a	5.7^a	5.5	10.4	45.1^a	78.0^a	2.9^b	1.6	5.8	7.4	14.9^b	17.5^c	6.1^a	4.9^a	6.5	10.4	33.5^a	56.2^a
South Korea	33.3^a	17.7^a	6.6	16.8^c	194.5^a	263.8^a	1.1	1.1	2.2	7.1	5.7	11.8	11.5^a	6.8^a	6.0	13.9	61.0^a	73.9^a
Malaysia	0.1	0.1	3.7	8.7	0.6	0.6	0.1	0.0	10.3^b	18.7^b	0.3	0.4	6.2^a	3.8^a	16.2^a	22.3^a	38.1^a	39.7^a
Philippines	22.3^a	13.5^a	17.1^a	23.0^a	127.0^a	180.4^a	3.3^a	1.8^c	1.6	6.6	16.9^a	18.6^b	6.9^a	4.4^a	11.5^b	18.6^b	32.1^a	43.5^a
Singapore	13.7^a	7.1^a	7.3	12.7	81.5^a	94.1^a	4.3^a	2.5^a	8.9^c	16.8^c	20.7^a	26.3^a	13.0^a	8.8^a	5.5	12.0	58.5^a	62.2^a
Thailand	28.1^a	17.4^a	34.9^a	49.5^a	187.6^a	273.1^a	0.8	0.8	8.3^c	18.3^b	3.8	8.6	5.8^a	3.8^a	15.3^a	19.9^b	38.0^a	51.3^a
Taiwan	4.4^a	3.1^a	7.7^c	15.1^c	27.1^a	39.5^a	4.4^a	2.6^a	4.7	15.1^c	20.6^a	26.8^a	5.3^a	4.2^a	10.8^b	15.9^c	29.9^a	36.6^a
Commodities																		
Gold	13.1^a	6.6^a	3.7	6.5	62.4^a	72.6^a	11.8^a	5.9^a	5.9	10.3	562^a	64.0^a	3.9^a	2.6^a	8.0^c	10.8	13.8^b	19.7^b
Silver	10.1^a	5.9^a	3.7	5.9	54.0^a	79.3^a	13.5^a	7.3^a	2.3	6.8	57.8^a	76.2^a	0.6	0.6	5.4	11.9	3.2	6.2
Platinum	6.4^a	3.2^a	6.0	6.4	35.4^a	37.4^a	7.0^a	3.5^a	3.0	5.2	33.9^a	34.2^a	0.5	0.3	7.6	9.4	3.3	3.7
Palladium	2.9^b	4.5^a	13.9^a	20.5^b	16.1^a	53.1^a	0.8	1.5	10.3^b	13.8	4.2	15.0	0.3	0.6	9.3^c	13.1	1.8	8.1

Note: ARCH$_5$ and ARCH$_{10}$ of conditional heteroscedasticity indicate the ARCH LM tests at 5 and 10 lags respectively. The LB and LB^2 of autocorrelations follow the Ljung-Box tests conducted at 5 and 10 lags. 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. The superscripts a, b and c indicate statistical significance respectively at 1%, 5% and 10% levels.

Table 3. Sign bias and asymmetry tests.

Period	Tests		Region	AUS	CAN	CHN	HNK	IND	IDN	JPN	KOR	MLY	PHI	SGP	THA	TWN	GLD	SLV	PLT	PLD
Full sample	*Sign Bias*		0.01	1.26	0.31	0.15	0.51	0.27	2.46^{b}	1.12	0.66	0.59	0.50	0.25	1.60	1.14	1.61	0.20	2.29^{b}	1.11
	Negative Bias		0.36	0.50	0.43	0.20	0.64	0.13	0.90	0.35	0.29	0.93	0.34	0.48	0.49	0.52	0.89	0.25	0.63	0.08
	Positive Bias		1.31	0.41	1.47	1.02	0.91	0.42	0.38	1.73^{c}	1.45	0.75	0.45	1.64	1.46	0.88	0.64	0.10	1.55	0.88
	Joint Bias		2.38	3.45	5.95	1.48	1.35	0.24	10.56^{b}	3.14	2.31	1.49	0.34	3.15	3.11	4.78	5.62	0.07	5.78	1.55
	Engle-Shephard	GLD	0.45	0.01	0.06	0.01	0.01	0.06	0.24	0.18	0.06	0.49	2.11	0.01	0.23	0.26				
		SLV	1.84	0.49	0.35	1.09	2.11	0.57	0.07	0.61	1.10	0.87	0.01	0.20	0.45	1.74				
		PLT	0.04	0.00	0.27	0.16	0.14	0.91	0.08	0.01	0.04	0.30	0.23	0.11	0.07	0.08				
		PLD	0.37	6.56^{b}	0.63	0.73	1.98	2.37	3.97	1.13	4.41	0.09	1.14	4.61^{c}	2.06	4.52				
Before COVID-19	*Sign Bias*		0.17	1.09	0.38	0.33	0.32	0.37	1.44	1.03	0.22	0.84	0.05	0.01	1.64	1.69^{c}	1.07	0.91	1.92^{c}	0.01
	Negative Bias		0.33	0.46	0.40	0.44	1.14	0.18	0.24	0.09	0.02	0.98	0.70	0.35	0.60	0.63	0.85	0.79	0.36	0.66
	Positive Bias		1.12	0.24	0.93	1.60	0.91	0.59	0.47	1.60	0.81	0.73	0.28	1.44	1.47	0.45	1.02	0.74	1.20	0.74
	Joint Bias		1.50	2.25	3.50	3.71	2.95	0.42	6.64^{c}	2.61	1.48	1.50	1.11	2.71	3.23	5.88	4.44	2.77	4.27	0.99
	Engle-Shephard	GLD	1.30	0.13	0.12	0.00	0.36		0.92	0.74	0.00	0.57	1.09	0.03	0.02	0.13				
		SLV	0.71	0.24	0.06	0.51	0.70	0.90	0.02	0.37	0.20	0.34	0.19	0.00	0.37	0.65				
		PLT	0.02	0.46	0.19	0.00	0.18		0.00	0.00	0.01	0.13	0.13	0.44	0.23	0.12				
		PLD	0.25	1.22	0.67	0.66	0.38		0.82	0.01	0.42	0.05	0.11	0.86	0.69	0.52				
During COVID-19	*Sign Bias*		0.81	0.38	0.41	0.02	0.69	0.54	0.24	0.79	1.37	0.04	1.00	0.67	0.43	1.41	0.81	1.08	1.43	2.22**
	Negative Bias		1.68	0.33	0.25	0.48	0.32	0.44	0.72	0.17	0.34	0.53	0.42	0.36	0.23	0.13	1.68^{c}	0.54	0.60	1.13
	Positive Bias		0.66	0.77	1.38	0.20	0.62	1.70^{c}	0.94	0.33	1.67^{c}	0.21	0.34	0.97	0.52	1.58	0.66	0.30	1.38	0.90
	Joint Bias		4.04	1.69	3.99	0.32	0.90	3.09	1.69	2.47	3.10	0.51	2.18	1.20	0.42	2.84	4.04	1.89	2.52	4.93
	Engle-Shephard	GLD	1.12	0.42	0.08	0.22	0.99	0.11	0.22	0.65	1.76	0.00	4.87^{c}	0.18	2.35	1.16				
		SLV	3.21	7.00^{b}	3.75	0.87	1.52	0.65	0.56	3.48	2.50	2.07	0.50	1.31	0.04	5.44^{c}				
		PLT	0.44	0.54	0.02	0.66	1.04	0.30	0.03	0.65	0.26	0.46	0.17	0.31	0.00	0.85				
		PLD	3.25	5.10^{c}	0.01	4.69^{c}	7.86^{b}	2.06	3.48	5.06^{c}	8.31^{b}	0.27	1.43	3.53	1.97	8.10^{b}				

