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Dynamic Connectedness between Indicators of the Ghana Stock Exchange Returns and Macroeconomic Fundamentals

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Abstract: The performance of the Ghana Stock Exchange (GSE) over the years has been susceptible to both crises and country-specific factors reflected in its macroeconomic fundamentals. Accordingly, the GSE composite index (GSECI) has experienced rapid fluctuations across time, coupled with a declining market capitalisation from a reduction in the number of existing firms. The plunge in the number of firms is partly linked to the banking sector clean-up in 2017, which induced the collapse and consolidation of some financial institutions as well as weaknesses in other macroeconomic variables. This ignites an investigation into whether the synergistic impact of listed firms that represent the financial sector and the soundness of the banking sector measures are dominant factors that could drive or respond to shocks. Hence, the study investigates the lead-lag relationships and degree of integration among two indicators of the GSE—GSECI and GSE financial index (GSEFI), seven banking financial soundness indicators and eight interest rate measures. The wavelet approaches (biwavelet and wavelet multiple) are utilised to address the research problem. The DCC-GARCH connectedness approach is then employed as a robustness check. We found high interconnectedness between the indicators of the GSE and banking sector financial soundness, relative to the interest rates. Notwithstanding, the Treasury bill measures drive the GSE indicators in the short-, and medium-terms. In comparison with the two indicators of the GSE, significant comovements are dominant between the GSEFI and the two forms of selected macroeconomic variables. We advocate that the comovements among the indicators of the GSE, banking sector financial soundness and interest rate measures are heterogeneous and adaptive, especially during crises, but more significant comovements are germane to the GSEFI. The study provides further implications for policy, practice, and theory.

Keywords: Ghana Stock Exchange financial index; Ghana Stock Exchange composite index; banking sector financial soundness; interest rates; spillover; contagion

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1. Introduction

The Ghana Stock Exchange (GSE), a platform for electronic trading, has witnessed ups and downs since its inception in November 1990, followed by the institution of the GSE automated trading system (GATS) in November 2008. The GATS replaced the manual trading system to facilitate enhanced liquidity, efficiency, and earn international competitiveness, to mention a few. The indicators of the GSE deliberated in this study are made up of the GSE financial index (GSEFI) and the GSE composite index (GSECI), which comprise about 13 companies and 38 companies, respectively. The number of existing firms on the GSECI has been inconsistent, majorly due to country-specific factors. For instance, the banking sector clean-up in 2017 led to the collapse and consolidation of some financial institutions. Hence, it can be suggested that the clean-up affected most financial firms belonging to the GSEFI category. However, since a bidirectional information flow exists between the GSECI and its constituents (Osei and Adam 2020), it is noticeable from Figure 1 that both the GSEFI and GSECI take on a similar course of decline during this period. Nonetheless,

the similarities of the indicators of the GSE beyond 2010 can be attributed to the rebasing of the economic statistics of the country in 2010, which progressed the economy into a middle-income category.

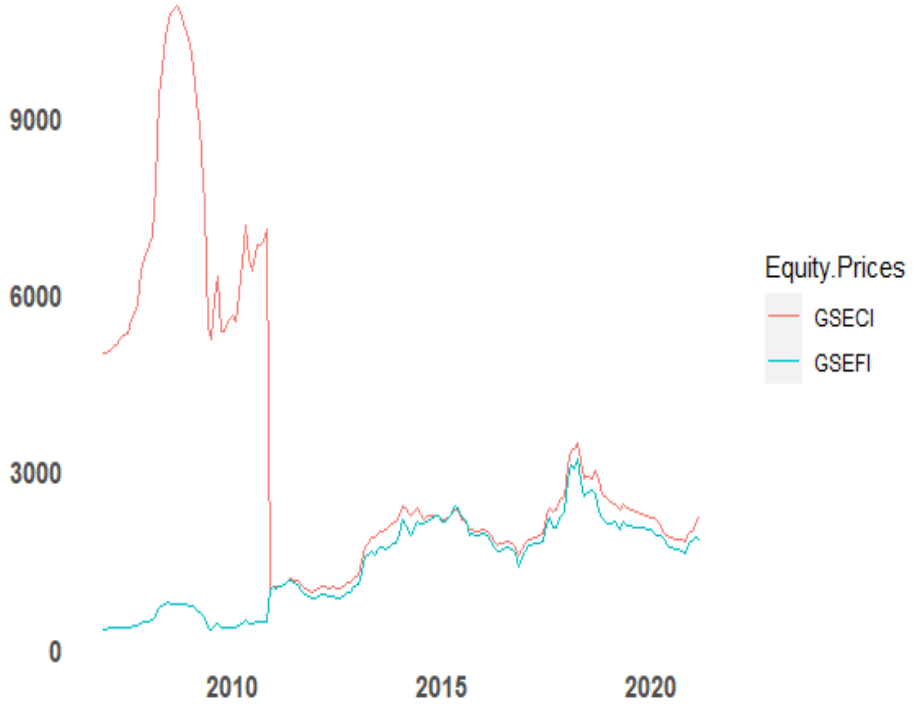


Figure 1. Combined plots of both GSEFI and GSECI from January 2007 to March 2021.

