UNIVERSITY OF CAPE COAST

STOCK RETURNS, EXCHANGE RATES, AND UNCERTAINTIES IN WEST AFRICA

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BY

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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

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own 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: Bernice Nkrumah-Boadu

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. George Tweneboah

ABSTRACT

This study examines the degree of interconnectedness between stock returns and exchange rates, and the influence of some uncertainty indices on such a relationship within a time-frequency domain in West Africa. The study adopts a quantitative research approach and an explanatory research design. Monthly observation of one hundred and five, from 1st March 2013 to 1st December 2021 is utilised. The wavelet approaches are employed in executing the purpose of this study. The findings reveal that, in West Africa, a negative correlation exists between stock return and currency rate. The partial wavelet coherence results indicate that global economic policy uncertainty, oil market implied volatility and the United States volatility index are key drivers of the comovements in the selected markets. Again, the study finds that the degree of integration among stock returns and currency rates in West African economies increases in the long-term when implied volatility indices are included in the multiple wavelet approach. It is suggested that investors who want to hedge against stock return fluctuations can do so using exchange rate. Also, policymakers and investors should consider the impact of external uncertainty measures in the formulation of policies regarding exchange rates and stock return integration at various investment horizons.

KEY WORDS

EPU

Exchange rate

GEPU

OVX

Stock return

VIX

Wavelet

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DEDICATION

To the Nkrumah-Boadu Family

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

AMH	Adaptive Market Hypothesis
BRVM	Bourse Régionale des Valeurs Mobilières
BVC	Bolsa de Valores de Cabo Verde
CBOE	Chicago Board Options Exchange
EMH	Efficient Market Hypothesis
EPU	Economic Policy Uncertainty
GEPU	Global Economic Policy Uncertainty
GSE	Ghana Stock Exchange
HMH	Heterogeneous Market Hypothesis
NSE	Nigeria Stock Exchange
OVX	Crude Oil Volatility Index
SLSE	Sierra Leone Stock Exchange
VIX	Volatility Index

CHAPTER ONE

INTRODUCTION

The connection between exchange rates and stock returns across nations has gained considerable interest due to the integration of global financial markets. The existing relationship between stock and exchange rates has been inconsistent. Some researchers found a positive correlation (Ogbole & Aladejare, 2015; Bala & Hassan, 2018; etc.) while others found a negative association (Do et al., 2015; Elhendawy, 2017; etc.). This inconsistency can be linked to the fact that the financial market is characterised by a high level of uncertainty. Accordingly, the dynamic characteristics of correlations may not always exist unless driven by some remarkable causes (Amoako et al., 2022; Agyei et al., 2022; Boateng et al., 2022).

Also, the few available studies conducted on the interplay between stock returns and exchange rates in West Africa ignored time and frequency domain analysis. It can be concluded that little is known about the impact of uncertainties on such associations across diverse investment horizons in West Africa. Hence, the focus of this study is to investigate the influence of uncertainties on the connectedness between stock returns and exchange rates at diverse investment horizons through the wavelet approaches.

Background to the Study

In the current state of the global economy, the foreign exchange and stock markets are ranked high in the overall classification of financial markets (Fasanya et al., 2021). The significance of these marketplaces is inextricably linked to their ability to facilitate global economic operations. For instance, the stock markets do not only play an essential part in the reallocation of assets across many sectors of an economy as they have become more interdependent (Mobarek & Mollah, 2005; Yartey & Adjasi, 2007; Aliyu, 2012; Tiwari et al., 2021; among others) but also as an economic health barometer and a register of investors' confidence (Kganyago & Gumbo, 2015). It is also crucial in deciding how quickly policy changes spread across the economy (Mbulawa, 2015). Indeed, a well-functioning stock market can help a country's economic development (Aliyu, 2012; Smales, 2017; Asafo-Adjei et al., 2021a; Tiwari et al., 2021).

The market for currency exchange is increasingly important in assisting global economic activity due to increasing levels of globalisation, currency variance and international dependency on the other hand (Fasanya et al., 2021). A lot of transactions including stock market transactions are conducted internationally and are most often valued in US dollar, the world's widely used currency (Efremenko et al., 2018; Owusu Junior et al., 2017; Jain & Biswal, 2016). This means that to trade internationally, local currencies must be converted to US dollars (Fasanya et al., 2021). Exchange rate movements (downward or upward) may determine the value of a firm's stocks (Suriani et al., 2015). This is because the domestic companies become less competitive thus reducing their profitability which consequently decreases

dividend. Reduction of return-on-investment results in a fall in the market value of enterprises (Vanita & Khushboo, 2015).

The literature establishes mechanisms that link the stock and foreign exchange markets. These two markets are connected through common metrics such as gross domestic product (GDP), interest rates, and inflation, among others. These factors have a combined effect on the two markets, linking them together (Roubaud & Arouri, 2018; Fasanya et al., 2021). Nevertheless, there are two basic theoretical explanations for how stock returns and currency rates interact. These are the stock-oriented and flow-oriented models. The flow-oriented theory argues that the correlation between exchange rates and prices of stock is either negative or positive, with causality propagating from exchange rates (Dornbusch & Fisher, 1980) while the stock-oriented model argues that causality originates from stock price to exchange rate (Branson, 1983). The relationship could also be positive or negative.

Till now, the literature is filled with numerous empirical works that have investigated the relationship between the two markets with varied findings reported across the world (Tabak, 2006; Caporale et al., 2014; Chortareas et al., 2011; Salisu & Ndako, 2018; Cavusoglu et al., 2019; Lou & Luo, 2018; Zheng et al., 2019; Živkov et al., 2021; Kallianiotis, 2021). However, the effect of major exogenous events, particularly economic or financial market uncertainties on the connectedness between them in West Africa is yet to be explored. The study by Pastor and Veronesi (2012) as well as that of Gomes et al. (2012) provide the earliest underpinning for this consideration. This is followed by the studies of Naifar and Hammoudeh (2016), Arouri et al. (2016), Liu et al. (2017), Xunpeng et al. (2017), Ji et al.

(2018), Gholipour (2019), Balli et al. (2020), among others. They observed that uncertainty can influence financial market returns and volatility through its effects on the market for labour, investment and personal spending decisions.

From a different point of view, uncertainty impacts investors, corporate entities and consumers in so many ways, discourages firms from engaging in new investment projects and leads consumers to engage in conservative spending behaviour (Handley & Limao, 2015; Converse, 2018). For example, an increase in uncertainty surrounding economic policies cause individuals to be more cautious in their lending habits resulting in rise in interest rates.

The diversity of studies demonstrates the significance of financial markets particularly, the stock and exchange rate markets for international investors and academics. Volatility is prevalent in these markets (Walid et al., 2011; Gholipour, 2019). The uncertainty metrics can be a decisive element that aids participants in the market in predicting the relationship between stock returns and currency rates, including resolving contradictions in empirical findings on the subject. It is worth noting that uncertainty indexes have a significant impact on macro indicators and financial markets (Aysan et al., 2019; Al-Yahyaee et al., 2019; Owusu Junior et al., 2021a). Accordingly, the predictive power of uncertainty indices may be the reason why prior studies conducted on the stock returns-exchange rate nexus found contradictory outcomes.

Specifically, three uncertainty indices are employed. These are – Crude Oil Volatility Index (OVX), Global Economic Policy Uncertainty (GEPU) and

the Chicago Board Options Exchange Volatility Index (VIX). The VIX is a benchmark for investors all over the world as it affects changes in price of commodity and stock markets (Chung & Chuwonganant, 2018). The level of risk indicated by the VIX indices informs investors' expectations and investment policies (Al-Yahyaee et al., 2019). The shocks of VIX indices may either have a direct or indirect effect on financial market fluctuations (Aimer, 2021).

The EPU increased significantly due to uncertainty arising from spending, tax, and monetary policy following the 2008 global financial crisis (Balta et al., 2013). Moreover, the OVX index has the power to predict future oil spot volatility (Chen et al., 2018), and other financial assets (Maghyereh et al., 2017; Antonakakis et al., 2019). Bouri (2015) argues that oil price shocks can transmit into equity markets leading to immediate instabilities in the market and distant disruptions of economic activities. This paper visits the predictability power of GEPU, VIX and OVX on the relationship that exists between stock return and exchange rates. The indexes have implications for portfolio risk assessments.

The study is done in the context of West African financial markets. The West African region considered in this study exhibit some characteristics. For instance, the capital market integration drive which is part of the plan for economic integration in the West Africa region covers integration in functional areas including the monetary system (Obadiaru et al., 2019). The high integration level within West African economies facilitates trade and investment (Umaru et al., 2018; Tyopev, 2019), and ensure their long-term sustainability (Ehigiamusoe & Lean, 2020).

Moreover, several West African countries have implemented policies and reforms to boost their financial markets, improve access to financial resources, and enhance regulatory and supervisory frameworks. In recent times, there has been privatisation of commercial banks, interest rate liberalisation, financial institution recapitalisation, and technological advancements have all been used to reposition the industry to promote growth (Ehigiamusoe & Lean, 2019).

It, therefore, goes to reason that anything that impacts (positive or negative) one market in the West Africa region could have ramifications for the African continent or the international community as a whole (Ehigiamusoe & Lean, 2019). However, the results on integration have shown a deterioration in the profile of macroeconomic convergence indicating a downward trend (Ndiaye, 2022). Thus, although there is some progress in the harmonisation of economic policies in the West African region, the presence of weaker convergence policies mitigates the real and effective convergence of economies. Nonetheless, the cost-benefit analysis of convergence in the monetary union process suggests an increased gain over losses which is transitory and requires a careful assessment of macroeconomic factors for enhanced policy and investment decisions (Umaru et al., 2018; Tyopev, 2019; Ndiaye, 2022).

With the expanding integration of international financial markets as supported by cross-border integration in West Africa (Ndiaye, 2022), evidence-based understanding of how exchange rates and stock markets interact and the influence of uncertainty indices in the West Africa region as well as their degree of integration is required. Furthermore, it is important to

investigate the nexus considering the heterogeneous and adaptive behaviours of markets regarding the irrationality of the participants (Ijasan et al., 2021). This is supported by the heterogeneous market hypothesis (HMH) of Müller et al. (1993) as well as the adaptive market hypothesis (AMH) of Lo (2004). The HMH and AMH are specifically relevant for this study due to the behavioural intentions of investors, thus considered irrational in their decision-making process.

Accordingly, the returns behaviour of financial markets largely experiences dynamics of unstable signals to heighten noise (Barson et al., 2022; Owusu Junior et al., 2021b; Asafo-Adjei et al., 2021c; Bossman et al., 2022). Hence, time-frequency as well as frequency-dependent techniques which have gained massive focus in finance and economics literature are utilised. This includes the partial wavelet, bi wavelet, and multiple wavelet. These techniques can effectively reveal the adaptive and heterogeneous behaviour of markets and their participants by addressing calendar time as well as intrinsic times of short-, medium-, and long-term (Owusu Junior et al., 2021a; He et al., 2021; Asafo-Adjei et al., 2021a; Tiwari et al., 2021; Boateng et al., 2022). Particularly for the bi-wavelet, the study examines the nexus between stock returns and exchange rates across the time and frequency domains. The partial wavelet is employed to investigate the conditional effect of uncertainty indices on the nexus between stock returns and exchange rates across time and frequency. The integration level among the variables employed in this study is addressed by the wavelet multiple. The wavelet multiple therefore deals with simultaneous assessment of the variables through intrinsic times (Tiwari et al., 2013; Asafo-Adjei et al., 2021b).

Therefore, the study investigates the influence of uncertainties on the nexus between stock returns and currency rates in West Africa in both time and frequency to divulge market inefficiencies. It further assesses the level of integration among stock returns and exchange rates amid uncertainties in the short-, medium-, and long-terms.

Statement of the Problem

The connectedness between exchange rate and stock returns in Africa is touted to be mostly negative (Raji et al., 2017). Notions from these studies are mostly restricted to the application of static models. Narrowing down to West Africa, similar outcomes can be found, especially in the case of Nigeria and possibly Ghana (Adjasi et al., 2008; Adjasi et al., 2011; Abiola & Olusegun, 2017; Owusu Junior et al., 2018; Bala Sani & Hassan, 2018; Tweneboah et al., 2019; Amewu et al., 2022; e.t.c.). There are, however, limited studies conducted on the dynamic nexus between the BRVM and exchange rate, thereby arousing a myopic view of the entire West African economy. A recent study conducted by Mhlongo and Olaomi (2021) employed DCC-GARCH approach to investigate the relationship between BRVM-CI and XOF without considering the frequency dimension. With the few studies conducted, what is entirely missing in the empirical literature is the effect of uncertainty indices on the nexus between exchange rate and stock returns simultaneously, across time and frequency, in the context of West Africa.

It can be inferred that existing knowledge about the nexus between exchange rate and stock returns with uncertainties in tandem is not enough to understand the heterogeneous and adaptive dynamics of markets and as well as their participants regarding market inefficiencies. Consequently, investors

may not have accurate information about the markets which may affect their investment decisions and plunge their confidence.

Moreover, it can be deduced from the significant impact of crises on most financial markets that analysis conducted at both time and frequency is worthwhile (Boateng et al., 2021; Owusu Junior et al., 2021b; Barson et al., 2022). For instance, the COVID-19 pandemic occasioned a significant impact on several financial markets across the globe, thereby driving asymmetric relationships across financial time series. Accordingly, it is believed, that the already existing relationships are dynamic, and the situation becomes more profound when uncertainties are considered.

A plethora of studies have been conducted on the stock return-exchange rate nexus across the globe (Boako et al., 2016; Abiola & Olusegun, 2017; Emenike, 2018; Živkov et al., 2020; Mattack, 2020). Additionally, the impact of uncertainty indices on stock markets (Xiao et al., 2018; Xiong et al., 2018; Albulescu et al., 2019; Hoque & Zaidi, 2019; Asafo-Adjei et al., 2020; Li et al., 2020; Fasanya et al., 2021; Tzeremes, 2021), as well as exchange rate (Juhro & Phan, 2018; Hoque & Zaidi, 2019; Bartsch, 2019; Abid, 2020), is replete in empirical studies. So far, the known works to date that mirror this study are Albulescu et al. (2019) which connected the EPU of United States with the spillover between the markets for oil and currency, Shaikh (2020) which examined the equity, commodity, interest rates, and currency markets, taking into consideration the US EPU index. Moreover, Fasanya et al. (2021) examined the United States EPU impact on the comovement of currency pairs that are most traded globally and oil.

Notwithstanding, there are still some crucial gaps to be covered. Firstly, the current study includes the nexus between BRVM and exchange rate in time and frequency domain which is ignored by most studies conducted in West Africa. This is needed for policy directions and investment decisions on the integration between stock returns and exchange rate in the West African economy, and also enhances effective comparison. Secondly, the influence of the various uncertainty indices on stock market and foreign currency rate markets is yet to be investigated in West Africa. This would be executed to address the lack of consensus in prior studies on the exchange rate-stock returns nexus.

Third, the study utilises the wavelet approaches to include; wavelet multiple, partial wavelet, and bi-wavelet in the West African region with uncertainties in perspective. Particularly, the bi-wavelet and partial wavelet techniques are superior since they account for both time and frequency in addressing the stock market and the currency rate nexus in light of uncertainties. The wavelet multiple is pertinent in addressing the integration and lead-lag relationship of stock returns, exchange rate and uncertainties intermittently for effective comparison.

Hence, the study examines the time and frequency nexus between stock returns and exchange rates in West Africa. It further assesses the impact of uncertainty indices on the stock returns and exchange rate nexus. Moreover, the dynamic interdependencies among stock returns, exchange rate and uncertainty indices are further explored in this study.

Purpose of the Study

The purpose of the study is to investigate the influence of uncertainties on the relationship between stock returns and exchange rates in West Africa. The dynamic interdependencies among stock returns and exchange rates in West Africa amid uncertainties are further ascertained in this study.

Research Objectives

1. Examine the relationship between stock returns and exchange rates in West Africa in time and frequency domain.
2. Investigate the influence of uncertainty indices on the relationship between stock returns and exchange rates in West Africa in time and frequency domain.
3. Assess the degree of integration among stock returns, exchange rates and uncertainty indices in West Africa

Research Questions

1. What is the relationship between stock returns and exchange rates in West Africa time and frequency domain?
2. What is the influence of uncertainty indices on the relationship between stock returns and exchange rates in West Africa in time and frequency domain?
3. What is the degree of integration among stock returns, exchange rates and uncertainty indices in West Africa?

Significance of the Study

Firstly, understanding the lead-lag relationship between exchange rates and stock prices is critical in establishing where government policy measures should be focused. If stock prices cause exchange rate fluctuations,

Governments can stimulate economic growth and equity markets in an attempt to avoid currency crises. If, on the other hand, it is discovered that variations in the exchange rate cause changes in stock prices, greater emphasis will be placed on exchange rate controls. The clarity of the relationship between these two variables is beneficial to investors and other market participants to develop effective hedging strategies. Understanding the lagging or leading relationships will also aid in investments based on the business cycle by identifying subsequent swings in the cycle and developing estimates that untangle the dynamics between the variables. As a result, this research could be extremely useful in influencing multinational corporations' operational decisions in Africa. To manage their exchange rate exposure, such enterprises must comprehend such relationships (Eissa et al., 2010).

