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Review article

Assessing the asymmetric interrelationships between sovereign bond yields and selected potential determinants: The case of frontier WAMZ economies

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ABSTRACT

The spot of frontier market economies in the global financial arena continues to be significant for many market participants because of their size, diversification advantage, and interconnectedness. Financial market innovations, globalization and pandemics have made it even more urgent to explore their dynamics. This paper focuses on analysing the risks associated with investing in frontier West African monetary zone bonds by appropriately modelling them in relation to cultural, administrative/political, geographic, economic and financial indicators that are specific to these countries, primarily due to their locations and interlinkages. This study employed the nonlinear autoregressive distributed lag model to investigate the asymmetric effects of different economic factors on sovereign bond yields in Ghana and Nigeria from July 2014 to September 2022 with 99 observations. Period selection allows researchers to unravel the complexities of market behaviour, investor sentiment, and policy effectiveness in the face of economic turmoil and uncertainty. The results provide valuable insights into how these factors affect bond yields differently in the two countries.

1. Introduction

Frontier markets are commonly known for their "less developed systems of accounting, regulation, and other financial infrastructure" in comparison to their developed market counterparts. Kearney points out that the capital markets of frontier economies are typically less efficient, with lower levels of trading activity and lower liquidity than developed markets, as observed by Wyman & WFE [1]. Global markets consistently demonstrate various advantages in advancing efficient and transparent sovereign bond markets. The government bond yield signifies the interest rates that governments need to pay for, acting as an indicator of the level of sovereign risk associated with a country. The yields of sovereign bonds have attracted the attention of numerous economic agents. First, governments are especially concerned about the yield of their bonds, whether they are newly issued or repurchased, as it directly impacts their costs. On the investor side, yield and volatility are of utmost importance since they represent the additional returns investors are willing to accept when assuming additional risk. Financial institutions and other economic agents also closely monitor government bond yields, as yields serve as a foundation for bond issuance and pricing in corporations within these countries.

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Previous studies have also shed light on the consequences of market contagion and interdependence in areas such as return behaviour, risk mitigation, global portfolio diversification, risk hedging and trading tactics, crisis management, and the formulation of policies and regulations [2-8]. The findings from these studies provide compelling evidence that financial markets' interlinkages have far-reaching effects on market participants both within individual economies and on a global scale. These observations have substantial implications for volatility modelling, suggesting the need to consider higher moments and explore alternative risk models. Thus, it is essential to adopt risk-modelling techniques that incorporate asymmetric distributions, which can capture extreme observations across various asset classes. This approach has become increasingly prominent in recent years. However, relying solely on risk modelling of financial market yields (returns) without considering country-specific time-invariant financial risks, independent of daily trading activities, is overly simplistic and potentially perilous for international portfolio decision-making.

This paper focuses on analysing the risks associated with investing in frontier market economy bonds by appropriately modelling them in relation to cultural, administrative (or political), geographical, economic and financial (CAGE*F) indicators that are specific to the countries under study, primarily due to their geographic locations and interlinkages. This analysis aims to enhance the effectiveness of international portfolio assessment. Our understanding of these linkages is limited, especially relating to frontier West African Monetary Zone (WAMZ) countries. This is motivated by recent debates surrounding the assets classes' financialization literature during the COVID-19 pandemic [9]. This study aims to significantly contribute to the literature by investigating how macroeconomic dynamics affect sovereign bond yields in frontier WAMZ economies. It particularly highlights the context of financial innovation during the pandemic and considers the unique macroeconomic challenges these economies confront, including weak institutions, fragile currencies, perceived corruption, market inefficiencies, and unsustainable debt levels. In light of these circumstances, the study delves into examining how these country-specific indicators exert a direct influence on sovereign bond yields. Understanding these dynamics could inform policymakers on effective strategies to strengthen institutions, improve currency stability, combat corruption, enhance market efficiency, and manage debt sustainability, thereby potentially reducing borrowing costs and promoting more stable economic conditions in frontier WAMZ economies. Higher bond yields indicate higher borrowing costs and are reflective of the risk profile of countries. Countries that are perceived as less risky, such as advanced economies, can borrow at lower interest rates than frontier economies. Therefore, comprehending the factors influencing bond yields in frontier markets is crucial, as it provides insights into the sources of sovereign risk. This analysis has become necessary due to recent increases in public debt in frontier countries, particularly on the African continent, coupled with credit rating agencies downgrading countries, including Ghana, Nigeria, South Africa, and Kenya [10]. The interest rate at which governments and corporations borrow is influenced by a combination of domestic and external economic factors. A well-functioning and growing economy sends positive signals to investors about the ability of governments and corporations to service their debts. Understanding the drivers of bond yields in frontier markets is vital for policymakers, investors, and stakeholders to make informed decisions and manage the risks associated with borrowing in these markets. It sheds light on the financial health and creditworthiness of frontier market countries, helping them navigate challenges and ensure sustainable economic growth.

Recent pandemics and wars have constrained fiscal space and made debt servicing more challenging for countries, particularly those with low growth and limited public revenues. For example, during the initial months of the COVID-19 pandemic, stimulus packages totalling $10 trillion were implemented worldwide. The European stimulus alone is equivalent to 30 times the present value [11]. The global debt reached $300 trillion, accounting for 260 % of GDP, and most developed countries surpassed the 100 % debt-to-GDP ratio. The leading economies adopting unconventional monetary policies have reduced the capacity of frontier economies to import and service sovereign debt. Credit rating agencies' risk assessments have often been influenced by implicit political criteria and have underestimated the economic scale of most frontier markets. For instance, despite steady growth of 3.6 % in 32 African countries, rating agencies have provided negative assessments for nearly twice as many countries as positive ratings, with Botswana being the exception on the entire continent. The crowding out effect of leading economies and credit rating downgrades has widened the gap between government bond yields and interest rates on swaps of the same maturity and currency denomination across the board. Such movements in government bond yields can have significant macroeconomic consequences, affecting consumption and investment decisions. For instance, higher government bond yields result in increased debt-servicing costs and can increase funding costs, leading to greater rollover risk. As risk aversion increases due to uncertainty about bondholders' ability to honour debt obligations, investors seek greater compensation for risk. Deleveraging and balance sheet-constrained investors developed a stronger preference for safer assets over riskier instruments, introducing differentiation among deficit units.

The field of studies and research on financial markets is vast and diverse, encompassing various aspects, such as market efficiency, liberalization, integration, capital flows, and return distributions [3,12,13]. Previous studies have utilized traditional composite market indices, stock market indices, currencies, macroeconomic variables, and commodities [14-19]. Moreover, the majority of these studies utilized low-frequency data spanning from annual to daily intervals. Despite these prior endeavours, the shifting terrain of financial asset categories, data generation methods, estimation techniques, and constantly evolving market conditions, in conjunction with the existing infrastructure, present opportunities for further studies to make significant and well-founded contributions to the literature on frontier market economies, especially on WAMZ economies. For instance, conventional time series techniques, such as autoregressive distributed lag (ARDL) cointegration analysis, error correction (EC) modelling, and Granger causality, are commonly employed by many researchers [20,21]. However, these econometric methods primarily focus on examining long-term relationships and short-term associations using symmetric analysis, often failing to capture potential asymmetries among variables. To address this limitation, a recent model by Pesaran, Shin & Smith was introduced as an asymmetric extension of the ARDL, known as the nonlinear ARDL cointegration procedure (NARDL), which is capable of capturing both long-term and short-term asymmetries among the variables under investigation [22,23]. This modelling approach is adopted in this study. Furthermore, another study explored the potential link between the utilization of woody biomass and economic growth, focusing on African countries [24], while a separate study

examined the relationship between energy consumption and economic growth within the context of the USA [25]. The NARDL is a valuable tool for investigating whether there are asymmetrical relationships between bond yields and selected potential determinants. The study adopts the Cultural, Administrative (or Political), Geographic, and Economic (CAGE) distance dimensions and extends to include the "Financial Distance" proxy by Global Liquidity Indicators [12]. This study examines the features of NARDL in the financial systems of frontier economies, focusing on the West Africa Monetary Zone (WAMZ). By doing so, the paper enhances our understanding of bond yield in frontier economies, revealing opportunities arising from latent differences in these markets despite their grouping. This knowledge can aid stakeholders in frontier market economies in making informed decisions to mitigate the negative effects of sovereign debt accumulation on economic activities.