The GSE indices have also experienced fluctuations in response to significant external economic situations, in addition to prevailing country-specific factors. The most recent event is the COVID-19 pandemic, which plunged several firms' market performance in response to other macroeconomic factors, as indicated in Figure 1. To contribute to the discussion on the lead-lag relationship between a market-based system and macroeconomic variables, it is important to pay particular attention to the financial sector and how it reflects the entire market-based system in stimulating or responding to shocks (Levine 2005; Osei and Adam 2020; Szturo et al. 2021; Duarte et al. 2022). This brings up a discussion on whether the synergistic effect of listed firms that represent the financial sector and the banking sector's financial soundness measures are dominant forces. The nexus between a market-based system vis-à-vis a comparative discourse on a significant market-based driver could be observed across time and frequency (Liu et al. 2022). This highlights the multifractality (Kantelhardt et al. 2002), heterogeneity (Müller et al. 1993), adaptive (Lo 2004), competitiveness (Owusu Junior et al. 2021b), delayed volatility of market competitiveness and external shocks—DVMCES—(Asafo-Adjei et al. 2022c), among others, replete in a market-based system concerning diversity in investors' behavioural intentions.

The dynamics in the market-based system, which is nonisolated, therefore correspond to the macroeconomic fundamentals, demonstrating their lead-lag relationships and degree of integration, accentuating interdependence or contagion effects depending on the overall economic situation. Since s a static approach might not provide a true meaning of what happens across time and investment horizons of short-, medium-, and long-term, it is intuitive to employ approaches that consider both time and/or frequency outcomes. A suitable technique in this regard is the family of wavelets (biwavelet and wavelet multiple). The biwavelet approach is particularly important in assessing the lead-lag relationship between two variables without losing both the calendar and intrinsic time dimensions. Hence, the biwavelet is restricted to only two variables. To resolve the difficulty with the biwavelet

in investigating the nexus among several variables, the wavelet multiple approaches are supplemented to assess the degree of integration simultaneously but executed only at investment horizons.

The studies that come close to ours are those of Boateng et al. (2022a) and Asafo-Adjei et al. (2021). Nonetheless, as Boateng et al. (2022a) examined the lead-lag nexus between commodities and macroeconomic fundamentals in the Ghanaian context, Asafo-Adjei et al. (2021) examined the finance-growth nexus in light of external shocks in an emerging economy context. This is followed by the studies of Abaidoo et al. (2021), Flori et al. (2021), Kinda et al. (2018), and Shahbaz et al. (2019), who investigated the nexus between commodities and banking sector financial indicators in a developed economy context. The few studies conducted in Ghana that consider the dynamic comovements with stock returns (without giving credence to the financial sector) are restricted to selected macroeconomic variables such as exchange rates (Owusu Junior et al. 2018; Agyei et al. 2022a; Amewu et al. 2022), economic policy uncertainty (Asafo-Adjei et al. 2021), and interest and inflation rates (Asiedu et al. 2021). Hence, discussion of the dynamic comovements and degree of integration among indicators of GSE, banking sector financial soundness, and interest rate measures are rarely explored in the unique context of a developing economy. However, recognising the role of the financial sector during prominent economic events and inculcating financial soundness as well as interest rate dynamics are indispensable courses of action as suggested by the *Bank of Ghana Banking Sector Report* in 2020.

The financial soundness indicators utilised in this study help to quantify and qualify the strength and weaknesses of the financial system based on some key areas that are relevant for policymakers, regulators, and other stakeholders. The Bank of Ghana economic database makes available seven financial soundness measures for the banking sector, including capital adequacy ratio (CAR), non-performing loans (NPL), return on equity (RoE), return on assets (RoA), and core liquid assets to total assets (CLATA), core liquid assets to short-term liabilities (CLASL), and credit to deposits (CD), corresponding to the key performance indicators advanced by the Asian Development Bank (2015).

Moreover, the comovements between stock returns and interest rate are well accentuated in the dividend discount model where a rise in interest rate plunges stock returns. To facilitate a rigorous investigation of interest rates, we employ eight forms of interest rates provided by the Bank of Ghana's economic database to investigate their asymmetric nexus with the indicators of the GSE. They include the following: monetary policy rate (MPR), 91-DAY Treasury Bill (TBill_91D), 182-DAY Treasury Bill (TBill_182D), 364-DAY Treasury Bill (TBill_364D), inter-bank weighted average (IBWA), average commercial banks' lending rate (ACBLR), average savings deposits rate (ASDR), and average time deposits rate (ATDR).

A trajectory of the raw series of some selected banking sector financial soundness and interest rate measures is shown in Figure 2. It is observable from Figure 2 that the macroeconomic variables experience rapid oscillations due to economic instability within the country (Owusu-Ankamah and Sakyi 2021; Amegavi et al. 2022). This contributes to the dynamic investigation of the comovements among the variables under consideration.

We, consequently, provide a contribution to prior studies in many ways. To begin with, the lead-lag relationship investigated with the biwavelet approach is performed between the indicators of GSE and the seven banking sector financial soundness measures as found in the Bank of Ghana economic database. Additionally, we examine the comovements between the GSE indicators and the eight interest rate measures using the biwavelet technique. This is relevant in the determination of a dominant factor, noting significant economic events such as the 2008 Global Financial Crisis, Eurozone crises, rebasing the economic statistics of the country in 2010, which progressed the economy into a middle-income category, the Ghana banking crisis between August 2017 and January 2020, and the COVID-19 Pandemic. Moreover, the degree of integration among the indicators of the GSE, banking sector financial soundness, and interest rate measures are examined simultaneously, highlighting the relevance of investment horizons using the wavelet multiple

approaches. The net pairwise directional connectedness approach is further employed as a robustness check. To the best of our knowledge, this study is the first to look into this discourse in the context of a growing economy.

