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Seasonality Effects, Stock Exchange and Foreign Exchange Markets: Comparative Analysis of Volatility Behavior During Covid-19

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study investigated the effects of seasonality on stock exchange and foreign exchange markets of two WAMZ and two BRICS countries which include Nigeria, Ghana, and Brazil and China. The Auto Regressive Integrated Moving Average (ARIMA) regression approach and the Markov-regime switching methodologies were executed. The parsimonious ARIMA estimates reported Nigeria's stock returns demonstrated lower volatility (SIGMASQ = 0.000141) than Ghana's stock returns (SIGMASQ = 0.004003). Similarly, Nigeria had a lower returns volatility than Ghana (SIGMASQ = 0.001829 < 0.07727) in the foreign exchange market of their respective local currencies in relation to the US dollar during the covid-19 era. Comparatively, Nigeria's stock and foreign exchange market performance showed lower returns volatility behaviour than Ghana's markets during the covid-19 period. Brazil's stock returns and the foreign exchange market return on the Brazilian Real

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had higher volatility compared to the Chinese stock market returns and the return on the Chinese Yuan exchange rate vis-à-vis the US dollar during the covid-19 era. Comparatively, Brazil's stock and foreign exchange performance showed higher returns volatility behaviour than China during the covid-19 period. The ARIMA estimates were upheld by the Markov-switching regression results which reveal highest volatility effect of the foreign exchange market in Ghana and Brazil. Ghana's stock market volatility reverted more quickly than that of Nigeria, while in the second and third regimes, volatility of the Nigeria's stock exchange reverted more speedily than that of Ghana. The Markov estimates also reveals that China had more time than Brazil for stock market volatility to be repaired in the first regime, 40.43 months as against 36.77 months but a much lower time for China's stock volatility to be restored in the second and third regimes, during and after the covid-19 pandemic. The expected durations in the regimes for the Brazilian forex market are 40.96, 47.98, and 33.99 months compared to 29.78, 27.55, and 21.65 months in the first, second, and third regimes. The study thus established that volatility on the returns of the Brazilian foreign exchange market before, during, and after the covid-19 pandemic takes longer time to die off unlike in the case of China's forex market. The empirical findings validate the significance of the business cycle theory in these markets. Accordingly, our findings explicate the presence of sizable effects of cyclical swings on the stock and foreign exchange markets of Ghana, and Brazil compared to that of Nigeria and China respectively.

Keywords: Stock market; foreign exchange market; volatility; returns; ARIMA; markov-switching regression; Nigeria; Ghana; Brazil; China.

JEL Classification: A20, B32, C26.

1. INTRODUCTION

Several scholarly researches have analyzed the past patterns in the foreign exchange rate and stock exchange price, specifically focusing on the short-term equilibrium trend [1,2]. They also investigated the effects of foreign exchange dynamics on global investment and finance [3, 4]. Recent researches have compared data from rich and developing nations affected by the COVID-19 pandemic in order to assess the effects of seasonality on stock exchange and foreign exchange markets using wavelet coherence and partial wavelet coherence [5,6]. Additionally, some studies included heteroskedastic modeling, like EGARCH [7]. To date, the researcher is aware of no study that analyzed data from ARIMA and Markov regime switching modeling in COVID-19-affected BRICS developed and WAMZ developing nations in order to investigate the seasonality's influence on foreign exchange and stock markets. This empirical investigation aimed to bridge this knowledge gap. The phenomenon known as *seasonality* describes how particular patterns or trends emerge at particular periods of the year. Adaramola & Adekanmbi [8] have observed that seasonal variations may impact the performance of stock exchange and foreign currency markets. Their findings are consistent with this phenomenon. The January impact is one of the main consequences of the seasonal influence on stock exchange markets. According to this impact, stock prices often increase in January after the December year-end sell-off. The repurchase of equities by investors for tax purposes in December is said to be the driving force behind this phenomenon. As a result, the stock market typically performs well in January. [9]. Another aspect of the seasonal impact on stock exchange prices is the summertime blues. This speaks to the summertime trend of stock markets doing worse, particularly in August [10]. This is due to lower transaction volumes and decreased investor participation throughout the summer. As a result, during the summer, stock values can be more volatile and subject to negative pressure [9].

In the foreign exchange market, seasonality can also play a role in influencing currency movements. Seasonal factors like mining or agricultural cycles have influenced the performance of currencies like the Australian dollar, New Zealand dollar (NZD), and Ghanaian Cedi. Similar to this, seasonal patterns in travel activity may have an effect on the performance of currencies that depend on tourism, such as the Pound Sterling, Swiss franc or the Euro. Interest rate differences, central bank policies, and the release of economic data are just a few of the variables that might impact the seasonal effect in foreign exchange markets. During some periods of the year, such as around significant economic events or geopolitical developments, these factors lead to heightened volatility. For instance, the market could be more volatile before significant central bank meetings or around year-end holidays. The foregoing can lead to significant fluctuations in currency values and trading volumes during these periods. In the West African Monetary Zone (WAMZ), seasonal patterns have been observed in both stock and foreign exchange markets. Researchers have found that these patterns can be attributed to a variety of factors, including macroeconomic indicators, investor behavior, and the traditional calendar cycles of holidays and festivals in the region [8,11]. An empirical investigation of these seasonal trends can provide investors with valuable insights and opportunities for profit in the WAMZ markets. In the stock markets of the WAMZ countries, seasonal patterns have been observed to coincide with macroeconomic factors such as earnings reports and announcements, as well as market sentiment and investor behaviour [12]. Studies have shown that stock prices tend to rally before major holidays or festivals in the region, as investors anticipate increased consumer spending and economic activities during these times [9,11]. Additionally, some sectors such as tourism and hospitality may experience seasonal fluctuations in stock prices based on the peak tourist seasons in the region [13]. In the foreign exchange markets of the WAMZ, seasonal patterns can also be attributed to a variety of factors, including interest rate differentials, trade balances, and geopolitical events [9]. For instance, some currencies may exhibit seasonal trends based on the timing of agricultural harvests or the fluctuations in commodity prices in the region. Moreover, central bank policies and interventions can also impact foreign exchange rates, leading to seasonal trends in currency pairs involving WAMZ countries [8]. By analyzing these seasonal patterns, investors and traders can develop strategies to capitalize on these trends and maximize profits in the WAMZ foreign exchange markets.

In the context of stock and foreign exchange markets in BRICS countries (Brazil, Russia, India, China, and South Africa), seasonality plays a significant role in influencing market performance. Studies have shown that certain times of the year exhibit higher levels of market activity and volatility, which impacted trading investment decisions [14,12]. Understanding these seasonal patterns is important for investors and traders looking to navigate the fluctuations of the stock and foreign exchange markets in BRICS countries effectively. In stock markets, seasonal trends can be attributed to a variety of factors such as corporate earnings releases, economic data announcements, and geopolitical events [10]. In BRICS countries, stock market performance tends to be influenced by sector-specific events, government policies, and global economic conditions. The Indian stock market is known to experience increased volatility during the festival season, as investor sentiment is typically driven by consumer spending patterns and market liquidity. Similarly, the Russian stock market may exhibit seasonal fluctuations due to fluctuations in commodity prices and geopolitical tensions. Also, foreign exchange market participants in BRICS have witnessed seasonal trends related to capital flows, export-import activities, and currency intervention by central banks [10]. For instance, the Brazilian real had been affected by seasonal fluctuations in response to changes in commodity prices and domestic economic conditions. Understanding these seasonal patterns can help traders and investors in BRICS countries to develop more effective trading strategies and make informed decisions based on market trends and insights.

The following research questions served as the study's direction: What impact does seasonality have on stock exchanges in developed and emerging countries? What impact does seasonality have on emerging and established countries' foreign exchange markets? Which countries in the WAMZ emerging region and the BRICS developed region have changed their stock exchange and foreign exchange market regimes? Are there any parallels between the foreign exchange and stock exchange markets in the industrialized BRICS countries and the emerging WAMZ countries? The primary goal of this research is to compare the data from industrialized and developing nations affected by the COVID-19 pandemic in order to investigate the seasonality influence on stock exchange and foreign currency markets. Examine how seasonality affects stock exchanges in developing and developed countries; look into how seasonality affects foreign exchange markets in developing and developed countries; look into changes in stock exchange and foreign exchange market regimes in developing and developed countries; and compare the stock exchange and foreign exchange markets in developing and developed countries are some of the specific goals. The empirical results of this study are helpful in pinpointing areas where more investigation on the impact of seasonality on stock prices and foreign currency rates in industrialized and emerging nations should be carried out. The research would help financial markets by hedging stock and foreign exchange risk. The CoviD-19 pandemic's seasonality in the stock markets of the BRICS and WAMZ nations emphasizes how crucial it is to comprehend the particular dynamics and elements that affect market performance in these areas [8]. The COVID-19 epidemic has caused unprecedented levels of volatility and uncertainty in the world's financial markets and economies [11]. Public health experts may create more potent plans for halting the virus's transmission and safeguarding these nations' most vulnerable citizens by learning more about the seasonality of COVID-19 [14]. Investors and governments may manage the possibilities and difficulties posed by the current epidemic more skillfully and make more informed decisions by examining these tendencies. The study's important conclusions provide insightful information about the trends in stock and foreign exchange market volatility in the chosen nations. The results are compared between markets and nations in a well-organized manner, which advances our knowledge of the fundamental causes of these trends. The choice of WAMZ and BRICS nations offers a useful comparative viewpoint that sheds light on how seasonality affects developed and emerging economies differently. A strong methodological framework for capturing the dynamic nature of the data and possible regime shifts is provided by the combination of ARIMA and Markov-regime switching models. With the research findings, the study offers a valuable contribution to the field of financial economics. The knowledge base has benefited from this study in the following mentioned ways: This research has added to the body of literature by utilizing the ARIMA regression approach to investigate the impact of seasonality on stock exchange and foreign exchange markets in poor nations (WAMZ) and developed countries (BRICS) affected by the COVID-19 epidemic. This work has added to the field by examining the impacts of volatility regime switches on stock exchange and foreign exchange markets in BRICS developed nations and WAMZ developing countries affected by the COVID-19 pandemic, using the Markov-Regime Switching regression technique. All things considered, traders and investors may be able to discern market trends and decide on their investment plans by examining the impact of seasonal patterns on both foreign currency and stock exchange markets. There are five sections to this research. Reviewing relevant literature is the focus of the second part. The third portion discusses the study methodology. Section Four deals with data analysis from an empirical perspective. The fifth portion contains a report on the results and recommendations.

2. LITERATURE REVIEW

2.1 Theoretical Literature Review

In this section, we provide a review of both the relevant theories and empirical studies. Since it offers a framework for comprehending stock price behaviour and projecting future market movements, the Dow Theory is a cornerstone of technical analysis of financial markets [15]. The idea of market patterns is among the fundamental ideas of the Dow Theory. Primary trends, secondary trends, and daily variations are the three groups into which Dow divides market movements [16,17]. The market's long-term oscillations, which can last anywhere from a few months to a few years, are the main trends. Corrections that take place inside the main trend and continue anywhere from a few weeks to a few months are known as secondary trends [18]. The daily fluctuations are the brief, few-day-long swings that take place inside the secondary trend. Investors may more effectively evaluate and interpret price action to make well-informed judgments if they have a better grasp of these various market movement patterns. The Dow Theory therefore admits that the market discounts all information. This indicates that the price of a security already takes into account all of the information that is currently accessible, including market sentiment, corporate profits, and economic statistics [19]. As a result, market players' expectations and combined actions cause price changes. Investors may steer clear of attempting to forecast future market movements based on outside variables and instead concentrate on evaluating price action and volume to make wise investment decisions by realising that the market is efficient and reflects all available information [20].

