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Dynamic linkage among oil prices, gold prices, exchange rate and stock market: A copula based study of selected Asian economies.

Anam Rafique[1*]. Muhammad Hussnain Ashraf[1]. Hammad Hassan Mirza[1]

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Abstract

This research explores the copula-based linkages between oil and gold prices, exchange rates, and stock markets in five Asian economies: Pakistan, India, Indonesia, Malaysia, and China. Using data from 2017 to 2024 and advanced copula models, we capture the non-linear and tail dependencies among these variables, particularly during periods of financial distress (COVID19). The findings indicate varying degrees of correlation across these economies, with oil price fluctuations significantly affecting stock returns in oil-exporting nations such as Indonesia and Malaysia, while gold prices serve as a stabilizing asset in India and Pakistan. Exchange rate volatility further influences stock market performance, particularly in China. The copula models reflected the non-linear and asymmetric dependencies especially during the extreme scenarios of the market while giving the investors understanding of risk management and portfolio diversification. These findings contribute to a deeper understanding of the interconnectedness of commodity prices, exchange rates, and stock markets in Asian economies, with practical implications for policymakers and investors. It can help investors and financial analysts to gain a better understanding on the interdependence of such variables and can promote their investment decision making process.

Keywords: Exchange rate, Oil prices, Gold Prices, Stock market index, Copula Method, Tail dependencies.

1. Introduction

The financial system is a crucial component of contemporary economies, facilitating the movement of funds from savers, who have excessive funds to those who need additional capital, like investors. The equity market is a vital part of this system. There I s substantial evidence

*Correspondence: Anam Rafique[1]

1- Malik Firoz Khan Noon Business School, University of Sargodha, Email: rafiqueanam92@gmail.com.

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showing that advancements in the stock market positively influence economic development (Levine, 2002; Enisan & Olufisayo, 2009). Equity markets are highly responsive to both domestic and international events, whether positive or negative, and they react promptly following such occurrences.

Negative incidents or occasions, whether internal or external, increase market volatility, adversely affecting performance and eroding investor confidence. This increased financial risk, resulting from changes in prices of assets, influences the wealth of shareholders. Financial crisis are significant upheavals that affect countries worldwide, regardless of whether they were developed or emerging economies. Technological advancements and globalization immediately spread the impact of crisis worldwide.

As the Coronavirus (COVID-19) evolved from a localized crisis in Hubei Province, China, to a global pandemic, stock prices plunged and volatility of markets surged worldwide. Around the globe, mid-March 2020 saw stock market volatility levels that matched or exceeded those experienced after crisis of late 1929 and1930s, October 1987 and December 2008 (Baker, 2009). In the markets where oil, gold, and other goods are traded, when prices swing a lot, it can bring different types of risks to the people involved in trading of those goods.

Historically natural oil, is the dominant basis of world's energy and is expected to retain this position in the future. So, Oil price tremors, have had significant impact on the stock market due to their far-reaching effects on various sectors of the economy. Changes in oil prices impact expected cash flows and discount rates of corporations, ultimately affecting stock prices. (Fisher, I. (1930). A significant body of research has explored the connections between the prices of oil and stock markets, yielding varied findings. (Jones & Kaul, 1996; Kilian & Park, 2009; Wang et al., 2013). For the oil-importing nations like Pakistan, India and China, where oil is main production factor, increasing oil prices negatively affect company profits. As a result, analysts anticipate lower cash flows, that impact stock values of these firms, leading to a depreciation in the stocks. Conversely, in oil-exporting economies, an increase oil price results in heightened profit expectations and subsequently, stock market growth. Such as the case of Indonesia and Malaysia which are oil exporting and have benefited from the surges in oil prices. Their economies flourished and GDP raised to high levels (Arouri et al., 2011; Salisu & Isah, 2017; Zhang et al., 2020). Thus, prices of oil affect the stock market returns as well as economies of many countries.

Gold is another main commodity that impact the stock markets. There is a positive linkage between stock return volatility and gold futures prices. Gold is a leading indicator of the economic development. Gold is an ancient and precious asset, classified as a highly liquid financial instrument. It embodies characteristics of both commodity and currency. To balance risk without sacrificing potential returns, retail investors and fund managers are strategically including gold in their stock portfolios. This helps them hedge against significant drops in stock prices (Hung & Vo, 2021). Because when economic downturns cause stocks and currency to decline in attractiveness, gold maintains its allure and continues to appreciate. (Arfaoui & Rejeb, 2017). During the 2008 financial crisis, gold prices increased by 6%, whereas the prices of several key minerals and other stocks dropped by around 40%.

Numerous studies highlight gold as an effective tool for investment diversification. Due to its frequent trading, the price of gold and its correlation with the stock market have become crucial considerations for investors, traders, policymakers, and academics alike. As a result, gold became a major focus of research in finance today.

The global COVID-19 pandemic significantly increased global gold demand, reaching 1083.8 tons in the first quarter of 2020. The pandemic's widespread impact led investors to seek safe-haven assets like gold (World Gold Council).

The market capitalization of companies and their stock price can be influenced by another factor—exchange rate fluctuation. Both stability of exchange rate and expansion of stock market stand as pivotal economic goals for all nations to attain. This happens because the financial health of any economy, can be judged by the strength of exchange rate. A robust exchange rate signifies the strength and viability of an economy, whereas a weakening currency signifies economic instability and vulnerability. Exchange rate volatility detrimentally impacts price levels, corporate profits, and overall economic activity. The relationship between exchange rates and stock market prices is both direct and indirect.

In globalized economies of the present world, having trade liberalizations, these two factors are increasingly intertwined. For example, international investors are actively channeling their capital into stock markets around the world. This surge in global investment is facilitating rapid capital movement across borders. Consequently, the returns for these investors are affected by fluctuations in foreign exchange rates. Additionally, volatility in exchange rate can introduce uncertainty in investment returns, making exchange rates a crucial factor in stock market variability (Khan & Ali, 2015).