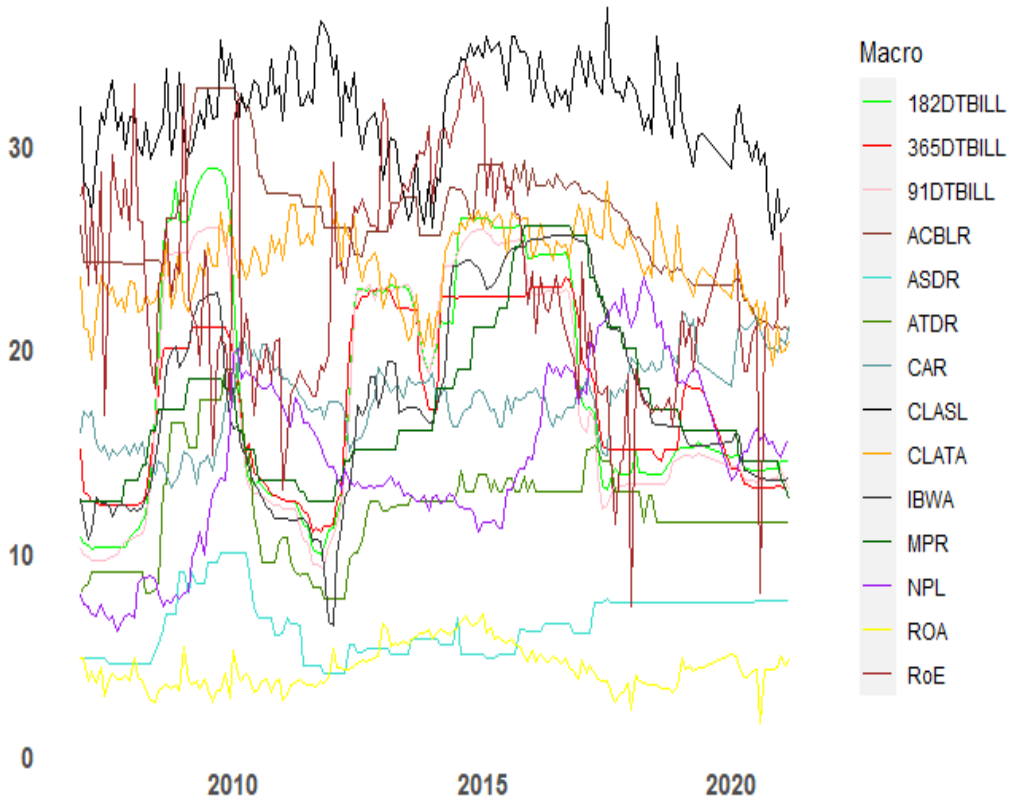


Figure 2. Combined plots of both banking sector financial soundness and interest rate measures from January 2007 to March 2021.

The study's findings highlight the significant correlations between the financial soundness of the banking sector and the GSE indicators about interest rates. Nevertheless, the Treasury bill measures lead the GSE indicators in the short-, and medium-terms. It must be noted that stronger interconnectedness was found between the GSEFI and the selected macroeconomic variables relative to the GSECI. This demonstrates that a proxy on the performance and growth of the GSE capturing an avalanche of companies offering financial services as a representation of financial development is not overemphasized.

We arrange the remaining sections as follows: the next part of the introduction section is a review of the literature. The study's methodology is displayed in Section 3. The methodology highlights sub-sections such as biwavelet, wavelet multiple, and data sources and descriptions. In Section 4, we present results in addition to the discussion. The analysis for this study is conducted across time and/or frequency, which are then supplemented with the DCC-GARCH approach as a robustness check. The study's practical implications are shown in Section 5, whereas the concluding part is shown in Section 6.

2. Literature Review and Research Hypotheses

2.1. Comovements between Market-Based System and Macroeconomic Variables

The financial sector interconnects with the real economy (Smith 1937; Bauer 1984; Demirgüç-Kunt and Levine 2018; Osei and Adam 2020; Idun 2021). This addresses the fact that the financial system, which we proxy by a market-based system (Levine 2005), despite the superiority in possible proxies (Asafo-Adjei et al. 2021), discounts almost everything (Tronzano 2021; Asafo-Adjei et al. 2022a, 2022b). Also, the existence of crises or economic events has given rise to addressing the important role a market-based system

plays in responding to or influencing other macroeconomic fundamentals, leading to their interdependent structures. The rise in correlations between the market-based system and other macroeconomic variables during turbulent periods contributes to the contagion literature (Baur 2012; Shahbaz et al. 2019; Boateng et al. 2022b; Agyei et al. 2022b; Bossman et al. 2022a, 2022b; Yarovaya et al. 2022; Gunay and Can 2022, etc.).

Nonetheless, a well-operating financial sector induces productive investment in the real sector, which could drive a positive change in other macroeconomic conditions across time and frequency (Asafo-Adjei et al. 2021; Ozenbas et al. 2022). It must also be noted that the improvement in the financial sector hinges on the performance of the economy (Schumpeter 1911; Robinson 1952). For instance, most developing economies witness depletion in their financial sector brought about by weaknesses in macroeconomic indicators contributing to their lead-lag comovements. Hence, the following hypotheses are formulated:

H1a. *A lead-lag nexus exists between the indicators of the GSE and macroeconomic variables across time and frequency.*

H1b. *There is a significant integration among the indicators of the GSE and macroeconomic variables across investment horizons.*