2.2 Review of Empirical Researches on Exchange Rate Stock Returns Performance

Bouri et al.'s (2021) investigation of the connections and spillover between the oil, stock, and foreign exchange markets revealed spillover between these asset markets. After the Global Financial Crisis (2008), BRICS-related literature expanded research on the topic. For example, Dahir et al. (2018) used the reliance-switchingcupola technique to "study the stock market and exchange rate dependence in BRICS." The analysis finds a negative correlation between foreign exchange and stock prices in the BRICS nations. Huang et al. (2021) use the VAR model to examine the connection between the shock price and exchange rate in the BRICS countries. The result establishes the main driver of the exchange rate and stock price. Exchange and interest rates have an impact on the performance of financial markets and share prices, according to a study by Aberese et al. (2019). Their findings suggested that it is possible to forecast the trade-off between risk and reward. Therefore, stakeholders and industry participants can control risk to guarantee a thriving financial sector. Zakri (2019) looked at how, between 2000 and 2017, the exchange rates of the United States' four trade partners affected the stock market and 10 other areas of the country's economy. Of the four currencies, the euro was the most volatile and the Chinese Yuan the least; nonetheless, over the course of the research period, the euro gained the greatest value. Additionally, the author discovered that the energy sector which likewise had the greatest average return was the most variable, while the nondurable sector was the least volatile. The euro and the pound were positively and substantially connected with U.S. equities, but the Japanese yen had a generally strong and negative relationship with the U.S. stock market. Furthermore, despite American concerns about the Chinese government's direct manipulation of the foreign exchange market to weaken the Yuan and give Chinese exporters a competitive edge in the global export market, U.S. stocks were positively but not significantly correlated with the Yuan. Muhammad [7] used the ARDL model to examine the short- and long-term relationships between the research variables in order to examine how the exchange rate affected the stock returns of the Shenzhen stock exchange from January 2008 to December 2018. According to the predicted ARDL results, the exchange rate significantly and negatively affects the stock returns of the Shenzhen stock market. The results for interest rates and inflation show that these factors have a statistically significant negative impact on stock returns. The projected findings of this study suggest that central bank policymakers should implement measures that contribute to exchange rate stabilization.

Raza et al. (2019) used the nonlinear ARDL technique and reported that the gold price had a good effect on the stock market values of the BRICS nations. However, they also found that the stock markets of Mexico, Malaysia, Thailand, Chile, and Indonesia had a negative impact on the price of gold. Additionally, they noted that rising oil prices had a detrimental impact on developing stock markets. For every emerging market this study focused on, the volatilities of these two macroeconomic factors appeared to have a detrimental impact. Jamaludin et al. (2019) expanded on Raza et al.'s study by integrating three distinct macroeconomic variables (inflation rate, money supply, and exchange rate). Additionally, their monthly data spans a ten-year period, from January 2005 to December 2015. The authors used Panel Data Regression Analysis to examine the link between the stock returns and the selected macroeconomic factors in the ASEAN nations of Singapore, Indonesia, and Malaysia. They discover that the inflation and exchange rates have a significant influence on these nations' stock markets. With just three nations and three basic macroeconomic variables, this study is seen as restricted in comparison to previous works that piqued the attention of the ASEAN countries. Junior and Tweneboah [20] conducted research to determine any potential connections between the stock market and exchange rate, which are crucial for portfolio decision-making. They used daily data and the quantile-in-quantile regression (QQR), quantile regression analysis (QRA), and ensemble empirical mode decomposition (EEMP) approaches for this goal. The authors have shown that a correlation exists between the stock markets of Morocco and Tunisia and currency rates.

2.3 Review of Empirical Researches on Covid-19 and Financial Market Performance

Dahlbom [21] explored how the changes in oil prices affect the stock returns in BRICS nations before and after the commencement of Covid-19 epidemic using multiple linear regression approach. The BRICS nations have emerged as significant players in the world's financial markets and have some of the fastest-growing economies. Therefore, it is crucial for market players to comprehend how various global factors, like the price of oil, affect these markets. Apart from their significance for the international financial markets, the BRICS nations comprise a number of the world's leading oil exporters and importers. Thus, it will be fascinating to see if the BRICS economies that import and export oil have different relationships between the oil price and the stock market. The analysis makes use of both the Brent and WTI oil prices, as well as the daily MSCI index results of each BRICS stock market. The analysis of the daily results was conducted between November 19, 2014, and January 30, 2023. Along with the returns from the global markets, exchange rates and interest rate fluctuations were also included in the model as control variables to regulate the macroeconomic conditions. An empirical investigation reveals a noteworthy correlation between the world oil prices and the stock returns of the BRICS countries. Muhammad [7] investigated how foreign currency risk affected the stock market and how COVID-19 played a moderating function. The study covers the four main stock exchanges of the SAARC member nations: the Indian BSE, the Bangladeshi Dhaka Stock Exchange, the Sri Lankan CSE, and the Pakistani PSX. The nations selected are those for whom historical data from significant stock exchanges in the member nations is readily available. The study's time frame was from January 1, 2010, to February 18, 2021. Utilizing the E-GARCH model estimate, the findings demonstrate that historical data may accurately forecast the present value of stock returns. In addition, the study reported that the PSX is characterized by persistent volatility, which indicates that negative news had a greater influence on volatility. The COVID-19 pandemic generated a time-varying pattern in exchange rates, stock market return, temperature, and the number of confirmed cases in G7 nations.

Scherf et al. (2022) analyzed the reaction of OECD and BRICS markets on the COVID-19 pandemic and found an important insight: In the period from January 22nd to May 20th, 2020, neither local nor global new COVID-19 cases had any significant impact on local stock markets. Moreover, in the period from January 22nd to March 27th, 2020, the increase of global cases has a significant positive effect on stock markets. However, the analysis also revealed, that the introduction of the first strict measures as government response had negative effects on the respective stock markets. The authors explain the reaction with negative economic consequences, which stock markets would expect from government restrictions. In contrary, the results of another study revealed a negative effect of COVID-19 across all the G7 and BRICS markets except for China. The insignificant impact on Chinese Benchmark Index indicates substantial governmental steps in containing the virus (Ledwani et al., 2021). Different findings were published in another paper, where daily growths in total confirmed infection cases and cases of death showed a significant negative relation with Chinese stock Hang Seng index and Shanghai Stock Exchange Composite Index (Al-Awadhi et al., 2020). Using a wavelet coherence analysis, the paper of Asofo-Adjei et al. (2020) differs from other studies about the impact of COVID-19 cases on financial market by analysing the co-movements of economic policy uncertainty and stock returns. It depicts a weak comovement between global EPU and stock markets in Africa in a short term (up to 16 days), but results show stronger co-movements in a long-term perspective (Asofo-Adjei et al., 2020). Also, Just et al (2020) show close dependence between S&P 500 index returns and both implied volatility &implied correlation during the COVID - 19 period.

Zhu & Zhu (2020) introduced a regime-switching combination approach to predict excess stock returns. The findings revealed that two-regimes are related to the business cycle. Based on the business cycle explanation of regimes, excess returns are found to be more predictable during economic contractions than during expansions. The study also provided insights on the economic sources of return predictability. Maroua et al. (2020) investigated the effect of COVID-19 pandemic on stock market in KSA applying an ARDL co-integration approach. More especially, they analyse the relationship between the natural logarithm of trading volume of Tadawull All shares index (TASI) and the natural logarithm of short run and the long-run. The bounds test for the period from March 02, 2020 till May 2020.Toda-Yamamoto causality test is implementable between variables. Their findings indicated that there is a negative impact of COVID-19 on stock market only in the long-run. Causality test reveals a unidirectional causality of COVID-19 prevalence on stock markets globally. Monday et al. (2022) examined the effect of COVID -19 outbreaks on the performance of the Nigeria stock exchange using secondary data for the period of 2nd March 2015 to 16th April 2020. The results from GARCH models revealed a loss in stock returns and high volatility in stock returns under the COVID-19 period in Nigeria as against the non COVID19 period. Also, the Quadratic GARCH (QGARCH) and EGARCH models with dummy variable were applied to the stock returns which shown that the COVID-19 has had negative effect on the stock returns in the Nigeria stock markets. The study therefore recommended that economic policy such as incentive to indigenous companies to create new employments, diversification of the economy to attract new investors, and flexible exchange rate regime that will aid business between Nigeria investors and the international market (trade) be implemented. Lastly, the government of Nigeria should ensure policy that ensures stable political environment and reduction in insecurity in the country. Mert et al. (2020) investigated the impact of COVID-19 on emerging stock markets over the period march 10-April 30, 2020. Findings revealed that the negative impact of pandemic on emerging stock markets fell gradually. It was noted in terms of regional classification, that the impact of outbreak was highest in Asian emerging markets whereas emerging markets in Europe experienced the lowest. It was also noted that official response time and the size.

Singh, Bansal, Bhardwaj, & Agrawal [22] examined this relationship and also found a cyclical relationship between temperature levels and confirmed COVID-19 cases. The research period, as defined by employing structural break analysis, runs from January 2019 to March 2021. Research reveals that in March 2020, all BRICS and Group Seven countries will have structural fractures or fissures, and every country in the world will have had a sharp decline in the value of their index. Research revealed that prior to the implementation of COVID-19; some nations had attained elevated standards for market performance throughout all the chosen financial systems. However, the average market index fell by 35 points for every penny inside the group of countries affected by the epidemic. Since this time has a significant influence on people's lives, the BRICS and Group 7 nations include market indexes.

In the top-15 most afflicted nations by the COVID-19 pandemic, Sharma, Tiwari, Jain, Yadav & Erkut [5] looked at the time-frequency connection between the number of confirmed cases, temperature, currency rates, and stock market return. From February 1, 2020, to May 13, 2020, they used Wavelet Coherence and Partial Wavelet Coherence on the daily data. Sachdeva & Sivakumar [23] evaluated empirically how the COVID-19 pandemic affected the performance of the stock markets in the BRIC countries. Infectious illness consequences are significant and have a direct impact on global financial markets. BRIC country indexes comprise our sample. We conducted the analysis using the market model event methodology technique. The estimation window is -150 days from the occurrence of the event date, and the event window was 72 days following the introduction of Novel COVID-19 as a human transmissible illness in the international press. Six sub-event windows had negative CARs during the 72-day event window. As to the report's findings, the cumulative average abnormal return (also known as CAAR) varies from day 0 to day 60, with a surge in COVID-19-infected patients in BRIC countries causing increased financial market stress. From day 60 to day 72, the CAAR ranges from -7.28 to -0.10 percent, indicating a rebound in the stock market after a notable fall in the closing prices of the chosen nations' indexes due to COVID-19.