Secondly, this study also provides further insight into the influence of three uncertainty indicators. The findings offer an intriguing opportunity for investors and policymakers, by suggesting partial hedging benefits toward risk exposures concerning both currency and stock fluctuations. These results are useful for investors and portfolio managers aiming for specific time horizons for their investment, preferences and risk assessment. The findings will also help policymakers focus on building optimal measures to promote stock-market stability, especially during crises, as well as designing an appropriate framework for foreign-exchange management to stabilise the currency.

Thirdly, this research work contributes to empirical works in the context of African stock market by adding new evidence and literature regarding EPU, OVX, and VIX effects on the relationship between stock returns and exchange rates. This study looks at the dynamic relationship

between stock markets and exchange rates and the period studied includes the pandemic period. Thus, this study also contributes to the developing body of knowledge about how COVID-19 affects financial markets.

Delimitations

The study covers only how stock return and exchange rate are correlated in West Africa, the influence of some uncertainty indicators (EPU, OVX, and VIX) and the interactions between these markets. The measures of the stock return and exchange rate are limited to US-based indices and the uncertainty indicators are limited to US and global based. The uncertainty indicators are limited to only the three employed as well. However, the selected uncertainty indices are remarkable in addressing shocks within the financial time series of most economies.

Moreover, this study concentrated on the financial markets of West African countries. In West Africa, there are five stock markets but only the return of three of the markets was used as the other two are small in size in terms of market capitalisation. This will not affect the findings of the study since the markets of countries omitted have similar characteristics as those included in the studies.

Limitations

The study is limited in a few ways. First, the research relied on a quantitative research approach only without considering the perception of the market participants through interviews. Despite this, results from a quantitative study are trustworthy and impartial. Second, the bi and partial wavelet analyses involve two and three variables respectively but in time and frequency domain. The wavelet multiple analysis includes more than three

variables but only in frequency though in the bivariate wavelet case, it resolves the challenges of comparing every pair of coherencies. Notwithstanding, the statistical frequency employed is robust for time-frequency domain research and minimises noise from the data.

Definition of Terms

Stock return: Stock returns are the changes in stock prices compared to the initial prices at which the investor purchased the stock (Muchiri, 2014). It may be calculated as the All-Share Index either in absolute terms or as a percentage of the total investment (Onoh, 2016).

Exchange rate: The exchange rate is defined as the rate at which one national currency is swapped for another (Ediriwickrama & Pathirana, 2021; Pole & Cavusoglu, 2021).

GEPU: This refers to the special uncertainty surrounding future evolutions of economic policies, in terms of global monetary policy, fiscal policy, and regulations (Pástor & Veronesi, 2013; Baker et al., 2016).

OVX: The Crude Oil Volatility Index is a measure of crude oil expectation of volatility. (Ji & Fan, 2016; Shaikh, 2019; Echaust & Just, 2021). The OVX reflects investor fear gauge of the global oil market (Jin & Zhu, 2021).

VIX: The CBOE VIX is a real-time indicator of market expectations for thirty-day volatility based on S&P500 index option prices (Neffelli & Resta, 2018).

Organisation of the Study

There are five sections to the study. The first chapter contains the background to the study, statement of the problem, the purpose of the study, research objectives and questions, significance, delimitations and limitations

of the study, definition of term and lastly the organisation of the study. Chapter Two focuses on review of literature which includes theories, concepts and empirical works. The third chapter deals with the research methods employed in the study, the model specifications used, as well as the measurement of variables in the study. The next chapter, that is Chapter Four, covers data presentation, analysis and the discussion of findings. Chapter Five completes the study with summary, conclusions, and recommendations. It ends with suggestions of areas for future studies.

CHAPTER TWO

LITERATURE REVIEW

Introduction

The study sought to investigate the relationship between stock return and exchange rate in West Africa, the impact of uncertainties on that relationship and the interaction among all the variables used by employing wavelet methodology. This chapter presents a comprehensive literature review related to stock return, exchange rates and uncertainty indices. The chapter begins with a theoretical review, discussing in detail, the various theories that underpin the study. The conceptual review follows and finally an empirical review of literature by other researchers that are relevant to the study.

Theoretical Review

There are two main theoretical explanations for the interplay between foreign exchange and stock returns in the extant literature in financial economics. These are stock-oriented and flow-oriented models. The informational transmission process, which generates the relationship between the two markets, is the focus of these two approaches. The theory of financial market integration is also discussed. This research is backed by the Heterogenous Market Hypothesis and the Adaptive Market Hypothesis as well.

Flow-oriented Model

The flow-oriented theory is based on the assumption that changes in exchange rates affect trade balance, global competitiveness, and ultimately the real production of a country, which affects enterprises' future and current stock values and cash flows (Dornbusch & Fisher, 1980). This means that a nation's

trade balance or current account determines the exchange rate in major part (Stavárek, 2005; Aloui, 2007).

Zhang (2016) offered a macroeconomic justification, arguing that the Efficient Market Hypothesis (EMH) of Fama (1970), which differs from the flow-oriented hypothesis, can be used to explain stock prices as the company's present value of anticipated future cash flows. As stated by the EMH, if the market is efficient, information that affects the productivity of a company and future cash flow should be reflected in its stock price. Inferring a causal relationship between the exchange rate and stock returns, stock prices would consequently respond to overall economic situations and prospects. However, the flow-oriented approach to exchange rates argues that the direction of impact is uncertain. Consequently, the final direction could be a positive or negative impact, with causality propagating through exchange rates. Thus, the causation is from exchange rates to stock prices (Stavárek, 2005; Aloui, 2007; Umer et al., 2015; Daggash & Abraham, 2017; Xie et al., 2020; Mattack, 2020; Korley & Giouvris, 2021).

A depreciation of the national currency, for instance, can increase exports in an economy where exports are the main economic driver. The economic expansion will cause the stock prices of businesses in that nation to increase. In an economy dominated by imports, instead, depreciation of the native currency leads to an increase in production costs, potentially resulting in low-profit margins and stock price declines (Zhang, 2016). In consequence, such a reduction has an impact on the ability of organisations to compete in both domestic and international markets (Yücel & Kurt, 2003; Daggash & Abraham, 2017; Chen et al., 2018; Nusair & Al-Khasawneh, 2022). Adjasi et

al. (2011) also argued that fluctuations in currency may change movement in stock prices since it equates supply and demand for asset value (bonds and stocks).

Stock-oriented Model

The stock-oriented approach argues that changes in stock price affect the exchange rate via capital and financial account (Branson, 1983; Frankel, 1992). The theory establishes a directional relationship between stock prices and exchange rates (Branson, 1983). There are two types of this model: monetary and portfolio balance models. The portfolio method says that changes in currency rates like other commodities are a consequence of market forces. A surge in stock markets causes a shift in the portfolio from foreign assets to assets dominated in the native currency, signaling a shift in currency demand, which will result in currency appreciation or depreciation (Branson, 1983; Frankel, 1992; Salisu & Oloko, 2015; Zhang, 2016; Bahmani-Oskooee & Saha, 2018; Nusair & Al-Khasawneh, 2022).

Foreign exchange is viewed as the value of the financial asset in the monetary approach. Because the present value of expected cash flows determines the value of a financial asset, the exchange rate is influenced by all macroeconomic parameters affecting the expected price. Hence, if the two variables are impacted by the same factors, innovations in stock price may affect exchange rate dynamics (Aloui, 2007; Umer et al., 2015).

Gavin (1989) asserted using the demand for money theory that a decline in stock price results in a decline in a nation's wealth, which in turn results in a decline in capital outflows, demand for money, and currency depreciation. Thus, the model argues that exchange rates and stock prices may

have an inverse relationship (Branson & Henderson, 1985; Frankel, 1992; He et al., 2021; Škrinjarić et al., 2021). Hence, stock prices influence exchange rates. Furthermore, the relationship between stocks and currency rates, according to this model, occurs due to rapid information flow between markets (Fauziah et al., 2015; Živkov et al., 2020). The importance of currency rates in balancing the supply and demand of foreign and domestic financial assets is also assumed in this model (Chkili & Nguyen, 2014; Mattack, 2020).

Financial Market Integration Theory

During the late 1980s and early 1990s, there was major growth in the level of global financial market integration. The rise in globalisation of investments seeking higher rates of return and the chance to diversify risk has been a major element supporting this development (Agénor, 2003). Private capital flows to developing nations have significantly increased in tandem with the level of global capital markets' increasing integration. The advantages and disadvantages of financial integration might be regarded from the perspective of individual investors (such as the chance for worldwide risk diversification) or the nations initiating the process of integration (Bekaert et al., 2007; Arouri & Foulquier, 2012).

In sub-Saharan African nations, one crucial component of market integration is the globalisation and liberalisation of the global economy together with technological advancements in communication and information. These factors have created conditions for investors to benefit from market interdependence and also led to a deepening of the financial sector (Ogbeide & Adeboje, 2020; Emenike, 2021). This has permitted the establishment of

enormous companies, the opening of financial markets, and the capacity to diversify into a wide range of financial assets (Alhassan & Biekpe, 2017).

Examining the connections between financial markets (stock and exchange rate) and uncertainties in the West African region is necessary given the rising interconnectedness of the global financial markets. On the other hand, one of the possible difficulties of market integration is the transmission of volatility shocks and various contagions of systemic risk, as well as the ensuing market instability. For the purpose of market stabilisation measures, a guide against the difficulties of regional financial and integration investment, it is appropriate to understand the nature of integration among the West African stock market, exchange rate, and uncertainties.

Adaptive Market Hypothesis

Financial market swings have captivated a variety of market participants over time, including academic researchers, speculative traders, and policymakers. The Efficient Market Hypothesis (EMH) has been a cornerstone idea and a source of heated controversy in the field of asset price modeling (Khuntia & Pattanayak, 2020). EMH's main argument is that asset value changes represent all information available, and therefore no economically exploitable mispriced assets exist (Fama, 1970).

Lo (2004; 2005) proposed the Adaptive Market Hypothesis (AMH) as an alternative paradigm to bridge the tense relationship between proponents of the EMH and behavioral economists who criticise it. Lo (2004) examined how efficiency varies over time and concluded that AMH is a more reliable approach than EMH since it states that human errors can cause arbitrage opportunities to surface at specific times and then vanish once they are

utilised. The AMH uses a logical coherent approach to determine the existence of market efficiencies and inefficiencies. In contrast to EMH, market efficiency evolves in AMH.

However, due to its abstract and qualitative nature, previous works have not explicitly explained the AMH, but its practical implications have been extensively investigated to illustrate how adaptive a market is. The first implication is that the relationship between risk and reward is extremely volatile. Second, investment opportunities change with time. Thirdly, different business environments have an impact on investing methods. The fourth consequence is that the key to market survival is the ability to adapt to changing market conditions (Lo, 2004).

As the AMH points out, market efficiency may be affected by changes in market conditions. Factors such as VIX, economic policy uncertainty, OVX and the economic environment may generate variations in market efficiency levels, as the AMH relates to the periodic variation in market efficiency through changes in institutional factors and market conditions (Ghazani & Araghi, 2014). As indicated by Lo's (2004) adaptive market theory, survival is the sole goal that matters for every financial market player, and fear and greed are tied to evolutionary factors, which are linked to the likelihood of survival. From the above, it is therefore essential to understand that uncertainties are related to periods of instability in an economy presented in specific periods.

Furthermore, the literature suggests that AMH cannot be used in place of EMH. The AMH, on the other hand, backs up the empirical variations of the EMH. Time-varying efficiency of stock or exchange rate markets, for example, could be better examined in light of AMH implications (Khursheed

et al., 2020). For currency markets, a plethora of research has identified changing market conditions, caused by the events such as central bank intervention (LeBaron, 1999; Jeon & Lee, 2002; Yilmaz, 2003), the global financial crisis (Ali et al., 2011), and financial crisis in Asia (Jeon & Seo, 2003; Ali et al., 2011; Al-Khazali et al., 2012), not forgetting the recent pandemic (COVID-19) (Rai & Garg, 2021), can affect other features and efficiency of the market. These occurrences have significant ramifications for market players' psychology and how they assimilate new information into prices, which could result in time fluctuation in a serial correlation of returns. Given Lo's (2004; 2005) AMH, such dynamic market conditions are most likely to determine the degree of return predictability.

The AMH has been the subject of recent empirical research to see if it can explain market behavior better than the EMH. These studies include both developed (Ito & Sugiyama, 2009; Kim et al., 2011; Lim et al., 2013; Alvarez-Ramirez et al., 2012; Ito et al., 2016; Boya, 2019) and emerging equity markets (Todea et al., 2009; Abdmoulah, 2010; Smith, 2012; Tuyon & Ahmad, 2016; Phan Tran Trung & Pham Quang, 2019; Charfeddine & Khediri, 2016; Shahid et al., 2019; Kılıç, 2020). AMH has also been researched in markets other than stock markets, such as foreign exchange (Neely et al., 2009; Almail, 2017; Kumar, 2018), bonds (Charfeddine et al., 2018; Li et al., 2021), cryptocurrency (Khuntia & Pattanayak, 2018; Chu et al., 2019; Ghazani & Jafafi, 2021), crude oil (Varghese & Madharan, 2019; Ghazani & Ebrahimi, 2019; Ghazani & Jafafi, 2021), and resort real estate investment trusts/lodging (Zhou & Lee, 2013; Almudhaf et al., 2020; Ijasan et

al., 2021). In these marketplaces, strong evidence of the AMH framework had been discovered.

In their studies, Baker et al. (2012), Antonakakis et al. (2013), Brogaard et al. (2015), Arouri et al. (2016), Arbatli et al. (2022) among others explored the effect of the levels of uncertainty surrounding economic policy in capital markets, more specifically on the return and volatility of securities. The results pointed to an adverse impact on the return and on the stocks' volatility positively, concluding that the level of uncertainty in these economies generated an impact on the securities pricing. Analysing the uncertainty regarding the level of efficiency of markets becomes relevant to understanding the impacts that periods of instability generate on the financial market, helping users in their decisions about resource allocations.

Heterogeneous Market Hypothesis

Researchers and investors have looked into fresh data over the years to improve the existent EMH and better comprehend the actual information flow that underpins financial markets. One of the innovative hypotheses that proposed non-homogeneous market players is the heterogeneous market hypothesis (Cheong, 2013; Cheong et al., 2016; etc.). Müller et al. (1993), Dacorogna et al. (1997), Peters (1994), and Dacorogna et al. (2001) pioneered this notion in the foreign currency and stock markets.

The Heterogeneous Market Hypothesis (HMH) views market participants as heterogeneous, with a wide range of endowments, investment horizons, information, geographical locations, information processing ability, institutional restrictions, trading horizons, and so on (Müller et al., 1993; Corsi, 2009; Chen et al., 2017; Owusu Junior et al., 2020; Patil & Rastogi,

2019; Hwang & Yu, 2021; Owusu Junior et al., 2021a; Adam et al., 2021). Participants in the market react to information at different times and with diverse interests and strategies, resulting in market data being noisy (Asafo-Adjei et al., 2021c). Financial time series, including stock and exchange rate markets, are surrounded by noise and endure quick changes due to the ubiquitous behaviour of unstable signals (Asafo-Adjei et al., 2021b).

The HMH theorises the existence of short-term (market makers/speculators), long-, and medium-term investors (central banks/institutional investors) (Mensi et al., 2016). Thus, according to HMH, various market players' reaction times vary greatly when given the same information set. Hence, testing the current phenomenon over several periods is unavoidable. Thus, motivated by HMH, this study uses the wavelet decomposition framework to elucidate newer insights into the conventional relationship between stock returns and exchange rates, and the impact of uncertainty indices in West Africa.

Consequently, the appearance of the coronavirus necessitates a more thorough examination of the stock market-exchange rate relationship in Africa. Given that stock markets are inherently diverse, which is prevalent during times of crisis and continues during times of high market volatility (Badshah et al., 2018), similar to pandemic conditions, a heterogeneous investigation is timely (Boateng et al., 2021).

Conceptual Review

A review of stock return, exchange rates, global economic uncertainty, OVX, and VIX are presented in this section. It explains what these terms mean and why they were employed in this research.

Stock return

A stock market is established to provide investors with a variety of investing and saving options. A stock market is set up to give investors a variety of saving and investing options. The fundamental goal of setting up a stock market is to simplify the process for participants in the market, as it collects savings from all groups and allows them to turn those resources into profitable investments. The stock market is critical for reallocating assets across many sectors of the economy (Ahmad & Ramzan, 2016). Stock return is one of several variables utilised in financial research, along with other influencing factors (Tangjitprom, 2012; Susan & Winarto, 2021).

Stock returns, described by Muchiri (2014), are changes in the value of a stock compared to the initial price at which it was purchased. According to Onoh (2016), returns on a stock are any changes in the value of the cash flows or investment, received from the investment by the investors, such as payments of dividends or interest. It may be calculated, either in absolute terms or as a percentage of the total investment, as the All-Share Index. This study adopts these definitions and measurements.

The stock market performance reflects how healthy a country's economy is (Das, 2021). Stock returns can be influenced by a variety of factors, both internal and external. Internal factors include financial performance, which characterises a company's financial state, and external factors like exchange rates, which can exacerbate the cause of external economic disruption (Mariano et al., 2015; Susan & Winarto, 2021).

