On the Relationship of Gold, Crude Oil, Stocks with Financial Stress: A Causality-in-Quantiles Approach

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Highlights

- The dependence structure of stocks, gold and crude oil with financial stress is examined.
- We used the nonparametric causality-in-quantile technique.
- Bilateral causality exists in mean and variance for gold and crude oil with respect to financial stress.
- Stocks influence financial stress both in mean and variance.

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ABSTRACT

We examined the dependence structure of stocks, gold and crude oil with financial stress using the nonparametric causality-in-quantile technique for the period from December 1993 to March 2017. The study finds the evidence of bilateral causality in mean and variance for gold and crude oil with respect to financial stress, and stocks to be influential to financial stress both in mean and variance.

Keywords: Gold; Crude Oil; Financial Stress; Causality-in-Quantiles

JEL Classification: G11; E44; B26

1. Introduction

Financial stress may be described as adverse economic forces that originate uncertain macroeconomic conditions in a real economy. The rising economic instabilities and market fluctuations intensify financial stress since the economic agents expect amplified probabilities of downside risks (Illing and Liu, 2006). Hakkio and Keeton (2009) argue that economists typically associate certain key features with financial stress. They are: (a) increased uncertainties about fundamental values of assets, (b) increased uncertainty about the behaviour of other investors, (c) increased asymmetry of information, (d) decreased eagerness to hold risky assets, and (e) decreased willingness to hold illiquid assets. However, the prominence and intensity of these features will vary according to different episodes of financial stress.

The expected future stream of cash flows from assets like stocks, gold and oil are dependent on macroeconomic variables such as inflation and risk-free rates. From a different macroeconomic perspective, the fundamental values of the assets reflect the economic outlook of a nation (Hakkio and Keeton, 2009). Consequently, a nation may fail to attract new investors if the fundamental values of assets depict plummeting tendencies. Moreover, the existing investors might also wither away as they would assign higher probabilities to pessimistic outcomes of financial loss. This possibility further deepens the roots of financial stress in an economy. Thus, the relationship is somehow endogenous and intertwined with bi-directional causalities, i.e., financial stress might affect the fundamental values of assets; therefore, the dwindling asset fundamentals may also act as a significant stressor.

In the recent past, researchers have attempted to disentangle the phenomenon of bilateral causation between financial stress and real assets. Sum (2013) empirically documented the relationship between market risk premiums and financial stress. Using a linear Granger causality test, the author concludes that financial stress causes a declination in market risk premium; nevertheless, the evidence of reverse causality was not significant. Nazlioglu et al., (2015) investigated the mechanism of volatility transmission between oil prices and financial stress using a Granger causality in variance test. The results account for a risk transfer mechanism from oil prices to financial stress before the global financial

crisis. However, a reverse causality, i.e., from financial stress to oil prices, was evident in the post-crisis era. In a recent scholarly effort, Reboredo and Uddin (2016) examined the co-movement and causality between financial stress and tradable energy and metal commodities using quantile regression and Granger causality test. Their study acknowledged the influence of financial stress on the intermediate and upper quantiles of commodity returns. Nonetheless, no evidence of co-movement was reported.

This study attempts to re-examine the relationship between stocks, gold, and crude oil with financial stress using causality-in-quantiles method. A re-examination appears pertinent and logical to understand and unveil the phenomenon of bi-directional causality. Hence, this study employs a non-parametric causality-in-quantile test, which is recently proposed by Balcilar et al., (2016a). Previous studies significantly applied the linear Granger causality tests. However, if the data is nonlinear (which is one of the stylised facts of financial time series), the linear causality results cannot be completely relied upon (Babalos and Balcilar, 2016; Bekiros et al., 2016). The causality-in-quantile method estimates the dependence structure using a nonparametric procedure, which minimises the probabilities of misspecification errors and also facilitates the detection of higher order dependencies (mean and variance). Also, the causality can also be detected when the market is bullish (higher quantiles), normal (intermediate quantiles) and bearish (lower quantiles).

Additionally, this study considers three assets, i.e., stocks, gold and crude oil with a purpose. Reboredo and Uddin (2016) argue that during the occasions of higher financial stress, the investors increasingly rebalance their portfolios to mitigate downside risks by transferring investments to commodities that are often viewed as save-haven assets – a phenomenon known as flight to quality. Furthermore, the authors have also posited a probable transmission of stress to commodities by portfolio rebalancing. Cheng et al., (2015) provide similar evidence of how trader's position changes in commodities markets in response to changes in stock market volatility. The authors concluded that both trader's position and commodity prices were affected by the stock market vulnerabilities. Thus, the study expects to offer newer insights by detecting the quantile causality in mean and variance between financial assets (stocks) and tradable commodities (gold and crude oil).