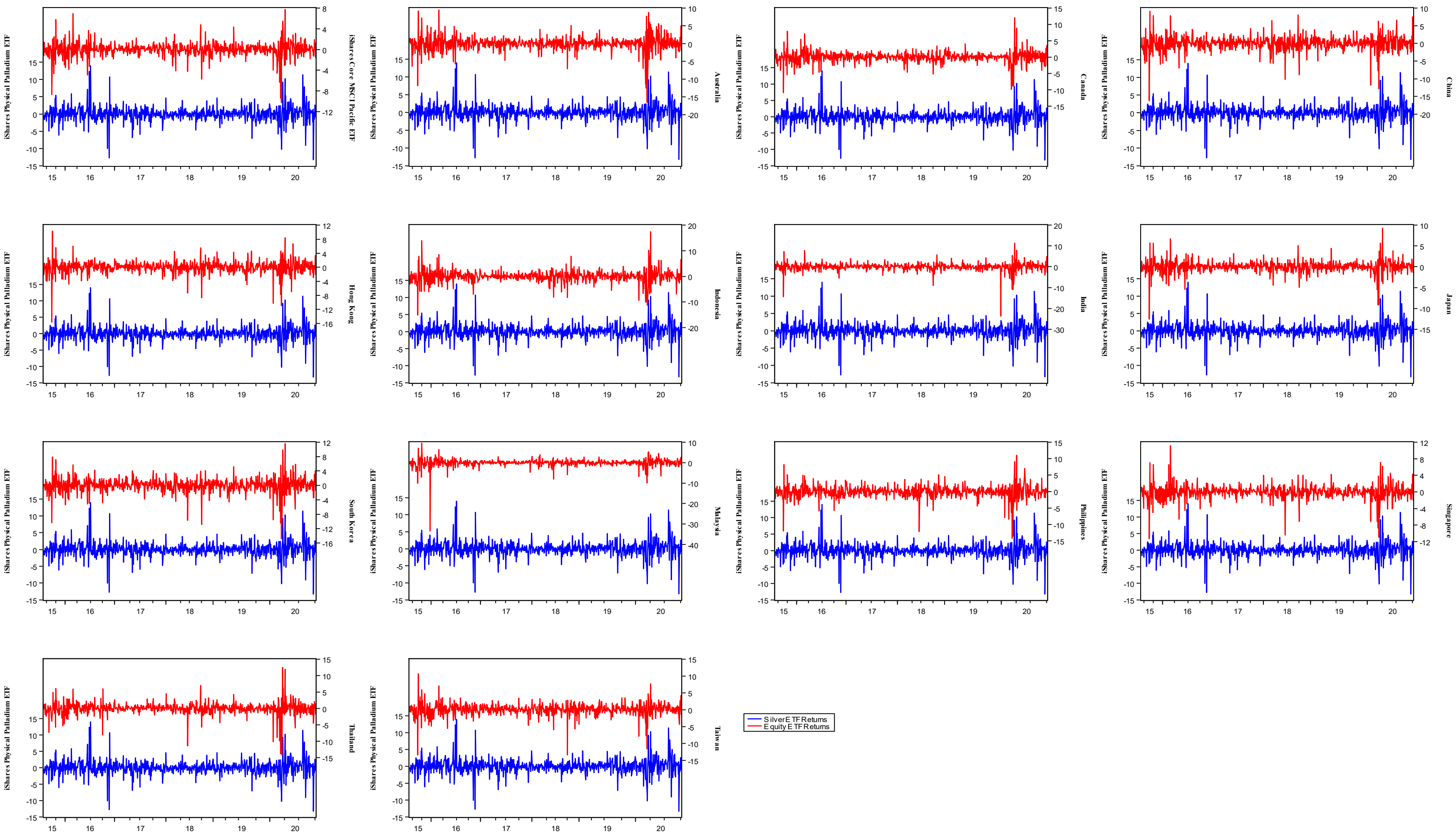
Note: ES test is the Engle-Sheppard CCC χ_2^2 test. The superscripts a, b and c respectively indicate statistical significance for 1%, 5% and 10% levels; Region denotes the Asia-Pacific Region Equity; AUS is an acronym for Australia; CAN for Canada; CHN: China, HNK: Hong Kong; IND: India; IDN: Indonesia; JPN: Japan; KOR: South Korea; MLY: Malaysia; PHI: Philippines; SGP: Singapore, THA: Thailand; and TWN: Taiwan. The precious metals ETFs are abbreviated as GLD, SLV, PLT and PLD, respectively denoting Gold, Silver, Platinum and Palladium.