There exists a causative linkage between stocks and exchange rates, as indicated by theories such as the goods market hypothesis (Dornbusch & Fischer, 1980). As per this hypothesis, fluctuations in exchange rate influence the competitiveness of many multinational firms, consequently impacting their revenues and stock prices. All of these arguments ask for thorough examination of the link between the financial variables and the commodity market. Oil and gold prices, exchange rate and stock market are interrelated and depend on one another either in long run or in the short run. So, it’s very important to analyze their dependence particularly at the time of crisis. (Nieh & Lee, 2001; Wong, 2017).

Global crises have demonstrated the unpredictable interconnections between commodities like oil and gold and financial variables such as exchange rates and stock markets. Investors struggle to diversify portfolios due to uncertainty in these relationships. Historically, these variables exhibit weak correlations in normal conditions but become significantly correlated during crises, affecting hedging strategies and risk assessments. Multinational firms also face challenges in managing exchange rate risks under such circumstances. Thus, a thorough examination of commodity-financial market dependencies is essential to address these challenges. A robust mathematical model is required to analyze the time-varying correlations and dependencies among these variables, particularly during economic downturns, to aid investors and

policymakers in making informed decisions. This research answers the following two research questions.

Q1: What is the relationship of oil prices, gold prices and exchange rate with stock market performance?

Q2: what will be the effect of pandemics on the tail dependency of macroeconomic variables and stock market returns?

Hence, the objectives of this work on "Dynamic Linkage among Oil Prices, Gold Prices, Exchange Rate, and Stock Market: A Copula-Based Study of Selected Asian Economies" are to find that how oil prices, gold prices and exchange rate are related to and impact the stock market. As well to know that what will be the possible impact of pandemics on the tail dependency of macroeconomic variables and stock market.

This study contributes in the following ways: It examines the dynamic relationship between oil and gold prices, exchange rates, and stock markets in emerging Asian economies using the Copula method. Understanding these interactions is essential for policymakers, financial institutions, and investors to analyze market forces and make informed decisions. The research provides valuable insights into risk management and portfolio diversification by highlighting how these financial variables are interconnected, helping investors optimize their strategies. Additionally, the findings have significant policy implications, enabling policymakers to design monetary and fiscal strategies to mitigate financial shocks caused by fluctuations in oil and gold prices. The study also enhances forecasting accuracy, allowing investors and financial analysts to improve decision-making by better understanding market dependencies. Furthermore, the application of Copula models advances financial econometrics by capturing time-varying dependencies and tail dependence between commodities and financial markets, particularly during crises. Tail dependency results are valuable for risk managers and portfolio strategists, who can use this information to prepare for extreme co-movements in financial assets and design more resilient hedging strategies during turbulent market periods. The differential behavior of oil, gold, and exchange rate linkages with stock indices across oil-importing (India, Pakistan, China) and oil-exporting (Malaysia, Indonesia) economies provides crucial input for international investors and fund managers. For example, gold demonstrated a stabilizing influence in India and Pakistan, making it a strong safe-haven asset in these markets, whereas oil price fluctuations were more influential in stock returns for Malaysia and Indonesia. This study provides practical insights for investors, policymakers, and financial analysts by highlighting significant tail dependencies between macroeconomic variables and stock markets, especially during crises like COVID-19. It underscores the importance of country-specific asset behavior, showing gold as a safe haven in India and Pakistan, while oil impacts stock returns more in Malaysia and Indonesia. The findings reveal nonlinear, asymmetric relationships between exchange rates and stock markets, offering guidance for monetary and exchange rate policies. By using copula models, the research presents a more accurate method for risk assessment and stress testing in emerging markets. It also supports region-specific portfolio diversification and enhances forecasting models, contributing to financial stability strategies in the post-COVID era.

The paper is structured as follows: section 2 reviews existing literature, section 3 outlines the research framework and methodology, data source, and the selected population and sample size, section 4 presents empirical results and discussion, and the final section covers conclusions, implications, limitations, and future research directions.

2. Literature review

2.1. Oil price and Stock markets

Imarhiagbe (2010) investigates the impact of oil prices and exchange rates on stock prices in six major economies from 2000 to 2010 using VAR models. It finds long-run relationships among the variables, with cointegration present in all countries except Mexico. Oil prices and exchange rates significantly influence stock markets, as confirmed by variance decomposition and impulse response analysis. In their study, Mohanty et al. (2010) utilized a two-factor regression model to investigate the relation between equity values of all oil and gas companies in Hungary, Romania, Slovenia, Poland and the Czech Republic. Findings show that the relation between oil price and market forces remain conditioned in these countries and depend on other factors as well. Jawadi et al. (2010) employed a sophisticated switching transition error correction model (ECM) to investigate the intricate linkage between oil and stock markets in three distinct countries: France, United States and Mexico. Their results show that dependency between the oil prices and stock is not simple and direct but rather dynamic. Aurori et al., 2010 found the same results, this article uses a new version of the VAR-GARCH method to find how much volatility is passed between the oil and equity markets in Europe and USA, focusing on different sectors. Indeed, the concurrent relationship like as discovered by Theys (2020) revealed relationship as to how fluctuation in the prices of crude oil affects the Indonesian stock market they found that there is a direct relationship between crude oil price and Indonesian stock market.

Moreover, Sukcharoen et al. (2014) compared the nature of integration between oil price and stock market returns in Japan, Canada, Germany, Hong Kong, France, Italy, the Netherlands, Switzerland, the United Kingdom, United States, Hungary, Poland, Russia, Spain, China, the Czech Republic, Finland and Venezuela. Utilizing copula methodology, they found weak dependence between prices of oil and equity returns in most cases. Bani-Khalaf & Taspinar (2022) found oil returns wielded a significant influence on market flexibility in many oil exporter countries. Liu et al. (2023) analyzes the impact of crude oil price volatility on stock returns in five major economies from 2000 to 2020 using advanced quantile-based methods. Results show that oil price uncertainty has asymmetric effects on stock returns depending on market conditions. The findings highlight the importance of tailored risk management and sector-specific hedging strategies. Pata et al. (2023) found crude oil prices has a more significant effect on SMR (stock market returns).

