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# Comovement between the Stock Markets and Commodity Market

Jahanzeb Marwat[a], Mujeeb-u-Rehman Bhayo[b], Ghulam Abbas[c]

[a]PhD Scholar & Faculty of Department of Business Administration, IBA University & SZABIST University, Larkana, Pakistan. Email: jahanzeb9040@gmail.com

[b]Assistant Professor, Department of Finance, School of Business Studies, Institute of Business Administration, Karachi Pakistan. Email: murbhayo@iba.edu.pk

[c]Associate Professor of Finance, Department of Business Administration, Sukkur IBA University, Pakistan. Email: g_abbas@iba-suk.edu.pk

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**Abstract**

The study extends the literature by investigating the comovement between developed and emerging countries' stock and commodity markets. G7 countries represent developed countries, while the emerging countries are represented by BRICS countries. Further, the Global S&P GSCI commodity index is used for the commodity market, comprising all major global commodities. The daily log returns of all the markets are used for analysis. Further, the wavelet coherence model investigates the comovement between the stock and commodity markets. The results show that the comovement between the stock markets of all the countries increases over time, particularly at the larger frequency scales. The comovement is higher during crises like the global financial crisis and COVID-19. Generally, comovement in the context of developed countries is higher than comovement in the context of emerging countries.

## 1 Introduction

The history of finding associations among various financial markets like the stock market (further termed SMKT) and commodity markets (further termed COMKT) dates back to the formation of formal exchanges. Stocks were initially traded in distinct emerging financial markets, whereas commodities were traded in physical markets. However, globalization and the Industrial Revolution linked financial markets like stock markets and commodities (Dejung & Cohen, 2018; Obstfeld & Taylor, 2003). These markets became even more integrated with the emergence of financial instruments like futures and options, allowing investors to speculate on price movements and manage risk. Some economic events, like the oil crises of the 1970s, highlighted this relationship by showing how shocks to commodity prices spread over the international stock markets (Abul et al., 2012). Further, recent technological advancement, the inclusion of AI, and the emergence of algorithmic trading strengthened this interdependence between these markets, i.e., equity and commodity (Azzutti et al., 2023; Kauffman et al., 2015; Yadav, 2015).

Researchers attempt to investigate the comovements of the commodity market with the stock market over time. The connection between major commodities like precious metals and energy commodities was initially explored in various stock markets. However, with time, other precious metals and agricultural products have also remained the focus of various studies. Moreover, in earlier studies, simple statistical models were employed, and various sophisticated models were also used to investigate the complex relationship between commodities and equities. The previous studies used simple models that could not capture the complex time-varying relationship between the equity and commodity market or considered only major commodity markets like oil and gold. Therefore, the current study aims to provide a comprehensive investigation of the comovement of the equity markets with the commodity market. The current study uses the global S&P GSCI commodity index for the commodity market. This index includes all the global commodities that have a liquid futures market. It includes commodities from the five major sectors: precious metals, agriculture, industrial metals, energy, and livestock. Further, this study employed a time-varying frequency domain model to investigate the association and lead-lag relationship over time between the various equity markets and the commodity index. Considering the differences between developed and emerging economies, the study included the stock markets of both developed and emerging countries.

The results of this study are important for investors, management, and policymakers. First, it enables the investors to make the right decisions regarding portfolio diversification by identifying comovement patterns. Suppose one can determine the times when commodities and equities are synchronized, or periods when these two are on an inverse pattern. In that case, one can better position his portfolio as a means of risk diversification and return maximization. Besides, wavelet analysis offers an understanding of the dynamic characteristics of various market relations. Such details provide the investors with a means of making changes to their investment plans depending on the degree of market correlation when they are at their heightened levels to minimize losses as much as possible.

Secondly, the findings can add value to strategic management planning as companies operating in the commodity production line and the equity markets can use such findings to predict the market and make the right decisions. In other words, appreciated by a firm to hedge its exposure to a commodity may demand comprehension of how fluctuant the pricing of the commodity influences stock returns over varying time scales. Besides, management

can use the comovement information to forecast effects that may be occasioned by changes in commodity prices on their financial statements for improvement in budgeting and financial forecasting.

Third, the study is useful for policymakers to develop effective policies to maintain market stability and safeguard investors. Governments and other organizations may benefit from wavelet analysis results in knowing the comovement structure between commodities and stocks. If it is high, then it is an indication of systemic risk. This facilitates putting policies in place for the management of markets to contain the effect of economic shocks on other related markets. Moreover, based on the lessons learned from the comovement patterns, one may add the knowledge that can help design appropriate regulatory measures for market fluctuations and investor security. Officials can, therefore, develop measures to protect the market during the period of high interaction of these markets.

## 2 Literature Review

The link between stock markets and commodity markets depends on several factors: economic, investor, and overall economic factors. Major commodities like gold, grains, and crude oil are globally traded, associated with a country's economy, and influence stock market prices (Mensi et al., 2015). Hence, fluctuations in the prices of key commodities, changes in the cost structures, and consequently, the profit margins of companies employing or utilizing those commodities are also likely to occur (Ahmadi et al., 2016). For instance, high inflations in the price of oil cause operational costs in transportation and manufacturing industries to rise, which may affect their profitability. On the other hand, companies engaged in oil exploitation or mining companies might see their stock prices increase as the prices of the respective commodities increase (Nasreen et al., 2020).

On the same note, investors' activities also help connect the stock market and commodity markets. During crisis periods or economic downturns, many people are willing to purchase commodities believed to be safe havens, like gold. This act enhances the demand for these commodities, which also influences the prices of stocks (Sheikh et al., 2020). On the other hand, when there is a good economic condition, investors are willing to buy stocks due to their confidence in them. Consequently, few investors may shift from commodities back to stocks due to increased returns (Siegel, 2021). These interactions may

create observable comovement characteristics whereby the conditions of one market influence investors' perceptions and actions in another.

In addition, any changes in the rates of inflation, interest, and other geopolitical forces, in turn, influence stock and commodity markets independently. Inflation can reduce corporate earnings and, thus, corporate profits and act to limit consumers' buying capacity and, therefore, affect stock markets (Sugito et al., 2018). Nevertheless, products such as gold and oil prices tend to rise during periods of higher inflation because investors use them as a hedge against inflation. Further, at the time, higher economic policy uncertainty and geopolitical risks can also affect the supply chain of some products, especially commodities, elevate their price and enhance the volatilities in the stock markets (Ding & Zhang, 2021; Ozkan et al., 2024)

## 2.2 Empirical Research

The broader review of studies from various decades is summarized in the discussion below. Most studies examine the macroeconomic effect of major commodities like oil and gold prices at the earlier stages. For example, Sargent (1976) documented a significant impact of higher oil prices on various macroeconomic indicators. Vincent et al., (1979) and Arndt (1979) also examine the association of oil prices with the macroeconomics of Australia and Indonesia, respectively. Van Duyne (1979) also found the significant macroeconomic effect of various commodities. Dusak (1973) explored the risk premium of the Future market of a few agricultural products and found that speculators are unable to get risk premium in the future market. Markham and Gilberg (1982) examined the association between stock and commodity options and highlighted contradictions between the two markets.

Researchers started examining commodity prices' connection with equities' market performance in greater detail during the 1980s. Hamilton (1983) examines the relationship of shock in oil prices with the US economy, showing significant spillover effects from shifts in economic activity on stock markets. Through his work, a direct connection was made between the fluctuations in commodity market prices and the status of the economy to which stock markets respond. Pindyck (1983) examines commodity markets' volatility and unpredictable nature and how they affect the financial system and the larger economy. Through his research, Pindyck (1983) brought attention to how fluctuations in commodity

prices can enhance market uncertainty and impact stock prices and investor behavior. Further research was being done to specifically examine how these markets were integrated. For example, Roll (1988) examined the relationship between changes in the market price of crude oil and the performance of equity markets, highlighting the direct effect of oil prices on the level of the market price of those companies that rely on energy.