(a)

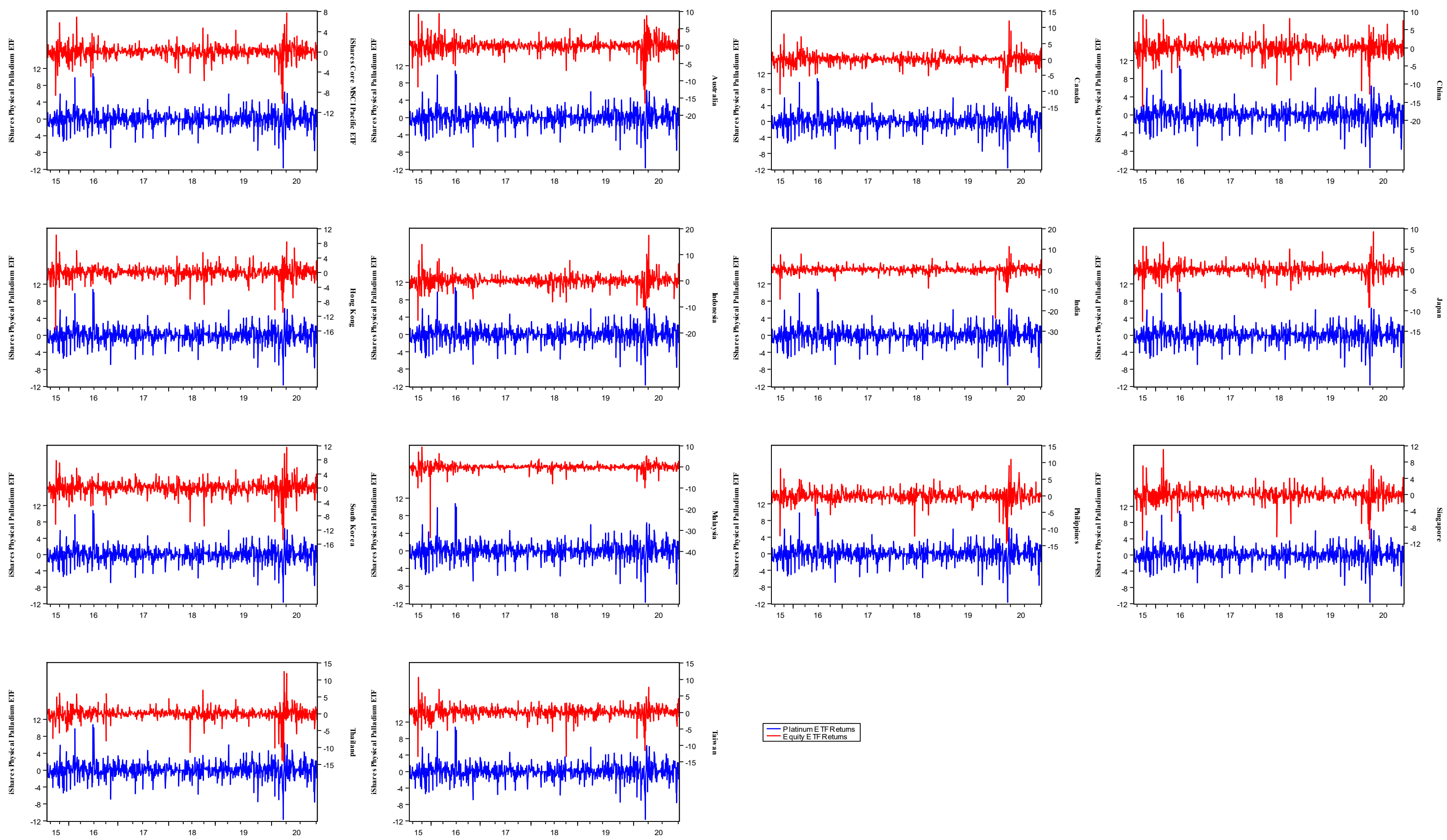
Figure 1. Co-movements between precious metals ETFs and Asia-Pacific equities ETFs returns: (a) Gold, (b) Silver, (c) Platinum, and (d) Palladium.

Note: The figures here presented are divided into four segments (a to d) each for the four precious metals ETF plotted against the overall Asia-Pacific and country specific equity stock ETFs.



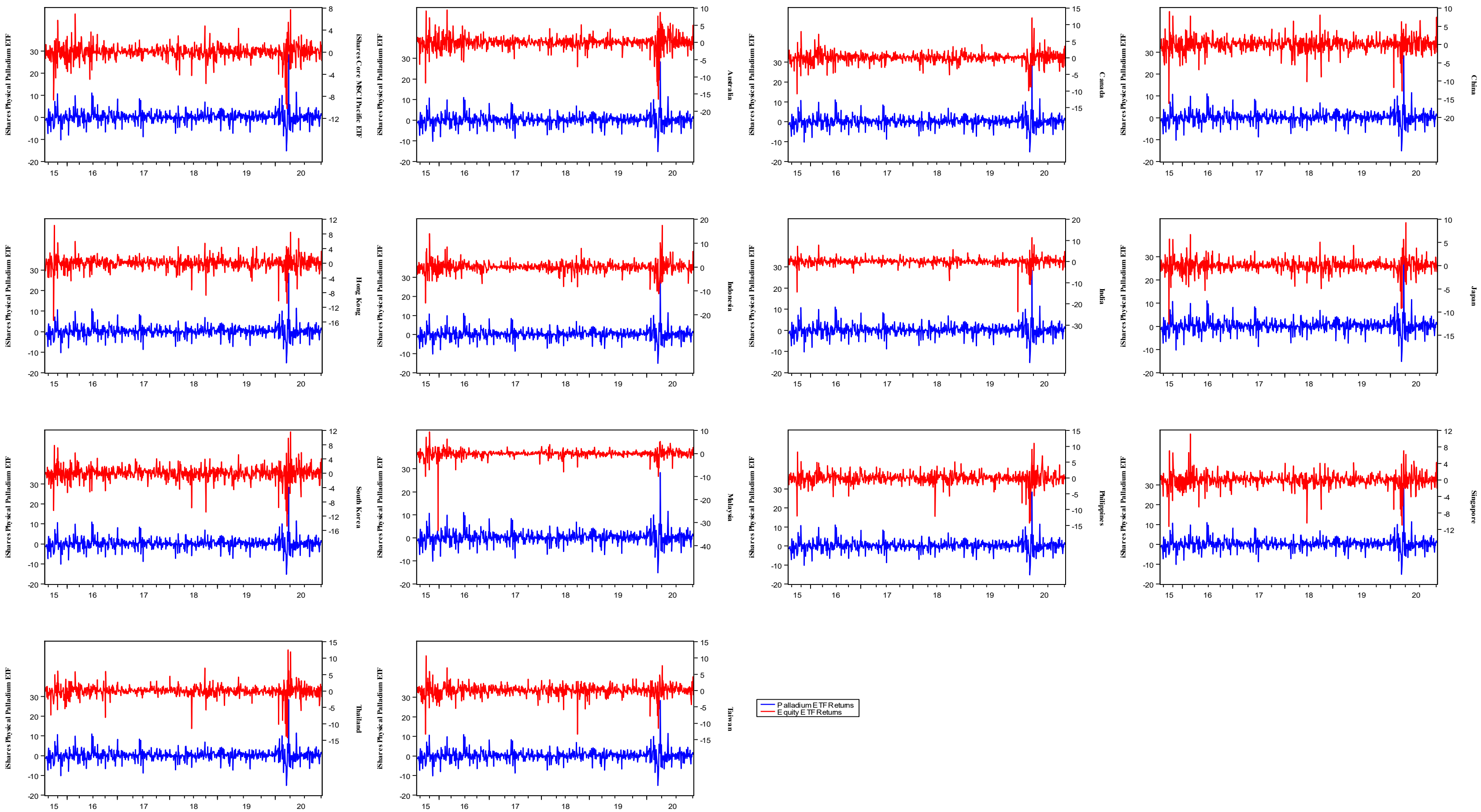
(b)

