UNIVERSITY OF CAPE COAST

GLOBAL UNCERTAINTIES AND COMMODITY RETURNS

MUSA SAM

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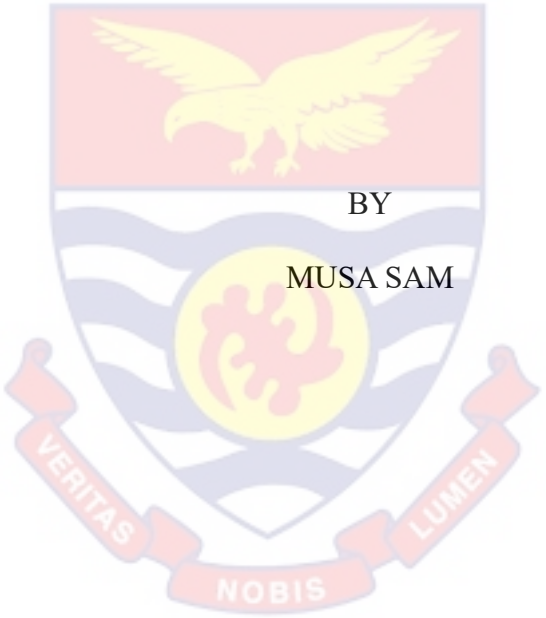

BY

MUSA SAM

Thesis submitted to the Department of Finance of the School of Business, University of Cape Coast, in partial fulfillment of the requirements for the award of Master of Commerce degree in Finance

JULY, 2024

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: ……. Date: ……

Candidate's Name: Musa Sam

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature: ……. ..... Date: ……

Supervisor's Name: Dr. Micheal Owusu Appiah

ABSTRACT

The relationship between commodity returns and global uncertainties has become a focal point of interest for researchers, particularly due to the increasing volatility in global markets. Commodities, as essential assets in the global economy, are often subject to fluctuations driven by factors such as geopolitical risks, economic policy uncertainties, and market shocks. This study investigates the extent of interconnection between global uncertainties and commodities returns at the global level using quantile regression and time and frequency domain analysis (Bivariate wavelet analysis). Utilising a monthly data from January 1, 2000, to December 31, 2023, the result from the quantile regression indicates an asymmetrical association between economic policy uncertainty and the selected commodities. Further, the bivariate wavelet reveals that the interdependence between the variables in the long term seem to be more pronounced compared to those in the short to intermediate term. With regards to the multiple wavelets, the result reveals a heightened connections among the variables during long-term periods, indicating that as a result of the integration of the global financial market, the commodity market is capable of reacting to external shocks. Therefore, investors are advised to implement risk management techniques such as allocating a portion of their portfolios to commodities or to diversify among these commodities during the period of induced market fluctuations caused by economic uncertainties and downtown. Also, policymakers should ensure that policies about the commodities should be formulated in a way to protect the commodity market from heightened shocks from these global uncertainties.

KEY WORDS

Geopolitical Risk

Economic Policy Uncertainty

Global Commodities

Heterogeneous Market Hypotheses

Efficient Market Hypotheses

Modern Portfolio Theory

Quantile Regression

Wavelet

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DEDICATION

To my family: Mr. Abass Arhinful, Hajara Abena Beduwa, Mohammed Sam, Habiba Sam, Ibrahim Sam, Salamat Sam and Wahab Sam

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ACRONYMS

AMH	Adaptive Market Hypothesis
CI	Confidence Interval
CNBC	Consumer News and Business Channel
COVID-19	Coronavirus Disease 2019
CWT	Continuous Wavelet Transform
EPU	Economic Policy Uncertainty
GDP	Gross Domestic Product
GEPU	Global Economic Policy Uncertainty
GNPC	Ghana national Petroleum Corporation
GPR	Geopolitical Risk
HMH	Heterogeneous Market Hypothesis
KCFSI	Kansas City Financial Stress Index
LME	London Metal Exchange
MODWT	Maximal Overlap Discrete Wavelet Transform
MPT	Modern Portfolio Theory
S&P GSCI	Standard & Poor's Goldman Sachs Commodity Index
TVP-VAR	Time-Varying Parameter Vector Autoregression
TVP-SVAR	Time-Varying Parameter Structural Vector Autoregressive
VIX	Volatility Index
WMC	Wavelet Multiple Correlations
WMCC	Wavelet Multiple Cross-Correlations

CHAPTER ONE

INTRODUCTION

Global uncertainties have profoundly influenced the commodity markets, shaping returns and investment patterns across the globe (Woode, Idun & Kawor, 2024). Thus, as the world becomes increasingly interconnected, factors such as geopolitical tensions, economic instability and climate change have introduce volatility into commodity markets, affecting returns on a wide range of commodities. Hence in addition to other financial assets, commodities including energy, metals and agricultural commodities are particularly sensitive to these uncertainties due to their unique characteristics. Despite this, financial investments in commodity market have surged, as a result of the increase in commodity markets funds, futures markets prospect and increased financialisation within the market. This heightened investment activity brings to light the need to understand how global uncertainties affect commodity market returns (Woode et al., 2024).

Background to the Study

The world economy has experienced a slew of unrelated shocks in recent years, including the US-China trade spat in 2018, the Covid-19 outbreak and the Russian invasion of Ukraine, rising inflation rates and the unexpected tightening of monetary policy (Ahir, Bloom, & Furceri, 2022). A notable pattern among these events, and a significant aspect of today's economic outlook, is the widespread uncertainty in both economic and policy domains (International Monetary Fund 2022). That is, a series of shocks have conspired to maintain a high level of uncertainty, ranging from Brexit, US-China trade tensions, the global pandemic and invasion of Ukraine by Russia

from different sources of policy and economic uncertainty should be accessible.

Although these economic policies and intense political unrest might sometimes benefit investors in a form of higher returns according to the growth-option theory (Stein & Stone, 2013; Van, Vo, & Le, 2017), they reduce the global supply of commodities due to reduction in the amount of investment in the commodity market as a result uncertain future market (Sun, Su, Mirza & Umar, 2021). This information points to the fact that policy uncertainty affects real economic activity as well as the commodity markets (Van et al., 2017). Consequently, during periods of significant heightened global uncertainties as a result of macroeconomic policy, commodity returns tends to fluctuate very often (Gong & Xu, 2022). Moreover, as commodities serve as key inputs in the manufacturing of numerous products, changes in their prices have a direct effect on production costs, which in turn causes shifts in the overall level of returns. While this can further present opportunities for investors in the form of higher returns, one of the primary goals of macroeconomic policy is to maintain price stability. However, in line with the general equilibrium framework developed by Pastor and Veronesi (2012), which analyses the connection between asset prices and policy uncertainties, one could contend that global uncertainties are crucial in affecting the commodity market.

In support of this argument is the fact that global commodity prices are anticipated to decrease by 21% in 2023 compared to the previous year (Word Bank, 2023). Also in terms individual commodities, energy prices are expected to drop by 26% this year. The price of Brent crude oil is predicted to average $84 per barrel in 2023, representing a 16% decline from the 2022

average. In addition to the above, the cost of natural gas in Europe and the U.S. are projected to be half of what they were in 2022, while coal prices are forecasted to fall by 42% in 2023. Fertilizer prices are also expected to decrease by 37% this year, marking the largest annual decline since 1976 (Word Bank, 2023). The risks to these forecasts lean towards upwards, due to the fact that many of the factors that have recently caused shocks to commodity markets are still in play. These factors include potential disruptions in energy and metal supplies (partly due to trade restrictions), escalating geopolitical tensions, a more robust-than-expected recovery in the industrial sector in China and the adverse weather condition (International Monetary Fund, 2023). All these elements could lead to lower-than-expected global growth, which is the primary downside risk that could pull the global economy down from its current or projected path (Word Bank, 2023).

The nexus between global uncertainties (GUs) and commodity returns (CRs) offers significant implications for achieving the Sustainable Development Goals (SDGs) (Lele, Agarwal, Baldwin & Goswami, 2021). Such stability is critical for promoting inclusive economic growth in line with sustainable development goal (SDG 8), as investments in commodity-dependent economies often translate into job creation and income generation, especially for less-endowed regions (Lele et al., 2021). Moreover, these insights can help governments design targeted strategies to mitigate risks associated with commodity price volatility, thus ensuring more equitable wealth distribution and addressing inequality reduction (SDG 10) (Lele et al., 2021).

In addition to the above, the link between GUs and CRs can encourage poverty alleviation (SDG 1) and foster inclusive growth by enhancing fiscal sustainability in resource-rich yet economically disadvantaged nations (Sedlak, 2023). Stable commodity markets can boost government revenues, enabling investments in public services such as education and health. These developments not only improve living standards but also lay the foundation for sustained economic transformation (Sedlak, 2023). Also, as countries integrate sustainable practices in resource management, such as renewable energy initiatives tied to commodity markets, they contribute directly to climate action (SDG 13) and responsible consumption and production (SDG 12).

The mechanism by which these uncertainties affect the commodity market is linked to the recent financialisation of commodities (Frimpong, Gyamfi, Ishaq, Kwaku Agyei, Agyapong & Adam, 2021). The financialisation process has led institutional investors to augment their investments in commodities compared to conventional assets. Therefore, precise forecasting of the volatility in the price movements of commodities is crucial for investors. This is because volatility serves as a critical factor in making investment and portfolio allocation decisions, managing risks, pricing derivatives, and evaluating the effectiveness of hedging (Frimpong et al., 2021). Consequently, global investors see commodity markets as alternative avenues for investment that help diversify their portfolios.

Additionally, commodities constitute a significant portion of household consumption (Ding, Huang, & Zhang 2021). Consequently, the effect of shocks related to Geopolitical Risk (GPR) and Economic Policy Uncertainty

(EPU) on volatility in commodities markets is anticipated to carry significant implications for the worlds' population, particularly for economically vulnerable segments of the population. In addition to causing fluctuations in prices, this flow of capital could elevate correlations among various commodities. This heightened correlation implies that investors may engage in simultaneous buying or selling of all commodity group within the portfolio. Therefore, the financialisation of commodities can be said to contributes to synchronized movements among commodities and bidirectional transmission of volatility (Frimpong et al., 2021).

Furthermore, financial markets serve as a transmission mechanism through which these global uncertainties influence the commodity market. Smales (2021) posit that the stock market is pivotal in channelling the effect of GPR on commodity returns. The author argue that financial market participants adjust their portfolios in response to GPR, which in turn affects commodity returns. Also, their research highlights the importance of comprehending the mechanisms within the financial market by which geopolitical risks influence commodity markets. Despite the above, GPR and EPU can exert influence on commodity markets by affecting the dynamics of supply and demand. Due to this, Ding et al. (2021) further contend that GPR and uncertainties in government policies have the possibility of diminishing supply and escalating demand, resulting in disruptions to the supply chain and price hikes. Consequently, factors such as political turmoil, conflicts and governmental supply directives can disturb the commodity market around the globe (Ding et al., 2021).

Various theoretical frameworks have been put forth to explore and deliberate on the effect of uncertainty on investments. Pioneering perspectives by Bernanke (1983) and Dixit and Pindyck (1994) propose that when uncertainty surfaces in an economy, it obstructs decision-making for both firms and investors, resulting in heightened production and financing costs. This negative influence extends to both demand and supply channels. A notable theory within this is the theory of irreversible investment. According to this theory, future uncertainties emanating from political and policy uncertainty will cause risk-neutral firms to reduce their investments. As a result, rational global investors are likely to see that sunk costs cannot be recouped during adverse market situations and may opt to decrease their investment in the commodity market (Bernanke 1983; Dixit & Pindyck, 1994).

Despite the multitude of uncertainties prevailing worldwide, there has been limited research on the combined effect of GPR and EPU on the commodity market, especially on a global scale. Nevertheless, there has been a noticeable surge in investment in commodities globally in recent times (International Monetary Fund, 2022). This surge is linked to the continuous support from worldwide financial bodies like the World Bank and the International Monetary Fund, fostering increased investor confidence and serving as a stimulus for individual farmers worldwide. For example, in the financial year 2023, the World Bank has pledged a total sum of $5.9 billion towards agriculture and its associated sectors (World Bank, 2023).

Researchers, policymakers and international investors have expressed significant interest in commodity markets, recognising their potential as a hedge and a means of portfolio diversification (Mitsas, Golitsis, &

Khudoykulov 2022; Monge, Rojo, & Gil-Alana 2023). According to Umar, Jareño and Escribano (2022), investors seeking optimal portfolio allocations and global diversification should consider the commodity market as a promising investment opportunity. Particularly during challenging periods marked by geopolitical tensions, assets from the commodity markets can deliver favourable returns for investors (Shaik, Jamil, Hawaldar, Sahabuddin, Rabbani, & Atif, 2023). To enhance portfolio diversification and maximise investment returns, global investors should be well-versed in the characteristics of each unique market and understand their interconnections (Rahman, 2022; Bossman & Gubareva, 2023).

Moreover, because of the inherent nature of how these variables respond to different types of shocks and crises, there is an asymmetric relationship between global uncertainties and commodity returns (Yousfi & Bouzgarrou, 2023). While global uncertainties, such as economic policy uncertainty (EPU) or geopolitical risks (GPR), may have predictable impacts on commodity prices during stable periods, their effects can vary significantly during times of high uncertainty or crisis (Rahman, 2022). For instance, during periods of severe geopolitical tensions or economic instability, commodity markets might react more intensely or in an opposite direction compared to calmer times, highlighting an asymmetric response. Additionally, commodity markets themselves are often driven by supply and demand factors that can amplify or dampen the impact of these uncertainties, further suggesting that the relationship may not be linear (Tao, Moncada, & Delarue, 2023). Thus, exploring the possibility of an asymmetric relationship is crucial for

understanding how different levels or types of uncertainty influence commodity returns in both normal and crisis conditions

An additional uniqueness of this study lies in the utilization of the wavelet decomposition approach, which serves to capture quick market reactions or volatility-driven dependencies. This technique allows for the identification of fluctuations across various time scales, enabling a detailed analysis of asset behavior and interdependencies (Verma, Sahu & Sahu, 2023). The approach further offers critical information for investors, enabling them to identify and avoid assets that move in tandem, especially during periods of heightened market volatility (Verma et al., 2023). Moreover, the study integrates the quantile regression method, which enhances the analysis by focusing on the conditional distribution of returns across different quantiles (Nusair & Al-Khasawneh, 2018). This allows for a more robust understanding of the tail-end risks and extreme market events that may not be captured by traditional regression models.

Considerable evidence in the literature also suggests that heightened uncertainties prompt firms to reduce their economic activities, consequently amplifying the volatility of spot and futures returns (Basu & Bundick, 2017; Cui, Wang, Sensoy, Liao & Xie, 2023). Resolving this conflicting perspective is pivotal given the growing significance of commodities in the global economy, particularly amidst the escalating frequency of persistent uncertainty.

Stylised facts about the study variables

As a preliminary checks to confirm the assertion made by empirical researchers that global uncertainties affect the commodity market, the

researcher utilises data on the respective variable. The movement in the commodity indices (depicted in Figure 2) and the associated uncertainties (illustrated in Figure 3) confirms the findings from empirical studies (Ahir et al., 2022; Shaik et al., 2023; Cepni, Pham, & Soytas, 2023). Most commodity indices generally show an upward trend despite global uncertainties like GPR and EPU. These findings further highlight the inherent volatility of the commodity market and emphasis the significant effect of GPR and EPU uncertainties on commodity returns. Therefore, the recent trends in global commodities, even amidst substantial global uncertainties, can be said to prompt questions about the perceived resilience of commodity markets. Additionally, as global markets become increasingly integrated, commodity markets are expected to be adversely affected by GPR and EPU.

Given this, global commodities need to exhibit safe-haven, hedging and diversification features to appeal to all types of investors to invest globally. However, international investors might hesitate to invest in certain markets because high market integration diminishes the benefits of diversification (Bossman & Agyei, 2022). In other words, if markets are highly integrated and move in the same direction, investing in different markets does not provide the typical risk reduction that diversification usually offers.

between global commodity returns and global uncertainties-primarily driven by GPR and EPU are crucial. This underscores the impetus for this study, which aims to explore the dynamic connectedness between global uncertainties and commodity returns worldwide.

Statement of the Problem

Global uncertainties caused by conflicts, power shifts and unpredictable shifts in fiscal, monetary and regulatory policies, has the potential to induce fluctuations in commodity markets (Foglia, Palomba, & Tedeschi 2023). Therefore, recent instances of numerous uncertainties around the globe have had widespread implications for global commodity markets, prompting both individual and institutional investors to seek new diversification opportunities (Owusu Junior, Frimpong, Adam, Agyei, Gyamfi, Agyapong, & Tweneboah, 2021; Asafo-Adjei, Bossman, Boateng, Owusu Junior, Idun, Agyei, & Adam, 2022). Evidence to this, is the recent substantial reduction in nickel return in 2022 (World Bank, 2023).

According to report by trading economies in 2022, the Nickel's 250 percent price surge (from a high of US$50,000 per tons in 2022 to just US$16,400 per tons) put the industry into disarray in slightly more than 24 hours, causing billions in losses for traders who had misjudged the market and prompting the London Metal Exchange (LME) to halt trading for the first time in three decades. This event is noted as the first substantial market failure following Russia's invasion of Ukraine, which affected the global markets and demonstrates how the exclusion of a leading nickel exporter (Russia to be specific) is causing widespread effects across the globe. Unlike in the stock market where short sellers profit from falling prices, commodity markets

differ. Producers, traders and users often take short positions to protect themselves from potential losses on the physical commodities they store. In principle, any fluctuations in futures market returns should be counterbalanced by corresponding changes in the value of inventories, provided that traders are able to fulfill their margin requirements.

In line with Global Sustainable Development Goals (SDGs) problem arise due to the inability to anticipate and effectively manage risks that disproportionately affect vulnerable economies and communities. Without a clear understanding of how GUs, such as GPR and EPU influence commodity prices, governments and international organizations face significant challenges in planning for sustainable economic growth (SDG 8) and poverty reduction (SDG 1) (Lele et al., 2021). Resource-dependent economies, often in developing regions, are particularly exposed to the risks of extreme price fluctuations, which can hinder their capacity to foster inclusive growth and achieve poverty alleviation targets (Lele et al., 2021). These economies may also struggle to diversify their industries, leaving them dependent on volatile markets, exacerbating the cycle of poverty and inequality (SDG 10) (Lele et al., 2021).

Furthermore, without an understanding of this relationship, addressing sustainable production and consumption (SDG 12) becomes increasingly difficult, as commodity price instability can disrupt both the supply and demand for essential goods (Mensah, Wieck & Rudloff, 2024). In the absence of reliable data on how global uncertainties shape commodity markets, it is challenging to create policies that can buffer the effects of price volatility (Mensah et al., 2024). This lack of insight makes it harder for governments to

implement long-term strategies that promote inclusive growth and climate action (SDG 13), while simultaneously reducing inequalities (Mensah et al., 2024). Moreover, the failure to anticipate commodity price changes can hinder investment in vital sectors such as education, healthcare, and infrastructure, thus impeding progress toward multiple SDGs and further delaying the achievement of a more sustainable, equitable global economy (Mensah et al., 2024).

Building on the aforementioned foundation, advocates of information flow theory (Odegard, 1982; Ross, 1989; Andersen, 1996 & Benthall, 2019) contend that asset returns are predominantly influenced by the interplay between the emergence of new information and the fundamental mechanism responsible for incorporating this information into the asset price. However, Fama (1970) contend this through his market efficiency theory that markets in general are anticipated to be efficient, giving all available market information.

Despite this, Müller, Dacorogna, Davé, Pictet, Olsen and Ward (2008) along with Lo (2004), propose, through their Heterogeneous Market Hypothesis (HMH) and Adaptive Market Hypothesis (AMH), that the Efficient Market Hypothesis (EMH) is not universally applicable, as the market may exhibit less efficiency than EMH suggests. This deviation arises from variations in beliefs and expectations among investors, coupled with the recognition that investors are not consistently rational and are susceptible to errors. According to the Heterogeneous Market Hypothesis, traders analyse past and current information and subsequently adopt various investment strategies based on their investment decisions (Owusu Junior et al., 2021; Müller et al., 2008). The Adaptive Market Hypothesis, in contrast, posits that

investors are generally rational, though not perfectly so. Thus, instead of pursuing optimal outcomes, they display satisficing behaviour and develop market strategies through a natural selection process in the market as described by Lo (2004). This implies that during periods of swift changes in geopolitical unrest and abnormal economic conditions, the Efficient Market Hypothesis (EMH) may not be applicable.

Moreover, according to the Adaptive Market Hypothesis, both irrational and rational investor behaviour are believed to be influenced by environmental conditions and the characteristics of individual investors. Thus, considering the theoretical foundations of both HMH and AMH, the implication for investors is that profit opportunities evolve, affecting the timing of strategy implementation and the significance of active portfolio management. Additionally, it can be deduced that the current understanding of how occurrences of uncertainty affect the relationship between global uncertainties and the commodity market is insufficient for comprehending market dynamics and participant behaviour regarding market inefficiencies. As a result, investors might have insufficient or inaccurate market information, which can affect their investment choices and confidence level. Given this information gap, it becomes crucial to conduct a study in both time and frequency domains.