This paper seeks to address the following question: Are there asymmetric interrelationships between bond yields and selected potential determinants? This question sheds light on the dynamics and complexities of sovereign bond markets. Addressing this issue will contribute to a deeper understanding of the financial landscape and assist stakeholders in making more informed decisions. The primary contribution of this paper is to fill the gap in our understanding of the frontier market bond yield of the WAMZ by utilizing the CAGE*F distance dimensions. Drawing insights from international trade, this approach highlights the significance of country-specific factors that can provide valuable insights for a comprehensive analysis of international bond yields. Moreover, it emphasizes the existence of distant dimensions that differentiate frontier market countries from each other. By focusing on these specific features, the study enhances our comprehension of the complexities and diversities within frontier markets, contributing to a more nuanced and comprehensive analysis of bond yield in these economies.

The introduction is followed by a literature review in section two; the methodology is described in section three; the results and discussion are presented in section four; and the paper concludes with policy implication in section five.

2. Literature review

This literature review seeks to assess the past and current status of asymmetric interrelationships in frontier finance. It looks at frontier market finance through risk assessment to provide important and new insights to the field. This section is organized into theoretical and empirical literature subsections.

2.1. Theoretical literature

The theoretical literature aims to explore the conceptual frameworks proposed for this paper. This subsection concentrates on theories regarding “distance dimensions” and “liquidity distance”.

2.1.1. “Distance still matters”

Pankaj Ghemawat’s term "distance still matters," challenges the idea that globalization has erased country differences, arguing that overlooking these differences is risky for cross-border trade. Recognizing these differences is crucial because they can negatively affect interactions but also reveal hidden opportunities. Misunderstanding this has led many multinational corporations to fail in their expansion efforts. Ghemawat highlights that various dimensions of distance can significantly affect foreign market assessments, influencing trade, bond investment, FDI, and equity flows. This understanding is essential for studying frontier market economies, which, despite being similarly classified, have distinct attributes that must be considered in investment and risk analysis [26].

2.1.1.1. The CAGE distance dimensions’ theory. The author applies the "distance still matters" concept using the CAGE distance framework, which categorizes country characteristics into cultural, administrative/political, geographic, and economic dimensions. Introduced in the early 2000s, this framework helps in international trade by identifying and prioritizing differences between nations for cross-border strategies. Ghemawat’s framework was endorsed [27]. This study was designed for industry and country levels, with implications both unilaterally and bilaterally. This study focuses on the bilateral level. Cultural distance includes language, ethnicity, religion, trust, norms, and values. Administrative distance involves colonial ties, regional trade blocs, common currencies, and political hostilities. Geographical distance considers location, borders, time zones, and climate. Economic distance addresses disparities in wealth, resource costs and quality, human resources, infrastructure, and knowledge bases [26,28].

The focus of this study lies in dissecting the aspects of economic distance. While frontier market economies are categorized by their wealth status and financial system stability, they can still benefit from a more comprehensive distance analysis. Therefore, this research delves into the nuanced differences that exist between these frontier market economies, especially in terms of their financial soundness. This culminates in the assessment of financial distance using liquidity indicators specific to frontier market economies.

2.1.1.2. Liquidity risk distance theory. Liquidity, characterized by the ease of financing or access to credit, is vital for investors aiming for financial stability in the markets where they invest. It provides assurance of resilience, irrespective of specific investment assets, and serves as a positive signal of goodwill. Country-specific liquidity measures are essential for assessing systematic risk at the economic or country level beyond individual asset idiosyncratic risk. Incorporating liquidity measures in international portfolio diversification strategies enhances overall risk assessment and provides a comprehensive understanding of the risk landscape [12]. The BIS has developed global liquidity indicators, encompassing both domestic and international total credit flows, which are significant for supporting financial systems. Many frontier market economies (FMEs) and developing countries now have access to quality monetary data and are significant international borrowers, with financial institutions assessing them based on their monetary discipline [29].

Liquid markets offer benefits such as improved allocation and information efficiency, making financial assets more attractive to investors and enabling easier transactions. They also help financial institutions manage greater asset-liability imbalances, lowering the likelihood of central banks intervening as lenders of last resort. Observing market liquidity conditions aids in averting and anticipating systemic liquidity crises, thereby enhancing financial stability [30,31]. Foreign investors in frontier market economy bonds should consider global liquidity due to its bidirectional relationship with risk appetite. Liquidity conditions influence risk appetite and vice versa, making it a critical factor to consider in investment decisions.

Studies highlight liquidity's significance for stakeholders [32,33,34,71]. Lower liquidity in assets or markets raises liquidity risk premia, increasing transaction costs and bid-ask spreads. Investors may seek a premium for bearing liquidity risk, especially during systematic and persistent liquidity shocks. Liquidity encompasses executing large transactions with limited price impact, low costs, and immediate execution. Deep and liquid financial markets are crucial for stability, enabling risk management and funding. Ensuring liquidity enhances financial stability and supports efficient risk management. Prudent liquidity levels are vital for economic sustainability and are viewed as the lifeblood of financial systems. Financial systems uphold cautious liquidity levels to withstand unexpected shocks, using liquid assets as insurance. Systemic liquidity requirements alleviate contagion and prevent collapse. Liquidity can internalize market externalities, which are vital during financially distressing periods when risk appetites are low and capital buffers may be insufficient.

In financial risk analysis, choosing the appropriate liquidity indicator is crucial because of its significance to individual investors and the overall stability of the financial system. Previous studies emphasize the crucial role of liquidity in finance research and stress the need to identify high-quality proxies for liquidity [34,35]. Global liquidity serves as an advanced measure of financial stress, offering insights into both the financial sector and the real economy by monitoring various cross-border flows. It provides a comprehensive quantitative assessment of credit that goes beyond traditional measures such as money supply and interest rates.

The financial literature is rife with diverse measures and proxies of liquidity. For instance, the International Monetary Fund (IMF) constructs liquidity measures by incorporating turnover rates and price impact metrics to evaluate different facets of market liquidity, encompassing tightness (costs), immediacy, depth, breadth, and resilience [34,35]. The methodology for determining the global valuation of liquidity risk acknowledges that liquidity risks are valued separately from market risks in global financial markets and fluctuate across nations due to geographical, economic, and political considerations. The authors acknowledge that considering multiple measures is essential since there is no singular theoretically accurate and universally embraced gauge for ascertaining the extent of liquidity in a market. Market-specific factors and idiosyncrasies must be considered [20,36]. This measure emphasizes the systematic dimension of liquidity, providing valuable insights for international portfolio diversification. A similar study developed four distinct aggregate measures of illiquidity (inverse of liquidity) to evaluate the pricing consequences of liquidity risk in the liquidity-adjusted capital asset pricing model [37].

Previous literature reviews have successfully categorized liquidity measures based on various features and their relation to asset classes or pricing. However, these studies have several limitations, such as overlooking certain features and low-frequency measures and neglecting broader aspects of liquidity measures, including dimensions, data frequency, cost of computing, data availability, instantaneity (periodicity), predictability, and potential usage [2,38]. This study employed the BIS global liquidity indicator, which offers a more comprehensive scope than many other indicators, as they conform to the IMF's liquidity construction. The Committee for Global Financial Stability (CGFS) also advocates quantity measures for capturing potential risks.

This study examines the spatial risk characteristics of frontier market economies through financial distance using time-invariant country-specific risk attributes. This finding aligns with the literature, which has extensively studied time-invariant factors related to CAGE and physical distance components. Given the uncertainty in liquidity measures, aggregate credit is a suitable proxy for financial distance. Studies stress the importance of aggregated credit in gauging international liquidity, especially in complex risk environments. Global credit aggregates offer insights into vulnerabilities in recipient countries' financial systems linked to cross-border credit flows, which strongly correlate with uncertainties in the global financial system. Thus, global liquidity indicators are vital for stability assessments, providing valuable insights into risk assessment by incorporating country-specific characteristics alongside global liquidity considerations [12,27,35,39,40].

