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Reactions of Bitcoin and Gold to Categorical Financial Stress: New Evidence from Quantile Estimation

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Abstract: This study examines the responses of Bitcoin and gold to categorical financial stress and compares the responses before and during the COVID-19 pandemic. The OLS and Quantile regression estimations revealed that gold and Bitcoin exhibit similar reactions in full and pre COVID-19 samples. Gold and Bitcoin respond positively to equity valuation and safe assets categories of financial stress. Gold also reacts positively to the credit category of financial stress suggesting that widening credit spreads are bullish for gold. Bitcoin and gold respond differently in the funding category, and there is no significant reaction to volatility-related financial stress. Overall, the effects of categorical financial stress on gold and Bitcoin are similar in the full sample and sub-sample before COVID-19, but the effects are heterogeneous. Interestingly, during the pandemic, the reactions of gold and Bitcoin to categorical financial stress have changed. Gold only reacts positively to the credit category of financial stress across quantiles. Bitcoin reacts positively to credit and safe asset categories but not across all quantiles. The findings offer insights into the effects of several systemic financial stress on the value of safe haven assets.

Keywords: gold; Bitcoin; financial stress; COVID-19

1. Introduction

In general, a safe haven asset is a financial instrument that sustains or increases in value during economic crises. Such assets are uncorrelated to conventional financial assets and can potentially appreciate in value during periods of a financial market crash (Tronzano 2020). Safe haven assets provide a hedge against risk and tend to outperform most financial asset markets. Following the global financial crisis of 2007–2009, the link between safe haven assets and financial stress has remained a focus for investors and policymakers. Additionally, the current COVID-19 pandemic has caused a paradigm shift in the financial markets, prompting investors to reallocate their investments from high-risk to low-risk assets. Gold and Bitcoin prices also reached new highs in 2020.

Monin (2019) developed the Office of Financial Research Financial Stress Index (OFR FSI), incorporating five categories of financial stress indicators, namely credit, equity valuation, funding, safe assets, and volatility. Such novel sub-indices measure various categories of systemic financial stress. The importance of understanding the nature of financial asset response to the occurrence of systemic crises has motivated us to investigate the reactions of safe haven asset classes to different categories of financial stress indicators. Considerations and understanding of the different financial stress categories and how they relate to safe haven asset prices can help investors and policymakers reduce the probability of financial stress and its ramifications. Furthermore, several studies found the safe haven role of gold during market turmoil for oil price risk, equities, and currencies (Akhtaruzzaman et al. 2021; Baur and McDermott 2010; Chemkha et al. 2021; Hood and Malik 2013; Jareño et al. 2020; Wang and Lee 2022). Similarly, some other studies also support the role of cryptocurrencies in times of market stress (Chemkha et al. 2021; Disli et al. 2021;

Jareño et al. 2020; Shahzad et al. 2019). Therefore, it would be insightful to examine how these two safe haven assets react to financial stress categories.

A growing literature on the impacts of financial stress on gold and Bitcoin has shown that these asset classes react to financial stress, and they also act as safe haven assets (Bouri et al. 2018; Das et al. 2018; Kocaarslan et al. 2019). For example, Miyazaki (2019) found that gold returns respond asymmetrically to financial stress; the responses are negative and positive in lower quantiles and upper quantiles, respectively. Jareño et al. (2020) documented that bitcoin returns respond negatively in the lower and upper quantiles during volatile periods. Zhang and Wang (2021) investigated the reactions of Bitcoin and gold to the U.S. FSI and China FSI, and they found that gold and bitcoin react differently to changes in financial stress in the United States and China. The evidence shows the safe haven qualities of Bitcoin and the hedging qualities of gold for FSI. To our best knowledge, a comprehensive investigation into the responses of gold and Bitcoin to categorical financial stress has yet to be examined. Jareño et al. (2020) found the quantile dependent effects of financial stress on bitcoin. Similarly, Bouoiyour et al. (2018) discussed the sensitivity of financial uncertainties to gold, which is subject to different states of the gold market, such as bearish, normal, or bullish, and they also highlighted that hedge and safe haven roles are mainly dependent on gold market conditions. Therefore, the current study also extends the empirical findings by employing categorical financial stress under the quantile regression framework with bearish, normal, and bullish market states. Such an investigation will provide an understanding of the response of gold and Bitcoin to various categories of financial stress and the safe haven properties of the asset classes. Therefore, this study aims to examine how gold and Bitcoin markets react to the disturbances in the global financial markets, as measured by categorical financial stress indicators, in different conditions of gold and cryptocurrency markets.