Due to increased degrees of financial globalisation and liberalisation, internationalisation, and integration, markets for stock around the world have

become rather more interdependent than isolated (Obadiaru et al., 2019). The Economic Community of West African States (ECOWAS) is promoting a process of capital market integration in the West African economies. The endeavor to integrate the capital markets is part of the region's economic integration goal, which includes integration in functional areas like the monetary system, commerce, and finance (Obadiaru et al., 2019). The Bourse Régionale des Valeurs Mobilières (BRVM), Ghana Stock Exchange (GSE) and Nigeria Stock Exchange (NGX) are the three largest stock markets in West African Region, all of which are designated by Morgan Stanley Capital International (MSCI) as frontier markets. The stock markets of Cape Verde (BVC) and Sierra Leone (SLSE) are among the others in the region (Obadiaru et al., 2019; Emenike, 2021). When compared to the others, the SLSE and BVC are relatively new and small. BVC was established in 2005. As of the end of 2018, it had ten listed companies with a market capitalisation of US$802.9 million (Obadiaru et al., 2019; Emenike, 2021). SLSE, established in 2007, had only three listed companies in 2017 and trades only on Mondays.

As of December 2020, the Nigeria Stock Exchange, located in Lagos, had 177 listed firms with a market capitalization of $13.09 billion. The Ghana Stock Exchange, situated in Greater Accra, had 39 listed firms with a market capitilisation of $12.76 billion. The BRVM which is situated in Abidjan, Côte d'Ivoire, had 46 listed firms in the market with a market capitalisation of $11.95 billion (Obadiaru et al., 2019; Emenike, 2021). It is a stock market for eight West African countries: Senegal, Benin, Guinea-Bissau, Niger, Cotê d'Ivoire, Burkina Faso, Togo and Mali. These three stock exchanges were chosen for the study because they are active and offer a substantial amount of

data for examination. The BVC and SLSE lack market indexes, are too shallow, and illiquid to monitor overall market performance. The two marketplaces were excluded from the research since there was not enough data to do so.

Exchange rate

The most liquid and largest financial market is the foreign exchange market (Record, 2003). Exchange rate stability is critical for the development and maintenance of a healthy economy. The currency rate is used as a parameter in the macroeconomic variable to control international competitiveness and to identify the country in the international trade position in the world economy (Pole & Cavusoglu, 2021). The exchange rate is defined by Ediriwickrama and Pathirana (2021) as the rate at which one national currency is traded for another.

In economics, there exist theories that describe how the market determines the exchange rate. Examples include Interest Rate Parity (IRP), International Fisher Effect (IFE), and Purchasing Power Parity (PPP). Cassel's (1918) theory of purchasing power parity claimed that two countries are in equilibrium when a similar basket of commodities is priced the same in both. According to the theory of IRP, Interest rate differentials between countries are equivalent to the difference between forward and spot exchange rates. The IFE explains that the movement of two currencies' exchange values is equal to the difference in the nominal interest rate (Ediriwickrama & Pathirana, 2021).

Over the last five decades, two major economic events have occurred in the international financial and monetary systems: The first was in 1973, the Bretton Woods fixed exchange rates system collapsed and the shift to a

flexible exchange rate system. Second, many capital constraints on global capital mobility were lifted, resulting in a greater level of global financial integration among nations. While the latter has offered portfolio diversification and additional international investment options to investors, The former enhanced the volatility of foreign exchange markets, hence increasing the dangers of these opportunities. (Phylaktis & Ravazzolo, 2005; Nusair & Al-Khasawneh, 2022).

According to historical studies on exchange rate regimes, governments have historically utilised floating, fixed, and fixed or floating exchange rates regimes (Rapetti & Frenkel, 2018). Nigeria and Ghana practice the floating exchange regime by intending to improve trade balances and bolster output (Addai et al., 2020; Asaleye et al., 2021). Since gaining independence in 1957, Ghana is one of the few nations that has never changed its currency rate regime. Nigeria has also had a float exchange regime since its independence in 1960. The Francophone African countries use the pegged exchange regime. In 1999, they changed their peg from the French franc to the Euro (Addai et al., 2020). However, irrespective of the exchange rate regime that a country chooses, there are tendencies for the economy to be exposed to different asymmetric shocks which might result in economic imbalances and the need for adjustment in the exchange rate policy over time (Asaleye et al., 2021). A vast number of studies have investigated the comovement between exchange rates and other macroeconomic variables empirically (Emenike, 2018; Owusu Junior et al., 2018; Guzman et al., 2018; Kumar et al., 2019; Adu et al., 2019; Narayan, 2020; Chen et al., 2020; Aimer, 2021; Naqvi, 2021; Itskhoki, 2021).

In this work, the Real Exchange Rate (RER) is used. At the macroeconomic level, the RER is one of the most relevant relative prices (Demir & Razmi, 2021). The RER compares prices in various countries. In other words, RER measures deviations from PPP, which stipulates that pricing levels in different countries should be equalised. A country's actual exchange rate is said to have appreciated if its consumer price level is higher. RER movements reflect differences in relative inflation rates across nations and nominal exchange rate depreciation: a real depreciation happens when nominal depreciation is not matched by more price inflation at home (Itskhoki, 2021). In contrast to bilateral exchange rates and nominal exchange rates, the real effective exchange rate can accurately reflect the worth of the currency. (Zhao, 2010).

The RER, which is usually viewed as a measure of international competitiveness, represents a significant policy determinant in the West African region (; Adu et al., 2019; Dumrongrittikul & Anderson, 2016). The real exchange rate used in this study is defined as the price of one US dollar in the local currency of the respective country (Owusu Junior et al., 2018). The dollar-based exchange rate was chosen because it is used as the invoicing currency in international trade, the world's most important reserve currency, and the currency in which the majority of international commercial transactions are conducted (Chen et al., 2020), given the universally-accepted safe-haven assumption linked with the USD when analysing uncertainty (Ciner et al., 2013; Owusu Junior et al., 2018).

GEPU

Concerns about Economic Uncertainty (EU) have grown since the global financial crisis (Baker et al., 2016). Economic uncertainty is a major factor in macroeconomic fluctuations (Brogaard & Detzel, 2015; Basu & Bundick, 2017), and financial markets (Pastor & Veronesi, 2013). The EU depicts a situation in which economic agents lack the required knowledge to confidently judge the current situation. As a result, uncertainty is an inherently unobservable term that has a great impact on the economic landscape. Economic Policy Uncertainty (EPU), which refers to the special uncertainty surrounding future evolutions of economic policies, is one of its most talked-about qualities (Pástor & Veronesi, 2013; Baker et al. 2016). EPU deals with the future status of an economy in terms of monetary policy, fiscal policy, and regulations (Asafo-Adjei et al., 2020).

Uncertainty concerning economic policies can have a variety of consequences for individuals and corporations since it has the potential to deter firms from embarking on new investment endeavors and to encourage individuals to be more frugal in their expenditures (Handley & Limao, 2015; Converse, 2018). A similar argument can be made for lenders, who may be more hesitant about lending as a result of increased uncertainty about government economic policies, resulting in higher interest rates. Thus, policy uncertainty can be argued to have direct economic consequences that eventually affect financial markets (Demirer et al., 2018).

Pastor and Veronesi's (2012) theory indicated that unpredictability in government economic policies leads to asset price correlation and increased volatility. Following the influential paper by Bloom (2009), changes in

economic policy uncertainty, such as those related to international trade disputes, Brexit referendums, or military conflicts, have been found to have a significant implication on the macroeconomy. For that reason, the impact of uncertainty shocks on major economic aggregates has piqued policymakers' interest, and it has also become the focus of numerous academic studies (Nilavongse et al., 2020).

EPU index proposed by Baker et al. (2016) has been examined by many studies and the relationship with other variables as well (Li, 2014; Ko & Lee, 2015; Li et al., 2015; Liu & Zhang 2015; Liow et al., 2018; Xiong et al., 2018; Hailemariam et al., 2019; Christou & Gupta 2020; Goodell et al., 2020). The predominant part of the literature on the consequences of shocks from uncertainty focuses on US economy (Bloom, 2009; Karnizova & Li, 2014; Baker et al., 2016; Leduc & Liu, 2016; Bakas & Triantafyllou, 2018; Basu & Bundick, 2017). These studies show that when uncertainty rises unexpectedly, investments, output, prices, employment, and interest rates all fall rapidly. However, the financial market, rather than only the U.S. economic uncertainty, may be largely influenced by global economic uncertainties.

Furthermore, existing uncertainty studies are mostly based on the structural vector autoregressive (SVAR) framework's time-invariant model assumption with constant coefficients (Bloom, 2009; Van Robays, 2016; Baker et al., 2016; Basu & Bundick, 2017; Bakas & Triantafyllou, 2018). Arguably, this assumption may not be particularly realistic, resulting in incorrect outcomes. This is because it is clear that financial market and macroeconomic structures are dynamic, and macroeconomic variables'

intercorrelations change over time (Mumtaz & Surico, 2009; Baumeister & Peersman, 2013; Riggi & Venditti, 2015).

Davis (2016) offers a GDP-weighted average of national EPU indices covering sixteen nations to calculate the GEPU (Ma et al., 2020). GEPU is one of the most well-known global risk variables in the financial markets (Baker et al., 2016; Arouri et al., 2016) and has been widely used in many studies as well (Yu et al., 2018; Yu & Song, 2018; Lyu et al., 2021). This study chooses the GEPU as it would better capture the economic policy of the West African region than the US EPU via wavelet methodology.

VIX

CBOE created and released the first volatility index (VIX) premised on the S&P 500 Index in 1993, intending to inform traders about stock market volatility over the ensuing 30 trading days. The index is developed using S&P 500 stock index options based on real-time (Tian & Zhang, 2020). Since its establishment, the VIX has been a swift and important measure of sentiments in the market (Whaley, 2000). It provides an instant view of market expectations for thirty days of calendar volatility as expressed by S&P500 index option pricing (Neffelli & Resta, 2018). With the success of the VIX, the German Futures and Options Exchange volatility index among other indices was created (Wen et al., 2021; Singh et al., 2018).

The VIX is sometimes referred to as the “fear index”. The appellation of “fear index”, is a result of how it responds to fluctuations in the market. It also works effectively in capturing market downtrends (Whaley, 2009). In the literature, the role of VIX as a natural barometer for the riskiness of financial markets has been thoroughly evaluated and discussed, mainly in reference to

the US equity market. Several other papers have also utilised implied volatility measures to study financial market integration and linkage. The importance of U.S. volatility indices (VIX) is emphasised in transmitting market uncertainty globally (Ding et al., 2014; Dutta, 2018).

In the seminal paper of Fleming et al. (1995), major results included: firstly, VIX is known as a fear gauge as it exhibited a statistically strong adverse connection with the equity index. Secondly, the asymmetry of VIX captured the positive and negative impact on the equity index returns. Sarwar (2012) extended these analyses of Fleming et al. by looking at the link among three indexes in the US, namely the S&P100, 600 and 500, and the VIX. The findings corroborated earlier research and highlighted a negative concurrent association that tended to strengthen during periods of high volatility while decreasing elsewhere. VIX as a fear gauge was also discussed by Chiang (2012) who discovered it asymmetrically responds to negative returns.

In related studies, Lu et al. (2017) examined the dynamic connection between the Japanese Yen exchange rate and VIX from 1998 to 2016. The investigation showed that the causal relationship is bidirectional in general, and the cross-correlations between the two sets of time series are multifractal. More recently, Bouri et al. (2020) focused on the dynamic nature of volatility in the financial market of United States. The authors examine the link between the implied volatilities of the S&P 500 and five major U.S. stocks from June 1, 2010, to May 4, 2018. The findings revealed that the connectedness appears to be dominated by the U.S. VIX index, and the volatility of some U.S. companies also contributes significantly.

OVX

The Crude Oil Volatility Index was introduced by the CBOE as a new measure of crude oil volatility expectation in 2007. It has evolved into a new gauge of investor sentiment for future oil prices based on implied volatility (Ji & Fan, 2016; Shaikh, 2019; Echaust & Just, 2021). Benedetto et al. (2020) underlined the fact that OVX is a measure of uncertainty related to West Texas Intermediate crude oil, similar to the relationship between VIX and S&P500. Although many studies find a link between the OVX and VIX, OVX appears to be a better predictor of oil price movements than VIX (Maghyereh et al., 2016; Dutta, 2018; Bašta & Molnár, 2019).

Nevertheless, OVX, which is calculated by applying the VIX methodology to United States Oil Fund options prices and reflects the markets' expectation of thirty-day volatility of crude oil prices, has been recently documented as a better measure of global oil price volatility and a more accurate measure of global oil price uncertainty with forward-looking information (Xiao et al. 2018; Jin & Zhu, 2021). Moreover, the OVX does not only contain historical volatility information but also reflects an investor fear gauge of the global oil market.

Additionally, crude oil trades are paid in US dollars, hence, fluctuations in the dollars against local currencies are the major factors conveying and further modifying the effects of oil prices on the local stock market (Tian et al., 2021). Future market risks are correlated with dynamic market uncertainty transmission, which is tied to shifts in investor sentiment (Dutta et al., 2017; Wen et al., 2019; He et al., 2020; Xiao et al., 2018; Cao et al., 2020; You et al., 2017). Therefore, it is important to look into the volatility

links between the West African stock and the forex markets. Additionally, You et al. (2017) showed that the asymmetrical effects of oil market shocks on stock returns might be made worse by investors' heterogeneous responses to both favorable and unfavorable shocks. Investors will therefore require knowledge of how the varied character of African stock markets responds to the asymmetric behaviors of the OVX in order to identify and apply suitable risk management methods that can shield them from jarring changes in equities sensitive to oil prices (Boateng et al., 2021; Hung & Vo, 2021).

Empirical Review

In this section, existing literature on the important concepts and relationships that this research sought to establish was reviewed here. Prior literature on the link between stock return and currency rate, the effect of uncertainty indices on the interdependence between stock return and exchange rate and the interaction among stock return, exchange rate and uncertainty indices were reviewed.

Stock return and Exchange rate

The literature is replete with studies on the connection between exchange rate and stock return. Apart from the theoretical investigation, there have been well-documented but puzzling empirical relations between stock return and exchange rates. The empirical evidence on the direction of causality between stock return and currency rates is mixed. Unidirectional causality from exchange rates to stock prices or stock prices to exchange rates has been documented in various research (Pan et al., 2007; Agrawal et al., 2010; Zubair, 2013; Boako et al., 2016; Abiola & Olusegun, 2017; Mikhaylov, 2018; Kumar, 2019; He et al., 2021). On the other hand, some studies found

bidirectional causality (Engle & Colacito, 2006; Acikalin et al., 2008; Guidolin, 2011; Chkili 2012; Tiwari et al., 2015; Singh, 2015; Emenike, 2018; Živkov et al., 2020; Mattack, 2020), while others found no causal association between the two variables (Ozair, 2006; Zubair, 2013; Suriani et al., 2015). Differences in reported results can be attributable to a variety of factors, including economic situations, international relations, domestic conditions, and geographic location, among others. The inconsistency in the results could be related to possible differences in trade volume, equity, risk assessment, and economic relations among the countries (Suriani et al., 2015).

Chkili and Nguyen (2014) used an MS-VAR model to investigate the relationship between stock and exchange rate return. The study conducted in the BRICS countries established that exchange rate changes do not have any effect on stock market returns. However, there was evidence of stock market returns affecting exchange rates in all countries, except South Africa. Amarasinghe and Dharmaratne (2014), applying both Granger causality and regression methods, recorded a relationship between the stock and exchange rate with causality from stock to exchange rate. The regression results showed that stock return is not an important determinant of changes in exchange rates. That suggests that Granger causality and regression have opposing conclusions. Suriani et al. (2015) discovered no relationship between exchange rate and stock price and that the variables are independent of one another. Empirical results by Do et al. (2015) supported a bidirectional relationship between stock and foreign currency markets in developing nations. Their research emphasised the significance of considering the informational transmission in financial markets' volatility and skewness,

particularly during tumultuous times. Živkov et al. (2015) researched the bidirectional spillover effect between exchange rate and stock returns in four Eastern European markets and discovered that volatility spillover effect has a greater impact on the stock market toward currency market than vice-versa.

Conversely, the study by Sui and Sun (2016) looked at the dynamic relations between forex, interest differentials, local stock returns, and S&P 500 returns. A strong spillover effect from foreign exchange rates to stock returns, but not otherwise was documented. The S&P 500 shocks significantly affect South Africa, Brazil, and China equity markets. Furthermore, during the financial crisis, there were stronger connections. Mitra (2017) reports a long-term positive association between stock returns and exchange rates based on annual data for South Africa from 1979 to 2014. Dahir et al. (2018) analysed the exchange rates-stock returns relationships for Russia, China, Brazil, South Africa and India. A positive relationship between the markets was observed in the medium and long term. Also, Afshan et al. (2018) used wavelet analysis to look into the causality between currency rates and stock prices in Pakistan, finding evidence for powerful coherence and bidirectional causality over a long timescale.

Similarly, when Mattack (2020) used the Toda-Yamamoto technique to determine whether exchange rates and stock prices are causally related, he discovered a bidirectional causality. Xie et al. (2020) used panel linear and nonlinear Granger causality tests with daily data over the period 1998–2019 for twenty-six countries and discovered that stock prices can predict exchange rates, but not vice versa. Second, the findings suggest unidirectional asymmetric causality from currency rates to stock prices and vice versa, but

the evidence is weak. Third, the empirical results of the symmetric panel Granger non-causality tests reveal that stock prices cause exchange rates and vice versa.

