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THE HEDGING ABILITY OF GOLD, SILVER AND BITCOIN AGAINST INFLATION IN ASEAN COUNTRIES

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ABSTRACT

This paper examines the hedging ability of gold, silver and Bitcoin against inflation in ASEAN countries. The inclusion of Bitcoin as a hedge is relatively new in literature and the effect of hedging has been exacerbated post global financial crisis (GFC), when the prices of precious metals have increased continuously. To serve this objective, the student-t EGARCH (1,1) model is first used to study the relationship between average asset return and inflation and next a quantile regression model is applied to explore the relationship between different quantiles of asset return and inflation. This ensures the hedging potential of each asset to be equally strong in bearish and bullish conditions. The tests show that the results from student-t EGARCH (1,1) model and quantile regression model are different while the results pre and post GFC are similar in most of the cases. The quantile regression model, which accounts for different quantiles for asset returns, indicates that gold, silver, and Bitcoin appear to be a hedge and safe haven in ASEAN countries. However, from the student-t EGARCH (1,1) model, which accounts for average asset returns, Bitcoin is a hedge asset but none of the three assets serves as a safe haven in ASEAN countries.

Keywords: Hedging, Inflation, Financial crisis, ASEAN, Assets

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INTRODUCTION

In this paper, we examine the hedging ability of gold, silver and Bitcoin against inflation in ASEAN countries. Traditionally, assets such as precious metals like gold and silver (Baur & Lucey, 2010) or currencies such as the Swiss franc and US dollar (Hossfeld & MacDonald, 2015) have been considered as a safe haven against inflation. More recently, Bitcoin has been discussed in literature with varying opinions. Some classify it as a safe haven (Urquhart & Zhang, 2019), while others believe it is a risky asset instead (Cheema et al., 2020). The effect of hedging has been exacerbated post global financial crisis (GFC), where the prices of precious metals like gold and silver have increased continuously. Gold price has doubled, silver price increased by 37%, while Bitcoin, after its introduction to the market in 2009, has risen from a single-digit price to a five-digit range.

This raises concern of investors on adopting gold, silver and Bitcoin to protect themselves by hedging away the purchasing power risk. This risk has been the primary concern of investors and governments all over the globe. The inflation rate fluctuation will raise purchasing power risk, causing investors to receive lesser real return than expected (Singh & Joshi, 2019). As a result, investors prefer an investment that can compensate for their losses due to deterioration in purchasing power. This offers a strong motivation to test the hedging ability of gold, silver, and Bitcoin in acting as hedge and haven against inflation rate risk. Adopting from Baur and Lucey (2010), a hedge is defined as an asset that is not relative to other assets or positively correlated with inflation rate on average and a safe haven is an asset that is not relative to other assets or positively correlated with inflation rate in extreme market conditions.

We focus on investigating in ASEAN countries before and after 2008 GFC. That milestone is considered because despite the belief of a safe haven asset to hedge against inflation, gold price dropped tremendously by more than 25% during 2007–2008, from more than USD1,000 per troy ounce to USD730 per troy ounce. Moreover, comparing the hedging properties of precious metals pre and post GFC, we see that the GFC is frequently reported as the most unrelenting crisis since the Great Depression of 1929 (Shrydeh et al., 2019). A report by Vu (2020) shows that the economy of this area is catching up with developed economies. Growth gaps between these markets suggest that ASEAN countries have the potential to collectively enhance market efficiency. One indication of this is the growth in Foreign direct investment (FDI) flows to this area. According to a report by The ASEAN Secretariat, in 2018, global FDI fell by 13.4%. Yet, FDI to ASEAN countries increased, and the amount was even higher than the average inflows to emerging countries (5.3% compared to 2.2%, respectively). However, inflation rates

in this area were generally higher than the rates in developed markets. As shown in Table 1, the means of annual inflation rates in 10 ASEAN countries over the period of 2001–2021 ranged from 0.31% in Brunei to 14.4% in Myanmar while the rates in developed markets such as the U.S., the U.K. and the EU were around 2%. Especially, as the inflation rates in most of the markets hit the peak in 2008 due to the GFC, the rates in ASEAN countries remained much higher than the rates in those advanced markets, with the exception of Brunei only. In 2021, inflation caught the attention again as it came to the U.S. at its highest level since 2008. The concern quickly spread to other regions in 2022 due to the higher demand in the recovery state after the COVID-19 lockdown and the rise in energy prices. Inflation rates were posted in Germany, the U.S. and the U.K. at 7.9%, 8.6% and 9%, respectively, in May 2022. High inflation remained geographically broad-based. Consumer price growth had even started rising in Asia, a region that until recently had largely been an exception to the worldwide pattern (Romei & Smith, 2022). It raised the concern about the long-term outlook for inflation in ASEAN region, which historically showed a higher level compared to the advanced economies.

Table 1
2008 inflation rate and mean of inflation rates over the period of 2001–2021 in the 10 ASEAN countries, the U.S., the U.K. and the EU

Country	2008 inflation rate	Mean of inflation rates
Indonesia	10.23	6.28
Thailand	5.47	1.87
Philippines	8.26	3.77
Singapore	6.63	1.53
Malaysia	5.44	2.05
Vietnam	23.12	6.39
Myanmar	26.80	14.39
Cambodia	24.10	4.07
Laos	7.63	5.56
Brunei	2.08	0.31
U.S.	3.84	2.19
U.K.	3.52	2.02
EU	4.16	1.89

In order to analyse the hedging ability of the asset against inflation, we will first use the student-t EGARCH (1,1) model to study the relationship between average asset return and inflation rate, adopting from Baur and Lucey (2010).

This is followed by the quantile regression model of Iqbal (2017) which allows to explore the relationship between different quantiles of asset return and inflation. Then the results are compared to examine whether the relationship using average returns will be identical to the output using different quantiles of returns. This is to ensure the hedging potential of each asset is equally strong in bearish and bullish conditions. If the results are similar, then it can be concluded that investors can invest in a hedge asset without concerns about the asset returns because the acquisition will yield identical performance in any returns. Otherwise, investors should be cautious about asset returns when making asset allocation decisions. To test the robustness of the main results, the data frequency for gold and silver is changed to quarterly, and Bitcoin is replaced with Litecoin.

Gold has the most extended history as a medium of exchange and a store of value. The simplest technique to analyse the hedging potential of the asset is a regression model in which gold returns are regressed on inflation (Dee at al., 2013). Expanding that method, Capie et al. (2005) and Baur and Lucey (2010) estimate a dynamic regression model and assume the error term to exhibit conditional autoregressive heteroskedasticity modelled via a GARCH process. This technique also accounts for the lagged effects. In addition, some research looks at the stable long-term relationship between consumer prices and gold price by using the cointegration regression and the VECM (Adrangi et al., 2003; Gosh et al. 2004; Khair-Afham et al., 2017). Worthington and Pahlavani (2007) also consider the structural breaks of the unstable long-term relationship between inflation and gold price by applying a modified cointegration approach developed by Saikkonen and Lütkepohl (2000a; 2000b; 2000c).