Few studies expand the scope of the research about the connection of the stock markets with the fluctuations in market prices of commodities by cross-comparison of various countries and commodities. A few major studies including Jones and Kaul (1996) attempt to investigate the cross-countries comparison of stock market reaction towards the fluctuations in oil prices. They found significant differences among various countries. Bodie (1983) explored the hedging ability of commodity futures. Their findings highlight that commodity futures can be used to hedge inflation, influencing portfolios of various stocks. Gorton and Rouwenhorst (2006) compared the market performance of commodity futures with the market returns of specific equity markets and bonds markets. Their findings describe the key basis for association among the market of commodities, stocks, and bonds. Similarly, Erb and Harvey (2006) also investigate the diversification ability of the commodity market against the stock market risks and argue that the commodity market can diversify the market risk of stocks. Geman (2005) defines the commodity as a new asset class and provides a comprehensive analysis of comparison among various commodities and also their comparison with the commodity derivatives.

The commodity markets are associated with the emerging countries's stock markets as well as the stock markets of developed countries. For example, Cong et al., (2008) investigated the association of changes in the stock market of China with the price volatility of crude oil. They found a significant influence of the oil price fluctuation on the stock market performance of China. Similarly, Kilian and Park (2009) documented a significant commodity market's impact on the stock market returns of the US. Park and Ratti (2008) found the impact of oil prices is significant on the selected European stock markets along with the stock market of the US. Basher and Sadorsky (2006); Khan (2023) consider various emerging countries and found a significant association of oil prices with the stock market performance of emerging countries. Jhunjhunwala and Suresh (2024) find the same relationship in India. In short, various studies compare the impact of various commodities on the stock market of various countries. Many of the studies observed a significant impact

on the stock market of various COMKTs like oil prices, gold prices, and other major commodities. However, the nature and intensity of impact varies across the countries.

The connection of the SMKT movements with the changes in market prices of commodities revisited by researchers multiple times with the use of more sophisticated econometric models to find further insights. Initially, studies such as Bodie (1983) and Gorton and Rouwenhorst (2006) used correlation analysis to find the association between the price movements of the SMKT and the changes in the prices of commodities. However, Erb and Harvey (2006) contribute to the literature by assessing the long-term equilibrium between the SMKT and bond market by using the cointegration model. Similarly, Sadorsky (2012); Mignon (2013) analyze the volatility spillover between SMKTs and COMKTs by using the GARCH models. Mensi, Hammoudeh, and Yoon (2014) explore additional insights about the influence of different market states on tand he connection between the SMKT and COMKT by utilizing regime-switching models. Ferrer et al., (2018) explore the complex connection between the equity and COMKT in the time-frequency framework by wavelet analysis. Few studies like Ji et al. (2018); Enilov et al. (2023); Kaur and Chaudhary (2024) used the network analyses to examine the volatility transmission among various SMKT and specific commodities.

The nature and structure of the connection between the SMKT and COMKT vary from country to country. Literature explored various dimensions of the comovement between the SMKT and COMKT in developed and emerging countries. The findings of some major studies are summarized in the following discussion.

Mensi et al. (2013) examine the return links and volatility transmission between the S&P 500 and energy, food, gold, and beverage price indices. Their findings indicate that volatilities are transmitted between the S&P 500 and the various commodity markets. Specifically, the past price shocks of the S&P 500 influenced variations of the oil and gold prices significantly. Their findings also show that the maximum conditional correlation exists between the gold index and the S&P 500 index and between the S&P 500 index and the WTI index. Boyrie and Pavlova (2018) estimate the association of equity markets and commodities while focusing on the distinction between emerging and developed markets. They found that specific emerging market equities are categorized into two groups: the first group is equipped with an index with a much lower correlation with commodities than the

developed markets, while the second one comprises Latin American equities with a higher correlation with commodities. In addition, diversified opportunities in agricultural and precious metal-based commodities are higher in the less developed markets.

A regime-switching model is employed by Demirer et al., (2015), to analyze the herd behavior of many sectors in commodities, including "energy, metals, grains, and livestock". They focused on the comparison of various states of market volatilities. Their findings show that during the high volatility state, the grains show significant herding behavior. Further, they argue that great price fluctuation especially in the energy and metal market plays a crucial role in the triggering of herding phenomena in the grain market. Vardar et al., (2018) investigate and identify the transfer of shock and volatility in daily stock market indices of the selected developed and emerging countries concerning five major commodities prices including crude oil, natural gas, platinum, silver, and gold. They concluded that in both the developed and under-developed countries, the effects are two-way volatility transmission between SMKT and the COMKT. Further, there is lower of unilateral volatility effects running from the COMKT to SMKT and substantial unilateral volatility effects originating from the SMKT to the COMKT in specific countries.

Sampurna and Maronrong (2019) point out the impact of the commodity price index on the Sharia stock market in developed and developing countries' volatilities. They defined commodity prices with the help of world oil and gold prices. Four Sharia stock market representations are known as "Indonesia Sharia Index (ISSI), FTSE Bursa Malaysia Hijrah Sharia Index (FBMHS Index), S&P Japan 500 Sharia Index (SHJ Index), and S&P 500 Sharia Index (SHX Index)". The authors documented that the nominal rates of the commodities substantially affect the stock prices. They also argue that commodity prices have the potential to predict stock prices in developed and developing countries.

Ali, Bouri, Czudaj, and Shahzad (2020) investigate the safe-heaven, hedge, and diversification characteristics for 21 commodities from different commodity categories for 49 SMKTs of various countries with different development levels of the global economy. According to their studies, proven hedging and safe-haven functions for particular commodities are confirmed in developed markets. Urom et al., (2021) argue that the results mainly depend on the type of commodity and country, thereby implying that the maximum benefits would have to be obtained using each stock market index together with the most

compatible commodity index. Mensi et al., (2021); Mezghani et al., (2023); Zghal et al., (2024) documented that mixed portfolio of COMKT and SMKT offered a higher hedge ratio for emerging as well as developed markets. Further, Shah, and Dar (2021), Mezghani at al. (2021), Amoako at al. (2022), Agyei and Bossman (2023), Lou, Xiao, and Lian (2024) also validate the diversification and hedging between the stock and commodity markets

Stoupos and Kiohos (2021) explore whether post-2008 comovement exists between the energy markets and five selected developed stocks. They considered some specific commodities related to Oil and Gas. Generally, their results provide very supportive evidence that oil and gas price fluctuations significantly influence the developed stock markets in the long run. Each stock index shows great model inflexibility to the long-term volatility responses of each energy commodity. Chang and Fang (2022) aim to analyze the effects of some other specific commodity indices including "crude oils, precious materials, livestock, and agricultural products" on China's stock market indices. Their findings show that there is a positive association exists between the commodities and the performance of the Chinese stock markets

Enilov et al. (2023) assessed the relationship of the global price of various commodities with the domestic markets. Their findings reveal that a time-varying causality is present among the markets that mainly depend on the level of the country's development. Urom et al., (2023); Woode et al., (2024) analyze the comovement of specific African stock markets with some global commodities. Further, they also considered the effects of the COVID-19 pandemic. They discover that, despite the selected equity markets, they show low integration with these commodities. The integration coefficients among the markets rose during the pandemic period. Billah et al. (2023) find the tendency to intensely correlate the prices of various commodities to the market returns of companies that engage with businesses of food and beverages. In this case, they conclude that the association of market prices depends on the size of the opposite shock. Further, the findings are also sensitive to extreme values, and the findings on both extremes are different compared to the entire sample estimation. This argument was validated by Lu, Zhang, Apergis, and Roubaud (2024) and Qin et al., (2024).