To capture the direction of causality, He et al. (2021) applying wavelet analysis claimed a negative correlation and a unidirectional causality running from the Turkish stock market to foreign exchange rates. Živkov et al. (2021) investigated the bidirectional volatility spillover effect between the exchange rate and stock of four African nations' markets using the wavelet, quantile regression and MS-GARCH models. They found evidence of the bidirectional volatility spillover effect. The influence of volatility extends from the exchange rate market to the stock market, and it is felt strongly in all African countries save Nigeria.

The empirical data on the nature of the association between stock prices and exchange rates are similarly inconsistent. Some researchers found evidence of positive correlations between exchange rates and stock returns (Ogbole & Aladejare, 2015; Bala & Hassan, 2018; Megaravalli & Sampagnaro, 2018; Mikhaylov, 2018; Kumar, 2019), while others found evidence of negative correlations (Do et al., 2015; Nkoro & Uko, 2016; Elhendawy, 2017; Delgado et al., 2018; Pole & Cavusoglu, 2021; Aftab et al., 2021; Rai & Garg, 2021).

For six Asian nations, Doong et al. (2005) investigated the dynamic link between stocks and currency rates and their results revealed a strong negative relationship in all countries except Thailand. Adjasi et al. (2008) investigated GSE and foreign exchange markets. The authors found evidence of a negative relationship between the two markets studied. It was also

discovered that a rise in the trade deficit and future predictions reduces stock market volatility, and vice versa. Also, it was noted that an increase in consumer price leads to a rise in stock market volatility.

The results from the research by Delgado et al. (2018) indicated that the exchange rate has a statistically negative and significant effect on the stock market index. This suggests a connection between an increase in the stock market index and an appreciation of the currency rate. Their research employed a Vector Autoregressive Model and included oil, the exchange rate, Mexican stock and the consumer price indexes. Narayan et al. (2020) reported depreciation of the yen against the U.S dollar leads to gains in Japan's stock returns.

Furthermore, Rai and Garg (2021) in their paper examined the influence of COVID-19 on the connectedness and volatility spillovers between stock and currency rates in BRIICS nations. They found significant negative dynamic correlations and volatility spillovers between stock and exchange rates in most BRIICS economies. Ding (2021) came to the conclusion that the relative sensitivity of the stock prices of two countries to the common stock factor determines the connection between exchange rates and stock prices. Particularly when domestic (foreign) stock prices are more sensitive to currency movements, rising US stock prices are linked to the appreciation (depreciation) of the US dollar. Additionally, the strength of the link relied on how closely the stock prices of the two nations were correlated.

Consequentially, Pole and Cavusoglu (2021) also found that exchange rates negatively affect stock returns in Nigeria. According to the paper, the Nigerian Central Bank should implement a deflationary fiscal policy and an

exchange rate stabilisation strategy to narrow the gap between actual and anticipated stock returns on the Nigerian Stock Market. Aftab et al. (2021) investigated the association between currency rate and stock markets for emerging economies in Asia using a novel method that considers exchange rate management. A time-varying negative association was documented. Moreover, in many cases, there was a two-way causality between the variables. India and China had much less of a relationship than the smaller economies such as Singapore, Korea Thailand and the Philippines.

From the above discussion, the diversity of studies shows how important the market for stocks and exchange rates are. The majority of the research conducted in this area focused on developed economies. Understanding how the two markets interact can help investors invest more effectively while assuming the least amount of risk. Furthermore, all of these studies produced distinct outcomes, which varied depending on the macroeconomic factors considered, the research methodology used, and the nations studied. This lack of consensus on the direction and nature of the relationship supports further research into the dynamic link between exchange rates and stock prices in West Africa and arrive at novel insights that will be useful in currency and portfolio risk management

Stock return, Exchange rate, and Uncertainties

Several studies in the literature relate currency, uncertainty and stock markets in discrete contexts, but little is known about how uncertainty indicators such as EPU, OVX, and VIX affect the link between currency rate and different classes of assets, in this case, stock. Other empirical works have also looked at different connections between stock market, exchange rates,

EPU, OVX, and VIX (Jayashankar & Rath, 2017; Juhro & Phan, 2018; Hoque & Zaidi, 2019; Bartsch, 2019; Abid, 2020; etc.).

Christou et al. (2017) investigated the impact of EPU on stock market returns for six nations, based on PVAR model estimates. The impact of the own country's EPU shocks and the US EPU shocks were assessed across the timeframe to account for international uncertainty spillovers. The major findings suggested that rising policy uncertainty has had a detrimental impact on stock market performance over the last decade. Furthermore, when uncertainty spillovers are taken into account, all countries except Australia show a significant negative relationship between stock market returns and US EPU shocks, which could be explained by opportunities that are favorable that investors could gain by investing in the country following a rise in policy uncertainty in the economy.

Similarly, Roubaud and Arouri (2018) add to the existing literature on the consequences of policy uncertainty on the interconnections between exchange rates, oil prices, and stock. They show that there are strong interrelations between stock markets, oil, and currency by implementing a VAR and a multivariate Markov Switching VAR model. Their research found non-linear associations, and that the links between them shift from one period to the next, but that they are stronger during volatile periods. Finally, they claimed that oil plays a significant role in the transmission of price shocks to the exchange rate and stock markets. Only EPU was included in this investigation. Other indices of uncertainty include the OVX, VIX, news-based uncertainty, and so on. This research might also be expanded to include other

developed and developing countries to see how their stock markets and currency rates react to oil prices, policy shocks and uncertainties.

By examining how GEPU affects Malaysian sectoral stock performance, Hoque and Zaidi (2019) contribute to the growing literature. The empirical findings showed that the linear framework fails to detect the effects of GEPU, whereas the Markov switching model showed that GEPU had a significant impact on all sectoral stock returns, except for the technology sector. The data also portrayed that the effects of GEPU differ according to sectors and regime states with adverse consequences outweighing positive outcomes. GEPU has a significant impact on stock returns in an environment that is highly volatile. As a result, the study suggested that GEPU has an asymmetric, non-monotonic, nonlinear, and state-dependent relationship with sectoral stocks in Malaysia. The results also implied that uncertainty about global economic policy might be a systemic risk factor and a predictor of stock market performance.

Albulescu et al. (2019) contributed to the growing literature on the monetary policy of US as a global financial cycle driver by looking at the possible causal effect of US EPU on the comovement between markets for currency and crude oil, using commodity currencies from emerging and advanced economies. A series of nonlinear and linear Granger-based causality tests showed that there is a causal link between policy uncertainty and the connection between oil and currency rate, especially at low frequencies and more so since the global financial crisis erupted. While across all frequency bands crude oil was a net transmitter of currency shocks, the spillover effects from oil primarily focused on the Australian and New Zealand dollars, which

are frequently employed as investment currencies in global trade schemes. An interesting application for future research would be to see whether domestic uncertainty, as compared to global uncertainty, provides an indirect route via which uncertainty can influence oil-currency market interactions. Another area of investigation will be the financial markets together with other indicators of instability.

Conversely, Wen et al. (2019) investigated the correlation of VIX, OVX and EPU with some macroeconomic variables in a nonlinear cointegrating ARDL model in China. Their empirical findings indicated that, except for OVX, there is evidence of a link between the variables. In the long run, the most important in fueling uncertainty in China's macroeconomy seemed to be the VIX. However, EPU and OVX also triggered reactions in the inflation rate, outputs, and supply of cash and influenced uncertainty in the economy. Although investors and policymakers would benefit from this study, it is limited to China and the use of US-based EPU.

Chen et al. (2020) employed Quantile Regression analyses to examine the link between the EPU of various markets and exchange rate volatility in China. The following are the findings: The influence of the EPU on exchange rate volatility was asymmetric. At all quantiles, EPU had a favorable and significant impact, with an inverted-U relationship. There were also heterogeneous effects of EPU from different markets on exchange rate volatility across quantiles. This study used EPU of specific nations rather than global EPU and is limited to China. The economic orientation of this country is different from that of African countries.

By applying the wavelet analysis technique, Das (2021) addressed frequency and time connections between stock, crude oil, and exchange rates. In India, there was evidence of multiple substantial comovements between the price of oil and the stock, as well as between the foreign exchange rate and the price of oil. This means that economic shocks in developed markets have an impact on the Indian market. Das (2021) also discovered a short-term effect of lower-scale volatility. Furthermore, wavelet coherency at a large scale had a slower influence on the relationships over time. This study did not consider other factors such as EPU, OVX, or VIX that can influence how these markets operate.

In the same vein, Shaikh (2020) looked at the commodity, interest rate, equity, and currency markets while taking the US economic policy uncertainty index into account. The empirical findings demonstrated that during times of economic uncertainty, market volatility remains high and favorable. Economic uncertainty is increased by the lack of future economic and political movements, and this uncertainty impacts many market specifics. The research revealed that the unpredictability of future occurrences is reflected in VIX-based volatility metrics in several markets. Asafo-Adjei et al. (2020) explored how global EPU shocks interact with stock returns of eight countries in Africa via the wavelet technique. The results revealed that global EPU correlates with most of the stock returns and was concentrated over a longer period. This indicated that investments in African stocks, in the short-term, are less susceptible to GEPU.

Fasanya et al. (2021) focused on the impact of uncertainty in economic policy in the US on the connectivity of oil and currency pairs that are

frequently traded. First, they discovered a substantial link between crude oil and currency markets, with oil as a net shock receiver. Next, EPU influences the interactions between oil and forex markets. The causality test evidenced that EPU around the median and lower quantiles drives the spillover for each asset. Finally, the importance of US economic policy which affects the financial cycle globally, and leads to changes in capital flows and asset price movements across financial markets, cannot be overstated.

The paper by Aimer (2021) looked at how EPU and VIX impacted exchange rates for the four nations that experienced the most COVID-19 pandemic-related fatalities. The results reveal that the co-integration experiments during the pre-pandemic period indicated a long-term favorable impact of the VIX index on the Brazilian real. The volatility index also had a positive impact on the exchange rates of the Swedish krona and the Indian rupee throughout the pandemic as well as on the Indian rupee prior to and during COVID-19.

In terms of the impact of EPU on exchange rates, Aimer (2021) discovered that while there was no statistically significant impact for the four nations during the pre-pandemic period, there was a positive association between the EPU and the Brazilian reals during the pandemic period. Specifically, the impact of the VIX shock was greater than the EPU shock. Kang et al. (2021) employed time and frequency analysis to study the association among US sector equity ETFs, oil, gold, stocks, and uncertainty indicators. According to the paper, VIX has the most effect on ETFs in the periods studied and OVX comes next. The US EPU had the lowest influence on ETFs, but ETFs showed a stronger association with oil than gold.

Comovements among gold, oil, ETFs, and uncertainty factors exhibited temporal asymmetry and were more pronounced in the short run.

It is clear that there are a lot of studies on the stock return-currency rates nexus, as well as the impact of volatility indices in various scenarios. The only known works to date that mirror this study so far are Albulescu et al. (2019), Shaikh (2020 and Fasanya et al. (2021) in developed states. However, there are still some crucial gaps that the earlier investigations have not yet filled. First, most research on the stock return-exchange rate nexus focuses on causal influence, with little attention paid to their dynamic interconnection in West Africa. Second, various uncertainty indices' impact on stock market and foreign exchange rate markets has yet to be fully investigated in West Africa. Third, is the use of static models.

The current research varies from theirs in two respects. First, the study is conducted in West Africa. Second, after first looking at the dynamic connectivity between stock return and exchange rate, this study uses wavelet techniques to estimate the influence of three uncertainty indices on the relationship between stock return and exchange rates in West Africa. Furthermore, the methodological choice is superior since it takes into consideration both the time horizons of economic decisions as well as the strength of links between the markets and the impact of uncertainty indices on time and frequency variations. In the time-frequency domain, wavelet analyses illustrate a comprehensive comovement between the datasets.

Chapter Summary

The chapter discussed stock return, exchange rates and uncertainties extensively. The chapter was based on the components of the study's

objectives. Several kinds of literature were assessed to obtain diverse views that have been articulated by earlier scholars in the area of study and formulate the hypotheses of this research. Several types of research have been conducted on the exchange rate-stock return, as well as the impact of uncertainties in various scenarios. So far, the only known works to date that mirror this study are Fasanya et al. (2021), Shaikh (2020) and Albulescu et al. (2019) in global setting.

The current research looked at the dynamic connectivity between stock return and exchange rate and uses wavelet techniques to estimate the influence of three uncertainty indices on such a relationship in West Africa. Furthermore, the methodological choice is superior since it takes into consideration both the time horizons of economic decisions, the strength of links between the markets and the impact of uncertainty indices on time and frequency variations.

CHAPTER THREE

RESEARCH METHODS

Introduction

This study sought to investigate the correlation between stock return and exchange rate in West Africa, the impact of uncertainties on that relationship and the interaction among all the variables used by employing wavelet methodology. This section details how the study was fulfilled. It presents the research philosophy, approach and design as well as the research method used. It also covers the description and measurement of variables, procedure for data collection, processing methods and analysis, the specification of the empirical model and ethical considerations. This chapter ends with a chapter summary.

Philosophical Foundations

Research philosophy is a collection of beliefs that drive the design and implementation of a study. Various research philosophies provide distinct perspectives on scientific studies (Tamminen & Poucher, 2020). As a result, every research is informed by the researcher's philosophical foundation in terms of his or her viewpoint on knowledge, values, and the theory underpinning the research, research methodologies, and research goals (Creswell, 2011).

To assist its research operations, business combines several disciplines of study and employs a range of theoretical philosophies borrowed from the social sciences. Positivism and post-positivism are the most popular. However, business is using philosophies linked to the traditions of social constructionism, social phenomenology, interpretivism and social

constructivism to present alternative methods for conducting business research, even though some researchers oppose their use because they believe they are not scientifically rigorous (Jennings, 2005). There is also the pragmatist research philosophy. Essentially, positivism and post-positivism deal with a quantitative methodology while social constructionism, social constructivism, social phenomenology, and interpretivism are associated with a qualitative methodology (Jennings, 2005).

The positivist research paradigm claims that the social world can be objectively understood (Žukauskas et al., 2018). Under this philosophy, knowledge is obtained through observation and measurement of variables (Boateng, 2014). The opposite is the interpretivism philosophy which claims that the social world can be viewed subjectively. According to this ideology, the research is dependent and based on the interest of the one undertaking the research (Žukauskas et al., 2018). The post-positivism view was introduced due to the criticism of the positivism philosophy (Jennings, 2005; Teddlie & Johnson, 2009). According to Gratton and Jones (2014), the post-positivist does not view perception to be a reality, although he/she believes that it is a window to reality where an image of reality can be triangulated with other perceptions. Unlike positivism, post-positivism incorporates mixed methods into the research design (Jennings, 2005).

The focus of social constructionism is on the things that are correct as a result of social interaction. It considers all knowledge, including representations of physical and biological reality, to be constructed (Taylor, 2018). Under the social constructivist perspective, people desire to understand the reality of the work and world. Individuals assign subjective interpretations

to their experiences about specific things or objects. These meanings are multifaceted, diverse and prompt the researcher to concentrate on a variety of views rather than grouping them into few ideas or categories (Creswell & Creswell, 2017). Phenomenology gives researchers a theoretical foundation to comprehend phenomena at the level of subjective reality.

It is a philosophy and methodology that is part of the constructivist/interpretivist paradigm. (Qutoshi, 2018). The origins of social phenomenology can be traced back to Edmund Husserl's intellectual phenomenology (Jennings, 2005). A pragmatist is a person who works with facts. It states that most of the time, the research problem dictates the research philosophy (Žukauskas et al., 2018).

From the preceding discussion, this research aimed to provide explanations and make predictions based on measurable outcomes, hence the positivist philosophy. This study involved collecting data on stock return, exchange rates and uncertainty indices to establish relationships. The direction of the association was determined through statistical analyses that resulted in the hypothesis being rejected or fail to be rejected based on theoretical models. This study is also quantitative.

Research Design

Research design can be conceived of as the structure of a study. It's cohesive that binds all of the research work's components together. It can also be defined as the blueprint within which the research is conducted (Akhtar, 2016; Sekaran & Bougie, 2016). These include descriptive, exploratory and explanatory research designs (Saunders et al., 2009; Akhtar, 2016).

The exploratory study involves finding out what's going on, seeking fresh insights, asking questions, and reassessing phenomena in a new light. Usually used when there is a topic concerning which there is minimal research expertise. The purpose of a descriptive study is to give a detailed portrait of events, situations, or individuals. It is widely used in the natural and physical sciences. Explanatory studies seek to establish causal relationships between variables. The purpose is to gain familiarity in unknown areas. Analysing situations or problems to describe how variables are linked is its focal point (Robson, 2002; Saunders et al., 2009; Akhtar, 2016).

Drawing from the quantitative research approach and positivist paradigm, the explanatory research design is the most appropriate to guide this study. This is because explanatory research is used to establish causal relationships between variables. The explanatory research design was employed to assess the link between stock return and currency rates, the influence of uncertainty indices on such relationships in West Africa and the interactions among the variables.

Research Approach

Three research approaches can be adopted by a study. These are quantitative, qualitative and mixed research approaches. The qualitative study involves the systematic exploration of social processes in natural environments (Teherani et al., 2015). It encompasses intuitive and perceptual experiences that cannot be quantified or appreciated numerically (Creswell, 2013).

Quantitative research is an objective, rigorous, formal, deductive technique and systematic strategy for creating and expanding knowledge to

solve problems (Burns & Grove, 2005; Mohajan, 2020). It explains phenomena by gathering numerically stable precise data that is examined using mathematical procedures, particularly statistics that ask who, where, how many, how much, what, when and how (Creswell, 2011; Mohajan, 2020). In a mixed-method study, data is collected using both qualitative and quantitative data analysis approaches in the same study. This type of study enables a policy researcher to quantitatively describe and qualitatively grasp difficult processes using figures, basic statistical analysis and charts (Creswell, 2011).