2.2. Nexus between the Indicators of the GSE and Banking Sector Financial Soundness Measures

The financial soundness indicators maximised in this study help to quantify and qualify the strength and weaknesses of the financial system based on some key areas that are relevant for policymakers, regulators, and other stakeholders. The core areas, according to the Asian Development Bank (2015), are the following: asset quality, earnings, liquidity, capital adequacy, and market sensitivity to risks. These key performance indicators are pertinent to resuscitating a country's financial integrity, investment climate, as well as policymaking procedures to ensure a stable financial sector. Hence, it is important to ascertain the extent to which a country's financial soundness and key performance indicators reflect its market-based system for sustainable growth. Accordingly, we formulate the following research hypothesis:

H1c. *There is a significant positive nexus between the indicators of the GSE and banking sector financial soundness measures.*

2.3. Nexus between the Indicators of the GSE and Interest Rate Measures

Moreover, the comovements between stock returns and interest rate are well accentuated in the dividend discount model where a rise in interest rate plunges stock returns. Thus, a rise in interest rates reduces firms' cash flows, which mitigates their overall performance and is reflected in share prices as a decline in two main ways. First, there is a fall in corporate earnings net of interest, and second, a decline in consumers' demand for products due to a high borrowing rate (Panda 2008). Hence, theoretically, an inverse nexus exists between stock returns and interest rates. It is quite intuitive to indicate that a surge in the interest rate paid by banks increases banks' deposits over time. The increase in banks' deposits is partly supported by a switch in capital from other sectors, which reduces the demand for the former's share and eventually decreases the share price, especially the share price of nonfinancial firms.

Considering interest rate as a cost of capital means that the opportunity cost of not depositing in banks from a rise in interest rates is substantial enough to distort the current stock market price, and vice-versa. In another sense, an increase in the interest rate paid to depositors of banks is followed by a rise in the lending interest rate which hampers overall investment in the economy, leading to a reduction in share price. To think differently in times of a rise in interest rates, which supports a surge in the performance of banks, can be reflected in their stock prices, represented by the GSEFI in an efficient market. However,

these notions cannot suffice when we consider interest rates as risk-free returns on bonds (Summers 1982; Panda 2008). In this manner, a rise in Treasury bill rates induces bonds to become attractive relative to stocks. Asset allocation, therefore, alters in favour of the bond market, leading to a fall in stock prices.

Nonetheless, a high inflation rate coupled with a non-existent real interest rate is unlikely for asset allocation to occur in favour of the bond market relative to the stock market in response to a high nominal interest rate (Summers 1982; Panda 2008). At this point, the negative nexus between stock returns and interest rates is not true. This raises concerns about the possible positive impact of interest rates on stock returns. For instance, an increase in interest rates in a rapidly growing economy would be followed by a rise in corporate earnings and then stock prices (Panda 2008). Accordingly, the stock returns and interest rate nexus could be bi-directional across time. However, it is expected that in the context of a developing economy, a negative nexus is more practicable due to growth constraints in times of poorly performing macroeconomic indicators (Owusu-Ankamah and Sakyi 2021; Amegavi et al. 2022; Obeng et al. 2022). Hence, the following research hypothesis is found:

H1d. *There is a significant negative comovement between the indicators of the GSE and interest rate measures.*

2.4. Dominant Leaders or Laggards of Macroeconomic Fundamentals

As evidenced by Ghana's macroeconomic fundamentals, the Ghana Stock Exchange's (GSE) performance has historically been vulnerable to both crises and nation-specific issues. The market capitalization of the GSE composite index (GSECI) has declined over time while experiencing fast volatility from the reduction in the number of existing firms. The 2017 banking sector clean-up, which led to the collapse and consolidation of some financial institutions as well as difficulties in other macroeconomic indicators, are some of the factors contributing to the decline in the number of firms. This sparks an examination into whether the synergistic impact of listed companies that represent the financial sector and the banking industry's soundness measures are the dominant elements that could cause or react to shocks. Categorically, the research hypothesis is provided as follows:

H1e. *The banking sector financial soundness measures are significant leaders or laggards in a network of market-based system and other macroeconomic fundamentals.*

H1f. *The GSEFI is a significant leader or laggard with macroeconomic fundamentals in comparison with the GSECI.*

3. Materials and Methods

3.1. Wavelet Approaches

The adaptability of financial time series due to structural changes that evolve across calendar times (Lo 2004) coupled with the heterogeneity of the series at various intrinsic times (Müller et al. 1993) enjoins that investigations are performed at time and/or frequency perspectives. These render wavelet approaches indispensable in the dynamic assessment of financial and economic time series. In this study, the biwavelet approach is relevant in investigating the comovements between two variables across time and frequency. This indicates that the biwavelet is limited to only two variables at a specific point in time. In this manner, one of the weaknesses of the biwavelet is the failure to investigate the nexus among several variables. Hence, the wavelet multiple approaches are further employed in this study to assess the degree of integration as well as determine leading or lagging variables among several economic indicators but executed only at investment horizons. It must also be noted that the wavelet multiple approaches lack time dimension. Notwithstanding, the superiority of the wavelet multiple approaches over other frequency-based techniques such as the wavelet multiple coherence or vector wavelet is the former's ability to reveal leading,

lagging, or a potential lead-lag variable rather than a mere correlation. The techniques employed in this current study have seen wider application in a plethora of studies in the finance and economics literature (Fernández-Macho 2012; Haseeb et al. 2020; Adebayo and Akinsola 2021; Asafo-Adjei et al. 2021; Owusu Junior et al. 2021a; Boateng et al. 2022a).

