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Hedge Ratios and Modelling select Global Financial Variables with BRICS.

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Abstract

This paper analyses the dependence structure between select global financial variables and BRICS's stock markets, further calculating the hedge ratios using conditional volatilities thereof. It is taken that the uncertainty in the stock market can be hedged using another class asset in the portfolio.

Relationship between WTI crude oil, Gold, S&P 500, US VIX, US EPU and BRICS's stock markets is studied from 1st January 2008 to 31st March 2020. Quantile Regression is used. VAR- DCC GARCH estimates have been used to calculate the optimal portfolio weights and hedge ratio among the BRICS equity and commodity market. WTI Crude oil is the most significant variable impacting the BRICS's stock markets across all the quantiles. However, the risk measuring indexes US EPU and US VIX do not significantly affect BRICS's stock markets. Among BRICS, Gold and Oil offer the most effective hedge against the volatilities in the South African stock market. A most expensive hedge is provided against the Russian stock market risks. This study analyses the non-constant relationship between the financial variables using quantile regression. This technique takes into account the presence of outliers too. Earlier researches have primarily focused on the developed markets; here the influence of the financial variables on the emerging markets is investigated.

Keywords: BRICS, Quantile Regression, WTI Crude oil, EPU, US VIX, Gold.

JEL Classification: G1, M2

Paper Classification: Research Paper

Introduction

Since the inception of globalization, a greater degree of interlinkage emerges among the economies (Piljak, 2012).Higher the degree of liberalisation in an economy, higher will be the impact of global financial market development (Hayo & Kutan, 2005). Therefore, understanding of financial variables present in the global environment is of paramount importance to any economy. This importance is primarily due to changes in the international environment, which may have a bearing on the investment decisions in the emerging economies, notably the decisions related to the portfolio strategies for the various financial assets. Moreover, the effects of the financial variables on stock markets might have changed over the period.

Therefore, there is a need to realise how global financial variables affect emerging markets,

as the emerging countries are more subject to a global crisis than any country-specific crisis (Kenourgios , Samitas, & Paltalidis, 2011).

The five emerging economies, Brazil, Russia, India, China and South Africa (hereafter BRICS) have gained a higher status in the global economic system. During the financial crisis, when the global growth rate of GNP per capita dropped to 1.7%, the BRICS continued to grow at 5.4% annually. The portion of the BRICS in total world export has improved from just 6% in 1995 to 16.8% in 2015. On the other hand, import has risen from 5.8% to 15.2% in 2015. According to UNCAD, BRICS attracted more than 12 percent of the world FDI during the period 2000-10 almost ¼ of the G7 countries.

Thus, economically BRICS is connecting with the world through increasing international trade, capital flows and market links. These features indicate the growing integration of the BRICS with the rest of the world. It is making the BRICS economy more susceptible to the changes in the global economic environment.

Literature Review

Ahmad et.al. (2013) reported that BRICS were strongly impacted during the Euro crisis period indicating the need to take measures for the contagious countries. Aloui, Aissa, & Nguyen (2011) studied the select emerging markets and the US for financial interdependence using copula functions. The study found stronger dependency between US and price dependent countries with finished product export-oriented markets. Zhang et.al (2013) employing DCC demonstrated the permanent increasing correlation among BRICS and the US after the financial crisis of 2008, thus reducing the diversification benefits.

Hwang et al. (2013) investigated the contagion and herding behaviour between some select emerging markets and the US and determined the factors of channels of contagion. DCC-EGARCH model was employed to study the dynamic correlation among the countries and further Bai and Perron test was applied to identify whether the structural break was occurring or not. The US financial crisis spillover had a different pattern for different countries. Sovereign TED spread and US Credit Default Spread (CDS) representing the risk increased the conditional correlation and increase in variables such as US VIX, information on foreign institutional investors decreased the conditional correlation. Kang & Ratti (2013) showed that US uncertainty index and positive oil market-specific demands shock both indicating higher risk influence stock markets returns. The oil demand shocks lead to variation in the uncertainty index which further accounts for variability in the stock market returns. Besides, the policy uncertainty had hit the returns of the auto and retail sector in the short run and gold sector in the long run.