The remaining paper is organized as follows: Section 2 presents the dataset and discusses the empirical models. The following section presents and discusses empirical results. The final section concludes the study with practical implications.

2. Empirical Methodology

2.1. Dataset and Descriptive Statistics

We consider the weekly frequency data of sub-FSIs, gold price, and bitcoin price and the sample cover period from July 2010 to November 2020. Researchers prefer the weekly for the following reasons. First, weekly data is utilized over daily data since the market may take some time to evaluate the implications of changes in economic variables and global risk factors on asset price. Additionally, it considerably minimizes the concerns of nonsynchronous trading bias and too much noise associated with higher frequency data for less frequently traded companies. Third, as compared to monthly data, weekly frequencies give a larger number of observations, resulting in more accurate conclusions.

Data related to categorical financial stress are extracted from the website of the Office of Financial Research (https://www.financialresearch.gov/financial-stress-index, accessed on 1 January 2021). Gold and Bitcoin data are obtained from World Council (London Est. Time) and Bloomberg, respectively. We employ the first difference in the data series, and they are stationary in their first difference form. The normality test results of variables are reported in Table 1, which indicate non-normality in distribution. Therefore, the use of quantile estimation, which is a robust alternative to the least-squares regression, will provide a better picture for robust inferences when conditions of linear regression are not fulfilled. Phillips–Perron (PP) and adjusted Dickey–Fuller (ADF) unit root tests also indicate that the series follows the stationary hypothesis. Thus, OLS and quantile regression could be estimated without error-correction adjustment.

Table 1. Descriptive Statistics and Unit-Roots Test Results.

	CR	EV	SA	FUND	VOLA	GOLD	BITCOIN
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std. Dev.	0.068	0.065	0.025	0.172	0.740	0.181	0.043
Skewness	−0.547	−0.277	0.055	−0.610	−0.236	−0.770	0.142
Kurtosis	5.440	6.878	4.829	13.632	23.668	7.314	26.277
Jarque-Bera	161.19 ***	345.98 ***	75.69 ***	2581.62 ***	9634.27 ***	472.89 ***	12,215.62 ***
Phillips-Perron (PP) Unit Root	−147.30 ***	−283.22 ***	−269.98 ***	−182.33 ***	−138.92 ***	−149.41 ***	−270.03 ***
Adjusted Dickey–Fuller (ADF) Unit Root	−10.56 ***	−9.33 ***	−9.14 ***	−9.12 ***	−9.79 ***	−9.85 ***	−11.97 ***

CR = credit, EV = equity-valuation, FUND = funding, SA = safe assets, and VOLA = volatility. *** denotes statistical significance at 1% level.

2.2. Empirical Models

Our aim is to examine the effects of financial stress on the gold and Bitcoin markets. Henceforth, we present the baseline with OLS.

$$Y_{i,t} = \alpha_i + \beta_{1,i}CR_t + \beta_{2,i}EV_t + \beta_{3,i}FUND_t + \beta_{4,i}SA_t + \beta_{4,i}VOLA_t + \varepsilon_{i,t} \tag{1}$$

Y is the vector of returns of safe haven assets i such as gold and Bitcoin. CR, EV, FUND, SA, and VOLA are financial stress categories related to credit, equity valuation, funding, safe haven assets, and volatility, respectively. Then, we follow the quantile regression approach of Koenker and Bassett (1978), Koenker and Hallock (2001), and re-formulated Equation (1) as below. This regression captures the picture of the conditional distribution and allows for the observation of asymmetric linear dependency through several distribution quantities (Mensi et al. 2014; Demiralay 2019; Hoque et al. 2021).

$$Q(Y_{i,t}) = \alpha_i + \beta_{1,i}(\tau)CR_t + \beta_{2,i}(\tau)EV_t + \beta_{3,i}(\tau)FUND_t + \beta_{4,i}(\tau)SA_t + \beta_{4,i}(\tau)VOLA_t + \varepsilon_{i,t}(\tau) \tag{2}$$