On the other hand, Wang et al. (2011) argue that the relationship between consumer prices and the price of gold is nonlinear and suggest using the threshold cointegration framework developed by Enders and Siklos (2001). In addition, Bampinas and Panagiotidis (2015) employ time invariant and a time-varying cointegration framework that allows for nonlinear adjustment and the smooth evolution of the long-run relationship. Recently, Beckmann and Czudaj (2020) consider nonlinearity and discriminate between long-run and time-varying short-run dynamics by applying a Markov-switching vector error correction model (MS-VECM). Mulyadi and Anwar (2012) apply Probit model which is from the uncertainty probability point of view, while Dee et al. (2013) use quantile regression to examine gold hedging and safe haven properties and find that gold is a good hedge for inflation if investors hold it for a long time. Additionally, gold is regarded as a safe haven property during the COVID-19 pandemic (Ji et al., 2020).

At the same time, the literature on the hedging ability of silver against inflation is less extensive. Several studies of the hedging ability of gold mentioned above also cover the hedging ability of silver (for example, Adrangi et al., 2003; Bampinas & Panagiotidis, 2015). They suggest that silver is considered as a replacement of gold in hedging against inflation because both gold and silver are universally acceptable and easily authenticated.

Bitcoin, which was introduced by Nakamoto in 2009, shows some similar features to gold and silver. Bitcoin was the first digital cryptocurrency, and it has occasionally been called digital gold (Popper, 2015). Both cryptocurrency and precious metals are produced through mining, although the physical mining process of precious metals differs from Bitcoin's digital mining. Bitcoin also has the same hedging ability as gold (Shahzad et al., 2020). Yet, Bitcoin's main difference from gold and silver is that it is decentralised. Recently, the volatility of Bitcoin price has attracted attention. Some believe that Bitcoin can replace gold as a hedge against inflation, especially when the country is dealing with hyperinflation (Henriques & Sadorsky, 2018). The rapid rise in the popularity of Bitcoin can also be explained by the low transaction fees across borders (Popper, 2015; Kim, 2017).

The literature on the hedging properties of Bitcoin is fairly well developed (Henriques & Sadorsky, 2018; Stensås et al., 2019) but the hedging ability against inflation is not widely studied (Matkovskyy & Jalan, 2020). While Qudah and Aloulou (2020) study the relationship between Bitcoin and inflation and suggest a model to hedge against inflation in the Gulf Cooperation Council (GCC) countries using the Bitcoin returns, Matkovskyy and Jalan (2020) conclude that bullish U.K., Euro and Japanese Bitcoin can hedge against inflation by offering higher returns. Phochanachan et al. (2022) who adopt Markov Switching Vector Autoregressive Regression (MS-VAR) to examine whether Bitcoin, gold, oil and stock can be used to hedge against inflation in 10 countries with the highest rate of cryptocurrency adoption, namely Ukraine, Russia, Singapore, Kenya, United States, India, South Africa, Nigeria, Columbia and Vietnam, reveal that all assets can hedge against inflation more effectively in the short run than long run. In their study, it is further contended that Bitcoin is an effective hedging asset in more countries than other assets in stable and turbulent regimes. Bitcoin also plays a role as a safe haven property and an effective hedge for some financial assets at different investment horizons, as contended by Kinkyo (2022). In the study, the researcher estimates the multivariate factor Stochastic volatility (SV) model by using the daily returns and decomposed series of Bitcoin, oil, gold, and the USD exchange rate of 13 currencies and find that Bitcoin provides better risk reduction than oil and gold, particularly over the medium and long terms. Moreover, Bitcoin

has been seen as a tool to protect savings in times of economic uncertainty, and hence, increases its relevance to be included in the diversified portfolios by the investors (Paule-Vianez et al., 2020). On the other hand, by observing the data between July 2010 and December 2020, Choi and Shin (2022) find that Bitcoin is not a safe haven property. Nonetheless, similar to gold, Bitcoin is an effective hedging asset against inflation.

We offer three significant contributions to the existing literature. First, this paper compares the results of two models, student-t EGARCH (1,1) and quantile regression model, to investigate the hedging ability of gold, silver, and Bitcoin against inflation. Most of the existing papers employ either one of these two techniques. A comparison of the results of the two methods provides a more comprehensive analysis on the topic. Second, we examine the hedging potential of the ASEAN countries' assets. Despite the economic growth potential in the Southeast Asia region, there is a lack of literature on studying hedging ability against inflation in this area. The majority of the research has been done on the developed markets like the U.S., U.K., EU and Japan (Bampinas & Panagiotidis, 2015; Beckmann & Czudaj, 2013; Matkovskyy & Jalan, 2020) or emerging markets like China (Dee et al., 2013) and GCC countries (Qudah & Aloulou, 2020). Third, this paper contributes to the literature on the topic by looking into the impact of the GFC on the hedging properties of gold, silver and Bitcoin. To the best of the authors' knowledge, this is the first attempt that considers the impact of the GFC.

This paper's main result shows that student-t EGARCH (1,1) and quantile regression model results are different. Moreover, the results pre and post GFC are similar in most of the cases. In the quantile regression model, which accounts for different quantiles for asset returns, gold, silver and Bitcoin appear to be a hedge and safe haven in ASEAN countries. However, in the EGARCH model, which accounts for average asset returns, only Bitcoin can be a hedge asset, and none of them serves as a safe haven asset in ASEAN countries. Another point to note is an asset requires a very volatile return to be a hedge asset, but a very stable return to be a safe haven asset. Besides, the negative correlation between asset returns and inflation appears in two conditions: (1) hedge ratio when asset return is below 25th quantile and (2) 99% percentile of inflation rate when asset return is above 90th quantile. The robustness test is in line with the preliminary results of this paper.

DATA AND METHODOLOGY

Data

Monthly data of gold, silver, and Bitcoin prices and the consumer price index (CPI) of 10 ASEAN countries are collected. CPI is used as the proxy for the inflation rate. The entire study period for gold and silver is from July 2001 to May 2020, which is divided into the pre-crisis period (July 2001 to August 2008) and post-crisis period (September 2008 to May 2020). The study period for Bitcoin is May 2012–May 2020 due to data availability. The data was collected from Thomson Reuters. Even though the period of observation for Bitcoin is different from gold and silver, it would not affect the results of our findings as we apply average change in the value of the variables over time, instead of absolute value. However, as Bitcoin is only available from May 2012, we could only observe the outcome of our study during post-crisis period but not during pre-crisis period.

The return of gold, silver and Bitcoin is measured by the average change in the asset prices over time, using the formula as follows:

$$r_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \times 100 \tag{1}$$

While the CPI is measured based on the average change in prices over time that consumers pay for a basket of goods and services.

$$CPI = \frac{Cost\ of\ market\ basket\ in\ given\ year}{Cost\ of\ market\ basket\ in\ base\ year} \times 100 \tag{2}$$

Methodology

The first methodology used in this paper is EGARCH. An OLS estimate is unable to deliver the best linear unbiased estimator (BLUE) if the variable is heteroscedastic (Gujarati, 2005). Hence, Engle (1982) developed the autoregressive conditional heteroscedasticity (ARCH) model to model the conditional variance. Bollerslev (1986) further developed the ARCH model to the generalised ARCH, also called GARCH. It simplifies the lags on disturbance terms by including a lagged variance term into the variance equation. For the past few decades, the GARCH model has been widely used in academic literature to capture financial data movement for volatility clustering (Holmes, 1996; Mallikarjunappa & Afsal, 2008; Malim et al., 2017).