Miller & Ratti (2009) examined long-run association for 1971 to 2008 between oil and six OECD countries. Vector error correction was utilised by allowing other macroeconomic variables as additional regressors to control short-run influences and introducing structural breaks in the stochastic trend. The study found an overall long-run relationship between real stock price and world oil price but after 1999, a substantial break and reversal sign was visible suggesting a change in the relationship in the last years. Reboredo (2012) concluded the sudden increase in the co-association of oil price and exchanges rates after the financial crisis even though no high dependence was found amid oil prices and rate of exchange. Ono (2011) found an affirmative association amid oil and equity market indices for BRICS except for Brazil. Volatility spillovers were observed between US, EU and BRIC markets and US financial catastrophe had further confirmed this contagion. Hammoudeh et al. (2013) found that among all risk factors, financial risk is the most sensitive element in the economy.They studied BRICS equity markets and the

SP 500. Mensi et al. (2018) analysed BRICS stock markets with the West Texas Intermediate and European Brent oil and gold prices across different frequencies using wavelet squared coherence. The variance and covariance extracted from the wavelet coherence are used to figure out the ratio of portfolio variances with and without co-movement between the markets. The result showed increasing cohesiveness between BRICS and oil at lower frequencies prices after the inception of the financial crisis, gold prices showed no evidence of co-movement with the BRICS.

Choudhary et al. (2015) studied the flight to safety effect among gold prices, LIBOR rates, stock markets return and volatility for the three developed countries through the financial crisis. Granger causality based on correlation integrals was used to assess the causality among the examined variables. The study reported the evidence of casualty among gold and stock market and LIBOR rates suggesting the reducing ability of gold to provide hedge during the financial crisis. Berger & Uddin (2016) measured the equity markets and commodity market index and checked for coherence between economic and equity uncertainty indexes employing wavelet and time-varying copula approach. The result concluded that dependence increases between S&P 500 and policy uncertainty index and S&P 50 and VIX over the longer time horizons. Ciner et al. (2013)explored the relationships among the major asset class for the US and UK during extreme market movement employing quantile regression. The noteworthy finding was that gold was a safe bet against the extreme downside movement of the exchange rate for both the markets. Bouri et al. (2018) probed whether the volatility indices of two strategic supplies (gold and oil) and developed markets forecasted the implied volatility of the BRICS market. Bayesian Graphical Structural Vector Autoregressive was employed to the multivariate time series to uncover the presence of concurrent and lagged casualty through the studied variables. The study pointed out the presence of domestic factors in the elucidation of the variation in the implied volatility of BRICS stock market. Applying time varying copula Wen et al. (2019) assessed the relation between Crude oil futures and emerging stock markets, and further determinants of the dependence pattern were analysed. Overall, positive dependence is found between oil and stock markets indicating the reducing diversification benefits over time. While regression analysis found oil volatility, US EPU and country specifics variables have positive impact on the dependence between oil and stock. Godil et al. (2020) employed Quantile ARDL to investigate the influence of Oil, Gold, US EPU and geopolitical risk on the Islamic securities rather than on conventional securities. The results suggested that oil prices cause difference in behaviour of Islamic and conventional securities under the bullish market conditions while US EPU causes different behaviour in both the securities under bearish market conditions. Hence, Islamic securities can be used for diversification of conventional securities under specific market conditions. Alqahtani et al. (2019) applied ARMA-DCC-EGARCH and time varying t copula model to examine the co-movement between oil uncertainty and GCC stock markets. The results provided the evidence of almost negative linkage between the GCC stock market and oil uncertainty index during the entire sample period. Although, Oman and Bahrain stocks are relatively less sensitive to the movements in oil uncertainty factor offering portfolio diversification benefits across GCC members. Aziz et al. (2020) studied the mean and volatility spillovers between stock and commodity by applying GARCH model. The results showed no volatility spillovers from rice, oil, gas and gold to stock markets while few spillovers were observed in few commodities. Also, neither mean nor volatility spillovers were spotted between gold and equity markets suggesting the scope of portfolio diversification. Zhang et al. (2020) used multivariate VAR-CC-GARCH and VAR-DCC-GARCH models to study the volatility spillovers between oil, gold spot, gold future and Chinese stock and bond. The study discarded the hedging property of gold as gold spot and future had weak correlations with the other variables suggesting gold can be used as diversifier.