The literature also explored the effect of COVID-19 on the connectedness between SMKT and COMKTs. Li at al. (2021) examine the connectedness among various COMKTs

and financial assets in the context of US and China during the period of COVID-19. Adekoya and Oliyide (2021) found evidence that COVID-19 drive connectedness among various COMKTs and SMKTs. Mishra at al. (2023) explored the connectedness during COVID in the context of India and found significance influence of the pendamic. Similarly, Bouri at al. (2021); Umar, Jareño, and Escribano (2022), Qi at al. (2022), Farid at al. (2022), Apergis et al., (2023), Iqbal at al. (2024) also found the significant influence of the COVID-19 on the connectedness among various markets.

The findings of the literature can be summarized as the comovement between the SMKTs and COMKTs increasing over time. Literature explored various short-term and long-term linkages between the mentioned markets in various countries. Further, the literature investigated the relationship between SMKT and COMKTs through various sets of models. Overall, the literature concluded that there are significant linkages between the SMKT and COMKT.. However, the nature and intensity of the relationship depend on various factors, like the type of commodity, the level of development of the stock market, and other macroeconomic factors. Different commodities can diversify the risks of various stock markets. Besides all these findings of the literature, some areas are overlooked. For example, literature used specific commodities like oil, gold, and grains while overlooking the effect of other commodities. Further, literature overlooked comparing the comovement between the developed and emerging countries in a time-frequency space with lead-lag relationships. Therefore, the current study considers comparing the comovement between the stock and commodity markets in the context of developed and emerging countries. Further, the study measures the commodity prices through a commodity index that comprises all major global commodities.

# 3 Methodology

The study used daily historical data on the SMKT and COMKT. The Global S&P GSCI commodity index is used for the COMKT.. This index includes all the major global commodities with a liquid futures market. It includes commodities from the five major sectors: precious metals, agriculture, industrial metals, energy, and livestock. Further, for the developed countries, the stock markets of G7 countries are considered, while for the emerging countries, the stock markets of BRICS countries are included. The infrastructure and economic policies of developed and emerging countries are different. Therefore, the nature of the association between the markets can be different. Hence, this study focuses on

comparing developed and emerging countries. The list of stock markets is provided in Table 3.1. The log-returns of the commodity and equity markets are obtained for empirical analysis.

**Table 1: List of stock Markets**

| Country | Equity Market |
|---|---|
| Canada | S&P/TSX Composite Index |
| France | MSCI France |
| Germany | DAX 30 |
| Italy | MSCI Italy |
| Japan | TOPIX /Nikkei 225 |
| UK | MSCI UK |
| US | S&P 500 |
| Brazil | Brazil Bovespa |
| Russia | MSCI Russia |
| India | MSCI India - Price Index |
| China | Shanghai SE Share - Price Index |
| South Africa | FTSE South Africa - Price Index" |

## 3.1 Wavelet Analysis Model

The study investigates the comovement through the bivariate technique of wavelet coherence. Wavelet analysis provides the relationship between time series data in time-frequency space and allows the non-stationary and non-normality of the data (Grinsted et al., 2004). Therefore, Wavelet analysis is more potent than linear econometric models that only work for normal or stationary data. Further, the technique provides point-by-point phase relationships showing which variable is leading or lagging at a specific time point. Due to these characteristics, the wavelet coherence model has the advantage over other time series comovement models like simple correlation, partial correlation, conditional correlation, and other causal effect models. Further, the wavelet coherence model provides both short-term and long-term comovement in the time-frequency space. So, the wavelet coherence model is appropriate for analyzing the comovements of financial markets with high-frequency data (Ozkan et al., 2024).

Further, the wavelet coherence model provides both short-term and long-term comovement in the time-frequency space. So, the wavelet coherence model is appropriate to analyze the comovements of financial markets with a high-frequency data (He at al., 2023):

$$R_t^2(s) = \frac{|M(s^{-1}W_t^{KL}(s)|^2}{M(s^{-1}|W_t^K(s)|^2).\ M(s^{-1}|W_t^L(s)|^2)}$$

In the equation, M is a smoothing operator that is obtained as S(W) = $S_{\text{scale}}(S_{\text{time}}(W(s)))$. The significance of the wavelet coherence is checked through Monte Carlo methods.

# 4 Results

## 4.1 Trends and Descriptive Analysis

The trends and descriptive analysis provide the nature and structure of the data distributions. The descriptive statistics of the market returns are summarized in Table 3. The table shows that the mean returns of all the markets are buoyant and fluctuate between the minimum and maximum values over time. Among the developed countries, the US equity market shows the highest average returns, i.e., 0.04%, while the equity market of Italy shows the lowest average daily returns, i.e., 0.016%. Conversely, among the emerging countries, the Russian equity market has the highest daily market returns, whereas the Chinese equity market has the lowest daily market returns. Among all the equity markets, the Brazilian and Russian equity markets show the highest standard deviations, which means they have the highest uncertainties.