2.4 Identifying the research Gap

All of the aforementioned research concentrated on the empirical tendency towards short-term equilibrium rather than examining the impact of seasonality on the foreign exchange rate and stock exchange markets. Furthermore, a few of the research used heteroskedastic modeling, such as EGARCH. To the best of the researcher's knowledge, no study has looked at how seasonality affects foreign exchange and stock markets by contrasting data from ARIMA and Markov regime switching modeling between developing WAMZ countries affected by the COVID-19 pandemic and developed BRICS countries. This investigation aimed to bridge this knowledge gap.

3. METHODOLOGY

The business cycle theory, a fundamental strategy for describing the long-term fluctuations in economic activity, is the basis of the theoretical technique of this study. The theory postulates that economies go through booms and busts, or cyclical phases that include expansion and recession [24]. According to Bandi & Tamoni [25], the BCT argues that these oscillations are an inherent feature of the economic system and are caused by a range of variables, including shifts in consumer optimism, governmental rules, and external shocks like natural catastrophes or wars. A business cycle's expansion phase is characterized by a rise in economic activity that generates employment growth, income growth, and higher consumer expenditure. High levels of investment and confidence characterize this time period as companies want to take advantage of the expanding market for products and services [26].

However, the cycle enters a contraction phase when the economy peaks and demand starts to decline. Economic activity slows down during a recession phase, which results in lower consumer spending, income declines, and job losses [26]. Pessimism and risk aversion characterize this time frame as companies become more circumspect about their investment choices. After the economy eventually hits a low point, a new phase of expansion begins, thereby restarting the cycle [13]. All things considered, the business cycle theory emphasizes how critical it is to comprehend the cyclical nature of economic activity and the possibility of both expansion and contraction. Policymakers may reduce the effects of economic volatility and foster long-term stability and prosperity by learning about the business cycle. The business cycle theory is still a useful tool for economists and policymakers to manage the volatility of the stock and foreign exchange markets in today's intricate global economy [10]. The aggregate demand equation, which says the following, is one of the basic equations of business cycle theory:

$$AD = C + I + G + NX \quad (1)$$

The terms AD, C, I, G, and NX in this equation stand for aggregate demand, consumption, investment, and government expenditure, respectively. Researchers may learn more about the variables influencing changes in aggregate demand, which in turn impacts the total amount of economic activity, by examining variations in these components. For policymakers to create effective monetary and fiscal policies to stabilise the economy during various business cycle stages, they must have a solid understanding of the aggregate demand equation. Equations from business cycle theory offer a framework for examining and comprehending the causes of the cyclical variations in economic market activity.

This study basically looks at how seasonality affects foreign exchange and stock markets. The research makes use of the ARIMA and Markov regime switching modeling methods in both the WAMZ developing nations and the BRICS developed countries affected by the COVID-19 pandemic. In time series analysis, the Autoregressive Integrated Moving Average (ARIMA) model is a popular econometric formula. It is an effective method for projecting values into the future using historical data. The moving average (MA) component captures the current value's linear dependence on previous forecast errors; the differencing (I) component eliminates trends in the data to achieve stationarity; and the autoregressive (AR) component captures the dependence of the current value on past values. When examining non-stationary time series data, that is, data where the series' mean and variance fluctuate over time, the ARIMA model becomes very helpful. The ARIMA model's ability to capture intricate patterns and correlations in each data point is one of its main features. Trends, seasonality, and periodicity are just a few of the many time series phenomena that the ARIMA model can successfully model by combining several elements including AR, MA, and differencing. This facilitates planning and decision-making by enabling academics and practitioners to provide forecasts and projections that are more accurate. The ARIMA model is a useful tool for academics and graduate students in a variety of subjects, including economics, finance, and engineering, because it is also rather simple to apply and understand. All things considered, the ARIMA model is a strong and adaptable econometric formula with many uses in forecasting and time series analysis. The following is the specification of the ARIMA AR(p) regression models for stock returns and exchange rates:

$$AR(p): stkr_t = \alpha + \sum_{i=1}^{p} \beta(stkr_{t-1}) + u_{1t} \quad (2)$$

$$AR(p): exrr_t = \alpha + \sum_{i=1}^{p} \beta(exrr_{t-1}) + u_t \quad (3)$$

$$MA(q): stkr_t = \gamma + d_o u_t + \sum_{i=1}^{p} \beta(stkr_{t-1}) + d_o u_{t-1} \quad (4)$$

$$MA(q): exrr_t = \gamma + d_o u_t + \sum_{i=1}^{p} \beta(exrr_{t-1}) + d_o u_{t-1} \quad (5)$$

where ARIMA (p, d, q) shows the number of lags of the dependent variable (p), number of times the variable is differenced for stationary (d), and number of lags of the error term (q). In addition, stkr is the stock market returns of individual countries, exrr is the exchange rate of individual countries, α and γ are constants, u is the error term and *t* denotes time period. The Markov switching model was also deployed to analyze the time-varying seasonal parameters. This model allows for the estimation of parameters that change according to different seasons as measured by the different states or regimes that characterized by Markov processes. We estimated the Markov switching model with three regimes, categorized into pre-covid-19, during covid-19, and post-covid-19. Accordingly, our MS regression model of three regimes switches between the 3 aforementioned regimes. The model specification for the variables is as follows;

$$stkr_t = \begin{cases} \varphi_1 + \beta_{11}\, stkr_{t-1} + \cdots + \beta_p\, stkr_{t-p} + \varepsilon_t & F_t = 1 \\ \varphi_2 + \beta_{12}\, stkr_{t-1} + \cdots + \beta_{p2}\, stkr_{t-p} + \varepsilon_t & F_t = 2 \\ \varphi_3 + \beta_{13}\, stkr_{t-1} + \cdots + \beta_{p2}\, stkr_{t-p} + \varepsilon_t & F_t = 3 \end{cases} \quad (6)$$

$$exrr_t = \begin{cases} \varphi_1 + \beta_{11}\, exrr_{t-1} + \cdots + \beta_p\, exrr_{t-p} + \varepsilon_t & F_t = 1 \\ \varphi_2 + \beta_{12}\, exrr_{t-1} + \cdots + \beta_{p2}\, exrr_{t-p} + \varepsilon_t & F_t = 2 \\ \varphi_3 + \beta_{13}\, exrr_{t-1} + \cdots + \beta_{p2}\, exrr_{t-p} + \varepsilon_t & F_t = 3 \end{cases} \quad (7)$$

where the regimes are indexed by F_t. In MS-AR model, the intercept and the parameters of the AR part are reliant on F_t, at time t. The F_t, is unobservable variables. The economic cycles/phases of the business cycle theory explains the implications of the switching regimes between periods of high and low volatility. Prior to covid-19 correspond to the expansionary phase of the business cycle, which is characterized by a rise in economic activity that results in higher earnings, more jobs being created, and more consumers spending. The covid-19 era corresponds to the contraction phase that is characterized by a slowdown in economic activity, which results in lower consumer spending, income declines, and job losses and investors became more cautious when making investments due to the epidemic and industry lockout. The economy eventually hits a low and depresses. The post-covid-19 period corresponds to the phase when the cycle is rejuvenated with a renewed phase of growth. High levels of confidence and investment marked this time period as companies looked to take advantage of the expanding demand for goods and services. In effect, the business cycle theory emphasizes how critical it is to comprehend the cyclical nature of economic activity and the possibility of both expansion and contraction. Hence, F_t (regime 1) pre-covid-19 phase of stock and exchange rate return ($stkr_t/exrr_t$), F_2 (regime 2) symbolizes the covid-19 phase of stock and exchange rate return ($stkr_t/exrr_t$), and F_3 (regime 3) signifies post-covid-19 phase of stock and exchange rate return ($stkr_t/exrr_t$)The transitions of the F_t, (regimes) obeys an ergodic and intricate first-order Markov-process. This implies that the effects of previous observations(s) for the stock and exchange rate return and regime(s) are completely captured in the recent stock and exchange rate return. The regime(s) observations are as represented in the following equation:

$$p_{ij} = prob(F_t = j / f_{t-1} = i) \;\; \forall \; i, j = 1, 2, 3 \quad (8)$$

Matrix *P* captures the probability of switching which is known as a transition matrix:

$$P = [p_{11}p_{12}p_{13},\; p_{21}p_{22}p_{23},\; p_{31}p_{32}p_{33}] \quad (9)$$

where: $\sum_{i=1}^{3} \rho_{ij} = 1$

The nearer the probability p_{ij} is to one the longer it takes to stay in the ith regime before shifting to the next regime and D stands for duration. The duration of a given state *j* is defined as follows:

$$\begin{cases} D = 1,\; if \;\; F_t = j \;\; and \;\; F_{t+1} \neq j;\;\; \Pr[D = 1] = (1 - p_{jj}) \\ D = 2,\; if \;\; F_t = F_{t+1} = j \; and \;\; F_{t+2} \neq j;\;\; \Pr[D = 2] = p_{jj}(1 - p_{jj}) \\ D = 3,\; if \;\; F_t = F_{t+2} = F_{t+3} = j \;\; and \;\; \Pr[D = 3] = p_{jj}^2(1 - p_{jj}) \end{cases} \quad (10)$$

Then, the expected duration of regime *j* can be derived as:

$$\begin{aligned} e^{Duration} &= \sum\nolimits_{j=1}^{\infty} jPr[D = j] \quad (11) \\ &= Pr[F_{t+1} \neq j \mid F_t = j] + 2 \times Pr[F_{t+1} = j, F_{t+2} \neq j \mid F_t = j] + 3 \times Pr[F_{t+1} = j, F_{t+2} = j, \\ &\quad F_{t+3} \neq j \mid F_t = j] + \ldots \\ e^{Duration} &= (1 - p_{ij}) + 2 \times p_{jj}(1 - p_{ij}) + 3 \times p_{jj}^2(1 - p_{ij}) + \ldots = 1/(1 - p_{ij}) \end{aligned}$$

Taking into account the regime switches and transitions between different states, the parameters of the MSRM were estimated with the Eviews 13 software by executing the Expectation-Maximization (EM) algorithm [27,28,29,30,31,32]. The EM is an algorithm that estimates a sample with missing data. The methodology is driven by the mutual dependence between the vector of parameters and the missing observations (caused by observable structural breaks and seasonal factors). The methodological steps involve estimating the missing values using the initially updated coefficient estimates often known as the smoothed or filtered state estimates, re-estimating again, substituting the initial estimated values for the missing values, estimating the coefficients using the completed data set, and so on [33-35]. The procedure involved empirical iteration till convergence. An E-step (expectation step) and an M-step (maximization step) make up each EM iteration. The E-step finds a conditional expectation of the missing data by operating a Kalman filter or a smoother designed with current estimated coefficients to obtain updated state estimates given the observed data, and then substitutes these expectations for the missing data. The M step implements ML estimation of the coefficient vector as if there were no missing data. The likelihood of accurately calculating the convergence to a local or global maximum rises with each iteration. The sole drawback of EM that was not too much of a concern in this research is that, because it is based on the number of missing data, it speed of convergence can become quite slow when the percentage of missing data is high.