In addition to the above, a World Bank report in 2023 on global growth prospects and a research study conducted by Yousfi and Bouzgarrou (2023) indicated that the worldwide commodity market faces significant susceptibility to shocks from global uncertainties. This is because, the market is marked by a lack of financial capital flow, affecting overall market performance and

contributing to the deterioration of global economic growth. Nonetheless, empirical studies have presented a contrasting perspective on the relationship between global commodities and these uncertainties (Traore & Diop, 2021). These scholars contend that, despite the financial market integration theory fostering strong connections between the markets of a country and those of other nations or regions, there are divergent opinions on the extent of this association. Nevertheless, relying solely on the long-term integration of the global commodity market may not be a sufficient strategy for predicting market trends across countries. Thus, these authors claimed that market activities are likely to persist despite geopolitical challenges, serving as a reliable source of income for the global economy and contributing to enhanced global economic growth.

Several studies have explored the relationship between GU and commodity returns offering valuable insights into how external shocks and economic volatility affect commodity markets. For example, Zaremba, Kizys, Aharon and Umar (2022) examined the impact of governance quality and technological innovation on Malaysia's sustainable growth, considering economic uncertainties. Similarly, Yang and Hamori (2021) investigated the role of information and communication technology in influencing commodity market outcomes, while also accounting for factors like financial development and foreign direct investment. These studies have contributed to understanding the broader implications of economic and geopolitical uncertainties on commodity prices, particularly focusing on specific economies or sectors. However, they often rely on aggregate data or focus on a single region, limiting their ability to generalize findings to a global context.

The current study investigates how GU affects commodity returns at a global level while incorporating specific country and commodity variations. Unlike previous studies that tend to focus on aggregated indices or specific nations, this research takes a more multidimensional approach by analysing commodity-specific index. This allows for a more granular understanding of how global uncertainties impact different commodities and regions (Tang & Zhong, 2023).

Therefore, while numerous studies have explored the influence of major uncertainties such geopolitical risk on global commodities (Gong & Xu, 2022; Hudecová, & Rajčániová, 2023; Wang, Bouri, Fareed, & Dai, 2022; Micallef, Grima, Spiteri, & Rupeika-Apoga, 2023), and the effect of economic policy uncertainty indices on global commodities (Xiao, Tian, Hou, & Li, 2019; Sun et al., 2021; Frimpong et al., 2021; Xiao, Su, & Ayub, 2022), there are still critical gaps that need to be addressed, particularly considering the conflicting views outlined above.

This research makes several unique contributions to the field of finance. First, it explores the interconnectedness among global uncertainties and the commodities market, a perspective often overlooked in studies confined to country and regional levels. Second, existing research do not delve into how the arrival of new caused by uncertainties around the commodity market affect investors decision and also fail to draw insights from the AMH and HMH (Asafo-Adjei et al., 2022; Woode Idun & Kawor, 2024).

Third, while extensive research has explored the effect of global uncertainties on the commodity market as a whole, they fail to employ the overall index which measures everything about the respective variables. In the

financial market, there exists a broader index that encompasses all individual assets with similar attributes. For example, there is an index for cryptocurrencies that captures the entire spectrum of individual cryptocurrencies. Similar indices exist for various financial assets, including commodities. However, most empirical studies concerning commodities typically measure them using the individual commodity prices (indices) rather than utilising comprehensive indices that provide a holistic view of these commodities (see Zhu, Huang, Wang, & Hau, 2020; Frimpong et al., 2022; Abrhám, Vošta, Čajka & Rubáček, 2021; Micallef etal., 2023; Francis, 2023; Woode, Idun & Kawor, 2024). Therefore, making accurate diversification decision based on the results of the above studies might not be ideal for investors since these studies fail capture the overall market performance of the global commodity market.

In furtherance to this, Oztek and Ocal (2013) and Rl & Mishra (2022) also argue that commodity indices present a more all-encompassing measure of the market, as they monitor the prices and returns of a basket of commodities. Additionally, they offer diversification advantages by mitigating the risk associated with exposure to a single commodity. This also add to fact that the outcomes from the previously mentioned studies may lack sufficient information for investors and policymakers to make well-informed decisions regarding the global commodity market, potentially exposing them to future volatility and risk. Therefore, this study aims to address this gap by investigating the interconnection among global uncertainties and the commodity market.

Purpose of the Study

The purpose of the study is to explore the effect, interdependence and the joint dynamics of global uncertainties on commodities returns.

Research Objective

1. To analyse the asymmetric relationship between EPU and commodities returns.
2. To examine the interdependence between GPR and commodities returns.
3. To explore the joint dynamics of GPR and EPU on commodities returns.

Research Hypotheses

The research will be guided by the following hypotheses:

Hypothesis 1

H_0 There is no asymmetric relationship between EPU and commodities returns.

H_1 There is an asymmetric relationship between EPU and commodities returns.

Hypothesis 2

H_0 There is no interdependence between GPR and commodities returns.

H_2 There is interdependence between GPR and commodities returns.

Hypothesis 3

H_0 There is no joint dynamics between GPR, EPU and commodities returns.

H_3 There are joint dynamics between GPR and EPU on commodities returns.

Significance of the Study

The examination of the interdependence between global uncertainties and commodities holds significance as it sheds light on the ways these global uncertainties influence the commodity market - a pivotal industry for many nations. The findings from this study have the potential to offer crucial information for policymakers and key players in the commodity market, assisting them in making better-informed decisions and crafting strategies to reduce the effects of global uncertainties on commodity returns. Furthermore, the study is poised to inform future research directions pertaining to the variables under investigation

Moreover, the study result offers crucial insight for portfolio management and construction. They serve as reliable information for both institutional and individual investors, providing a comprehensive understanding of the dynamics within the global commodity market. This information is also valuable for policymakers and governments as it sheds light on how regulations at the local, regional and international levels affect more efficient asset and fund management. Notably, the estimation techniques employed in this study span different time horizons, rendering the results particularly pertinent for policymakers, investors and practitioners across various time scales—from short-term to long-term. Furthermore, the study's findings can facilitate the attraction of capital inflows into the commodity market by local, regional and international investors. This influx of capital can contribute to increased performance of the commodities market, thereby enhancing safety investment while concurrently reducing poverty worldwide.

Delimitations

This research will concentrate on examining how global uncertainties affect the commodity market. The scope of this study will be confined to utilising GPR) and EPU as specific uncertainties, with a specific emphasis on the commodity market. For the sake of convenience, secondary databases were utilised to collect the necessary data. The primary estimation techniques employed for the analysis were quantile regression and wavelet analysis. It is crucial to note that these techniques, while valuable, may come with certain limitations and assumptions that could affect the validity and generalisability of the results.

Limitations

Despite making unique and valuable contributions to the existing knowledge on the area under consideration, this study does have its own inherent limitations, as outlined below. The study did not incorporate all commodity index due to issues of inaccessibility and unavailability of market data for certain categories of commodities. Consequently, the study may not have revealed essential diversification benefits associated with those commodities. Additionally, the presence of missing values in the data series for some commodities index and the policy uncertainty index led to a reduction in the dataset. This reduction may have constrained the study's results and, subsequently, affected the conclusions drawn. Nevertheless, it is crucial to highlight that meticulous process of estimation was employed to limit the potential impact of the aforementioned drawbacks on the study's findings.

Given these inherent limitations, breaking down the data becomes a valuable strategy to address the complexities mentioned earlier, ensuring that the data series used in these analyses has navigated the highlighted challenges. Consequently, this study undertook a decomposition of the data series related to all the study variables. This breakdown reveals the diverse investing time horizons of commodity market participants, aligning with the AMH, HMH and modern portfolio theory. Therefore, this study marks the first exploration of how global commodities are influenced by geopolitical risk and economic uncertainties while incorporating the intricacies of investor behaviour.

Definition of Terms

Commodity Returns

Commodity returns refer to the profits or losses generated from investing in or trading physical commodities or their derivatives, such as futures and options (Umar, Jareño & Escribano, 2021). Commodities include various categories like energy (oil, gas), agricultural products (grains, livestock), precious metals (gold, silver), and industrial metals (copper, aluminum). The performance of these returns is influenced by factors such as supply and demand dynamics, geopolitical events, weather conditions, and macroeconomic indicators like inflation and currency fluctuations. Investors monitor commodity returns to assess market opportunities, hedge against risks, and diversify their portfolios, as commodities often have a low correlation with traditional asset classes like stocks and bonds (Umar et al., 2021).

Global Uncertainties

Global uncertainties encompass unpredictable and destabilizing events that affect the world economy, markets and financial systems (Ahir et al., 2022). These include economic policy uncertainty (EPU), geopolitical risks (GPR), pandemics, natural disasters, and shifts in international trade policies. Such uncertainties create volatility in markets by influencing investor sentiment and altering global supply chains. For instance, events like the COVID-19 pandemic and the Russian invasion of Ukraine have disrupted commodity prices and returns due to fluctuating supply, demand, and trade flows. Understanding the impact of global uncertainties is crucial for policymakers, investors, and researchers as they navigate their influence on markets and the global economy (Ahir et al., 2022).

Organization of the Study

This study is structured into five chapters. Chapter one includes the background of the study, problem statement, study objectives, research hypotheses, significance, limitations and delimitations. The second chapter delve into the previous studies on global uncertainties and the commodity market, along with the theoretical underpinnings for this research. In Chapter three, the methods applied in the study were detailed. Chapter four was dedicated to the interpretation and discussion of the results, whereas Chapter five focus on the summary, conclusions, recommendations and policy implications derived from the study's findings.

CHAPTER TWO

LITERATURE REVIEW

This chapter basically talks about theories which underpin the topic under consideration, the conceptual review as well as empirical works that are related to the study. The chapter finally provides the gaps identified and the contribution to existing studies.

Theoretical Review

To explore how global uncertainties (geopolitical risk and uncertainty about economic policy) affect global commodities return, three main theoretical frameworks are utilised. These consist of the Modern Portfolio Theory (MPT), Heterogeneous Market Hypothesis (HMH) and the financial market integration theory.

Modern Portfolio Theory (MPT)

The Modern Portfolio Theory describes how investors can use strategic asset allocation to increase a portfolio's expected return while retaining a certain degree of risk, or, on the other hand, to reduce risk while aiming for a specific expected return (Markowitz, 1952). In order to quantify the optimal level of diversity required to balance risks which are often represented by the expected variance in returns, against the anticipated mean return of a given investment portfolio, Harry Markowitz brought this theory to the field of finance in 1952. The theory seeks to maximise returns from a portfolio by selecting and adjusting the asset bundles in a given portfolio in a proportionate manner. Also, this theory is better suited to explain how optimal diversifications can be found. When faced with a decision between two or more portfolios that have comparable values and return rates, the core

principles of MPT can be use by investors to select the portfolio that carries the least amount of risk (Abakah, Tiwari, Alagidede, & Gil-Alana, 2022).

Furthermore, according to the MPT framework, investors give priority to the net additional contribution that their asset portfolios make. Thus, the benefit from financial asset in an investment portfolio is considered more advantageous than the risks inherent in the assets (Markowitz, 1952). Additionally, MPT can offer a framework for comprehending the potential influence of risk and return on investor's choices (Ahmad & Sarver, 1994; Andersen,1996). External factors that can have a large effect on commodity returns in this case include shocks from GPR and uncertainties surrounding government policy. MPT suggests that a portfolio diversification strategy, which involves holding a range of imperfectly correlated assets, can help investors mitigate this risk (Fang, Lin, & Chang, 2023). In this sense, gains in other assets may be able to balance the negative effects on the portfolio of a decrease in one asset as a result of elevated GPR or uncertainty over economic policy. Accordingly, commodities may not be the optimal investment, even though great profits are anticipated, if they significantly raise the total risk of the portfolio (Assaf, Charif, & Mokni, 2021).

The theory also emphasises the importance of the correlation between different assets in a portfolio (Bouri, Demirer, Gupta, & Marfatia, 2019). Therefore, in explaining objective one which seeks to analyse the asymmetric relationship between economic policy uncertainty and commodities, the core principles of MPT can be used to understand how these uncertainties influence the performance and risk of a commodities portfolio. Thus, MPT can provide optimal investment decision on how investors might diversify against policy-

related risks and optimise their commodity investments to accomplish a desired outcome of balance in risk and return. The argument is that, given that different possible investors may respond differently to different shocks, the risk or expected variance of returns in a portfolio can be minimised through effective diversification. This means that diversification can successfully reduce portfolio risk as long as the returns from different commodities do not exhibit perfect correlation over time.

In the pursuits for obtaining higher returns from the commodity market, prospective investors must apply the MPT's tenets to select commodities that meet their needs taking into consideration risk management strategies (Wu, Zhu, Chen, & Huang, 2023). The strategy of diversifying to reduce risk exposure is one of the most common approaches to risk management. Therefore, to reap benefits from diversification, investors need to ascertain the ideal degree of diversification (Bouri et al., 2022). Similar to stock market portfolios, the effect of commodity diversification is seen in the relationship that exists between total risk levels and the number of commodities included in a portfolio. Therefore, a predicted decrease in risk is experienced when additional assets are combined into a single commodity portfolio. Stated differently, diversification of assets plays a major role in reducing risk in a portfolio. In order to highlight and assess the significance of financial assets, especially commodities, in determining portfolio composition, portfolio theory has been applied in this study.

Heterogeneous Market Hypothesis (HMH)

Researchers and scholars have investigated over time how to enhance the assertions made by Fama (1970) under his theory of market efficiency and

develop a clearer and more detailed grasp of the concepts that support the financial markets. This led to the proposal of the heterogeneous market hypothesis theory (Dacorogna, Mller, Olsen, & Pictet, 2001; Müller et al., 2008), which holds that market participants are heterogeneous in character. Proponents of this theory are therefore of the view that traders in the markets have varying expectations, informational backgrounds and ways of interpreting the world. These variations result in a broad spectrum of trading habits, which affect price dynamics (Hussain, Hussain, & Qambari, 2020). Contrary to the assumption of homogeneity among market participants, the HMH argues that people process the same information differently, influenced by their unique trading preferences and available opportunities. This a as result of the variety of trading activities with varying durations from short-term to long-term investments period. To put it another way, the financial market is made up of investors using a spectrum of investment strategies, from short to long durations. Hence the aggregation of these differing volatility periods has given rise to the long memory effect observed in financial markets (Hussain et al., 2020).

The idea that commodity returns are diverse is emphasised by the HMH, which calls for a careful analysis of the underlying data generation procedures and market microstructure behaviour. Commodity markets are thought to be more volatile than stocks and other financial market instruments (Tiwari, Boachie, Suleman, & Gupta, 2021; Woode et al., 2024). In addition to the above, the commodity market is also characterised by lower trading frequencies relative to equities, substantial transaction and opportunity costs and comparatively lower levels of market efficiency. This means that

disruptions in commodity returns are short-lived, as prices are expected to return to their usual trend. Therefore, investors can use past information to forecast future price movements (Shaik et al.,2023).

Heterogeneity can result from a variety of variables, including changes in the resources available to agents, institutional constraints and risk tolerance (Jiang, Marsh, & Tozer, 2015). Further, it can also result from variations in the ways that information is processed, time periods and geographic locations. The concentration of this study is the heterogeneity resulting from new information and time horizons. This is because, the HMH theory acknowledges that different market participants may react differently to shocks from these uncertainties. Therefore, in explaining the third objectives, the core principle of the HMH theory can be used to explain the varied and nonlinear market responses from market participant, illustrating how these uncertainties collectively influence the commodity markets and the diverse behaviors and expectations of market participants. The fundamental notion is that participants with diverse information and time frames perceive, address and contribute to various forms of volatility (Tiwari et al., 2021; Bossman & Agyei, 2022).

Hence global uncertainties can create a heterogeneous market environment for the commodity market. Because each market player has a different perspective, risk tolerance and strategic objective and may perceive and respond to these risks in different ways (Zaremba, Kizys, Aharon, & Umar, 2022). In the commodities market for example, some traders may see an increase in GPR or uncertainty as a result of economic policy as an indication to reduce their exposure, while others may see it as an opportunity

to increase their holdings in expectation of future price increases. In addition, the way these risks affect the returns of commodities varies depending on the market, the regulations in place, and the nature of the commodities being sold. Since market participants are diverse and have varying responses to changes in the market, the heterogeneous market hypothesis (HMH) is relevant in this situation. These varied reactions may affect the dynamics of commodity investment, which may then affect the market prices of such commodities (Yip, Brooks, Do, & Nguyen, 2020).

Financial Market Integration Theory

The current level of global financial market integration has increased dramatically as a result of the growing globalisation of investments (International Monetary Fund, 2022). This increase can also be attributed to the trend that is occurring in many different economic areas as well as the use of technology to facilitate communication and the exchange of information (Bau & Matray, 2023). These elements have created a climate that allows investors to profit from the interdependence of the world economy and have also encouraged the financial sector to grow (Zhang & Broadstock, 2020). Thus, based on the tenets of these theories, it can be said that the interconnectedness of the financial market causes information, shocks, and uncertainties to be disseminated internationally, thereby affecting investor returns. Thus, integrated markets mean that events in one market (like global uncertainties) can affect other markets (like the commodity market). This theory explains how global uncertainties can lead to price changes in commodities due to their interconnected nature. For example, geopolitical

tensions in oil-producing regions can affect global oil prices, reflecting the integrated nature of financial markets (Zhang & Broadstock, 2020).

Thus, price transmission from global financial market to domestic and regional markets is crucial for comprehending the level of integration among economic agents worldwide (Hu, Zhang, Ji, & Wei, 2020; Ajates, 2020). Therefore, lack of price transmission between markets, resulting in poor market integration can have important consequences for economic welfare. In addition to the above, incomplete price transmission caused by trade policies, transaction costs, or other factors can diminish the information accessible to economic agents, potentially leading to decisions that result in inefficient outcomes (Bau & Matray, 2023). Given this, it is necessary to investigate the connection between the commodity markets and these risks globally. Additionally, in order to successfully execute market stabilisation strategies, it is critical to comprehend the mechanisms of how commodity markets integrate as well as how global uncertainties affect international investments.

Additionally, the theory contends that basic economic ties between nations particularly those resulting from international trade and networks are the means by which negative shocks are disseminated (Silva & Selden, 2020). Based on this, one could argue that a unique mechanism for the cross-market propagation of unfavourable financial shocks has been shown by a series of financial crises since 1990. This market turmoil has propagated quickly from the market that caused the uncertainty to other markets with distinct market structures or with minimal economic linkages, in contrast to the conventional transmission mechanism of cross-market economic fundamental (Umar, Gubareva, Naeem, & Akhter, 2021). Therefore, in explaining objective two,

the financial market integration theory can be used to explain how these external shocks from geopolitical risks are transmitted across different markets and how interconnected financial markets respond to such shocks. This in the end will help to understand how geopolitical events in one part of the world can affect commodity return globally, reflecting the integrated nature of modern financial markets.

Conceptual Review

A review of GPR, EPU, commodity market (agricultural commodities, energy commodities and metal commodities are discussed in this section. These fundamental concepts were examined in greater detail and defined to clarify their meanings and their application within the context of this study.

Geopolitical Risk

GPR is the potential for crises like wars, terrorist attacks and conflicts that can impact international relations between countries significantly. It includes the likelihood of these risks occurring and the additional risks resulting from the intensification of current events. Central banks, financial media and corporate managers commonly refer to GPRs as significant determinants of investment choices, suggesting their influence on financial markets and business cycles (Caldara & Iacoviello, 2018). Considering the recent trends in global economic integration and financial market globalisation, one can argue that GPR have a notably severe effect on investment decisions and the performance of financial assets across the global economy.

Caldara and Iacoviello (2018) created a global GPR index using newspaper data and text analysis techniques. According to their definition,

geopolitical risk pertains to conflicts, terrorist incidents and diplomatic tensions between states. They quantified geopolitical risk by aggregating the count of articles addressing these occurrences. Hence, following the introduction of the GRP, numerous researchers have investigated how geopolitical risks impact the development of asset return. For instance, Jana and Ghosh (2023) found no significant effect of geopolitical risk on agricultural investment. However, their study provides empirical evidence that while geopolitical risk may not significantly affect the stock returns of defense firms, it does play a crucial role in influencing the volatility of these returns. This suggests that while stock returns might be relatively insensitive to geopolitical risk, the latter remains a significant factor in the volatility of commodity returns. Moreover, geopolitical risks are viewed as critical factors affecting financial markets, as they have the potential to amplify other types of risks, such as climate change risks, economic uncertainties and trade policy instabilities (Gong & Xu, 2022; Micallef et al., 2023; Bossman, Gubareva & Teplova, 2023). Considering the important nature of these risk and how it affects the financial market particularly the commodity market, it is important to put into perspective the reactions of players and participant of these market during this period.