2.2. Empirical literature

2.2.1. Bond yield determinants

Political stability and geopolitical tensions are recognized as significant sources of uncertainty in bond markets, affecting investor confidence and yield levels [41]. The researchers specifically investigate the impact of political risk on sovereign bond spreads, revealing how these factors contribute to market volatility and influence investors' perceptions of risk.

Recent research highlights the varying effects of governmental responses to economic shocks on bond yields. Studies examining economic resilience during crises, such as the COVID-19 pandemic, illustrate diverse strategies and their consequential impacts on bond market dynamics [42].

Sector-specific characteristics, contribute to distinct fluctuations in sovereign bond yields. This phenomenon gains prominence amidst global transitions towards sustainable finance and the adoption of climate-related policies [43].

Other studies indicate a connection between rising long-term financing expenses and the displacement of the private sector, given

that governments are often perceived as risk-free or more creditworthy than private entities (29, 44, 45 & 46). The researchers investigated the "role of budget variables in assessing country-to-country solvency". The researchers posited a positive lineage with budget deficit and government bond yields [29]. Kameda conceded that a sovereign deficit increase impacts sovereign bond yield through Japanese government bonds. The researcher determined that a one-percent increase in debt-to-GDP resulted in a 0.0026 increase in bond yield [44]. Similarly, Gill posited that the coefficients of debt-GDP and the interest rate in selected countries in Europe are related to both positive and negative relationships [45]. However, Capelle-Blancard et al. studied 20 OECD companies using ESG and concluded that ESG performance decreases risk default and the sovereign bond yield [47]. One study posited that a country with high credibility in relation to political stability, good economic management and better debt servicing management would have a lower bond yield, which may result in deficit expansion [28]. To understand its relationship to bond yield, numerous researchers have also investigated a public debt variable, which is also a macroeconomic indicator. The key among them include [33,46,48].

Poghosyan expanded upon the research conducted by Kinoshita and Laubach, utilizing data from 22 advanced countries. They suggested that an increase in the debt-to-GDP ratio is positively associated with bond yields [48]. Jaramillo & Weber examined the impact of rising debt-to-GDP ratios on bond yields in emerging economies, concluding that an increase in public debt leads to a greater rise in bond yields due to uncertainty surrounding economic growth prospects [33]. Pharm conducted empirical studies spanning 18 years on bond yields and sovereign debt in emerging Asian markets, revealing weak to negative correlations between sovereign bond yields and government debts [46].

Other researchers have examined macroeconomic variables, including monetary policy, and proposed that they influence nominal interest rates through their impact on inflation expectations. Inflation is often considered a proxy for the quality of economic management; hence, a higher inflation rate suggests a lower creditworthiness rating [49]. Nguyen & Bui studied government expenditures and economic growth, emphasizing the role of corruption control. They found a significant positive relationship [50].

Researchers have examined the factors affecting the sovereign bond differential in European Monetary Union countries using Bayesian model averaging. The findings revealed that the GDP ratio and term of growth were significant, with a 100 % probability of inclusion. Market sentiment also played a crucial role, with a 99 % probability of inclusion and a positive effect. Trade balance had an 80 % probability of inclusion with a favourable outlook and a 73.1 % probability with a negative effect [42]. Furthermore, the study highlighted several factors with positive signs for inclusion, such as the total sovereign credit-to-GDP ratio, the median interest rate, GDP growth, inflation change, capital formation, and the US interest rate. Conversely, inflation, total debt, and the total debt-to-EMU debt ratio had negative signs upon inclusion in the model [21].

The empirical literature contains numerous studies comparing estimates of ADR and NARDL [21,24,25,51,52]. While this review provides a few examples, it is worth noting that a key limitation of these studies is their lack of application to WAMZ sovereign bond yields, particularly those involving distance dimensions. They lack the ability to explicitly examine spatial interdependencies among countries to offer a wider range of information for risk management objectives.

2.2.2. CAGE finance distance framework and liquidity risk distance

Aligned with the CAGE distance framework, various distance measures, primarily economic, are used to identify disparities or similarities between economies to assess their risks and opportunities. The authors analyse the resemblances between economies to gauge their risks and opportunities. They characterize economic distance as the most significant percentage disparity in unit costs across 35 sectors in 40 countries, illustrating the smallest uniform ad valorem tariff capable of halting bilateral trade. Conley & Ligon, investigating cross-country economic growth spill overs, employ the transportation costs of physical and human capital elements, calculated through UPS shipping rates and airline fares, as indicators of economic distance [20,53].

Another study established country distance rooted in psychic distance, utilizing information from 170 Spanish SMEs and 99 potential export markets. This technique characterizes country distance by disparities in national culture, language, education, industrial development, political systems, religions, and time zones. Martin & Drogendijk expanded on this by developing a country distance index using partial least squares analysis of socioeconomic progress, physical attributes, and cultural and historical differences [10, 32].

Previous studies [12,56,57] support the use of the BIS GLI's liquidity for risk measurement, highlighting its importance for international financial stability. In this study, researchers propose "financial distance," adapting the CAGE framework and international trade concepts to country-specific liquidity measures. They adopted the CGFS approach, which has contributed to the current BIS indicators for global liquidity and clarified the ambiguity surrounding their measurement.

Again, the CAGE framework has seen gradual application both in internationalization decision making in MNCs and in trade. For instance, we employ the CAGE framework to assess the distances between Croatia and EU member countries in terms of the opportunities for trade. Combining these differences and similarities, the author concludes that cooperation has potential for development in Croatia [58]. In addition, per capita GDP is used as a measure of relative economic distance to investigate the effect of bilateral foreign trade and FDI inflows on Vietnam in combination with ASEAN countries, Korea, Japan, Australia, and New Zealand. A significant positive influence is evidenced for Vietnam [59].

The finance literature has struggled to determine the factors driving cross-border fund flows, while international macroeconomic and trade studies have shown promise with distance measures. While finance research traditionally focuses on portfolio adjustments and flow-return relationships, it is increasingly drawing from international trade and distance measures for insights into cross-border flows. However, geographical disparities present both risks and rewards, motivating this paper's investigation. Importantly, limited research exists on frontier sovereign states in this context, and no studies consider country-specific characteristics. Therefore, extending the study to incorporate distance concepts such as CAGE factors for unstudied countries offers an opportunity to contribute new insights to the sovereign bond market literature. The discussion highlights that existing research on cross-border flow drivers

primarily revolves around geographic distance within the CAGE framework or physical distance. However, this study introduces a novel distance indicator, termed financial distance, to complement the CAGE framework. Financial distance will be applied specifically to cross-border bond flows, serving as a systematic tool for financial risk assessment. This indicator is measured using Global Liquidity Indicators[1] (GLI) utilized for Frontier Market Economies.

3. Methodology

3.1. Data and variables

Table 1 depicts the data variables for sovereign bond yields in Ghana and Nigeria, along with the rationale for their selection, covering the period from July 2014 to September 2022 using monthly figures with a total of 99 observations. This period offers a rich context for understanding how market variables in WAMZ economies respond to global uncertainties. Period selection allows researchers to unravel the complexities of market behaviour, investor sentiment, and policy effectiveness in the face of economic turmoil and uncertainty.

3.2. Nonlinear autoregressive distributed lag (NARDL)

Previous studies [60,61,62] have discussed various aspects of finance by relying on parametric gravity and spatial econometric models, which may be constrained by distributional assumptions. To address this limitation, this paper employs nonlinear autoregressive distributed lag (NARDL) analysis based on country-specific liquidity measures. By clustering countries based on liquidity distances and testing autocorrelations, this study aims to inform decision-making regarding bond investments, particularly for risk management and portfolio diversification. Additionally, it explores whether investors should focus on bonds from neighbouring countries with similar financial distances to their home economies. This study is unique in WAMZ frontier markets.

The NARDL method was adopted to investigate the potential asymmetry in the determinants of sovereign bond yields in both the short term and long term. This method allows for cointegration and asymmetric drift between variables simultaneously [52]. This approach offers advantages over GARCH models, providing flexibility by not requiring all variables to be integrated of order one (I(1)) and allowing for cointegration. Additionally, the NARDL model can satisfy robustness tests even with smaller sample sizes, making it an appealing choice. The researchers' ability to examine both short-term and long-term asymmetric relationships between sovereign bond yields and their potential determinants has driven the use of this methodology. The NARDL is a great tool for detecting whether asymmetrical interrelationships exist among sovereign bond yields and their underlying determinants.