From the previous studies, the possibility arises that various global factors present in the environment could impact the economies all over the world. Thus, it would be interesting to study the co-movement between these global variables and BRICS as the financial crisis set on. Quantile regression is used to examine the dependency amid the financial variables and BRICS. Lee & Zeng (2011) used the Quantile Regression to check the influence of oil fluctuations on the stock prices across different G7 countries. The results specifically indicated that the quantile regression had provided significantly different results than the traditional assumptions based OLS technique. Oil prices did influence the stock returns differently during pessimistic or optimistic behaviour of the investors. Nusair & Al-Khasawneh (2018) studied the interactions between shocks of oil and stock market returns of the GCC countries during specific market conditions. The result suggested that in every GCC country except Bahrain, extreme market conditions i.e. bullish and bearish were impacted differently by the oil prices shocks than normal market conditions. Shahjad et al. (2017) explored the requirement between gold, benchmark bonds and ten stock markets using the quantile-on-quantile technique. The empirical findings show that gold-bond and gold-stock did not have a uniform relationship but depend upon the market conditions.

Previous studies ventured to procure evidence of different dependence structure between the stock market and other financial variables. This study further extends the efforts in analysing this non-constant or time-varying relationship between the financial variables using quantile regression, which is a better technique and not yet used extensively. This technique even takes into account the presence of outliers. Secondly, earlier researches have primarily focused on the determinants of advanced stock markets like the US and those of Europe. The more detailed study is needed to investigate the effect of various financial variables on the emerging markets.

Research Methodology

The present study used secondary data for the analysis. The daily closing prices from January 01, 2008, to March 31, 2020, have been taken. This period is considered to examine the effect of the select variables on the stock markets of BRICS countries. The data is used in logarithm returns for the analysis.

List of Variables used

SL.NO	VARIABLE	SYMBOL	SOURCE
1.	WTI CRUDE OIL	LR_C	Quandl.com
2.	Economic Policy Uncertainty Index	LR_EPU	EPU.com
3.	GOLD	LR_G	Gold.org
4.	S&P 500	LR_S&P	MSCI.com
5.	US VIX	LR_VIX	Bloomberg.com
6.	BRAZIL is represented by MSCI BRAZIL index.	LR_BR	
7.	RUSSIA is represented by MSCI RUSSIA index	LR_RUS	
8.	INDIA is represented by MSCI INDIA index.	LR_IND	
9.	CHINA is represented by MSCI CHINA index.	LR_CH	
10.	SOUTH AFRICA is represented by MSCI SOUTH AFRICA index.	LR_SA	

WTI Crude oil, S&P 500, Gold, US VIX and US EPU represent the global market conditions which could influence the international investment decisions, BRICS is considered to be one of the top recipients of the global investment

This study considers the following questions, *what is the dependence structure and co-movement between select global variables and various BRICS stock markets? How different regressors affect dependence structure? Finally, can the WTI Crude Oil and Gold be used to hedge the equity market volatility?*

Quantile Regression

Generally, the OLS technique has been used widely to investigate the impact of variables on the other variables. This approach is based on certain traditional assumptions such as normality of the data, homoscedasticity and linearity in the parameters. Therefore, this technique measures the linear relationship between the variables.

To understand the complicated dependence relationship between variables, a more advanced technique is used here. Quantile Regression relaxes the assumptions of the OLS method as stated earlier.

If y is linearly dependent on x, the τth conditional quantile function of y is specified as:

$$Q_y(\tau/x) = \inf\{b|F_y(b|x) \geq \tau\} = \sum k\beta_k(\tau)x_k = x'\beta(\tau)$$

Where $F_y(b \mid x)$ is the conditional distribution function of y given x. QR coefficient $\beta(\tau)$ examines the dependence relationship between vector x and the τth conditional quantile of y.

If exogenous variables are incorporated, the dependence is unconditional. Otherwise, it is conditional dependence. The dependence structure of y is determined by the value of $\beta(\tau)$ for $\tau \in [0,1]$. The dependence structure of y on the explanatory variable x could be 1) constant if the values of $\beta(t)$ do not change for different values of t 2) monotonically increasing (decreasing) with the value of t 3) symmetric (asymmetric) where the value of $\beta(t)$ is the same for high and low quantiles.

In quantile regression, the aim is to minimize the sum of weighted residuals. The weights are a function of corresponding quantiles represented as $Q_y(\tau|x) = x^T\beta$. Thus, it is minimized

$$\min_{\beta \in R} \sum_{i=1}^{n} (y_i - x_i^T\beta)$$

Analysis

The analysis is presented as follows.

Descriptive statistics

Table 1 presents the descriptive statistics.