Economic Policy Uncertainty

EPU talks about ambiguity surrounding the future development of economic policies (Pástor & Veronesi, 2013; Baker Bloom & Davis, 2016). Recently, concerns about economic uncertainty have grown as a result of the outbreak of the Covid-19 and the numerous political unrests around the world (Suh & Yang, 2021). Further, the presence of economic uncertainty

significantly affects the stability of macroeconomic conditions (Ma, Guo, Chevallier, & Huang, 2022; Abid, 2020) and financial markets (Zhang, Lei, Ji, & Kutan, 2019). EPU depicts a situation in which management of economies around the globe lack adequate knowledge for assessing the current conditions. As such, global uncertainties have become a fundamentally unobservable element with a significant impact on the economic environment (Al-Thaqeb & Algharabali, 2019).

Uncertainties in an economy can have diverse effect on corporation and individuals as it is capable of preventing them from exploiting new investment avenues (Gholipour, 2019; Cepni, Guney, & Swanson, 2020). A similar argument can be made for participant in the commodity market, who may be more hesitant about government policies and regulations towards the commodity market. As a result, it can be argued that policy uncertainty has direct economic repercussions that ultimately influence the commodity market (Long, Li, & Luo, 2023).

Commodity Market

Commodity markets are integral to the global economy (Gong & Xu, 2022). As a result, changes within these markets can greatly influence the global economic environment, just as developments in the global economy can affect commodity markets. Thus, a thorough understanding of the factors influencing commodity supply and demand is essential for uncovering the nature of price movements and the driving forces behind them (Fang & Shao, 2022). Commodities are broadly categorised into two main types: soft commodities and hard commodities. Hard commodities are made up of natural resources that are obtained through mining or extraction processes such as

gold and oil. Soft commodities encompass products such as corn, wheat, coffee, sugar, soybeans, and pork. Trading of these commodities occurs either directly in spot markets or via financial contracts that reflect their current or anticipated prices (Fang & Shao, 2022).

Fry-McKibbin and McKinnon (2023) contend that, in spite of recent developments, the integration of global markets and the financialisation of commodities have led to higher levels of price volatility and increased speculation. This heightened volatility acts as a conduit for transmitting risk and return spillovers among various commodity categories. Also, the connections among various commodities play a crucial role in business cycle analysis, asset allocation strategies and risk management practices. Consequently, a considerable body of research has investigated the causal relationships among different commodity markets (Fang & Shao, 2022; Fry-McKibbin & McKinnon, 2023). In addition, the extreme price volatility during the pandemic has prompted numerous questions about the interconnections between different commodities. As a result, investors are keenly focused on discovering potential diversification and hedging strategies across different commodity groups to reduce the risk of price crashes and improve portfolio diversification (Fry-McKibbin & McKinnon, 2023).

Agricultural Commodities

Agricultural commodities are products derived from plants or animals, utilised for human consumption, industrial purposes, or trade. According to the Standard & Poor's Goldman Sachs Commodity Index (S&P GSCI) classification, agricultural commodities can be broadly categorised into grain, livestock, softs, and dairy (Blomberg 2023). These are additionally categorised

as sub-indices of the S&P GSCI Agriculture Index. The S&P GSCI Softs Commodity Index focuses on traded agricultural products such as coffee, sugar, cocoa and cotton, which are categorised as soft commodities. Further, the S&P GSCI Grains Index comprises agricultural commodities like wheat (both Chicago and Kansas varieties), corn and soybeans. Finally, the S&P GSCI Livestock and Dairy Index includes lean hogs, live cattle, feeder cattle and various dairy products such as butter, cheese, dry milk and dry whey.

According to the World Bank, in 2014 agriculture contributed approximately $2.894 trillion to worldwide wealth in terms of constant 2010 U.S. dollars (World Bank, 2023). In addition to this, during the global financial crisis of 2007−2008, equity markets declined while agricultural commodity prices increased, attracting investors to the agricultural market. Currently, the sector contributes about 4.3293 % to global GDP in 2022, according to the World Bank collection of development indicators. Although, this represents a smaller portion of the word GDP but comparatively this contribution has improved since 2014. This can be attributed to the increasing production of biofuels which have boosted the demand for agricultural commodities like corn and soybeans contributing to higher market prices for these products. Additionally, increased demand from emerging nations including China also supported increasing prices (Wu, Ren, Wan, & Liu, 2023).

Metal Commodities

Metal commodities are essential raw materials utilised in numerous industries, including construction, manufacturing, electronics, and renewable energy. Traditionally, metals have been categorised into precious metals and

base metals, both of which are used in industrial applications (Al-Yahyaee, Rehman, Al-Jarrah, Mensi, &, Vo, 2020). Precious metals are rare, naturally occurring elements valued for their scarcity, attractive properties and historical use as a store of wealth. In contrast, industrial metals, or base metals, are more abundant and generally less expensive, yet crucial for industrial and manufacturing processes. Examples of industrial metals include copper, aluminum, nickel, zinc and lead. In recent years, trading volumes for all types of metals on global exchanges have surged, enhancing their role in global price discovery (Al-Yahyaee et al., 2020).

Despite significant changes in supply and consumption, metal prices have fluctuated around a relatively stable trend in real terms over the past century. Major price variations have primarily been driven by global shocks, such as wars, the Great Depression of the 1930s, and China's rapid industrialisation in the 2000s. In 2022, iron ore had the largest global market size among metals, exceeding 280 billion U.S. dollars, followed by gold, with a market value of nearly 200 billion U.S. dollars (Trading Economies, 2023). These metals are crucial for infrastructure, manufacturing and technological development, underscoring their vital role in modern economies.

Energy Commodities

Energy commodities are essential resources that drive the global economy, including various fuels and sources for energy generation (Yu, Wenhui, Anser, Nassani, Imran, Zaman, & Haffar, 2023). Crude oil is the most significant energy commodity which is crucial for modern transportation and industry, and is refined into products like gasoline, diesel, and heating oil. The prices of energy commodities are highly influenced by geopolitical events,

production levels from major suppliers such as OPEC, and global economic conditions (Zhang, Shinwari & Zhao, 2023). In the global economic context, energy intensity is expected to decrease as new, energy-efficient technologies are adopted. Consequently, global per capita energy needs in 2050 will be 10 percent lower than in 2016, even with the rising demand from the growing middle class in emerging economies (Zhang et al., 20223).

Empirical Review

Asymmetric relationship between EPU and commodities returns.

The literature contains numerous studies exploring the asymmetry relationship or the link between economic policy uncertainty and the commodity market. Further, besides theoretical inquiries, there have been extensively documented yet perplexing empirical relationships between EPU and the commodity market. Based on this, the effects of shocks from EPU on economic indicators can be said to be symmetric or asymmetric as highlighted by earlier researchers (He, Wang, & Yin, 2020; Wen, Khalid, Mahmood, & Zakaria, 2021; Bossman, Gubareva & Teplova, 2023; Cao, Cheng, & Li, 2023). At the global level, EPU is meaningful because, it can have a negative effect on the global economy by reducing confidence, investment and trade flows (Alnour, Altintaş, & Rahman, 2023).

As a result, Long, Li and Luo (2023) looked at the asymmetric effects of global economic policy uncertainty (GEPU) on grain prices around the world and came out with to two main conclusions. First, the research showed that the effect of EPU on global grain prices is asymmetrical for both short- and long-term periods. Therefore, in order to respond to changes in EPU, whether they are rising or falling, certain pricing control measures must be put

into place. Second, variations in the asymmetric influence of EPU on global grain prices were noted by the study. That is, the price decline that follows a fall in EPU is greater than the price increase that follows an increase in EPU for wheat and maize. On the other hand, for soybeans, a rise in EPU triggers a higher price increase, while a decline in EPU signals a lower price decrease.

Li, Chavas, Etienne and Li (2017) stress that unusual price fluctuations increase risk and create uncertainty for both producers and investors. In addition to creating security concerns for these economic agents, price volatility leads to food shortages. Purchasing decisions have become dubious in the industrial sector due to the unpredictable nature of price swings, particularly for commodities with long production cycles. Alnour et al. (2023) look at the association between EPU and agricultural commodities. They discover that EPU has the potential to have a significant impact on the economy, making food insecurity worse and putting more strain on financial markets and human wellbeing. Chen, Verousis, Wang, and Zhou (2023) examine the impact of financial strain on the volatility of commodity prices in a different study. They examine the Kansas City Financial Stress Index (KCFSI) and the Commodity Price Index Variance using data spanning from 1990 to 2020. Their findings indicate a strong correlation between financial stress and changes in commodity prices.

Xiao, Tian Hou and Li (2019) on the other hand used the time-varying parameter vector autoregression (TVP-VAR) method to investigate how economic policy uncertainty affects food prices in China. They concluded that the prices of grain futures are significantly impacted by the uncertainties of economic policy. In a similar vein, Wen, Khalid, Mahmood and Zakaria

(2021) observed that food prices are more affected by negative shocks to economic policy uncertainty than by favourable ones. According to these studies, it is expected that food prices will rise as economic policy uncertainty increases. This is because increased policy uncertainty affects the predictability, costs, investments, and prices of agricultural products, which in turn reduces agricultural production.

The asymmetry and co-movement between energy prices and the prices of different food items from 1992 to 2017 were revealed by Chowdhury, Meo, Uddin and Haque (2021) using the wavelet coherence approach. Positive shocks had a stronger and longer-lasting effect, as they demonstrated asymmetrical reactions. Comparably, a similar model was used by Alnour, Altintaş and Rahman (2023) to examine the asymmetric relationship between Brent and West Texas intermediate oil prices and global food prices between 1990 and 2017. Their results showed the existence of asymmetrical effects, with the overall food prices reacting to positive shocks from the oil price.

Bairagi (2022) conducted a cross-continental investigation and found that Economic Policy Uncertainties (EPUs) from China, Europe, Australia and Japan had a significant beneficial impact on the Australian stock market. Conversely, Sim and Zhou (2015) propose that oil shocks and global uncertainties act as symmetrical indicators for predicting stock returns. Das and Kumar (2018) suggest that global EPU has a stronger influence on stock markets in developed economies, while domestic EPU exerts a more considerable effect on stock markets in developing nations. Hung (2021) discovered that domestic EPU triggers short-term volatility spillovers into the BRICS stock markets and observed a two-way volatility spillover between

EPU and these markets after the European debt crisis. Syed and Kamal (2022) report that EPU in the US significantly influences the Indian stock market, whereas EPU in China has a minimal short-term effect. Mishra and Debata (2020) claimed that the Indian EPU has a major impact on the Nifty stock market and proposed that elevated EPU causes stock market volatility.

According to Ullah, Zhao, Amin, Syed and Riaz (2023), the economic uncertainty in China increases due to Covid-19. The research also found that stock returns in both the Shanghai and Shenzhen stock markets fell as a result of Covid-19. It showed how the pandemic led to a sustained increase in economic uncertainty, which had a major influence on the stock returns of these exchanges. Frimpong et al., (2021) looked at the time-frequency link between the uncertainty of global economic policy and the pricing of different food items, like corn, rice and oats. They used wavelet coherence and partial wavelet coherence techniques to analyse the data from 1997 to 2019. The study found that the interconnection of the agricultural commodities market is influenced by uncertainties in global economic policy.

In their study, Albulescu, Demirer, Raheem and Tiwari (2019) investigated how US EPU impacts the connection between commodity currencies from both developed and developing economies and oil returns. Their findings indicate that EPU influences how oil and currency markets interact, facilitating the transfer of risk between these markets. Comparably, Yang and Hamori (2021) looked at the causal relationship between systemic risk in the crude oil market and worldwide EPU using Diebold and Yilmaz's connectivity metric. The importance of EPU as a crucial economic factor influencing systemic risk in financial markets is shown by their research. A

study by Bilgin, Gozgor, Lau and Sheng (2018) examined the asymmetric correlations between important uncertainties like the skew index, VIX index, EPU index, Partisan conflict index, gold and WTI crude oil prices. Moreover, they noticed that rising gold prices are correlated with a rise in the uncertainty index. Interestingly, they pointed out that improvements in economic policy conditions do not correspond with drops in gold prices. However, unlike previous studies (Huang, Li, Zhang, & Chen, 2021; Ullah, Zhao, Amin, Syed, & Riaz, 2023), Bilgin, Gozgor, Lau and Sheng (2018) study are constrained in scope since it ignores recent policy concerns resulting from events like COVID-19 and geopolitical risks.

The HMH posits that financial markets are not homogeneous, meaning that different markets, assets and investors respond differently to the same economic shocks (Kahyaoglu & Kahyaoğlu, 2020). In the context of commodity markets, this theory suggests that commodity returns are influenced by the specific characteristics of each commodity, as well as the varying reactions of market participants, depending on factors such as market structure, investment preferences, production cycles, and geographical location (Kahyaoglu & Kahyaoğlu, 2020). Therefore, the relationship between economic EPU and commodity returns is likely to be asymmetric, as commodities do not respond uniformly to economic policy shocks.

In addition, the responses of commodity markets are further influenced by the varying degrees of market integration and investor behavior, with some markets being more resilient or reactive to changes in policy uncertainty than others (Shi, Broussard & Booth, 2022). The asymmetry comes from the fact that positive or negative shocks (such as a policy that favours or restricts

commodity trade) will have varying magnitudes of impact on commodity returns, depending on the nature of the shock and the specific characteristics of the market or commodity involved (Shi et al., 2022). Hence, to empirically explore this relationship on a global scale, particularly during periods characterized by frequent policy uncertainty, and to understand its potential implications for agricultural commodities, the study aims to test the hypotheses outlined below:

$H_{0\,A}$: there is no asymmetric relationship between EPU and commodity returns.

$H_{1\,B}$: there is an asymmetric relationship between EPU and commodity returns.

Interdependence between GPR and commodity returns

GPR has an obvious effect on commodities returns, as shown by the economy's supply-and-demand dynamics. Supply-side geopolitical risks have the potential to produce abrupt shocks to the commodities market (Hamilton, 1983; Mork, 1989). As a result, it is not a fresh endeavour to investigate the relationship between geopolitical uncertainty and the commodity market returns. Reboredo (2012) investigated how the price of oil correlates with the prices of agricultural commodities, aiming to explore the structural dependence of returns among these commodities. The researcher found no indication of a substantial relationship between oil and agricultural prices using bivariate copulas with time-varying dependence factors utilising weekly data. The relationship between oil and several commodity markets, such as wheat, rice, cotton, and coffee, was also investigated by Ghorbel, Hamma and Jarboui (2017) using time-varying Archimedean copulas. Their investigation

showed that there is a structural dependency between agricultural commodities and oil.

The study by Mensi, Tiwari, Bouri, Roubaud and Al-Yahyaee (2017) revealed a correlation between the implied volatility indices of crude oil and the prices of corn and wheat, using wavelet copula techniques. Their results indicate that most of the time there appears to be time-varying asymmetric tail dependence, suggesting that the time frame under consideration has an impact on the interdependence structure between the commodities. Similar to this, Jiang, Marsh and Tozer (2015) examined the dynamic interaction between the markets for metals, oil and agricultural raw commodities using a combination of copula and wavelet techniques. According to their research, the oil market has a dependency dynamic that puts it ahead of the metal market but behind the agriculture market.

According to Gong and Xu (2022), the effect of GPR on the commodity markets are interrelated around the globe. Just and Echaust (2022) claim that during the Covid-19 pandemic's recovery phase and the start of the Russian-Ukrainian war, agricultural commodities markets showed significant interconnectedness. According to Babar, Ahmad and Yousaf (2023), soybeans show the most and lowest effectiveness as receivers during the Russia-Ukraine conflict, while maize and sugar are the most and least efficient transmitters of spillover, respectively. On the other hand, research by Wang, Bouri, Fareed and Dai (2022) indicates that GPR is the source of spillover indices, with soybeans and wheat appearing as net return recipients of spillover amid tensions between Russia and Ukraine.

Further, Li, Cong, Xie, Wang and Wang (2022), contend that geopolitical developments have a detrimental effect on the price of natural resources. Similar to this, Li and Liu (2019) looked at the relationship between geopolitical tensions and bilateral commerce between China and Japan, highlighting that the effect differs based on the kinds of goods involved. They discovered that diplomatic squabbles have a negative impact on consumer goods, but no discernible correlation was seen for raw resources or intermediate items. The economic consequences of terrorism fears on firms, such as higher insurance and wage premiums that can result in a drop in trade, were emphasised by Gaibulloev and Sandler (2019).

By employing nonparametric causality-in-quantiles tests, Balcilar, Bonato, Demirer and Gupta (2018) demonstrate that GPR has an adverse effect on the BRICS stock market's volatility measures, implying that GPR contribute to unfavourable volatility in these markets. Furthermore, the relationship between GPR, Islamic equity and Sukuk bonds was investigated by Bouri, Demirer, Gupta and Marfatia (2019). They discover that volatility indices for the Islamic equity market are typically more impacted by GPR than returns. Nonetheless, volatility metrics and Islamic bond returns are often predicted by GPR.

In addition, the significance of GPR as part of risk assessment has increased since the political conflict between Russia and Ukraine began (Umar, Bossman, Choi, & Teplova, 2022; Zaremba, Kizys, Aharon, & Umar, 2022). According to Engel and Campos-Martins (2020) geopolitical tensions are intensified when countries are exposed to political developments in other countries. Also, Caldara and Iacoviello (2022), add that commodity prices

have been significantly influenced by the proliferation of geopolitical worries in recent years. Geopolitical risk has been shown by Qian, Zeng and Li (2022) to be a catalyst for both current and future volatility in the oil market. Similarly, Nonejad (2022) found that the volatility of crude oil prices is affected by geopolitical events. Changes in the GPR index can be used to predict Bitcoin price volatility and returns, according to a study by Aysan, Demir, Gozgor and Lau (2019). Furthermore, the research indicates that Bitcoin may function as a buffer against noteworthy geopolitical developments. In a similar vein, Cunado, Gupta, Lau and Sheng (2020) show that GPR usually have a large negative effect on oil returns using a time-varying parameter structural vector autoregressive (TVP-SVAR) model. The reduction in oil consumption brought on by downturns in the world economy is primarily responsible for this effect.

Umar, Polat, Choi and Teplova (2022) investigate how geopolitical risks resulting from the Russian-Ukrainian conflict affect different financial markets by using the TVP-VAR-based connectedness technique established by Antonakakis, Chatziantoniou and Gabauer (2020). Along with a number of important commodities markets, their study primarily focuses on the European and Russian financial markets. Their results suggest that Russian bonds and European stocks are net shock emitters. Furthermore, return connectedness in short-term frequencies and volatility connectedness in long-term frequencies appear to have been impacted by the military tensions in Ukraine. Salisu, Pierdzioch and Gupta (2021) note that fluctuations in GPR are predictive of volatility in the oil market, and Shen, Liang, Li, Liu and Lu (2021) discover that a rise in GPR stimulates M&A activity among Chinese companies in the

energy and electric power sectors, attributing this pattern to elevated levels of uncertainty.

Okhrin, Uddin and Yahya (2023) use high-frequency intraday data covering the Covid-19 crisis period and the ongoing conflict in Ukraine to investigate the asymmetric and nonlinear relationships among stock and commodity markets. Their findings show a significant increase in links during the Covid-19 epidemic, a pattern that intensifies even more if hostilities break out. But the increased reliance is more noticeable near the bottom of the distribution, suggesting an uneven relationship between the commodities and stock markets under investigation. Similarly, Bossman and Gubareva (2023) use a nonparametric regression model to examine the asymmetric financial effects of geopolitical risk (GPR) resulting from the Ukrainian crisis on the seven main emerging markets (E7) and developed markets (G7). Their research indicates that there is asymmetry and non-uniformity in the effects of GPR on financial markets.

The studies described above are only a few examples of the growing body of research that highlights how important it is for participant in the commodity market and other sector to take geopolitical risk into account. While the reviewed studies have shown that geopolitical events and commodity returns are correlated, this does not necessarily imply a causal relationship (Hudecova & Rajcaniova, 2023; Vo & Tran, 2023). Correlation alone does not establish that one factor directly influences the other. Without a clear causal link, the findings from empirical research may offer limited practical value, as they might not accurately reflect the underlying mechanisms driving the observed correlations. This therefore requires

causality in quantile which can uncover how the influence of geopolitical risks varies across different levels of commodity returns, such as low, medium, and high return scenarios. This can help identify whether geopolitical risks have different effects during periods of high volatility versus periods of stability, thus providing a clearer picture of causation rather than mere correlation.

Further, the speculative nature of commodity markets introduces significant noise and volatility, which complicates the analysis of interdependence. The markets are influenced by myriads of factors, including investor sentiment, speculation, and short-term fluctuations, which can obscure the true relationship between geopolitical risks and commodity returns. This noise can make it difficult to discern meaningful patterns and draw robust conclusions from empirical studies, as the volatility may overshadow any potential signals of interdependence. Hence by employing wavelet decomposition, researchers can identify and analyse the relationship between geopolitical risks and commodity returns across various time scales, reducing the effect of short-term noise and volatility that may obscure meaningful patterns.