The NARDL differs from earlier models, such as the ARDL cointegration model, in which the NARDL gauging approach ignores the impact of asymmetry by decaying the interpretive datasets into their partial incremental sum of gains (+) and losses (−) changes; the NARDL method aids in the exploration of the linkages between positive and negative alterations. Equation (1) depicts the nexus of the long-run asymmetry breakeven point as follows [52]:

$$y_1 = \beta^{+1} X_t^{+1} + \beta^{-1} X_t^{-1} + \varepsilon_t \tag{1}$$

where $\beta^{+I} + \beta^{-I}$ represents the asymmetrically abiding framework that reflects asymmetric changes, ε_t denotes system noise, and y_1 is the regressand. X_t is a k*l matrix of regressors expected to decay, as shown in equation (2) below

$$X_t = X_t^{+1} + X_t^{-1} \tag{2}$$

$X_t^{+1} + X_t^{-1}$ represent skewed cumulative total values of (+) and (−) alterations in X_t, respectively, as written in equation (3) below.

$$X_t^{+1} = \sum_{j=1}^{t} \Delta X_t^{+1} = \mathrm{Max}(\Delta X; 0), X_t^{-1} = \sum_{j=1}^{t} \Delta X_t^{-1} = \mathrm{Min}(\Delta X; 0) \tag{3}$$

A combination of equation (1) and the ARDL unrestricted (p, q) produces below the error correction model of the asymmetric stance.

$$\Delta X_t = \alpha 0 + r y_{t-1} + \beta^{t1} X_{t-1} \sum_{j=1}^{p-1} \Delta X_t^{+} ej \Delta y_{t-1} + \sum_{j=1}^{p-1} \left[\!\left[\Delta X_t^{-} \mathrm{ej} \Delta y_{t-1} + \sum_{j=1}^{p-1} \pi^{+1} + \Delta X_{t-J}^{+} + \pi^{-I} \Delta X^{-}{}_{t-J} \right) \right. \tag{4}$$

Equation (4) above is fairly representative of the asymmetric variations among X_t^{+1} and y_{t-1} $\sum_{j=1}^{P-1} Xt^{+}$ and indicates the level momentary "asymmetric dynamics" of ΔX_t and the long-term asymmetric coefficient" of X_t premediated

$$\beta^{\dagger} = \frac{\Theta +}{r}, \frac{\Theta^{-}}{r}$$

[1] Junior & Alagidede (2020) defined liquidity indicator as US dollar denominated credit to non banks outside of the US. This comprises both foreign credited and domestic denominated in US dollars to non banks in the respective recipient country agents.

Table 1
Data variables used.

Objective	Variable(s)	Rationale	Freq.	Duration	Source(s)
Sovereign Bond yield	• FTSE (FRNTEMGBI) • Global Liquidity indicators	• Estimate bond yield among FMEs • Assess CAGE*F's impact on bond yield among FMEs	Monthly	2014–2022	MSCI, Bloomberg, DataStream, BIS, Central Bank sources

Notes. The table depicts the variables and rational for their selection. The frequency, duration and sources are also outlined.

The expanded NARDL model used to estimate the variables under study is represented by equation (5) below

$$\begin{aligned}\Delta SDY_t = {} & \alpha 0 + rSDY_{i,t-1} + \beta^{+1} LE_{i,t-1} + \varnothing^{+1} CP_{i,t-1} + ¥^{+1} LF_{i,t-1} + \delta^{+1}\, PR_{i,t-1} + \beta^{-1} LE_{i,t-1} + \varnothing^{-1} CP_{i,t-1} + ¥^{-1} LF_{i,t-1} + \delta^{-1}\, PR_{i,t-1} \\ & + \sum_{j=1}^{p-1} \Delta rSDY_{i,t-1} + \sum_{j=1}^{p-1} \left(\Delta\beta^{+1} LE_{i,t-1} + \beta^{-1} LE_{i,t-1}\right) + \sum_{j=1}^{p-1} \left(\Delta\varnothing^{+1} CP_{i,t-1} + \Delta\varnothing^{-1} CP_{i,t-1}\right) + \sum_{j=1}^{p-1} \left(\Delta¥^{+1} LF_{i,t-1} + \Delta¥^{-1} LF_{i,t-1}\right) \\ & + \sum_{j=1}^{p-1} \left(\Delta\delta^{+1}\, PR_{i,t-1} + \Delta\delta^{-1}\, PR_{i,t-1}\right) + \varepsilon_t \end{aligned} \tag{5}$$

where SDY = sovereign bond yield; the level of liquidity (LE); the consumer price index (CP); the level of fraud (LF); and the political risk (PR) of the jth sovereign region at time t. α0 is the intercept, and ξt is the error term.

Empirically, the SDY and CP are logarithmically transformed. All other variables are in percentage terms. LE^+, CP^+, LF^+ and PR^+ represent the partial positive changes in the underlying variables. LE^-, CP^-, LF^- and PR^- represent the partial (-changes) of the components under study.

The NARDL model was used to estimate the asymmetric cumulative dynamic multiplier effect on y_1 of a unit change in X_t^+ and X_t^-. The positive and negative cumulative multiplier effects are represented by W_n^+ and W_n^-, respectively, in equation (6) [52]:

$$W_n^+ = \sum_{j=o}^{i} \left(\frac{\#yt+j}{\#Xt}\right);\; W_n^- = \sum_{j=o}^{i} \left(\frac{\#yt-j}{\#Xt}\right) \mathrm{i} = 0, 1, 2 \tag{6}$$

It is important to understand the multiplier effect, as enumerated above, which can be used to interpret the lengths of timing and the adjustments of disequilibrium if h $\rightarrow\infty$, $W + _n \rightarrow \beta^+$ and $W_n^- \rightarrow \beta^-$, where β^+ and β^- represent the asymmetric long-term parameters. By bootstrapping 10,000 times, the confidence level of the dynamic multiplier effect can be obtained.

4. Results and discussion

Global financial markets have experienced remarkable growth and transformation over the past few decades, with emerging and frontier economies becoming increasingly integrated into the global financial system. The Frontier WAMZ (West African Monetary Zone) economies, comprising countries such as Nigeria, Ghana, Gambia, Guinea, Sierra Leone, and Liberia, have experienced significant growth in their financial markets, including their bond markets [30,55]. These countries' bond markets have played a crucial role in financing their respective governments' fiscal needs and providing investment opportunities for institutional and individual investors.

The objective of this study is to explore how bond yields in the WAMZ economies are affected by various factors, which is vital for market participants, policymakers, and academics. It specifically examines the intricate relationship between bond yields and selected determinants within these economies, with a particular focus on bond market dynamics and market structure. Through this examination, the study aims to elucidate how these factors interact and influence bond yields. This analysis is critical for shaping effective monetary and fiscal policies, as well as guiding strategic investment decisions.

Table 2
Descriptive statistics for Ghana and Nigeria.

		Mean		Standard. Deviation		Minimum		Maximum	
Variable	Obs.	Ghana	Nigeria	Ghana	Nigeria	Ghana	Nigeria	Ghana	Nigeria
CPI	99	79.689	277.862	21.154	88.041	46.850	159.7	140.600	478.2
Fraud	99	120.717	160.091	92.858	61.398	47.000	40	246.000	224
Political Risk	99	4.657	184.222	1.423	3.776	3.000	173	7.000	189
Liquidity index	99	3635.818	5164.687	2217.642	2952.069	1250.000	1521.333	7532.667	10842.333

Notes: This table reports the results of the descriptive statistics of countries understudy. The mean, standard deviation minimum and maximum variables are analysed.

4.1. Descriptive statistics

In this section, we present the descriptive statistics for the variables used in the study for both Ghana and Nigeria. Table 2 provides an overview of the observations, means, standard deviations, minimums, and maxima for bond yield, the consumer price index (CPI), fraud, political risk, and the liquidity index for Ghana and Nigeria.

4.1.1. Bond yield

Fig. 1 shows that the bond yields in Ghana and Nigeria experienced significant fluctuations from July 2014 to September 2022. This essay will discuss some key events and trends that could have influenced the bond yields in these countries, focusing on specific months and yield volumes while providing in-text citations to support the claims.