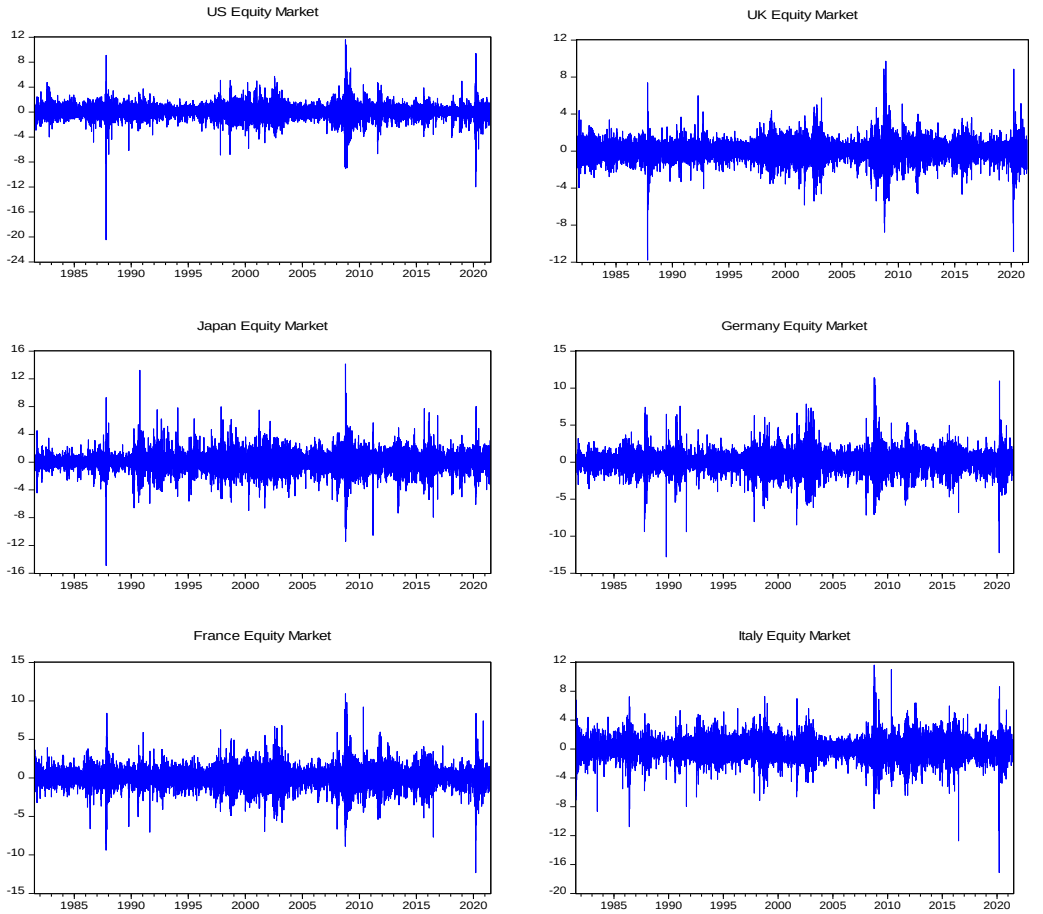
**Table 2 Descriptive Analysis**

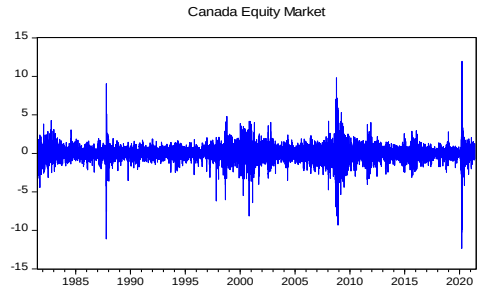
| | Mean | Median | Std.Dev. | Skewness | Kurtosis |
|---|---|---|---|---|---|
| US | 0.04 | 0.035 | 1.182 | -0.195 | 14.035 |
| UK | 0.017 | 0.015 | 1.122 | -0.171 | 10.823 |
| JAPAN | 0.016 | 0 | 1.433 | -0.12 | 9.074 |
| GERMANY | 0.039 | 0.057 | 1.432 | -0.074 | 8.883 |
| FRANCE | 0.029 | 0.029 | 1.347 | -0.076 | 9.256 |
| ITALY | 0.016 | 0.013 | 1.462 | -0.314 | 10.876 |
| CANADA | 0.028 | 0.05 | 1.058 | -0.689 | 19.719 |
| BRAZIL | 0.07 | 0 | 2.044 | 0.835 | 23.297 |
| RUSSIA | 0.073 | 0.054 | 2.576 | 0.172 | 18.259 |
| INDIA | 0.048 | 0.035 | 1.428 | -0.333 | 11.611 |
| CHINA | 0.038 | 0.012 | 1.663 | 0.806 | 29.542 |
| South AFRICA | 0.044 | 0.014 | 1.205 | -0.455 | 9.795 |
| COMMODITY_MARKET | 0.021 | 0.013 | 1.24 | -0.494 | 11.763 |

*The trends analysis of all the markets is presented.. The figure shows that the daily returns of SMKT of all the markets are closer to their average values. However, there are some extreme values where the market jumps ups and downs higher. Therefore, the data is winsorized by 1% at both ends to remove the outliers.*

Winsorization is one of the statistical methods that is commonly used to work with the extreme values of the data (Cheng & Young, 2023). This method warrants the replacement of the first and the last observation with the correspondingly specified percentile. Thus, winsorization preserves the shape of the distribution by removing only the values that can significantly affect the results of further analysis. It is most popular in cases of statistical processing of financial data under which the presence of an outlier substantially distorts the value of mean and standard deviation. Winsorization is useful for keeping robust and reliable statistical outcomes, although it does not remove all outliers, only those up to the selected percentile

**Figure 1: Trends of all Markets**




Canada Equity Market
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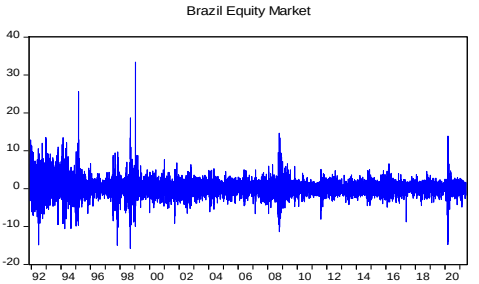
Brazil Equity Market
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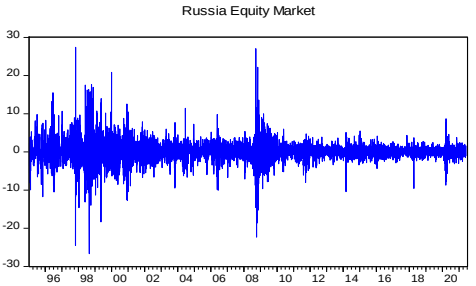
Russia Equity Market
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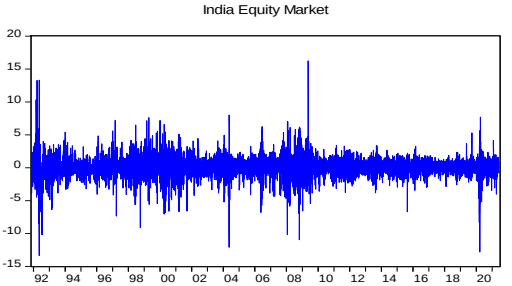
India Equity Market
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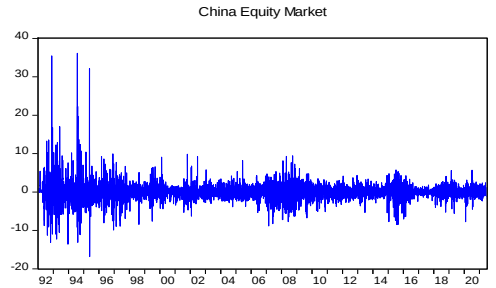
China Equity Market
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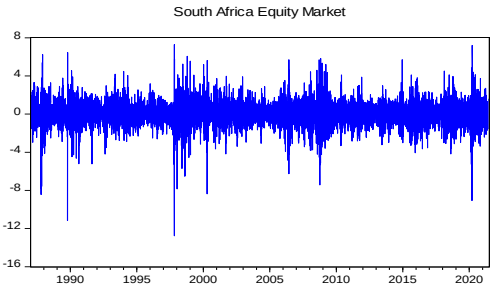
South Africa Equity Market
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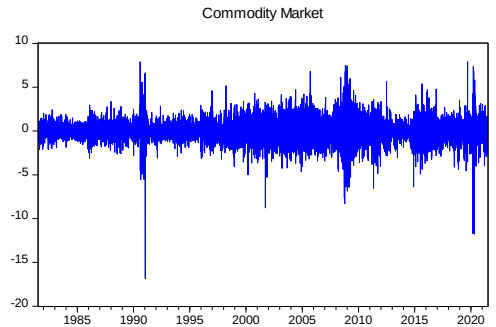
Commodity Market
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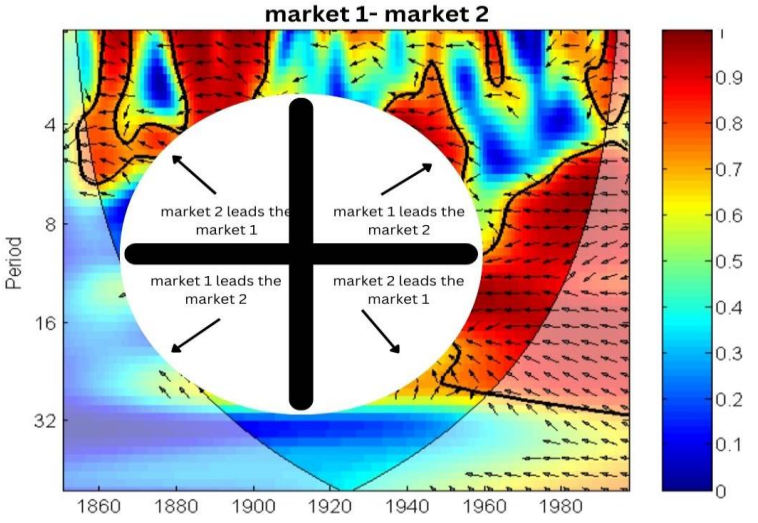
## 4.2 Wavelet Analysis