The rationale for implementing the Markov switching regression in this study derived from the fact that the Markov process is particularly useful in modeling economic phenomena where structural shifts occur over time, such as seasonal cycles, financial crises, business cycles, and changes in monetary policy. Also, by incorporating regime switches into the model, economists are able to capture the dynamics of the data more accurately and account for uncertainties in the data-generating process. Largely, the econometric equation of a Markov switching model provides a powerful framework for understanding and analyzing economic data that exhibit structural breaks and regime shifts, allowing for more informed policy decisions and forecasts. Using the Eviews 13 software to estimate the ARIMA model, the maximum likelihood estimator (MLE) was implemented. The MLE method consists of maximizing the log-likelihood (Π) function as in the following specification.

$$\underset{\beta}{Optimize}\ \ln[\Theta_T(\beta)|X]$$

$$s.t.\ nonlinear,\ equality\ and\ inequality\ contrstaint$$

where ln [.] is the Π objective function, β is the vector of parameters, and *X* is the vector of explanatory variables. The MLE technique finds the values of the parameters which maximize the likelihood of obtaining the data that we have observed. Having calibrated more than one model, the best ARIMA model, that is, the choice of the parsimonious model was determined following these four preconditions. 1) estimated equation with the most significant coefficients; 2) lowest volatility as shown in the SIGMASQ coefficient; 3) highest R2 adjusted; and 4) estimated regression coefficients with the lowest AIC. For the chosen ARIMA model, the following parameters of the ARIMA model were estimated using the available data: (1) mean of the series, (2) autoregressive (AR) coefficients, (3) moving average (MA) coefficients, (4) innovation series, and (5) variance of the innovation series.

Two (2) developing African nations covered in the West African Monetary Zone (WAMZ) include Nigeria and Ghana only. Similarly, two (2) of the five BRICS member nations including: Brazil and China were included as they were considerably developed nation within the BRICS member nations. Russia is also a developed nation within the BRICS countries, but difficulty in accessing Russian exchange to the US dollar from relevant databanks necessitated the exclusion of the country from the BRICS country block. Foreign exchange and stock exchange returns were obtained from World Bank and International Monetary Fund's databases. We estimated the ARIMA regression model with daily data for the covid-19 period precisely. Hence, the data set for the ARIMA regression analysis spans from December 1, 2019 to December 30, 2022. The data set for Markov-switching regression analysis spans between three periods. These include, pre-covid-19 (2000M1-2019M11), covid-19 era (2019M12-2020M12), and post-covid-19 (2021M1-2023M12). Both ARIMA and Markov-Switching regressions were performed using the E-views 10 econometrics software.

4. RESULTS

From Fig. 1, the trend of the foreign exchange market returns in Nigeria and Ghana representing African nations shows a lot of dynamic changes. For instance, Nigerian's foreign exchange returns showed that the returns rose continuously throughout the four quarters of 2019 to 2021. Throughout the period, there was a rise in sharp rise all through 2019 and 2022. Ghana's exchange returns similarly maintained a gradual continuous rise throughout 2019 to 2020 and this rose at a steeper rate from the first quarter of 2021 through 2022. On the right pane of the figure, shows the trend of the stock exchange market returns in Nigeria and Ghana representing developing African. From the figure, Ghana's exchange returns showed that there was a rise, fall and rise in the stock exchange market returns throughout the four quarters of 2019, 2020 and 2021 respectively. For Nigeria, there was a sharp drop in returns throughout the covid-19 era in 2020 and this hit the rock bottom price before a gradual rise in 2021. Ghana's exchange returns similarly maintained a gradual continuous rise throughout 2019 to 2020 and this rose at a steeper rate from the first quarter of 2021 through 2022.

From Fig. 2, the trend of the stock market price in Brazil and China representing developed BRICS nations shows a lot of dynamic changes. In the case of Brazil and China both showed that the stock market returns rose continuously throughout the four quarters of 2019 and 2020. Throughout the period, there was a rise in sharp rise all through 2019 and 2020. However, in 2021 Brazil's stock returns fell while china maintained a flat curve increase from the first quarter of 2021 through 2022. On the right pane of the figure, shows the trend of the foreign exchange market price in Brazil and China which are representing developed BRICS member countries. From the figure, Brazil's foreign exchange returns showed that there was a very steep rise, progressive rise and slow fall in the foreign exchange market returns throughout the four quarters of 2019, 2020 and 2021 respectively. For China, there was a slow drop in returns throughout the covid-19 era in 2019 and very steep fall in prices 2020 and this rose gradually in 2021.

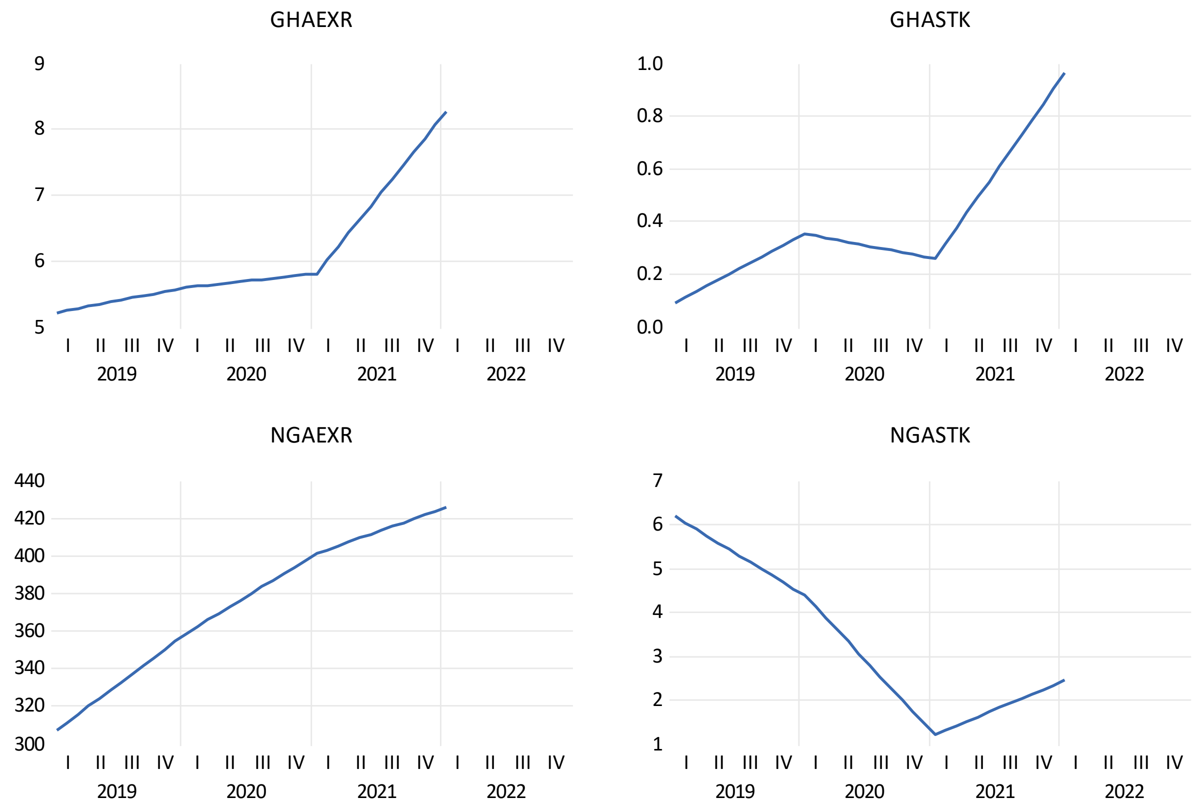

Fig. 1. Seasonality patterns on stock market dynamics and exchange rate in developing WAMZ countries, Nigeria (NGA) and Ghana (GHA)

Source: Authors' regression output from E-view version 13

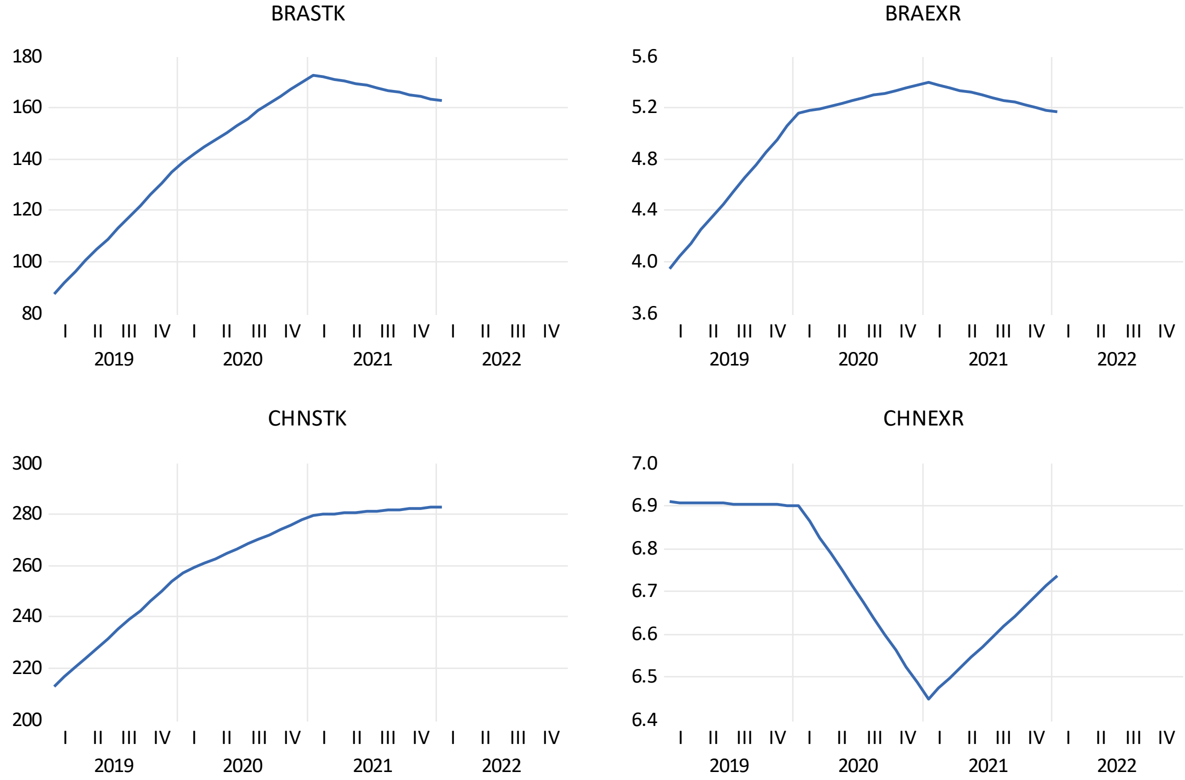

Fig. 2. Seasonality patterns on stock market returns and exchange rate in developed BRICS nations – Brazil (BRA) and China (CHN)

Source: Authors' regression output from E-view version 13

Table 1 shows the Nigeria has higher average stock and foreign exchange returns than Ghana within the WAMZ block of developing nations. While China has a higher average stock and foreign exchange returns than Brazil within the developed BRIC nations. Nigeria had the highest foreign exchange returns variability at 36.6 exchange deviation compared to Brazil at 26.6 exchange of its local currency for the US dollar. Nigeria as a developing WAMZ nation and China as a BRIC developed nation had the highest foreign exchange to returns at 425.98 NGN and 283.03RMB. Within 2019 to 2022, the measure of skewness for Nigeria's and Ghana's stock exchange returns, and Ghana's exchange returns were positively signed while other was negatively skewed. A high kurtosis shows outliers. Within 2019 to 2022, the Nigeria's stock and exchange, Brazils stock, China's stock and foreign exchange were *platykurtic* as the value were less than a value of three (3). GHASTK had a kurtosis value of 3.509. Since the values are greater than 3. This shows that Ghana's stock price was *leptykurtic* , that is, longer and had fatter tails than the normal distribution. Some of the variables including GHAEXR, and BRAEXR were *mesokurtic* as they were approximately equal to 3 within the period of review. With exception of GHASTK, GHAEXR and BRAEXR that are not normally distributed (p>0.05), the Jarque bera test shows that the rest of the series are normally distributed.