2.2. Gold prices and Stock markets

Fluctuations of the gold prices usually influence the global stock markets and generally are inversely related. An increase in gold prices gives an indication of economic problems or inflation and this leads to investors moving their funds from equities to gold hence a drop in the stock prices (Baur & Lucey, 2010). Shaique et al. (2016) navigated through the dynamics of the Pakistan's financial configuration focusing on the relationship between KSE-100 index and gold prices. They found absence of long-term relationships between KSE-100 index and gold price. Raza et al.

(2016). found the prices of gold had a positive effect on the stock markets of the BRICS countries, it had negative effects on the Thai, Mexican, Indonesian, Chilean and Malaysian stocks. Shabbir et al. (2019) found that price of gold has a direct impact on the stocks as well as the price of oils. Morema & Bonga (2020) found that there are significant volatility spillovers from gold and equity market. Khalaf & Taspina (2020) found that gold returns demonstrated greater salience in Kuwait, Bahrain, Saudi Arabia, and Jordan. Triki & Maatoug, (2021) analyzes the relationship between the US stock market and gold prices under geopolitical tensions using the Geopolitical Risk Index (GPR) from 1985 to 2018. Applying an MV-GARCH model and dynamic copula, the study finds that gold correlates less with the S&P500 during peaceful times and more during high-risk periods. The results highlight gold's effectiveness as a safe haven and hedging tool, especially during geopolitical crises. Pata et al. (2023) found that there is a time-varying causal relationship from crude oil prices and gold prices to Turkish stock market returns (SMR) and volatility, independent of market conditions. Cui et al. (2023) investigate gold's role as a safe-haven asset during COVID-19 using ARDL and nonlinear ARDL models with data from 2020 to 2021. They find that oil and gold volatility increase gold prices in the long run, while silver volatility has a negative effect. COVID-19 consistently boosts gold prices, confirming its safe-haven status during the pandemic.

2.3. Exchange rate and stock market

Suresh, (2009) found a positive relation in short run and a negative relation in long run between exchange rate and stock market. Agrawal et al. (2010) found that there is a negative relationship with -ve coefficient between Nifty return and Indian Exchange Rates. Kayalar et al. (2017) found that dependency between exchange rate and stock markets is not symmetric and the strength of the linkage differs depending on the market. Bala Sani, (2018) found exchange rates exert an influence on equity market volatilities. Hung & Vo, (2021). analyze volatility spillovers between exchange rates and stock prices among BRICS countries during the pandemic, finding strong connections, especially from Russia to India and Brazil to South Africa. China shows weaker volatility links, underscoring key economic implications of these spillovers. Bhargava & Konku, (2023) study how major currency fluctuations impact U.S. stock returns, finding notable volatility spillovers from the Australian dollar and euro. Their results highlight asymmetric effects and call for further multivariate analysis during financial crises.

2.4. Oil, Gold, Exchange rate and Stock Market

Singhal et al. 2019 found that oil has negative effect, gold has positive effect and exchange rate has negative effect on stocks. Asaad, (2021) analyzed interactions among oil price, gold price, exchange rate, and the ISX60 index in Iraq using daily data from pre- and during-COVID-19 periods. Using ARDL, correlation matrix, unit root, and Granger causality tests, it found varying correlations across time frames. No long-run cointegration existed in the full and pre-COVID-19 samples, and no clear conclusion was reached during COVID-19. In the short run, oil price, gold price, and exchange rate had no significant impact on the Iraq stock exchange. Kumar et al. (2023) found oil has positive impact on stocks and exchange rate has negative. Sujit & Ray (2023) found that exchange rate has negative impact in both short run and long run while no impact was seen for oil and gold in their selected sample.

These hypotheses are grounded in the observed importance and linkage among variables, as highlighted in the reviewed literature, especially during times of financial crises.

H1: The linkages among oil and gold prices, exchange rates, and stock markets in selected Asian economies exhibit no significant non-linear dependencies and tail dependencies.

H2: The linkages among oil and gold prices, exchange rates, and stock markets in selected Asian economies exhibit a significant non-linear dependencies and tail dependencies.

3. Methodology

This study employees Copula method to find the linkage between oil prices, gold prices, exchange rate and stock market. The population for the study is, Asian economies. Selected sample consists of five Asian economies on the bases of oil importing countries (India, China and Pakistan) and oil exporting countries (Malaysia and Indonesia). The daily prices of gold, crude oil, the local currency exchange rate between the sampled economies' currencies and the US dollar, and performance statistics on the principal stock market make up the time series data. This study's sample period runs from January 2017 to June 2024. This is the interested sample period because it covers COVID 19 pandemic.

As the conventional methods like ARCH and GARCH do not effectively analyze the correlation between variables, so a contemporary method of analysis which is copula method, is used in this study. We will find the tail dependencies of variables as well.

Tail dependence can be defined as the level of dependence at the corner of a bivariate distribution on either the upper-right or lower-left side. The idea of tail dependency has typically been brought up in financial applications pertaining to credit or market risk. For multivariate random vectors, definitions of tail dependence are mostly associated with their bivariate marginal distribution functions. This will simply explain that how much the prices of oil and gold as well as stock market and exchange rate will correlate in case of crisis, even if in normal circumstances they don't particularly affect or relate to one another. Tail dependence is calculated by copula method, Copula approach is used to investigate any potential linkage between our two sampled commodities which are oil and gold and the financial and economic variables under consideration. Originating from the Latin term meaning "a link, tie, bond" the concept is underpinned by the notable Sklar theorem. This theorem posits that the distribution of any continuous random vector can be articulated through the utilization of a copula and the corresponding marginal distributions. In accordance with Sklar's theorem, copula integrates Cumulative Distribution Functions of all random variables, incorporating its own distinctive parameters. This process facilitates the independent and exclusive modeling of dependence between all random variables. In contrast, the marginal functions singularly characterize the shape and scaling aspects, encompassing parameters such as mean, skewness, kurtosis, and the like.