The study finds an evidence of bi-directional causality both in mean and variance for gold and crude oil with financial stress. However, stocks are found to influence financial stress more strongly. The causality of financial stress over stocks depicts a weak evidence. The rest of the paper is organised as follows: Section 2 briefly describes the data and also explains the methodologies used. Sections 3 discusses the main results of the study. Section 4 highlights the key findings of the study, and finally, Section 5 concludes.

2. Data

The study considers weekly data for the period spanning from 31 December 1993 to 24 March 2017 (1213 observations). As a proxy of financial stress, the study considers the

Financial Stress Index (FSI) data provided by Federal Reserve Bank of St. Louis[1]. The gold spot prices data for the US are obtained from the World Gold Council. For world crude oil prices, the study uses the West Texas Intermediate (WTI) spot prices. As a proxy for stocks, this study considers the S&P 500 Index. The crude oil and stock prices are extracted from the Bloomberg database. The index-based returns are calculated for the variables with consideration to the differences between natural logs, i.e., $R_t = \ln(P_t / P_{t-1})$.

In Table 1, the summary statistics for stocks, gold, and crude oil is exhibited. Gold shows the least minimum value, whereas the highest minimum value relates to stock returns, followed by crude oil. The highest maximum value is observed for crude oil, whereas the lowest value refers to stock. The mean returns are found to be highest in stock; gold and crude oil returns remain indifferent. Returns volatility in terms of standard deviation is highest for crude oil and lowest for gold. The negative skewness coefficients signify more frequent negative returns than positive returns. The stocks show larger negative skewness coefficient, whereas minimum skewness is represented by gold. The kurtosis coefficients are positive and leptokurtic for gold and stock. Positive kurtosis coefficients connote higher probabilities of realising positive returns. The Jarque-Bera test rejects the null hypothesis of normality. The Ljung-Box Q-statistic at a lag order of 10 provides evidence of serial dependence for all the series under examination. The linear correlation coefficient of crude oil and stock returns with financial stress is negative. However, the coefficient for gold returns is positive (weak though). The positive correlation of gold with stress could be an outcome of flight to quality phenomenon.

Table 1. Statistical properties of stock, gold and crude oil

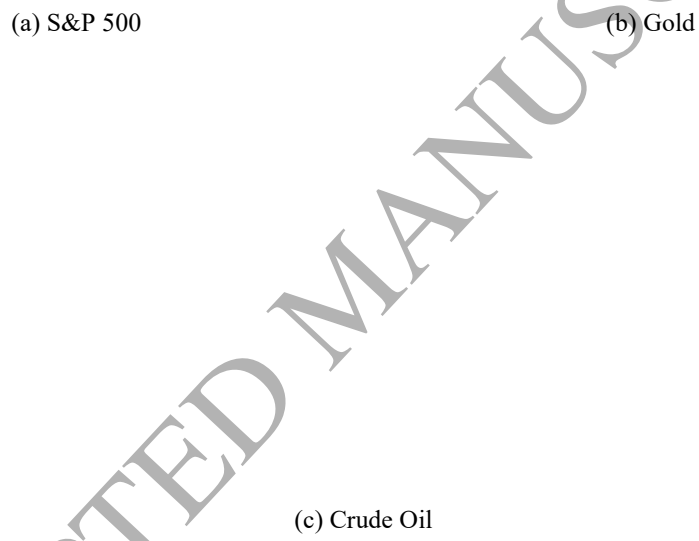
	Stock	**Gold**	**Crude Oil**
Minimum	-0.20	-0.14	-0.19
Maximum	0.11	0.15	0.25
Mean	0.0013	0.0010	0.0010
Standard Deviation	0.0236	0.0234	0.0425
Skewness	-0.764	-0.119	-0.203
Kurtosis	6.668	4.340	2.671
Jarque-Bera	2341.40	944.26	364.42
Ljung-Box Q-Statistic (10)	32.13	18.25	62.96
	(0.00)	(0.05)	(0.00)
Linear Correlation with Stress	-0.049	0.005	-0.046

Note: The critical value of the Jarque-Bera test at 5% level is 5.99. The Ljung-Box test was performed taking a lag of 10. The p-values are reported in parentheses.