The results of wavelet analysis are presented in two-dimensional figures. The vertical axis represents the frequency of periods, whereas the horizontal axis shows the time. The frequency scale generally ranges from 0-1024, divided into sub-ranges, including 0-4, 4-16, 16-64, 64-256, and 256-1024. The red and blue contours indicate the highest and lowest correlation or comovement between specific markets, respectively. The intermediate levels of comovement are labeled with yellow and green colors. The range for the highest correlation is 0.7-0.9, whereas the range for the lowest is 0-0.3. The colored contours with solid-black borders represent that the comovement or correlation is significant at the 5% significance level, estimated from the Monte Carlo simulations. The direction of correlation (positive or negative) and lead-lag connection between any pair of asset markets of any specific country is represented by arrows. The arrows pointed to the right (left) represent the positive (negative) correlation. The arrows pointed upward, right-upward, and left downward indicate that the first market leads the second market in a particular pair of markets on a specific spot of the time-frequency space. In contrast, arrows point downward, left-upward, and right-downward, representing that the second market is leading the first market in the particular time-frequency frame, as shown in Figure 3.1.

**Figure 2 Arrow Directions of Wavelet Coherence**



The results of the comovement between the stock market and the commodity market are shown in Figure 4.3. The figure shows that the comovement substantially higher in all the countries during the crisis periods such as global financial crises and COVID-19. This finding is aligned with the argument of Creti et al. (2013), who state that the comovement between the stock market and the commodity market increased due to the financialization of commodities, particularly after the global financial crises. Further, the comovement varies with time horizon and frequency scale.

The comovement is higher in the developed countries compared to the emerging countries. Among the developed countries, France and Germany show higher comovement. In contrast, the US and Canada show a lower comovement between the money and the stock market than the other developed countries. On the other hand, among the emerging countries, China and India show lower comovement between the markets except during global financial crises where the comovement is higher in both the countries. The direction of the comovement is positive in the context of almost all the countries. The major reason for this positive change can be international trading, as many commodities are traded in international markets. Therefore, the prices of commodities can be influenced by global economic events and geopolitical factors. These same events can also impact the countries' stock markets, particularly those heavily involved in global trade. For example, disruptions in oil supply due to geopolitical tensions can lead to higher oil prices, which can, in turn, impact both energy company stocks and broader stock market indices.

The nature and intensity of the comovement at each time-frequency point differ across countries. The unique nature of the comovement between the stock market and commodities can be attributed to the unique policies and government responses to various domestic and international events. The section below provides A detailed description of each country is comovement.

In the context of the US, the nature and intensity of the comovement between the stock market and the commodity market vary over time and frequency scales. The comovement is lower and highly volatile at the lower scale, 4-16 days and 16-64 days. At the higher frequency scales, i.e., 64-256 and 256-1024, the comovement is very high (red contours) during 1998-2002, 2007-2014, and 2020-21. The comovement is mostly positive, and the stock market is leading (as the arrows point right-upward). However, at specific points

during 1998-2002, the comovement was negative, and the commodity market was leading the stock market.

In the context of the UK, the comovement is also lower and highly volatile at the shorter frequency scale. At the larger frequencies 64-256 and 256-1024, the comovement is significantly higher during 2007-2014 and 2020-21. The direction of the comovement is positive over each scale and time, and the equity market is leading the commodity market. Similarly, the comovement between Japan's equity and commodity markets is significant at scales 4-16 and 16-64 but frequently changes over time. The comovement became comparatively stable and higher during 1998, 2008-12, and 2021 at scales 64-256. Overall, the comovement increased from 2008 to 12 and 2020 to 2. In Japan, the direction of comovement is also positive, and the equity market is leading the commodity market.

The stock market of Italy also shows a time-varying comovement with the commodity market. The comovement is comparatively higher during 2007-14 and 2020-21 over each frequency scale. However, at a lower scale, the comovement is volatile. The arrows point towards the right side representing the in-phase or positive comovement between the stock and commodity markets. Similarly, the comovement between the German stock market and the commodity market was also higher and more stable during the various crisis periods. For example, the comovement was higher during the period 2008-14 and 2021, representing the periods of global financial crises and COVID-19. However, during 2008-14, the commodity market is leading. However, in 2021, the stock market is leading the commodity market. The comovement is highly volatile at frequency scales 4-16 and 16-64. Overall, the comovement is positive except 1990-91 where the comovement is negative.

The comovement in France's stock and commodity markets is higher during 2009-14 and 2021 at the scale of 4-16 and 16-64 days. During 1990-93, 1998-2002, 2008-14, and 2020-21, the comovement is comparatively stable at the frequency scale of 64-256. The comovement is found in-phase over each frequency scale and time, and the stock market is lading except 1990-93, where the comovement is out-phase, and the commodity market is leading. Similarly, the comovement rate in Canada's markets increased after the global financial crisis. On the higher scales 64-256, the comovement showed a substantial increase after 2007. The comovement was also significant at the frequency scale of 1024 from 1993

to 2003 when the commodity market was leading. The comovement is positive except during 2001-03 at 256-day scale where the comovement is negative.