HMH also asserts that financial markets, including commodity markets, are not uniform but are composed of different segments that exhibit distinct characteristics and responses to various economic shocks (Atipaga, Alagidede & Tweneboah, 2024). As a result, the relationship between GPR and commodity returns is likely to vary across commodities, and this interdependence will not be uniform across all markets. HMH suggests that these differences result in varying degrees of interdependence between GPR and commodity returns, with certain commodities experiencing stronger

correlations with GPR due to their specific vulnerabilities or dependencies (Atipaga et al., 2024). In markets where commodities are more tightly integrated with global trade flows and geopolitical factors, the interdependence between GPR and returns is likely to be stronger (Atipaga et al., 2024). On the other hand, commodities with lower exposure to geopolitical events may exhibit weaker interdependence or may only respond to geopolitical risk under certain conditions. The current research is motivated to contribute to the aforementioned literature threads by recent discoveries that highlight the diversity and interconnection in cross-market connectedness dynamics. To contribute to this, the current study examines the relationship that exists between commodities returns and geopolitical risk through the following hypothesis testing:

$H_{0\,C}$: there is no interdependence between geopolitical risk and agricultural commodities.

$H_{1\,D}$: there is interdependence between geopolitical risk and agricultural commodities.

Joint dynamics of GPR and EPU on commodity return.

Considerable emphasis has been paid to the effects of GPR and EPU as drivers of dynamic fluctuations in asset correlations. Policy uncertainty has a favourable influence on the long-term oil-stock correlation, according to Bonaccolto Caporin and Gupta (2018); however, Fang, Yu and Li (2017) showed that EPU has a negative impact on U.S. stock and bond market correlations. It was recently found by Hu, Zhang, Ji and Wei (2020) that in difficult economic times, the EPU effect on the correlation between stocks and commodities strengthens. Further research on the causal linkages between oil

markets and agricultural products was conducted by Vo, Vu, Vo and McAleer (2019). Their results show that variations in crude oil prices significantly affect the volatility and prices of agricultural commodities. Meanwhile, Umar, Jareño and Escribano (2022) confirm that agricultural commodities react favourably to changes in the crude oil market. Expanding upon this, Shiferaw (2019) backs up the results of Vo et al., (2019) by pointing out that the relationship between the price of energy and agricultural commodities is dynamic. This suggests that significant price movements frequently occur between crude oil and agricultural products.

Su, Wang, Tao and Oana-Ramona (2019) also add that there is evidence of price spillover between two variables in commodities, demonstrating a dynamic, positive and bidirectional causal relationship between crude oil and agricultural prices. Pal and Mitra (2019) demonstrate a significant association between returns in the crude oil and agricultural commodity markets, which supports this observation. The nature and dynamics of volatility spillovers between the price of crude oil and the markets for agricultural commodities during the global financial crisis were examined by Lu, Yang, and Liu (2019). Their findings suggest that during this crisis, there is a bidirectional volatility spillover between the markets for agricultural commodities and crude oil. Conversely, Hailemariam, Smyth and Zhang (2019) investigate the time-varying impact of global oil prices on economic policy uncertainty (EPU) using a nonparametric panel data technique. They show that when there is a spike in worldwide aggregate oil demand, global oil prices have a negative impact on EPU.

Furthermore, EPU responds asymmetrically to changes in global oil prices, according to Kang, Tiwari, Albulescu and Yoon (2019). This suggests that different shocks to global oil prices have distinct effects on different parts of EPU. On the other hand, Degiannakis, Filis and Panagiotakopoulos (2018) come to the conclusion that distinct shocks to the world oil price have differing impacts on EPU. But according to Yang (2019), there is little effect of fluctuations in oil prices on EPU. Zhang and Yan (2020) contend that an uneven impact of EPU exists on oil price returns. On the other hand, Bonaccolto, Caporin and Gupta (2018) show that EPU has an impact on the lower and upper quantiles of the returns on global oil prices in both positive and negative ways using a non-parametric approach using quantile projections. Depending on the models selected, Mei, Zeng, Cao and Diao (2019) find that EPU has a mixed effect on the volatility of oil prices. Hu, Zhang, Ji and Wei (2020), on the other hand, use high-frequency data to show that EPU shows a time-varying influence on the realised volatility of global oil prices.

Zheng, Zhao and Hu (2023) examine how geopolitical uncertainty affects commodity futures in China over a range of time periods and find that the commodities markets are more intricate than the oil market. This complexity results from a number of elements, as noted by Lyu, Yi, Hu and Yang (2021), including the extent of financialisation of the market, the storability of commodities, transit convenience, supply flexibility, and dependence on weather conditions. The single-factor prediction model for pandemics and epidemics, according to Salisu and Shaik (2022), still shows that Islamic stocks have better hedging potential than conventional stocks

during the Covid-19 pandemic, even after taking into account oil prices, GPR and EPU.

Cunado, Gupta, Lau and Sheng (2020) explored the association between geopolitical risks (GPRs) and oil prices. Their research indicates that as GPR influences economic circumstances in both established and emerging nations, impacting oil costs based on overall economic performance, it makes sense that geopolitical issues will influence changes in the oil market through fluctuations in oil demand. Gong and Xu (2022) highlight that, among other uncertainties, geopolitical uncertainty stands out as a crucial component that propels the volatility seen in commodity markets. The relationship between geopolitical risk, financial instability and conventional energy sources like oil and gas, as well as precious metals like gold and silver, were examined by Shahzad, Mohammed, Tiwari, Nakonieczny and Nesterowicz (2023). Their analysis showed that the main shock transmitters in this networked architecture are geopolitical risk, financial instability, and oil returns.

The financial market integration theory suggests that as financial markets become more integrated, the behavior of different financial assets, including commodities, becomes increasingly correlated (Hadi, 2023). The theory emphasizes that markets are not isolated but are interconnected through global networks of trade, capital flows and information (Hadi, 2023). This integration leads to the idea that shocks in one market (such as a geopolitical event or policy change) can propagate quickly across markets, including commodity markets, due to the interconnected nature of financial systems (Hadi, 2023). In line with this theory, the researcher argues that increased uncertainty in global markets, driven by geopolitical instability or economic

policy shifts, will result in higher correlations between commodity returns across countries and regions. The current study uses these techniques to try and verify the following hypothesis:

$H_{0\,E}$: there is no joint dynamics between global uncertainties and commodity returns.

$H_{1\,F}$: there is a joint dynamic between global uncertainties and commodity returns.

Gaps in existing studies

Both the empirical assessment and the theories employed in the study indicate that the returns on commodities are very sensitive to global uncertainties (geopolitical risk and uncertainties in economic policy). The literature further clarifies how these two uncertainties relate to the commodities market globally. This is significant because global government policies that support stable economic activities and geopolitical risk are what determine the best returns on commodities. Although empirical research has illuminated the connection between commodities, EPU and GPR, it is crucial to recognise certain limitations that demand attention and additional study. It can be seen from the reviewed studies that, most of earlier researcher fail to account on how the arrival of new information as a result of uncertainties affect the commodity market. Therefore, this is one of the gaps in empirical studies that the current study seeks to address, in order to gain a more thorough knowledge of the dynamic's relationship between the study variables.

Also, the level of interconnection among commodities and global uncertainties which has been noted in the literature deserves more

investigation to determine if these uncertainties and its associated news are the cause of shocks into the commodity market. Recognising the lack of information about market interconnectedness is critical, especially in the periods of continuous political upheaval and economic instability that the world is experiencing. Gaining an understanding of these uncertainties' effects on world's commodities market is crucial for developing strategies for portfolio management, market regulation, and asset allocation that work.

In addition to the above, substantial portion of the literature relies on individual commodities, which may not adequately capture the evolving nature of how global uncertainties affect the modern commodity markets. That is, as financial markets have become increasingly complex with the advent of new financial instruments and technologies (such as Artificial Intelligent cryptos'), occurrences in a single financial market may not always predict current or future behaviour of the global financial market.

Contribution to existing studies

The reviewed studies indicate a significant volume of research exploring the relationship between GPR, EPU and commodities. These investigations span analyses conducted at national and regional levels, employing diverse methodological approaches. This study makes a significant contribution to existing research by extending the analysis of the relationship between GUs and commodity returns CPs beyond the aggregate global level. This is achieved through the expanding of the study data in the current study. Further, the study's key contribution lies in its multidimensional approach, which examines how varying types of global uncertainties affect individual commodities and their respective markets. Also, this research offers a novel

connection between commodity price fluctuations and the achievement of the Sustainable Development Goals (SDGs), which has been underexplored in existing studies. While much of the literature on GUs and CPs has concentrated on their impact on economic growth or market volatility, this study extends the discussion to incorporate broader socio-economic outcomes such as poverty reduction, inclusive growth, and sustainable development.

However, this study diverges from the reviewed literature in three key aspects. First, this study is on the global scale. Second, it contextualises how the arrival of new information emanating from global shocks affect the commodity market and situate this into the core premise of the heterogeneous market hypothesis and financial market integration. Third, this study extends beyond previous research by employing commodity index that captures the overall market dynamics. This index provides a holistic measure of the market, tracking prices and returns across a diverse basket of commodities. Moreover, it offers diversification advantages by mitigating the risk associated with exposure to a single commodity. Furthermore, to look at how these uncertainty indexes affect global commodities, the current study uses wavelet and quantile regression approaches. Among the many benefits of these approaches is their capacity to evaluate market relationships and analyse market actions over a variety of time and frequency intervals. These techniques also take into consideration how these uncertainties affect commodity fluctuations in the time and frequency domains, which makes it possible to measure the speed at which new information enters the market.

Chapter Summary

This chapter explained the theories that guided the research. The Modern Portfolio Theory, which modifies and chooses assets within a portfolio in an effort to maximise returns were examined. It has also been established in literature that times of uncertainty may have an impact on investor behaviour and levels of investment in the commodity market. As a result, the chapter also included the theory of the heterogeneous market hypothesis, which describes the trading patterns, expectations, and informational sets of various investors and influences their choices at such times. Additionally, the financial market integration theory was also considered in this section. The association between global commodities, economic policy uncertainty and geopolitical risk was then empirically justified in the chapter. The chapter further pointed out the shortcomings in current research and described the advancements that this study has introduced.

CHAPTER THREE

RESEARCH METHODS

Introduction

The chapter present the techniques and approach adopted to explain the relationship between the study variables and how this present opportunities and challenges to investor in the commodity market globally. This chapter offers a detailed examination of the research paradigm used in the study, design and approach, covering the definitions, sources and measurements of variables, the specifications and justifications of models and methods employed.

Research Paradigm

According to Kivunja and Kuyini (2017), research paradigm is a framework of beliefs and practices that guide the research process. It is an approach or a pattern to conduct research that reflects the philosophy of a scientific research and approach. Therefore, this research is underpinned by the positivist paradigm. Positivist paradigm is based on the premise that the world is objective and can be measured and observed. This perspective assumes the existence of one objective reality, which can be known, described and explained accurately by people. To understand their surroundings, positivists use their sensory experiences as the basis for gaining knowledge (Saunders, Lewis, & Thornhill, 2023). The ability to detect social reality suggests that variables can be used to quantify and depict it. Consequently, adopting this paradigm involves the collection of data related to these variables, the analysis of this data using statistical techniques and validation or rejection of hypotheses to form generalisations. Research within this paradigm

produces result that can be reported quantitatively, enabling forecasting in relation to a particular occurrence (Saunders, Lewis, & Thornhill, 2023).

The choice of the positivism research paradigm for this study was driven by the need to gather data on GPR, EPU and commodities and analysing it with the use of econometric analysis to establish relationships and thereby affirming or refuting the hypotheses to determine whether GPR and EPU affect commodities market globally.

Research Design

According to Saunders, Lewis and Thornhill (2003), research designs can be categorised as descriptive, explanatory or exploratory. An explanatory research design was applied in this study. Studies that focus on identifying causal links between variables are considered explanatory, as demonstrated by empirical research (Saunders et al., 2003; 2023). The emphasis of explanatory research design lies in investigating a situation to clarify the association between variables. In this study, a research effort aimed at understanding the relationship between geopolitical risk, economic policy uncertainty and commodity return on a global scale was adopted.

Research Approach

Research approach refers to the structured and methodical techniques that researchers use to conduct their studies, varying in their foundational logic and inquiry (Saunders et al., 2003). As outlined by Sileyew (2019), research can generally be categorized into three primary approaches: the qualitative approach, the mixed approach and the quantitative approach. In this study, the quantitative research approach was adopted because there exist numerical data

on every variable used in this research to answer the research questions and test the respective hypotheses.

Data Collection Procedures

The study explained the nexus between GPR, EPU and commodity returns at the global level. As a result, secondary monthly data on GPR, EPU and commodities were sourced from Caldara and Iacoviello (2018) measure for adverse political event, and Baker, Bloom and Davis (2016) measure for economic policy uncertainty and Standard & Poor's Goldman Sachs Commodity Index (S&P GSCI) for commodities. The data span from the year 1990-2023. This period was chosen to cover most of the global uncertainties such and covid-19 pandemic and the Russia-Ukraine war. Further, the motivation for the period selection is that the indicators that make up economic policy uncertainty currently spans from the year 1987 – 2023.

Pre and Post Estimation Justification

In order to ensure the robustness and appropriateness of the estimation technique, several pre-estimation diagnostics were performed (Yılmaz, 2023). One of the key checks involved testing for stationarity in the data, which is essential for time series analysis to avoid spurious results. To do this, the researcher utilized the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test to examine whether the data series were stationary at levels or required differencing to achieve stationarity. The results for this as indicated on table 1 indicated that the data were non-stationary, meaning that the time series data exhibited trends or unit roots that could undermine the reliability of traditional time series models (Yılmaz, 2023). Given these findings, it was

necessary to adopt a different approach that could accommodate non-stationary data and capture the underlying dynamics effectively.

Due to this the researcher adopted the wavelet decomposition approach to address the non-stationarity of the data (He, Gokmenoglu, Kirikkaleli & Rizvi, 2023). The wavelet technique is well-suited for handling non-stationary time series data, as it allows for the decomposition of data into different frequency components, thereby isolating short- and long-term dependencies. This technique is particularly useful when dealing with complex, multiscale relationships, such as those often found in financial and economic time series (He et a., 2023). This approach provides a more flexible and effective way to model the data, ensuring that the analysis accounts for non-stationary behaviors while preserving the essential patterns of the series.

Model 1- the asymmetric relationship between EPU and commodities returns.

Model 1 is a quantile regression equation tailored for the first objective, derived from the quantile regression equations originally developed by Koenker and Bassett Jr (1978); Assifuah-Nunoo, Junior, Adam and Bossman (2022). The baseline models employed in these studies were modified to explore the asymmetric relationship between economic policy uncertainty and commodity returns.

Model 1

$$ComoR_t = \alpha_0 + \alpha_1 EPUR_1 + \varepsilon_t \quad (1)$$

Where $ComoR_t$ and $EPUR_1$ are the returns for commodities and economic policy uncertainty respectively, with ε_t representing the error term. The equation is therefore converted into a log-returns and is expressed as

$$ComoR_t = lnP_t - lnP_{t-1} \quad (2)$$

$$EPUR_1 = lnP_t - lnP_{t-1} \quad (3)$$

Where $ComoR_t$ and $EPUR_1$ are the commodity returns and economic policy uncertainty compounded continuously while P_t and P_{t-1} are the commodity return and economic policy returns in the current period and previous period respectively.

The traditional OLS model in Equation (1) can best render a response to only a query in this study, that is, whether or not economic policy uncertainty is essential for commodity volatility (Nusair & Al-Khasawneh, 2018; Assifuah-Nunoo et al., 2022) but may fail to respond to a very essential query like whether or not persistent increase in policy uncertainty will affect commodity returns differently for "markets with low returns" than for "markets with high returns". Nusair and Al-Khasawneh (2018) suggested that QR is effective in examining how EPU shocks influence commodity returns in different market environments. With QR, a model of the conditional φ^r quantile of the explained variable is generated for specified values of $\varphi \in (0, 1)$. Therefore, the contingent QR model for $ComoR_t$ given EPU_t could be expressed as

$$QComoR_t^{(\emptyset / EPUR)} = \alpha^{\emptyset} + \beta_1^{(\emptyset)} EPUR_t' \beta^{\emptyset} \quad (4)$$

Where $QComoR_t$ is the regressand and commodity return is defined by $QComoR_t^{(\emptyset / EPUR}$ with the intercept being represented as $\alpha^{\emptyset,}$ and allowed to be subject to Ø. A vector of the σ^{th} related coefficients are defined as $\beta^{\emptyset}$ and $EPUR'$ defines a vector of regressors, which in this study, is restricted to economic policy uncertainty index. The estimates derived from this approach are more reliable because they are more resistant to outliers in the response

measurements. Following Koenker and Bassett (1978), the τ^{th} quantile coefficients of the conditional distribution is expressed as

$$\min_{\gamma \epsilon^k}[\sum t : ComR_t \geq \partial^{\tau} + EPU_t'\beta^{\tau}\varphi | ComoR_t - \partial^{\tau} - EPU_t'\beta^{\tau}\varphi + \sum t : QComoR_t <$$

$$\partial^{\tau} + EPU_t'\beta^{\tau}\varphi + | \text{Com}R_t - \partial^{\tau} - EPU_t'\beta^{\tau}\varphi | \quad (5)$$

The minimisation problem of Koenker and Bassett (1978) in Equation (5) could be expressed as the minimised weighted deviations from the contingent quantile

$$\min_{\gamma \epsilon^k}[\sum t \, \rho\tau(ComR_t - \partial^{\tau} - EPU_t'\beta^{\tau}\varphi) \quad (6)$$

where the weighting factor, termed a check function, is represented by $\rho\tau$ and holds for the set $\varphi \in (0, 1)$.

In examining the asymmetric relationship between economic policy uncertainties and commodity returns using QR estimations, the study models the quantile relationships to conform to the traditional OLS model defined in Equation (1) as

$$QComoR_t\,(\tau/EPUR) = \partial_0^{\tau} + \partial_2^{\tau}\, EPUR_t \quad (7)$$

Objective one seeks to analyse the asymmetric relationship between economic policy uncertainty and commodities across broad range of quantiles. This was done to examine the potential effects of economic policy uncertainty on commodities at various quantiles. To achieve this, six (6) distinct quantiles, ranging from the 0.05 to 0.95 were taken into account in the analysis. The researcher further divided the market conditions into three quantile-based categories: the lower quantiles represented by 0.05 and 0.2, the middle quantiles detonated 0.4 t and 0.60, whiles the upper quantiles are represented by 0.70 and 0.95. The selection of the various quantiles was guided by empirical studies. According to Owusu Junior, Adam and Tweneboah (2020), a

quantile should have a minimum data size of thirty (30). Therefore, given that the total number of data points utilised in the study is one hundred and ninety-one (N=191) from descriptive statistics in table two (2), the number of quantiles needed for this data point is ($\frac{191}{30}$ = 6.3667 quantiles). This explain why two quantiles were chosen for each of the lower, middle and upper quantiles, making a total of six quantiles as shown on table 3.

Model 2- the interdependence between GPR and commodity returns

Model 2 is cross wavelet transform (CWT) for analysing interdependence between geopolitical risk and commodity return. Assuming that x(q) and y(q) represent two distinct return series for geopolitical risk and commodities, a cross-wavelet transformations involving the two-return series can be written as W_m^x (r, p) and W_m^y (r, p) following (Gouhier, Grinsted, Simko, Gouhier, &Rcpp, 2013). These separate cross wavelet transforms are then combined to obtain their joint cross wavelet transform, as depicted in the following equation:

$$W_m^{xy}(r, p) = W_m^x(r, p)\,{}^{*}W_m^y(r, p), \quad (8)$$

In the equation above, "r" depict position, "p" depict scale, whiles the complex conjugate is represented by $*$. The joint cross wavelet transformation (CWT) is a crucial step that helps to differentiate sections within the time-frequency domain, capturing the degree of interdependence of the two-return series, even when their shared strong power is not present. Essentially, it helps in identifying the specific areas where the two series exhibit relationships. A CWT of one (1) signifies that the degree of interdependence between the two-return series is high while a CWT of 0 denotes a lack of significant

interdependence. In the subsequent step, an expression for the return series that relies on the square of the wavelet transform is depicted below.

$$R^2(r, p) = \frac{|S(s^{-1} W^{xy}(r,p))|2}{|S(s^{-1} W^{x}(r,p)|2 \, |S(s^{-1} W^{y}(r,p)|2} \quad (9)$$

The smoothing variable "S" is introduced to strike a balance between resolution and significance in the given expression. The value of R^2 (r, p) ranges between 0 and 1, where values closer to zero indicate a weak association, while values closer to one indicate a strong association. Stronger dependencies or correlations are visualized through hotter colours, whereas milder colours represent weaker correlations. However, unlike the Pearson correlation coefficient which ranges from -1 to 1, the squared wavelet coherence by default belongs to the 0 and 1 interval. As a result, cross wavelet transform (CWT) is unable to detect whether the analysed return series move in opposing or similar directions. It also does not also differentiate between negative and positive correlations. Despite this, a value of 1 in the CWT indicates a high level of interdependence relationship, while a value of 0 suggests a low level of interdependence.