This study applied the quantitative research approach. This study dealt with quantities, numerical data, and analysing variables (dependent and independent) to get results with specific statistical models (Apuke, 2017).

Data Sources and Description

This study explains the relationships among stock return, exchange rates and uncertainty indexes in West Africa. Grounded on this premise, monthly data on stock return, exchange rates, and uncertainties were collected. The data were cleaned to remove all unobserved data. The monthly data spanning from March 1st, 2013 to December 1st, 2021 yielding a total of 105 observations was used. The motivation for the period selection (2013-2021) was due to the consistent availability of data for effective comparison. Data on the variables were gleaned from EquityRT for stock return, Yahoo finance for exchange rates. Also, data on the uncertainties utilised in this study was found from the works of Baker et al. (2016) and Investing.com.

Model Specification

The study looks at the interdependence between stock return and currency rates, the influence of uncertainty indices (GEPU, OVX, VIX) on such connection and the interactions among stock return, exchange rate, and the uncertainty indexes in West Africa utilising bi, partial and multiple wavelet techniques.

Model 1

Bi-wavelet

The interconnectedness of stock return and exchange rate in West Africa is examined using the cross-wavelet transform (CWT) methods by Ng and Chan (2012). In the time-frequency region, the CWT explains covariance as shown below

$$N_{xy} = N_x(i,s)N_y^*(i,s) \quad (1)$$

where * denotes a complex conjugate, *x(t)* is stock return and *y(t)* is exchange rate, $N_y^*(i,s)$ and $N_x(i,s)$ reveal the CW of series *y(t)* and *x(t),* in the order given (Torrence & Compo, 1998; Li et al., 2020).

The absolute squared value of normalising a wavelet cross-spectrum to a single wavelet power spectrum is known as Wavelet Transform Coherence (Grinsted et al., 2004). In view of that, the coefficient squared of wavelet is indicated as

$$R^2(x,y) = \frac{\left|\rho(s^{-1}N_{xy}(i,s))\right|^2}{\rho(s^{-1}|N_x(i,s)|^2)\rho(s^{-1}\left|N_y(i,s)\right|^2)} \quad (2)$$

where ρ represents a smoothing element, which equalises significance and resolution, and $0 \leq R_{xy}^2(\acute{\imath}, s) \leq 1$. A score near zero suggests a weak link, whereas a value reaching one indicates an association that is strong.

Model 2

Partial wavelet

The partial wavelet approach displays the level of distortion in the comovements of two variables over frequency and time, rather than focusing on causal linkages. The PWC is used to analyse the correlations between stock returns and currency rates in relation to uncertainty indicators such as the VIX, EPU, and OVX (Frimpong et al., 2021; Huang et al., 2021). This is important in order to determine the extent to which these uncertainty metrics can influence or distort the relationship between stock returns and exchange rates. The PWC can be defined as

$$R_p^2(x,y,z) = \frac{|R(x,y) - R(x,z) \bullet R(x,y)^*|^2}{[1-R(x,z)]^2[1-R(y,z)]^2} \quad (3)$$

where $R_p^2(x,y,z)$ is between 0 to 1. In this research, *x* and *y* denote the stock return and exchange rate while *z* signifies the uncertainty measures. PWC is calculated using Monte Carlo techniques.

Model 3

Wavelet Multiple

Fernández-Macho (2012) defines the Wavelet Multiple Correlation (WMC) denote by $\Omega X(\lambda_j)$ as a set of multiscale coherence computed from Xt below. The roots squared of the regression coefficient of determination (R^2) developed by the linear combination of $w_{ijt}, i = 1, 2, \ldots, n$ variables for

which R^2 is maximum are calculated at each wavelet scale λ_j. Hence WMC is achieved as in Eq. (4)

$$\Omega X(\lambda j) = \left(1 - \frac{1}{max\ diag P_j^{-1}}\right)^{1/2} \quad (4)$$

where Pj represents the (m x m) correlation matrix of W_{jt}

Regarding the regression theory, then the WMC can be expressed as in Eq. (5)

$$\Omega X(\lambda j) = \frac{Corr(w_{ijt}, \widehat{w}_{ijt}) Cov(w_{ijt}, \widehat{w}_{ijt})}{(Var(w_{ijt}) Var(\widehat{w}_{ijt}))^{1/2}} \quad (5)$$

where w_{ij} is selected to maximise $\Omega X(\lambda_j)\ and\ \widehat{w}_{ijt}$ are the regression values fitted of w_{ij} on the other wavelet coefficients at scale λ_j.

The Wavelet Multiple Cross Correlation (WMCC) is produced by permitting a lag τ between fitted and observed figures at each scale λ_j

$$\Omega X, \tau(\lambda_j) = Corr(w_{ijt}, \widehat{w}_{ijt+\tau}) = \frac{Cov(w_{ijt}, \widehat{w}_{ijt+\tau})}{Var(w_{ijt}) Var(\widehat{w}_{ijt+\tau})} \quad (6)$$

where m = 2, WMCC and WMC converge with the standard WCC and WC

From Eq. (6), a nonlinear function of all $m(m - 1)/2$ wavelet correlations of scale λ_j and a steady estimator of WC from the MODWT can be:

$$\widetilde{\Omega} X(\lambda_j) = \left(1 - \frac{1}{maxdiag\ \tilde{P}_j^{-1}}\right)^{1/2} = \frac{Corr(\widetilde{w}_{ijt}, \widehat{\widetilde{w}}_{ijt})\ Cov(\widetilde{w}_{ijt}, \widehat{\widetilde{w}}_{ijt})}{(Var(\widetilde{w}_{ijt}) Var(\widehat{\widetilde{w}}_{ijt}))^{1/2}} \quad (7)$$

where $\widetilde{w}_{ij}$: the regression of the same set of regressors $\{\widetilde{w}_{kj}, k \neq i\}$ maximises the R^2, $\widehat{\widetilde{w}}_{ij}$ signifies conforming fitted values, and $L_j = (2^j - 1)(L - 1)$ is the number of wavelet coefficients influenced by the boundary

conditions associated with wavelet filter of length L and scale λ_j but $\tilde{T} = T - L_j + 1$ is the number of wavelet coefficients not affected by the boundary conditions.

In the same vein, an appropriate estimator of the WMCC can be computed as

$$\widetilde{\Omega}X,\tau(\lambda_j) = \frac{Corr(\tilde{w}_{ijt},\hat{\tilde{w}}_{ijt+\tau})\, Cov(\tilde{w}_{ijt},\hat{\tilde{w}}_{ijt+\tau})}{(Var(\tilde{w}_{ijt})Var(\hat{\tilde{w}}_{ijt+\tau}))^{1/2}} \quad (8)$$

Measurement of Variables

For the study, stock return was measured as the result obtained from investing in the stock market (Willem et al., 2014; Muchiri, 2014). The return of stock markets employed includes the Bourse Régionale des Valeurs Mobilières, Ghana Stock Exchange, and Nigeria Stock Exchange and denominated in US dollars. Cape Verde and Sierra Leone Stock Exchanges were excluded due to their small size (in terms of market capitalisation) and data availability. The real exchange rate was utilised in this study and defined as which is the cost of one US dollar in the local currency of each country. (Owusu Junior et al., 2018). This study used the USD/West African currency exchange rates representing a direct quote. The West African currencies included the Ghana Cedi, Naira and the West African CFA franc. Because it is used as the invoicing currency in international trade, the most important reserve currency in the world, and the currency in which the majority of international commercial transactions are conducted, the US dollar was regarded as the exchange rates currency (Chen et al., 2020). Moreover, the United States has a financial market that is well-established which on a global scale, contributes to the demand for its currency (Owusu Junior et al., 2018). It

has been demonstrated that using common currency returns in related studies is the most effective way to reduce exchange rate noise (Pukthuanthong & Roll, 2009).

The CBOE Volatility Index (VIX) is calculated by averaging the half-quote amounts of a variety of put and call options on the S&P500 index. It yields a measure of continuous thirty-days predicted on stock market volatility in the United States. The VIX index is measured in percentage points and corresponds to the predicted movement of the S&P500 index during the next thirty-day period, which is then annualized (Smales, 2021). This study uses the CBOE VIX index as an indicator that represents a measure of global uncertainty (Andini & Falianty, 2022; Beirne et al., 2022). The CBOE OVX is a volatility index for crude oil markets. The OVX reflects market players' apprehensions about future oil price volatility (Qadan & Nama, 2018). Multiplying two weighted sums of option mid-quote values yields the OVX (Adrangi & Chatrath, 2022).

The GEPU indicator is a weighted average of GDP of national EPU indices for many nations (Baker et al., 2016). GEPU is a risk that has a global effect on stock market and exchange rate fluctuations (Hoque & Zaidi, 2019). Through a reduction in both international and local investor participation, the GEPU annihilates the degree of economic flexibility and financing environment that influence the performance of financial markets (Hoque & Zaidi, 2019). The GEPU has an impact on commodity markets, such as oil, which in turn has an impact on stock and currency markets and economic performance (Kang et al., 2017). The table below summarises the description of the above-mentioned variables.

Table 1: Description of Variables and Source of Data

Variables	Measurement	Source
West Africa Stock market – GSE, NGX, BRVM	1. GSE-CI 2. NSE-ASI 3. BRVM- CI	EquityRT
Exchange Rate	USD/West African currencies 1. USD/GHS 2. USD/NGN 3. USD/XOF	Yahoo Finance
Uncertainties	1. Global EPU: GDP-weighted average of national EPU indices	Baker et al. (2016)
	2. VIX	Investing.com
	3. OVX	

Source: Author's construct (2022)

Data Processing and Analysis

Data of this study were processed using Wavelet with R programming software. The wavelet technique has the advantage of enabling researchers to determine the connectedness and the lead-lag link between/among variables on various time scales (Owusu Junior et al., 2017; Tiwari et al., 2015; Tweneboah, 2019; Tweneboah et al., 2019; He et al., 2021). The data were cleaned to remove all unobserved data. The returns were analysed based on absolute returns calculated as the log difference between monthly of the series as indicated below:

$$L_t = InR_t - InR_{t-1} \qquad (9)$$

where L_t is the natural logarithm of the simple gross return of stock, R_t is the new index and R_{t-1} the old index.

The wavelet techniques are used in analyses of this study. The availability of codes and statistical interpretations for analyses were contained

in the bi-wavelet package provided by Gouhier et al. (2013). For WMCC, to affirm the potential lagging and leading variables, both negative and positive data are needed. Localisations at negative lag indicate the leading variable and lagging variable for positive lag at the respective scales. There is neither leading nor lagging of a variable at the zero-lag of localisation lines (dashed). A scaled variable can lag or lead all of the other variables (Tiwari et al., 2013; Tweneboah et al., 2019).

Chapter Summary

This chapter dealt with the research methods of this study. This included a discussion on research philosophy, design and approach, data collection procedures, model specification, measurement of variables, data processing and analysis and ethical consideration. The study is underpinned by the positivist research philosophy, quantitative and explanatory research approach and design respectively. This study utilised the bivariate, partial and multiple wavelet analysis for research questions of the study respectively.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The purpose of the study was to look into the relationship between West African stock return and exchange rate, the impact of uncertainties on that relationship and the interaction among all the variables used by employing wavelet methodology. This chapter presents the analysis of the data, findings of the research and testing of the hypothesis through the use of the bi, partial and multiple wavelet techniques.

The chapter begins with descriptive statistics of the data used in running the analyses to achieve the research objectives. The main results; the relationship between stock return and exchange rate; the effect of uncertainties (GEPU, OVX, VIX) on the relationship between stock return and exchange rate; and the interactions among the variables are shown after. The chapter ends with a summary of the research findings.

Descriptive Statistics

The price and return data are graphically plotted in Figure 1 for stock return, exchange rates of West Africa and uncertainty indicators. It is analysed that the fluctuations observed depict instability or the high speculative nature of the financial market. However, the returns illustrate stationarity which confirms the stylised fact of time series data.

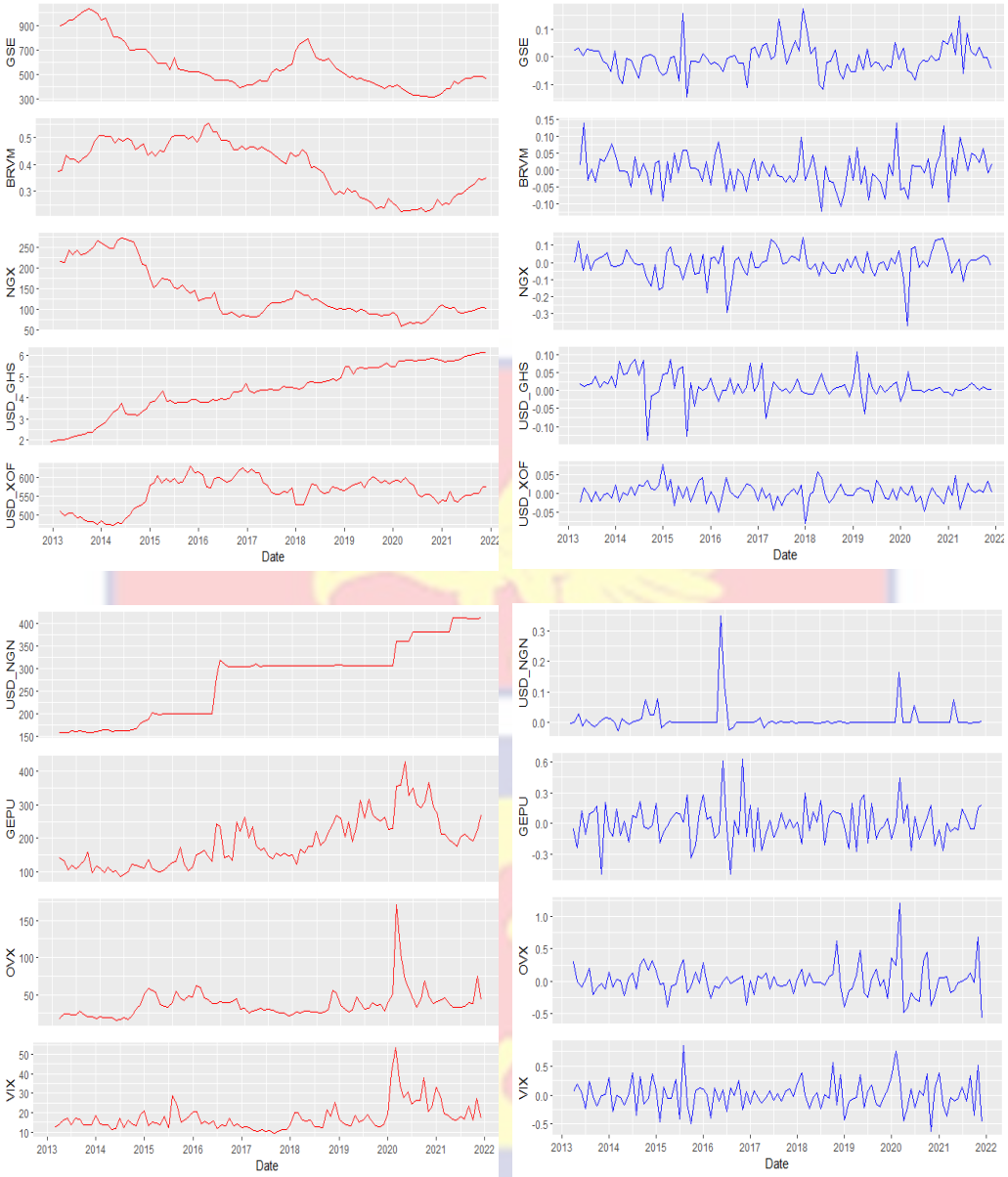


Figure 1: Plots of price and returns series for Stock return, Exchange rates and Uncertainty indicators
Source: Author's construct (2022)

Table 2 shows the descriptive statistics for the variables used in this research. These are stock return (GSE, NGX and BRVM), exchange rates (USD/GHS, USD/NGN, and USD/XOF) and uncertainty indicators (GEPU, OVX, and VIX). The results presented in the tables include mean, skewness, kurtosis, standard deviation and normality test of monthly data spanning from 1st April 2013 to 1st December 2021 yielding a total of 105 observations.

Table 2: Descriptive Statistics

Variable	Mean	Std. Dev.	Skew.	Kurt.	Norm test.	ADF	KPSS
GSE	-0.0062	0.0536	0.6337	1.6667	0.9562***	-3.8129**	0.1465*
BRVM	-0.0006	0.0500	0.2408	0.3804	0.9866	-3.8395**	0.2442*
NGX	-0.0070	0.0800	-1.2495	4.1650	0.9142***	-3.722***	0.1221*
USD/GHS	0.0110	0.0362	-0.7094	3.9978	0.8809***	-5.3869***	0.3719**
USD/NGN	0.0091	0.0417	5.9109	41.4030	0.3590***	-4.6761***	0.0605*
USD/XOF	0.0011	0.0235	-0.1101	1.2628	0.9846	-3.976***	0.1033*
GEPU	0.0061	0.1861	0.3231	1.3658	0.9734**	-6.0143***	0.0527*
OVX	0.0081	0.2433	1.2456	4.8635	0.9188***	-6.597***	0.0441*
VIX	0.0029	0.2550	0.4298	0.8306	0.9772*	-6.4484***	0.0354*

*Levels of significance [***, **, *] suggest significance at 1%, 5% and 10% respectively*
Source: Author's construct (2022)

The exchange rates and uncertainty indices have positive mean returns while that of African stock returns is negative. The USD/NGN has the highest average compared with the rest. VIX has the highest (0.2550) standard deviation while USD/XOF (0.0235) has the lowest. This suggests that a strong indicator of uncertainty in the markets is VIX. All indexes have higher standard deviations than their means, which suggests that these markets are riskier. The NGX, USD/GHS and USD/XOF exhibit left skewness while the rest are skewed to the right indicating an asymmetric distribution.