Sklar (1959) demonstrated that every multivariate distribution could be broken down to its marginal distributions and a copula, that links them together. This makes estimating multivariate distributions simpler because it involves estimating the easier univariate distributions and their dependencies (Geenens, 2024).

There are different families of copula like *Elliptical copulas* such as Gaussian and Student-t copulas. *Archimedean copulas*, such as Clayton, Gumbel, and Frank copulas, are used for capturing asymmetric dependence structures by using single parameter. *Extreme value copulas* help in modeling tail dependencies. *Vine copulas* also known as pair-copula constructions help in finding highly flexible dependence by breaking joint distributions into multiple bivariate copulas. Each copula family has discrete properties matched to different types of dependence structures in data.

4. Analysis and results

4.1. Descriptive Analysis

In this chapter, we delve into the complex relation between oil and gold prices, exchange rate, and stock markets across selected Asian countries. Employing a copula-based methodology, this study seeks to uncover the interdependencies and potential co-movements among these critical financial variables, particularly during periods of economic stress. The results provide a detailed understanding of how these markets are interconnected. By analyzing these relationships, we aim to contribute to literature on financial markets linkages and offer valuable inferences for investors, policymakers, and the researchers interested in complexities of emerging markets in Asia.

First of all, descriptive statistics are calculated for each country Pakistan, India, China, Indonesia and Malaysia respectively.

After that correlations were found among oil prices, gold prices, exchange rate and stocks for each country.

Copula Fitting

Copula method is applied on the log returns of data and best fit model for each country describing the relation and linkage of prices of oil and gold and exchange rate with the stock market for each country is determined. Further discussion elaborates the results for each country.

Also, tail dependency is checked for each country with each independent variable to access whether there are chances of the correlation of these variables in the time of crisis**.** Following the analysis of each variable, this section explains the results of different types of copulas that are applied on each variable for each country.

As per rules that one of the five main families of copula is selected with high log likelihood value and low AIC (Akike Information Criterion) and low BIC (Baysian Information Criterion) value that copula will be the best fit for data.

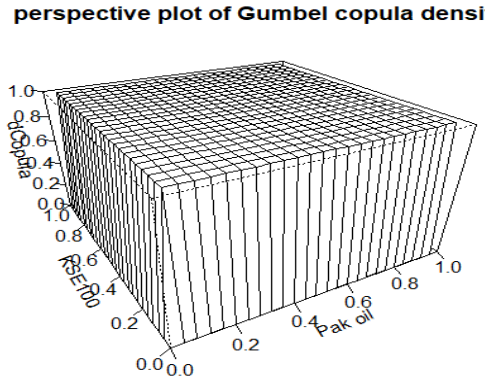
First of all, the impact of Oil, gold and exchange rates on stocks in Pakistan is explained in Table 1.

Table 1: The impact of Oil, gold and exchange rates on stocks in Pakistan

		Gaussian	Student-t	Gumbel	Clayton	Frank
Pakistan	LogLik (df)	0.008	0.073	0.312	0.278	0.106
Gold and stock index		-1	-2	-1	-1	-1
Tau -0.084	AIC	1.983	3.855	1.377	1.444	1.788
Pargum 0.991	BIC	7.373	14.633	6.767	6.834	7.178
ParClay -0.0167	Left Tail	0	8.08E-12	0	0	0
Rho 0.056	Right Tail	0	8.08E-12	0.012327	0	0
Pakistan	LogLik (df)	0.433	1.19	-4.30E-07	0.303	0.378
Exchange rate and stock index		-1	-2	-1	-1	-1
Tau -0.076	AIC	1.134	1.619	2	1.394	1.245
Pargum 0.973	BIC	6.523	12.398	7.39	6.783	6.634
ParClay -0.0368	Left Tail	0	0.341	0	0	0
Rho 0.093	Right Tail	0	0.341	0	0	0
Pakistan	LogLik (df)	1.616	2.023	-9.72E-07	0.874	1.28
Oil and Stock Index			-2	-1	-1	-1
Tau -0.074	AIC	-1.231	-0.0454	2	0.251	-0.56
Pargum 0.964	BIC	4.159	10.733	7.39	5.64	4.83
ParClay-0.0279384	Left Tail	0	4.32E-05	0	0	0
Rho 0.0379289	Right Tail	0	4.32E-05	0	0	0

Pakistan: Linkage between Oil price and KSE 100 index.

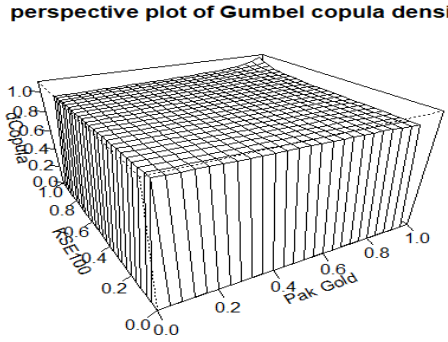
From the table, based on highest log likelihood and lowest AIC or BIC values, as these metrics typically indicate the best fit for the data, we can say that **Student T** copula best fit. The log likelihood value is 2.023and AIC value is -0.045. **Left Tail Dependency** value is 0.000 which means that there is no probability of extreme co movement during a crisis.



Pakistan: Linkage between Gold price and KSE 100 index.

As per table, it could be said that based on highest log likelihood and lowest AIC or BIC values, the best copula for Gold and stock in Pakistan is **Gumbel** with Log likelihood of 0.312 and lowest AIC of 1.376.