Table 1: Descriptive Statistics

	LR_BR	LR_RUS	LR_IND	LR_CH	LR_SA	LR_VIX	LR_EPU	LR_G	LR_S_P	LR_C
Mean	-0.00037	-0.00012	0.00004	-0.00003	0.00019	0.00027	0.00025	0.00018	0.00012	-0.00056
Median	0.00009	-0.00001	0.0000	0.0000	0.0000	-0.00434	-0.01082	0.0000	0.00054	0.0000
Max	0.16619	0.80278	0.80278	0.14059	0.07224	0.76825	3.21568	0.06888	0.10957	0.64535

Min	-0.19434	-0.25593	-0.13254	0.12838	-0.09476	-0.69315	-3.14833	-0.09596	-0.12765	-0.69315
Std.Dev	0.02326	0.02722	0.02505	0.01667	0.01253	0.07733	0.49548	0.01174	0.01294	0.03092
Skewness	-0.62624	7.75832	10.1294	-0.03811	-0.52582	0.96196	0.07036	-0.29989	-0.58076	-0.71226
Kurtosis	11.2516	244.579	331.493	8.62854	5.86276	9.63533	2.07104	6.81928	14.7337	151.217
Jarque-Bera	16993	7965253	1462872	4702.7	1636.89	12800	570.44	6211.7	28960	3032753
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

The highest mean return is displayed by US VIX followed by EPU and South Africa. The WTI crude oil exhibited the least mean return among the variables. The median of all indices is different from the mean return exhibiting the non-normality of each series. The highest volatility is observed in US EPU index followed by US VIX; both the index representing the risk element and lowest volatility is found in Gold. The Global variables except for US VIX and US EPU displayed negative skewness and the country indices except India and Russia showed negative skewness. The measure of kurtosis found all the variables series are leptokurtic. Further, the Jarque-Bera test confirmed that the series are not normally distributed.

Correlation

Table 2: Unconditional correlation

	LR_BR	**LR_RUS**	**LR_IND**	**LR_CH**	**LR_SA**	**LR_VIX**	**LR_EPU**	**LR_G**	**LR_S_P**	**LR_C**
LR_BR	1									
LR_ RUS	0.5 (0.00)	1								
LR_ IND	0.43 (0.00)	0.89 (0.00)	1							
LR_CH	0.40 (0.00)	0.38 (0.00)	0.35 (0.00)	1						
LR_SA	0.17 (0.00)	0.20 (0.00)	0.16 (0.00)	0.38 (0.00)	1					
LR_VIX	-0.43 (0.00)	-0.30 (0.00)	-0.31 (0.00)	-0.21 (0.00)	-0.07 (0.1955)	1				
LR_ EPU	-0.01 (0.67)	-0.03 (0.12)	-0.03 (0.09)	-0.02 (0.20)	-0.04 (0.03)	0.01 (0.45)	1			
LR_G	0.09 (0.00)	0.15 (0.00)	0.10 (0.1065)	0.06 (0.0004)	0.10 (0.00)	0.02 (0.19)	0.00 (0.96)	1		
LR_S_P	0.62 (0.00)	0.36 (0.00)	0.35 (0.00)	0.28 (0.00)	0.11 (0.1418)	-0.70 (0.00)	0.00 (0.91)	-0.03 (0.64)	1	
LR_C	0.29 (0.00)	0.25 (0.00)	0.23 (0.00)	0.14 (0.00)	0.07 (0.00)	-0.19 (0.00)	0.00 (0.89)	0.07 (0.00)	0.23 (0.00)	1

The correlation of WTI crude oil is found to be positive and significant with the BRICS, diminishing the diversification opportunities for investors. US VIX has a negative and significant correlation with the BRIC which has been widely documented in the literature (Chandra & Thenmozhi, 2015; Kumar, 2012). As the uncertainty in the stock market increases (which is symbolised here by the US VIX)the market price of the stock declines. The correlation between EPU and BRIC was not found to be significant, although South Africa has a significant negative correlation with the EPU.

Gold does not significantly correlates with the US VIX rejecting the notion that as the uncertainty in the equity market increases, investors prefer to buy gold. While, Gold exhibited a significant and positive correlation with the country indices, confirming the hedging property of the gold as the literature suggests (Choudhary, Hassan, & Shabi, 2015). The BRIC is positively correlated with the movements in the S&P 500. It means the events which positively influence the US stock market, increases the return in other stock markets also. Crude oil is negatively correlated with the US VIX, providing the opportunity to diversify but crude oil has positive significant co-movements with the S&P 500.

Model Estimation

Models have been estimated for BRICS and compiled in the Tables 3 to 7.