Figure 1. *Continued.*



(c)

Figure 1. *Continued.*



(d)

Figure 1. *Continued.*

3. The model

Following the formal preliminary tests discussed in the preceding section, this study employs the GARCH-based VARMA model proposed by Ling and McAleer (2003). Additionally, we favour this methodology owing to its ability to capture interdependencies among financial markets with or without asymmetric shock effects (Salisu and Mobolaji, 2013; Salisu and Oloko, 2015; Al-Maadid et al., 2016; Salisu et al., 2020; Sikiru and Salisu, 2021).[3] Based on the outcome of the sign bias and Engle-Shephard tests, we formulate a VARMA-GARCH model that reflects the same as follows:

$$r_t^{stk} = \varphi_1^{stk} + \phi_1^{stk} r_{t-1}^{stk} + \theta_1^{stk} r_{t-1}^{fin} + \varepsilon_t^{stk} \tag{1}$$

$$r_t^{fin} = \varphi_2^{fin} + \phi_2^{fin} r_{t-1}^{fin} + \theta_2^{fin} r_{t-1}^{stk} + \varepsilon_t^{fin} \tag{2}$$

where r_t^{stk} is for the returns on stocks (stk); r_t^{fin} denotes the returns on each of the financial innovations (fin) related to precious metals; φ^{stk} and φ^{fin} are constant terms; ϕ^{stk} and ϕ^{fin} are coefficients of the lagged terms of own-returns; θ^{stk} and θ^{fin} are coefficients of lagged terms of returns measuring cross-return spillovers between the two financial assets; ε_t^{stk} and ε_t^{fin} are independently and identically distributed errors while the superscripts define the asset classes. The superscripts 1 and 2 denote the parameters for stock returns and financial innovation returns, respectively. The conditional variance equations which provide the estimates of the volatility and shock spillover effects between the two asset classes are specified in Equations (3) and (4) as:[4]

$$h_t^{stk} = c_1^{stk} + \alpha_1^{stk}\left(\varepsilon_{t-1}^{stk}\right)^2 + \alpha_1^{stk}\left(\varepsilon_{t-1}^{fin}\right)^2 + \beta_1^{stk}\left(h_{t-1}^{stk}\right) + \beta_1^{stk}\left(h_{t-1}^{fin}\right) + \gamma^{stk}\varepsilon_{t-1}^2 I_{t-1}^{stk} \tag{3}$$

$$h_t^{fin} = c_2^{fin} + \alpha_2^{fin}\left(\varepsilon_{t-1}^{fin}\right)^2 + \alpha_2^{fin}\left(\varepsilon_{t-1}^{stk}\right)^2 + \beta_2^{stk}\left(h_{t-1}^{stk}\right) + \beta_2^{fin}\left(h_{t-1}^{stk}\right) + \gamma^{fin}\varepsilon_{t-1}^2 I_{t-1}^{fin} \tag{4}$$

where h_t is the conditional variance while ε_t^2 is a measure of shock. Therefore, the conditional variance equations show that conditional variance for each sector is dependent on its immediate past values and innovations as well as past values of conditional variance and innovations from the other sector. The conditional covariance equation which is assumed to follow the constant conditional correlations is expressed as:

$$h_t^{SF} = \rho^{SF} \times \sqrt{h_t^{stk}} \times \sqrt{h_t^{fin}} \tag{5}$$

where ρ^{SF} is the constant conditional correlations between equity and financial innovations in precious metals while SF distinctly denotes Stock returns (*S*) and financial innovations (*F*).

[3] A similar methodology was recently employed by Salisu et al. (2020) and Sikiru and Salisu (2021) to analyze possible hedging strategies during COVID-19 pandemic. Our study further adds to the emerging literature on the possible mitigation strategies against the risks associated with the current pandemic by considering ETFs as alternative options.

[4] The specifications in Equations (3) and (4) follow the asymmetric version. The symmetric version of the model excludes the own asymmetric effects as part of the independent variables in both equations.