Figure 1 presents the risk confidence sensitivities for stock, gold and crude oil. The Value-at-Risk (VaR) is represented on the vertical axis; the confidence levels are denoted on the horizontal axis. At 99% confidence level, the historical VaR for both gold and stock is 7%. The VaR for crude oil is at the maximum, which is approximately 12%.

[1] The data can be retrieved from the following link: https://fred.stlouisfed.org/series/STLFSI

Thus, the inference based on historical data show that hedging the crude oil from stocks could be a relatively risky proposition.



(a) S&P 500 (b) Gold

(c) Crude Oil

Figure 1. Risk confidence sensitivity for stock (S&P 500), gold and crude oil (WTI)

3. Estimation Methodology

The nonlinear causality in stock, gold or crude oil $y(t)$is examined with the predictor financial stress $x(t)$, and then the quantile causality is tested in reverse order. Following Jeong et al., (2012), the quantile-based causality may be defined as:

With respect to a lag vector $\{y_{t-1},...,y_{t-p},x_{t-1},...,x_{t-p}\}$, $x(t)$ does not cause $y(t)$ in the θth quantile if

$$Q_\theta\left(y_t|y_{t-1},...,y_{t-p},x_{t-1},...,x_{t-p}\right)=Q_\theta(y_t|y_{t-1},...,y_{t-p}) \tag{7}$$

and further, $x(t)$ may be assumed to cause $y(t)$ in the θth quantile respective to $\{y_{t-1},...,y_{t-p},x_{t-1},...,x_{t-p}\}$ if

$$Q_\theta\left(y_t|y_{t-1},...,y_{t-p},x_{t-1},...,x_{t-p}\right)\neq Q_\theta(y_t|y_{t-1},...,y_{t-p}) \tag{8}$$

where $Q_\theta(y_t|.)$ is the θth quantile of $y(t)$. The conditional quantiles of $y(t)$, $Q_\theta(y_t|.)$ depends on t and the quantiles are restricted between zero and one, i.e., $0\prec\theta\prec 1$.

The implications of the causality in mean from $x(t)$ to $y(t)$ in the θth quantile is that the historical values of $x(t)$ may assist to predict the values of $y(t)$in θth quantile, but not in other quantiles. As stated earlier, this test is an extension of Jeong et al., (2012) to test for the second moment. Besides, while testing the causality in the higher order moments, a common complication arises is the k^{th} moment, which usually implies causality in m^{th} moment for $k\prec m$. The causality-in-quantile method applies a sequential nonparametric Granger quantile causality approach of Nishiyama et al., (2011) to eliminate the stated complication.

In order to justify the application of the nonlinear causality-in-quantile method, the hypothesis of linearity of the data is tested following previous studies (Babalos and Balcilar, 2016; Balcilar et al., 2016b). To facilitate comparability of a linear VAR(1), Granger causality test was performed (see Table 2). The results depicted that the null hypothesis of financial stress does not Granger-cause stocks, gold, and crude oil cannot be rejected at all levels of significance. The BDS test (Broock et al., 1996) was performed on the residuals of AR(1) process in addition to VAR(1) residuals of the variables with the financial stress equation in order to check the independent and identical distribution (*i.i.d.*) property of the series. Table 3 presents the results of the BDS test, which provide considerable evidence of failure to accept the null hypothesis of *i.i.d.* for residuals of both AR(1) and VAR(1) processes at various levels of embedded dimensions. Thus, the phenomenon of nonlinearity is present in the relationship between financial stress and stocks, gold, and crude oil. Hence, the linear Granger causality test is susceptible to misspecification error probabilities. Table 4 also exhibits multiple structural breaks (Bai and Perron, 2003) on AR(1) residuals, which further justify the applicability of the causality-in-quantile approach.

Table 2. Linear VAR (1) Granger Causality Test

Null Hypothesis	***F*-Statistics**	***p*-value**
Stress $\neq\succ$ Gold	0.00	0.98
Stress $\neq\succ$ Crude Oil	0.99	0.32
Stress $\neq\succ$ Stock	1.92	0.17

Note: $\neq\succ$ represents "do not Granger-cause".