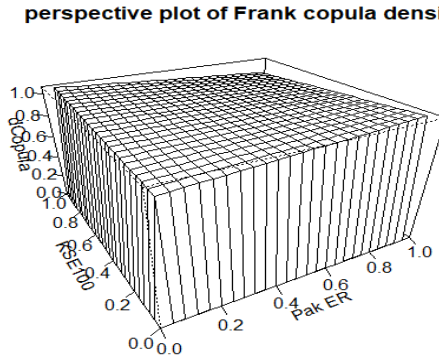
According to table the left tail dependency value will show whether gold and stock for Pakistan will co move in Crisis or not **Left Tail Dependency** value is 0.000008077325 it means that there is a very low or no probability of extreme co movement during a crisis.



Pakistan: Linkage between exchange rate and KSE 100 index.

From the table, based on highest log likelihood and lowest AIC or BIC values, as these metrics typically indicate the best fit for the data, we can say that **Student T** copula best fits. The log likelihood value is 1.191 and AIC value is 1.619.

Left Tail Dependency value is 0.341 which means that probability of extreme co-movement during a crisis is low.



In short we can say that overall there is low probability that these variables will co move with stock simultaneously at the time of crisis in the case of Pakistan. But there are moderate chances that exchange rate might show co movement with stocks during the crisis.

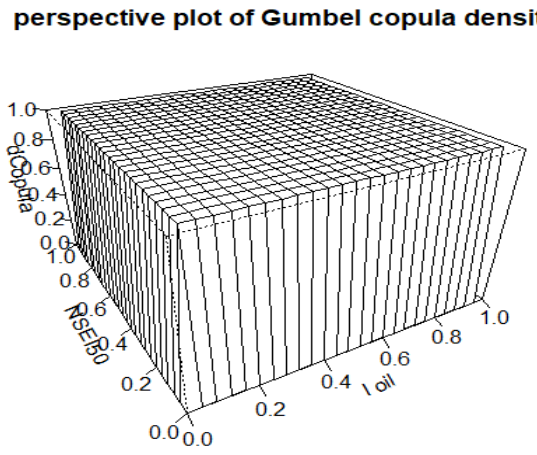
Table 2:

		Gaussian	Student-t	Gumbel	Clayton	Frank
India	LogLik (df)	0.031	0.776	0.599	0.017	0.037
Gold and stock index		-1	-2	-1	-1	-1
Tau -0.067	AIC	1.937	2.447	0.803	1.967	1.926
Pargum 0.891	BIC	7.327	13.226	6.192	7.356	7.316
ParClay -0.026	Left Tail	0	2.84E-04	0	5.76E-29	0
Rho 0.069	Right Tail	0	2.84E-04	0.0164	0.00E+00	0
India	LogLik (df)	0.667	0.604	0.000	1.373	0.654
Exchange rate and stock index		-1	-2	-1	-1	-1
Tau 0.093	AIC	0.666	2.791	2.000	-0.745	0.692
Pargum 0.984	BIC	6.055	13.570	7.390	4.644	6.082
ParClay 0.069	Left Tail	0	0.452	0	0	0
Rho 0.183	Right Tail	0	0.452	0	0	0
India	LogLik (df)	0.246	0.175	0.000	0.076	0.492
Oil and Stock Index		-1	-2	-1	-1	-1
Tau 0.084	AIC	1.508	3.650	2.000	1.848	1.017
Pargum 0.927	BIC	6.897	14.429	7.390	7.238	6.406
ParClay -0.8328	Left Tail	0	1.45E-04	0	0	0
Rho 0.0382	Right Tail	0	1.45E-04	0	0	0

India: Linkage between oil price and NSEI50 index

As per table, we can conclude that the Student T copula is best for these two variables in India. This conclusion is drawn from its highest log likelihood value of 0.175 and the lowest AIC (Akaike Information Criterion) of 3.650.

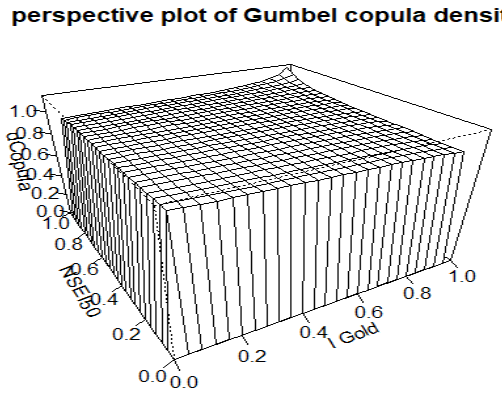
Additionally, Left Tail Dependency value, which is 0.002, indicates that this value is low, it suggests that there is a minimal probability of a strong co movement in India during times of financial turmoil between these variables.



India: Linkage between gold prices and NSEI50 index:

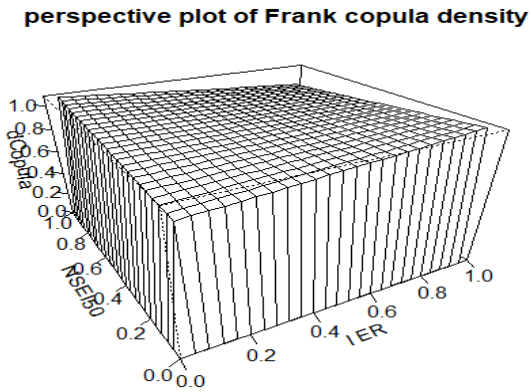
According to the table, Student T copula is best for these variables in India. We can conclude this on the bases of its highest log likelihood value of 0.777 and the lowest AIC (Akaike Information Criterion) of 2.447.

Also, Left Tail Dependency value of 0.001 suggests that there is a minimal chance of a strong co-movement during periods of financial instability.



India: Linkage between exchange rates and NSEI50 index:

Student T copula is best for these two variables based on the table, in India. We can support this conclusion by its highest log likelihood value of 0.604 and lowest AIC of 2.791. The Left Tail Dependency value is 0.452. As the value is quite low, it means a moderate likelihood of a strong co movement between theses variables in India is expected during times of financial instability.