where $0 < \tau < 1$, τ-th conditional quantile of Y_i and $\beta(\tau)$ is the model parameter to be estimated in the QR model. As the return structures are dependent on some external factors (Mensi et al. 2014; Demiralay 2019; Hoque et al. 2021), in this study, we consider it the subject of financial stress. It can be (1) constant if the $\beta(\tau)$ coefficients do not vary across quantiles; (2) monotonically declining (increasing) if the $\beta(\tau)$ coefficients decline (rise) across quantiles; and (3) symmetric (asymmetric) if the $\beta(\tau)$ coefficients are the same (different) for low and high quantiles. In this investigation, we evaluate the quantile regression equations at 0.10, 0.25, 0.50, 0.75, and 0.90. Following Hoque et al. (2021), this study considers quantiles 10% and 25% as bearish conditions and quantile 50% as normal conditions. Quantiles of 75% and 90% are categorized as bullish conditions. Standard errors are determined using Buchinsky's (1995) bootstrapping pairings. As a result, we believe that the errors evaluated with this approach are asymptotically effective under heteroscedasticity and misspecification because this method includes drawing pairs with replacements from the sample with equal probability (Chevapatrakul 2015).

3. Empirical Discussion

3.1. OLS Estimation

First, this study presents the results of OLS estimation in Table 2. In the full sample, we observe that gold and Bitcoin react positively to financial stress categories such as equity valuation and safe assets. These findings suggest the existence of safe haven properties in gold and Bitcoin for equity valuation and safe assets. Gold also reacts positively to the credit category of financial stress and, therefore, could be a safe haven for this category of financial market uncertainty. On the role of the safe haven, our results are supported by

the findings of Das et al. (2019). However, the current findings differ significantly from those of Zhang and Wang (2021), who experimentally demonstrated how gold had lost its safe heaven class for US and Chinese FSI. We also note that gold and Bitcoin respond differently to the funding category of financial stress, and there is no significant reaction to volatility-related financial stress. Financial stress related to the volatility category captures the implied and realized volatility of several financial asset markets, and the insignificant results indicate that gold and Bitcoin prices are uncorrelated to the prices of other financial asset markets. Such a finding reaffirms the hedging and diversification properties of gold and Bitcoin. Bitcoin can act as a diversifier of risk related to volatility-related financial stress for gold investments. On the hedging and diversification of gold and Bitcoin, our findings are related to those of Zhang and Wang (2021). Furthermore, the overall significant positive effect of categorical financial stress on gold and bitcoin is not surprising, given that financial market uncertainty and increased systemic risks have prompted investors to respond by adjusting their investment with safe haven assets. Similar patterns of responses to FSIs were observed before the COVID-19 outbreak.

Table 2. OLS-Estimation.

Variable	C	CR	EV	SA	FUND	VOLA	R-Squared	F-Statistic
Panel A: Full-Sample: Jul-2010 to Nov-2020								
GOLD	0.00 (−0.01)	1.867 (15.47) ***	0.931 (11.1) ***	0.915 (3.77) ***	−0.229 (−4.99) ***	−0.003 (−0.57)	0.674	221.64 ***
BITCOIN	0.00 (−0.03)	−0.009 (−0.24)	0.094 (3.63) ***	0.925 (12.26) ***	0.023 (1.97) **	0.002 (1.23)	0.437	83.10 ***
Panel B: Before COVID-19: Jul-2010 to Feb-2020								
GOLD	−0.0000 (−0.0081)	1.873 (14.68) ***	0.940 (10.89) ***	0.940 (3.68) ***	−0.236511 (−4.951) ***	−0.003 (−0.49)	0.673	204.5 ***
BITCOIN	−0.000 (−0.002)	−0.019 (−0.49)	0.0907 (3.37) ***	0.938 (11.81) ***	0.025 (1.72)	0.002 (1.24)	0.433	75.71 ***
Panel C: During COVID-19: Mar-2020 to Nov-2020								
GOLD	0.0005 (0.060)	1.601 (5.286) ***	0.268 (0.607)	0.361 (0.520)	0.157 (0.822)	−0.020 (−1.13)	0.744	20.36 ***
BITCOIN	−0.000 (−0.006)	0.173 (2.198) ***	0.402 (3.50) ***	0.554 (3.07) ***	−0.037 (−0.76)	−0.001 (−0.333)	0.670	14.24 ***

Note: This table reports the estimated results of Equation (1). CR = credit, EV = equity-valuation, FUND = funding, SA = safe assets, and VOLA = volatility. T-statistic are presented in parenthesis. *, **, and *** denotes statistical significance at 10%, 5% and 1% level, respectively.