Quantile Regression: Brazil as a dependent variable

Table 3: Quantile Regression Estimates: Brazil

	0.05	.10	.25	.50	.75	.90	.95
LR_C	0.12481 (0.00445)	0.14559 (0.0000)	0.16407 (0.00000)	0.16216 (0.00000)	0.14147 (0.00000)	.0.16498 (0.00000)	0.12478 (0.00849)
LR_G	0.19209 (0.02008)	0.20557 (0.00000)	0.20339 (0.00000)	0.18326 (0.00000)	0.21396 (0.00000)	0.20252 (0.00000)	0.19253 (0.02259)
LR_EPU	-0.00046 (0.82203)	-0.00048 (.64534)	-0.00017 (0.79820)	-0.00034 (0.55009)	-0.00034 (0.63313)	-0.00118 (0.23811)	-0.00109 (0.61188)
LR_S&P	1.7378 (0.00000)	1.15215 (0.00000)	1.01656 (0.00000)	1.02172 (0.00000)	0.94646 (0.00000)	1.00781 (0.00000)	1.02573 (0.00000)
LR_ VIX	0.00761 (0.68572)	0.01548 (0.07868)	0.00661 (0.24023)	0.00568 (0.24626)	-0.00610 (0.33167)	0.00442 (0.61602)	-0.00279 (0.87821)

Quantile Regression: Russia as a dependent variable

Table 4: Quantile Regression Estimates: Russia

	0.05	.10	.25	.50	.75	.90	.95
LR_C	0.22548 (0.00000)	0.19856 (0.00000)	0.19404 (0.00000)	0.16493 (0.00000)	0.19318 (0.00000)	0.15620 (0.00000)	0.12370 (0.00000)
LR_G	0.45997 (0.00000)	0.34098 (0.00000)	0.24385 (0.00000)	0.27195 (0.00000)	0.32489 (0.00000)	0.40099 (0.00000)	0.38530 (0.00000)
L R _ EPU	-0.00309 (0.09958)	-0.00361 (0.00237)	-0.00115 (0.07283)	-0.00063 (0.20160)	-0.00145 (0.02914)	0.00217 (0.0568)	-0.00165 (0.30938)
LR_S&P	0.65518 (0.00000)	0.72881 (0.00000)	0.68249 (0.00000)	0.60594 (0.00000)	0.59589 (0.000000)	0.69093 (0.00000)	0.71462 (0.00000)
LR_ VIX	-0.01812 (0.25916)	-0.00228 (0.82222)	0.00407 (0.48089)	-0.00143 (0.72190)	-0.00571 (0.23341)	-0.00458 (0.38319)	-0.00828 (0.54594)

Quantile Regression: India as a dependent variable

Table 5: Quantile Regression Estimates: India

	0.05	0.10	0.25	0.5	0.75	0.90	0.95
LR_C	0.14736 (0.00020)	0.16363 (0.00000)	0.16884 (0.00000)	0.16263 (0.00000)	0.18404 (0.00000)	0.15625 (0.00000)	0.12582 (0.00000)
LR_G	0.17634 (0.03880)	0.17744 (0.00015)	0.16555 (0.00000)	0.18368 (0.0.0000)	0.23067 (0.00000)	0.24990 (0.00000)	0.29064 (0.00001)
LR_EPU	-0.00129 (0.56751)	-0.00298 (0.01786)	-0.00132 (0.05770)	-0.00058 (0.25414)	-0.00116 (0.09595)	-0.00109 (0.00159)	-0.00178 (0.27159)
LR_S&P	0.65343 (0.00000)	0.58883 (0.00000)	0.63134 (0.00000)	0.54211 (0.00000)	0.47486 (0.00000)	0.54314 (0.00000)	0.57985 (0.00000)
LR _VIX	-0.01572 (0.28108)	-0.01162 (0.15406)	-0.0006 (0.99180)	-0.00415 (0.24338)	-0.01491 (0.00110)	-0.00951 (0.34343)	-0.02217 (0.02338)