3.1.1. Biwavelet

We investigate the time-frequency comovements among the banking sector's financial soundness, interest rates, and stock market indices in Ghana using the biwavelet approach. The study's emphasis is on CWT because it has a better extraction advantage and has induced myriad studies to welcome its application (Wu et al. 2020; Bossman et al. 2022a, etc.).

The wavelet power spectra (WPS) can be obtained over a specified time series from the squared absolute value similarly to the standard spectral approaches of $w_x(i,s)$, defined in Equation (1) as follows:

$$WPS_x(i,s) = [w_x\ (i,s)]^2 \tag{1}$$

where i and s denote time and scale respectively

We consider wavelet transformation coherence (WTC) in this study. Torrence and Compo (1998) define WTC as the squared value normalization of a cross-absolute spectrum to a single wavelet power spectrum. Equation (1) is the squared wavelet coefficient as follows:

$$R^2(x,y) = \frac{\left|\rho\left(s^{-1}W_{xy}(\acute{\imath},s)\right)\right|^2}{\rho(s^{-1}|W_x(\acute{\imath},s)|^2)\rho(s^{-1}\left|W_y(\acute{\imath},s)\right|^2)} \tag{2}$$

here ρ is a smoothing factor and the square difference ranges from 0–1. A number near to 1 indicates a strong connection, whereas a number close to 0 indicates a weak connection. The statistical significance of this nexus was tested using the Monte Carlo method.

The disturbances in the oscillation are shown by the WTC Phase difference in a certain period. Using Bloomfield et al. (2004) as a guide, Equation (3) considers the phase difference between $x(t)$ and $y(t)$.

$$\varnothing_{xy}(\acute{\imath},s) = \tan^{-1}\left(\frac{\Im\left\{S\left(s^{-1}W_{xy}(\acute{\imath},s)\right)\right\}}{\Re\left\{S\left(s^{-1}W_{xy}(\acute{\imath},s)\right)\right\}}\right) \tag{3}$$

In Equation (2), the letters $\Im$ and $\Re$ stand for imaginary and real operators, correspondingly. The wavelet coherence difference is highlighted as a source of inspiration in the wavelet coherence map's phase pattern dimension. In the graphic representation of the biwavelet, arrows pointing right and left, up and down, as well as up and down, are used. Right and left arrows correspondingly point up and down, and left and right arrows correspondingly point up and down, respectively, signifying the first variable and second variable lead. A red (warm) indicates areas with a lot of comovements, whereas blue (cool) indicates areas with fewer comovements (Agyei et al. 2022a). The outcomes have little significance outside of the sphere of impact (COI).

3.1.2. Wavelet Multiple

We utilise the wavelet multiple approaches in this study to investigate the degree of integration among macroeconomic fundamentals in Ghana, simultaneously in a frequency domain. We are also able to detect the lead-lag relationship among the financial time series across investment horizons (short-, medium-, and long-term). In this study, wavelet multiple cross-correlations (WMCC) and wavelet multiple correlations (WMC) are specifically used. The WMC examines how integrated the variables are whereas the WMCC has the property of determining the leading or lagging variables, as well as a potential lead or lag.

Let $X_t = x_{1t}, x_{2t}, \ldots, x_{nt}$ follows a multivariate stochastic process and let $W_{jt} = w_{1jt}, w_{2jt}, \ldots, w_{njt}$ be a resultant scale λ_j. The wavelet coefficients discovered in earlier works are estimated using MODWT (Fernández-Macho 2012). Therefore wavelet multiple correlations (WMC) is in Equation (4), as follows:

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

where Pj is an (n × n) correlation matrix in W_{jt}

Fitted values of z_i from a theory of regression is $\hat{z}_t$, therefore the WMC is in Equation (5) as follows:

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

where w_{ij} is used to capitalize on $\Omega X\left(\lambda_j\right)$ and $\hat{w}_{ijt}$ represents the fitted values in the regression of w_{ij} on the outstanding wavelet coefficients at scale λ_j.

As a result, WMCC can be determined by allowing a lag τ between fitted values and observations made at a specific scale λ_j (see below)

$$\Omega X, \ \tau\left(\lambda_j\right) = Corr\left(w_{ijt}, \ \hat{w}_{ijt+\tau}\right) = \frac{Cov\left(w_{ijt}, \ \hat{w}_{ijt+\tau}\right)}{Var\left(w_{ijt}\right) Var\left(\hat{w}_{ijt+\tau}\right)} \tag{6}$$

where for n = 2, WMCC and WMC unite with the cross-correlation and standard wavelet correlation.

To calculate WMCC and WMC let $X = \{X_1, X_2, \ldots, X_T\}$ be the recognition of the multivariate stochastic process X_t for $t = 1, 2, \ldots, T$. MODWT of order J is linked to individual univariate time series $\{X_{1i}, \ldots, X_{1T}\}$, for $i = 1, 2, \ldots, n$, the $J\ length - T$ vectors of coefficients of MODWT $\widetilde{W}_j = \left\{\widetilde{W}_{j1}, \widetilde{W}_{j1}, \ldots, W\widetilde{W}_{j,\,T-1}\right\}$, $for\ j = 0, 1, \ldots, J$ is obtained.

A nonlinear function of all $\frac{n(n-1)}{2}$ wavelet correlations of scale λ_j and a steady estimator of wavelet correlation from the MODWT are shown in Equation (7) as follows:

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

where $\widetilde{w}_{ij}$: the regression of the equivalent set of regressors $\left\{\widetilde{w}_{kj}, \ k \neq i\right\}$ optimize the R^2, as indicated by Fernández-Macho (2012). For an extensive presentation of methods, prior studies such as Agyei et al. (2022a), Asafo-Adjei et al. (2022a), Boateng et al. (2022a), among others can be considered.