In line with the objective of this paper, the estimated coefficients obtained from the VARMA-GARCH model are employed to evaluate the optimal weights and hedging ratios between Asia Pacific Equities and Precious metals financial innovations. The optimal portfolio weights (OPW) establish the proportion of investments in both categories of financial innovations be included in a portfolio to ensure optimality. Significant volatility spillovers between two investment assets in a portfolio may indicate that investments in the two assets are volatile and susceptible to risk and uncertainty. Hence, investors engage in hedging to mitigate such associated risks through investment in futures contract without jeopardising expected future returns. The expected returns are assumed to be zero to avoid forecasting problems, thus, making the problem similar to estimating risk-minimizing portfolio weights (Kroner and Ng, 1998, Shrydeh et al., 2019). Following the approach proposed in Kroner and Ng (1998) and Arouri et al. (2011), we construct the optimal portfolio weight of holding the two assets using the conditional variance and covariances obtained in Equations (1) and (2) as:

$$\varpi_{SC,t} = \frac{h_t^{stk} - h_t^{SC}}{h_t^{fin} - 2h_t^{SC} + h_t^{stk}} \tag{6}$$

and

$$\varpi_{SC,t} = \begin{cases} 0, & \text{if } \varpi_{SC,t} < 0 \\ \varpi_{SC,t}, & \text{if } 0 < \varpi_{SC,t} \leq 1 \\ 1, & \text{if } \varpi_{SC,t} > 1 \end{cases} \tag{7}$$

where $\varpi_{SC,t}$ denotes the weight of a given precious metal ETF in a one-dollar equity/precious metal ETF investment portfolio at time t. On the other hand, the proportion assigned to equity assets is calculated as $1 - \varpi_{SC,t}$ while h_t is the conditional covariance at time t. The optimal hedge ratios (OHR) (denoted as $\alpha_{SC,t}$) between the and equity and ETF returns is defined as:

$$\alpha_{SC,t} = \frac{h_t^{SC}}{h_t^{stk}} \tag{8}$$

4. Discussion of results

As mentioned in the introduction, this paper aims to evaluate the hedging effectiveness of financial innovations in precious metals market (i.e. the market for investment in exchange traded funds for gold, silver, platinum and palladium) against the risk associated with the Asia-Pacific financial markets during the COVID-19 pandemic. Therefore, we mainly discuss the results of the optimal portfolio weights (OPW) and optimal hedge ratios (OHR) in order to assess the hedging relationship between the two asset classes while the results of the VARMA-GARCH model used in calculating the OPW and OHR are available upon request. Tables 4 and 5 respectively summarize the results for OPW and OHR.

The outbreak of the COVID-19 pandemic reveals the robustness and resilience of the ETFs as they continue to provide investors with alternative portfolios and diversification buffers to absorb the investment risks associated with the highly volatile global investment space brought in by the pandemic impact (Chelley-Steeley and Park, 2011; Charupat and Miu, 2013; Lechman and Marszk, 2015; Dannhauser, 2017; Marszk and Lechman, 2018; Jin et al., 2019; Naeem et al., 2020; Ozdurak and Ulusoy, 2020; Sakarya and Ekinci, 2020). However, the financial crisis provoked by the COVID-19 pandemic has highlighted that not all the financial innovations perform at the same level of optimality, particularly given the huge divergence in the performance for different emerging markets and various financial market under discussion; be it crude oil, foreign exchange, stocks, bonds or commodity market (Sukcharoen et al., 2015; Lau et al., 2017; Cheng et al., 2018; Arunanondchai et al., 2019).

Regardless of the data sample, the estimated optimal portfolio weights show positive portfolio weight of each of the precious metals' financial innovations in a portfolio combination with the Asia-Pacific equities. Using the data sample during COVID-19, the estimated results show that financial innovations in gold, silver, platinum and palladium respectively have OPW of 0.511, 0.408, 0.458 and 0.426, respectively. The OPW estimate indicates, for instance, that the proportion of financial innovation in gold to be held in a fund portfolio combination that combines gold and Asia Pacific equity is about 51%. Like the COVID-19 sample, the results for the full sample and the pre-COVID-19 sample also show that financial innovation in gold maintains an outperformance over the three other precious metals considered, including silver, platinum and palladium. This evidence aligns with the recent studies examining the hedging prowess of gold against risk associated with the travel and tourism sector (Sikiru and Salisu, 2021) and crude oil market (Salisu et al., 2020) during the COVID-19 pandemic. The results suggest that irrespective of the post-crisis volatilities, having gold ETF in equities provides a portfolio option that provides more percentage of optimality than either silver, platinum, or palladium. The OPW results also show that the silver outperforms platinum, while platinum performs better than palladium. The results are true for the three data samples-full, pre-COVID and COVID sample periods.

Conversely, the results of the OHRs are negative for gold across the three sub-samples, but otherwise for silver, platinum, and palladium. Following Baur and Lucey (2010), when there is a negative correlation between two assets within a given portfolio, which could also be represented with the hedge ratios, it provides an indication of hedging. By implication, these results suggest that financial innovation in gold provides effective and suitable hedge for Asia-Pacific equities. However, the absolute values of the OHR show declines during the COVID-19 period compared to the estimates for the pre-COVID sample. This implies that the hedging effectiveness of gold for equities declines during the COVID-19 period for the Asia-Pacific region and all the countries considered. Similar diminishing effectiveness of gold as a hedging tool during crisis is also found by Kumar (2014) and Shrydeh et al. (2019).

In passing, we appraise the findings on the basis of the contributions of the study argued in the introductory section. First, the choice of the Asia-Pacific markets explored for the pandemic risks appears to be supported by the findings obtained from the OHR of the countries. The findings show identical results across the competing hedging securities and the data samples; full, pre-COVID and COVID-19 samples. Our results appear to also indicate that pandemic-induced financial crisis cut across all the Asia-Pacific markets as also witnessed during the previous Asian crisis and the global financial crisis (Kim, 2005; Liu, 2014; Hengchao and Hamid, 2015; Lin, 2015; Chow, 2017; Ahmed and Huo, 2019). Additionally, although we are unable to show that financial innovations in precious metals (as a whole) possess hedging effectiveness to shield investors in the stock markets under consideration, we however confirm the ability to provide investment alternative for financial innovation in gold as previously found for physical gold (Beckmann et al., 2018; Salisu et al., 2019; Huynh, 2020). Consequently, we establish that the ability of financial innovations in precious metals to hedge various market risks may well be limited to gold as also obtained by Lau et al. (2017) and Cheng et al. (2018) against oil market and currency market risks.

Table 4. Optimal portfolio weights.