Table 3. BDS Test

AR(1) and VAR(1) Processes	Dimensions 2	3	4	5	6
AR(1): Stocks	8.26 (0.00)	10.97 (0.00)	14.46 (0.00)	17.35 (0.00)	20.23 (0.00)
AR(1): Gold	7.21(0.00)	10.08 (0.00)	13.75 (0.00)	20.35 (0.00)	31.26 (0.00)
AR(1): Crude oil	2.81 (0.00)	3.73 (0.00)	5.54 (0.00)	7.80 (0.00)	10.45 (0.00)
VAR(1): Stocks	7.95 (0.00)	10.73 (0.00)	13.96 (0.00)	16.76 (0.00)	19.27 (0.00)
VAR(1): Gold	7.25 (0.00)	10.11 (0.00)	13.80 (0.00)	20.40 (0.00)	31.29 (0.00)
VAR(1): Crude oil	3.00 (0.00)	3.98 (0.00)	5.50 (0.00)	7.58 (0.00)	10.42 (0.00)

Note: The *z*-statistic is reported as various embedded dimensions. The *p*-values are reported in parentheses.

Table 4. Structural Breaks

Models	Break Dates
AR(1): Stocks	1998/07/17; 2002/02/15; 2005/02/09; 2009/02/27; 2013/05/10
AR(1): Gold	1997/06/20; 2001/02/16; 2004/04/10; 2008/03/14; 2011/09/02
AR(1): Crude oil	1998/06/19; 2002/01/18; 2005/09/02; 2009/02/02; 2013/09/06

Note: Dates are in YYYY:MM:DD format

4. Main Results

Figure 2 shows causality in mean between financial stress and stocks, gold, and crude oil. The test-statistics of the non-parametric quantile causality test are denoted on the vertical axis. The horizontal axis represents the lower (0.25), intermediate (0.50) and upper (0.75) quantiles. The horizontal grey solid line shows the value of 1.95 and this corresponds to a critical value at 5% level of significance. The null hypothesis states that the financial stress does not Granger-cause stocks, gold, and crude oil in mean or variance. For the causality in various conditional distribution levels, financial stress is found to Granger-cause the mean returns in gold. The causality maximises at the upper quantiles of the data. Gold is also detected to cause financial stress, which is maximised at the intermediate levels. According to Baur and McDermott (2010), the nominal prices of gold rose by 42% during the global financial crisis of 2008. This flight to quality itself may indicate a sign of financial stress, which is substantiated by the bi-directional causalities. Concerning the crude oil mean, financial stress is not detected to have any predictive power up to quantile 0.45. However, beyond quantile 0.45 up to quantile 0.90, the financial stress appears to cause crude oil returns. However, crude oil demonstrates a higher predictive ability of financial stress as indicated by the hump-shaped causality estimate curve. The dominance of crude oil for development and progress of an economy is evident. Ratti and Vespignani (2016) provided empirical evidence for global interest rate tightening by positive innovations in the global oil prices; a decline in oil prices was observed on a positive innovation in interest rates. Hence, the implications of causality results for crude oil can be practically justified. Regarding stocks, financial stress appears to have highest predictive abilities at the lower quantiles of 0.15 to 0.35 when the market is bearish. In the intermediate quantiles of 0.40 to 0.50, the financial stress does not appear to Granger-cause stock. At the higher quantiles of 0.55 to 0.80, the financial stress again appears the causal variable for stock. However, there exists strong evidence that stocks contribute to financial stress can be substantiated. The theoretical explanation that

may be attributed to this phenomenon could be, as discussed earlier, the prevalence of stock indices as an important barometer of the economic growth.

Figure 3 shows the causality in variance; both gold and crude oil appear to cause volatility in financial stress. Similarly, financial stress can also be observed to Granger-cause in variance for both gold and crude oil. The stocks cause variance in financial stress, however, the reverse was found to be statistically insignificant. These results part away significantly from linear causality tests. Hence, the causality at different conditional levels allowed the study to draw valuable implications.

5. Conclusions

This paper attempts to explore the relationship of stocks, gold, and crude oil with financial stress using the nonparametric causality-in-quantile test proposed by Balcilar *et al.,* (2016a). We found strong evidence of nonlinearity and structural breaks in the data and therefore we used the nonparametric causality-in-quantiles test proposed by Balcilar et al., (2016a). The results entail significant bi-directional causality both in mean and variance for gold and crude oil with financial stress. However, stocks are found to influence financial stress more strongly. The causality of financial stress over stocks depicts a weak evidence. This study offers new insights towards the relationship between gold, crude oil and stock with financial stress by detecting the dependence structure of the assets at various conditional quantiles. These findings could be extremely relevant for portfolio re-balancing measures at different market states.

Figure 2. Causality in mean between Financial Stress (FSI) and Gold, Crude Oil (WTI), Stock (S&P 500)

Figure 3. Causality in variance between FSI and Gold, Crude Oil, Stock

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