Quantile Regression: China as a dependent variable

Table 6: Quantile Regression Estimates: China

	0.05	.10	.25	.50	.75	.90	.95
LR_C	0.06807 (0.00000)	0.03808 (0.00000)	0.04508 (0.00000)	0.0349 (0.00000)	0.03633 (0.00000)	0.02891 (0.00000)	0.01683 (0.00000)
LR_G	0.06732 (0.15075)	0.09241 (0.02452)	0.12085 (0.00000)	0.08143 (0.00000)	0.11127 (0.00000)	0.12748 (0.00077)	0.09105 (0.26455)
LR_EPU	-0.00402 (0.00033)	-0.00074 (0.49942)	-0.00050 (0.41060)	-0.00010 (0.79796)	-0.00067 (0.27559)	-0.00088 (0.28949)	-0.00192 (0.31985)
LR_S&P	0.34728 (0.00001)	0.34758 (0.00000)	0.32510 (0.00000)	0.27065 (0.00000)	0.30926 (0.00000)	0.26608 (0.00000)	0.29552 (0.00526)
LR_ VIX	0.00874 (0.50845)	0.00026 (0.96252)	-0.00549 (0.32779)	-0.00612 (0.06856)	-0.00622 (0.23391)	-0.00639 (0.26733)	0.00238 (0.90084)

Quantile Regression: South Africa as a dependent variable

Table 7: Quantile Regression Estimates: South Africa

	0.05	0.10	0.25	0.50	0.75	0.90	0.95
LR_C	0.03768 (0.00000)	0.05782 (0.00003)	0.02661 (0.00505)	-0.00132 (0.86935)	-0.01011 (0.31518)	-0.02104 (0.00000)	0.02334 (0.22103)
LR_G	0.15982 (0.00040)	0.07561 (0.02384)	0.08154 (0.00001)	0.05582 (0.00001)	0.06360 (0.00094)	0.07671 (0.00389)	0.06926 (0.15488)
LR_EPU	-0.00117 (0.35617)	-0.00194 (0.01829)	-0.00114 (0.02438)	-0.00058 (0.07774)	-0.00042 (0.32437)	-0.00100 (0.12093)	-0.00032 (0.79480)
LR_S&P	0.24519 (0.00000)	0.22552 (0.00000)	0.14660 (0.00000)	0.06229 (0.00001)	0.04031 (0.08100)	0.03824 (0.18304)	0.03753 (0.45086)
LR_VIX	0.02351 (0.01654)	0.02626 (0.00031)	0.00838 (0.02563)	0.00021 (0.94104)	-0.00889 (0.01936)	-0.01122 (0.00091)	-0.00818 (0.46037)

Dependence between BRICS markets and WTI crude oil and Gold

Calculations of Tables 3 to 7 have been used to show the results. Individual countries have been taken to analyse the relationship. In Brazil, (refer Table 3) the WTI crude oil affects the Brazil market significantly and positively in all the quantiles. In the tail regions, the oil impact on Brazil stock is lesser as compared to the intermediate quantiles. This positive dependence is expected as Brazil is the 9thbiggest producer of oil in the world and its rising export is helping the economy to recover itself from the recession (EIA).

Also, Russia is the third major producer of crude oil and more than one-third of the export of the OECD countries comes from Russia. From the results (Table 4), Russia has a positive dependence on the oil across all the quantiles but this dependence decreases with movement to the higher quantiles. In the lowest quantiles, oil has maximum impact on the stock market.

The Indian stock market (refer Table 5) shows a significant and positive dependence on oil prices, it is contrary to the outcomes of (Fang & You, 2014)Fang & You, (2014) where this relationship was found to be negative. This impact is maximum in the intermediate quantiles and least in the upper tail regions. Oil has the least positive significant impact on the Chinese stock among the BRICS. The comovement starts declining as the quintiles go higher (refer to Table 6).

The changes in the oil prices do not impact the South Africa stock in the three upper tail regions (refer Table 7). In the rest of quantiles, the relationship between the stock market and oil was positive and significant. The association amongst oil and stock market changes from positive dependence to negative.

The results for the effect of the Gold on the stock market shows that the dependence between gold and Brazil is significantly positive for all the quantiles (refer Table 3). Further, this dependence structure is uniform in the intermediate quantiles, though the least impact is found in the middle quantiles. Hence, the positive co-movement indicates gold does not provides safe haven benefit against uncertainties in the Brazilian stock price movement. The impact of gold on the Russian stock market (refer Table 4) is significant and positive across all the quantiles. The falling price of gold has the most bearing on the stock market.

Again, this dependency starts increasing in the upper quantiles. Contrarily, the Gold has the least positive significant effects on the Indian stock market (refer Table 5) in the lower quantiles. The same dependence structure has been observed for the Chinese stock market (refer to Table 6). In the upper and lower quantile, gold offers hedging against Chinese stock market risks (weak). In South Africa's case (refer Table 7), the dependence is found to be positively significant in all the quantiles except extreme upper quantiles. The dependent coefficient is similar except in the lower tail regions where the impact of oil is maximum.