Model 3 the joint dynamics of GPR, EPU, and commodity returns

To analyse the dynamic relationship among the study variables in the frequency domain, the multivariate wavelet technique was adopted. This approach allows in examining the leading and lagging relationships among the variables across different time frames, including short-term, medium-term, and long-term. In particular, the wavelet multiple correlations (WMC) and the wavelet multiple cross-correlations (WMCC) were utilised to assess dynamic relationship among the variables and to further identify any leading or lagging properties among them. Following the approach employed by Gouhier et al.

(2013) and Opoku, Adam, Isshaq and Owusu Junior (2023), the baseline model for examining the third objective is presented below in the paragraphs below:

Consider a multivariate stochastic process represented by X_t = x_1t, x_2t, ..., x_nt. Using the MODWT, the researcher can obtain a resultant scale λ_j denoted by W_jt = w_1jt, w_2jt, ..., w_njt. Following Fernandez-Macho's (2012) specification, the wavelet multiple correlations (WMC), denoted as ΩX(λj), are computed as a series of multiscale integration measures derived from X_t. These coherence values, representing the square roots of the maximum coefficient of determination (R^2) obtained from linear combinations of variables W_ijt (where I = 1, 2, ..., n), are computed at each wavelet scale λ_j. Previous studies have indicated that the predictors {zk, k ≠ I} can be expressed as R^2 i = 1 - ρ-ii, where ρ-ii represents the i^{th} diagonal element of the inverse of the complete correlation matrix P. Thus, the calculation of WMC can be formulated as follows:

$$\Omega X(\lambda j) = (1 - \frac{1}{\max diag P_j^{-1}})^{\wedge}\frac{1}{2} \quad (10)$$

Where P_j is the (n x n) correlation matrix of W_{jt}

Based on regression theory and the fitted values of zi denoted as $\hat{z}_t$, the wavelet multiple correlations (WMC) can be represented as:

$$\Omega X(\lambda j) = \frac{Corr(W_{ijt}, \acute{W}_{ijt}) Cov(W_{ijt}, \acute{W}_{ijt})}{(Var(W_{ijt}) Var(\acute{W}_{ijt}))^{\wedge}\frac{1}{2}} \quad (11)$$

Where the variable W_{ij} is chosen to maximize ΩX(λj), while the fitted values $\acute{W}_{ijt}$ are obtained from the regression of W_{ij} on the remaining wavelet coefficients at scale λj.

WMCC can be defined as the result of introducing a lag τ between the observed and fitted values at each scale λj.

$$\Omega X, \tau\ (\lambda j) = Corr\left(W_{ijt}, \acute{W}_{ijt+\tau}\right) = \frac{Cov(W_{ijt}, \acute{W}_{ijt+c})}{(Var(W_{ijt})Var(\acute{W}_{ijt+c})} \quad (12)$$

Further, when there are two variables (n = 2), the wavelet multiple correlations (WMC) and wavelet multiple cross-correlations (WMCC) converge with the conventional wavelet correlation and cross-correlation techniques.

In order to compute WMC and WMCC, the stochastic process X_t, for the multivariate is analyse where t varies from 1 to T. This process is denoted as X = {X1, X2, ..., XT}. By applying a MODWT of order J to each of the individual time series $\{X1_i, X2_i, ..., X3_T\}$ for i = 1, 2, ..., n, the T- vector length for the MODWT was obtained, represented as $\acute{W}_j$ = {Ẃj1, Ẃj2, ..., $\acute{W}_j$, T-1}. Equation 12 encapsulates a nonlinear function that incorporates all n(n-1)/2 wavelet correlations at scale λj. It serves as a reliable estimator for wavelet correlation derived from the MODWT.

$$\Omega X(\lambda j) = (1 - \frac{1}{\max diag p_j^{-1}})\wedge\frac{1}{2} = \frac{Corr(W_{ijt}, \acute{W}_{ijt})Cov(W_{ijt}, \acute{W}_{ijt})}{(Var(W_{ijt})Var(\acute{W}_{ijt}))\wedge\frac{1}{2}} \quad (13)$$

Where W_ij represents the result of regressing the same set of regressors {Ẃkj, k≠ i}. The objective is to maximize the coefficient of determination (R^2). The fitted values obtained from this regression are denoted as $\acute{W}_{ij}$ The term Lj = (2j – 1) (Lj -1) refers to the coefficient of the amount of wavelet subject to the boundary conditions can be found by the properties of a wavelet filter with a length of L and a scale of λj. In contrast, Ť = T - Lj + 1 shows the coefficient of wavelet that the boundary condition cannot be impacted.

Similarly, a reliable estimator for the WMCC can be calculated as follows:

$$\Omega X(\lambda j),\ \tau(\lambda_j) = \frac{Corr(W_{ijt}, \acute{W}_{ijt+\tau})Cov(W_{ijt}, \acute{W}_{ijt+c})}{(Var(W_{ijt})Var(\acute{W}_{ijt+\tau}))^{\wedge}\frac{1}{2}} \quad (14)$$

When establishing the confidence interval (CI) for WMC, Fernandez-Macho simplifies the process by utilizing the arctan h(r) transformation, with arctan(.) representing the inverse hyperbolic tangent function for ease of calculation (see Owusu Junior et al. 2021).

Log-returns Computation

The return for geopolitical risk is computed below:

$$r\,t\ = l\,n\ \ G_t - l\,n\ \ G_t\text{-}1 \quad (15)$$

where $r\,t$ denotes the continuously compounded returns, G_t is the geopolitical risk in period t , and A_t-1 denotes the geopolitical risk in the previous period t – 1.

Data Processing Tool

R programming software was used to process the data in this study with Quantile Regression and Wavelet analysis adopted as the estimation technique. While ordinary least squares regression estimates the average value of the response variable under certain conditions, quantile regression does not rely on distributional assumptions. It can identify how the effects of covariates differ throughout the entire distribution of the response variable (Koenker, Bassett Jr, 1978). Quantile regression can also be more robust to outliers and extreme values than ordinary least squares regression. In contrast, the wavelet technique facilitates the examination of interconnectedness and lead-lag relationships among variables across different time frames. The analyses were supported by codes provided by the quantile regression of Koenker and

Bassett Jr (1978) and the bi-wavelet package provided by (Gouhier et al., 2013).

Measurement of Variables

The fact that these measurements have been widely used in the body of existing research served as guidance for the selection of measurement for each variable. Commodities which represent the response variable were measured utilising agricultural commodity indexes, energy commodity index and metals commodity index. Agricultural commodities comprise the Standard & Poor's Goldman Sachs Commodity Index (S&P GSCI). Thus, S&P GSCI Softs, the S&P GSCI Grains and the S&P GSCI Livestock. The S&P GSCI Softs commodity index, is an index for traded agricultural products defined as soft commodities: coffee, sugar, cocoa, and cotton. The S&P GSCI Grains includes the agricultural commodities of wheat, corn, and soybeans. Finally, the S&P GSCI Livestock includes those commodities of lean hogs, live cattle, and feeder cattle. The above represent the various indexes for the agricultural commodities.

Energy commodity index is also made up of Standard & Poor's Goldman Sachs Energy Commodity Index (S&P GSCI). This index captures the following energy commodities crude oil, heating oil, natural gas gasoline and low sulphur gasoil. Further, the Standard & Poor's Goldman Sachs Metal Commodity Index (S&P GSCI- Metals) is made up of industrial metals (aluminum, copper, nickel, zinc) and precious metals (gold, silver, Platinum and Palladium).

GPR and EPU which were the independent variables were proxied using Caldara and Iacoviello (2018) measure for adverse event and Baker,

Bloom and Davis (2016) measure for economic policy uncertainty respectively. Geopolitical risk index of Caldara and Iacoviello was constructed by counting the number of occurrences of articles discussing geopolitical events and risks in newspapers. To measure geopolitical risk, the approach involves calculating the proportion of news articles focused on negative geopolitical incidents relative to the total number of articles in each month's newspapers for the given country or region.

In constructing the index, automated text search is programmed to identify articles containing references to six sets of words. Group one (1) deals with terms associated with explicit mentions of GPR and is reference to large-scale military tensions involving various regions worldwide. Group two (2) consists of words directly tied to nuclear tensions such as the cold war like the ongoing Russia invasion of Ukraine. Groups three (3) and four (4) focus on references related to threats of war and terrorist threats, respectively. Finally, Groups five (5) and six (6) capture media coverage of actual adverse geopolitical events that are likely to result in increased geopolitical shocks, such as terrorist acts or the commencement of a war. Unlike many other uncertainty proxies, the GPR index does not systemically increases during recessions and financial crises but does spike during wars or terrorist acts. Empirical results show that the index is not affected by media bias, economic recession and financial crisis.

Economic policy certainty of Baker et al., (2016) on the other hand is a GDP-weighted average of national EPU index. Each national EPU index reflects the relative frequency of own-country newspaper articles that contain a trio of terms pertaining to the economy (E), policy (P) and uncertainty (U).

EPU index accounts for several factors, including prior measures of uncertainty. Collectively, this index attempts to reflect all sources of uncertainty within the economy, which made the index attractive to and widely cited by scholars from different fields. The EPU index has become prominent in the economic and finance field in general as one of the best measures for uncertainty. The index has also continuously evolved, as its founders are gradually adding new countries and sub-indices that account for specific types or sources of uncertainty (Baker et al., 2016).

Further, the EPU index was formulated by considering previous initiatives and indices designed to quantify economic uncertainty (Baker, Bloom & Davis, 2016). It is based on three different aspects for measuring uncertainty: stock market volatility, expectations derived from business surveys and newspaper coverage. Recognising EPU as a comprehensive concept and targeting unexpected shifts in the economic system, Baker et al., (2016) opted to measure multiple components to encompass all potential origins of unforeseen alterations in the financial and economic system. The first section of the index focusses on media coverage and issues related to governmental uncertainty in major newspapers within each country. This encompasses coverage of political and regulatory uncertainty in the media. The second section of the index focuses on documents published by the United States Congressional Budget Office, specifically those dealing with new tax information. The third section of the index is based on economic and financial forecasts from the Federal Reserve Bank, centering on future expectations for macro-level variables like the consumer price index and government expenditures (Baker et al., 2016).

Table 1: Variable measurements and Data Sources

Variable	Measurements	Data Source	Empirical Justification
Commodities	S & P GSCI Commodity Index	Blomberg.com, Food and Agriculture Database	Oztek and Ocal (2013); Aït-Youcef (2019); Umar Jareño and Escribano (2021); Bonato (2019)
Geopolitical Risk	Caldara and Iacoviello measure for adverse political event	https://www.matteoiacoviello.com/gpr.htm	Zhang, He, Zhang and Wang (2022); Agoraki, Kouretas and Laopodis (2022); Abid, Dhaoui, Kaabia and Tarchella (2023)
Economic Policy Uncertainty	Baker, Bloom and Davis measure of EPU	Economic Policy Uncertainty Index	Zhang, He, Wang and Liang (2023); Al-Thaqeb and Algharabali (2019) and Foglia and Dai (2022)

Ethical Consideration

The study excluded human participants, thereby minimising ethical concerns like seeking consent from participant and confidentiality. Nevertheless, secondary data was employed for analysis, and the researcher ensured the acquisition of essential data on GPR, EPU and various commodity returns from a trustworthy database (Food and Agriculture Organisation database and Bloomberg). Further, the study meticulously applied suitable data processing techniques and software, prioritizing adherence to pertinent ethical standards.

Chapter Summary

This chapter outlined the research methods used in the study, which is grounded in the positivism paradigm and employs a quantitative research approach. To investigate the connections between GPR, EPU and commodities in the global financial market, the study adopted an explanatory research design. The study included six major commodity indexes based on available data. In all, three models were developed to explain the three objectives that the study seeks to achieve. The first model was designed to explore the asymmetric link between EPU and commodities. Model two was developed to examine the interdependence between geopolitical risk and commodities and whiles the third model explore the joint dynamics of geopolitical risk, economic policy uncertainty, and commodity returns. The study mainly employed the quantile regression, wavelet coherence and multiple wavelet techniques to estimate the models.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The prime objective of the study was to investigate how global uncertainties affects major commodity returns on the global financial market by employing quantile regression and wavelet estimation technique. This chapter details the data analysis, research findings and hypothesis testing conducted using these estimation techniques. The chapter starts with the summary of descriptive obtained from the analyses in order to achieve the research objectives. Furthermore, results on the asymmetric relationship between economic policy uncertainty and major commodity return, interdependence between GPR and commodities returns and joint dynamics between GPR, EPU and commodity returns are depicted afterwards. In addition to the above, the summary of the findings from the research are also presented in this chapter.

Descriptives Statistics

Figure 4 display the price and return patterns for GPR, EPU and the selected commodity during the specified timeframe under consideration. Throughout the period, the data reflects fluctuations in the various series, with prices series often returning to their normal behaviour after peaks or troughs, while returns depict stationarity throughout the sampled period. Table 2 provides evidence in support of this conclusion using the Augmented Dickey-Fuller test.

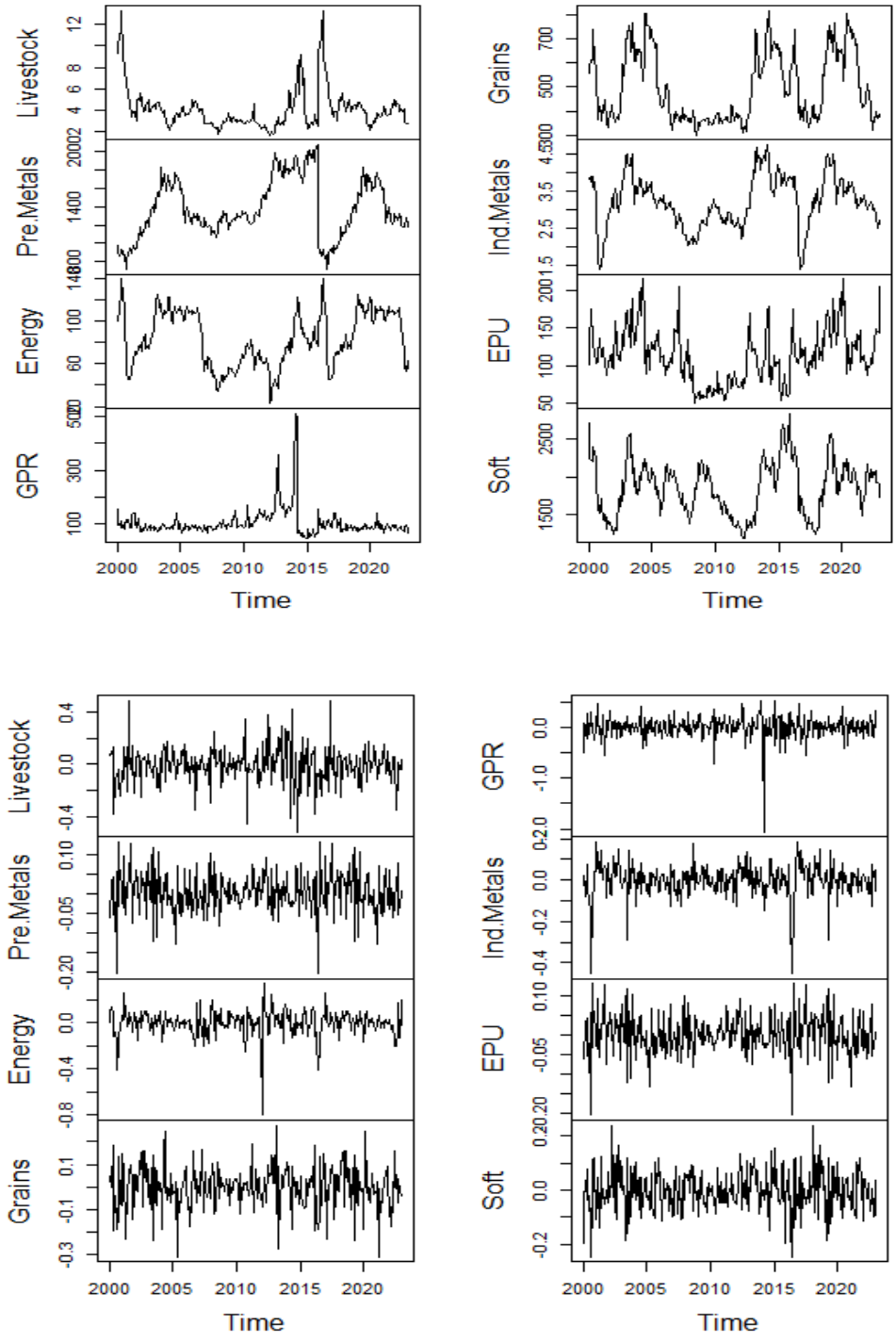

Figure 4: Graph of price series (upper section) return series (lower section) for the study variables
Source: Estimated based on the data obtained for the study variables.

EPU, GPR and commodity returns (agricultural commodities: grains, soft, and livestock; energy commodities: crude oil, heating oil, natural gas and gasoline; industrial metal commodities: copper, aluminium, lead, nickel, and

zinc and precious metals: gold, silver, platinum and palladium) are among the variables this study looked at. Table 2 present the summary of descriptive for these variables. These results, which are based on monthly data from January 1, 2000, to December 31, 2023, yielding 191 observations, include the standard deviation, mean, kurtosis, skewness, and normality test.

Table 2 presents the descriptive statistics for the study. It can be seen from the table that soft commodities have the highest mean value, followed by precious metals, grains, energy, livestock, and industrial metals. The standard deviation analysis indicates that industrial metals have the lowest standard deviation, suggesting greater stability and reliability in their values. Kurtosis values reveal that livestock and GPR exhibit leptokurtic distributions, while the other series show platykurtic distributions. All series except industrial metals are positively skewed, indicating an asymmetrical distribution of returns. To investigate the presence of unit roots, the Augmented Dickey-Fuller and the Jarque-Bera was applied. Findings from Table 1 demonstrate that, at a 5% significance level, the return series are stationary, thereby rejecting the null hypothesis of a unit root. The data reflects fluctuations among different series, with prices returning to normal behaviour after extreme highs or lows, while returns remain stationary.

Further, the Zivot and Andrews (1992) test for stationarity with structural breaks was also employed. Unlike the ADF test, which assumes no structural breaks, the Zivot and Andrews test allows for the possibility of a single structural break in the data. This is particularly useful for time series data where external shocks, such as economic crises or policy changes, may cause sudden shifts in the series. Results indicate that even when allowing for

potential structural breaks, the return series remains stationary at a 1% significance level. This further strengthens the robustness of the findings, suggesting that fluctuations in the commodity markets are not solely due to random noise but are influenced by structural factors. These structural breaks could be linked to significant events or market financialization, as discussed by Mensi et al. (2014), and contribute to the overall dynamics of commodity price movements (Tweneboah et al., 2020).

Table: 2 Summary of Descriptives

	N	Mean	Std. Dev.	Skew.	Kurt.	ADF(t-test)	JB Test (t-test)	ZVA (t-test)	Break date
Livestock	191	3.81024	1.836	2.332	6.899	-6.53**	0.037**	-9.987***	01-02-2011
Pre. Metals	191	1424.109	319.4117	0.174	-0.903	-6.332**	0.827**	-12.139***	01-02-2015
Energy	191	78.665	25.447	0.138	-0.998	-6.754**	0.021**	-10.611***	01-07-2018
GPR	191	105.818	58.784	4.201	23.548	-8.062**	0.077**	-13.549***	20-08-2020
Grains	191	486.558	142.439	0.663	-1.001	-6.831**	0.024**	-9.895***	30-12-2014
Ind. Metals	191	3.199	0.712	-0.020	-0.477	-6.755**	0.012**	-14.488***	28-12-2019
EPU	191	104.797	35.477	0.681	0.047	-6.331**	0.043**	-14.142***	13-05-2019
Soft	191	1833.92	366.069	0.260	-0.590	-5.144**	0.043**	-17.108***	19-07-2020

Note: Std. Dev., Skew., and Kurt., represent standard deviation, skewness and kurtosis. Also, ADF depict Augmented Dickey-Fuller, JB is the Jarque Bera test ZVA represent Zivot and Andrews (1992) test for stationarity whiles [*** and **] signifies the significance level at 1% and 5%.

In Table 3 below, the study also shows the pairwise association between the various commodities, GPR, and EPU. To aid in the simple interpretation and understanding of the computed coefficients, the p-values indicating the significance of these connections are also indicated for several degrees of significance. Moreover, these correlations were carried out as preliminary analyses to determine the extent and nature of the relationship or links between these uncertainties and the international commodities that were the subject of the investigation. Understanding the typical degree of portfolio diversification and the volatility as a result of these uncertainties will be made easier with the help of this analysis. This will help determine the degree of portfolio diversification by measuring the intrinsic correlation between the variables across the study period, as stressed by Wang and Su (2023).