	Full sample				Before COVID-19				During COVID-19			
	Gold	Silver	Platinum	Palladium	Gold	Silver	Platinum	Palladium	Gold	Silver	Platinum	Palladium
Pacific Region	0.590	0.476	0.529	0.462	0.591	0.463	0.525	0.493	0.511	0.403	0.458	0.426
Australia	0.591	0.575	0.613	0.275	0.593	0.461	0.613	0.328	0.547	0.530	0.489	0.543
Canada	0.505	0.671	0.522	0.357	0.517	0.484	0.569	0.451	0.526	0.511	0.518	0.524
China	0.471	0.374	0.519	0.550	0.527	0.528	0.525	0.326	0.547	0.469	0.525	0.650
Hong Kong	0.490	0.464	0.505	0.378	0.512	0.443	0.569	0.389	0.539	0.491	0.517	0.645
India	0.460	0.452	0.672	0.439	0.485	0.334	0.517	0.451	0.026	0.130		
Indonesia	0.454	0.472	0.419	0.282	0.481	0.421	0.621	0.261	0.532	0.521	0.522	0.637
Japan	0.503	0.469	0.498	0.470	0.497	0.447	0.500	0.438	0.510	0.481	0.506	0.484
South Korea	0.496	0.079	0.443	0.371	0.513	0.384	0.502	0.392	0.558	0.507	0.524	0.511
Malaysia	0.492	0.470	0.499	0.502	0.493	0.507	0.496	0.515	0.512	0.482	0.430	0.505
Philippines	0.498	0.295	0.506	0.464	0.511	0.514	0.528	0.528	0.530	0.493	0.519	0.591
Singapore	0.471	0.598	0.430	0.341	0.505	0.476	0.527	0.491	0.555	0.492	0.516	0.483
Thailand	0.519	0.504	0.512	0.496	0.518	0.486	0.528	0.456	0.543	0.524	0.505	0.518
Taiwan	0.475	0.479	0.471	0.431	0.497	0.511	0.522	0.534	0.553	0.506	0.492	0.654

Note: The table reports average optimal portfolio weights (OPW) in an equity and precious metals ETFs investment portfolio.

Table 5. Optimal hedge ratios.

	Full sample				Before COVID-19				During COVID-19			
	Gold	Silver	Platinum	Palladium	Gold	Silver	Platinum	Palladium	Gold	Silver	Platinum	Palladium
Pacific Region	−0.094	0.101	0.165	0.240	−0.106	0.105	0.168	0.227	−0.031	0.114	0.205	0.189
Australia	−0.078	0.088	0.117	0.326	−0.079	0.108	0.112	0.290	−0.044	0.150	0.151	0.195
Canada	−0.060	0.110	0.178	0.277	−0.065	0.136	0.148	0.232	−0.038	0.149	0.160	0.188
China	−0.105	0.118	0.142	0.226	−0.086	0.076	0.145	0.302	−0.020	0.135	0.173	0.194
Hong Kong	−0.085	0.118	0.156	0.308	−0.059	0.108	0.135	0.296	0.016	0.163	0.175	0.191
India	−0.076	0.088	0.107	0.226	−0.065	0.111	0.113	0.223	−0.210	0.250	0.074	0.218
Indonesia	0.043	0.192	0.287	0.320	0.023	0.222	0.189	0.327	0.037	0.193	0.239	0.150
Japan	−0.128	0.031	0.117	0.195	−0.127	0.027	0.089	0.203	−0.032	0.094	0.154	0.215
South Korea	−0.093	0.352	0.171	0.269	−0.093	0.163	0.158	0.257	−0.037	0.169	0.149	0.205
Malaysia	−0.043	0.120	0.169	0.161	−0.059	0.040	0.158	0.163	0.001	0.147	0.208	0.135
Philippines	−0.012	0.214	0.196	0.246	−0.011	0.128	0.149	0.221	0.055	0.217	0.196	0.188
Singapore	−0.092	0.080	0.203	0.351	−0.062	0.058	0.114	0.267	−0.052	0.099	0.151	0.243
Thailand	0.029	0.211	0.256	0.261	0.074	0.188	0.221	0.303	0.043	0.192	0.280	0.245
Taiwan	−0.072	0.124	0.167	0.223	−0.099	0.068	0.085	0.207	−0.010	0.171	0.206	0.152

Note: The table reports average optimal hedge ratios (OHR) in an equity and precious metals ETFs investment portfolio.

5. Conclusions

In this study, we assess whether financial innovations in precious metals i.e. funds containing passive investment in precious metals (contrary to direct investment in the indexes containing physical precious metals) can provide good hedges against risks associated with the Asia-Pacific equities, before and during the unprecedented global pandemic (COVID-19). We motivate the study for the economic consequences of the pandemic in the Asia-Pacific stock markets given past incidences of financial crises (for example, the 1997 Asian crisis and the 2007/2008 global financial crisis) that have resonated shock spillovers across the region in the past. We also justify the role of financial innovations in precious metals for hedging effectiveness given the flexibility of the alternative investment funds to serve as diversified investment portfolio which could be traded as a single stock and also has the advantage of eliminating the need for investors to physically hold commodities (i.e. precious metals) and worry about storage concerns.

We collect daily prices of four prominent precious metals ETFs (as the proxy for financial innovations in the precious metals) including gold, silver, platinum and palladium alongside equity prices of the Asia-Pacific region as well as 13 country-specific equity prices. We compute the optimal portfolio weights and optimal edge ratios based on the estimates of conditional variance and covariance obtained from the VARMA-GARCH model which is suitable for tracing spillover transmissions between or among financial markets. While the results vary for the considered precious metals, the overarching evidence suggests that combining gold ETFs in an Asia-Pacific equity portfolio would provide both a valuable portfolio combination that could improve the risk-adjusted performance and provide premium for investors in addition to serving as an effective hedge for equity-related risks. Similar optimal portfolio performance is established for the three other precious metals considered, silver, platinum, and palladium. However, each of the precious metals financial innovations outperforms the others as listed, respectively.

In all, we arrive at three major conclusions. One, we demonstrate that the best outcome in terms of the ability of precious metals' financial innovations to hedge financial market risks can be realized using the financial innovation in gold as previously established for physical gold in the extant literature. In other words, the use of financial innovations in silver, platinum, and palladium as hedges for risks associated with Asia Pacific equities is less desirable compared to gold. Two, the hedging effectiveness of gold as well as other precious metals suffers a decline during the COVID-19 pandemic. This contrasts with the full sample period and the period before the pandemic. An extension of this study that accommodates more emerging and developed stock markets in other regions including the OECD countries would offer a broader perspective for meaningful generalizations.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

Ethics declaration

There are no ethical issues to declare in this paper.

References

Ahmed AD, Huo R (2019) Impacts of China's crash on Asia-Pacific financial integration: volatility interdependence, information transmission and market co-movement. *Econ Model* 79: 28–46.