Between 2014 and 2016, both Ghana's and Nigeria's economies were negatively impacted by the decrease in oil prices [63]. The decline in oil prices led to reduced government revenues and increased fiscal deficits, prompting higher bond yields as investors demanded higher returns to compensate for heightened risks [64]. For example, Ghana's bond yields increased from 25.75 in July 2014 to a peak of 26.41 in August 2014, while Nigeria's bond yields rose from 11.67 in July 2014 to 14.84 in December 2014 (see Fig. 1).

In 2015–2016, Nigeria experienced a currency crisis and economic recession, which resulted in high inflation and even higher bond yields [30]. Investors required more significant compensation for the risks associated with investing in Nigerian bonds, pushing bond yields up to 16.71 in September 2015. Ghana's bond yields also increased during this period, reaching 25.72 in November 2015.

In 2017, both countries experienced economic recovery, with improved oil prices and increased political stability [64]. This recovery likely contributed to a decrease in bond yields as investor confidence improved and perceived risk decreased. Ghana's bond yields decreased from 19.96 in January 2017 to 16.16 in February 2018, while Nigeria's bond yields decreased from 16.73 in January 2017 to 13.71 in April 2018.

Fig. 1 further shows that the COVID-19 pandemic in 2020 caused significant economic disruptions worldwide, affecting both Ghana and Nigeria [30]. Bond yields initially spiked due to heightened uncertainty and risk aversion, with Ghana's bond yields reaching 22.78 in January 2020 and Nigeria's bond yields peaking at 9.89 in the same month. However, bond yields later declined as central banks around the world implemented accommodative monetary policies to support their economies [30]. By June 2020, Ghana's bond yield had decreased to 20.00, and Nigeria's bond yield had decreased to 7.96.

In 2022, Ghana experienced a significant spike in bond yields, possibly due to increased concerns over the country's fiscal sustainability and rising inflation [65]. Ghana's bond yields surged from 22.12 in April 2022 to a staggering 41.16 in September 2022. On the other hand, Nigeria experienced relatively stable bond yields during this period, potentially reflecting improved economic conditions and investor confidence in the country's macroeconomic management. Nigeria's bond yields hovered approximately 10.00–13.13 between April and September 2022 [65].

4.1.2. Independent variables

Table 2 displays the descriptive statistics for Ghana and Nigeria, focusing on four key variables: the consumer price index (CPI), fraud, political risk, and the liquidity index. The discussion analyses these statistics by juxtaposing them with the literature and incorporating in-text citations.

The CPI is an important indicator of inflation in an economy. In Ghana, the mean CPI is 79.69, with a standard deviation of 21.15, indicating a relatively low inflation rate. On the other hand, Nigeria's mean CPI is much greater at 277.86, with a standard deviation of 88.04, suggesting higher inflation levels in the Nigerian economy [64]. This difference could be attributed to various factors, such as differing monetary policies, fiscal policies, and structural factors within the two economies [31].

Fraud is a critical concern for investors and can impact investment decisions in a country. In Ghana, the average fraud level is 120.720, with a standard deviation of 92.860, while in Nigeria, the mean fraud level is greater at 160.090, with a standard deviation of 61.400. This finding suggests that Nigeria may have more significant fraud issues than Ghana does, which could negatively impact investor confidence in the country.

Political risk is another crucial factor that investors consider when making decisions about investing in a country. In Ghana, the

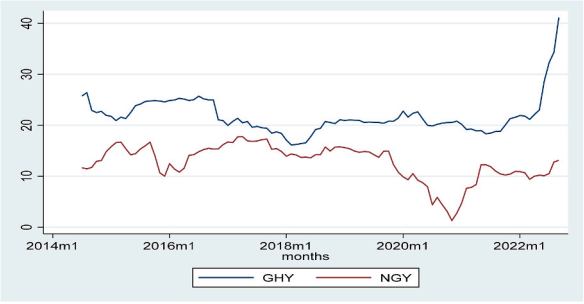

Fig. 1. Bond yields for Ghana and Nigeria.
Source: Authors' own construction 2023

average political risk score is 4.66, with a standard deviation of 1.42, indicating moderate levels of political risk. In Nigeria, the political risk score is much greater, with a mean of 184.22 and a standard deviation of 3.78. This indicates that Nigeria may have a greater level of political risk than Ghana [64]. The difference in political risk could be attributed to factors such as the level of political stability, governance, and the prevalence of conflict in the two countries [66].

The liquidity index is a measure of the ease with which assets can be converted into cash in a market. A higher liquidity index suggests a more liquid market, which is generally more attractive to investors [30]. In Ghana, the mean liquidity index is 3635.82, with a standard deviation of 2217.64, while in Nigeria, the average liquidity index is significantly greater at 5164.69, with a standard deviation of 2952.07. This suggests that Nigeria's market is more liquid than Ghana's market is, which may attract more investors seeking ease of entry and exit from the market.

4.2. Stationarity test

The stationarity test is a crucial phase in time series analysis that serves to ascertain the stationary nature of a time series. A stationary time series maintains constant statistical properties, including mean, variance, and autocorrelation, over time. Nonstationary time series data can result in misleading regression outcomes and erroneous inferences. The augmented Dickey–Fuller (ADF) test and the Phillips–Perron (PP) test are widely employed for assessing stationarity and are the most common methods for this purpose.

Table 3 presents the results of the ADF and PP tests for Ghana. The results indicate that all variables are nonstationary in level but become stationary after taking the first difference, suggesting that they are integrated of order one, I(1). The same pattern is observed in Table 5 for Nigeria, with all variables being nonstationary in level but stationary after taking the first difference, confirming their I (1) status.

The presence of nonstationary in levels for both Ghana and Nigeria implies that these time series data may exhibit trends, seasonality, or random walk behaviour, causing their mean and variance to change over time. Taking the first differences, however, removes these nonstationary components and makes the series stationary. This approach is crucial in time series analysis because using nonstationary data in regression models may lead to unreliable results and misleading conclusions.

The results from Table 4 demand further analysis using cointegration tests and error correction models to examine the long-run relationships between the variables [67]. Additionally, since the variables are stationary in first differences, differenced variables can be used in vector auto regression (VAR) or vector error correction (VECM) models to investigate the short-term dynamics and Granger causality among variables [67].

4.3. Optimal lag length selection

4.3.1. Ghana

For Ghana, the optimal lag length for the time series model is determined by examining various statistical criteria. At lag 0, the Akaike information criterion (AIC), Hannan–Quinn information criterion (HQIC), and Schwarz Bayesian information criterion (SBIC) exhibit high values. However, at lag 1, these values significantly decreased, suggesting an improved model fit (Table 5).

The Lagrange multiplier test further supported this finding, revealing a notable improvement in the model from lag 0 to lag 1 ($p = 0.000$). Although lag 2 also shows statistical significance, the increase in AIC, HQIC, and SBIC compared to lag 1 implies that lag 1 is the most suitable choice for balancing model complexity and data fit (Table six).

4.3.2. Nigeria

As indicated in Table 6, the determination of the optimal lag length in the time series model involves analysing various statistical measures. The results show that at lag 0, the values for AIC, HQIC, and SBIC are relatively high, indicating a poorer fit. At lag 1, there was a significant improvement in model performance, as evidenced by the LR test ($p = 0.000$) and lower AIC, HQIC, and SBIC values.

However, at lag 2, the model further improved, with the lowest FPE and AIC values, and continued to significantly change according to the LR test. This finding suggested that lag 2 is the most appropriate choice, as it provides a balance between model complexity and data fitting accuracy (see Table 6).

Table 3
Stationarity test for Ghana.

Variables	Levels		First Differences		
	ADF	PP	DF PP		I
Bond yield	−1.765	−2.142	−3.961**	−6.613***	I [1]
CPI	−1.641	−3.890**	−3.542**	−5.851***	I [1]
Fraud	−1.580	−1.366	−5.639***	−9.836***	I [1]
Political Risk	−2.302	−1.182	−5.991***	−10.170***	I [1]
Liquidity index	−2.096	−1.154	−6.197***	−10.253***	I [1]

Notes: The values are the test statistic which are compared with the test critical values/asymptotic critical values at 1 %, 5 % and 10 % significant levels. I is the order of Integration and ***$p < 0.01$, **$p < 0.05$, *$p < 0$.