Similar to this, the WMCCs reliable equation can be approximated as follows:

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

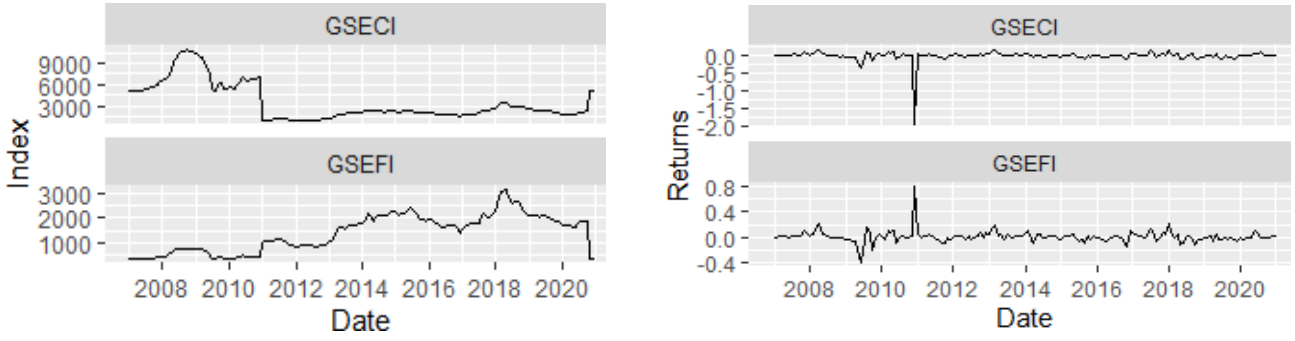
3.2. Data Sources and Description

Monthly data in support of this study include—Ghana Stock Exchange financial index (GSEFI), Ghana Stock Exchange composite index (GSECI), seven banking financial soundness indicators which are—capital adequacy ratio (CAR), non-performing loans (NPL), return on equity (RoE), return on assets (RoA), and core liquid assets to total assets (CLATA), core liquid assets to short-term liabilities (CLASL), and credit to deposits (CD), and eight interest rate measures—monetary policy rate (MPR), 91-DAY Treasury

Bill (Tbill_91D), 182-DAY Treasury Bill (Tbill_182D), 364-DAY Treasury Bill (Tbill_364D), inter-Bank weighted average (IBWA), average commercial banks' lending rate (ACBLR), average savings deposits rate (ASDR), and average time deposits rate (ATDR). The monthly data span January 2007 to March 2021 and is utilised in this study due to consistent data available for the selected data. The data employed are relevant to the stock markets and economic indicators of the Ghanaian economic environment, which has experienced rapid ramifications due to economic events. The monthly data cover severe happenings such as the 2008 Global Financial Crisis, Eurozone crises, rebasing the economic statistics of the country in 2010, which progressed the economy into the middle-income category, the Ghana banking crisis between August 2017 and January 2020, and the COVID-19 Pandemic. The data on GSEFI and GSECI were gleaned from the Ministry of Finance database whereas the remaining data were gleaned from the Bank of Ghana economic database. Estimations were performed using the logarithmic returns.