The long-run analysis was based on the ARIMA regression estimation. The results of the chosen parsimonious regression are as presented in Table 2. From Table 2, Nigeria's stock returns demonstrated lower volatility (SIGMASQ = 0.000141) than Ghana's stock returns (SIGMASQ = 0.004003). Similarly, Nigeria had a lower returns volatility than Ghana (SIGMASQ = 0.001829 < 0.07727) in the foreign exchange market of their respective local currencies in relation to the US dollar during the covid-19 era. Nigeria and Ghana's two period lagged value of stock returns was significant [AR(2), p<0.05] while their moving average component was significant at one lag [MA(1), p<0.05]. Ghana's three period lagged value of foreign exchange returns was also significant [AR(3), p<0.05]. Comparatively, Nigeria's stock and foreign exchange market performance showed lower returns volatility behaviour than Ghana's markets during the covid-19 period.

Table 1. Developing African WAMZ and Developed BRICS nations

Measures	NGASTK	NGAEXR	GHASTK	GHAEXR
Mean	3.331115	375.2272	0.382930	6.067578
Median	2.798521	379.9814	0.313558	5.700704
Maximum	6.185134	425.9792	0.962700	8.272400
Minimum	1.209606	306.9210	0.088500	5.217367
Std. Dev.	1.632694	36.60462	0.223795	0.871381
Skewness	0.350527	-0.331759	1.196334	1.261427
Kurtosis	1.618502	1.838713	3.509826	3.289833
Jarque-Bera	3.700021	2.757801	9.226537	9.941897
Probability	0.157236	0.251855	0.009919	0.006937
Measures	**BRASTK**	**BRAEXR**	**CHNSTK**	**CHNEXR**
Mean	145.0548	5.021617	261.2360	6.726836
Median	155.8809	5.214984	268.4067	6.713143
Maximum	172.7864	5.394401	283.0379	6.908385
Minimum	87.48180	3.944471	212.9576	6.448975
Std. Dev.	26.60930	0.422446	22.07631	0.161071
Skewness	-0.801960	-1.307995	-0.806722	-0.175603
Kurtosis	2.276124	3.349588	2.328611	1.547093
Jarque-Bera	3.204894	3.568873	4.58094	10.29784
Probability	4.773861	10.73866	4.708195	3.444523
Observations	0.091911	0.004657	0.094979	0.178662

Source: Authors' regression output from E-view version 13

Table 2. ARIMA Regression Analysis for Developing Countries of WAMZ

		NGASTK		
Variables	**Coefficients**	**S.D**	**t-val**	**Prob.**
C	-0.075462	0.204482	-0.369042	0.7145
AR(2)	0.828036	0.305619	2.709373	0.0107
MA(1)	0.946187	0.367018	2.578041	0.0147
SIGMASQ	0.000141	3.46E-05	4.073895	0.0000
R-squared = 0.8301 (D.W =1.934), Adjusted R-squared = 0.8143, F-Statistics = 52.174 (p=0.000)				
		NGAEXR		
Variables	**Coefficients**	**S.D**	**t-val**	**Prob.**
C	3.240574	0.999501	3.242192	0.0028
AR(2)	0.929379	0.217720	4.268687	0.0002
MA(1)	0.948500	0.389869	2.432871	0.0207
SIGMASQ	0.001829	0.000557	3.282196	0.0025
R-squared = 0.9114 (D.W =1.887), Adjusted R-squared = 0.9031, F-Statistics = 109.73 (p=0.000)				
		GHASTK		
Variables	**Coefficients**	**S.D**	**t-val**	**Prob.**
C	0.029498	0.032587	0.905212	0.3721
AR(2)	0.809701	0.298002	2.717104	0.0105
MA(1)	0.960666	0.434958	2.208641	0.0345
SIGMASQ	0.004003	0.000895	4.471938	0.0000
R-squared = 0.8100 (D.W =1.967), Adjusted R-squared = 0.8100, F-Statistics = 45.478 (p=0.000)				
		GHAEXR		
Variables	**Coefficients**	**S.D**	**t-val**	**Prob.**
C	0.094211	0.054559	1.726775	0.0939
AR(3)	0.686860	0.266122	2.581002	0.0146
MA(1)	0.545015	0.125403	4.346116	0.0001
SIGMASQ	0.077270	0.017378	4.446434	0.0001
R-squared = 0.7499 (D.W =1.906), Adjusted R-squared = 0.7265, F-Statistics = 31.997 (p=0.000)				

*Note: * Coefficient is significant at 0.05 level of significance (p<0.05)*
Source: Authors' regression output from E-view version 13

From Table 3, Brazil's stock returns demonstrated higher volatility (SIGMASQ = 0.435775) than China's stock returns (SIGMASQ = 0.325993). Similarly, Brazil had higher returns volatility than China (SIGMASQ = 0.000579 > 0.000137) in the foreign exchange markets of the Brazilian and Chinese individual local currencies (Real and Yuan) vis-à-vis the US dollar during the covid-19 era. The Brazil's two period lagged value of stock returns was significant [AR(2), p<0.05] while China's three period lagged value of stock returns also passed the test of statistical significance [AR(3), p<0.05]. In regards to exchange rate, Ghana's three period lagged value of foreign exchange returns was significant [AR(3), p<0.05] as compared to one period lagged effect for China. Comparatively, Brazil's stock and foreign exchange performance showed higher returns volatility behaviour than China during the covid-19 period.

From Table 4, the equation modeled by Markov-regime switching probabilities with 2 regimes and constant transition of probabilities in the low and high volatility regimes for WAMZ countries. With regards to stock returns for the Nigerian stock exchange, the results show a sizable state dependence given 0.9727 probability of staying in regime 1 while the corresponding expected durations in the regimes are approximately 36.68 months in the first regime and 35.21 months for second regime, and 40.32985 months in Nigeria. Comparatively for Ghana, the corresponding expected durations in a regime are approximately lower at 24.43 months in the first regime but higher at 42.55 months in the second regime, and 50.89 months in the third regime. This explains that it took Ghana a lower time than Nigeria for stock returns volatility driven by covid-19 pandemic to be restored in the first regime but a higher time for Ghana's stock volatility to be restored in the second and third regimes respectively.

Table 3. ARIMA Regression Analysis for Developed BRICS Countries

		BRASTK		
Variables	**Coefficients**	**S.D**	**t-val**	**Prob.**
C	1.876724	2.302718	0.815004	0.4211
AR(2)	0.923148	0.277961	3.321142	0.0022
MA(1)	0.947549	0.371414	2.551193	0.0157
SIGMASQ	0.435775	0.080074	5.442138	0.0000
R-squared = 0.9065 (D.W =2.0189), Adjusted R-squared = 0.8977, F-Statistic = 103.44 (p=0.000)				
		BRAEXR		
Variables	**Coefficients**	**S.D**	**t-val**	**Prob.**
C	0.036486	0.021891	1.666737	0.1053
AR(3)	0.771943	0.186179	4.146243	0.0002
MA(2)	0.451929	0.154696	2.921390	0.0063
SIGMASQ	0.000579	0.000146	3.964471	0.0004
R-squared = 0.7685 (D.W =1.987), Adjusted R-squared = 0.7974, F-Statistic = 35.412 (p=0.000)				
		CHNSTK		
Variables	**Coefficients**	**S.D**	**t-val**	**Prob.**
C	1.965973	0.623705	3.152089	0.0035
AR(3)	0.816805	0.145932	5.597174	0.0000
MA(1)	0.530191	0.160173	3.310111	0.0023
SIGMASQ	0.325993	0.065747	4.958303	0.0000
R-squared = 0.8313 (D.W =1.938), Adjusted R-squared = 0.8154, F-Statistic = 52.561 (p=0.000)				
		CHNEXR		
Variables	**Coefficients**	**S.D**	**t-val**	**Prob.**
C	-0.000369	0.031514	-0.011699	0.9907
AR(1)	0.866590	0.34274	2.516421	0.0171
MA(1)	0.056611	1.358976	0.041675	0.9670
SIGMASQ	0.000137	0.213895	4.746310	0.0000
R-squared = 0.7861 (D.W =1.941), Adjusted R-squared = 0.7662, F-Statistic = 39.223 (p=0.000)				

*Note: * Coefficient is significant at 0.05 level of significance (p<0.05)*
Source: Authors' regression output from E-view version 13

Table 4. Markov-regime Switching Results for developing WAMZ nations

Variable	Regime	Variable	Coefficient	Std. Error	z-Statistic	Prob.	Transition probability	Constant expected duration
NGASTK	Regime 1	Constant	1.941018	0.136511	14.21878	0.0000	0.972722	36.68774
		LOG(SIGMA)	-0.792286	0.243736	-3.250589	0.0012		
	Regime 2	Constant	4.837189	0.276173	17.51505	0.0000	0.971624	35.21308
		LOG(SIGMA)	-0.099412	0.222589	-0.446618	0.6552		
	Regime 3	Constant	2.304892	0.134857	17.091378	0.0000	0.971923	40.32985
		LOG(SIGMA)	1.3765619	0.046279	297.44849	0.0000		
NGAEXR	Regime 1	Constant	346.9334	8.096163	42.85159	0.0000	0.9732	37.3293
		LOG(SIGMA)	3.163519	0.211156	14.98192	0.0000		
	Regime 2	Constant	408.4028	5.115589	79.83494	0.0000	0.9708	34.3388
		LOG(SIGMA)	2.460473	0.328381	7.492736	0.0000		
	Regime 3	Constant	5.687960	0.241759	23.527397	0.0000	0.961432	27.91345
		LOG(SIGMA)	1.029834	0.001497	687.93186	0.0000		
GHASTK	Regime 1	Constant	0.709764	0.064703	10.96955	0.0000	0.959078	24.43665
		LOG(SIGMA)	-1.809196	0.271585	-6.661614	0.0000		
	Regime 2	Constant	0.268948	0.017292	15.55307	0.0000	0.976500	42.55409
		LOG(SIGMA)	-2.547745	0.160232	-15.90039	0.0000		
	Regime 3	Constant	13.48958	0.286934	47.012832	0.0000	0.996262	50.892713
		LOG(SIGMA)	2.398471	0.009287	258.26111	0.0000		
GHAEXR	Regime 1	Constant	7.179268	0.238315	30.12506	0.0000	0.963709	27.55506
		LOG(SIGMA)	-0.368520	0.238952	-1.542233	0.1230		
	Regime 2	Constant	5.559631	0.042883	129.6467	0.0000	0.975911	41.51194
		LOG(SIGMA)	-1.675948	-0.17025	-9.846552	0.0000		
	Regime 3	Constant	-9.348615	0.012845	-727.8016	0.0000	0.9512726	59.0486
		LOG(SIGMA)	-1.172939	0.005276	222.31595	0.0000		