The kurtosis of NGX, USD/GHS, and USD/NGN analysed shows high peaks and fat tails (leptokurtic) relative to the normal distribution and this suggests non-normality of those distributions. The kurtosis of GSE, BRVM, USD/XOF, GEPU, and VIX is less than 3 which means that these data sets have lighter tails than a normal distribution and lack outliers. They are platykurtic. With the exception of BRVM and USD XOF, the Shapiro-Wilk test of normality rejects the null hypothesis, proving that the distribution is truly non-normal.

The Kwiatkowski-Phillips-Schmidt-Shin test (KPSS test) and Augmented Dickey-Fuller test (ADF test) are the most popular statistical tests used for stationarity tests in a given time series. The ADF and KPSS test results in Table 2 show that the data is stationary at the first difference at the various levels of significance. This means that the statistical properties like variance, mean, covariance and others with time do not vary. According to Kibria et al. (2022), time-series data must be stationary before evaluating the parameters for a model. Furthermore, these findings are consistent with financial time series facts that have been stylised. Also, the magnitudes and directions of skewness differ between the data can infer time-varying dynamics in the series. These features give credence to the use of the frequency-and-time varying wavelet techniques.

The study further shows the unconditional correlation matrix between the stock returns, exchange rates and uncertainty indices in Table 3. This is presented to illustrate the degree and significance of association among the variables under consideration in this study. Through this, the researcher can decipher the averaged level of portfolio diversification as well as volatility

spillover with the uncertainty indices. That is, over the sampled period, the unconditional relationship between the variables is ascertained to infer the extent of portfolio diversification as averred by Agyei et al. (2022).

The unconditional correlation coefficients are presented for the BRVM, GSE, NGX, GEPU, OVX, VIX, USD_GHS USD_NGN and USD_XOF. The direction, as well as the magnitude of the relationship, can be found in Table 2. The p-values of the relationships illustrating the significance of the relationships are also presented for varying levels of significance. This is done to facilitate easy interpretation of the estimates.

Table 3: Unconditional Correlation Matrix

Probability	BRVM	GEPU	GSE	NGX	OVX	USD_GHS	USD_NGN	USD_XOF	VIX
BRVM	1.0000								
GEPU	-0.1814*	1.0000							
	(0.0641)								
GSE	0.1726*	-0.1659*	1.0000						
	(0.0784)	(0.0909)							
NGX	0.2826***	-0.2760***	0.1828*	1.0000					
	(0.0035)	(0.0044)	(0.0620)						
OVX	-0.4039***	0.1624*	0.0144	-0.3547***	1.0000				
	(0.0000)	(0.0979)	(0.8844)	(0.0002)					
USD_GHS	-0.0554	0.0246	-0.3503***	-0.0524	-0.0324	1.0000			
	(0.5744)	(0.8036)	(0.0002)	(0.5954)	(0.7429)				
USD_NGN	-0.0764	0.3473***	-0.0526	-0.6266***	0.1846*	0.0625	1.0000		
	(0.4388)	(0.0003)	(0.5943)	(0.0000)	(0.0593)	(0.5266)			
USD_XOF	-0.3391***	0.0108	-0.2427**	-0.2500**	0.1827*	0.0776	0.0071	1.0000	
	(0.0004)	(0.9127)	(0.0126)	(0.0101)	(0.0621)	(0.4314)	(0.9426)		
VIX	-0.1476	0.0161	0.0094	0.0027	0.4832***	0.0073	-0.0072	0.0825	1.0000
	(0.1331)	(0.8705)	(0.9241)	(0.9782)	(0.0000)	(0.9408)	(0.9423)	(0.4026)	

*Levels of significance [***, **, *] suggest significance at 1%, 5% and 10% respectively*

Source: Author's construct (2022)

From Table 3, it can be seen that the relationship between the variables is mostly negative. It is also clear that all significant relationships with the BRVM are negative which is good for diversification. Additionally, the GSE and NGX depict a significant relationship with GEPU to partly confirm the finding of Asafo-Adjei et al. (2020) when the bi-wavelet technique was utilised. This implies that these stock indices are vulnerable to external uncertainty shocks.

It can further be seen that the exchange rate of the selected countries and their respective stock returns are negative. This shows that exchange rate and stock returns in West Africa are inversely related. This is not startling because, exchange rates from these economies are mostly weaker against the US dollar, and as such, adverse movements may have a ravaging influence on stock returns. In such a case, an increase in exchange rates which means depreciation of the local currency would correspond to a fall in stock returns. Nonetheless, since stock markets of Africa are mostly less developed (Boateng et al., 2021; Asafo-Adjei et al., 2020, etc.) of which the countries under consideration in this study are no exception, volatility transmission from stock returns can also hurt exchange rate. In this sense, both the flow-oriented and stock-oriented models can be manifested in this study depending on the direction of causality from the time and/or frequency approaches adopted for this study.

Results

Research Question 1: What is the relationship between stock return and exchange rate?

The bi-wavelet technique was employed to assess the correlation between stock return and exchange rate. The availability of codes and statistical interpretations for analyses were contained in the bi-wavelet package given by Gouhier et al. (2013). Negative correlations are denoted by left-pointing arrows, whereas positive correlations are shown by right-pointing arrows. The first variable leads with left-pointing arrows and right-pointing arrows downwards and upwards respectively, while the second variable leads with right-pointing arrows downwards and left-pointing arrows upwards (Gouhier et al., 2013; Asafo-Adjei et al., 2021c; He et al., 2021; Boateng et al., 2022).

The colour pallet is given, and the surface colour shows the intensity of the interdependence between the matched series. Those with substantial interactions are shown in red, whereas parts with weaker series correlation are highlighted in blue (Gouhier et al., 2013). The interpretations of the data frequency scales of the wavelet factors are as follows: Scale 0-8 represents the short-term (0-4 months), scale 8-16 is the medium term (4-8 months) and scale 16-32 is the long-term (8-12 months) as similar notations indicated by Asafo-Adjei et al. (2021a) and Boateng et al. (2022).

Figure 2 displays the comovements between stock return and exchange rates using the bi-wavelet technique. As a result, the stock return of three stock markets and exchange rates of three currencies are employed –GSE, NGX,

BRVM and USD/GHS, USD/NGN, USD/XOF respectively. The analysis is presented based on three possible combinations of the variables employed.

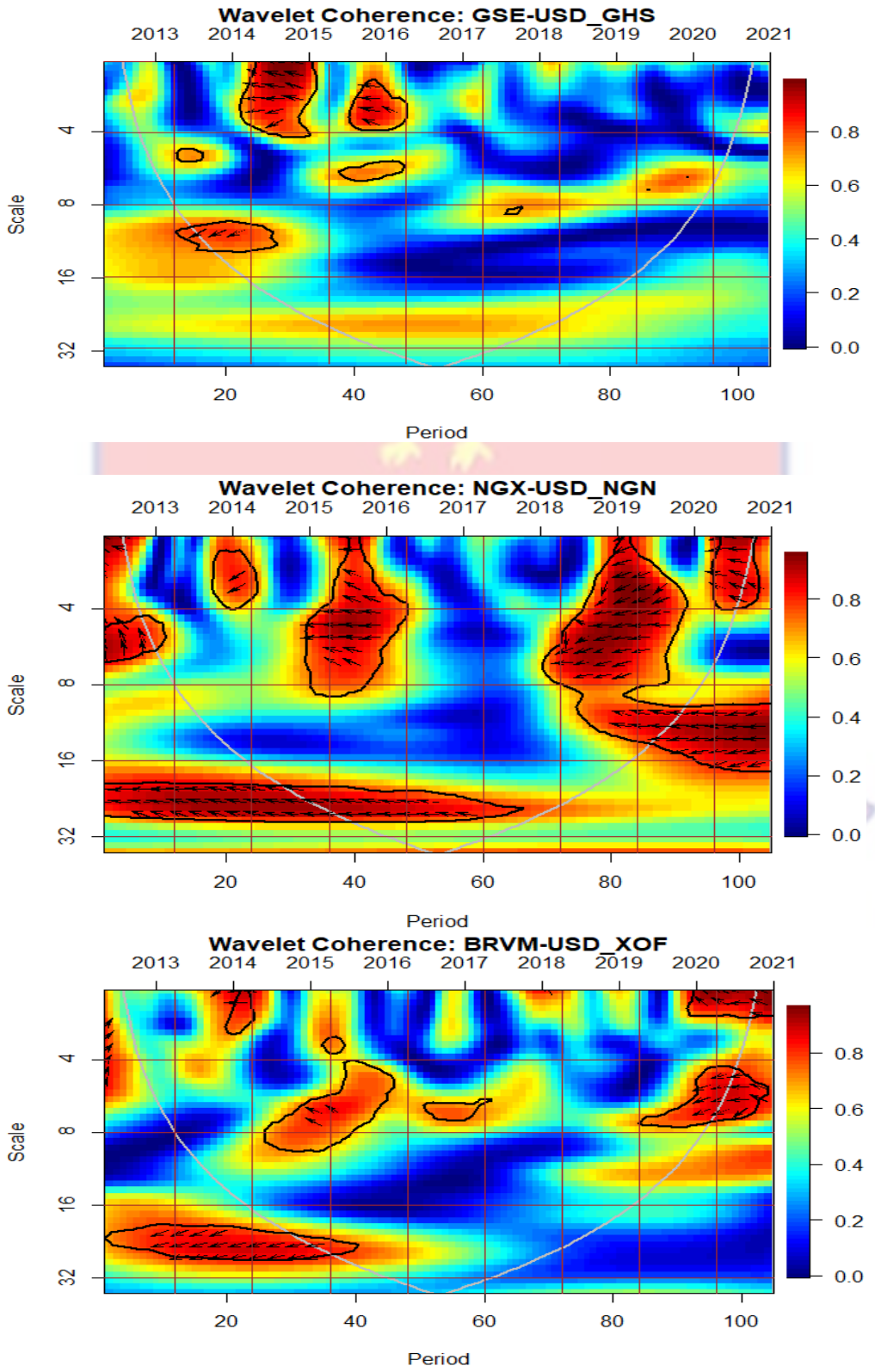


Figure 2: Bi-wavelet between Stock return and Exchange rates
Source: Author's Construct (2022)

A careful look at Figure 2 depicts that there are high comovements between the stock return and currency rates, and are mostly negative throughout the time-frequency as shown by the left-pointing arrows. In the short-term, exchange rates (USD/GHS, USD/NGN) lead at most times as indicated by the left-pointing upwards arrows (2015-2016 and 2013, 2015 to 2016, 2021 respectively). It was also revealed that NGX and BRVM led for the period 2014 and 2019 to 2021. This is at approximately at scale 0-8 months.

In the medium-term, exchange rates (USD/XOF, USD/NGN) lead again for 2015, 2019-2021 respectively (approximately scale 8-16 scale). In 2014, GSE led in the interaction between GSE and USD_GHS. It was observed that there was no evidence of lead-lag relationship between GSE and USD/GHS in the long-run. USD/NGN and BRVM lead in the long-run for 2013 to 2017 at the higher scales of 16 and 32 as revealed by the left arrows pointing upwards and downwards respectively.

From the above, the heterogeneity in the leading or lagging financial market dynamics across time-frequencies explains the HMH and AMH. In addition, the strong and low comovements between stock return and exchange rate in time-frequency domain are illustrative of the AMH (Lo, 2004) and the HMH (Müller et al., 1997). This is because the patterns of interdependencies between the two markets are significantly explained by each other for most time-frequency. Consequently, this may cause an arbitrage where investors can study the pattern of significant comovements to determine their assets allocation and portfolio choices which contradicts the efficient market

hypothesis. However, there were no right-pointing arrows and suggestive of no homogeneous market dynamics of increasing risks or risk transmission.

The intensity of the comovements between the stock return and exchange rates reduce as follows –NGX-USD/NGN, BRVM-USD/XOF and GSE-USD/GHS. Specifically, in the short-run, at approximately 0–8 scales, there is not much to say of the coherency between stock return exchange rates as the comovement is weak specifically from 2017 to 2021 for GSE-USD/GHS, 2017 to 2018 for NGX-USD/NGN and 2016 to 2017 as well as 2019 to 2020 for BRVM-USD/XOF. This renders diversification within these markets practically possible as the correlation between the markets is low. There was evidence of strong correlations among the variables in the short-run too. The periods are 2013-2016, 2019 to 2021 for NGX-USD_NGN, 2014, 2020-2021 for BRVM-USD_XOF and 2014-2016 for GSE-USD_GHS.

At 8-16 scale, the results revealed that from 2019 to 2021, the correlation between NGX and USD_NGN was strong. At the same time scale, it was noted that the relationship between BRVM and USD_XOF and GSE and USD_GHS were strong from 2015 to 2016, and 2020-2021 and 2013 to 2014 respectively. In the long-run, the association was strong for NGX-USD_NGN in 2019 to 2021, for BRVM-USD_XOF from 2015 to 2016, 2020 to 2021, and GSE-USD_GHS from 2014 to 2018. The high comovements between the stock markets (Nigeria and BRVM) and exchange rate between 2019 and 2021 can be ascribed to the significant impact of the COVID-19 on these economies.

This indicates that stock return and currency rates display high uncertainties across different periods and this could imply that uncertainties

lead to a decline in domestic stock returns. This means that investors will be steered away from domestic markets, causing capital outflows to increase and putting upward pressure on exchange rates. Consequently, one market is likely not to transfer or heighten the risk to another market.

Research Question 2: What is the influence of uncertainty indices on the relationship between stock returns and exchange rate in West Africa in time and frequency domain?

Having observed the interactions between stock return and exchange rates, the next is to assess the impact of uncertainties on the connectedness of these markets. Figure 3 provides the influence of uncertainties on the comovements through the partial wavelet. The interpretations of the colour pallet, the surface colour and scales for the data frequency of the wavelet scales have identical connotations to those mentioned earlier in the analysis of bi-wavelet discussions

There are various uncertainty measures the literature offers based on macroeconomic and financial variables and investor sentiment. For this reason, the study employs three uncertainty indices – GEPU, VIX and OVX. The analysis is presented based on 9 possible combinations of stock return and exchange rates. The uncertainty indices are therefore set as controls for each possible combination through the partial wavelet.

It is more intuitive to perform interpretations for each country with regard to the impact of the three uncertainties rather than making comparison across same uncertainties for all countries (Amoako et al., 2022). This is because comparing the impact of same uncertainties for all countries would lack enough basis in the case of diverse country specific exchange rate and

stock returns. Hence, comparisons are made among the uncertainties for each country with similar basis in terms of exchange rate and stock returns nexus following the partial impact of the uncertainties.

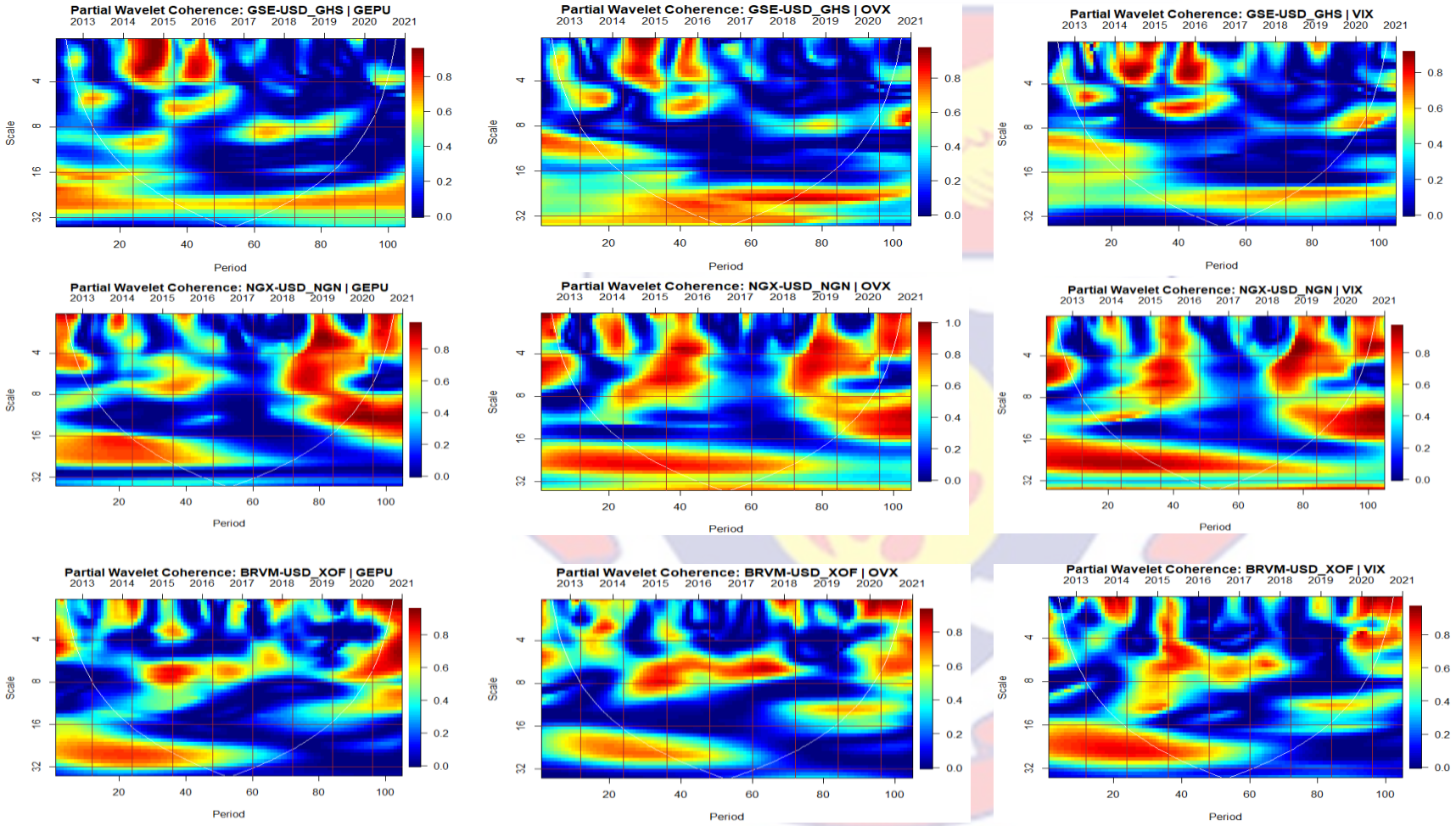


Figure 3: Partial wavelet coherence between Stock return and Exchange rates with Uncertainty measures
Source: Author's Construct (2022)

A significant drop in the strength of the coherence area between stock return and exchange rates in all instances of the partial wavelet coherence indicates that GEPU, OVX, and VIX are key drivers of the comovements of the selected markets. The finding emphasises the importance of uncertainty as a driver of assets prices connectedness across financial markets, following the financial market globalisation.