Nelson (1991) introduces exponential GARCH (EGARCH) to capture asymmetric responses in the conditional variance. Empirical evidence suggests that the EGARCH model is superior to the traditional GARCH model (Lee

& Brorsen, 1997). Yet, a normal EGARCH (1,1) model is insufficient if the conditional variance is not following normal distribution because it cannot explain the entire leptokurtosis. Consequently, this paper adopts a non-normal distribution of the student-t EGARCH (1,1) model proposed by Bollerslev (1986) to explain the degree of leptokurtosis.

First, the student-t EGARCH (1,1) approach will be adopted to perform maximum likelihood estimation. The econometric model is expressed as follow:

$$r_{Gold,t} = \alpha + \beta r_{inflationrate} + e_t \tag{3}$$

$$r_{Silver,t} = \alpha + \beta r_{inflationrate} + e_t \tag{4}$$

$$r_{Bitcoin,t} = \alpha + \beta r_{inflationrate} + e_t \tag{5}$$

$$\beta = \rho_1 + \rho_2 D(r_{inflationrate}, q_{90}) + \rho_3 D(r_{inflationrate}, q_{95}) + \rho_4 D(r_{inflationrate}, q_{99}) \tag{6}$$

Where α is the parameter and e_t is the error term. Equations 3 to 5 show the asset return as the function of the inflation rate. They estimate the relationship between inflation and gold, silver and Bitcoin, respectively. In Equation 6, $D(r_{inflationrate}, q_{90})$, $D(r_{inflationrate}, q_{95})$ and $D(r_{inflationrate}, q_{99})$ are the dummy variables to capture high inflation. This indicates whether gold, silver and Bitcoin can hedge against high inflation. This paper categorises the high inflation rate as at upper q% percentiles, i.e., 90%, 95%, and 99%. If the inflation rate is above specific percentiles, the dummy variable will be one and anything below will be zero. If one of the parameters ρ_2, ρ_3 and ρ_4 is significantly different from zero, the relative asset will have non-linear relation with the inflation rate. Hence, the asset is a hedge against the inflation when the coefficient of ρ_1 (hedge ratio) is significantly positive. A positive coefficient is required because asset returns should increase when inflation rates rise for an asset to be a hedge asset.

Next, we employ quantile regression analysis to study the relation between specific percentiles of asset returns with the inflation rate and determine whether these financial variables' hedging capabilities are equally strong in bearish (low percentiles) and bullish conditions (high percentiles).

The quantile regression follows this method:

Let Y be a random variable with probability distribution function $F(y) = P(Y \leq y)$, the τth quantile of Y given X is as following:

$$Q_\tau(x) = \{y : F(y \mid x) \geq \tau\}, \text{ where } 0 < \tau < 1 \tag{7}$$

Suppose we have the quantile regression of $Q_\tau(x) = x'\beta(\tau)$ where $\beta(\tau)$ is the vector of coefficients related with x for the τth quantile. The formula to acquire estimator of $\beta(\tau)$ used as:

$$\hat{\beta}(\tau) = argmin_\beta \sum_{i=1}^{n} \rho_\tau(y_i - x'\beta) \tag{8}$$

where ρ_τ is asymmetric weighted absolute value function, defined by

$$\rho_\tau(z) = \{\tau z \qquad \text{if } z \geq 0, (\tau - 1)z \qquad \text{if } z < 0.$$

To estimate whether gold, silver and Bitcoin hedges purchasing power risk, the following conditional quantile regression model is being used:

$$\begin{aligned} Q_\tau(x) = {} & \beta_{0(\tau)} + \beta_{1(\tau)} r_{inflation} + \beta_{2(\tau)} r_{inflation} \times D(r_{inflation}, q90) + \\ & \beta_{3(\tau)} r_{inflation} \times D(r_{inflation}, q95) + \beta_{4(\tau)} r_{inflation} \times D(r_{inflation}, q99) + e_t \end{aligned} \tag{9}$$

From Equation 9, $D(r_{inflation}, q90)$, $D(r_{inflation}, q95)$ and $D(r_{inflation}, q99)$ represents the dummy variables for inflation rate in upper percentiles which are 90%, 95%, and 99%. If the inflation rate is above certain percentiles, the dummy variable will be one, and anything below will be zero. When β_1 of the specified percentile is significantly positive, the examined asset is said to be a hedge against inflation in that percentile. When the sum of $\beta_{1(\tau)}$, $\beta_{2(\tau)}$, $\beta_{3(\tau)}$, and $\beta_{4(\tau)}$ is more than or equal to zero, then the examined investment is a safe haven against inflation for that certain quantile. The quantiles being used for each response variables (τ) are 10th, 25th, 50th, 75th and 90th.

EMPIRICAL RESULTS

Figure 1 shows the returns of gold, silver and Bitcoin over the period of study. The return of Bitcoin has the highest degree of fluctuations, followed by silver, while the return of gold is the most stable amongst them. Brunei appears to have the lowest inflation rates among the ASEAN countries, U.K., U.S. and EU (Table 1). The Brunei government has been regularly maintaining domestic price stability and establishing efficient payment systems in the country. In addition, the Currency Board Agreement signed between Brunei and other countries contributes to its macro account stability and price stability which is recognised by the International Monetary Fund.

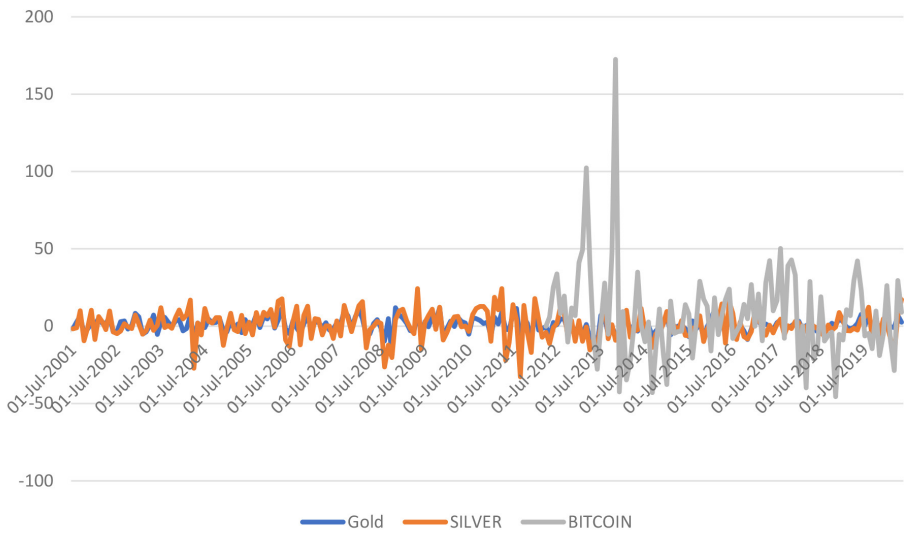

Figure 1. Return of gold, silver and Bitcoin from July 2001 to December May 2020
Source: Authors' calculation

The descriptive statistics of sample variables are detailed in Table 2. It can be seen that the gold market has a relatively higher average return and carries a lower associated dispersion as compared to the silver market. This indicates that gold is a safer and profitable investment as it is less volatile than silver. Among all the 10 ASEAN countries, Vietnam has the highest inflation rate on average, followed by Indonesia, Laos, Cambodia, Philippines, Malaysia, Thailand, Singapore and Myanmar. Similarly, Vietnam has the highest variability of data, followed by Cambodia, Laos, Indonesia, Singapore, Thailand, Philippines, Malaysia and Myanmar. Brunei appears to have the lowest inflation rate as well as variability.