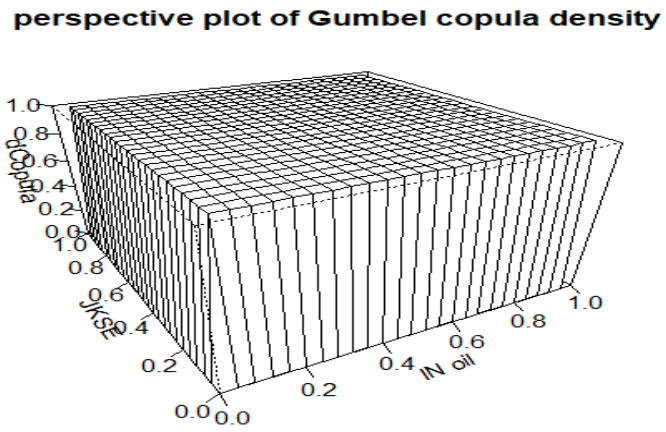
In summary, we can observe that during a crisis in India, there is an overall low probability that these variables will exhibit simultaneous co movement with stock prices. This suggests that, during financial crisis, these variables are unlikely to move in tandem with stock prices. However, there is a moderate likelihood that the exchange rate may demonstrate some level of co movement with stock prices during such crises.

Table 3

		Gaussian	Student-t	Gumbel	Clayton	Frank
Indonesia	LogLik (df)	0.081	0.754	0.000	0.014	0.079
Gold and stock index		-1	-2	-1	-1	-1
Tau 0.0274	AIC	1.837	2.493	2.000	1.972	1.841
Pargum 0.920	BIC	7.227	13.272	7.390	7.361	7.231
ParClay -0.010	Left Tail	0	0.493	0	0	0
Rho 0.775	Right Tail	0	0.493	0	0	0
Indonesia	LogLik (df)	0.131	-0.173	0.000	0.483	0.282
Exchange rate and stock index		-1	-2	-1	-1	-1
Tau 0.274	AIC	1.738	4.347	2.000	1.034	1.436
Pargum 0.900	BIC	7.128	15.126	7.390	6.424	6.825
ParClay -0.087	Left Tail	0	0.457	0	0	0
Rho 0.272	Right Tail	0	0.457	0	0	0
Indonesia	LogLik (df)	0.019	-0.072	0.000	0.000	0.001
Oil and Stock Index		-1	-2	-1	-1	-1
Tau 0.082	AIC	1.962	4.145	2	1.999	1.998
Pargum 0.930	BIC	7.352	14.924	7.390	7.389	7.388
ParClay -0.025	Left Tail	0	1.15E-06	0	0	0
Rho 0.097	Right Tail	0	1.15E-06	0	0	0

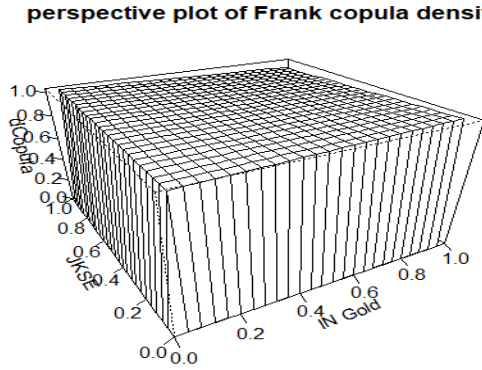
Indonesia: Linkage between Oil prices and JKSE index:

According to the table, the Gaussian copula is the most appropriate model for these variables in Indonesia. This stance is supported by its highest log likelihood value of 0.0189 and the lowest AIC (Akaike Information Criterion) of 1.962. Moreover, The Left Tail Dependency is 0. Since this value is relatively low, it means that talk of a high co movement between variables in Indonesia during cycles of financial volatility is wishful thinking.



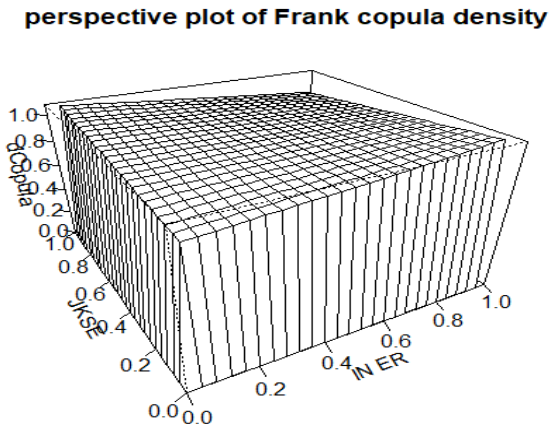
Indonesia: Relation between Gold price and JKSE index:

Out of all the versions of copula function the Gaussian copula is the most appropriate for these two variables in Indonesia. We can say this by its highest log likely hood value of 0. 755 and lowest AIC of 2. 493. Further, the Left Tail Dependency value is 0. 493. As this value is small, it suggests that there is just a moderate significant probability of a strong co movement occurring between these two variables.



Indonesia: Linkage between Exchange rate and JKSE index:

According to the data presented in the table, the Gaussian copula is identified as the most effective model. This is supported by its highest log likelihood value of 0.1309 and the lowest AIC (Akaike Information Criterion) of 1.738. Additionally, the Left Tail Dependency value is 0.456. Although these values suggest a moderate chance of co movement between these variables in Indonesia during periods of financial distress.



In short, there is generally a low likelihood that these all three variables will show simultaneous correlation with stock prices during a crisis in Indonesia. This indicates that, on the whole, these variables are not expected to move in tandem with stock prices during periods of financial distress. However, it is worth noting that there are chances that the gold may exhibit some moderate co-movement with stock during such crises and exchange rates will show a strong co movement with

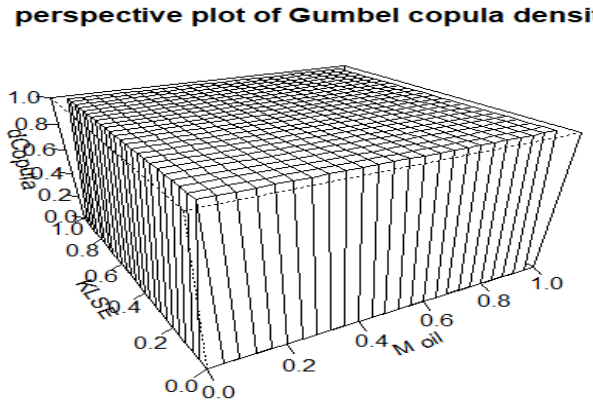
stock during crisis. This suggests that while the tail dependency between other variables and stock prices remains minimal, the exchange rate might reveal a more significant co movement with stock prices during times of economic or financial instability.