Table: 3 Correlations Matrix

	Livestock	P.Metals	Energy	GPR	Grains	I.Metals	EPU	Soft
Livestock	1							
P. Metals	-.267**	1						
Energy	.505**	.159*	1					
GPR	0.029	.249**	-0.128	1				
Grains	.379**	.489**	.727**	0.071	1			
I. Metals	.284**	.605**	.662**	.157*	.751**	1		
EPU	.211**	0.019	.456**	.143*	.465**	.359**	1	
Soft	.345**	.267**	.543**	-.168*	.533**	.527**	0.096	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

All the selected commodities and EPU have a positive association, from the correlation matrix above. This suggests that the selected commodities and EPU have direct connection, which does not favour investors worldwide

in terms of diversification. Consequently, investors are advised not to build a portfolio that is composed of these commodities only, and are instead urge to incorporate other commodities, such as stocks and other financial asset, in order to achieve diversity. With regards to GPR and the selected commodities, there exist a difference in the relationship. For example, soft show a negative correlation, while the remaining commodities all shows a positive association. Considering the above relationship, it appears that GPR has a significant effect on the selected commodities. This may be attributed to trade disruptions, supply chain interruptions and production disturbances resulting from geopolitical events. These initial observations regarding the characteristics of commodities, GPR, and EPU further laid the path for empirical evaluations using sophisticated techniques like quantile regression and wavelet analysis.

Main Result

Objective 1: To analyse the asymmetric relationship between economic policy uncertainty and commodity returns.

Although the Ordinary Least Squares (OLS) estimation offers a general knowledge of the relationship between the sampled commodities and economic policy uncertainty, it ignores the nuances within this relationship in the markets. According to Mosteller and Tukey (1977), results from conventional OLS techniques provide only a partial understanding of the relationship between the independent and dependent variables. Additionally, OLS regression is influenced by outliers and less resilient compared to quantile regression, which addresses requirements that linear regression cannot, such as normality, independence, homoscedasticity, and linearity (Koenker, 2005; Mensi, Hammoudeh, Reboredo & Nguyen, 2014; Nusair &

Al-Khasawneh, 2018; Assifuah-Nunoo et al., 2022). Therefore, objective 1, which seeks to investigate the asymmetric relationship between EPU and commodity returns, was examined using the quantile regression method. The quantile regression framework assesses the variation in a specific quantile of the dependent variable due to a one-unit change in the predictor. The statistical interpretations for the analyses were based on the quantile regression technique developed by Koenker and Bassett Jr (1978), Koenker and Hallock (2005).

The outcomes derived from both the conventional Ordinary Least Squares (OLS) model expressed in Equation (1) and the Quantile Regression (QR) model specified in Equation (7) are depicted in Tables 4 below. As per the findings in Table 4, it is observed that at the lower quantiles across all conditional distributions of quantiles, EPU has a positive effect on all the commodities, except livestock where the correlation is negative. The result seems to depart from the findings from the correlation matrix. However, only few quantiles show a negative association suggesting that investors might interpret it as unfavourable, anticipating destruction in economic activity and consequently, lower commodity return. This potential uptick in commodity returns (except for livestock) could foster investor confidence in both the global economy and the commodity market, potentially leading to increased investment in these commodities. Moreover, the notable negative correlation observed for livestock at these quantiles implies that there is a possibility of higher diversification benefit for investors in the commodities market. This indicates that fluctuations in extreme uncertainties notably affect the returns of

livestock commodities, although other commodities (grains, soft, energy, precious metals and industrial metals) exhibit an exception to this pattern.

Finding from the intermediate and the upper quantiles seems not to be different from the one obtained under the lower quantile. That is, economic policy uncertainty has a positive effect on all the commodities, except livestock where the correlation is negative. This suggests that livestock commodities exhibit heightened sensitivity to fluctuations resulting from government policy uncertainties across all quantiles. Also, it is important to highlight that this influence is not uniform, as indicated by the diverse estimated coefficients across the quantiles. Given this variability, there is a risk that individuals might overestimate the market's opportunities while underestimating or disregarding the dampening effects stemming from EPU. Therefore, in order to maximise return from investment, investors need to take into account not only the effect of uncertainty levels on commodities returns but also the asymmetric effects across diverse market conditions. A careful examination of the findings also indicates that both positive and negative shocks have equivalent effects on all commodity indices. However, firms, investors, and traders react differently to these shocks and would not differentiate between various shocks from economic policy due to the lack of notable asymmetry in the bullish market.

The results across the quantiles indicate a significant asymmetrical effect of economic policy on the commodity market. Further, there is a substantial co-movement among commodities due to shocks and disruptions originating from global economic policy uncertainty. Thus, it can be deduced that global policy uncertainty has a profound effect on the commodity market

and the overall global economic activities. However, the degree of asymmetry in this relationship fluctuates throughout the sampled period, with some quantiles indicating positive asymmetries, while a few others show negative asymmetries, suggesting smaller losses or minimal effects associated with the sampled commodities. It is essential to recognise that the outcomes confirm alternative hypothesis (H1) which say that, there is an asymmetric relationship between EPU and commodities returns, hence the null hypothesis of no asymmetric relationship is rejected. Nevertheless, investors and decision maker are advised to utilise these findings with caution as not all commodity indices were included in the study due to data limitations.

This discovery aligns with research conducted by Cao et al., (2023) as well as Wen, Khalid, Mahmood and Zakaria (2021). Despite variations in settings and methodologies, these studies reveal a mutual relationship. Implicitly, the fluctuations in returns within commodities markets exhibit an inverse correlation with economic policies. This observation suggests that investors can benefit from possible diversification during heightened uncertainty from economic policy. However, the findings resonate with that of Bossman, Gubareva and Teplova (2023), who assert that agricultural commodities can mitigate the negative impacts of EPU, and also echoes the conclusion drawn by Tiwari et al. (2021) that agricultural commodities offer a protection against unfavorable conditions from political unrest. Also, the present study diverges from the results reported by He, Wang and Yin (2020), which indicated a one-way relationship between policy uncertainty and US stocks despite being in a different certain.

Table: 4: Quantile Estimates for Economic Policy Uncertainty and Commodity Returns

Commodities	Variable	OLS	0.05	0.2	0.4	0.6	0.7	0.95
Soft	EPU	0.001 ***	0.189	0.196	0.245	0.269	0.383	0.503
Ind. Metals	EPU	0.000 ***	0.363	0.443	0.515	0.532	0.535	0.571
Grains	EPU	0.037 *	0.022	0.075	0.216	0.390	0.390	0.558
Energy	EPU	0.067 .	0.132	0.262	0.316	0.334	3341.000	0.389
P. Metals	EPU	0.000 ***	1	1	1	1	1	1
Livestock	EPU	0.354	-0.327	-0.315	-0.313	-0.298	-0.191	-0.053

Causality in Quantile

Wiener (1956) and Granger (1969) introduced the concept of causality, which is essential to comprehending dynamic interactions in time series data. Causality in quantile highlights the importance of predictability, which is crucial information for investors, politicians, and economists. Finding the existence of a causal relationship between two variables is the main goal of the Granger Causality Test (Archer, Junior, Adam, Asafo-Adjei, & Baffoe, 2022). Therefore, once a causal relationship is established in time series analysis, it is critical to evaluate its strength. The researcher must first define a null hypothesis and an alternative hypothesis before conducting the Granger Causality Test. The null hypothesis is that the predictor variable does not cause changes in the response variable whiles the alternative hypothesis is that the predictor variable does cause changes in the response variable. Given the findings from the quantile regression the researcher moves forward by conducting a causality in quantile test, to ascertain the degree of causal links present in the sample variable and validate the resilience of the quantile regression model. Since autocorrelation in the quantile residuals may

compromise the validity of the results from the quantile regression and produce erroneous correlations, the researcher considers this extra step to be appropriate taking into consideration findings from empirical works such Woode, Owusu Junior, Adam, Assifuah-Nunoo and Adjei (2023).

Thus, the researcher conducts a non-linear causality-in-quantile analysis, expanding on previous studies (Archer et al., 2022; Woode et al., 2023). The significance of this analysis lies in its ability to capture diverse causal relationships from global uncertainty to the conditional distributions of commodity returns, in contrast to the traditional Granger causality test, which only assesses the average distribution. Consequently, this approach may demonstrate how causality functions in both low and high commodity returns. Figure 5 shows the outcomes of the mean-related causality test. This figure displays the test statistics on the vertical axis inside each graph and the quantiles on the horizontal axis. The horizontal solid line denotes the 5% significance threshold, or a critical value (CV) of 1.96. If the curve of the test statistics rises above the horizontal line at specific quantiles, it suggests that the null hypothesis of no causality can be rejected at those quantiles. Conversely, if the curve falls below the horizontal line, the null hypothesis cannot be rejected, indicating no significant causality at those quantiles. However, the intersection points where the curve crosses the critical value line highlight specific quantiles where the causal relationship is statistically significant. This suggests that causality is not uniform across all levels of commodity returns but varies depending on the quantile being examined.

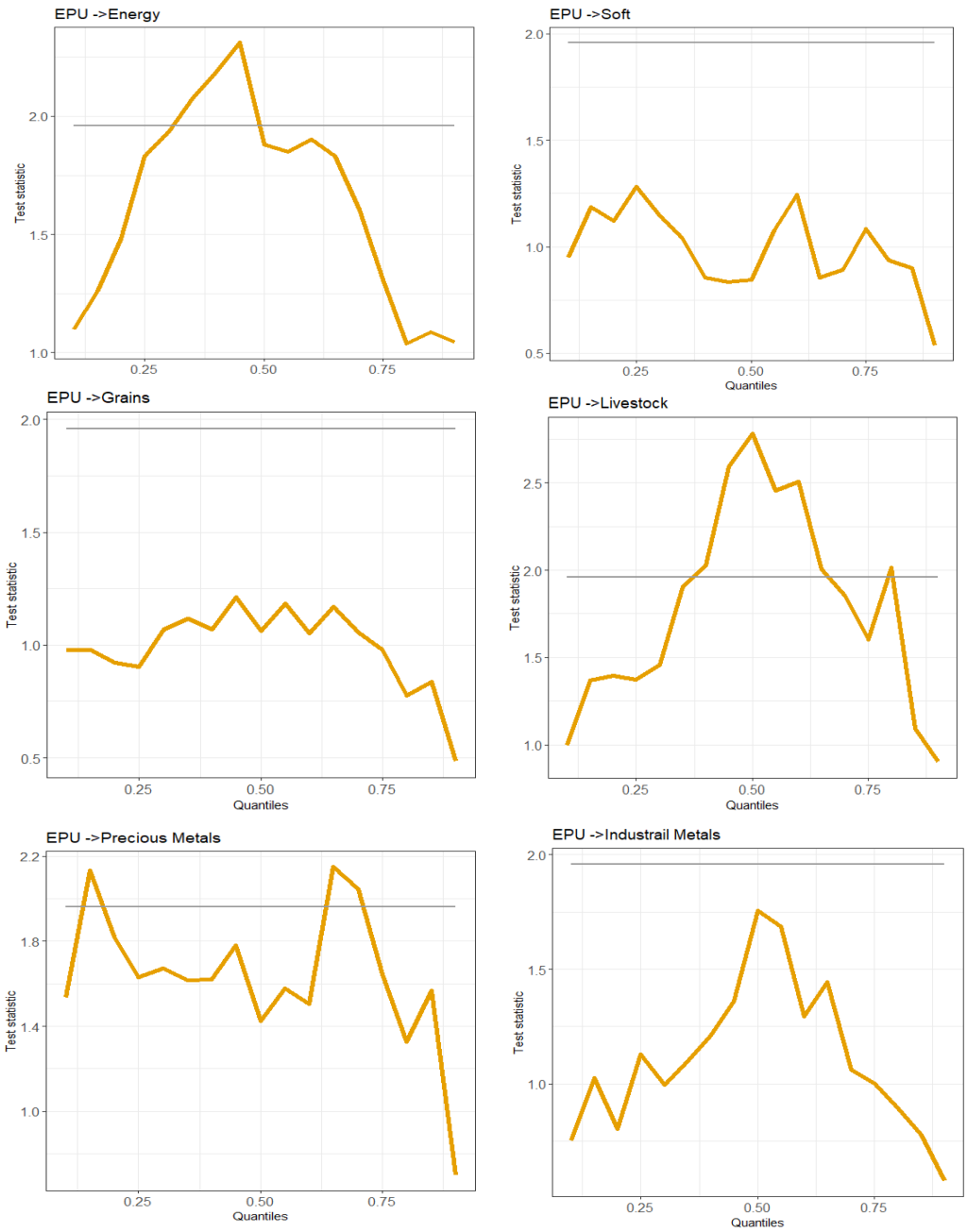

Figure 5: Robustness test for quintile regression
Source: Estimated based on the data obtained for the study variables.

Objective 2: To examine the interdependence between GPR and commodities returns.

The study employed the wavelet coherence econometric approaches to investigate the second objective, which seeks to investigate the interdependence between geopolitical risk and commodities. From figures 4, 5

and 6, deep blue and light blue colours on each colour bar signifies a weak interconnectedness. Further, deep green and light green colour implies a mild or moderate interconnectedness whiles yellow and red colours suggest strong dependency. Arrows inside the "cone of influence" are given close consideration during the decision-making process. Relationships between the two variables that are out of phase or in phase are indicated by arrows pointing left or right as shown on table 4 below. When arrows point "downward and right" or "upward and left," it means that geopolitical risk is led by the second variable, which is a commodity. A relationship that is out of phase shows a negative correlation, whereas one that is in phase indicates that the variables are positively coexisting. Importantly, the region of significance at the 5% level is determined by where the arrows lie inside white contour lines.

Table 5: Summary of Arrows Representing Lead-Lags Dynamic

In- Phase	→	Out- of- Phase
First Variable Lead	↗	Second Variable Lead
Second Variable Lead	↘	First Variable Lead

Source: Roesch and Schmidbauer (2016)

The wavelet coherence frequency scale interpretations are shown in Table 5. From the table, short term is represented by the 2-4 monthly scale as evidenced on the y-axis of the wavelet coherence diagram. In addition, the medium term is represented by 4-8 monthly frequency whiles the long-term period is represented by 8-32 monthly frequency. These notations are in accordance with that of Agyei, Bossman, Benchie, Asiamah and Arhin (2023).

Table 6: Time and Frequency Scale Interpretation

Frequency	Scale	Scale Meaning
Monthly	2-4	Short-Term
Monthly	4-8	Medium-Term
Monthly	8-32	Long-Term

Source: Sam, 2024

The squared wavelet coherence between GPR and energy commodity returns is depicted in Figure 6 below. It is evident from the squared wavelet coherence (down) that, in the short term (between 2008 and 2009 and 2011 and 2012), there is a negative interdependence between GPR and energy returns. This is represented by the arrows moving upward left and downward right on the wavelet coherence plot. This finding also indicates a modest association between GPR and energy. Surprisingly, it is important to note that this interdependence was led by energy, thereby presenting potential diversification benefit for investors who intend to invest in energy commodities over the short-term period.

Many interdependencies were also driven by energy returns in the intermediate term, demonstrating the power of energy commodity and its ability to resist to shocks from GPR. This can be seen from arrows pointing downward right between the year 2011 and 2012. The dependency structure observed at this point also depict negative relationship between GPR and energy return. Diversification benefit inherent in energy commodities is revealed in this instance too. At the same time during the intermediate term, there is an arrow pointing downward left in the year 2015. At this level, GPR drive the relationship with the interdependence between the variables being positive. Additionally, it can also be seen that in the long run between 2014 to

2016 on a monthly frequency, there was a couple of arrows facing downward right signifying that energy commodity drives the relationship during this period. Also, it worth adding that this finding present diversification opportunities to investors during this period. Furthermore, the correlation between the variables is strong as represented by the red colour on the wavelet coherence colour bar.

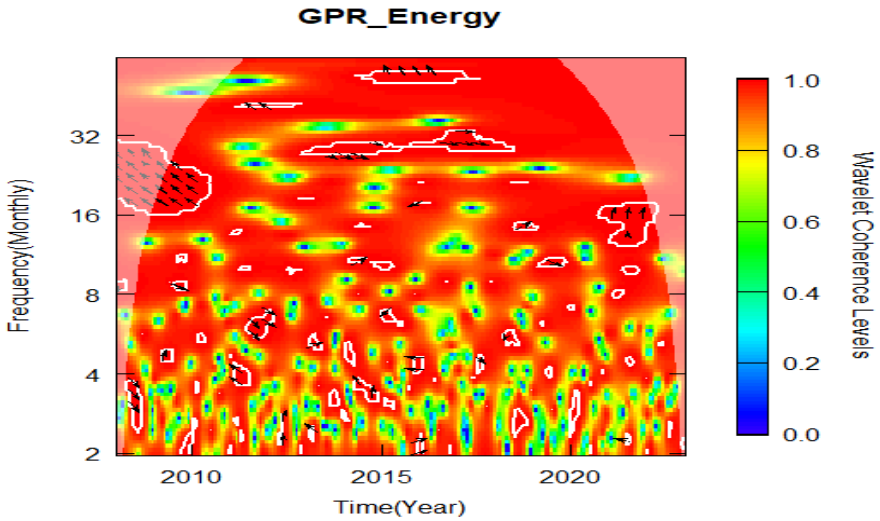

Figure 6: Wavelet coherence for GPR and Energy Commodity Index
Source: Estimated based on the data obtained for the study variables.

Figure 7 below show the squared wavelet coherence for GPR and the agricultural commodity returns (soft, livestock and grains). At 2-4 monthly frequency between the year 2017 and 2018 in the short-term, it can be observed that the correlation between GPR and soft returns was positive and weak. Furthermore, it is crucial to highlight that GPR is the main driver of this association, with a cloud of arrows moving in the upward right direction. This finding further implies that any inherent portfolio diversification found in soft commodities is eliminated. However, during the intermediate term between the year 2009 - 2010 and 2019 - 2020, the correlation between the variable is negative with clouds of arrows moving in the upward left direction. This

further suggest that portfolio diversification benefit associated with soft was not eliminated during this time. Despite the above findings in the short-term and the medium term, the relationship between the variables in the long-term cannot be clearly established except for the early stage during the long-term (between 8-10 monthly frequency during the year 2010-2012) where the relationship is positive. It is important to add that soft commodity return drove the relationship presenting a novel diversification opportunity to investors who consider investing in the commodity market during this period.

With regards to relationship between GPR and grains commodity returns in the short-term, GPR drives the relationship across the entire short-term period. These are clearly indicated by arrows moving downward left between the years 2011- 2012, 2013-2014 and 2017-2018 respectively. These findings remove any potential diversification benefit associated with grains hence investors should can consider adding other commodities into their investment portfolio. The relationship between GPR and grains in the medium-term period is not different from the one observed in the short-term as GPR was the leading variable during this period too. Further, these revelations are supported by arrows moving rightward up and leftward down respectively during the year 2016 and 2022. Hence, any potential diversifications benefit attributed to grains were removed during the medium- term also. Surprisingly, the long-term period was characterised by a mix of positive and negative relationship, with the positive relationship occurring between 2009-2010 as shown by arrows moving leftward down. The negative relationship on the other hand was observed between 2016-2018 with group of arrows moving in the downward right direction.

Also, from the squared wavelet coherence depicting the relationship between GPR and livestock returns, it becomes apparent that within the short-term and medium-term timeframe, livestock commodity returns drives GPR during the year 2011(short-term) and 2013 (medium-term) respectively. These is shown by consecutive series of directional arrows facing upwards left direction. Also, it worth mentioning that the relationship at this time depict a negative interdependence, which present possible diversification benefit across short-term and medium-term period. Furthermore, it can also be seen that the findings in the long-term seems not be different since livestock returns continue to drive GPR. The above result occurred between the year 2014-2015. Also, it worth adding that any potential diversification benefit associated with livestock was maintained during this period.