**Figure 3 Wavelet Coherence between Stock and Commodity Market**

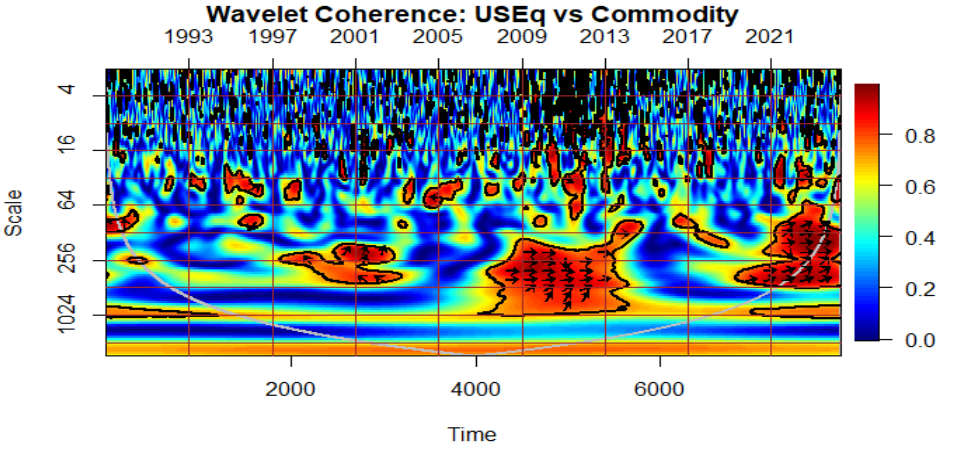



**Figure 4 Wavelet coherence between Stock and Commodity Market**

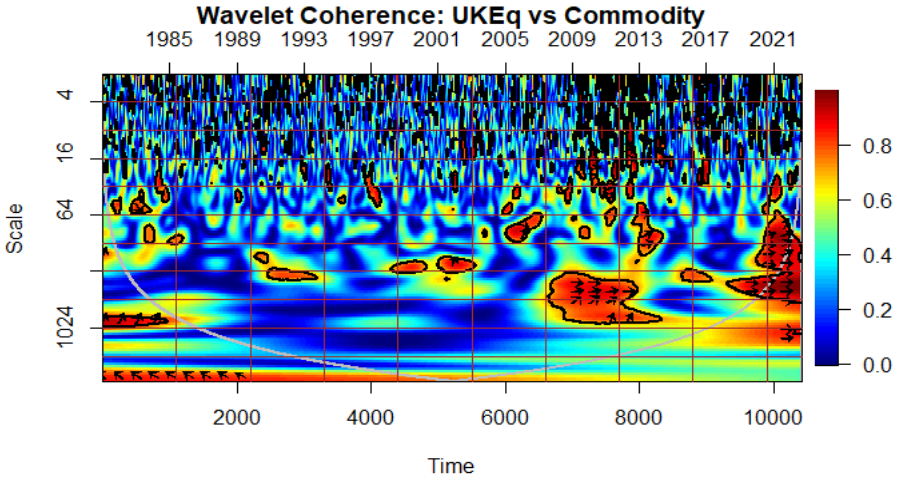


**Figure 5 Wavelet Coherence between Stock and Commodity Market**

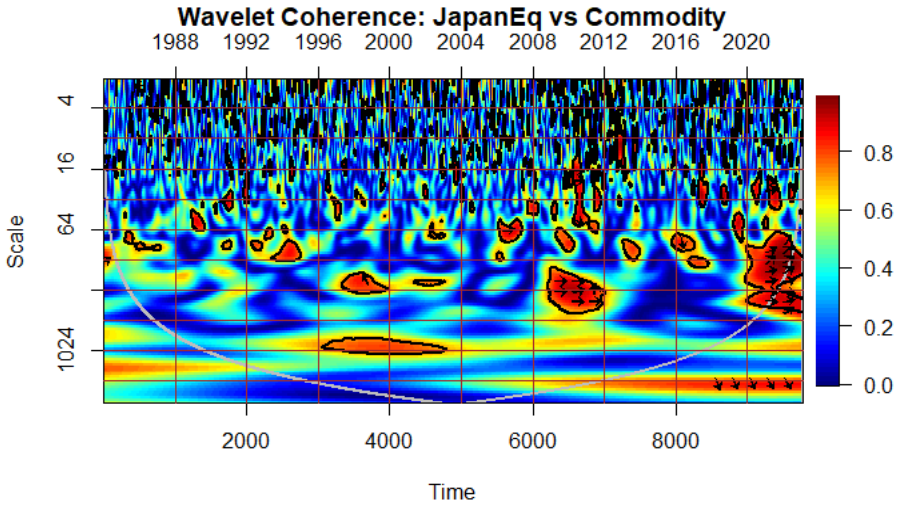



**Figure 6 Wavelet Coherence between Stock and Commodity Market**

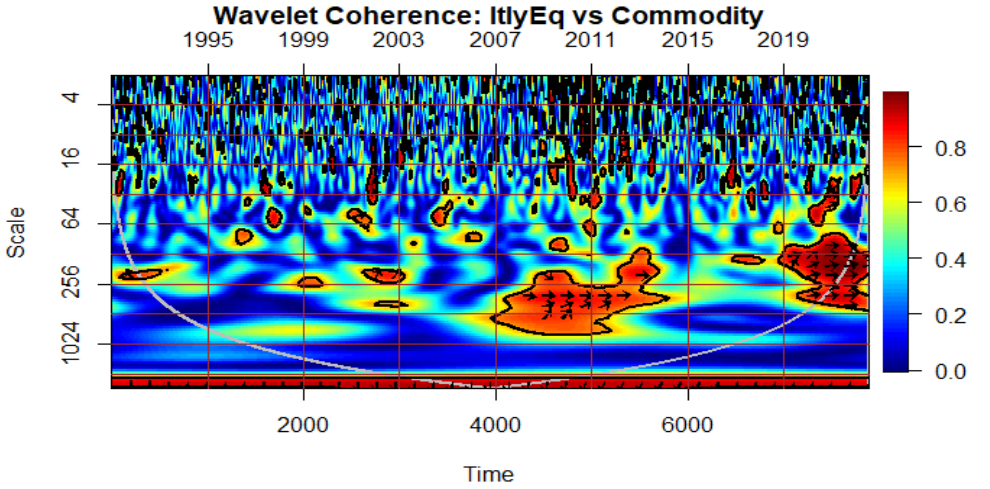


**Figure 7 Wavelet Coherence between Stock and Commodity Market**

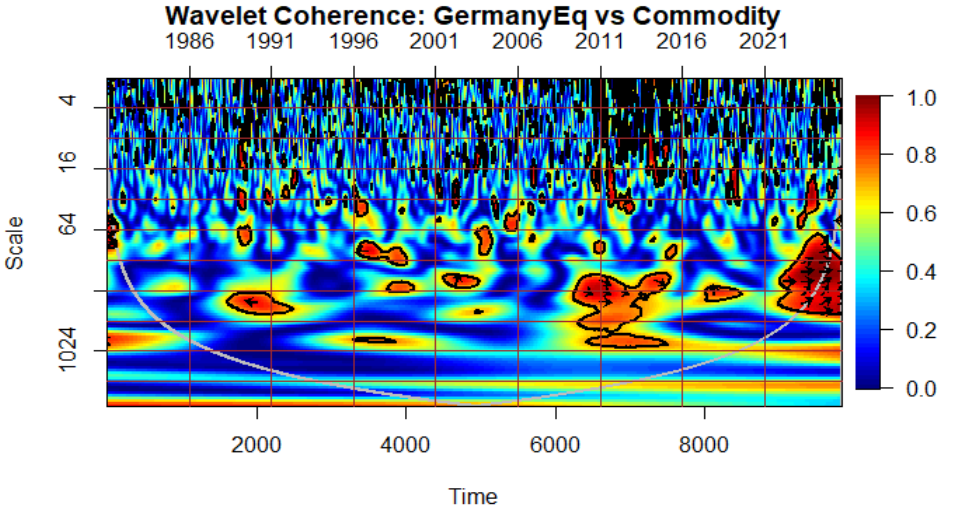



**Figure 8 Wavelet Coherence between Stock and Commodity Market**

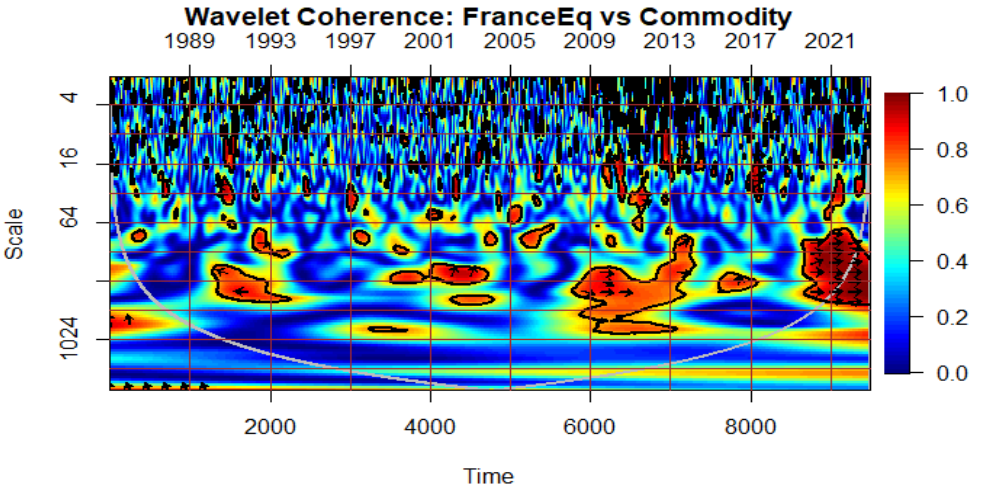


**Figure 9 Wavelet Coherence between Stock and Commodity Market**

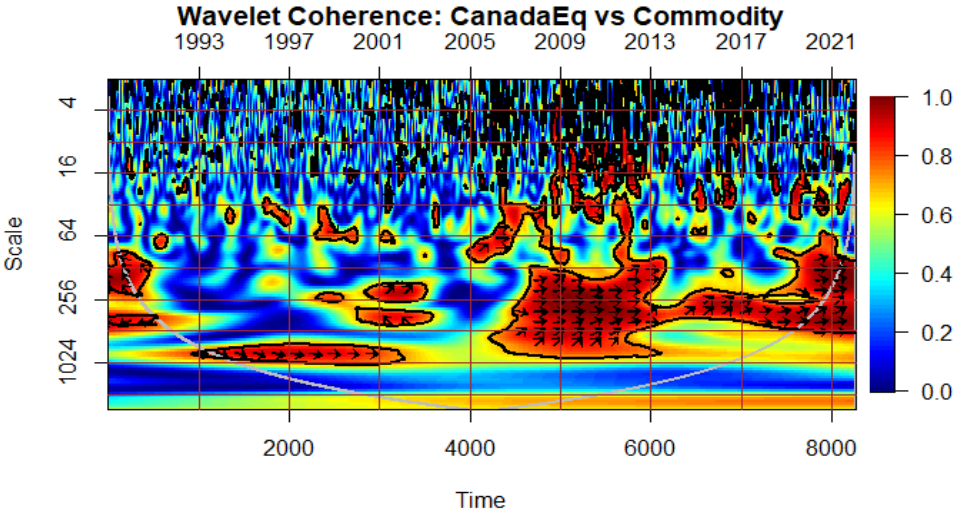



**Figure 10 Wavelet Coherence between Stock and Commodity Market**

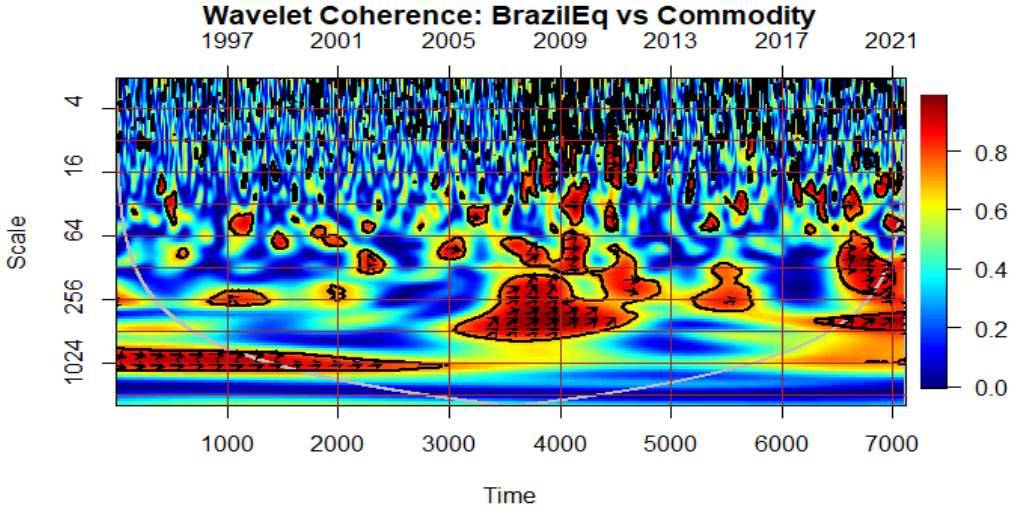


**Figure 11 Wavelet Coherence between Stock and Commodity Market**

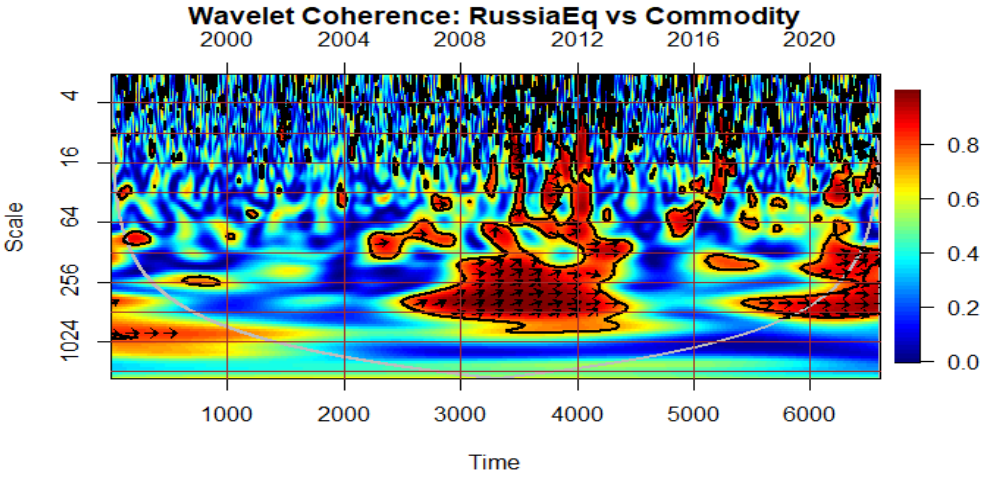



**Figure 12 Wavelet Coherence between Stock and Commodity Market**

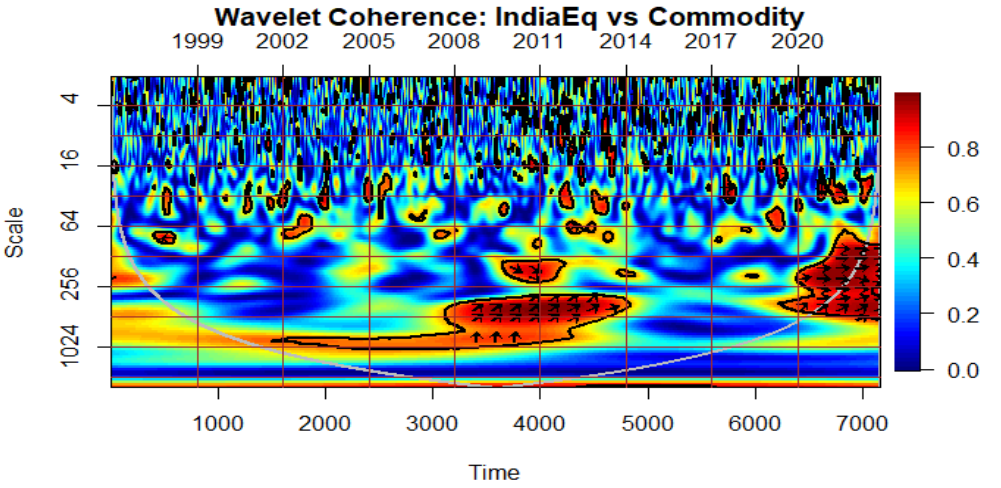


**Figure 13 Wavelet Coherence between Stock and Commodity Market**

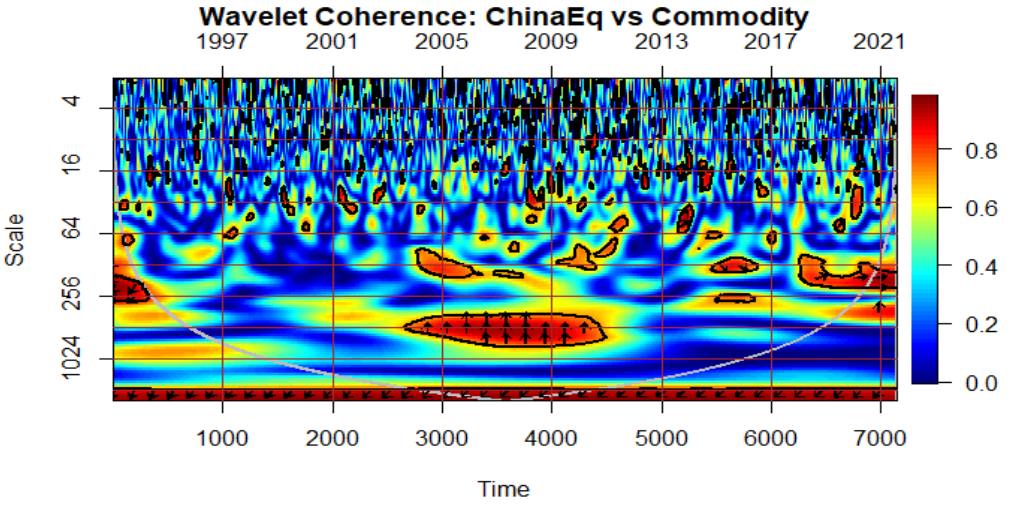
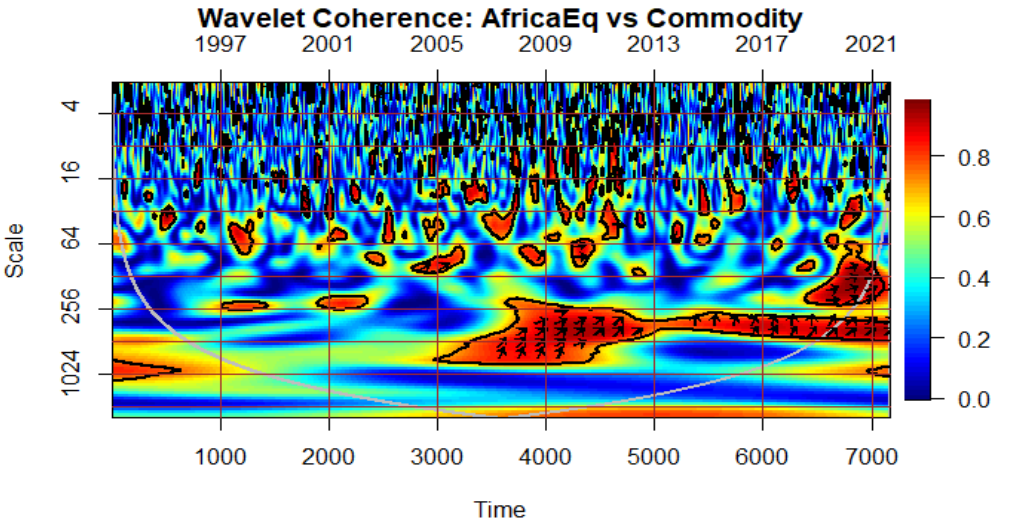



**Figure 14 Wavelet Coherence between Stock and Commodity Market**




The comovement is also found significant between the commodity market and stock markets of the emerging countries. The comovement between the commodity market and

the stock market of Brazil was higher at each frequency scale during 2007-12; however, it was more stable and significant at the larger scale of frequency 64-256. Similarly, the comovement is significant during 2020-21. The comovement is also substantial at the frequency scale of 1024 days during 1994-2004. The comovement is positive, and the equity market leads the commodity market. However, in contrast, the comovement is negative, and the commodity market is leading during 1998 and 2002 on a scale of 16-256.

The comovement between the stock market of Russia and the commodity market is significant and stable at the larger scale of frequency 16-64 during 2007-13, 2015-16, and 2020-21. The arrows point towards the right side, representing the comovement's positive direction in the time-frequency frame. Similarly, the comovement in India is also higher and more visible at the longer scales of frequency 64-256 and 256-1024 during 2002-07, 2007-14, and 2020-21. The comovement is positive, and the equity market is leading during 2002-14 at scales of 256-1024 days, and during 2020-21 at 64-256. In contrast, the commodity market led during 2010-11 on a frequency scale of 64-256 days.