Dependence between BRICS and Global stock market

S&P 500 may symbolise the Global stock market (Khalifa et al. ,2014; Hammoudeh et al. ,2008; Harris et al. ,2003). The effect of S&P 500 on the Brazilian stock market (refer Table 3) is found to be positive and significant in all quantiles. The increase in the return for the S&P 500 also increases the return in the Brazilian stock market. The lower quantiles coefficients are different from the rest of the quantiles as the impact starts decreasing. Among the BRICS, the S&P 500 has the highest impact on the Brazil stock market. For Russia (refer Table 4), the effect of the S&P 500 on stock markets is significant and positive in all the quantiles.

On the other hand, the Indian stock market (refer Table 5) has positive comovement with the S&P 500 but it intensifies in the bearish market conditions. China has also a positive significant relationship with the S&P 500 in all quantiles (refer Table 6) but the coefficient decreases during the bullish market conditions. However, South Africa (refer Table 7) is not significantly impacted by the activities in the S&P 500 in the upper tail regions. This indicates that among the BRICS, the global stock market has the least influence on the South African market.

Dependence between BRICS and uncertainty Indices

The EPU index does not significantly affects the Brazilian stock market (refer Table 3) indicating the segregation of the Brazil market from the economic policy uncertainty in the global market. The same has been observed for the Russian stock market (refer Table 4), where no significant relation was found amongst EPU and the Russian market. At the same time, the EPU index has significant affect on the Indian stock market (refer Table 5) only in the 10th and 90th quantiles. The Chinese, South African markets are also not impacted by the variation in the uncertainty policy index (refer to Table 6 and 7). Overall, this means US EPU index does not have any impact on the BRICS.

No dependence is observed between the US VIX and Brazilian stock markets (refer Table 3) for any quantile suggesting increasing uncertainty in the global market does not transfer to the local market. The US uncertainty index does not impact the Russian market (refer Table 4) in any quantile (Sarwar, 2012). The US VIX has a major impact on the Indian market (refer Table 5) only in the upper quantiles where the relationship is found to be negative. It has been detected for India, that the surge in the volatility in the global market shrinkages the stock prices of India.

US VIX does not affect the prices of the Chinese stock market (refer Table 6) across all the quantiles. For South Africa (refer Table 7), the dependence was found for upper quantiles as well as lower quantiles (75th and 90th). The relationship was positive for the lower quantiles and negative for the upper quantile. The negative relationship in the upper tail region specifies that growing volatility in the market forces the investors to sell the equity shares.

Cross Hedge Ratio and Portfolio Weights Results

The VAR- DCC GARCH (1, 1) model has been used to compute the optimal portfolio weights and hedge ratio between the BRICS and commodity market. The uncertainty in the market can be hedged using another class asset in the portfolio. Kroner & Ng (1998) have provided the formula for calculating the optimal portfolio weights using conditional volatilities of the select multivariate GARCH model as follows:

$$w_t^{ij} = \frac{h_t^i - h_t^{ij}}{h_t^j - 2h_t^{ij} + h_t^i}$$

$$w_t^{ij} = \begin{cases} 0, & if\ w_t^{ij} < 0 \\ w_t^{ij}, & if\ \ 0 < w_t^{ij} < 1 \\ 1, & if w_t^{ij} > 1 \end{cases}$$

Where, w_t^{ij} and (1- w_t^{ij}) represents the weight of the stock and commodity asset in a portfolio at time t respectively. h_t^i and h_t^j represent the conditional volatility of the stock and gold/oil market respectively. Further, h_t^{ij} measures the covariance amongst the stock and commodity market returns at time t. Moreover, the estimates from the model can be employed to construct the portfolio hedge ratio between the BRICS stock and commodity market.