Al-Maadid A, Caporale GM, Spagnolo F, et al. (2016) Spillovers between food and energy prices and structural breaks. *Int Econ* 150: 1–18.

Arouri MEH, Nguyen DK (2010) Oil prices, stock markets and portfolio investment: evidence from sector analysis in Europe over the last decade. *Energ Policy* 38: 4528–4539.

Arouri MEH, Jouini J, Nguyen DK (2011) Volatility spillovers between oil prices and stock sector returns: implications for portfolio management. *J Int Money Financ* 30: 1387–1405.

Arunanondchai P, Sukcharoen K, Leatham DJ (2019) Dealing with tail risk in energy commodity markets: futures contracts versus exchange-traded funds. *J Commodity Mark* 20: 100112.

Baker SR, Bloom N, Davis SJ, et al. (2020) Covid-induced economic uncertainty. NBER Working Paper No. 26983.

Balcilar M, Cerci G, Demirer R (2016) Is there a role for Islamic bonds in global diversification strategies? *Manage Financ* 42: 656–679.

Baur DG, Lucey BM (2010) Is gold a hedge or a safe haven? *Anal Stock Bond Gold Financ Rev* 45: 217–229.

Beckmann J, Berger T, Czudaj R (2018) Gold price dynamics and the role of uncertainty. *Quant Financ* 19: 663–681.

Charupat N, Miu P (2013) Recent developments in exchange-traded fund literature: pricing efficiency, tracking ability: and effects on underlying securities. *Manag Financ* 39: 427–443.

Chelley-Steeley P, Park K (2011) Intraday patterns in London listed exchange traded funds. *Int Rev Financ Anal* 20: 244–251.

Cheng C, Chen C, Lai H (2018) Revisiting the roles of gold: Does gold ETF matter? *N Am J Econ Financ*, 100891.

Chow HK (2017) Volatility spillovers and linkages in Asian stock markets. *Emerg Mark Financ Trade* 53: 2770–2781.

Conlon T, McGee R (2020) Safe haven or risky hazard? Bitcoing during the COVID-19 bear market. *Financ Res Lett* 35: 101607.

Corbet S, Larkin C, Lucey B (2020) The contagion effects of the COVID-19 pandemic: evidence from gold and cryptocurrencies. *Financ Res Lett* 35: 101554.

Dannhauser CD (2017) The impact of innovation: Evidence from corporate bond exchange-traded funds (ETFs). *J Financ Econ*, 537–560.

Devpura N, Narayan PK (2020) Hourly oil price volatility: the role of COVID-19. *Energy Res Lett* 1: 13683.

Ferri R (2009) *The ETF Book: All You Need to Know About Exchange-Traded Funds*, Eds., Hoboken, NJ: Wiley.

Gao S (2001) ETFs "The new generation of investment funds". *ETFs Indexing* 1: 101–105.

Harper TJ, Madura J, Schnusenberg O (2006) Performance comparison between exchange-traded funds and closed-end country funds. *Int Financ Mark I Money*, 104–122.

Haslem JA (2003) *Mutual funds: Risk and Performance Analysis for Decision Making*, Eds., Oxford: Blackwell Publishing.

Hehn E (2005) Introduction, In: Hehn, *Exchange Traded Funds: Structure, Regulation and Application of a New Fund Class*, Eds., Heidelberg: Springer Berlin, 1–6.

Hengchao Z, Hamid Z (2015) The impact of subprime crisis on Asia-Pacific Islamic stock markets. *J Asia-Pac Bus* 16: 105–127.

Huynh DL (2020) The effect of uncertainty on the precious metals market: new insights from transfer entropy and neural network VAR. *Resour Policy* 66: 101623.

Iyke B (2020a) COVID-19 The reaction of US oil and gas producers to the pandemic. *Energy Res Lett* 1: 13912.

Iyke BN (2020b) The disease outbreak channel of exchange rate return predictability: evidence from COVID-19. *Emerg Mark Financ Trade* 56: 2277–2297.

Jin J, Yu J, Hu Y, et al. (2019) Which one is more informative in determining price movements of hedging assets? Evidence from Bitcoin, gold and crude oil markets. *Phys A* 527: 121121.

Junttila J, Pesonen J, Raatikainen J (2018) Commodity market based hedging against stock market risk in times of financial crisis: the case of crude oil and gold. *J Int Finan Mark I Money*, 255–280.

Kaur P, Singh J (2020) Price formation in Indian gold market: analyzing the role of gold exchange traded funds (ETFs) against spot and futures market. *IIMB Manage Rev*, 59–74.

Kim S (2005) Information leadership in the advanced Asia-Pacific stock markets: return, volatility and volume information spillovers from the US and Japan. *J JPN Int Econ* 19: 338–365.

Kraft B (2012) Getting an edge with exchange-traded funds, In: *Trade Your Way to Wealth*.

Kroner KF, Ng VK (1998) Modeling asymmetric comovements of asset returns. *Rev Financ Stud* 11: 817–844.

Kumar D (2014) Return and volatility transmission between gold and stock sectors: application of portfolio management and hedging effectiveness. *IIMB Manage Rev* 26: 5–16.

Latunde T, Akinola LS, Dare DD (2020). Analysis of capital asset pricing model on Deutsche bank energy commodity. *Green Financ* 2: 20–34.

Lau MCK, Vigne SA, Wang S, et al. (2017) Return spillovers between white precious metal ETFs: the role of oil, gold, and global equity. *Int Rev Financ Anal* 52: 316–332.

Lechman E, Marszk A (2015) ICT technologies and financial innovations: The case of exchange traded funds in Brazil, Japan, Mexico, South Korea and the United States. *Technol Forecast Soc Change* 99: 355–376.

Lee M, Chiou JS, Wu PS, et al. (2005) Hedging with S&P500 and E-mini S&P500 stock index futures. *J Stat Manage Syst* 8: 275–294.

Leung T, Ward B (2015) The golden target: analyzing the tracking performance of leveraged gold ETFs. *Stud Econ Financ* 32: 278–297.

Li Y, Liang C, Ma F, et al. (2020) The role of the IDEMV in predicting European stock market volatility during the COVID-19 pandemic. *Financ Res Lett* 36: 101749.

Lin C (2015) Asia-Pacific stock return predictability and market information flows. *Emerg Mark Financ Trade* 51: 658–671.