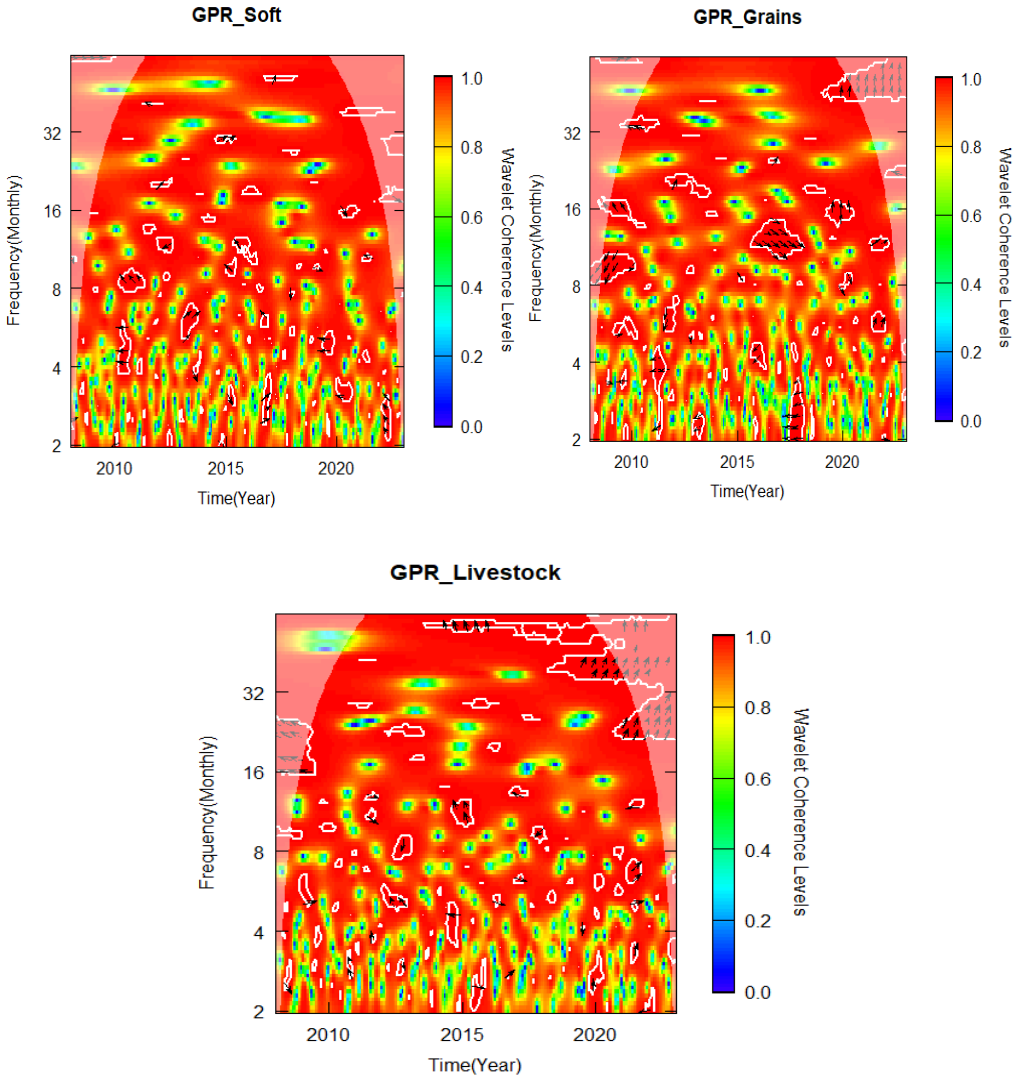

Figure 7: Wavelet coherence for GPR and Agricultural Commodity Group
Source: Estimated based on the data obtained for the study variables.

Figure 8 below illustrates the squared wavelet coherence between GPR and metal commodity returns. At 2-4 monthly frequency in the short-term and 4-8 monthly frequency in the medium term, it can be observed that there is no clear or well-defined correlation between GPR and the returns on precious metals. In other words, fluctuations in GPR do not consistently align with movements in precious metals prices during this specific time frame. Despite these findings in the short and medium-term, the relationship between GPR

and precious metals in the long-term is mix. Between the year 2004-2009 and 2011-2013 in the long-term, there was a group of arrows moving upwards right and leftward left. Considering this, the relationship at this point can be said to be positive with GPR driving the association at both instances. The relationship further suggests that any diversification potential for metals commodities at this point is eliminated. However, there was a negative correlation between GPR and precious metals at the same time in the long term, occurring between 2019-2022. This is evidenced in group of arrows moving towards the downward right direction. Additionally, these findings implies that precious metals return drive the relationship, presenting a possible potential diversification benefit for investors.

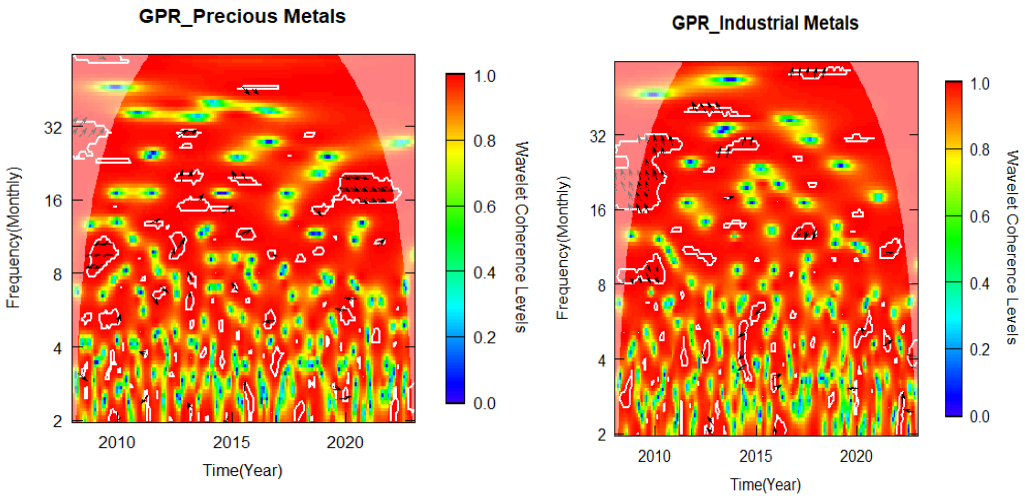

Figure 8: Wavelet coherence for GPR and Metal Commodity Index
Source: Estimated based on the data obtained for the study variables.

Objective 3: To explore the joint dynamics of geopolitical risk, economic policy uncertainty and commodity returns

Up to this point, the analysis employed in this research has unveiled that the interdependence among the variables fluctuates over time. While the

importance of this analysis cannot be overstated, it is equally crucial to assess the combined effect of the global uncertainty on the commodity market. This further enhances the understanding of how each of the commodity indices react to these uncertainties and provide a possible opportunity for risk reduction. Consequently, this research delved deeper into examining the joint dynamic connectedness of each variable through frequency domain analysis. Therefore, objective three (3) which seeks to explore the combine effect of GPR and EPU on commodities will be examined using Wavelet Multiple Correlations (WMC) and Wavelet Multiple Cross-Correlations (WMCC). These approaches amalgamate all the variables in the study into a single visual depiction, explaining how the variables interact with each other and ensure easy analysis of the data.

Wavelet Multiple Correlation (WMC)

The WMC gives a correlation coefficient to interpret the interrelationship between the variables of interest across multiple frequencies. From tables 7 and 8 and figures 9 and 10, the results reflect the degree of connectivity between the variables over both short-term and long-term periods in a seamless manner. The analysis does not directly identify which variable is leading or lagging, but rather shows the nature of the connection between the variables.

From figure 9 and 10 below, the degree of integration in the monthly return series is significantly high as 0.9447 and 0.9304, suggesting strong persistence in the returns over time. Additionally, the number of multiple connections increases over time, and there is a medium-to-long-term relationship between the variables across the wavelet scale. In other words,

when considering GPR and EPU, the monthly returns in one of these commodities markets can account for approximately 94% and 93% of the returns in the other markets, respectively, based on scales 1 through 8. It is essential to acknowledge that the elevated market integration is primarily attributed to the robust interconnectedness of the global commodity market, which supports the fundamental principles of financial market integration theory.

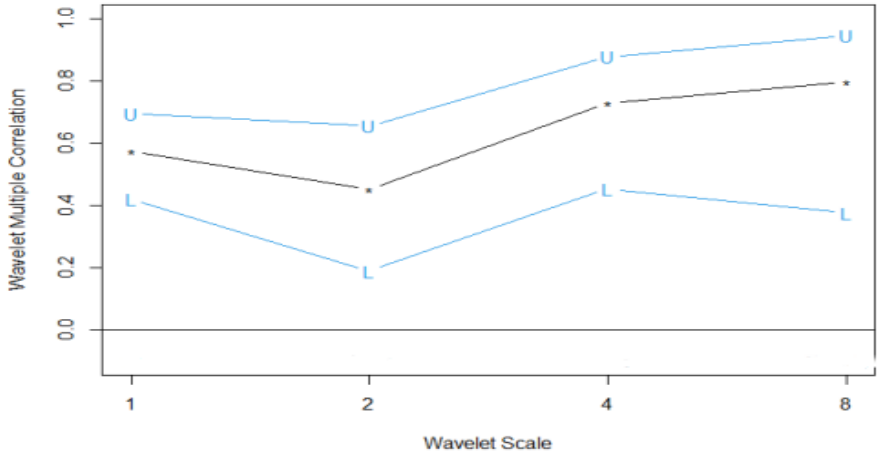

Figure 9: WMC for GPR and the selected commodities index for both upper and lower panel.
Source: Estimated based on the data obtained for the study variables.

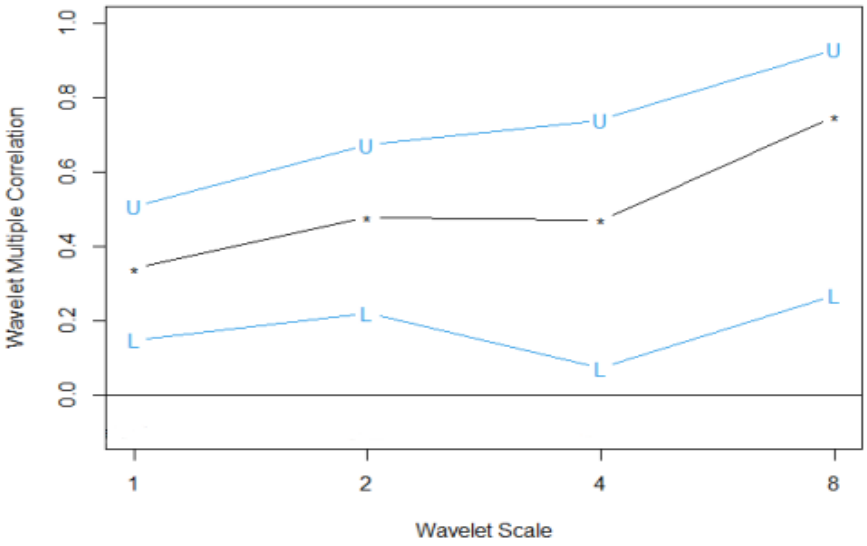

Figure 10: WMC for EPU and the selected commodities for both upper and lower panel.
Source: Estimated based on the data obtained for the study variables.

In addition to the above findings, it can also be seen from figures 7 and 8 above that there is a comparably high degree of integration in the monthly return series for the dynamic relationship between GPR and commodities than the dynamic relationship between EPU and the commodities. Despite these disparities, the result suggests that the degree of integration in the market is high taking into consideration short to long-term market conditions and hence the possibility of shocks in one market having a ripple effect in the other market is high. Consequently, investors might be less inclined to decrease their portfolio risk when they construct a portfolio across the global commodity market. The specific findings indicate that, across all levels of analysis, there is a strong degree of integration observed between GPR and the commodities than EPU and the commodities.

Table 7 Wavelet Multiple Correlation for GPR and Commodities

Scale	WMC (Lower)	Correlation	WMC (Upper)
1	0.4201	0.5731	0.6945
2	0.1899	0.4524	0.6545
3	0.4529	0.7289	0.8775
4	0.3755	0.7966	0.9447

At the first scale on table 7, the correlation stands at 0.5731, with the upper and lower panels being 0.6945 and 0.4201. Moving to the second scale, the association between the variables stood at 0.4524, with the boundaries (upper panel and lower panel) recording 0.6545. and 0.1899. At the third scale, the correlation reaches 0.7289, with the bottom and top panels showing 0.4529 and 0.8775. At the fourth scale, the correlation peaks at 0.7966, with the bottom panel reaching 0.3755 whiles the top panel reaches 0.9447.

However, the correlation stands at 0.3396 on WMC for EPU and commodities at scale one (1) as shown on table 8 below. At the same time the bottom and top panels reached 0.1482 and 0.5065. Moving to the second scale, the correlation is 0.4768, with the bottom panel and top panel reaching 0.2197 and 0.6719. On the third scale, the correlation was 0.4711, with the bottom and top panels recording 0.0731 and 0.7397. At scale four (4), the correlation peaks at 0.7483 whiles the bottom and top panel at the same level reaches 0.2687 and 0.9304.

Table 8: Wavelet Multiple Correlation for EPU and Commodities

Scale	WMC (Lower)	Correlation	WMC (Upper)
1	0.1482	0.3396	0. 5065
2	0.2197	0.4768	0.6719
3	0.0731	0.4711	0.7397
4	0.2687	0.7483	0.9304

Based on the aforementioned findings, it be could argue that the correlation differs substantially over time and across various frequencies. The result also suggests that changes or fluctuations in GPR may significantly influence commodity markets than that of EPU, potentially affecting investment decisions and market volatility. This further confirms the findings revealed from the WMC shown on figures 9 and 10 above.

Wavelet Multiple Cross-Correlation (WMCC)

The WMCC identifies which variables lead or lag in paired series at different time lags. Tables 9 and 10 illustrates the localization and lead/lag variables for GPR, EPU and the selected commodity coefficients for four wavelet scales. The vertical axis in Figures 11 and 12 carry the same meaning

as previously discussed under the WMC whiles the horizontal axis represents the lag length of the series. From figures 11 and 12 also, both negative and positive lags are set at 20 days each. To ascertain which variables may act as leading or lagging, data for both lags are required. Positive lags indicate the lagging variable whiles negative lags shows the leading variable for the various scales. No variable lag or lead at lag zero (0) of the localisation lines. In addition, the wavelet multiple indicates the degree of connectedness between the paired series and identifies the most important pair at particular scales, making it clear whether it responds to shocks first or last among the other variables.

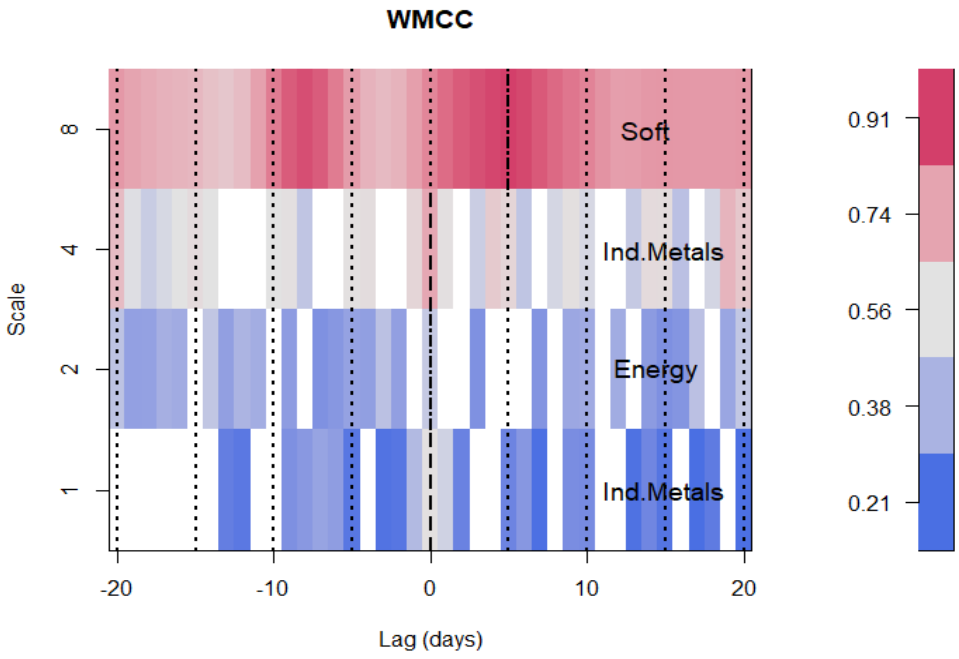

Figure 11: WMCC for GPR and the selected commodities.
Source: Estimated based on the data obtained for the study variables.

Table 9: WMCC for the variables

Scale	Localisation	Lags (Days)	Lead/Lag Variable
1	0.1409	0	Industrial Metals
2	0.4311	0	Energy
3	0.6826	0	Industrial Metals
4	0.7597	5	Soft

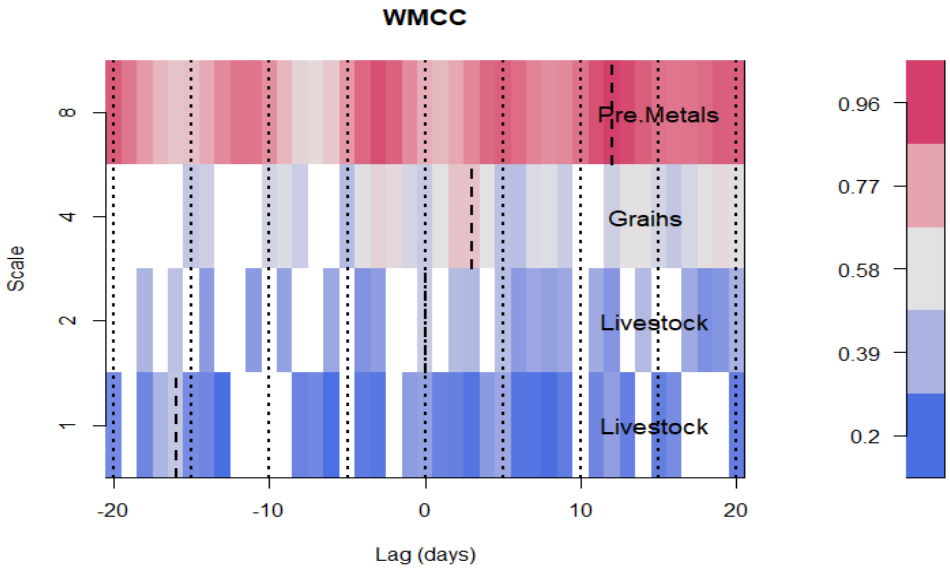

Figure 12: WMCC for EPU and the selected commodities Indices
Source: Estimated based on the data obtained for the study variables.

Table 10: WMCC for EPU and the selected commodities Indices

Scale	Localisation	Lags (Days)	Lead/Lag Variable
1	0.4253	-16	Livestock
2	0.4400	0	Livestock
3	0.7627	3	Grains
4	0.9693	12	Precious Metals

Figure 11 above, depict the WMCC for GPR and the commodities. It is evident that, in the long term, soft and industrial metals optimize the WMCC through a linear combination of all other variables, followed by energy and then industrial metals commodities in the medium and short term. However, the localisation for industrial metals (both in the short-term and long-term) and energy are indeterminate whiles that of soft indicate a lagging variable in the long-term. This indicates that, over the long term, soft market may be considered to present a possible diversification benefit to investor. This is due the market ability to resist to external shocks from global uncertainties. Thus, in order to minimise risk, global investors need to employ appropriate asset allocation strategy.

For WMCC between EPU and commodities in figure 12 above, precious metals and grains optimises the WMCC in the long term followed by livestock commodity in the medium-term and short-term period. Further, it is appropriate to add that the localisation for both precious metals and grains makes them a lagging variable. Therefore, one could argue that the market for these commodities (precious metals and grains) may present possible diversification and other investment opportunities to investors over the long-term period. With regards to livestock, the localisation in the short-term makes it a leading variable while that of the medium-term is indeterminate. Considering this, it can be concluded that livestock market is the market to be the affected by shocks from these uncertainties (GPR and EPU) over the short-term period. However, investors and policy makers should note that the finding above is market facing. That is, market conditions can vary over different time and frequency horizons. While some market segments might not

perform well in the short term, they could become favorable in the medium or long term. Conversely, markets that are currently performing well in the short term might not sustain this performance over longer periods. Therefore, investment decisions should consider these temporal dynamics, balancing short-term performance with potential medium- and long-term outcomes.

Interestingly, none of the global uncertainties demonstrate the capacity to lag or lead. The outcomes presented above support the claim by Owusu Junior et al. (2021) that when markets exhibit high interconnectedness, the transmission of uncertainties among closely connected markets becomes difficult. However, the negative effect of these global uncertainties on commodity returns could be more pronounced over the long term, as indicated by the squared wavelet coherence findings. The explanation above also confirms that the null hypothesis (H3) which assume no joint dynamics between GPR, EPU, and commodity return is rejected.

Discussion of Main Result

Asymmetric relationship between EPU and commodities returns.

It was revealed that asymmetric relationship exists between economic policy (EPU) and commodities returns. Most of the asymmetric relationship on the respective quantiles were found to be positive with few quantiles showing negative asymmetric relationship. This implies that the nexus between EPU and the sampled commodities is mostly adverse, hence an intense EPU at the global level correspond to a reduction in commodity returns (mostly for livestock in the case of this study). The negative asymmetry between this uncertainty and the commodity market empirically indicates a drop in investors profits as a result of reduction level of returns.

This is to be expected since a lot of macroeconomic fundamentals and firms related uncertainty embedded in this index, exposing the commodity market to various risk.