Table 4:

		Gaussian	Student-t	Gumbel	Clayton	Frank
Malaysia	LogLik (df)	0.340	0.166	0.471	-0.695	0.253
Gold and stock index		-1	-2	-1	-1	-1
Tau -0.084	AIC	1.320	3.669	1.058	3.390	1.494
Pargum 0.936	BIC	6.710	14.448	6.447	8.780	6.883
ParClay 0.042	Left Tail	0	2.44E-05	0	2.51E-13	0
Rho 0.066	Right Tail	0	2.44E-05	0.016371	0	0
Malaysia	LogLik (df)	0.988	1.085	0.000	1.754	1.038
Exchange rate and stock index		-1	-2	(1)1	-1	-1
Tau 0.064	AIC	0.024	1.830	2.000	-1.507	-0.075
Pargum 0.937	BIC	5.413	12.609	7.390	3.882	5.314
ParClay 0.087	Left Tail	0	0.497	0	0	0
Rho 0.029	Right Tail	0	0.497	0	0	0
Malaysia	LogLik (df)	2.340	2.376	0.000	1.717	2.075
Oil and Stock Index		-1	-2	-1	-1	-1
Tau -0.028	AIC	-2.681	-0.752	2.000	-1.434	-2.149
Pargum 0.994	BIC	2.709	10.027	7.390	3.955	3.240
ParClay 0.039	Left Tail	0	6.12E-04	0	0	0
Rho 0.237	Right Tail	0	6.12E-04	0	0	0

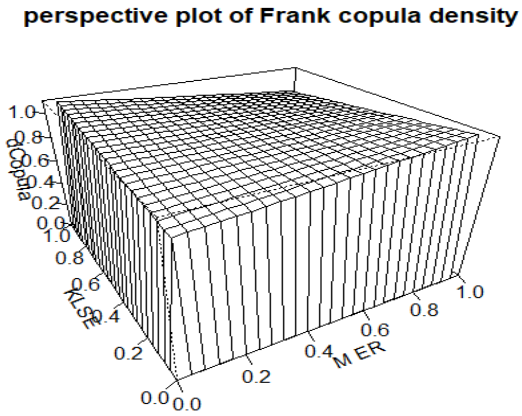
Malaysia: Linkage between Oil and KLSE index:

Linkage between oil and stock in Malaysia is best explained by Student T copula. This conclusion is based on its highest log likelihood value of 2.376 and the lowest AIC (Akaike Information Criterion) of -0.752. The Left Tail Dependency value is 0.000. This value implies a likelihood of no co movement between these variables during periods of financial distress in Malaysia.



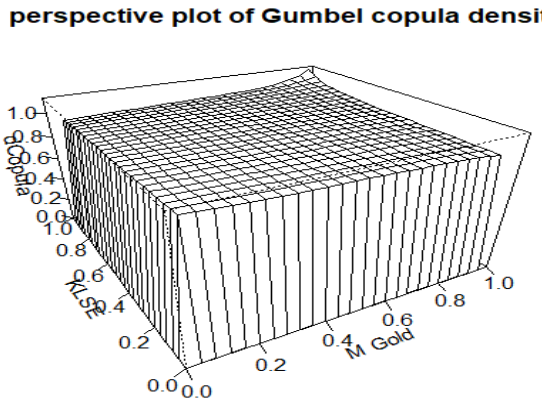
Malaysia: Linkage between Gold prices and KLSE index:

The Gaussian copula is most effective model for examining the linkage between Gold and stock in Malaysia as predicted by the table above. This is evidenced by its highest log likelihood value of 0.340 and the lowest AIC (Akaike Information Criterion) of 1.320. The Left Tail Dependency value is 0. These results indicate no likelihood of any kind of substantial co movement between these variables in Malaysia during periods of financial distress.



Malaysia: Linkage between exchange rate and KLSE index:

As per table the Gaussian copula is the best model for finding relation between exchange rates and stock price in Malaysia. It is evident by its highest log likelihood value of 0.988and the lowest AIC (Akaike Information Criterion) of 0.024. Furthermore, the Left Tail Dependency value is 0.497. These findings indicate a moderate likelihood of a substantial co movement between these variables during periods of financial distress in Malaysia.



Considering the aforementioned analysis, we can conclude that in the context of Malaysia, oil and gold are likely to exhibit no co movement during periods of crisis. But there are moderate chances of co movement between these two variables in Malaysia during financial crisis. And probability of such a co movement occurring is significant, indicating that these two variables tend to move in tandem under economic stress or uncertainty.