The comovement between the Chinese stock market and commodity market is lower and more diverse compared to the comovement in the context of other countries. The comovement is negative, the stock market is leading 1994-95, negative, and the commodity market is leading during 2004-08, and positive, with the leading role of the stock market during 2020-21. The comovement was most stable and visible during 2004-12. Similarly, the South African stock market and the commodity market are comparatively higher at the scales of 64 days and become more visible and stable during 2006-21 at the frequency scale of 64-256 and 256-1024. The direction comovement is positive, and the stock market is leading at each point of the time-frequency frame.

The above findings show that the comovement between the commodity and equity markets started to become visible after the year 2000 and was dramatically higher during the global financial crises and COVID-19 in almost all countries. This finding is associated with the fact that the relationship between commodity and equity markets increases due to the financialization of commodities that continuously increased after 2001, as discussed (Cheng & Xiong, 2014). The comovement is positive in almost all of the countries. The same direction of the comovement was also witnessed by Huy et al. (2021), who investigated the comovement by using the data of the S&P composite and MSCI global

index as equity market and S&P GSCI index as a proxy for the commodity market. The intensity of the comovement is lower in China, Germany, and Japan compared to the other countries.

# 5 Conclusion

The study examines the comovement between the stock and commodity markets in the context of developed countries (G7) and emerging countries (BRICS). The employed wavelet coherence on the daily log returns of the markets to investigate the comovement in time-frequency space. The study's findings show that the comovement between the stock and commodity markets has increased over time, which is more visible during various crises. The increasing comovement between the stock market and commodity market is likely to show that global commodities performance also influences the stock markets of developed and emerging countries. Consequently, investors should closely follow the price movements of the commodities to develop effective portfolios.

## 5.1 Theoratical

The main theoretical contribution of the study is comparative analysis of developed and emerging markets. Focusing on G7 (developed) and BRICS (emerging) economies, this research adds comparative insights about the distinct risk, return, and diversification benefits for investors in each group of countries. Moreover, wavelet analysis captures short-term and long-term comovement patterns both of which provide additional depths in traditional methods of examination like correlation and cointegration analyses, which limit themselves to the linear relations prevailing over time. Likewise, the wavelet approach captures the influence of shocks on markets or types across time frequencies and, in this way, contributes to economic cycle theories and market integration theories.