Table 4
Stationarity test for Nigeria.

Variables	Levels		First Differences		I
	ADF	PP	ADF	PP	
Bond yield	−2.461	−1.900	−6.511***	−8.626***	I (1)
Consumer price	−1.959	−1.416	−3.648**	−3.813**	I (1)
Fraud	−1.882	−1.944	−5.477***	−9.747***	I (1)
Political Risk	−3.946	−3.230	−5.838***	−9.794***	I (1)
Liquidity index	−2.066	−1.861	−5.636***	−10.528***	I (1)

Notes: The values are the test statistic which are compared with the test critical values/asymptotic critical values at 1 %, 5 % and 10 % significant levels. I is the order of Integration and ***p < 0.01, **p < 0.05, *p < 0.

Table 5
Optimal lag length selection for Ghana.

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	−1994.04				1.3e+12	42.0851	42.1394	42.2195
1	−1290.78	1406.5	25	0.000	820203*	27.8059*	28.1317*	28.6123*
2	−1268.46	44.63*	25	0.009	871712	27.8624	28.4598	29.3409

Notes: This table reports the results of values of optimal lag length for time series analysed using AIC, HQIC, SBIC at various lags.

Table 6
Optimal lag length selection for Nigeria.

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	−2309.410				1.0e+15	48.724	48.788	48.859
1	−1553.620	1511.600	25.000	0.000	2.1e+08	33.339	33.665*	34.146*
2	−1516.670	73.912*	25.000	0.000	1.6e+08*	33.087*	33.685	34.566

Notes: This table reports results of values of optimal lag length for time series analysed using AIC, HQIC, SBIC at various lags.

4.4. Cointegration

4.4.1. Ghana

For Ghana, the cointegration test results suggest the presence of a long-term equilibrium relationship among the variables in the model. At a lag of "r = 0″, the trace statistic is 148.260, which exceeds the critical value of 68.520, indicating at least one cointegration equation (Table 7).

However, for "r ≤ 1″ and "r ≤ 2″, the trace statistics are 30.202 and 14.830, respectively, both of which fall below their corresponding critical values of 47.210 and 29.680, respectively. This implies that there is no additional cointegration equation at these levels, suggesting that there is one stable long-term relationship among the variables in the Ghanaian context (Table 8).

4.4.2. Nigeria

As in Table 8, the cointegration test reveals multiple long-term equilibrium relationships among the variables. The trace statistic at lag "r = 0″ is 213.23, significantly exceeding the critical value of 68.52, which indicates the presence of at least one cointegration equation.

Furthermore, at "r ≤ 1″, the trace statistic is 50.670, surpassing the critical value of 47.210, suggesting the need for a second cointegration equation. However, at "r ≤ 2″ and "r ≤ 3″, the trace statistics are 25.75 and 11.037, respectively, both of which are below their corresponding critical values, indicating that no additional cointegration relationships are needed. This points to the existence of two stable long-term relationships among the variables in the Nigerian.

Table 7
Cointegration test for Ghana.

Lag	Trace Statistics	Critical Value	Maximal Eigen Value	Critical Value
r = 0	148.260	68.520	118.060	33.460
r ≤ 1*	30.202	47.210	15.370	27.070
r ≤ 2	14.830	29.680	11.354	20.970

Notes: This table reports the results of cointegration test for Ghana. The T-statistic and the maximal Eigen with their critical values are analysed.

Table 8
Cointegration test for Nigeria.

Lag	Trace Statistics	Critical Value	Maximal Eigen Value	Critical Value
r = 0	213.230	68.520	162.550	33.460
r ≤ 1	50.670	47.210	24.926	27.070
r ≤ 2*	25.750	29.680	14.713	20.970
r ≤ 3	11.037	15.410	7.306	14.070

Notes: This table reports the results of cointegration test for Nigeria. The T-statistic and the maximal Eigen with their critical values are analysed.

4.5. Error correction model

The error correction model (ECM) is an essential component of the nonlinear autoregressive distributed lag (NARDL) framework, particularly when analysing time series data for bond yields in the context of frontier WAMZ economies such as Ghana and Nigeria. This section presents the results of the ECM analysis, which reflects both the short-term and long-term dynamics of bond yields relative to various determinants.

4.5.1. Ghana

In the Ghanaian context (see Table 9), the vector error correction model reveals intricate dynamics within the bond market, both in the short and long term. The model's core lies in the error correction term (ce1), which highlights the speed at which deviations from equilibrium are corrected. For the bond yield, denoted D_ghy, the adjustment process is relatively swift, with an approximately 2.05 % monthly correction toward equilibrium, as mirrored by the significant coefficient of −0.020538. This rapid adjustment indicates a responsive bond market to short-term fluctuations.

Similarly, the consumer price index (CPI), a crucial indicator of inflation, shows a comparable adjustment rate, with a coefficient of −0.019537. This suggests that inflationary trends are quickly factored into bond yield movements, underlining the sensitivity of the bond market to inflationary pressures.

In contrast, variables such as fraud, political risk, and the liquidity index demonstrate a more sluggish adjustment in the short term. Their less significant coefficients in the model imply a delayed reaction or a less immediate impact on bond yields, pointing to a market that may be less sensitive to these factors in the short run.

In the long-term scenario (Table 10), the cointegration equation (_ce1) reveals significant equilibrium relationships. Notably, there is an inverse relationship between CPI and bond yields, indicating that higher inflation tends to correspond with lower bond yields in the long term. This relationship is essential for understanding the economic forces at play in Ghana's bond market, as it reflects the interplay between macroeconomic factors and bond market dynamics.

The coefficients in the _ce1 cointegration equation represent the long-term equilibrium relationships among the variables. The variable "ghy" is normalized, indicated by its coefficient of 1. The *cons* term represents the constant in the cointegration equation.

4.5.2. Nigeria

Table 11 shows the Vector Error Correction Model (VECM) analysis, which mirrors a structure similar to Ghana's model, focusing on key variables such as bond yield, the Consumer Price Index (CPI), fraud, political risk, and the liquidity index. The essence of the VECM in Nigeria's context lies in its ability to reveal how bond yields adjust to short-term economic shocks and disturbances. The error correction term is pivotal in this aspect, indicating the speed and magnitude of the bond market's response to immediate economic changes.

Table 9
Short-run dynamics for Ghana.

Variable	Coefficient	Standard Error	z value	P value	95 % Confidence Interval
D_ghy					
ce1 (L1)	−0.021	0.002	−9.160	0.000	−0.025 to −0.0161
cons	4.763	0.511	9.310	0.000	3.761 to 5.765
D_ghcpi					
ce1 (L1)	−0.019	0.002	−10.340	0.000	−0.0232 to −0.0158
cons	5.336	0.431	12.380	0.000	4.491 to 6.181
D_ghf					
ce1 (L1)	−0.002	0.046	−0.030	0.973	−0.093 to 0.089
cons	−1.553	10.626	−0.150	0.884	−22.378 to 19.273
D_ghpr					
ce1 (L1)	−1.66E-05	0.001	−0.030	0.972	−0.001 to 0.001
cons	−0.037	0.109	−0.340	0.734	−0.251 to 0.177
D_ghli					
ce1 (L1)	0.271	0.731	0.370	0.711	−1.161 to 1.704
cons	0.736	166.826	0.000	0.996	−326.237 to 327.710

Notes: The coefficients ce1 (L1) and ce2 (L1) represent the short-term dynamics of the error correction terms, while cons denote the constant in each equation.

Table 10
Long-run dynamics for Ghana.

Cointegration Equation	Variable	Coefficient	Standard Error	z value	P value	95 % Conf. Interval
_ce1						
ghy	1	–	–	–	–	–
ghcpi	−5.003	0.442	−11.320	0.000	−5.869 to −4.136	
ghf	−0.219	0.057	−3.850	0.000	−0.331 to −0.108	
ghpr	−39.124	6.221	−6.290	0.000	−51.317 to −26.931	
ghli	0.002	0.004	0.640	0.525	−0.005 to 0.0100	
cons	798.835	–	–	–	–	

Notes: The coefficients in the cointegration equations represent the long-term equilibrium relationships between the variables. The "ngy" and "ncpi" variables are normalized in each equation, as indicated by their coefficients of 1 and 0 (omitted), respectively. The "cons" is the constant term in each cointegration equation.