However, during the COVID-19 pandemic, gold only reacted positively to the credit category of financial stress. This finding strongly suggests that gold has strong safe haven properties for credit-related financial market stress. As the findings show, when credit market uncertainty arises, investors are likely to prefer low risk and exhibit flight to safety behavior (McCauley and McGuire 2009). Additionally, the insignificant response to other categories of financial stress infers the existence of hedging properties for those categories of financial stress. Furthermore, Bitcoin showed positive responses to credit, equity valuation, and safe asset-related financial stress during the COVID-19 period. These findings are slightly contradictory to those of Disli et al. (2021), as gold and cryptocurrency did not exhibit a safe haven for traditional, sustainable, and Islamic investors during the COVID-19 pandemic crisis. Overall, the financial stress category and time-dependent responses of gold and Bitcoin interestingly indicate that the role of gold and bitcoin for global financial systemic risk could be different depending on the financial stress category and time. Different responses to different categories of financial stress are supported by Bouoiyour et al. (2018), as they presented evidence that gold price responds differently to various types of uncertainties.

3.2. Quantile Estimations

We present the results of quantile regression in Tables 3 and 4. We also demonstrate the quantile coefficients of the full sample in Figures 1 and 2, which highlight that the degree of coefficients of FSI categories varies across the quantiles.

Table 3. QR-Estimation of GOLD.

Variable	C	CR	EV	SA	FUND	VOLA	Pseudo R-Squared	Adjusted R-Squared	Slope-Equity	Symmetric
				Panel A: Full-Sample: Jul-2010 to Nov-2020						
τ = 0.10	−0.103 (−15.68) **	1.764 (7.83) ***	1.055 (7.85) ***	1.451 (4.99) ***	−0.241 (−2.94) **	−0.008 (−0.81)	0.4805	0.4756		
τ = 0.25	−0.048 (−9.69) ***	1.799 (12.12) ***	0.916 (9.95) ***	1.257 (3.99) ***	−0.241 (−4.80) ***	−0.004 (−0.98)	0.4721	0.4672		
τ = 0.50	−0.002 (−0.48)	1.700 (12.79) ***	0.910 (8.26) ***	0.980 (4.07) ***	−0.171 (−3.95) ***	0.000 (−0.05)	0.4558	0.4507	68.79 ***	35.23
τ = 0.75	0.045 (9.94) ***	1.723 (12.12) ***	0.825 (7.19) ***	0.889 (2.89) **	−0.164 (−2.88) **	0.004 (0.62)	0.4255	0.4202		
τ = 0.90	0.109 (12.81)***	1.530 (5.73)***	0.916 (9.01) ***	1.347 (3.29) ***	−0.203 (−1.37)	−0.005 (−0.67)	0.3890	0.3833		
				Panel B: Before COVID-19: Jul-2010 to Feb-2020						
τ = 0.10	−0.103 (−14.87) ***	1.763 (7.64) ***	1.054 (7.88) ***	1.451 (4.86) ***	−0.241 (−2.78) **	−0.008 (−0.66)	0.4814	0.4762		
τ = 0.25	−0.049 (−9.69) ***	1.762 (11.85) ***	0.919 (9.61) ***	1.345 (4.54) ***	−0.237 (−4.82) ***	−0.004 (−0.95)	0.4749	0.4695		
τ = 0.50	−0.002 (−0.66)	1.747 (12.53) ***	0.969 (9.09) ***	1.037 (4.27) ***	−0.195 (−4.50) ***	−0.001 (−0.02)	0.4563	0.4508	48.50 **	23.75
τ = 0.75	0.043 (8.93) ***	1.745 (12.08) ***	0.818 (6.93) ***	0.991 (2.88) ***	−0.172 (−2.88) ***	0.006 (1.56)	0.4219	0.4161		
τ = 0.90	0.108 (13.33) ***	1.569 (7.19) ***	0.885 (8.91) ***	1.266 (3.12) ***	−0.225 (−1.99) **	−0.004 (−0.61)	0.3884	0.3822		
				Panel C: During COVID-19: Mar 2020 to Nov-2020						
τ = 0.10	−0.046 (−3.02) ***	2.055 (4.81) ***	0.147 (0.274)	−1.459 (−1.72) *	0.259 (1.155)	−0.016 (−0.91)	0.5208	0.4524		
τ = 0.25	−0.033 (−2.10) **	1.974 (4.45) ***	0.356 (0.636)	−0.833 (−1.019)	0.1353 (0.589)	−0.004 (−0.225)	0.5268	0.4592		
τ = 0.50	0.003 (0.30)	1.459 (4.33) ***	0.317 (0.686)	0.188 (0.234)	0.139 (0.58)	−0.014 (−0.576)	0.5381	0.4722	63.0 ***	25.51
τ = 0.75	0.029 (3.05) ***	1.471 (5.28) ***	0.296 (0.907)	0.537 (0.921)	0.055 (0.251)	−0.027 (−1.150)	0.5479	0.4833		
τ = 0.90	0.063 (3.20) ***	1.358 (3.54) ***	0.1762 (0.308)	1.163 (1.02)	0.320 (1.110)	−0.042 (−0.932)	0.5286	0.4613		