Considering the scenarios above, investor should implement diversification strategies to safeguard their international trade. In the same way, local investors not engaged in international trade might need to boost their efficiency to remain competitive against foreign entities in the domestic market. These findings could also be vital for investors and policymakers aiming to ensure stable financial position. A two-way relationship was identified between EPU and the selected commodities across various quantiles, indicating that EPU influences commodities returns across different quantiles. In contrast with the EMH, the MPT and the AMH were theoretically validated, especially when it came to dynamic asymmetric diversification qualities. The proven ability of certain of the chosen commodities (like soft, metals and energy) to offer potential diversification provided the foundation for this validation. Therefore, in accordance with these theories (MPT and AMH) principles, investors should seek commodities that offer high returns while exposing their portfolios to relatively low associated risks (Markowitz, 1952).

Interdependence between GPR and commodity returns

It was found from the wavelet coherence that there exist both positive and negative interdependence between GPR and the sampled commodities. Specifically, negative interdependence was found to exist between livestock and GPR across short-term, medium-term and long-term period whiles positive interdependence was found to exist during the intermediate term and

long-term period respectively. For GPR and grains, the findings indicates that the short-term period is characterised by a mix of positive and negative interdependence, whiles that of the medium-term and long-term is characterised by positive interdependence. Also, for GPR and soft, the result reveal positive and negative interdependence in the short-term whiles the medium-term period and long-term period shows positive interdependence and negative interdependence respectively. Further, the wavelet coherence reveals both positive and negative interdependence between GPR and energy commodity group, with this relationship occurring evenly across short-term, medium-term and long- term period. In addition to above, the result for the interdependence between GPR and metal commodity group seems not to differ from the one obtained for other commodity indices. However, most of these interdependences were observed in the intermediate to long-term period.

In essence, when there are both favorable and unfavorable relationships between GPR and the sampled commodities, it suggests that investors could benefit from diversification by incorporating these commodities into their portfolios. However, negative relationships only indicate that commodities may serve as hedges during both calm and turbulent market periods. Thus, in investment cycles where there is negative correlation between Global Policy Risk (GPR) and the selected commodities, it is advisable for investors to include these assets in their portfolios (Shahzad, Ramzan, Shah, Doğan, & Ajmi, 2022). However, investors should bear in mind that strategic and timely portfolio rebalancing is essential for optimising allocations among these assets (Gouhier et al., 2013 Yu, Fang, Sun, & Du, 2018).

The results highlight how crucial it is for investors to use diversification and hedging tactics in times of global disasters. In times of crisis, the dissemination of information and its effect on various markets become more pronounced. Rational, yet sometimes irrational, investor behaviour leads to reactions to geopolitical unrest, such as the Russia inversion, or news regarding political uncertainty. This reaction is rooted in the competitive market hypothesis outlined by Owusu Junior et al. (2021), which suggests that during stressed market periods, spillovers and arrival of new information between markets intensify due to investors' suboptimal attitudes. Consequently, fluctuations in asset prices naturally reflect investors' expectations and apprehensions. Further, previous research indicates that the growing level of global market integration has heightened the market's susceptibility to external shocks (Yang & Hamori, 2021; Wang, Bouri, Fareed & Dai, 2022; Umar, Bossman, Choi & Teplova, 2022). Hence, in environments with substantial global market integration, asset prices are influenced more by common factors rather than isolated ones. Additionally, it is observable that, apart from higher frequency bands, Global Policy Risk (GPR) has a notable influence on long-term international fluctuations. This phenomenon could be attributed to the market's prolonged digestion of trading noise.

Joint dynamics of geopolitical risk, economic policy uncertainty and commodity returns

Findings from the joint dynamics of how GPR and EPU affect the commodity market were crucial to give deeper understanding into the degree of integration and how news from these uncertainties affect the studied

commodities. Also, the result from joint dynamics explains how markets react to geopolitical events and policy changes, and how these reactions propagate across different asset classes and markets. For example, an increase in geopolitical tensions may lead to higher uncertainty, prompting investors to seek safe-haven assets such as gold (which belongs to meal commodity group), while also affecting other commodity returns due to disruptions in supply chains or changes in trade policies.

The study found that the joint dynamics and integration among GPR, EPU and commodities increases in the short-term utilising WMC and WMCC respectively. This indicates that economic fundamentals at the global level are strongly interconnected, thereby limiting adverse effects of external shocks emanating from either geopolitical event or economic policy uncertainty. Specifically, the findings from WMC reveal that the degree of integration in the market is high taking into consideration short to long-term market conditions. That is, shocks from GPR and EPU do not substantially influence the trend or conduct in the commodity market at the global level. The evidence further suggests that integration within commodity markets requires a period of time before they ultimately converge in the long term. As a result, the risk within global economies increases for long-term portfolio investments. Therefore, investors aiming to reduce their portfolio risk in global markets are advised to focus on short- and medium-term periods. This will restore confidence among market participants across the global market. It has also been established in literature that international diversification is believed to reduce portfolio risk (Xiao, Su, & Ayub 2022; Li, Ali, Ayub, & Ullah, 2023). However, this study, especially when considering the long term, does not seem

to substantiate this claim. It is highly likely that the benefits of international diversification will vary depending on the market conditions, such as whether there is a period of high or low uncertainty and whether investments have a short- or long-term horizon, according to the multiscale analysis. The findings offer significant benefits to investors, allowing them to diversify their portfolio during the period of persistent and intense global uncertainties.

Also, based on the findings from the WMCC, GPR and EPU could neither influence nor change the dynamics of the commodity returns. Specifically, soft and industrial metals optimise the WMCC for GPR and the selected commodities through a linear combination of all other variables, followed by energy and then industrial metals commodities in the medium and short term. For the WMCC between EPU and the selected commodities, precious metals and grains optimises the WMCC in the long term followed by livestock commodity in the medium- and short-term period. The intuition behind this established in theory is that investors aim to receive higher required rates of return during periods of risk and uncertainty, which leads to asset prices falling. Nevertheless, the study's findings suggest that the risk-return trade-off may not be guaranteed at all times.

Overall, the results indicate that GPR and EPU shocks have a negative effect on commodity futures returns in bearish markets, while they have a positive but long-lived effect in bullish markets. However, the effect of these uncertainties in bullish markets is weaker and less durable than in bearish markets, implying that other factors may dominate the price movements of agricultural commodities in favourable market conditions. These findings partly confirm the result obtained by Umar et al. (2022) who observed a

pronounced short-term relationship between GPR and the volatility across three stock markets.

Economic Implications of the findings

For every objective, the findings suggest significant practical implications and economic insights. Regarding the way they interconnected, livestock typically show strong coherence with these uncertainties during both short-term and medium-term trading periods. These kinds of integration pose challenges for diversification because movements in one asset or market segment are closely tied to movements in others. Traditional diversification strategies may be less effective in reducing portfolio risk. Thus, investors should remain vigilant when navigating their investment choices in livestock during the short-term and medium-term period. Additionally, investors may have to rely on other asset instead of livestock in this instance.

Further considering the interdependence structure of grains, it can be said that they generally exhibit low coherence with global uncertainties on all investment horizon. The nature of dependence among these uncertainties and grains presents possible diversification opportunity during the various investment horizon. That is, these commodities are largely efficient during short to medium term due to their defining features. Therefore, investing in grains on the global commodity market is recommended for investors.

Also, the nature of interdependence for soft, GPR and EPU is generally high during the long-term trading period. Given the high interdependence among soft commodities, GPR and EPU during the long-term trading period, traditional diversification strategies may not be appropriate for investors. The soft market emerges as particularly susceptible to external disruptions. This

vulnerability may stem from its consistent performance despite the competition it faces from other significant agricultural commodities.

In addition to the above, the kind of interdependence between energy commodity group, GPR and EPU is low and seems to occur mostly in the short-term and long-term period. Considering this, investors need to monitor the interdependence between these factors and adjust their portfolios dynamically. Since the interdependence is low but varies across different periods, regular reassessment of the portfolio composition is necessary to maintain optimal diversification. That is, the low correlation can be beneficial for diversification as it suggests that combining these assets in a portfolio can reduce overall risk.

Additionally, the interdependence between metals commodity group, GPR and EPU is generally high over long-term trading periods. This can be seen from the wavelet coherence in figures 5, 6 and 7 and the WMCC in figures 10 and 11 respectively. This is also evidence to the fact that both precious metals and industrial metal optimises the WMCC taking into consideration both GPR and EPU. Therefore, investors are advised not to invest solely in this commodity group but rather consider a possible diversification with other commodities

Table 11: Summary of findings and economic implications

Metal Commodity Market	Energy Commodity Market	Agricultural Commodity Market
Objective one (1): Asymmetric relationship between economic policy uncertainty and commodities		
• Mixed. • Possible diversification at the middle quantile. • Possible diversification at the upper quantile.	• Possible diversification at the lower quantile. • Possible diversification at the middle quantile. • Mixed	• Mixed. • Possible diversification at the middle quantile. • Mixed
Objective two (2): Interdependence between geopolitical risk and commodities		
• No potential portfolio benefit in the short-term • Mixed • Possible diversification in the long-term.	• Mixed. • No potential diversification benefit in the medium-term • No potential diversification benefit in the long-term	• Mixed. • No potential diversification benefit in the medium-term. • Diversification benefit in the long-term.
Objective three (3): Joint dynamics of geopolitical risk, economic policy uncertainty and commodity returns		
• Indeterminate (Industrial metal market) • Drive other variables during long-term period • Possible diversification (precious metal market	• Indeterminate	• Strong Co-movement • Drive other variables in the long term • Diversification (soft and grain market)

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This study explored the asymmetric relationship, the degree of interdependence and the joint dynamic relationship between global uncertainties (GPR and EPU) and commodities return, at the global level. Following the intense explanation of the study result presented by the techniques employed, the key findings obtained from which both theoretical and practical conclusions can be drawn are presented in this section. Also, this chapter delve into the main findings and generalisation to make a recommendation for potential portfolio diversification benefit, possible allocation of asset for investors and policy formulation and management. Further, important recommendations to direct further study and knowledge acquisition are also included in this chapter.

Summary

Despite the performance of the commodity market recently as a result of covid-19 and Russian inversion of Ukraine, the market continues to be an essential component of international trade. In addition to this, the commodity market has a substantial effect on personal economies by generating a variety of jobs, both directly and indirectly. As a result, a number of alliances between global economies and sub-regions have been formed, which has spurred capital flow from the commodity market into the real economy and vise verse. While these agreements primarily target economic growth and bolster investor confidence, the increasing push for integration across global markets is evident. Consequently, the markets in each country involved may become

more susceptible to shocks stemming from political instability and uncertainty in government policies (Rahman, 2022; Bossman et al., 2023). This heightened vulnerability could potentially disrupt the stability and functioning of the global economy, as interconnected markets become more interdependent and exposed to external influences.

This shifts in the market are increasingly capturing the interest of numerous economic participants, both public and private, and are also prompting greater attention from academic researchers. However, unlike the majority of prior studies that primarily concentrate on the static effect of these uncertainties on individual commodity, this research delves into the time-frequency dynamics of return spillover from global uncertainties to the commodity market, particularly focusing on grains, livestock, soft, energy, precious metals and industrial metals commodities.

To investigate these dynamics, this study employs quantile regression and wavelet analysis. Quantile regression was utilized to capture the asymmetric relationships between commodity returns and global uncertainties across various market conditions, while wavelet coherence analysis was applied to explore the time-frequency dynamics of return spillovers. This was done based on the core principles of the financial market integration theory, heterogeneous market hypothesis and the modern portfolio theory. Grounded in financial market integration theory, the heterogeneous market hypothesis, and modern portfolio theory, the research aimed to achieve three main objectives: to analyze the asymmetric relationship between EPU and commodity returns; to examine the interdependence between GPR and

commodity returns; and to explore the joint dynamics of GPR, EPU, and commodity returns.

Findings from the Objectives

In relation to the first objective of the research, the finding from this study revealed that the asymmetrical relationship between EPU and the commodities returns generally tends towards a positive direction, despite few quantiles showing negative outcomes across short, medium, and long-term periods. This suggests that the degree of significance connection between EPU and the sampled commodities increases as the investment horizon extends from short to long-term, indicating a dynamic nature of the asymmetrical relationship between the variables studied. Based on these empirical revelations, this study has gathered sufficient proof to refute the default hypothesis of "no asymmetric relationship between economic policy uncertainty and agricultural commodities".

Finding from the second objective revealed a mix of positive and negative interdependence across the time-frequency domain analysis. Premised on this result, the study finds a reciprocal association between GPR and the sampled commodities returns. These findings also implies that there is a mutual integration between the study variables which confirms the core principles on the financial market integration theory. Notwithstanding with this, most of the interdependence were led by the sampled commodities highlighting its dominance over the study period. Hence, this study finds sufficient support to refute the default hypothesis of "no interdependence between geopolitical risk and commodity returns".

The third objective indicates that the joint dynamics and integration among GPR, EPU and the commodities increases in the long-term utilising, WMC and WMCC respectively. Overall, soft, precious metals and grains market lag in the long-term presenting a potential investment opportunity. Also, the livestock market was found to be vulnerable to external shocks emanating from these uncertainties. These findings support the financial market integration theory and the claim by Owusu Junior et al. (2021) that when markets exhibit high interconnectedness, the transmission of uncertainties among closely connected markets becomes difficult (except for the livestock market in this case). Considering the revelations above, this study has sufficient evidence to refute the default hypothesis of "no joint dynamics between geopolitical risk, economic policy uncertainty and commodity returns".

Conclusion

Considering objective one, the result reveals an asymmetrical relationship between EPU and the selected commodities. More precisely, this research elucidated that the asymmetric relationship between EPU and commodities returns is most accurately analysed and observed through multiscale quantiles. This empirical investigation further reinforced the notion that a particular commodity return, particularly livestock, were vulnerable to uncertainties regarding the global economy over the medium to long term. However, the presence of positive correlations between EPU and commodities on most quantiles indicates the phenomenon of financialisation. Consequently, one could contend that the risk diversification advantages typically associated with commodities diminish during periods of uncertainty. As a result, these

findings reinforce the notion of the financialisation of global commodity market.

The theories employed in this study provides a robust foundation for understanding the relationship between GU and commodity returns. This theory includes: HMH, financial market integration theory, and the MPT. These theories collectively explain the importance of considering asymmetries, interdependence and time-frequency dynamics in analysing market behaviors. Also, the integration of these theoretical perspectives not only strengthens the analytical approach but also bridges existing gaps in the literature on the interconnectedness between GU and commodity markets.

Based on the second objective, it can deduce that the interdependence among commodities and geopolitical risk in the global financial market intensifies as implied volatilities span from short-term to long-terms. Nonetheless, the connections in the long term seem to be more pronounced compared to those in the short to intermediate term, indicating that persistent shocks from geopolitical risk exert a stronger effect on commodity return. Thus, despite the recent deepening trend of world economic integration, uncertainties stemming from both domestic and foreign political environments have led to increased return volatility in the global commodity market. Therefore, the notion that uncertainties cannot affect a highly integrated market as part of the core principles on the financial market integration theory cannot be established based on the finding from the wavelet coherence.

With regards to the third objectives, it can be concluded that the joint dynamics and integration among geopolitical risk, economic policy uncertainty and the sampled commodities increases in the long-term. In other

words, the frequency domain analysis uncovered heightened connections during long-term periods, indicating that due to the integration of the global financial market, the commodity market is capable of reacting to external shocks triggered by significant global events such as geopolitical unrest and policy uncertainty. This is not surprising, as soft and precious metal commodities optimise the WMCC through a linear combination of all other variables, followed by industrial metals and grains commodities. However, as empirical studies in the literature on financial contagion highlight, this research also discovered that the combined dynamics of the uncertainty analysed and commodities returns result from both integration and contagion.

Recommendations

Finding from the review of the connections between the global uncertainties and the commodities market returns in this study produced compelling results supported by theories and key assertions made by empirical studies on financial market**.** Based on findings from the study, the following recommendations can be made regarding asset allocation, policy management, and portfolio construction**.**

Asset Allocation and Portfolio Construction

First, the presence of both positive and negative correlations between EPU and commodities market across specific quantiles in short and long-term periods is attributed to the unrestricted markets and the growing financialisation of commodity markets. As a result, when investors and traders follow the crowd or make decisions based on overall shocks to the commodity market rather than the unique characteristics of each commodity, it can lead to correlated movements in commodity prices and this can cause portfolio returns

to exhibit higher co-movements. Investors are therefore advised to implement risk management techniques such as allocating a portion of their portfolios to commodities or to diversify among these commodities during period of induced market fluctuations cause by economic uncertainties and downtown.

Second the interdependence between GPR and the sampled commodities is high taking into consideration short to long-term implied volatilities. However, the detection of arrows pointing in both right and left directions suggest the occurrence of lead-lag effects over the study period. As such, heightened fluctuations may lead to opportunities for diversification for investors, whether local or international, who have short-term investment horizons. Thus, in order to diversify across international commodity markets, portfolio investors may find it more advantageous to give short-term investment a higher priority than long-term investment, since chances for diversification may prove more profitable for the former. When considering the impact of GU on commodity returns, it is essential to factor in different time horizons, as the effects of uncertainties may vary significantly across short, medium and long-term periods. In the short term, commodity markets may react more swiftly and with higher volatility to immediate geopolitical events or policy changes, while in the medium term, these impacts could be moderated by market adjustments or policy interventions. Over the long term, the influence of GU may be more structural, affecting trends in global supply chains, technological advancements, or investment patterns.

Third, the joint dynamics and integration among GPR, EPU and the sampled commodities increases in the long-term. Despite this, none of the uncertainty was able to lead the commodities. Stated differently, the pattern or

behaviour of commodities in the global financial market (except livestock market) is not significantly affected by shocks resulting from these two uncertainties. This should give participants in the commodity market confidence. Further global commodity investors will benefit from this outcome because it enables them to use efficient ways to manage portfolio risks associated with geopolitical risk and unpredictability in economic policy. However, investors in general are advise to give adequate consideration to investment in soft commodities and precious metals commodities since they are the commodities to response to shocks from these two uncertainties considering the findings from the WMCC.

As expected, the results align with the global trend of governments implementing policies aimed at creating business-friendly environments to attract both foreign and domestic investors to their capital markets. However, there may have been a lack of emphasis or oversight on portfolio construction by investors. Therefore, this research recommends that investors will integrate the findings and conclusions from this study into their fundamental strategies for asset allocation, particularly in the realm of international portfolio management. This approach would not only facilitate capital flows but also accelerate global economic prospects. Additionally, it would contribute to enhancing the level of integration, financialisation, and liberalization of the global financial market further and ensure global resistant against these shocks which will result in increased return from investment.

Policy Management

Considering the presence of both positive and negative correlations between global uncertainties and the commodity return, policymakers should

consider both of this when creating policies about the commodity market. That is policies about the commodities should be formulated in a way to protect the commodity market from heightened shocks from these global uncertainties. Also, financial market authorities should improve the basic regulatory system with regards to the commodity market through participation in multilateral forums to address global challenges such as food security, trade barriers, and climate change impacts on commodity returns.

Given the extensive integration of commodities market, as shown on the multiple wavelet correlation, it is recommended that policies should be directed towards achieving global unification, thereby bolstering local and regional prospects of the commodity market. Moreover, effective development and implementation of policies in relation to the commodity market of each economy is paramount. This will promote transparency and information sharing in the commodity markets to improve market efficiency and reduce the potential for herd behaviour or speculative trading. Further, considering the nature of commodity markets, policymakers should engage in international cooperation and coordination efforts to address cross-border challenges and promote stability in commodity trade. This could involve collaboration with other countries or international organisations to develop common standards, regulations, or response mechanisms.

Theoretical Recommendation

From the perspective of financial market integration theory, policymakers and investors should focus on enhancing transparency and reducing barriers that limit the free flow of information and capital across borders. Integrated financial markets allow commodities to be priced

efficiently by reflecting global uncertainties such as geopolitical risks (GPR) and economic policy uncertainty (EPU). Further, drawing on the heterogeneous market hypothesis (HMH) and modern portfolio theory (MPT), commodity investors should adopt diversified strategies tailored to different market participants' varying time horizons and risk tolerances. Additionally, optimizing portfolio allocation to commodities during periods of heightened global uncertainty could serve as a hedge, ensuring stability and resilience in volatile markets

Suggestions for Further Research

Future studies should explore how various uncertainty indexes on a broader range of financial market beyond the commodities market. This includes analysing how uncertainty indexes influence bonds, cryptocurrencies, and other assets. In doing this, future studies could explore how emerging uncertainty measures, such as news-based uncertainty indexes and currency volatility metrics affect this market.

Further, future studies should focus on a deeper investigation into sector-specific volatility indexes, such as those for the energy sector, gold miners and new related to Omicron (which is a variant of the Covid-19 virus). Analysing how sector-specific uncertainties affect market returns can help investors and policymakers develop targeted strategies for managing risks.

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