Source: *Authors' regression output from E-view version 13*

Table 5. Markov-Regime Switching Results for developed BRICS nations

Country	Regime	Variable	Coefficient	Std Error	z-Statistic	Prob.	Transition probability	Constant expected duration
BRASTK	Regime 1	Constant	125.1000	5.754243	21.74048	0.0000	0.972810	36.77766
		LOG(SIGMA)	3.077720	0.180347	17.06551	0.0000		
	Regime 2	Constant	166.9131	1.108862	150.5266	0.0000	0.971425	34.99587
		LOG(SIGMA)	1.293536	0.248126	5.213231	0.0000		
	Regime 3	Constant	7.298393	0.003615	2018.9192	0.0000	0.913586	35.99123
		LOG(SIGMA)	3.98486	0.012398	321.4115	0.0000		
BRAEXR	Regime 1	Constant	5.271593	0.016468	320.1199	0.0000	0.975590	40.96745
		LOG(SIGMA)	-2.628610	0.172475	-15.2405	0.0000		
	Regime 2	Constant	4.499194	0.115646	38.90474	0.0000	0.964264	47.98272
		LOG(SIGMA)	-1.051367	0.230770	-4.55591	0.0000		
	Regime 3	Constant	2.30412	0.00273	844.0000	0.0000	0.968826	33.98729
		LOG(SIGMA)	-0.83785	0.000479	1749.1649	0.0000	0.9511153	35.056896
CHNSTK	Regime 1	Constant	249.8731	4.582776	54.52440	0.0000	0.975269	40.43485
		LOG(SIGMA)	2.980369	0.160573	18.56078	0.0000		
	Regime 2	Constant	281.1730	0.446533	629.6801	0.0000	0.966803	30.12335
		LOG(SIGMA)	0.226508	0.314705	0.719747	0.4717		
	Regime 3	Constant	302.92387	8.286411	36.55670	0.0000	0.923538	23.45679
		LOG(SIGMA)	5.02893	0.002719	1849.5513	0.0000		
CHNEXR	Regime 1	Constant	6.904558	0.000719	9597.186	0.0000	0.966419	29.77852
		LOG(SIGMA)	-6.043695	0.214176	-28.2183	0.0000		
	Regime 2	Constant	6.630641	0.024971	265.5343	0.0000	0.975932	27.54901
		LOG(SIGMA)	-2.189919	0.157745	-13.8827	0.0000		
	Regime 3	Constant	2.48908	0.024971	99.67882	0.0000	0.905113	21.65012
		LOG(SIGMA)	1.938589	0.001745	1110.9392	0.0000		

Source: Authors' regression output from E-view version 13

With regards to exchange rate returns, results showed that there is sizeable state dependence given 0.9732 probability of lasting in first regime while the corresponding expected durations in the regimes are approximately 37.3 months in the first regime and 34.33 months for the second regime and 27.91345 months in the third regime for Nigeria. Comparatively for Ghana, the corresponding expected durations are approximately lower at 27.55 months in the first regime but higher at 41.5 months in the second regime, and 59.0486 months in the third regime respectively. This explains that it took Ghana a lower time than Nigeria for foreign exchange volatility caused by covid-19 pandemic to be restored in the first regime but a higher time than Nigeria, for Ghana's stock volatility to be restored in the second regime and third regimes respectively

From Table 5, the equation modeled Markov-regime switching probabilities with 2 regimes and constant transition of probabilities in the low and high volatility regimes for BRICS countries. The Brazilian Markov estimates reveals sizeable state dependence in the transition probabilities with a relatively higher probability of remaining in the origin regime at 0.9728 probability while the corresponding expected durations in the regimes are approximately 36.77 months in the first regime, 34.99 months in the second regime, and 35.99123 months in the third regimes for Brazil. Compared to Brazil, the corresponding expected durations in a regime are approximately higher for China at 40.43 months in the first regime but lower at 30.12 months and 23.45679 months in the second and third regimes respectively. This shows that China had more time than Brazil for stock market volatility to be repaired in the first regime but a much lower time for China's stock volatility to be restored in the second regime during the covid-19 pandemic and third regime after the covid-19 pandemic. With regards to exchange rate returns, the Markov results show some sizeable state dependence in the transition probabilities with a relatively higher probability of remaining in the origin regime at 0.9755 probability while the corresponding expected durations in the regimes are approximately 40.96 months in the first regime and 47.98 months for the second regime and 33.98729 months in the third regime in Brazil. Comparing with China, the corresponding expected durations in a regime are approximately lower at 29.78, 27.55, 21.65 months in the first, second and third regimes respectively. This explains that it took Brazil more time than China for foreign exchange volatility to be restored in all the three regimes taking into cognizance the presence of covid-19 pandemic.

5. DISCUSSION

The outcome is consistent with Sachdeva & Sivakumar's [23] findings that the COVID-19 pandemic had a major impact on the conduct of the stock and financial markets in the BRIC countries. The outcome is consistent with Dahlbom's [21] findings, which indicated a strong correlation between the world oil price and the returns on the BRICS stocks. Over the course of the research period, the relationship's degree fluctuates depending on which nation's import and export oil. Dahlbom [21] found little indication of a greater association since the start of the Covid-19 epidemic, which is in contrary to other investigations. The findings corroborate Muhammad's [7] findings about the stock returns of Pakistan, Sri Lanka, and India, which indicate that historical values may accurately forecast present stock return values. The PSX is characterized by persistent volatility, with negative news having less of an influence on volatility. The outcome demonstrates that COVID-19 has an influence on the market, although a mild one. The positive and large mean value of Bangladesh indicates that previous stock returns may accurately anticipate the present value of stock returns. The outcome still supports the findings of the same author about exchange rate risk, its effect on stock returns, and how COVID-19 impacts both markets during a pandemic. The findings demonstrate that volatility persists across all currencies, that its negative effects are minimal, and that the impact of COVID-19 is not always detrimental to all markets.

The empirical results corroborate those of Junior, Tetteh, Nkrumah-Boadu, & Adjei [20], who discovered that stock markets responded to information transmission and the epidemic in lead lags prior to, during, and after Covid-19. Overall, the results indicate that spillovers and information transfer occur more frequently in the short term than in the medium- and long-term timeframes. According to the research, despite the fact that the majority of African stock markets were not vulnerable to the pandemic's contagion impact, it is crucial to reconsider the idea that stock market co-movements in Africa are immune to one another, particularly during difficult times globally. The outcome is consistent with research by Singh, Bansal, Bhardwaj &

Agrawal [22], which discovered significant correlations at reduced frequencies and demonstrated a significant long-term influence on G7 stock market returns, and exchange rates, as well as verified COVID-19 examples. The results also corroborate the findings of Sailaja, Kalyan & Khan [6], who discovered that the average market index fell straight for every penny within the group of countries that used the pandemic strike. Due to the significant disruptions to people's lives during this time, the market indexes for the BRICS and Group 7 nations also fell sharply. The results also supported the findings of Sharma, Tiwari, Jain, Yadav & Erkut [5], who discovered strong connectivity at low frequencies display indicating a significant impact of COVID-19 cases on the stock market returns and exchange rate returns of countries under investigation. The results of this analysis supported earlier research that revealed distinct seasonality patterns in the stock markets during the COVID-19 pandemic across the BRICS and WAMZ nations [14]. Inferentially, during pandemics, stock returns often show a negative trend and are more volatile. According to Daramola & Adekanmbi [8], this is a result of increased apprehension and ambiguity over the virus's potential to spread. It's interesting to note that during specific times of the year, stock returns in the BRICS and WAMZ countries have also demonstrated resilience and recovery [13]. This is likely because of the governments' efforts to introduce incentive measures that assist economic recovery. Higher investor composure and more market activity as a result have raised stock returns. Brazil's winter months, from June to August, saw a spike in the number of COVID-19 cases [14]. South Africa likewise showed this tendency, with a notable spike in the number of cases during the winter months of June and July. On the other hand, summertime in China and India saw surges in the number of cases, indicating that the seasonality of COVID-19 may differ between the BRICS nations. Similarly, there have been annual variations in the number of cases in the WAMZ nations, with certain countries seeing greater transmission rates during the dry season and others during the wet season. Regarding the model's implications for policy, the findings indicated that Brazil and Nigeria's exchange rates and foreign exchange rates had significant volatility effects. In contrast, Ghana's comparable predicted regime lengths are roughly greater at 41.5 months for the second regime and 59.05 months for the third, but lower at 27.55 months for the first. This indicates that due to the COVID-19 pandemic, Ghana would have had less foreign exchange volatility than Nigeria under the first regime; nevertheless, under the second and third regimes, Ghana saw greater volatility in the foreign exchange market than Nigeria. Inferentially, Ghana's foreign exchange volatility reversed faster during the first regime than Nigeria's, while Nigeria's forex market volatility reverted faster under the second and third regimes. The findings highlight the importance of the business cycle hypothesis, a fundamental concept in economics that describes how the economy changes over time. As a result, our research clarifies the existence of significant cyclical swing effects in the foreign exchange and stock markets of Brazil, Ghana, and Nigeria.

6. CONCLUSION

This study looks at how seasonality affects stock exchange and foreign exchange markets in COVID-19-affected poor nations in the Western Asia and Pacific (WAMZ) and BRICS developed countries. Using ARIMA and Markov-regime switching methodologies, the study examines the effects of seasonality on stock and foreign exchange markets in two WAMZ countries (Nigeria and Ghana) and two BRICS countries (Brazil and China). It seeks to shed light on these markets' volatility patterns during the COVID-19 epidemic. The extensive technique used in the work is one of its strong points. The study provides a strong analytical framework to capture the effects of seasonality and volatility in various regimes by utilizing both ARIMA and Markov-regime switching models. Furthermore, the comparative examination that draws attention to the distinct effects of seasonality on emerging (WAMZ) and developed (BRICS) countries adds value. The results have more credibility because the findings are backed up by solid empirical facts. The research findings are scientifically comprehensive, having been based on statistically significant outcomes. The study was approached with a focus as evidenced by the well-articulated research questions and objectives. The thorough literature review skillfully situates the study within the body of current knowledge, emphasizing the knowledge gap and the study's distinctive contribution. With an emphasis on the COVID-19 era, the research findings offer exceptional and relevant empirical insights into the effects of seasonality on stock and foreign exchange markets in both BRICS and WAMZ countries. By using both ARIMA and Markov-regime switching models to examine these intricate interactions, the authors have significantly advanced the research. According to the conservative ARIMA estimates, Nigeria's stock returns showed less volatility than Ghana's (SIGMASQ = 0.004003). Nigeria's stock returns showed lower volatility (SIGMASQ = 0.000141). Similar to Ghana, Nigeria saw less return volatility in the foreign exchange market of their respective local currencies relative to the US dollar during the COVID-19 timeframe (SIGMASQ = 0.001829 < 0.07727). In contrast, during the COVID-19 era, Nigeria's stock and foreign exchange markets had lower return volatility behaviour than Ghana's markets. In comparison to the Chinese stock market returns and the return on the Chinese Yuan exchange rate in relation to the US dollar during the COVID-19 era, Brazil's stock returns and the foreign currency market return on the Brazilian Real saw greater volatility. In contrast, during the COVID-19 era, Brazil's stock and foreign exchange performance displayed higher returns volatility behaviour than China. The Markov-switching regression findings supported the ARIMA estimates. According to Markov calculations, Ghana and Brazil had the biggest volatility effects in the foreign exchange market. In contrast, Ghana's predicted durations were found to be lower 27.55 months for the first regime but higher 41.5 months for the second and 59.05 months for the third. Inferentially, Ghana's foreign exchange volatility reversed faster during the first regime than Nigeria's, while Nigeria's forex market volatility reverted faster under the second and third regimes. The anticipated lengths of the first and second regimes, with respect to stock returns for the Nigerian stock exchange, are around 36.68 months and 35.21 months, respectively, and 40.32985 months in Nigeria. In contrast, Ghana has shorter equivalent periods for the first, second, and third regimes, at 24.43 months, 42.55 months, and 50.89 months, respectively. As a result, Ghana saw a quicker restoration of stock return volatility during the first regime than Nigeria did, but the Nigerian stock market experienced a slower restoration of volatility during the second and third regimes. This was due to the COVID-19 pandemic.