Ling S, McAleer M (2003) Asymptotic theory for a vector ARMA-GARCH model. *Econ Theory* 19: 280–310.

Liu L (2014) Extreme downside risk spillover from the United States and Japan to Asia-Pacific stock markets. *Int Rev Financ Anal* 33: 39–48.

Lypny G, Powalla M (1998) The hedging effectiveness of DAX futures. *Eur J Financ* 4: 345–355.

Maghyereh A, Awartani B, Hassan A (2018) Can gold be used as a hedge against the risks of Sharia-compliant securities? Application for Islamic portfolio management. *J Asset Manage* 19: 394–412.

Marszk A, Lechman E (2018) Tracing financial innovation diffusion and substitution trajectories. Recent evidence on exchange-traded funds in Japan and South Korea. *Technol Forecast Soc Change* 133: 51–71.

Naeem M, Umar Z, Ahmed S, et al. (2020) Dynamic dependence between ETFs and crude oil prices by using EGARCH-Copula approach. *Phys A* 557: 124885.

Narayan PK (2020a) Oil price news and COVID-19-Is there any connection? *Energy Res Lett* 1: 13176.

Narayan PK (2020b) Did bubble activity intensify during COVID-19? *Asian Econ Lett* 1.

Narayan PK (2020c) Has COVID-19 changed exchange rate resistance to shocks? *Asian Econ Lett* 1.

Narayan PK, Devpura N, Wang H (2020) Japanese currency and stock market-What happened during the COVID-19 pandemic? *Econ Anal Policy* 68: 191–198.

OECD (2020) Coronavirus: The world economy at risk. OECD Interim Economic Assessment. Available from: https://www.oecd.org/berlin/publikationen/Interim-Economic-Assessment-2-March-2020.pdf.

Okorie DI, Lin B (2020) Crude oil price and cryptocurrencies: evidence of volatility connectedness and hedging strategy. *Energy Econ* 87: 104703.

Olson E, Vivian A, Wohar ME (2019) What is a better cross-hedge for energy: equities or other commodities? *Glob Financ J* 42: 100417.

Ozdurak C, Ulusoy V (2020) Price discovery in crude oil markets: Intraday volatility interactions between crude oil futures and energy exchange traded funds. *Int J Energy Econ Policy* 10: 402–413.

Qin M, Zhang YC, Su CW (2020) The essential role of pandemics: A fresh insight into the oil market. *Energy Res Lett* 1.

Reboredo JC, Naifar N (2017) Do Islamic bond (sukuk) prices reflect financial and policy uncertainty? A quantile regression approach. *Emerg Mark Financ Trade* 53: 1535–1546.

Sakarya B, Ekinci A (2020) Exchange-traded funds and FX volatility: Evidence from Turkey. *Cent Bank Rev* 20: 205–211.

Salisu AA, Obiora K (2021) COVID-19 pandemic and the crude oil market risk: hedging options with non-energy financial innovations. *Financ Innov* 7: 34.

Salisu AA, Ogbonna AE (2021) The return volatility of cryptocurrencies during the COVID-19 pandemic: assessing the news effect. *Glob Financ J* [In press].

Salisu AA, Vo XV, Lucey B (2021) Gold and US sectoral stocks during COVID-19 pandemic. *Res Int Bus Financ* 57: 101424.

Salisu AA, Akanni LO (2020) Constructing a global fear index for the COVID-19 Pandemic. *Emerg Mark Financ Trade* 56: 2310–2331.

Salisu AA, Vo XV (2020) Predicting stock returns in the presence of COVID-19: the role of health news. *Int Rev Financ Anal* 71: 101546.

Salisu, AA, Mobolaji H (2013) Modeling returns and volatility transmission between oil price and US-Nigeria exchange rate. *Energy Econ* 39: 169–176.

Salisu AA, Ebuh GU, Usman N (2020) Revisiting oil-stock nexus during COVID-19 pandemic: some preliminary results. *Int Rev Econ Financ* 69: 280–294.

Salisu A, Adediran I (2020) Uncertainty due to infectious diseases and energy market volatility. *Energy Res Lett* 1.

Salisu AA, Ndako UB, Oloko TF (2019) Assessing the inflation hedging of gold and palladium in OECD countries. *Res Policy* 62: 357–377.

Salisu AA, Oloko TF (2015) Modeling oil price-US stock nexus: a VARMA-BEKK-AGARCH approach. *Energy Econ* 50: 1–12.

Salisu AA, Vo XV, Lawal A (2020) Hedging oil price risk with gold during COVID-19 pandemic. *Res Policy* 70: 101897.

Salisu AA, Sikiru AA (2020) Pandemics and the Asia-Pacific Islamic stocks. *Asian Econ Lett* 1.

Sikiru AA, Salisu AA (2021) Hedging against risks associated with travel and tourism stocks during COVID-19 pandemic: the role of gold. *Int J Financ Econ* [In press].

Selmi R, Mensi W, Hammoudeh S, et al. (2018) Is bitcoin a hedge, a safe haven or a diversifier for oil price movements? A comparison with gold. *Energy Econ* 74: 787–801.

Shahzad SJH, Aloui C, Jammazi R, et al. (2019) Are Islamic bonds a good safe haven for stocks? Implications for portfolio management in a time-varying regime-switching copula framework. *Appl Econ* 51: 219–238.

Sharma SS (2020) A Note on the Asian market volatility during the COVID-19 pandemic. *Asian Econ Lett* 1.

Shrydeh N, Shahateet M, Mohammad S, et al. (2019) The hedging effectiveness of gold against US stocks in a post-financial crisis era. *Cogent Econ Finance* 7.

Sukcharoen K, Choi H, Leatham DJ (2015) Optimal gasoline hedging strategies using futures contracts and exchange-traded-funds. *Appl Econ* 47: 3482–3498.

Tari MJ (2010) Exchange-traded funds (ETFs). *Encyclopedia Quant Financ*.

Urom C, Abid I, Guesmi K, et al. (2020) Quantile spillovers and dependence between bitcoin, equities and strategic commodities. *Econ Model* 93: 230–258.

Yang MJ, Lai YC (2009) An out-of-sample comparative analysis of hedging performance of stock index futures: dynamic versus static hedging. *Appl Financ Econ* 19: 1059–1072.

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