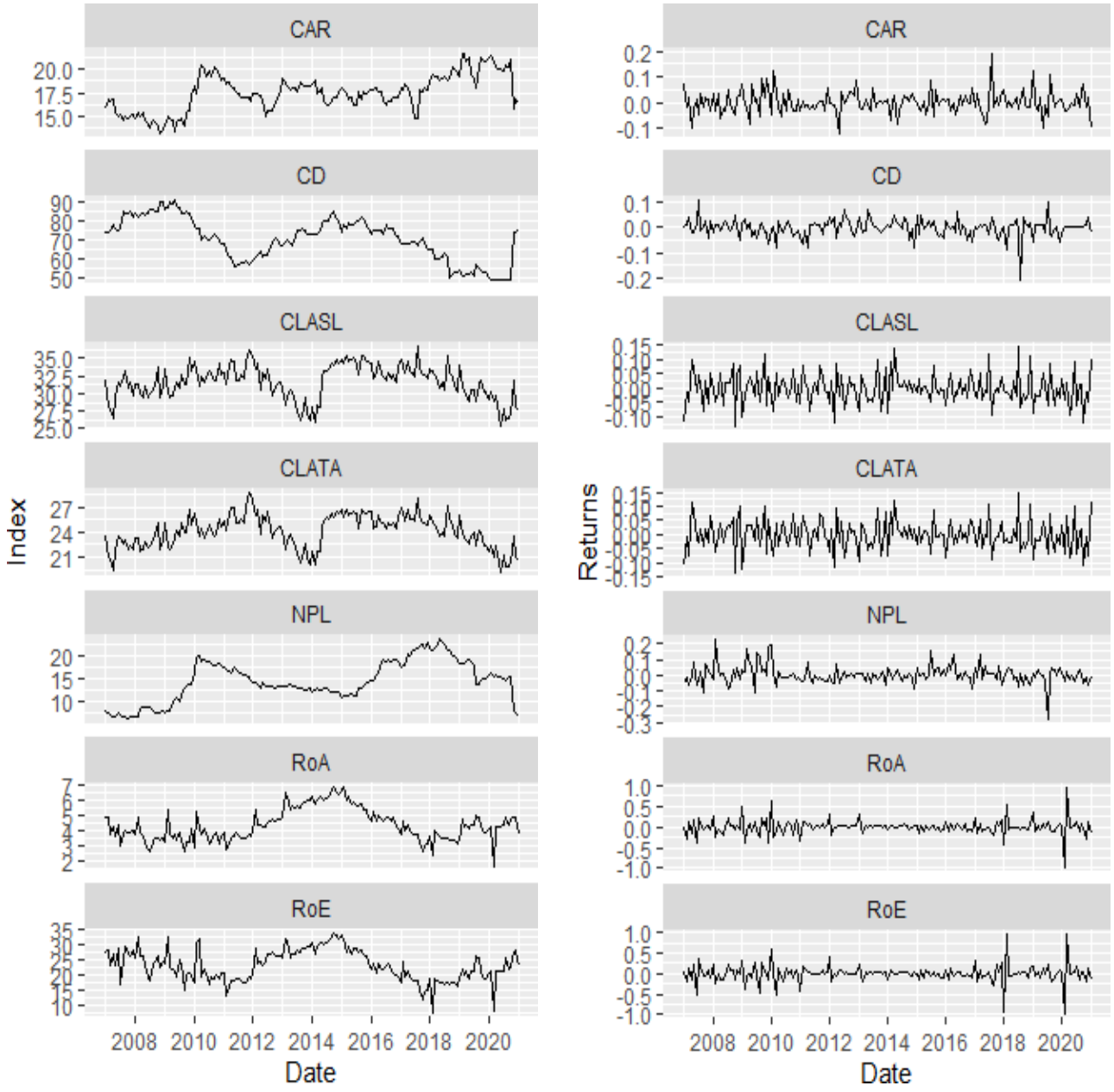
In Figure 3, we provide a pictorial presentation of time series plots for both indexes and returns from 2007 to 2021. We considered two stock market indices, seven banking sector indicators, and eight interest rates for Ghana. It can be seen that the GSEFI trends upwards with a downwards spike in the latter part of 2019. On the other hand, GSECI, which has eleven sub-divisions such as Advertising and Production, Agriculture, Distribution, Education, Exchange Traded Funds, Finance, Food and Beverages, and Insurance, Manufacturing, Mining, and others, recorded a sharp decline between 2009 and 2011. Thereafter, there was a downward trend without rebounds over the sampled period. The banking sector's financial soundness and interest rates experience rapid oscillations, with some variables depicting similar behaviour. The returns series also exhibits volatility clustering throughout the period.

Table 1 displays the preliminary statistics of GSE, banking sector financial soundness, and interest rates in Ghana. On average, GSEFI, CAR, NPL, MPR, Treasury bill rates except for 364 days, ASDR, and ATDR experience positive returns for the sampled period. It can be analysed that few variables are negatively skewed indicating that most observations or median values exceed the mean, which is suggestive of more dropdowns over the years. There are high variations in ROE and ROA. This demonstrates that they may fluctuate rapidly relative to the remaining variables. Clearly from the Jarque–Bera statistic, the return series are not normally distributed, except CLATA and CLASL.



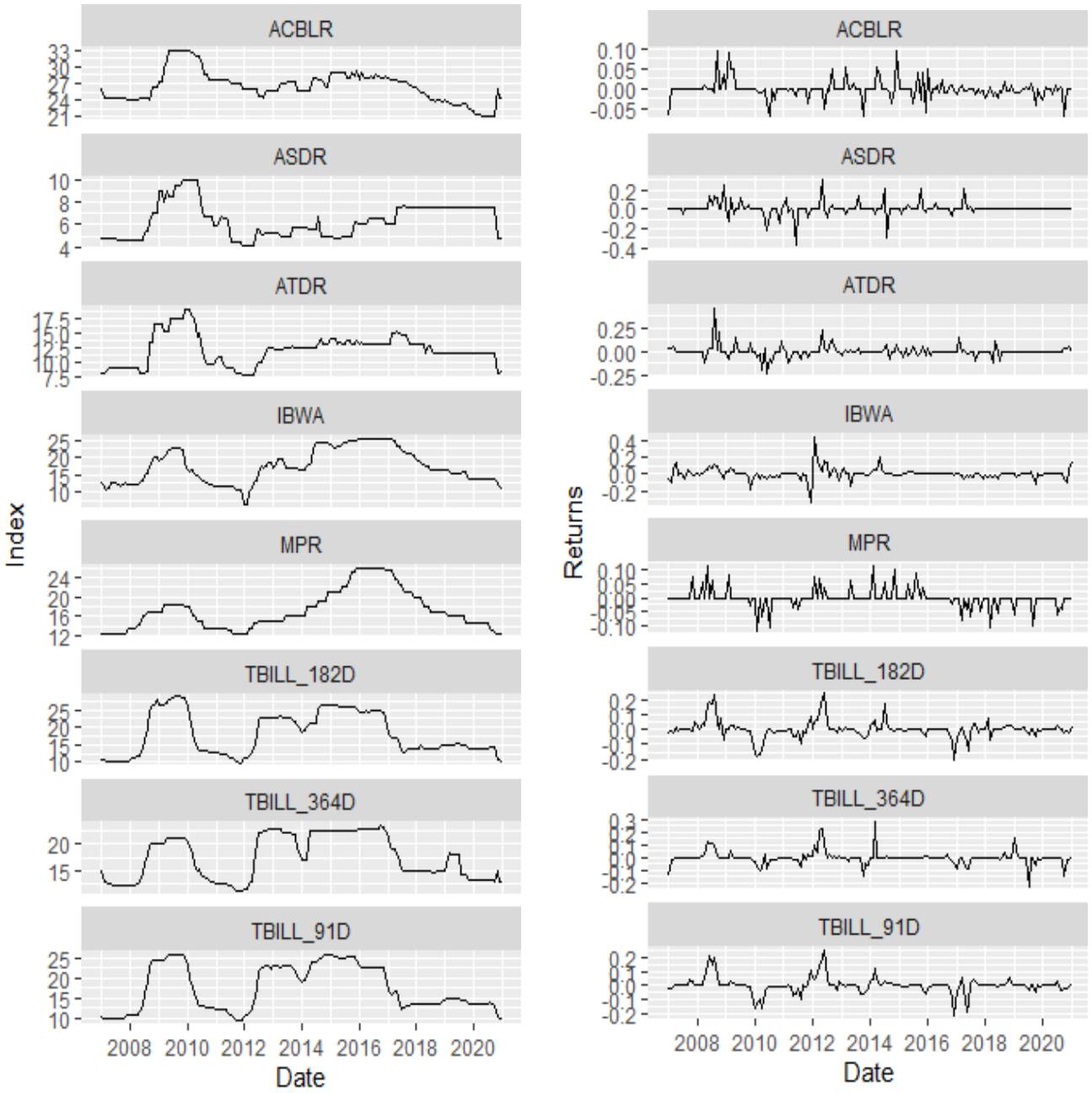
(**a**)