Note: This table reports the estimated results of Equation (2) for gold. CR = credit, EV = equity-valuation, FUND = funding, SA = safe assets, and VOLA = volatility. T-statistics are presented in parenthesis. *, **, and *** denotes statistical significance at 10%, 5% and 1% level, respectively. 10% and 25% quantiles belong to bearish conditions, and 50% quantile belongs to normal conditions. Quantiles of 75% and 90% belong to the bullish condition.

Table 4. QR Estimation of Bitcoin.

Variable	C	CR	EV	SA	FUND	VOLA	Pseudo R-Squared	Adjusted R-Squared	Slope-Equity	Symmetric
					Panel A: Full-Sample (Jul-2010 to Nov-2020)					
τ = 0.1	−0.024 (−17.56) ***	−0.015 (−0.46)	0.077 (4.25) ***	1.030 (16.11) ***	0.025 (2.41) ***	0.004 (3.37) ***	0.3924	0.3867		
τ = 0.25	−0.014 (−12.67) ***	−0.044 (−1.19)	0.089 (3.13) ***	1.016 (14.76) ***	0.028 (1.65) *	0.002 (1.71)*	0.4052	0.3996		
τ = 0.50	−0.002 (−1.70) *	−0.058 (−1.78)*	0.085 (3.00) **	1.011 (12.80) ***	0.032 (2.02) **	0.000 (−0.34)	0.3798	0.3741	74.81 ***	35.23
τ = 0.75	0.013 (8.81) ***	−0.047 (−0.87)	0.078 (2.74) **	1.047 (8.15) ***	0.017 (1.30)	−0.002 (−1.23)	0.3379	0.3317		
τ = 0.90	0.028 (15.17) ***	0.013 (0.35)	0.073 (3.21) ***	0.956 (10.30) ***	0.021 (2.32) ***	0.002 (0.85)	0.3367	0.3305		
					Panel B: Before COVID-19: Jul-2010 to Feb-2020					
τ = 0.1	−0.025 (−16.81)***	−0.0334 (−1.01)	0.072 (3.64)***	1.074 (16.08)***	0.032 (3.46)***	0.004 (2.55) **	0.3965	0.3904		
τ = 0.25	−0.014 (−11.95)***	−0.043 (−1.14)	0.088 (3.03)***	1.00 (13.88) ***	0.029 (1.64)	0.002 (1.75) *	0.4018	0.3958		
τ = 0.50	−0.002 (−1.38)	−0.068 (−1.95) ***	0.086 (2.90) ***	1.044 (12.12) ***	0.031 (1.91) *	0.001 (0.53)	0.3785	0.3722	40.53 **	20.67
τ = 0.75	0.014 (9.01) ***	−0.071 (−1.66) *	0.063 (2.14) **	1.024 (7.57) ***	0.029 (2.29) **	−0.001 (−0.27)	0.3421	0.3355		
τ = 0.90	0.028 (14.24) ***	−0.008 (−0.21)	0.070 (2.93)	0.989 (10.26) ***	0.023 (2.06) **	0.002 (0.66)	0.3417	0.3350		
					Panel C: During COVID-19: Mar-2020 to Nov-2020					
τ = 0.1	−0.014 (−2.95) ***	0.238 (1.29)	0.571 (1.98) **	0.443 (0.94)	−0.127 (−1.20)	0.001 (0.11)	0.4823	0.4084		
τ = 0.25	−0.008 (−2.53) **	0.116 (0.72)	0.374 (1.62)	0.779 (2.27) **	−0.07 (−0.70)	−0.004 (−0.67)	0.5100	0.4400		
τ = 0.50	−0.001 (−0.17)	0.066 (0.45)	0.197 (1.15)	0.873 (2.67) **	0.009 (0.12)	−0.006 (−0.96)	0.4576	0.3801	24.02 **	18.07
τ = 0.75	0.012 (2.92) ***	0.147 (1.64) *	0.576 (3.51) ***	0.572 (1.96) **	−0.004 (−0.07)	0.002 (0.42)	0.4440	0.3646		
τ = 0.90	0.018 (3.99) ***	0.119 (1.30)	0.666 (3.93) ***	0.617 (2.01) **	0.004 (0.07)	0.006 (1.06)	0.4985	0.4269		

Note: This table reports the estimated results of Equation (2) for bitcoin. CR = credit, EV = equity-valuation, FUND = funding, SA = safe assets, and VOLA = volatility. T-statistics are presented in parenthesis. *,**, and *** denotes statistical significance at 10%, 5% and 1% level, respectively. 10% and 25% quantiles belong to bearish conditions, and 50% quantile belongs to normal conditions. Quantiles of 75% and 90% belong to the bullish condition.