According to Markov estimates, China's stock market volatility recovered faster than Brazil's during the first regime (40.43 months versus 36.77 months). However, China's stock volatility recovered much faster during the second and third regimes (30.12 months and 23.45679 months, respectively) during the COVID-19 pandemic than during the second and third regimes (34.99 months and 35.99 months). In contrast to the first, second, and third regimes' durations of 29.78, 27.55, and 21.65 months, the anticipated durations in the regimes for the Brazilian FX market are 40.96, 47.98, and 33.99 months. Thus, the analysis confirms that, in contrast to China's forex market, volatility in the returns of the Brazilian foreign currency market before, during, and after the COVID-19 outbreak takes longer to fade off. The outcomes show how important the business cycle hypothesis is. In light of this, our research explains why the stock and foreign exchange markets in Ghana and Brazil, as opposed to Nigeria and China, respectively, are significantly more affected by cyclical fluctuations. The government should adopt a flexible exchange rate strategy that is adaptable enough to ensure the stability of the value of the national currency, according to the findings. In times of high exchange rates, the government may choose to increase its supply of foreign currency to the foreign exchange market, and in times of low exchange rates, it may choose to decrease it. One illustration of a discretionary policy is this one. Also, while making investment decisions in the stock and foreign exchange markets of Nigeria, Ghana, Brazil, and China, market players must seriously consider the impacts of seasonality. The researchers in this study faced some challenges, which they overcame to guarantee the achievement of the study's goals. Initially, the research only covered two BRICS and WAMZ countries. This was due to the difficulty in obtaining the pertinent data set for a few countries from the World Bank's Development Indicators database within the allotted time frame. For the estimating exercise, the researchers did, however, use data for the two nations that were accessible. In order to determine the seasonality impacts on foreign exchange rates and stock market closing prices rather than stock returns, we therefore propose the necessity of using more regularly occurring data, such as daily or weekly data.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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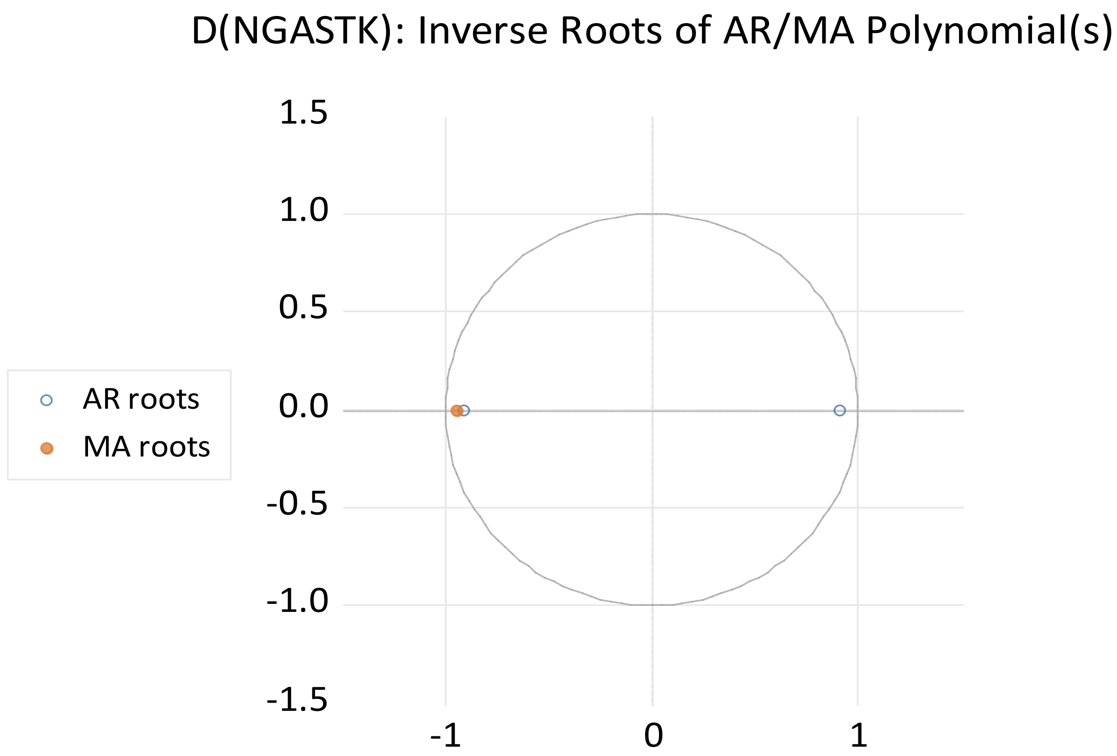
APPENDIX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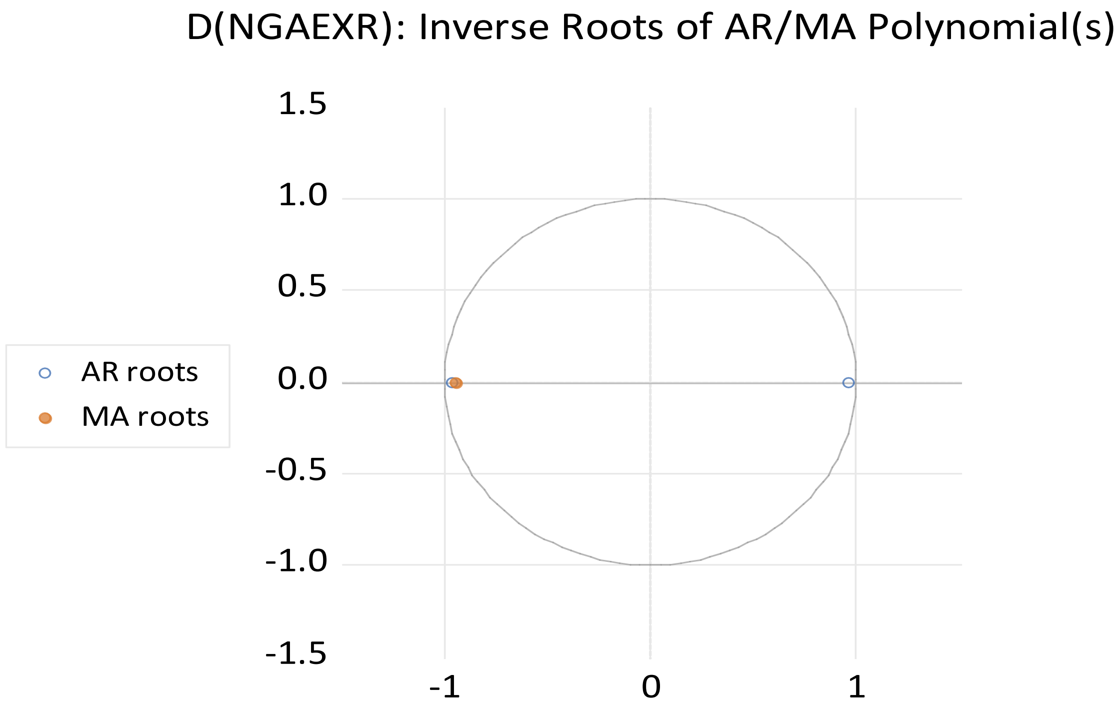
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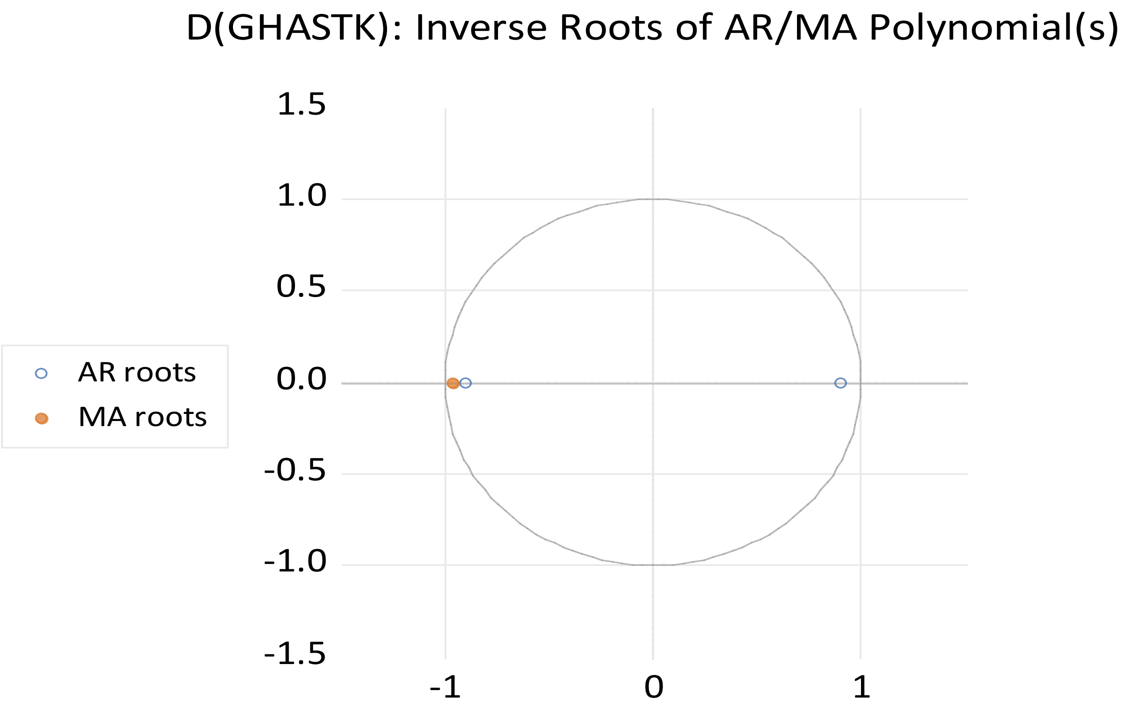
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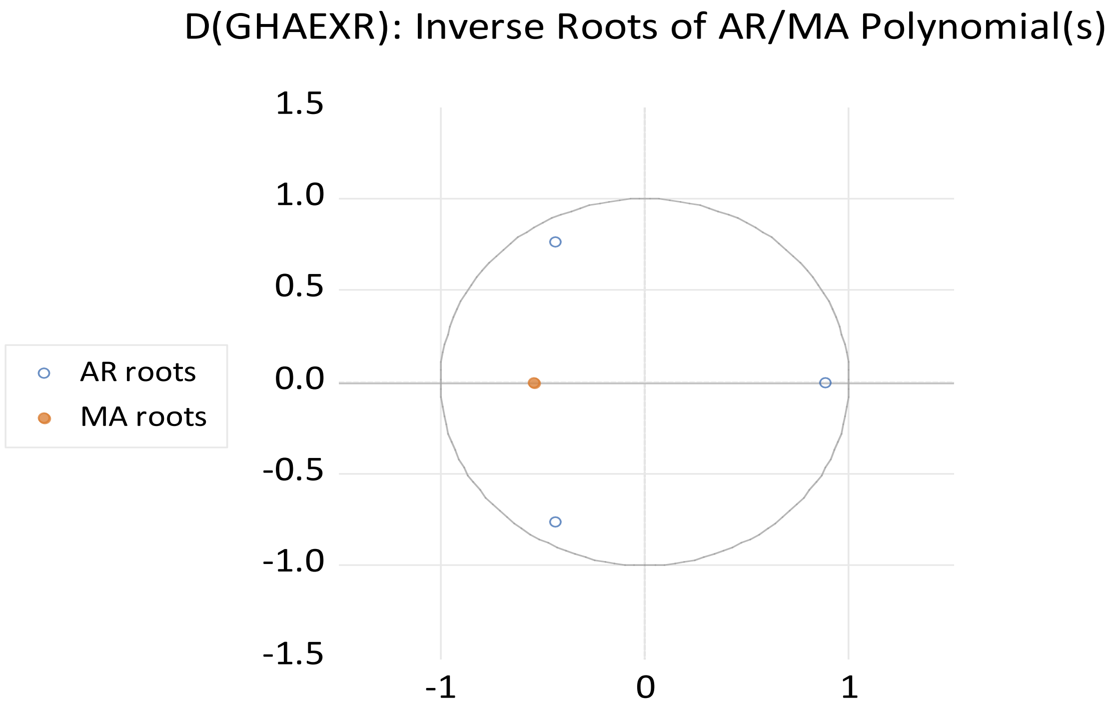
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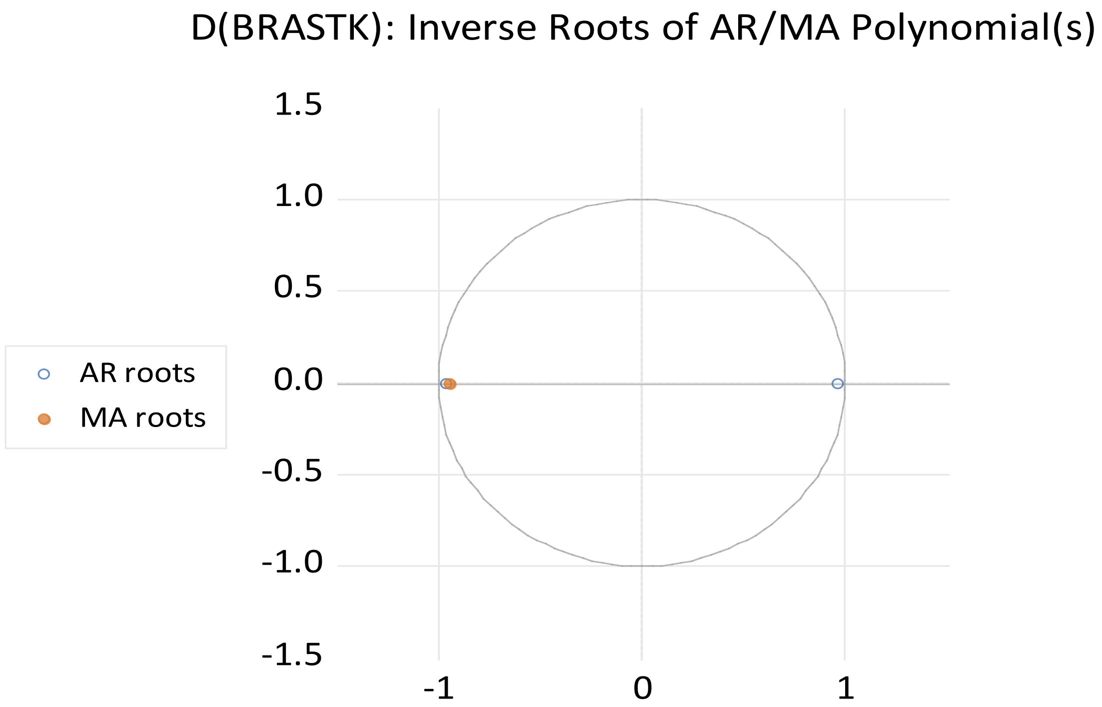
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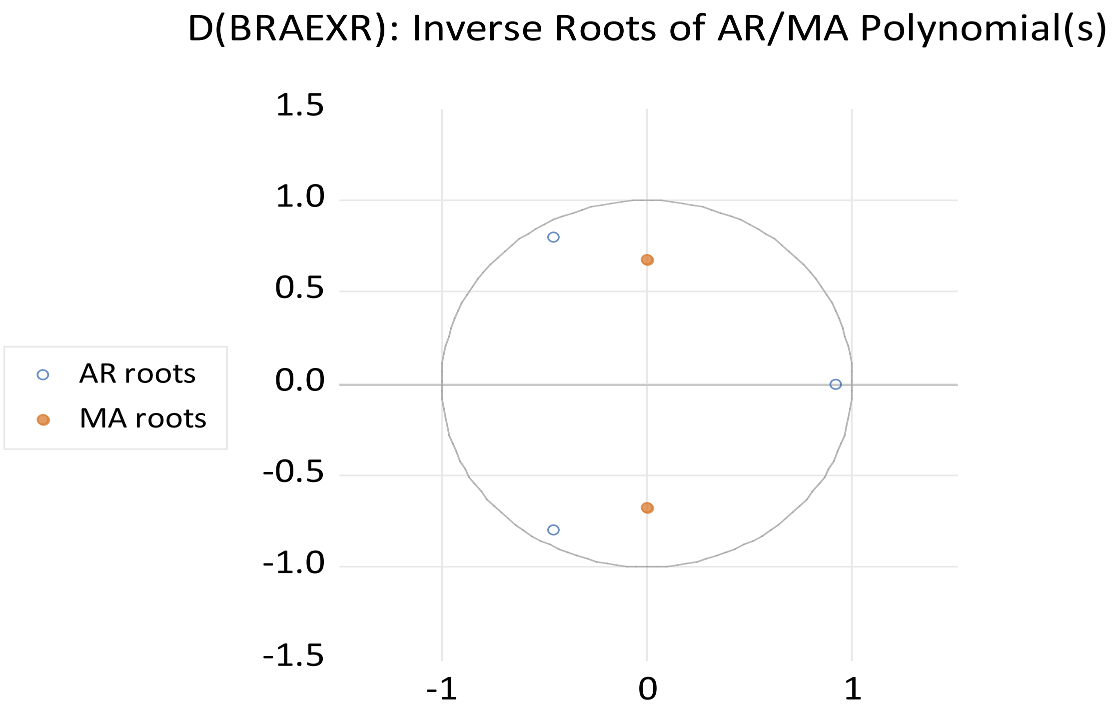
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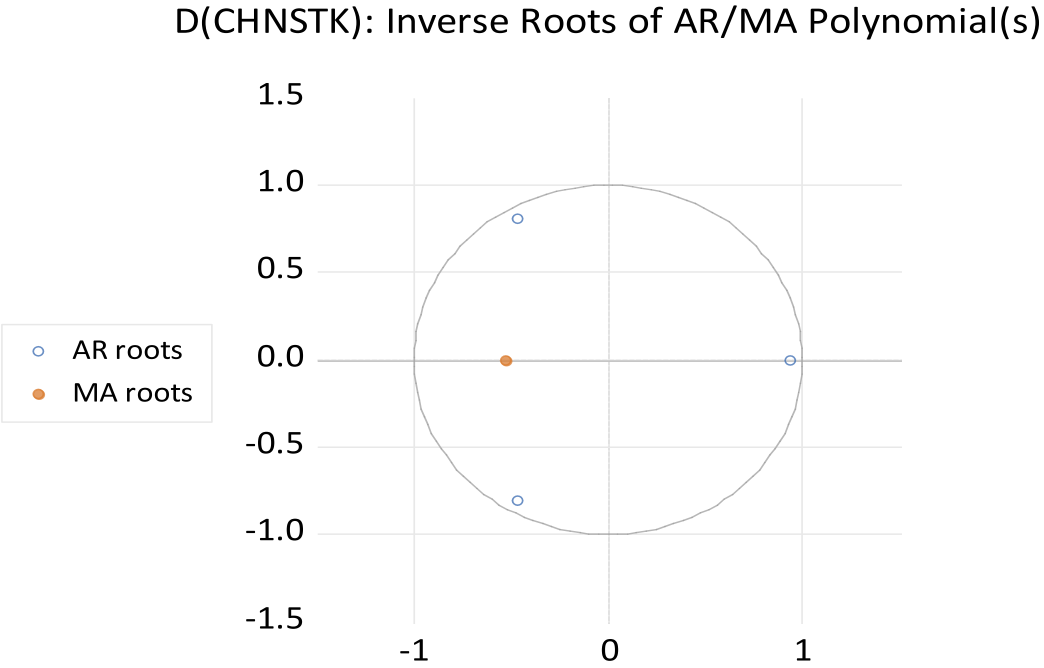