From Tables 2 and 3, during the pre-crisis period, the return of gold and silver is indifferent, but the variability of return is larger for silver than gold. Top three countries with high inflation rates during the pre-crisis period are Indonesia, Laos and Vietnam. On the other hand, during the post-crisis period, the return of gold is higher than silver. Top three countries with high inflation rates during the post-crisis period are Vietnam, Indonesia and Laos. Brunei remains as the country with lowest inflation rate during both pre-crisis and post-crisis periods.

Table 2
Descriptive statistics of monthly returns of assets and CPI during the pre-crisis (July 2001–August 2008)

	Obs.	Mean	Median	S. D.	Minimum	Maximum
Panel A: Dependent Variables						
Gold	86	1.30	1.73	4.39	–9.59	11.46
Silver	86	1.34	1.51	8.42	–27.10	17.65
Bitcoin (not applicable during this period)						
Litecoin (not applicable during this period)						
Panel B: Sample Countries CPI						
Indonesia	86	9.45	7.64	3.76	3.73	18.35
Thailand	86	3.03	2.47	2.02	0.28	9.14
Philippines	86	4.52	4.11	2.05	1.94	10.54
Singapore	86	1.41	0.73	2.08	–1.10	7.57
Malaysia	86	2.35	2.07	1.48	0.68	8.52
Vietnam	86	7.55	7.23	5.69	–0.30	28.32
Myanmar	86	1.95	1.63	1.84	–2.70	8.55
Cambodia	86	6.71	4.39	7.50	–2.63	34.22
Laos	86	9.02	8.08	3.81	3.43	18.21
Brunei	86	0.33	0.70	1.38	–3.11	2.22

Table 3
Descriptive statistics of monthly returns of assets and CPI during the post-crisis period (Sept 2008–May 2020)

	Obs	Mean	Median	S. D.	Minimum	Maximum
Panel A: Dependent Variables						
Gold	141	0.52	0.30	5.04	–18.45	12.06
Silver	141	0.19	–0.27	9.09	–32.71	24.29
Bitcoin	97	7.80	5.94	29.60	–45.55	172.50
Litecoin	86	2.81	–4.48	43.10	–55.38	285.03
Panel B: Sample Countries CPI						
Indonesia	141	4.80	4.13	2.03	2.19	11.93
Thailand	141	1.34	1.26	1.82	–4.35	6.06
Philippines	141	3.29	3.07	1.82	–0.37	10.14
Singapore	141	1.63	0.68	2.13	–1.57	6.75
Malaysia	141	2.04	1.92	1.66	–2.89	8.17
Vietnam	141	6.64	4.65	6.04	0.00	27.90

(*Continued on next page*)

Table 3 (*Continued*)

	Obs	Mean	Median	S. D.	Minimum	Maximum
Myanmar	141	0.43	0.38	0.78	–2.35	3.65
Cambodia	141	3.25	2.66	3.71	–5.69	26.45
Laos	141	3.57	3.06	2.64	–2.26	9.76
Brunei	141	0.16	0.11	0.88	–1.68	2.70

Student-t EGARCH (1,1)

Table 4, Panels 1A and 1B show the student-t EGARCH (1,1) results for gold in ASEAN countries pre-crisis and post-crisis. Gold can act as a hedge against inflation during the pre-crisis period in ASEAN countries because they offer a significant positive coefficient. This is in line with Adrangi et al. (2003), Beckmann and Czudaj (2013) and Bampinas and Panagiotidis (2015) who find that gold is able to hedge inflation. Yet, when the test is carried out in different percentiles, gold does not serve as a safe haven in both pre-crisis and post-crisis periods. This is consistent with the finding of Dee et al. (2013), who used daily and monthly prices of gold and stock prices of China from October 2002 to April 2012 and concluded that gold is not a safe haven when investors face inflation risk in China mainland market.

Table 4 Panel 3 shows the hedging properties of Bitcoin against inflation in ASEAN countries. Bitcoin appears to serve as a useful hedge asset against inflation as the hedge ratio yields a significant positive result. This outcome is in line with the work by Qudah and Aloulou (2020) who find that Bitcoin is a hedge asset in most of the GCC countries (Bahrain, Kuwait, Oman, Saudi Arabia and the United Arab Emirates) and the paper by Matkovskyy and Jalan (2020) who confirm the hedging ability of Bitcoin in the U.S., U.K., EU and Japan. Qudah and Aloulou (2020) find that Bitcoin is negatively associated with inflation but unrelated to GDP and foreign trade activities between 2009 to 2017. However, our result shows that Bitcoin does not have safe haven property in all countries, except for Indonesia. During the 90% percentile of the inflation rate, Bitcoin acts as a weak haven in Indonesia.

Table 4
EGARCH estimation results between gold/silver/Bitcoin returns and inflation of ASEAN countries

	Indonesia	Thailand	Philippines	Singapore	Malaysia	Vietnam	Myanmar	Cambodia	Laos	Brunei
Panel 1A: The results of gold return during pre-crisis										
ρ_1	0.062**	0.062**	0.062**	0.064**	0.066**	0.067**	0.062**	0.062**	0.062**	0.062**
$\sum \rho_2$	0.000	0.002	0.017	1.031	0.657	0.927	–0.088	0.000	0.003	–0.219
$\sum \rho_3$	0.000	0.000	–0.019	–1.190	0,460	–2.094	0.093	0.000	0.000	0.496
$\sum \rho_4$	0.000	0.009	0.000	0.833	–3.320	2.522	0.000	0.000	0.000	–0.011
Panel 1B: The results of gold return during post-crisis										
ρ_1	0.017	0.022	0.018	0.020	0.020	0.019	0.020	0.018	0.020	0.016
$\sum \rho_2$	–0.179	0.798	–1.416	0.113	0.287	0.856	0.666	0.462	0.234	–0.944
$\sum \rho_3$	1.240	–1.061	2.666	1.335	1.019	1.232	–0.890	1.034	–0.207	1.378
$\sum \rho_4$	–0.536	–0.420	–1.644	–1.203	–1.440	–1.914	0.129	–1.705	0.678	2.215
Panel 2A: The results of silver returns during pre-crisis										
ρ_1	0.022	0.016	0.019	0.014	0.019	0.019	0.029**	0.021	0.020	0.019
$\sum \rho_2$	0.977	–1.964**	–0.181	1.275	0.879	0.473	–0.113	1.541	–1.269	0.036
$\sum \rho_3$	–2.699	0.164	–2.069	–0.932	0.620	–2.823	–1.321	–4.003	0.823	1.194
$\sum \rho_4$	2.146	–3.844**	4.584	–5.231	–4.424	4.630	2.091*	–6.982	–1.873	–10.489
Panel 2B: The results of silver returns during post-crisis										
ρ_1	0.001	0.002	0.002	0.001	0.003	0.001	0.002	0.001	0.002	0.002
$\sum \rho_2$	0.010	1.263	0.508	–0.065	–0.157	0.169	0.089	0.250	0.598	0.385
$\sum \rho_3$	–0.125	–2.045	–0.815	0.407	–0.414	0.039	0.828	–0.378	–0.213	–0.493
$\sum \rho_4$	0.746	0.382	1.122	–0.247	1.699*	0.031	–1.125	0.830	–0.481	0.442