We note that the effects of FSI categories on gold returns are identical in terms of direction across quantiles in the full sample and sub-sample before the COVID-19 pandemic. However, the effects are heterogeneous. Although the coefficients vary across the quantiles, gold exhibits responses that are similar to those in the OLS estimation. We find that in the full-sample and pre-COVID-19 sub-sample, responses to financial stress categories are positive and strongly significant in lower quantile or bear markets. However, an interesting point to note is that evidence of positive effects on gold in lower quantiles suggests that the gold market may not serve as a safe haven asset for credit, equity valuation, and safe asset-related financial stress. In reality, a lower quantile is associated with a bear market in which the gold price continues to fall, and the positive effect means that an increase in financial stress could lead to a decrease in the gold price or returns.
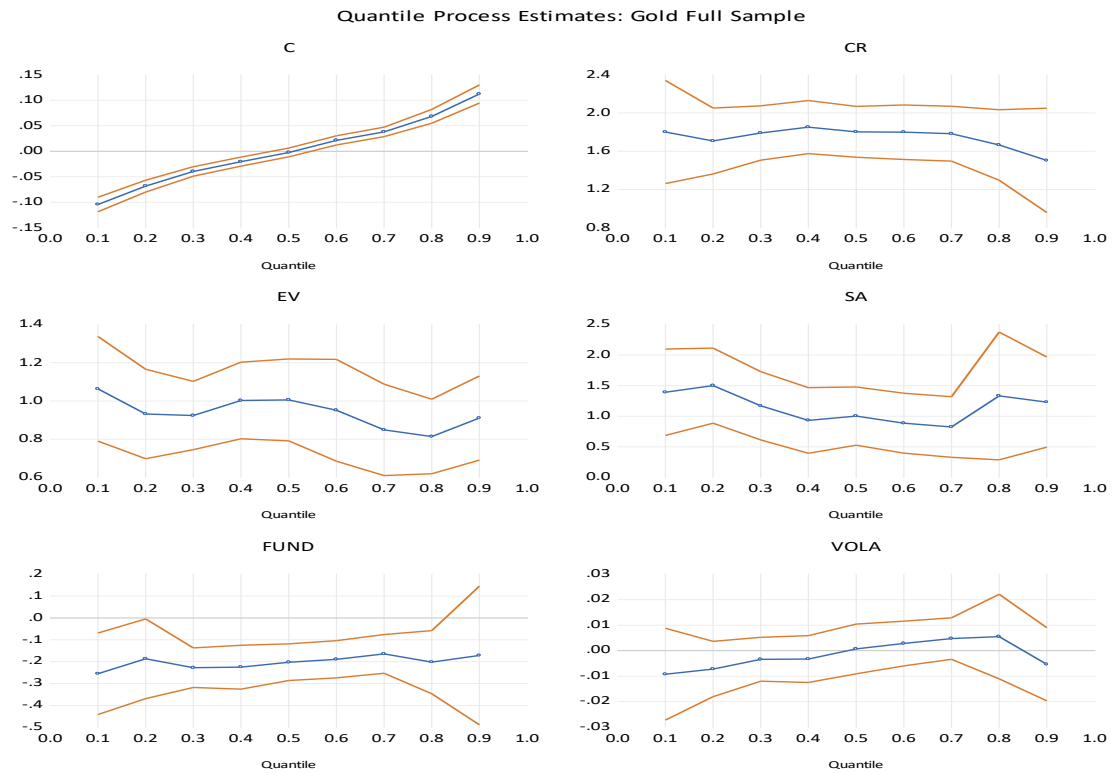
Quantile Process Estimates: Gold Full Sample

Figure 1. Quantile-Coefficients for Gold in Full-Sample.