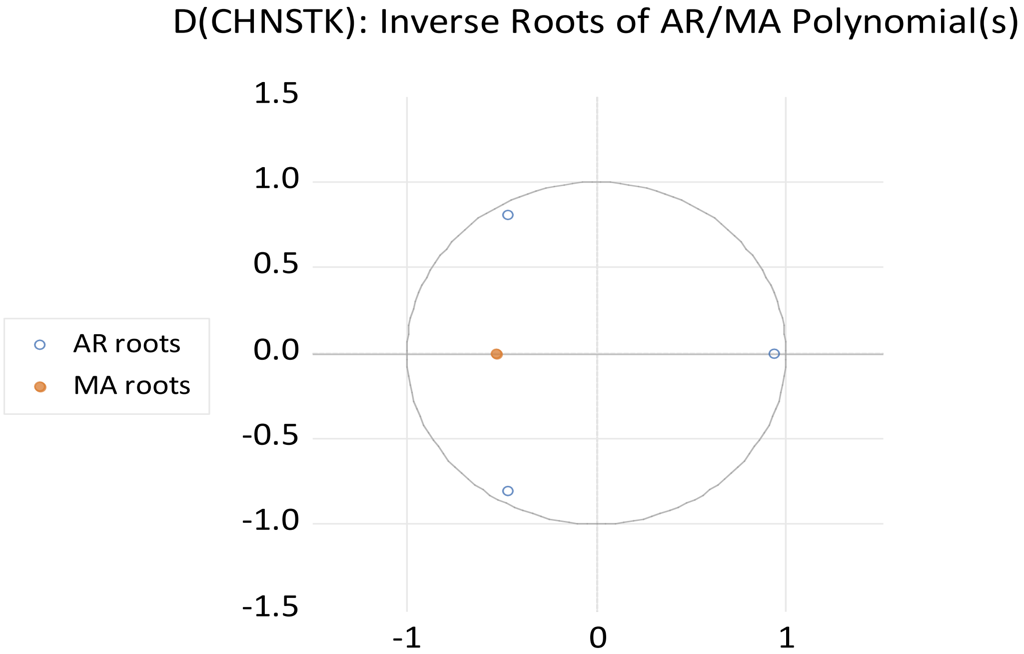

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