(*Continued on next page*)

Table 3 (*Continued*)

	Indonesia	Thailand	Philippines	Singapore	Malaysia	Vietnam	Myanmar	Cambodia	Laos	Brunei
Panel 3: The results of Bitcoin returns during May 2012–May 2020										
ρ_1	0.010**	0.013*	0.009**	0.013**	0.009**	0.011**	0.009**	0.010**	0.011**	0.009*
$\sum \rho_2$	0.881***	0.601	0.326	–1.650	0.820	–1.164*	0.205	0.422	0.523	0.617
$\sum \rho_3$	–1.7808**	0.139	–0.240	0.739	0.049	1.721	–1.846	–3.117*	1.464	0.091
$\sum \rho_4$	0.624	–1.886	–2.541	0.652	–0.021	0.011**	0.009**	0.010**	0.011**	0.009*

Notes: ρ_1 represents hedge ratio, the hedge property against inflation. ρ_2, ρ_3, and ρ_4 represent the safe haven property at 90% percentile, 95% percentile, and 99% percentile of inflation rates, respectively. ***, **, * indicate statistical significance at the level of 0.01, 0.05 and 0.10, respectively.

Quantile Regression

Tables 5, 6 and 7 demonstrate the hedging potential of gold, silver, and Bitcoin, respectively, in ASEAN countries according to different quantiles of 10th, 25th, 50th, 75th and 90th of asset returns to access each asset's hedging potential from its bearish to bullish condition.

The results for hedging ability of gold against inflation in quantile regression as shown in Table 5 are partly similar to the student-t EGARCH (1,1) results as only specific quantiles of gold returns imply that gold is able to hedge against inflation. During both pre-crisis and post-crisis periods, gold can be a hedge asset in almost all ASEAN countries as long as its return is around 10% of the average value. The finding of the ability to hedge is consistent with Wang et al. (2011) who confirm an efficient hedge of gold against a high momentum of inflation. The exception happens in Brunei where gold returns need to be relatively volatile to hedge against inflation during the pre-crisis period. In the post-crisis period, gold is unable to serve as a hedge asset in Brunei. This can be explained by its already very high per capita income and its oil dominant economy (Vu, 2020).

The safe haven property of gold analysed by the quantile regression model is notably different from the student-t EGARCH (1,1) model. In the quantile regression model, gold appears to play a safe haven property in all ASEAN countries, except for Singapore in the pre-crisis period. These outcomes reflect that gold can be a haven property to investors in ASEAN countries when their purchasing power decreases. Besides, gold is a safe haven only when its prices are not volatile (returns of below the 25th quantile) in the majority of ASEAN countries with the exception of Laos and Brunei, where gold can also be a haven when its returns are highly volatile (returns of above the 75th quantile).

Next, the results of the hedging ability of silver return against inflation in ASEAN countries are presented in Table 6. The quantile regression result for silver is quite similar to gold. All ASEAN countries accept silver as a hedge asset against inflation except for Brunei during the post-crisis period. In a nutshell, silver needs to be more volatile to be a hedge asset against inflation, which is similar to the hedging ability of gold. During inflation, investments in bonds and other fixed income assets are less appealing as it could not hedge against currency depreciation, unlike commodities, which could hedge against uncertainty in the market. The demand for commodities, such as gold and silver, keeps the prices higher. This could offset the risks of inflation as appreciation in their prices could generally be higher than the rate of inflation. As a result, investments in gold and silver are a better hedge than paper assets.

Table 5
Quantile regression of gold vs. inflation rate in ASEAN countries

Panel A: Pre-crisis										
	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
	Indonesia					**Thailand**				
ρ_1	–0.51	–0.18	0.14	0.41	0.83	–1.32	–0.49	0.71	1.35	2.4
$\sum \rho_2$										
$\sum \rho_3$										–13.29
$\sum \rho_4$	7.46	7.32				11.71				-6.74
	Philippines					**Singapore**				
ρ_1	–0.9		0.38	0.96	1.75	–1.83			2.59	3.7
$\sum \rho_2$			–6.92		–9.73					–14.06
$\sum \rho_3$										–9.63
$\sum \rho_4$										–9.34
	Malaysia					**Vietnam**				
ρ_1	–1.65	-0.67	0.65	1.9	3.25	-0.51	-0.2		0.56	1.08
$\sum \rho_2$										
$\sum \rho_3$						8.68			–13.35	–19.89
$\sum \rho_4$	8.33			–12.23	–17.34	–7.65	–8.05	–11.98	–14.6	–15.38
	Myanmar					**Cambodia**				
ρ_1	–1.23	–0.54		1.32	2.82	–0.41			0.57	0.99
$\sum \rho_2$		5.61			–8.86					
$\sum \rho_3$						6.66			–14.39	–20.4
$\sum \rho_4$	13.85	11.58	7.00			8.01	7.30			–6.04

(*Continued on next page*)

Table 5 (*Continued*)

Panel A: Pre-crisis										
	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
			Laos					**Brunei**		
ρ_1	–0.58	–0.21	0.18	0.44	0.77	–0.76				0.67
$\sum \rho_2$		8.73				5.7	5.25	5.31	5.5	4.97
$\sum \rho_3$		–10.48	–10.05	–8.94	–9.8	–13.59	–13.64	–7.86	–6.26	–7.64
$\sum \rho_4$	13.31	12.74	10.74	6.4	6.28	11.39	11.38			
Panel B: Post-crisis										
	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
			Indonesia					**Thailand**		
ρ_1	–1.14	–0.59		0.83	1.45	–1.59	–0.77		0.92	1.6
$\sum \rho_2$	3.72					–12.25	–8.52			
$\sum \rho_3$	–9.03	6.74				16.99	10.34			
$\sum \rho_4$	23.71				–7.82	9.75	7.69			–9.44
			Philippines					**Singapore**		
ρ_1	–1.74	–0.8		1.23	1.98	–1.61	–0.56		1.16	1.78
$\sum \rho_2$	6.21		–2.99	–6.82	–11.35					
$\sum \rho_3$					5.26					
$\sum \rho_4$	23.99	8.32			–9.19	23.81	16.49		–7.81	–9.32
			Malaysia					**Vietnam**		
ρ_1	–2.42	–1.09		1.23	2.38	–0.9	–0.42		0.57	0.95
$\sum \rho_2$	6.79									–7.78
$\sum \rho_3$										
$\sum \rho_4$	24.6	8.33			–13.16	24.35	18.73		–9.28	–11.26

(*Continued on next page*)

Table 5 (*Continued*)

Panel B: Post-crisis										
	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
	Myanmar					**Cambodia**				
ρ_1	–3.1	–2.12		1.14	1.79	–1.43	–0.81		0.89	1.5
$\sum \rho_2$										
$\sum \rho_3$			5.13			15.7		8.18		
$\sum \rho_4$	13.43				–5.89	29.06	17.21		–16.93	–32.22
	Laos					**Brunei**				
ρ_1	–1.63	–0.74		0.68	1.59					
$\sum \rho_2$						–3.24				5.85
$\sum \rho_3$	11.61					5.39	5.6	6.05		
$\sum \rho_4$			–6.71	–8.65	–11.72	–20.16	–20.95	–23.27	–25.54	–30.32

Notes: ρ_1 represents hedge ratio, the hedge property against inflation. ρ_2, ρ_3 and ρ_4 represent the safe haven property at 90% percentile, 95% percentile and 99% percentile of inflation rates, respectively. Only significant coefficients are presented for the ease to read.