Quantile Process Estimates: BitCoin Full Sample
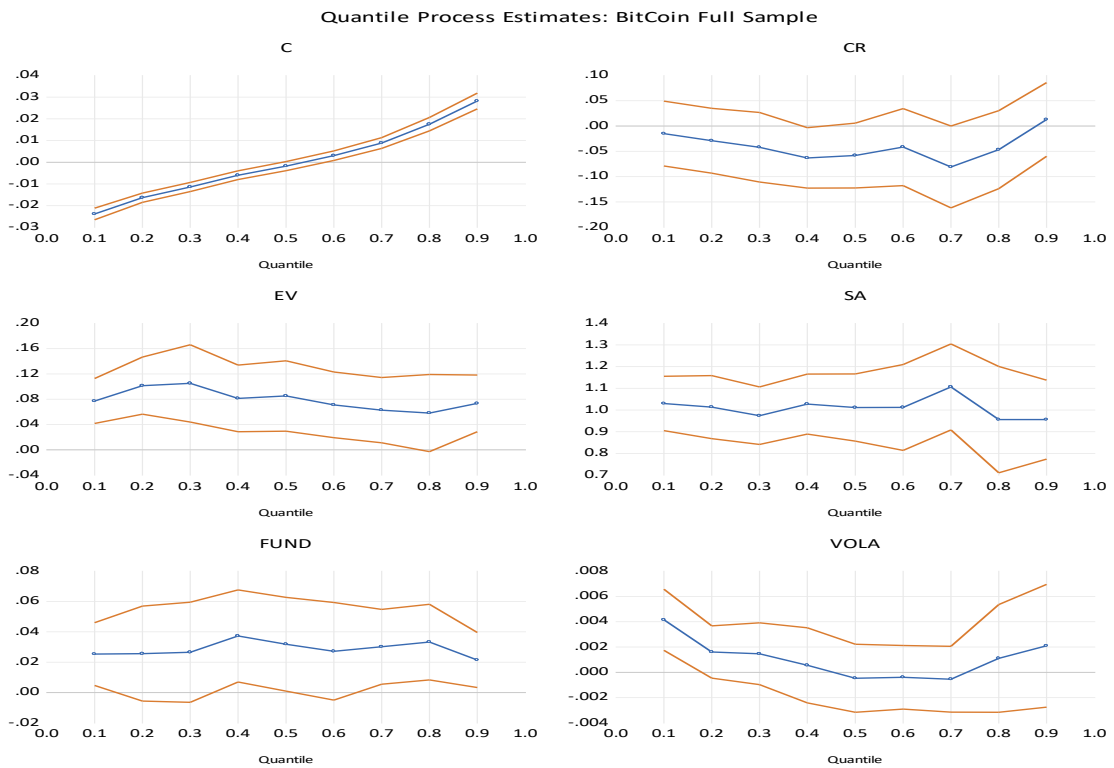

Figure 2. Quantile-Coefficients for Bitcoin in Full-Sample.

On the other hand, for average and higher quantiles, the positive response to the credit category of financial stress implies that when credit spreads widen, the situation is bullish for gold. This is because investors are unwilling to hold debt and thus increase their demand for safe haven assets such as gold. Similarly, for the equity valuation FSI category,

positive responses to gold suggest that falling equity values make investors lose confidence, become more risk-averse, and hence more inclined to hold safe assets instead of risky assets. Consequently, investors increase their demand for safe haven assets such as gold. Investors' asset migration from risky to safe haven holdings pushes up the valuation of safe haven assets (McCauley and McGuire 2009). Additionally, a similar economic implication is applicable to safe assets and funding-related financial stress. Furthermore, the negative insignificant effects of volatility-related financial stress across the quantiles suggest that gold could act as a hedge and diversifier during bearish and bullish states, respectively. Therefore, our findings are supported by the study of Bouoiyour et al. (2018), as they empirically argued that the hedging and safe haven roles of gold are subjected to gold market conditions such as bearish, normal, or bullish.