Specifically, it was found that VIX has the most significant effect on the comovements between stock return and currency rates in Ghana in the long-term. This is because, the VIX is directly related to financial markets, and as a result, shocks from one market cause a contagion to the other, which heightens immediate volatility indices in the financial markets. Consequently, VIX is capable of transmitting more shocks to the financial market as compared to the other uncertainty indices. In addition, in the long-term, OVX has the highest impact on the comovements between the BRVM and USD_XOF correlation. Also, the GEPU has the most impact on the comovements between the NSE and USD_NGX.

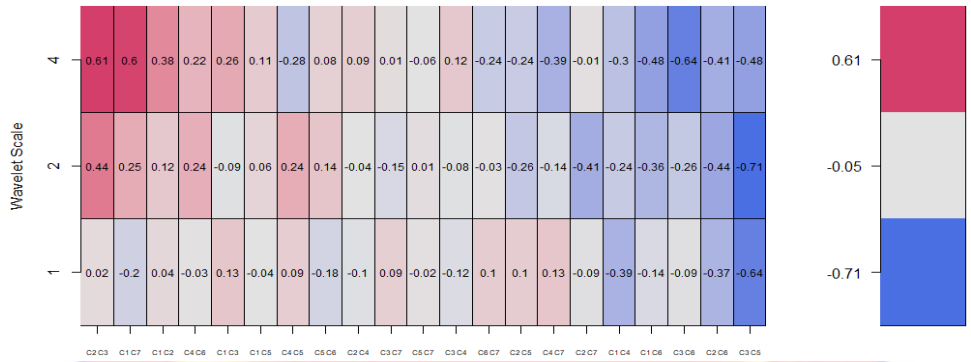
Conversely, in the short to medium run, it can be observed that GEPU has the greatest impact on the comovement between stock returns and currency exchange for all countries. This means that external shocks influence short-term and medium-term investments in most West African economies.

Research Question 3: What is the degree of integration among stock returns, exchange rate and uncertainty indices in West Africa?

The study presents findings based on the wavelet multiple. For this reason, the Bivariate Contemporaneous Correlations (BCC), Wavelet Multiple Cross-Correlations (WMCC) and Wavelet Multiple Correlations (WMC) are utilised in this study. These techniques integrate everything into a single graphic, making it easier to analyse the data.

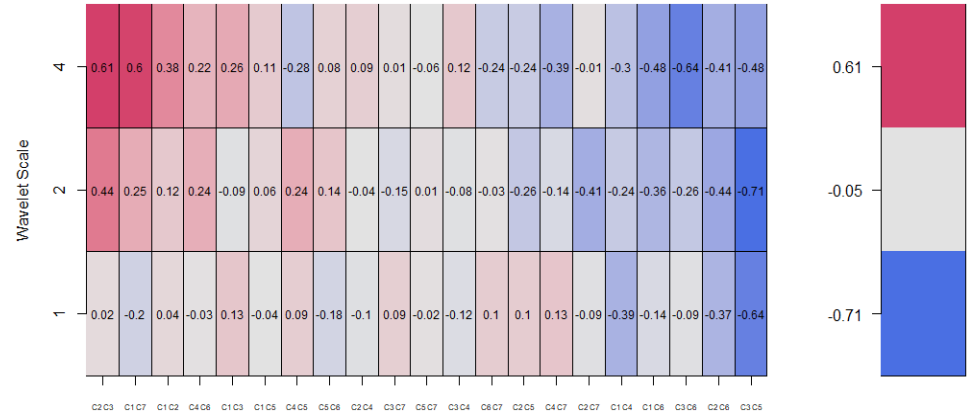
Specifically for the BCC, all six country-specific variables are combined with each uncertainty index to ascertain their bivariate comovements due to the limit of seven variables. The horizontal axis provides the combinations for calculating the correlation coefficients of the wavelet from Figure 4. The commonalities between the pairs of stock return- exchange rates and uncertainty indices nexus weaken as it shifts to the right from the left. The time intervals are represented on the vertical axis of the wavelet scales. The BCC addresses the correlation between the realisations of two possible time series combinations in the same time frame (wavelet scale). Scale 1 represents the short-term (0-4 months), scale 2 is the medium term (4-8 months) and scale 4 is the long-term (8-12 months). At 3 wavelet scales, the BCC is considered. Presented beneath each Figure are the codes for the variables.

Comovement between Stock return-Exchange rate and VIX



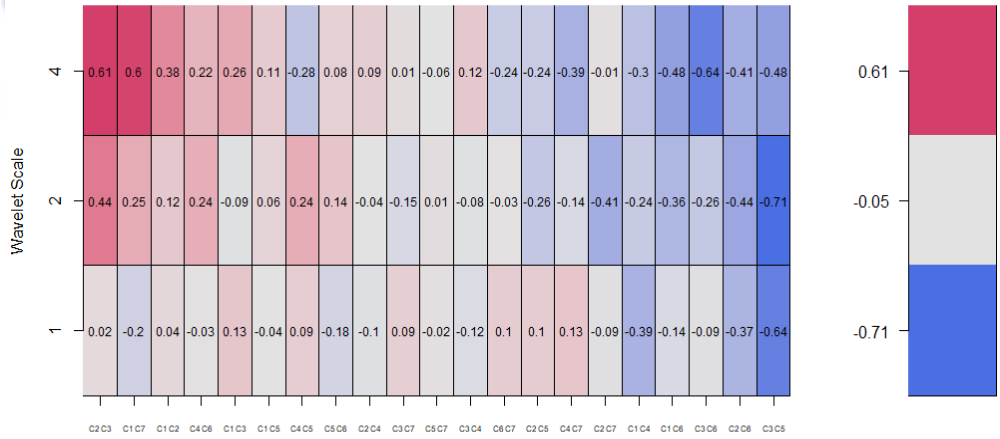
The variables codes are GSE (C1), BRVM (C2), NGX (C3), USD_GHS (C4), USD_NGN (C5), USD_XOF (C6) and VIX (C7)

Comovement between Stock return-Exchange rate and GEPU



The variables codes are GSE (C1), BRVM (C2), NGX (C3), USD_GHS (C4), USD_NGN (C5), USD_XOF (C6) and GEPU (C7)

Comovement between Stock return-Exchange rate and OVX



The variables codes are GSE (C1), BRVM (C2), NGX (C3), USD_GHS (C4), USD_NGN (C5), USD_XOF (C6) and OVX (C7)

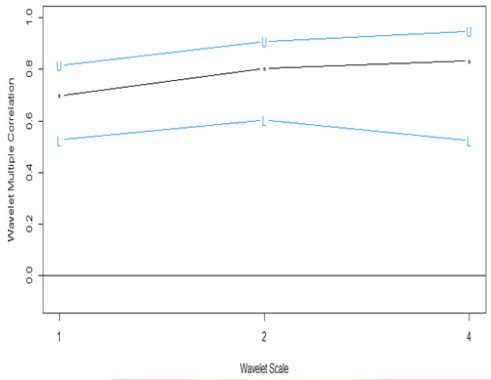
Figure 4: Wavelet bivariate correlations matrix
Source: Author's Construct (2022)

Figure 4 displays the wavelet correlation matrix for each of the three uncertainty indices with stock return-exchange rates across three scales. Specifically, BRVM and NGX indicate the maximum degrees of co-movement with fluctuating coefficients from 0.02 to 0.61 at various time frames with an average of 0.36 demonstrating the presence of moderate correlation figures. Generally, the comovements in the markets are strong. This means that, in all periods, the advantages of portfolio diversification are increased among stock and exchange rate markets. This suggests that a natural-based portfolio has the potential for diversification. Notwithstanding, comovements between the stock return-exchange rate and uncertainty indices are more negative across all the periods. This suggests that GEPU, OVX and VIX drive more uncertainty in the financial market volatilities. Consequently, investors can hedge against financial market volatilities using the uncertainty indices.

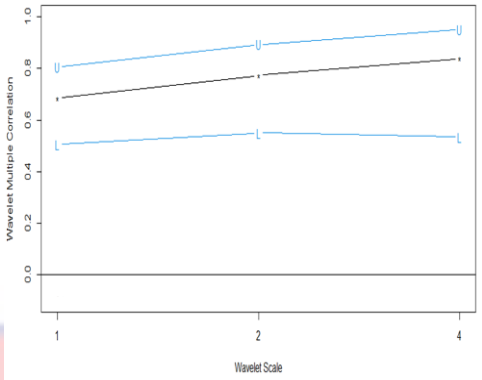
Wavelet Multiple Correlation

The WMC provides a single correlation value to understand the relationship in the system of variables chosen at different frequencies. Table 4 and Figure 5 establish the degree of integration among the variables (stock return, exchange rates and uncertainties). Table 4 and Figure 5 found the level of connection between the variables from the long to the short period dynamics in a continuous manner. It does not necessarily reveal which variable is lagging/leading, but rather how the variables are connected.

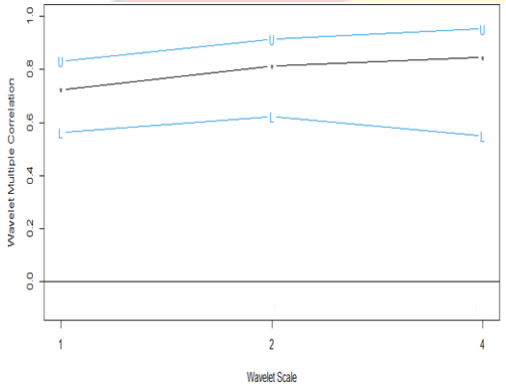
OVX and Stock return-Exchange rate



VIX and Stock return-Exchange rate



GEPU and Stock return-Exchange rate



Overall

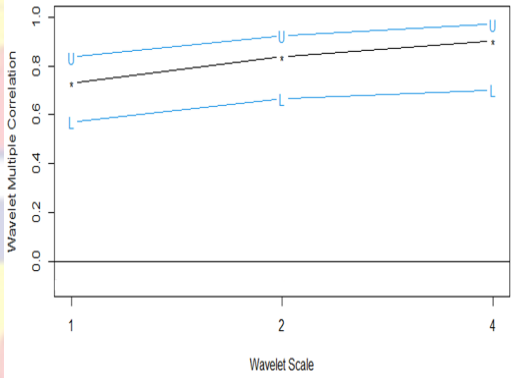


Figure 5: Wavelet multiple correlations between Stock Return-Exchange rate and Uncertainty indices
Source: Author's construct (2022)

The monthly return series has a degree of integration that is relatively high as 0.97. The number of multiple links continues to rise over the horizon. There is a medium-to-high association between the markets throughout the time period. This is because monthly returns in one of these markets may be described to a degree of roughly 97% by the other markets from scale 1 up to scale 4 monthly interdependences in the financial markets and uncertainty indices. It can be inferred that the high integration among the markets is because of the high interconnectedness among the stock return-exchange rate nexus.

Table 4: Wavelet Multiple Correlations

Scale	WMC 'lower'	Correlation	WMC 'upper'	WMC 'lower'	Correlation	WMC 'upper'
	OVX and Stock return-Exchange rate			VIX and Stock return-Exchange rate		
1	0.56874	0.6983	0.8158	0.5060	0.6844	0.8067
2	0.6647	0.8036	0.9083	0.5500	0.7727	0.8928
4	0.7003	0.8337	0.9488	0.5346	0.8386	0.9504
	GEPU and Stock return-Exchange rate			All variables		
1	0.5616	0.7236	0.8322	0.5687	0.7286	0.8354
2	0.6227	0.8138	0.9133	0.6647	0.8366	0.9244
4	0.5504	0.8451	0.9525	0.7003	0.9029	0.9709

Source: Author's construct (2022)

The level of integration for the monthly return series is comparatively high reaching around 0.9029 for the WMC, 0.7003 and 0.9709 for the lower and upper panels respectively at scale four and this increase over the horizon. There is a high level of integration between the markets when short-term to long-term scales are taken into consideration.

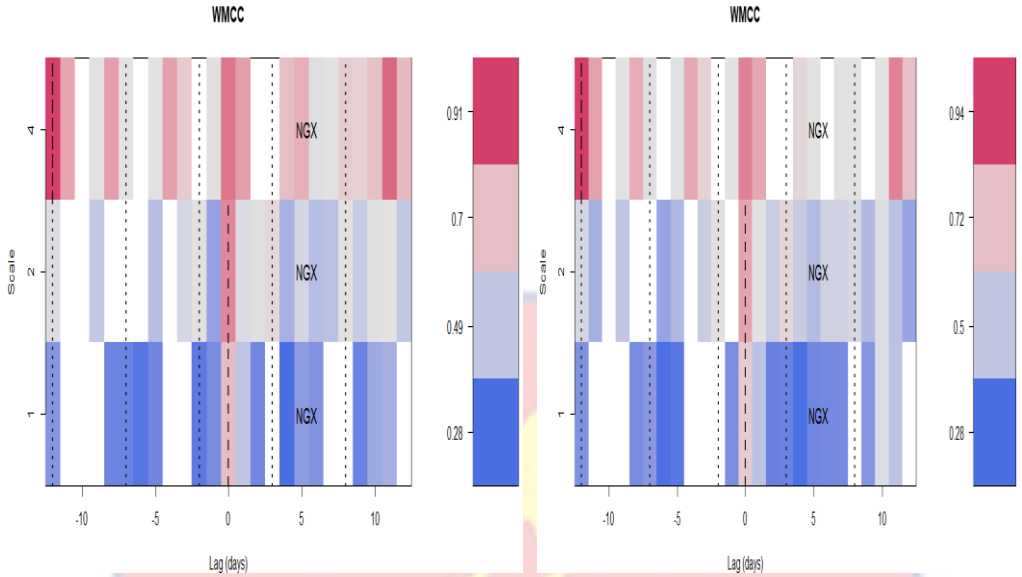
For the specific results, at all scales, the degree of integration between GEPU and stock return-exchange rate is the highest. At scale one, the correlation is 0.7236 with 0.5616 lower and 0.8322 upper panels. At scale two, the correlation is 0.8138 with lower panel of 0.6227 and 0.9133 for the upper panel. On scale four, the correlation is 0.8451 with 0.5504 and 0.9525 for the lower and upper panels respectively. The second highest is the level of integration between OVX and stock return-exchange rate and hence the degree of interaction between VIX and stock return-exchange rate comes last at all scales.

Wavelet Multiple Cross-Correlation

The WMCC indicates the leading or the lagging variables in the system at different lags. Table 5 depicts the WMCC coefficients for three wavelet scales. The scales on the y-axis in Figure 6 have identical connotations to those mentioned earlier in the analysis of wavelet multiple discussions. The x-axis, on the other hand, reflects the series' lag length. In this situation, the positive and negative lags are each 10 days. To affirm the potential lagging and leading variables, we need both negative and positive data. Localisations at negative lag indicate the leading variable and lagging variable for positive lag at the respective scales. No lead or lag occurs at the 0 lag of localisation lines.

Accordingly, WMCC shows the interdependence level among variables and directs the most influential variable at a specified scale to act as a lagging (the variable to react to shocks last after the remaining variables) or leading (mover to respond to shocks first) variable. This is the economic implication of WMCC.