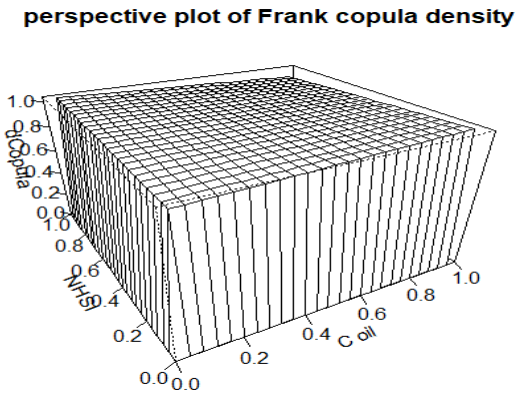
Table 5

		Gaussian	Student-t	Gumbel	Clayton	Frank
China	LogLik (df)	0.075	4.196	0.000	0.309	0.000
Gold and stock index		-1	-2	-1	-1	-1
Tau 0.189	AIC	1.851	-4.391	2.000	1.382	2.000
Pargum 0.994	BIC	7.240	6.388	7.390	6.772	7.390
ParClay -0.046	Left Tail	0	0.466	0	1.62E-08	0
Rho 0.028	Right Tail	0	0.466	0	0	0
China	LogLik (df)	0.058	-0.010	0.157	-0.055	0.163
Exchange rate and stock index		-1	-2	-1	-1	-1
Tau 0.416	AIC	1.883	4.021	1.687	2.111	1.673
Pargum 0.947	BIC	7.273	14.800	7.076	7.500	7.063
ParClay -0.424	Left Tail	0	0.570	0	2.91E-15	0
Rho 0.154	Right Tail	0	0.570	0.008	0	0
China	LogLik (df)	0.260	0.708	0.000	0.163	0.149
Oil and Stock Index		-1	-2	-1	-1	-1
Tau -0.453	AIC	1.479	2.584	2.000	1.674	1.702
Pargum 0.992	BIC	6.869	13.364	7.390	7.064	7.092
ParClay -0.036	Left Tail	0	0.316	0	0	0
Rho 0.032	Right Tail	0	0.316	0	0	0

China: Linkage between Oil prices and HSI index:

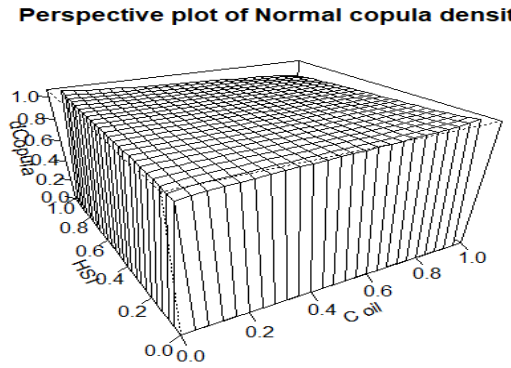
According to the table, the student-T appears to be the most appropriate model for analyzing the linkage between oil and stocks in China. This assessment is supported by its highest log likelihood value of 0.708 and the lowest AIC (Akaike Information Criterion) of 2.584, which suggest that Student-T is accurate for the data.

Additionally, the Left Tail Dependency value is 0.3161122. It's a low value that shows there is very moderate probability of a strong correlation in periods of financial instability.



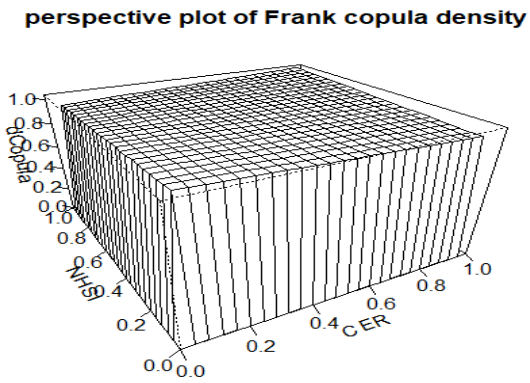
China: Linkage between Gold price and HSI index:

The table indicates that the student-T copula is suitable for investigating the link between these two variables in China. We can conclude this on bases of its highest log likelihood value of 4.196, and the lowest AIC (Akaike Information Criterion) of -4.391. Moreover, the Left Tail Dependency value is 0.466 which suggests that there is a moderate probability of co-movement between them in China during periods of instability.



China: Linkage between exchange rate and HSI index

The Student-T model is the most appropriate for analyzing the relationship between exchange rate and stock prices in China as indicated by table. We can support this conclusion by its highest log likelihood value of 0.011 and the lowest AIC (Akaike Information Criterion) of 4.021. Left Tail Dependency value is 0.571. This value shows a reasonable probability of a co-movement between these variables in China during financial instability.



Building upon the analysis provided, it can be inferred reasonably that in the context of China, there is a good likelihood that all the three independent variables will exhibit co- movement during times of crisis. This suggests that these variables are prone to move together when the economy is under pressure or is periods of significant uncertainty. This indicates that during periods of economic turbulence or instability, the interplay between these assets becomes more pronounced, reflecting their interconnected nature in response to external shocks.

In light of the comprehensive analysis, it can be stated that during times of crisis, the exchange rate is likely to exhibit co movement with stock prices across all the examined economies which are India, Pakistan, China, Malaysia, and Indonesia. This co movement is particularly prominent in the cases of Indonesia and India. Regarding gold prices, the analysis reveals a moderate co movement between the prices of gold and oil in Indonesia, and a notable correlation in China. However, this relationship is expected to be almost negligible in the cases of Pakistan, Malaysia, and India. When examining oil prices, the data suggests that for China there may be a moderate co- movement between stocks and oil prices during periods of crisis. In comparison, stock markets of remaining economies like India, Pakistan, Malaysia, and Indonesia, are not predicted to be significantly influenced by fluctuations in oil prices under similar conditions.

5. Conclusion

Using copula-based models, the study captures the dependency structure between these variables beyond linear correlations, offering a more nuanced understanding of their interrelationships. Copulas are beneficial in this context as they allow the modeling of tail dependencies, which is critical in understanding extreme market movements. The selected Asian economies Pakistan, India, Malaysia, Indonesia and China are examined for their unique financial structures and exposure to global economic changes. In light of the comprehensive analysis, it can be stated that during times of crisis, the exchange rate is likely to exhibit co movement with stock prices across all the examined economies which are India, Pakistan, China, Malaysia, and Indonesia. This co

movement is particularly prominent in the cases of Indonesia and India. Regarding gold prices, the analysis reveals a moderate co movement between the prices of gold and oil in Indonesia, and a notable correlation in China. However, this relationship is expected to be almost negligible in the cases of Pakistan, Malaysia, and India. When examining oil prices, the data suggests that for China there may be a moderate co- movement between stocks and oil prices during periods of crisis. In comparison, stock markets of remaining economies like India, Pakistan, Malaysia, and Indonesia, are not predicted to be significantly influenced by fluctuations in oil prices under similar conditions.

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

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