Table 6
Quantile regression of silver vs. inflation rate in ASEAN countries

Panel A: Pre-crisis										
	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
	Indonesia					**Thailand**				
ρ_1	–0.83	–0.32		0.77	1.15	–2.62	–1.02	1.05	2.48	3.47
$\sum \rho_2$										

(*Continued on next page*)

Table 6 (*Continued*)

Panel A: Pre-crisis										
	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
	Indonesia					**Thailand**				
$\sum \rho_3$	14.48				–11.17	–16.25	–23.71		–20.99	–22.86
$\sum \rho_4$	9.84	9.64				34.87	30.75			
	Philippines					**Singapore**				
ρ_1	–2.16	–0.75		1.75	2.8	–3.2			3.2	5.64
$\sum \rho_2$	13.57				–12					–21.06
$\sum \rho_3$					–10.96			–14.31	–15.95	–18.36
$\sum \rho_4$	–21.34	–24.61	–28.28	–31.3	–32.85					
	Malaysia					**Vietnam**				
ρ_1	–3.66	–1.49		2.55	5.26	–1.2	–0.59	0.32	1.04	1.73
$\sum \rho_2$			–11.9							–11.04
$\sum \rho_3$						20.97	17.43	–15.64	–23.43	–32.17
$\sum \rho_4$	28.19	28.15		–24.15	–34.4	–22.62	–24.52	–28.53	–30.97	–32.02
	Myanmar					**Cambodia**				
ρ_1	–3.24	–2.33		2.42	3.77	–1.28	–0.5		0.96	1.69
$\sum \rho_2$	11.46	8.66		–13.5	–9.66					–13.64
$\sum \rho_3$						30.87	13.97	–15.45	–24.88	–33.01
$\sum \rho_4$	26.26	23.25								–11.03
	Laos					**Brunei**				
ρ_1	–1.34	–0.29		0.86	1.41					1.17
$\sum \rho_2$	15.81			–11.66	–14.29					8.19

(*Continued on next page*)

Table 6 (*Continued*)

Panel A: Pre-crisis										
	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
	Laos					**Brunei**				
$\sum \rho_3$						–29.4	–29.4			–8.89
$\sum \rho_4$						26.35	26.31			
Panel B: Post-crisis										
	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
	Indonesia					**Thailand**				
ρ_1	–2.33	–1.09	–0.1	1.33	2.74	–2.56	–2.03		1.74	3.11
$\sum \rho_2$	9.67					–22.42	–12.33			
$\sum \rho_3$							16.62			
$\sum \rho_4$			–16.38	–24.3	–33.18	14.69			-28.8	-32.17
	Philippines					**Singapore**				
ρ_1	–3.71	–1.55	–0.03	1.86	3.91	–3.45	–1.98		2.12	3.65
$\sum \rho_2$				–13.44	–24.12					
$\sum \rho_3$				8.77						
$\sum \rho_4$			–15.63	–26.38	–34.78				–18.41	–20.83
	Malaysia					**Vietnam**				
ρ_1	–4.71	–2.18		1.72	4.09	–1.65	-0.8		0.84	2.12
$\sum \rho_2$	13.98	8.44								
$\sum \rho_3$										–19.55
$\sum \rho_4$	11.94			–22.71	–37.16	29.59		–16.3	–30.84	–38.94

(*Continued on next page*)

Table 6 (*Continued*)

Panel B: Post-crisis										
	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
	Myanmar					**Cambodia**				
ρ_1	–5.96	–3.95	–2.31		1.69	–2.38	–1.46		1.21	3.05
$\sum \rho_2$					21.91	–16.8				–14.24
$\sum \rho_3$		12.3	10.79	10.32	–7.4	35.98	25.04	15.51		
$\sum \rho_4$	15.78			–16.79	–22.01	31.54	13.95	–13.87	–45.33	–85.03
	Laos					**Brunei**				
ρ_1	–2.81	–1.56		1.31	2.71					
$\sum \rho_2$						–18.67				
$\sum \rho_3$							11.2			
$\sum \rho_4$		–11.31	–17.58	–35.75	–47.81		–24.38	–27.6	–30.27	–37.43

Notes: ρ_1 represents hedge ratio, the hedge property against inflation. ρ_2, ρ_3 and ρ_4 and represent the safe haven property at 90% percentile, 95% percentile, and 99% percentile of inflation rates, respectively. Only significant coefficients are presented for the ease to read.

Table 7
Quantile regression of Bitcoin vs. inflation rate in ASEAN countries

	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
	Indonesia					**Thailand**				
ρ_1	–5.062	–2.211		4.767	9.773	–9.888	–4.62		4.898	13.333
$\sum \rho_2$					93.677	34.8				66.691
$\sum \rho_3$					–145.658					–70.586
$\sum \rho_4$				–46.075	–46.965					–37.52

(*Continued on next page*)

Table 7 (*Continued*)

	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
	Philippines					**Singapore**				
ρ_1	–9.189	–2.788		9.797	15.696	–11.015			13.71	24.087
$\sum \rho_2$				–36.531	–41.804	34.416			–37.645	–62.489
$\sum \rho_3$					–66.87	27.003				
$\sum \rho_4$										
	Malaysia					**Vietnam**				
ρ_1	–9.973	–4.279		8.758	15.313	–5.876	–2.402	0.344	6.102	13.149
$\sum \rho_2$			36.051			30.955				–43.006
$\sum \rho_3$	40.964				–31.934					–27.64
$\sum \rho_4$			–30.611	-43.295	–47.451					–33.076
	Myanmar					**Cambodia**				
ρ_1	–10.89			15.248	22.474	–8.514	–2.753	2.712	8.468	18.613
$\sum \rho_2$			24.426						–29.032	–49.831
$\sum \rho_3$					–32.354					–39.795
$\sum \rho_4$				–69.43	–83.288					
	Laos					**Brunei**				
ρ_1	–6.148	–3.203	1.458	7.247	13.386				–15.244	–19.125
$\sum \rho_2$						–40.214				54.089
$\sum \rho_3$				143.683	121.915					
$\sum \rho_4$				–175.632	–178.632	37.386	40.754			

Notes: ρ_1 represents hedge ratio, the hedge property against inflation. ρ_2, ρ_3 and ρ_4 represent the safe haven property at 90% percentile, 95% percentile, and 99% percentile of inflation rates, respectively. Only significant coefficients are presented for the ease to read.

Silver serves as a haven asset in all ASEAN countries, except for Singapore during pre-crisis period and Laos during post-crisis period. Moreover, most of the significant results are shown at the silver returns of below the 10th quantile. Thus, silver return needs to be more stable to be a haven asset against inflation.

The succeeding asset to be investigated is Bitcoin. Bitcoin can be a hedge asset against inflation in all ASEAN countries except for Brunei as shown in Table 7. Among the 10 countries, only Cambodia can hedge over inflation when Bitcoin's return is above the 50th quantile. Bitcoin returns must be at least above the 75th quantile to hedge against inflation in the remaining nations.