However, during the COVID-19 pandemic, the gold price's reaction to FSI categories changed considerably, indicating that gold may have lost some of its appeal as a safe haven asset. With the exception of the credit category FSI, the gold price did not respond significantly to other types of financial stress across all quantiles. Gold still reacts positively to the credit category of financial stress across all quantiles, suggesting that widening credit spreads are bullish for gold. While gold is generally considered a safe haven asset, interestingly, during the pandemic, gold had no significant reaction to the safe asset category of financial stress. Therefore, our findings infer the safe haven properties of gold for credit-related financial stress and diversifiers or hedgers for other categories of financial stress. These findings are relevant to investors in terms of portfolio diversification and hedging during the crisis. These findings are supported by Akhtaruzzaman et al. (2021), as they report that gold has shown safe haven in the first phase of COVID-19, but in the second phase, it holds diversifier or hedger properties. Li and Lucey (2017) also presented that gold does not appear to be the best safe haven asset for the US equities and bond indexes. Zhang and Wang (2021) also demonstrated how gold lost its safe heaven class for US and Chinese FSI. The overall findings during the COVID-19 period contradict the findings reported earlier in the pre-COVID-19 sub-sample that both gold and Bitcoin react positively to safe asset category financial stress. This could be due to the grim and unprecedented impact on the economy and society caused by the COVID-19 pandemic. Pandemic-related crises and their financial ramifications have a varying degree of impact on macroeconomic developments and financial markets. Therefore, we have not observed a similar response of gold to categorical financial stress before and during the COVID-19 period.

For Bitcoin, in the full sample, we observe that Bitcoin responds positively to equity valuation, safe assets, and funding FSI categories across quantiles. Similar patterns of responses were observed in the sub-sample before the COVID-19 pandemic. As discussed earlier, positive effects on Bitcoin in the lower quantile suggest that the Bitcoin market may not serve as a safe haven asset for all categorical financial stress. These findings are supported by Jareño et al. (2020) in their findings of the quantile-dependent effects of financial stress on Bitcoin, and therefore, the role of Bitcoin in financial stress categories is also dependent on Bitcoin market condition. Regarding the role of safe haven, our results are supported by the findings of Das et al. (2019). However, similar to gold during the COVID-19 pandemic, Bitcoin's reaction to FSI categories has also changed. In times of pandemic, Bitcoin responds positively to financial stress in the equity valuation category, but only in the upper quantiles. This implies that investors only hold assets with safe haven properties in bull markets for equity valuation-related financial stress. Additionally, it reacts positively to safe asset category financial stress in average and bull markets. This implies that increases in the financial stress index of the safe asset category indicate higher valuations of safe assets, suggesting that investors are switching from risky to safe asset holdings. Bitcoin's positive response to the safe asset FSI category suggests that increases in the index value of the safe asset category led to increases in Bitcoin's price. Furthermore, insufficient response to other categorical financial stress suggests the diversifier or hedging role of Bitcoin. The results infer that Bitcoin holds the potential to complement gold as a

safe haven asset. These findings are also supported by Jareño et al. (2020), showing the quantile dependent sensitivity of Bitcoin to categorical financial stress.

4. Conclusions

Our main results revealed the responses of gold and Bitcoin to financial stress categories capturing different features of systemic financial stress and highlighting the hedge and safe haven properties of gold and Bitcoin in the full sample and pre COVID-19 subsample. The roles of gold and Bitcoin in different categorical financial stress vary depending on market conditions. However, during the COVID-19 outbreak, gold performed differently, and it exhibited safe haven properties for credit-related financial stress and served as a diversifier or hedger for other categorical financial stress. Bitcoin also showed different behavior during the COVID-19 pandemic; it reacted positively to equity valuation and safe asset categories of financial stress. Overall, the findings indicate that gold consistently holds safe haven properties in the credit category of financial stress in the full sample as well as before and during the pandemic. As for Bitcoin, the evidence indicates that it consistently responds positively to the safe asset category in all sample periods and the equity valuation category during COVID-19. Overall, Bitcoin offers more safe haven properties than gold, as it holds safe haven properties for two financial stress categories.

Our empirical results have several practical implications for investors and portfolio managers. First, our findings are related to categorical financial stress, and thus they provide insight into how different types of categorical financial stress affect gold and the Bitcoin market. Thus, investors should pay attention to different categories of financial stress to prepare for uncertainty and hedge their investment risk using gold and Bitcoin investment. Second, our findings are also related to the market states' dependent role on gold and Bitcoin in hedging against the various categorical financial stress. Our findings highlight that investors should consider gold or Bitcoin as a safe haven investment in bullish market states. Third, during the pandemic, investors looking for a safe haven investment in gold and Bitcoin should be cautious as such asset class may not necessarily offer a safe haven investment avenue for all categorical financial stress.

Author Contributions: Conceptualization, M.E.H. and S.-W.L.; Data curation, M.E.H.; Funding acquisition, S.-W.L.; Methodology, M.E.H.; Supervision, S.-W.L.; Writing—original draft, M.E.H.; Writing—review and editing, S.-W.L. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement: Data are publicly available on the OFR Website, Gold Council, and Bloomberg.

Conflicts of Interest: The authors declare no conflict of interest.

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