The calculated hedge ratio will minimise the risk of the portfolio by taking a long or buy position in an asset (here stock) and a short or sell position in another asset (here gold/oil). (Kroner & Sultan, 1993)have provided the formula for the same as follows:

$$\beta_t^{ij} = \frac{h_t^{ij}}{h_t^j}$$

Table 8: Hedge Ratio Summary

	Mean	St. Dev.	Min	Max
Brazil/Gold	0.29	0.27	-0.49	1.18
Brazil/Oil	0.23	0.16	-0.09	0.86
Russia/Gold	0.34	0.38	-0.92	3.46
Russia/Oil	0.28	0.22	-0.48	1.32
India/Gold	0.32	0.39	-0.92	3.46
India/Oil	0.28	0.23	-0.48	1.32
China/Gold	0.12	0.20	-0.36	0.82
China/Oil	0.08	0.10	-0.29	0.55
South Africa/Gold	0.07	0.13	-0.50	0.67
South Africa/Oil	0.02	0.06	-0.21	0.37

The hedge ratio between the stock market and gold varies from 0.07 to 0.34 (refer to Table 8). The gold offers the cheapest hedge in case of South African stock market. For instance, to minimize the portfolio risk investor should possess one dollar long position in South African equity and 7 cents short position in a gold future contract.

The optimal hedge ratio for the Russian stock market and Gold is indicated to be most expensive such as taking one dollar long position in the Russian stock market and 34 cents short position in Gold future contract. In the case of India equity, the investor should park one dollar long position in the stock and 12 cents short position in Gold.

The hedge ratio between the stock market and oil ranges from 0.02 to 0.28.The oil provides the cheapest hedge to the South Africa stock where the investor should take a long position in oil future worth 2 cents to hedge one dollar of stock. For hedging the Russian and Indian stock, investors ought to take a long position in oil 28 cents. The Chinese stock can be hedged by taking 8 cents long position in Oil.

Table 9: Portfolio Weights Summary

	Mean	St. Dev.	Min	Max
Brazil/Gold	0.79	0.10	0.21	1.00
Brazil/Oil	0.40	0.18	0.00	0.88
Russia/Gold	0.86	0.08	0.38	1.00
Russia/Oil	0.53	0.20	0.00	1.00
India/Gold	0.86	0.09	0.38	1.00
India/Oil	0.53	0.19	0.00	1.00
China/Gold	0.59	0.11	0.12	0.92
China/Oil	0.25	0.14	0.00	0.90
South Africa/Gold	0.50	0.14	0.05	0.95
South Africa/Oil	0.20	0.12	0.00	0.85

The optimal portfolio weights between BRICS stock market and gold differs from 50% to 86% (refer Table 9). The results suggested what proportion of one dollar investor should seek in stock and commodity market. In the portfolio of Brazil stock market and gold, an investor should park 79 cents in stock and 21 cents in the gold. For the Indian stock market and Gold, optimal weights are found to be 14% and 86% respectively. The same weights hold for the Russian stock market and Gold. In the case of Oil, this weight varies from 53% to 20%. For every one dollar invested in South Africa stock market and oil, an investor should invest 80 cents in the South African stock market and 20 cents in the Oil. In the portfolio of Chinese stock market and Oil, the weights are to be 75% and 25% respectively. In the portfolio of Russian and Indian stock market with the oil, 53 cents are ought to be invested in oil for minimizing the risk.

Summary and Conclusion

This study determines the impact of select global variables on the movement of BRICS stock markets. Highest mean return is observed in the US VIX followed by US EPU and South Africa stock market. Volatility is highest in US EPU index followed by US VIX and the lowest is found in Gold. Positive correlation is found between Crude oil and BRICS. Countries indices are negatively correlated with the US VIX but no significant correlation is found with the EPU.

Further, Quantile regression analyses the dependence structure among the variables. Findings suggest that oil should be analysed carefully as it has a significant relationship with all the countries and non-uniform coefficients across the quantiles. The Gold offers weak hedging against Chinese stock market risk in the upper and lower quantile only. The policy uncertainty index exerts no influence on the BRICS in any quantile.

The BRICS stock market moves positively with the S&P 500 movements indicating assimilation of the BRICS with the global market. However, the S&P 500 has no bearing on South Africa stock market in the upper tail regions. The fear gauge index known as VIX has no influence on the BRICS market except Indian markets significant dependence in the upper quantile. The significant dependence was found for upper quantiles as well as lower quantiles for South Africa.

Lastly on calculating the cross hedging, among the BRICS gold provides the cheapest hedge against South Africa equity market while most expensive hedge is provided against the Russian equity market. The hedge ratio amid the BRICS stock market and oil suggested the cheapest hedge against uncertainties in South Africa stock market.

This research is particularly very useful to the police maker, energy traders, risk manager and international investors for portfolio opportunities and hedging strategies. The findings can be used while taking investment decisions regarding two important strategic commodities, crude oil and Gold.

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