Besides, Bitcoin can serve as a safe haven asset against inflation in all ASEAN countries except for Cambodia. The significant negative coefficient from the sample of this country denotes that investing in Bitcoin during high inflation period in Cambodia will cause losses. Aside from this, although the National Bank of Cambodia introduces a government-backed cryptocurrency in 2017 for internal use, the citizens are not allowed to perform transactions using cryptocurrency (The Law Library of Congress, 2018). This might be a reason why Bitcoin does not play as a haven asset in this country.

Hedging Ability of Gold, Silver and Bitcoin on Overall Data

Table 8 Panel A presents the EGARCH result. By using the student-t EGARCH (1,1) model, the analysis concludes that gold and Bitcoin can hedge against inflation in ASEAN countries, but silver is unable to do so. Regarding the safe haven property, the results are mixed as some show the significant safe haven property while the majority of them are insignificant.

Table 8
EGARCH results for July 2001–May 2020

Panel A						
Asset countries	Gold		Silver		Bitcoin	
	Hedge	Safe haven	Hedge	Safe haven	Hedge	Safe haven
Indonesia	Yes				Yes	90%
Thailand	Yes				Yes	
Philippines	Yes	95%			Yes	
Singapore	Yes				Yes	
Malaysia	Yes	95%			Yes	
Vietnam	Yes				Yes	
Myanmar	Yes	99%			Yes	

(*Continued on next page*)

Table 8 (*Continued*)

Panel A						
Asset countries	Gold		Silver		Bitcoin	
	Hedge	Safe haven	Hedge	Safe haven	Hedge	Safe haven
Cambodia	Yes			95%	Yes	
Laos	Yes				Yes	
Brunei	Yes				Yes	
Panel B						
Asset countries	Gold		Silver		Litecoin	
	Hedge	Safe haven	Hedge	Safe haven	Hedge	Safe haven
Indonesia	Yes					
Thailand	Yes					
Philippines	Yes					
Singapore	Yes					
Malaysia	Yes					
Vietnam	Yes					
Myanmar	Yes					
Cambodia	Yes					
Laos	Yes					
Brunei	Yes					

Notes: A "yes" indicates the asset is able to hedge against inflation; a "blank" indicates the asset is unable to do that. 90%, 95%, and 99% are quantiles of inflation rates, at which the asset is a safe haven asset against inflation. Panel A and B present the results of the main test and the robustness test, respectively.

Table 9 Panel A summarises the quantile regression results on gold, silver, and Bitcoin's hedging ability against inflation in ASEAN countries. It is a pivotal point to note that all three assets tend to be hedge and safe haven assets in the sample countries. This differs from student-t EGARCH (1,1) results which only show the hedging property of gold and Bitcoin. In addition, although gold, silver and Bitcoin need to have volatile returns to be hedge assets in most of the cases, they will be haven assets as long as the returns remain stable. Moreover, comparing the quantiles of the returns to achieve the hedging or safe haven property, it can be seen that the values are not the same for all three assets. Hence, financial hedging capabilities of gold, silver and Bitcoin do not perform equally strong in bearish and bullish conditions.

Table 9
Quantile regression results for July 2001–May 2020

Panel A:

Countries	Gold			Silver			Bitcoin		
	Hedge	Safe haven		Hedge	Safe haven		Hedge	Safe haven	
	Quantile	Inflation	Quantile	Quantile	Inflation	Quantile	Quantile	Inflation	Quantile
Indonesia	50th–90th	90%	10th	50th–90th	90% 99%	10th 10th	75th–90th	90%	90th
Thailand	75th–90th	90% 99%	10th 10th	75th–90th	99%	10th–25th	75th–90th	90%	10th, 90th
Philippines	50th–90th	90%	10th 10th	75th–90th	90%	10th–25th	75th–90th	90%	10th
Singapore	50th–90th	99%	10th	50th–90th	99%	10th–25th	75th–90th	90% 95%	10th 10th
Malaysia	75th–90th	90% 99%	10th 10th	75th–90th	90% 95%	10th 90th	75th–90th	90% 95%	50th 10th
Vietnam	50th–90th	90% 99%	10th 10th	75th–90th	95%	25th	75th–90th	90%	10th
Myanmar	50th–90th	90% 99%	10th 10th–25th	75th–90th	90% 99%	10th–25th 10th	75th–90th	90%	50th
Cambodia	75th–90th	90% 99%	10th 10th	75th–90th	90% 99%	10th 10th	50th–90th	No	
Laos	50th–90th	90%	10th–25th	75th–90th	90% 99%	10th–25th 10th	75th–90th	95% 99%	10th, 75th–90th
Brunei	No	90%	75th–90th	75th–90th	90%	75th–90th	No	90% 99%	90th, 10th–25th

Table 9 (*Continued*)

Panel B:

Countries	Gold			Silver			Litecoin		
	Hedge	Safe haven		Hedge	Safe haven		Hedge	Safe haven	
	Quantile	Inflation	Quantile	Quantile	Inflation	Quantile	Quantile	Inflation	Quantile
Indonesia	50th– 90th	90%	10th–25th	75th–90th	90% 99%	10th–25th 10th	75th - 90th	95%	all
Thailand	50th–90th	90%	10th–25th	75th–90th	90% 99%	10th–25th 10th–50th	No		no
Philippines	50th–90th	90%	10th	75th–90th	90%	10th	75th–90th		no
Singapore	50th–90th	No		50th–90th	95% 99%	75th 10th–50th	No	90% 95%	90th 10th–25th
Malaysia	50th–90th	90%	10th–25th	75th–90th	95%	10th	75th–90th	99%	10th–25th
Vietnam	50th–90th	90%	10th	50th–90th	90%	10th	75th–90th	99%	All
Myanmar	50th–90th	99%	10th	50th–90th	90%	10th	75th–90th	95% 99%	10th–25th 10th
Cambodia	50th–90th	90% 95% 99%	10th 10th 10th	75th–90th	90% 99%	10th–25th 10th–25th	75th–90th	90%	10th
Laos	50th–90th	90%	10th–25th	75th–90th	90%	10th–25th	75th–90th	90% 99%	10th all
Brunei	No	90%	75th–90th	No	90%	75th–90th	No	90%	90th

Notes: "No" means the relative asset is unable to serve as a hedge/safe haven asset against inflation in that country. 90%, 95%, and 99% are quantiles of inflation rates, at which the relative asset is able to serve as a hedge/safe haven asset against inflation. 10th, 25th, 50th, 75th, and 90th are quantiles of asset returns, at which the relative asset is able to serves as a hedge or safe haven asset. Panel A and B present the results of the main test and the robustness test, respectively.

Lastly, an unexpected outcome is the appearance of a significant negative coefficient in both the EGARCH result and the quantile regression result. In quantile regression, there are two conditions where the negative coefficient is consistent to appear in the hedging ability of gold, silver, and Bitcoin against inflation in ASEAN. This is in line with the result in paper by Hoang et al. (2016), who employ the nonlinear autoregressive distributed lags model to examine the relationship between gold and the CPI of some G7 and East Asia countries. They find a significant negative coefficient between the two variables only for Japan.