OVX and Stock return-Exchange rate VIX and Stock return-Exchange rate



GEPU and Stock return-Exchange rate Overall

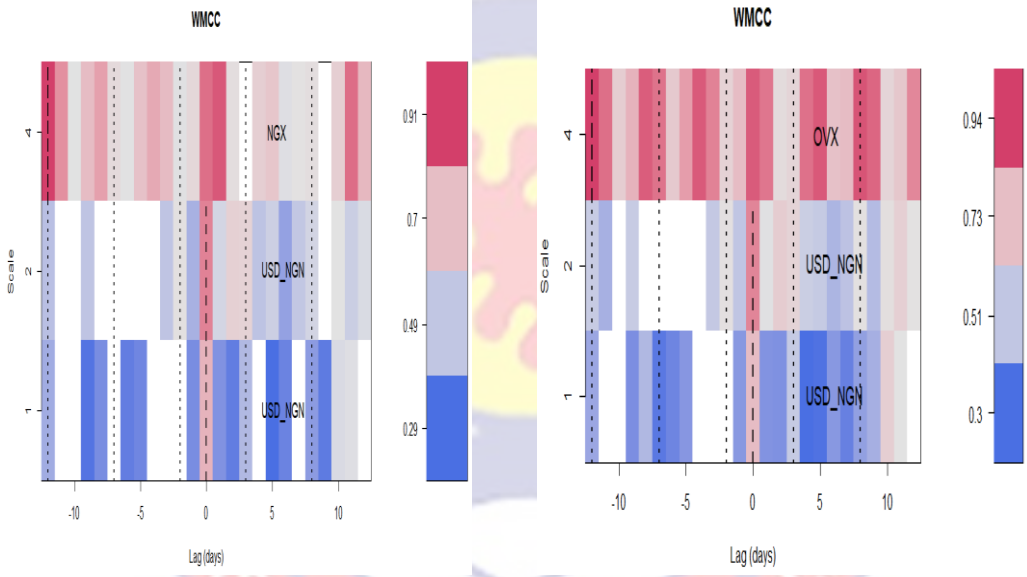


Figure 6: Wavelet multiple cross-correlations between Stock Return-Exchange rate and Uncertainty measures
Source: Author's construct (2022)

From Figure 6, NGX maximises the MCC from a linear combination of the other markets at most scales. This is followed by USD_NGN in the short to medium-terms and lastly by OVX in the long run. NGX, UDS_NGN and OVX possess the capacity to lag or lead the remaining markets. In

addition to this, NGX leads the markets in the long period for the interdependencies between stock return-exchange rate and VIX, OVX and GEPU but for all the variables, it is OVX. This signifies that in the long-term, NGX leads all the remaining 7 markets, and it is considered the first to respond to shocks. Aside from OVX, none of the uncertainty indices has the potential to lag or lead. This supports the argument made by Owusu Junior et al. (2021a) that when there are strong interdependencies among markets, it is difficult for uncertainties to permeate among the highly interconnected markets. But the adverse impact of these uncertainty indices on the commodities may become stronger and severe, with successful penetration as revealed from the bivariate case.

Table 5 shows the results of the WMCC coefficient which is the same as the results in figure 6. The table displays the scale, localisation, time lag, and lead or lag variable.

Table 5: Wavelet Multiple Cross-Correlations

Scale	Localizations	Time Lag (days)	Leading/ Lagging variables	Localizations	Time Lag (days)	Leading/Lagging variables
	GEPU and Stock return-Exchange rate			OVX and Stock return-Exchange rate		
1	0.7236	0	USD_NGN	0.6983	0	NGX
2	0.8138	0	USD_NGN	0.8036	0	NGX
4	0.9103	-12.5	NGX	0.9076	-12.5	NGX
	VIX and Stock return-Exchange rate			ALL nine variables		
1	0.6844	0	NGX	0.7286	0	USD_NGN
2	0.7727	0	NGX	0.8366	0	USD_NGN
4	0.9384	-12.5	NGX	0.9401	-12.5	OVX

Source: Author's construct (2022)

The USD_NGN maximises, from a linear combination of uncertainties with stock return-exchange rate, the multiple cross-correlations at one to two scale representing a short-medium co-movement from the table above. The higher degree of integration for NGX in the medium-run comovements with other variables contradicts Tweneboah et al. (2019), who found that Ghana led the comovements at the highest scale.

Furthermore, Nigeria exchange rate market can lead or lag specifically at scales one and two for the overall results and the relationship between GEPU and stock return-exchange rates at time 0. It features in the dynamics of the short and medium terms, which makes it the first mover in responding to shocks among the selected markets in West Africa concerning financial market. OVX leads the market at scale 4 (negative lag).

The Nigeria stock market has the potential to lead or lag (at time zero) at scales one and two for the relationship between VIX and stock return-exchange rate and OVX and stock return-exchange rate. It also has the potential to lead (negative lag) at scale four for all the relationships tested. This provides reasonable evidence to suggest that on average, uncertainties cannot drive the financial market when there are strong interdependencies among markets (Owusu Junior et al., 2021b).

Discussion of Results

The relationship between stock return and exchange rate

It was found that high comovements exist between stock returns and exchange rate in West Africa economies. The comovements were all found to be negative suggesting the adverse nexus between stock and exchange rate for all economies. Hence, an increase in exchange rate in West Africa corresponds

to a fall in stock returns. The increase in exchange rate in this case signifies a depreciation of the domestic currency because of the utilisation of a direct quote in this study. This finding, therefore, supports the view that the depreciation of the West African currencies against the USD decreases the returns of stock market. A negative correlation between these two markets empirically indicates a drop in corporate revenues and profits following a depreciation in the exchange rate. This is not surprising because of the exposure of the dominant firms in the indices to exchange rate risk regarding their dominant role as net importers (Pole & Cavusoglu, 2021; Ding, 2021; Živkov et al., 2021).

Businesses may employ hedging procedures to protect their overseas trade in this situation. Domestic enterprises that do not trade worldwide may need to improve their efficiency to compete in local markets with their foreign counterparts. These connections may be important to policymakers to maintain financial stability. A bidirectional relationship was found between the two financial markets at various investment horizons highlighting the fact that each economic indicator drives the other at certainty time and frequency recognising the role of the flow-oriented model and stock-oriented model. Consequently, the study divulged that the nexus between stock and exchange rate markets is frequency-dependent.

The outcome from the causal impact of exchange rate on stock returns is in line with the flow-oriented model. Accordingly, the study rather revealed a negative impact of exchange rate on stock returns. Moreover, stock returns were found to influence exchange rate adversely in economies of West Africa at certain times and frequencies. The outcome of negative impact of stock

returns on exchange rate accentuates the stock-oriented model. Notwithstanding, it was found that exchange rate led the relationship most of the time highlighting the dominance of the flow-oriented model in this study.

This finding is in line with studies like Do et al. (2015), Afshan et al. (2018), Emenike (2018), Mattack (2020), Živkov et al. (2020), Živkov et al. (2021). Though in different settings and using different techniques, these works found a bidirectional relationship. The result of this study is also consistent with the results of He et al. (2021) that claimed that the relationship between the stock market of Turkey and foreign exchange is negative. Additionally, similar to this study include the results of Rai and Garg (2021) who observed strong negative dynamic correlations and volatility spillovers between stock and exchange returns. Also, these findings match those of Lou and Luo (2018), Cavusoglu et al. (2019), Kallianiotis (2021), Pole and Cavusoglu (2021), Aftab et al. (2021) among others. These studies found an inverse relationship between stock return and exchange rates. The current study departs from the outcomes obtained by Boako et al. (2016), Abiola and Olusegun (2017), He et al. (2021), etc. who found a unidirectional relationship.

The study also revealed the significant impact of crises, especially, the aftermath of Eurozone crisis and COVID-19 pandemic on the nexus between stock returns and exchange rates in most economies in West Africa. This indicates that returns behavior of these markets in West Africa mostly responds to serious economic events.

The findings provided by this study have implications for investors of stock markets in West Africa. The inverse causality to stock returns from

exchange rate in West Africa informs investors that a rise in exchange rate has a detrimental impact on their portfolio including stock returns from West Africa across diverse investment horizons. Policymakers and governments must fine-tune their policies on exchange rate in West Africa to have a positive effect on stock market returns (Lin, 2012). Nonetheless, investors who seek to hedge against fluctuations in stock returns can do so using exchange rate of these economies (Manasseh et al., 2019). In this regard, especially, during serious economic events, a portfolio with stock and a reliable currency rate market from these economies would induce safe haven potential.

The influence of uncertainties on the relationship between stock return and exchange rate

It was revealed that VIX has the most significant impact on the comovements between stock returns and exchange rates in Ghana in the long-term. As a result, VIX can effectively capture long-term fluctuations in the markets. Kang et al. (2021) reported a similar result in a different setting. Speculative investors in the Ghanaian economy are therefore advised to hedge against changes in the financial markets using the US VIX. Similarly, in the long run, OVX has the most significant impact on the comovements between BRVM and USD_XOF. This implies that crude oil volatility has a pass-through effect on the stock return and exchange rate nexus for BRVM economies.

It is necessary that speculative investors of BRVM monitor the dynamics of crude oil implied volatility to minimise their investment risk. They can do so by hedging against adverse fluctuations in the OVX market.

Also, the GEPU has the most impact on the comovements between NGX and USD_NGN. Policymakers of Nigeria should deploy appropriate country-level policies to minimise external policy uncertainty shocks in the long-term for speculative investors to enjoy potential diversification benefits (Asafo-Adjei et al., 2020).

On the other hand, in the short to medium period, GEPU had the most significant impact on the comovements between stock returns and exchange rate for all markets of countries studied. This implies that external policy uncertainty shocks influence short-term and medium-term investments in most West African economies. Policymakers and governments of the West African economies should arrange policies that mitigate the impact of GEPU on economic activities short and medium frequencies.

The significant impact of GEPU on the nexus between stock returns and exchange rate partly supports the outcome of Albulescu et al. (2019). Albulescu et al. revealed that the financial market is connected dynamically, and policy-induced uncertainties play a crucial role in driving this interaction. Even though their nonlinear causality techniques are different from the one explored in this study, the results do not differ. This suggests that economic policy uncertainty has a significant impact on financial market interactions.

The integration among stock returns, exchange rates and uncertainty indices in West Africa

The study found that integration among GSE, NGX, BRVM, USD_GHS, USD_NGN, and USD_XOF increases in the long-term amid implied volatility indices. This indicates that economic fundamentals in West Africa are highly connected restricting the unfavourable impact of external

shocks. This supports the findings obtained by Owusu Junior et al. (2021a) on the less tendency for the US VIX to drive the highly integrated BRICS economics when the WMCC was estimated.

From the current study, OVX and VIX could not drive or alter the dynamics of the current existing integration in the WMCC estimations. At that point, the Nigerian stock market was dominant depicting high financial market development (Doguwa et al., 2014; Adekoya & Kofi Nti, 2020) relative to other West African economies. The outcome of this work explains the immunity of the highly integrated returns of stock and exchange rates to shocks from OVX and VIX in West Africa. However, the dynamics changed when the GEPU was considered. This implies that shocks from GEPU hit West African economies differently relative to the analogous impact of OVX and VIX on these economies.

Consequently, the adverse impact from all implied volatility indices within the system of connectedness had OVX driving the West African economy in the long-term. This implies that when the West African economy is hit by diverse forms of uncertainty index, at least one uncertainty index could emerge to drive the dynamics of both markets. In this sense, OVX is the first variable to respond to shocks but transmits speculative bubbles to the rest of the markets in the long period. One surprising outcome of this study is the tendency for the Nigerian exchange rate to have the potential to either drive or lag all other variables in the short and medium periods in the presence of GEPU. As a result, the short-term and medium-term impact of GEPU on stock returns and exchange rate in West Africa as found from the partial wavelet has the Nigerian exchange rate responding to or transmitting significant shocks to

all other West African economies. In this case, the exchange rate from Nigeria becomes dominant, hindering the highly developed stock markets.

Chapter Summary

The descriptive analyses for stock return, uncertainties and exchange rate were reported in this chapter. The descriptive analyses revealed that, on average, USD/NGN had the most mean return than the others. The test of normality using Shapiro-Wilk, except for BRVM and USD_XOF, showed that the distribution is not normal. The hypotheses of the study were tested through the bi, partial and multiple wavelet techniques. The results from the bi wavelet depicted that there were high comovements between the stock return and currency rates, and were negative throughout the time-frequency shown by the left-pointing arrows.

The partial wavelet coherence results indicated that uncertainties such as GEPU, OVX, and VIX are key drivers of the comovements of the selected markets. The study found that integration among stock returns and exchange rates in West African economies increases in the long-term amid implied volatility indices through the multiple wavelet methodology.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The section presents the summary, conclusions and recommendations of the study in line with the identified findings on stock returns and exchange rates in light of three uncertainty indices. The uncertainty indices include GEPU, OVX and VIX. A summary of the research process and the key findings are provided as well. This is followed by conclusions and recommendations in line with the findings of the study and suggestions for further studies.

The study examined the influence of uncertainties on the relationship between stock returns and exchange rates in West Africa. Hence, time and frequency as well as frequency-dependent techniques were employed to reveal the level of market inefficiencies. The study was supported by the following research objectives:

1. Examine the relationship between stock returns and exchange rates in West Africa in time and frequency domain.
2. Investigate the influence of uncertainty indices on the relationship between stock returns and exchange rates in West Africa in time and frequency domain.
3. Assess the degree of integration among stock returns, exchange rates and uncertainty indices in West Africa.

Summary of Findings

The first objective looked at the association between stock return and exchange rate. High negative comovements between the stock return and

currency rates throughout the time-frequency were recorded. A bidirectional relationship was found between the stock market returns and exchange rate recognising the role of the flow-oriented model and stock-oriented model. The outcome from the impact of exchange rate on stock returns was in line with the flow-oriented model. Also, stock returns were found to influence exchange rate adversely in economies of West Africa at certain times and frequencies. This outcome on the leading role of stock market returns accentuates the stock-oriented model. Notwithstanding, it was found that exchange rate led the relationship most of the time highlighting the dominance of the flow-oriented model.

The second objective explored the influence of three uncertainties on the relationship between returns of stock and exchange rate. In all cases for the partial wavelet coherence, the strength of the coherence area decreases between stock return and exchange rates**.** In the long-term, it was found that VIX has the greatest effect on the comovements between stock return and currency rates in Ghana and OVX had the most significant impact in BRVM. Also, GEPU had the most impact on the comovements between the stock returns and exchange rates in Nigeria. Conversely, it was clear that GEPU had the highest impact on the comovements between stock returns and exchange rates for all countries in the short to medium term.

The last objective examined the interactions among all the variables and revealed that the integration among exchange rates and stock returns in West African economies increases in the long-term amid implied volatility indices. It was found that OVX and VIX could not drive or alter the dynamics

of the current existing integration in the WMCC estimations. The Nigerian stock market was the dominant depicting high financial market development.

However, the dynamics changed when the GEPU was considered. This implies that shocks from GEPU hit West African economies differently relative to the analogous impact of OVX and VIX on these economies. One surprising outcome from this study is the tendency for the Nigerian exchange rate to have a propensity to either lag or lead all others in the short and medium-term in the presence of GEPU.

Conclusions

The following conclusions are derived from the study's findings:

From objective one, the relationship between stock return and exchange rate can be concluded that is negative. The outcome of the causal impact of exchange rate on stock returns follows the flow-oriented model.

It can be concluded from objective two that, VIX, OVX and GEPU are capable of transmitting shocks to the stock return and exchange rate nexus. VIX had the greatest effect on the comovements between stock return and currency rates in Ghana, OVX in BRVM and GEPU in Nigeria. Conversely, the GEPU impacts on the comovements between stock returns and exchange rates were the highest for all countries in the short to medium term.

From objective three, it is concluded that the integration among stock returns and exchange rates in West African economies increases in the long-term amid implied volatility indices. This indicated that economic fundamentals in West Africa are highly connected restricting the adverse impact of external shocks.

Recommendations

The following recommendations are provided based on the findings of the study:

Investors who seek to hedge against fluctuations in stock returns can do so using exchange rate from these economies across investment horizons. In this regard, especially, during serious economic events, a portfolio with stock returns and a reliable exchange rate market from these economies would induce safe haven potential.

Speculative investors in the Ghanaian economy are advised to hedge against changes in stock returns and exchange rate using the US VIX in the long-term. Speculative investors of BRVM should monitor the dynamics of crude oil implied volatility to minimise their investment risk. They can do so by hedging against adverse fluctuations in the OVX market. Policymakers of Nigeria should deploy appropriate country-level policies to minimise external policy uncertainty shocks in the long-term for speculative investors to enjoy potential diversification benefits.

Considering the high economic integration among the macroeconomic variables indicated by the wavelet multiple, it is advisable that inclusive integration policies are geared towards convergence in the West African region to promote each member's comparative advantage. Moreover, an effective monetary union would be worthwhile if the West African region introduce policies to consolidate the economic union, structural policies for transformation and the creation of value, harmonization of fiscal policies, and financial system unification.

Suggestions for Further Studies

It will be fascinating to follow up on this research by looking into the role of uncertainty indexes on other instruments in the financial market such as bonds, cryptocurrency, commodities, etc., and for different regions or countries as well. Other uncertainties such as news-based uncertainty, currency volatilities, cryptocurrency volatility index, volatility index for the energy sector, gold miners based volatility index, developed market volatility index, volatility index based on the US treasury, etc. could be explored too.

Furthermore, there are several measures for stock and foreign exchange markets denominated in other currencies aside the US dollars. For example, the nominal exchange rate could be employed. Other currencies such as pounds, euros, etc. could be looked at.

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