Table 11
Short-run dynamics for Nigeria.

Variable	Coefficient	Standard Error	z value	P value	95 % Confidence Interval
D_ngy					
ce1 (L1)	0.035	0.026	1.340	0.180	−0.016 to 0.086
ce2 (L1)	0.008	0.005	1.770	0.077	−0.001 to 0.017
cons	−0.327	0.305	−1.070	0.284	−0.924 to 0.271
D_ncpi					
ce1 (L1)	−0.078	0.019	−4.100	0.000	−0.116 to −0.041
ce2 (L1)	0.014	0.003	4.250	0.000	0.008 to 0.021
cons	−0.644	0.223	−2.890	0.004	−1.081 to −0.207
D_ngf					
ce1 (L1)	1.009	0.509	1.980	0.048	0.010 to 2.008
ce2 (L1)	0.179	0.089	2.000	0.046	0.004 to 0.354
cons	−1.988	5.949	−0.330	0.738	−13.648 to 9.673
D_ngpr					
ce1 (L1)	0.072	0.033	2.180	0.030	0.0072 to 0.138
ce2 (L1)	0.009	0.006	1.500	0.132	−0.003 to 0.020
cons	0.544	0.389	1.400	0.161	−0.217 to 1.307
D_ngli					
ce1 (L1)	26.987	8.879	3.040	0.002	9.584 to 44.389
ce2 (L1)	5.074	1.558	3.260	0.001	2.021 to 8.127
cons	0.071	103.673	0.000	0.999	−203.124 to 203.267

Notes: The coefficients ce1 (L1) and ce2 (L1) represent the short-term dynamics of the error correction terms, while cons denote the constant in each equation.

Table 12
Long-run dynamics for Nigeria.

Cointegration	Variable	Coefficient	Standard Error	z value	P value	95 % Confidence Interval
_ce1						
	ngy	1	–	–	–	–
	ncpi	0 (omitted)	–	–	–	–
	ngf	0.046	0.013	3.600	0.000	0.0211 to 0.072
	ngpr	−0.691	0.203	−3.390	0.001	−1.090 to −0.292
	ngli	−0.003	0.0002	−11.460	0.000	−0.004 to −0.003
	cons	99.298	–	–	–	–
_ce2						
	ngy	−4.44E-16	–	–	–	–
	ncpi	1	–	–	–	–
	ngf	−0.351	0.063	−5.540	0.000	−0.475 to −0.227
	ngpr	−0.695	0.999	−0.700	0.487	−2.653 to 1.263
	ngli	−0.009	0.001	−7.340	0.000	−0.012 to −0.007
	cons	101.665	–	–	–	–

Notes: The coefficients in the cointegration equations represent the long-term equilibrium relationships between the variables. The "ngy" and "ncpi" variables are normalized in each equation, as indicated by their coefficients of 1 and 0 (omitted), respectively. The "cons" is the constant term in each cointegration equation.

The Consumer Price Index, an essential gauge of inflation, would be particularly instrumental in short-term dynamics. Its coefficient within the VECM framework reflects the immediate impact of inflationary trends on bond yields, highlighting the sensitivity of Nigeria's bond market to inflation. Variables such as fraud, political risk, and the liquidity index also play a role, each contributing to

short-term movements in bond yields, albeit with potentially varying degrees of significance and speed of adjustment.

Table 12 indicates that the long-term dynamics in Nigeria's bond market, as inferred from the cointegration equations, would likely uncover significant relationships between these variables and bond yields. Such relationships are crucial in understanding the fundamental economic forces influencing the bond market. For instance, a significant long-term relationship between CPI and bond yields would suggest a profound impact of inflation on investment decisions and risk assessments in the bond market.

4.6. Nonlinear autoregressive distributed lags (NARDLs)

4.6.1. Ghana

The nonlinear autoregressive distributed lag (NARDL) model is employed to analyse the asymmetric effects of different economic factors on bond yields for Ghana and Nigeria. This model allows for the exploration of how positive and negative changes in the explanatory variables affect bond yields differently [52].

The NARDL estimation results for Ghana (Table 13 Panel A) reveal that lagged bond yields (BD(-1)) have a significant negative impact on current bond yields. This finding may indicate that the bond market in Ghana is mean-reverting, meaning that when bond yields rise above their historical average, they tend to subsequently decline, and vice versa [68]. This mean-reverting behaviour could be the result of market participants adjusting their expectations based on past bond yield levels or the influence of monetary policy decisions aimed at stabilizing the market [69].

In Ghana, both positive changes in the consumer price index (CPI (−1)Pos.) and negative changes in the CPI (CPI(-1)Neg.) have significant positive effects on bond yields. This finding suggests that both inflationary pressures and deflationary pressures can lead to higher bond yields. This result is somewhat unexpected, as traditional economic theory posits that higher inflation leads to higher bond yields due to increased uncertainty and expectations of higher interest rates [70]. However, the positive relationship between deflationary pressures and bond yields may be explained by the fact that deflation can also increase uncertainty and negatively affect the economy, leading investors to demand higher yields as compensation for these risks [54].

The other variables, including fraud, political risk, and the liquidity index, do not significantly affect bond yields in Ghana. These findings might indicate that these factors have less influence on bond yields in the Ghanaian market or that their effects are more difficult to capture within the scope of the NARDL estimation. Nevertheless, it is worth noting that other studies have shown significant relationships between political risk and bond yields in various countries, suggesting that the impact of political risk on bond yields may be context dependent.

Table 13 shows that the diagnostic tests conducted for NARDL estimation for Ghana include the Portmanteau test, the Breusch–Pagan heteroskedasticity LM test, the Ramsey RESET test, and the Jarque–Bera test on normality. The Portmanteau test and Breusch−Pagan heteroskedasticity LM test indicate no significant issues related to autocorrelation and heteroskedasticity,

Table 13
NARDL estimation for Ghana.

Variable	Coefficient	t-Statistic	p value
Panel A: NARDL estimation for Ghana			
BD (-1)	−0.967***	−3.910	0.000
CPI (-1)Pos.	1.616**	2.380	0.020
CPI (-1)Neg.	1.443**	2.030	0.047
FR (-1)Pos.	0.306	1.000	0.321
FR (-1)Neg.	0.298	0.980	0.330
PR (-1)Pos.	−0.015	−0.110	0.910
PR(-1)Neg.	0.207	1.610	0.112
LI(-1)Pos.	0.059	0.210	0.832
LI(-1)Neg.	−0.011	−0.040	0.971
Constant			−0.032
Adjusted R-squared			0.375
F-Statistic			3.340
Prob.>F			0.000
Panel B: Long-run of NARDL			
CPI(-1)Pos.	1.672**	4.246	0.043
CPI(-1)Neg.	−1.492*	3.198	0.078
FR(-1)Pos.	0.317	1.148	0.288
FR(-1)Neg.	−0.308	1.102	0.298
PR(-1)Pos.	−0.015	0.013	0.909
PR(-1)Neg.	−0.214	2.596	0.112
LI(-1)Pos.	0.061	0.045	0.833
LI(-1)Neg.	0.011	0.001	0.971
Models Diagnosis test			
Portmanteau test up to lag 40 (chi2)	Chi2 = 31.810		0.802
Breusch/Pagan heteroskedasticity LM test (chi2)	Chi2 = 3.040		0.083
Ramsey RESET test (F)	F-statistic = 0.512		0.676
Jarque-Bera test on normality (Chi2)	Chi2 = 23.420		0.001

Notes: Diagnostic tests conducted for NARDL estimation for Ghana and ***p < 0.01, **p < 0.05, *p < 0.05.

Table 14
NARDL estimation for Nigeria.