Comparisons of The Hedging Ability of Gold, Silver and Bitcoin

In essence, all three investment assets seem to play a hedging role against inflation risks of the top 3 ASEAN countries, namely Vietnam, Indonesia and Laos. As for the role of safe haven property, only Bitcoin is relevant to curb extremely high inflation rate in Indonesia. During the pre-crisis period, gold can hedge against inflation risks of these three nations at the average to bullish market conditions, while gold returns under the bullish market condition are only able to hedge against the inflation risks during the post-crisis period. Generally, silver and Bitcoin could be used as hedging assets at their bullish market conditions in these top three high inflation countries. In general, gold could be a safe haven in their bearish condition in these three countries under both economic conditions (pre-crisis and post-crisis) except for Laos, which is associated with higher rates of return of gold. Similarly, silver could be a safe haven at its bearish condition for all ASEAN countries, except for Laos, in which silver is irrelevant to curb inflation risk. On the other hand, Bitcoin could be a safe haven for Indonesia and Laos in bullish conditions but in bearish conditions for Vietnam. This indicates that these three assets are playing roles as hedge and safe haven assets to keep purchasing power intact for countries with relatively high inflation risks.

Robustness Test

The robustness of this paper's results is tested in two ways: (1) the data frequency for gold and silver is changed to quarterly, and (2) Bitcoin is replaced with Litecoin. While they vary in few fundamentals, Litecoins are heavily based on Bitcoins (Spurr & Ausloos, 2020). Both cryptocurrencies employ the proof-of-work consensus mechanism and use the same underlying blockchain and verification method. Many researchers also consider Litecoin as an altcoin (for example, Spurr & Ausloos, 2020; Sarkodie et al., 2021). As our research focuses more on the bigger picture of the hedging ability of cryptocurrencies rather than the specifics of the mechanics of cryptocurrencies, we believe that using Litecoin as an alternative is appropriate for the purpose of this research.

Table 5 Panel B shows the results from student-t EGARCH (1,1) which indicate that gold and silver results are reasonably robust as data frequency changes have no impact on gold and silver hedging ability. However, Litecoin does not produce the same effect as Bitcoin, as Litecoin is unable to hedge against inflation in ASEAN countries. This may be due to the small market share of Litecoin, compared to Bitcoin (less than 3% and 80%, respectively) (Ciaian et al., 2018). It would lead to less liquidity and less efficiency of Litecoin in comparison with Bitcoin (Jana et al., 2017).

The next robustness test is performed using quantile regression. Table 6 Panel B reports the results which show minor differences with the main result in Panel A. Firstly, gold fails to show its hedging ability in Singapore and silver is not a hedge asset in Brunei when the quarterly data was used, although they are able to hedge against inflation in the main results. Secondly, when Litecoin replaces Bitcoin, the difference in the results happens in Thailand, Singapore and Cambodia as Litecoin is unable to be a haven asset in Thailand and Philippines while Bitcoin is not a safe haven asset in Cambodia.

Overall, the results from the robustness test are in line with the primary results of the paper with minor variations. Hoang et al. (2016) also found some differences in results when data frequency is changed.

CONCLUSION

This paper investigates the hedging ability of gold, silver, and Bitcoin against inflation in ASEAN countries from July 2001–May 2020, separating the period to before and after GFC to understand whether hedging ability changes after the crisis period. Student-t EGARCH (1,1) and quantile regression analysis are used. We also consider the safe haven property of the assets. Even though the results do not change much from before to after GFC period by using the student-t EGARCH (1,1) but quantile regression models show that both gold (at a lower quantile) and silver (at a higher quantile) are safe haven assets in majority of ASEAN countries. Hence, using quantile regression analysis complement the findings from the EGARCH model and provide more elaborative results on the hedging and safe haven ability of gold and silver during different economic situations.

Regarding the hedge property, the empirical evidence suggests that only Bitcoin is a hedge asset in EGARCH model's results while in the quantile regression result, the returns of all three assets show significant positive relationship with inflation, except for Brunei. It indicates that when the inflation rate increases, returns of assets also increase to compensate for the loss in investors' purchasing

power. Besides, investors need to be cautious as the average return of gold, silver, and Bitcoin has to be highly volatile to hedge against inflation.

In terms of safe haven property, the quantile regression model shows that the assets are able to serve as safe haven assets in most of ASEAN countries. Before the GFC, gold and silver were not assets in Singapore, but they are after the GFC. A robustness check is also carried out. Results for gold and silver are relatively robust as their hedging and safe haven property remains while Bitcoin's hedging ability is not consistent with its proxy, Litecoin, in Thailand, Brunei and Philippines.

Thus, this paper provides evidence that hedging potential of gold, silver and Bitcoin against reducing purchasing power of money is not as straightforward. Using quantile regression analysis could complement the findings from the EGARCH model and provide more elaborative results on the hedging and safe haven ability of these three assets in this study. For instance, although there is no evidence that silver is a hedge asset against inflation risk in the ASEAN countries using the EGARCH model, it could be so when examining using the quantile regression approach. Hence, the results of our study indicate the usefulness of both methods in examining the role played in hedging and safe haven against the inflation risks, further strengthening the methodology aspect for similar research in future.

This paper provides useful information to investors in managing their portfolios against the adverse conditions of assets to be hedged in the ASEAN countries as well as under different economic conditions. The hedging potential and safe haven property of the investment assets, namely gold, silver and Bitcoin, are not uniformly strong but are dependent on the state of the market conditions of the assets as well as different economic scenarios. It is recommended that the investors could have a mix of these three investment assets in their portfolio to hedge against the purchasing power risk. The use of a mixed investment portfolio of gold, silver and Bitcoin is important to curb inflation risks especially in countries that suffer high inflation rate, such as, Vietnam, Indonesia and Laos (in this study), and similar countries in the future. Even though Bitcoin is effective in curbing inflation risks, it is not recognised as a legal tender in most countries and the investors should be cautious of the risks associated with Bitcoin usage. The few countries where Bitcoins are banned will have a limited impact on our findings. For example, Thailand banned cryptocurrencies in March 2022, which is after the research time frame and hence provides no impact on the research outcome. Indonesia has banned the use of cryptocurrencies since 2018. It provides us with strong motives for the importance of accepting Bitcoins as our results show that

Bitcoin is relevant in curbing high inflation in Indonesia. The ban on Bitcoin does not have a significant impact on ASEAN countries as a group and its impact on Indonesia is enlightening as it provides traction on the benefits of using Bitcoin.

Since gold is relatively more effective in curbing inflation risks under different economic conditions and in view of the riskiness of Bitcoin, it is recommended that the investors should hold a higher proportion of investment in gold rather than Bitcoin, to gain diversified benefits. In a nutshell, we strongly recommend investors to hold more gold since in this study, we have examined that gold could be a safe haven asset during the bearish condition for countries which suffer high inflation risks under both economic conditions (pre-crisis and post-crisis). In addition, gold serves as a hedge and can keep investors' purchasing power intact during bullish conditions.

As Bitcoin can be a hedge asset and safe haven in ASEAN countries, it is recommended that the policy-makers, institutional investors and bankers should consider its legitimate status and could play a role in managing its price volatility.

As our paper concerns the use of gold, silver and Bitcoin as hedging and safe haven assets against inflation risks in the ASEAN region, future research could consider the stock market or foreign exchange risks hedging ability of the investment assets in the same region of which study is still lacking.

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