## 5.2 Practical Implications

The findings are important for investors, policymakers, and management of the company. Investors can draw conclusions from this research regarding strategic portfolio diversification. Awareness of the time-varying and frequency-dependent stock-commodity comovement pattern will allow investors to adjust assets strategically between stocks and commodities in developed and emerging markets to optimize portfolios based on prevailing market conditions. Findings from the study will help policymakers and central banks in the anticipation and management of potential systemic risks. A study like this will give

policymakers insight into how global commodities, such as oil or gold, have a differential impact on national stock markets so that they can design specific macroeconomic policies and regulations in countries to account for interdependencies during volatile periods. Since the decisions of management are based on commodity inputs, this research can take advantage of a better understanding of the relationship between stock and commodity price movements, which will help in formulating more effective hedging strategies against commodity price volatility and capitalizing on periods of lower correlation for stable input costs.

### 5.3 Limitations

Historical data availability and quality, especially regarding emerging markets from all G7 and BRICS countries, would be a limiting factor for this study. Reliable long-term data may be relatively scarce or unavailable in most such markets. Furthermore, the connection between stock and commodity markets may be susceptible to other exogenous factors like changes in geopolitical shifts, regulatory reforms, and technological innovations that lie beyond its scope. This limits the extension of the findings into other settings or market situations.

### 5.4 Future Research Directions

Future studies can further extend this analysis by adding other emerging and, importantly,additional countries from Asia, Africa, and Latin America, which would yield much more comprehensive insights about the role of regional and global economic structures in influencing comovement dynamics. Also, considering increasing focus on ESG factors, future research can also examine how ESG considerations impact the comovement between stock and commodity markets.

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