Variable	Coefficient	t-Statistic	p value
Panel A: NARDL estimation for Nigeria			
BD (-1)	−0.169**	−2.040	0.045
CPI (-1)Pos.	0.871**	2.450	0.034
CPI (-1)Neg.			
FR (-1)Pos.	−0.390	−0.470	0.641
FR (-1)Neg.	0.0110	0.100	0.992
PR (-1)Pos.	−2.128**	−2.120	0.041
PR(-1)Neg.	4.812	0.470	0.639
LI(-1)Pos.	0.029	0.090	0.92
LI(-1)Neg.	2.948	1.170	0.246
Constant	0.591**	2.220	0.03
Adjusted R-squared			−0.0812
F-Statistic			2.41
Prob.>F			0.028
Panel B: Long-run of NARDL			
CPI(-1)Pos.	1.672**	4.246	0.043
CPI(-1)Neg.	−1.492*	3.198	0.078
FR(-1)Pos.	0.317	1.148	0.288
FR(-1)Neg.	−0.308	1.102	0.298
PR(-1)Pos.	−0.015	0.013	0.909
PR(-1)Neg.	−0.214	2.596	0.112
LI(-1)Pos.	0.061	0.045	0.833
LI(-1)Neg.	0.011	0.001	0.971
Models Diagnosis test			
Portmanteau test up to lag 40 (chi2)	Chi2 = 26.630		0.948
Breusch/Pagan heteroskedasticity LM test (chi2)	Chi2 = 2.458		0.117
Ramsey RESET test (F)	F-statistic = 3.565		0.020
Jarque-Bera test on normality (Chi2)	Chi2 = 15.600		0.070

Notes: Diagnostic tests conducted for NARDL estimation for Nigeria and ***p < 0.01, **p < 0.05, *p < 0.05.

respectively. The Ramsey RESET test suggested that the model was well specified, while the Jarque-Bera test indicated some deviation from normality. Overall, the diagnostic tests provide reasonable confidence in the robustness of the NARDL estimation results for Ghana.

4.6.2. Nigeria

For Nigeria (Table 14 Panel A), the NARDL estimation results show that the lagged bond yield (BD(-1)) has a significant negative effect on the current bond yield. Like for Ghana, this result may indicate that the bond market in Nigeria also exhibits mean-reverting behaviour, potentially due to market participants adjusting their expectations or the influence of monetary policy decisions (68 & 69).

Table 14 indicates that positive changes in the CPI (CPI(-1)Pos) have a significant positive effect on bond yields in Nigeria, suggesting that inflationary pressures lead to higher bond yields. This result aligns with conventional economic theory, which posits that higher inflation leads to higher bond yields due to increased uncertainty and expectations of higher interest rates [70]. However, unlike in the case of Ghana, negative changes in the CPI do not have a significant effect on bond yields in Nigeria. This difference may be attributed to the specific economic conditions and market dynamics in each country.

Political risk (PR (−1) Pos) in Nigeria has a significant negative impact on bond yields, implying that a reduction in political risk can lead to lower bond yields. This finding is consistent with previous research that has identified a significant relationship between political risk and bond yields in various countries [45]. Lower political risk can enhance investor confidence and reduce the risk premium demanded by investors, thereby leading to lower bond yields. Other variables, such as fraud and the liquidity index, do not have significant effects on the NARDL estimation for Nigeria. This result might suggest that these factors have less influence on bond yields in the Nigerian market or that their effects are more challenging to capture within the scope of the NARDL estimation. The diagnostic tests conducted for NARDL estimation for Nigeria include the Portmanteau test, Breusch−Pagan heteroskedasticity LM test, Ramsey RESET test, and Jarque-Bera test for normality. The Portmanteau test and Breusch−Pagan heteroskedasticity LM test indicate no significant issues related to autocorrelation and heteroskedasticity, respectively. The Ramsey RESET test suggested that the model was well specified, while the Jarque-Bera test indicated some deviation from normality. Overall, the diagnostic tests provide reasonable confidence in the robustness of the NARDL estimation results for Nigeria.

5. Conclusion and policy implications

This study employed the nonlinear autoregressive distributed lag (NARDL) model to investigate the asymmetric effects of different economic factors on bond yields in Ghana and Nigeria. The analysis considered various explanatory variables, such as the consumer price index, fraud, political risk, and liquidity index, and their positive and negative changes. The results provide valuable insights into how these factors affect bond yields differently in the two countries.

For Ghana, the NARDL estimation results indicate that both inflationary and deflationary pressures can lead to higher bond yields, as evidenced by the significant impacts of alterations, whether positive or negative, in the consumer price index. This finding suggests that market participants in Ghana may react to both types of pressure, adjusting their expectations accordingly. The other variables, including fraud, political risk, and the liquidity index, did not significantly affect bond yields in Ghana, indicating that these factors might have less influence on bond yields in the Ghanaian market or that their effects are more challenging to capture within the NARDL estimation.

In the case of Nigeria, the results reveal that inflationary pressures and reductions in political risk are significant factors influencing bond yields. Positive changes in the consumer price index showed a significant positive effect on bond yields, implying that addressing inflation could contribute to lowering bond yields in Nigeria. Additionally, reductions in political risk were found to have a significant negative impact on bond yields, suggesting that improving political stability could provide a more conducive environment for economic growth and development.

This research adds to the current body of literature by offering a comprehensive analysis of the asymmetric effects of economic factors on bond yields in Ghana and Nigeria using the NARDL framework and incorporating descriptive statistics in the analysis:

This paper extends the application of distance theory by examining how country-specific determinants influence bond yields. By incorporating these determinants, the study refines the theoretical framework and offers deeper insights into the relationships between bond yields and geographical, economic, and institutional factors.

This empirical contribution fills the gap in knowledge regarding the risk assessment of frontier market bond yields, specifically considering spatial risk dimensions. This approach emphasizes the importance of country-specific characteristics, which are crucial for comprehensive analyses of international portfolio risk. Additionally, it underscores at least one way in which frontier market countries differ from each other.

Based on the empirical evidence, we offer the following thoughts for policy consideration. First, political stability emerges as a crucial determinant affecting sovereign bond yields. Policymakers in WAMZ countries should prioritize initiatives aimed at strengthening governance frameworks, promoting political stability, and reducing geopolitical tensions. This can be achieved through institutional reforms, transparent governance practices, and effective conflict resolution mechanisms.

Also, given the varied impact to sovereign on economic shocks, WAMZ countries should adopt proactive measures to enhance economic resilience. This includes building robust fiscal buffers, implementing flexible monetary policies, and establishing contingency plans to mitigate the impact of external shocks, such as global financial crises or pandemics.

Finally, given the interconnectedness of global financial markets, WAMZ countries should prioritize regional cooperation and integration initiatives. This includes enforcing the implementation of the use of common currency, harmonizing regulatory frameworks, facilitating cross-border investments, and enforcing intra-regional trade to enhance market stability and resilience against external shocks.

However, the study did not examine how improved institutional capacity and technical expertise affect bond yields. Future research could expand on this analysis by incorporating variables such as institutional capacity, technical expertise, external shocks, or global economic trends as variables to predict bond yields. Additionally, exploring the potential impacts of policy interventions on bond yields in these markets could provide valuable guidance for governments in these economies.

Authors' statements

All the authors contributed to the work reported in the manuscript.

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Data availability statement

The data in relation to the findings of this study are available upon request.

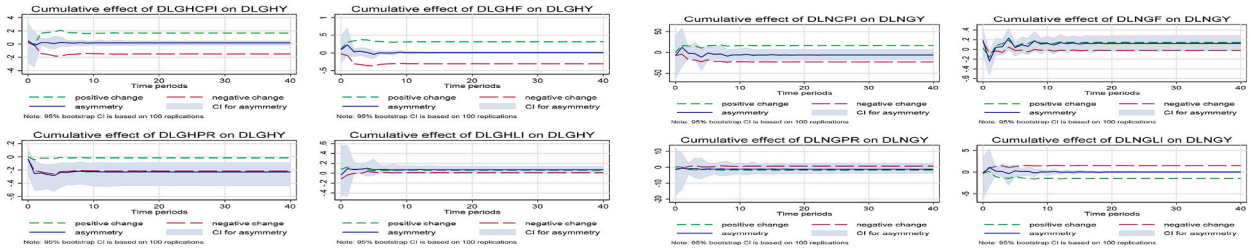
CRediT authorship contribution statement

Akwasi Adom-Dankwa: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Francis Atsu:** Writing – review & editing, Supervision. **Emmanuel Numapau Gyamfi:** Writing – review & editing, Supervision. **Godfred Amewu:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix



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