Figure 3. *Cont.*



(**b**)

Figure 3. *Cont.*



(**c**)

Figure 3. Plots of indexes and returns series. (**a**) Series of indicators of the Ghana Stock Exchange. (**b**) Series of the banking sector financial soundness measures. (**c**) Series of interest rate measures.

Table 1. Preliminary statistics.

	Mean	Std. Dev.	Skewness	Kurtosis	Jarque–Bera
GSEFI	0.0102	0.0924	3.1326	33.9046	6836.1320 ***
GSECI	−0.0049	0.1638	−10.4179	124.7517	104,896.1000 ***
CAR	0.0017	0.0433	0.6711	5.3914	51.7044 ***
NPL	0.0041	0.0573	0.2974	8.5965	217.7645 ***
ROE	−0.0012	0.2111	−0.0578	12.0847	567.5034 ***
ROA	−0.0001	0.1798	0.3267	13.0049	691.1092 ***
CLATA	−0.0009	0.0528	0.1562	2.9098	0.7267
CLASL	−0.0010	0.0521	0.2286	3.0867	1.4882
CD	−0.0025	0.0346	−1.1646	10.2044	394.1314 ***
MPR	0.0001	0.0325	0.1063	7.8083	159.2572 ***
TBILL_91D	0.0015	0.0577	0.5186	8.7516	234.8304 ***
TBILL_182D	0.0019	0.0586	0.8036	8.6472	237.0098 ***
TBILL_364D	−0.0009	0.0531	1.1847	13.1958	753.2817 ***
IBWA	0.0005	0.0645	1.2018	20.0215	2031.6150 ***
ACBLR	−0.0013	0.0225	0.8434	8.6709	240.6562 ***
ASDR	0.0029	0.0690	−0.2889	14.2266	868.7943 ***
ATDR	0.0022	0.0624	2.1827	21.1482	2395.3440 ***

Note: *** denotes significance at the 1% level.

4. Results and Discussion

The analysis of this study was achieved with the aid of wavelet techniques. To investigate both the time and frequency dimensions of the variables, the biwavelet and partial wavelet techniques are utilized. The wavelet multiple techniques are further considered to account for the frequency dimension. Since we utilise monthly data, we set, lj, $j = 1, \ldots 4$, according to Boateng et al. (2022a), where the wavelet components have corresponding relationships to times of 2–4 months (short term), 4–16 months (medium term), and above 16 months (long term).

4.1. Time-Frequency Domain

The biwavelet method is used to evaluate the degree of bicausality, or unidirectional link, between two time-frequency variables. With the use of this technique, one might determine how closely two variables move together through time and frequency. Calendar time is represented by the horizontal axis, and the frequency domain by the vertical axis (intrinsic time or time horizons). They constitute the time-frequency domain framework when combined (Owusu Junior et al. 2021a; Boateng et al. 2022a). The programmes for the analysis and statistical explanations were obtained from Gouhier et al. (2013). The outcomes are insignificant outside of the cone of influence (COI).

4.1.1. Interconnectedness between GSEFI and Banking Sector Financial Soundness

The comovements between GSEFI and banking sector financial soundness are shown in Figure 4. It can be seen that the comovements of GSEFI with CAR and NPL are strong in the short term between 2012 and 2017. Comovements between GSEFI and CAR are negative, suggesting that a rise in the performance of GSEFI is occasioned by a fall in CAR and vice versa. Hence, in the short-term, a rise in investment within the GSEFI increases the proportion of a bank's risk-weighted credit exposures to a greater extent, which eventually dwindles the CAR. This is not startling because investment in marketable equities poses more risks (Panda 2008). Moreover, we find more negative comovements between GSEFI and NPL between 2014 and 2015. The negative comovements are mostly downwards, indicating that GSEFI drives CAR and NPL but only in the short term.

We also find that GSEFI drives ROE and ROA mostly in the medium term. Before 2012, the comovements were negative indicating, the adverse relationship between GSEFI, and ROE and ROA. Thus, at this point, the development of the financial markets and returns in the banking sector are inversely related. That is, a rise in GSEFI leads to a fall in ROE and ROA. This may be due to the weak financial sector reforms during this period with low-performance indicators.

However, beyond 2016, there are traces of positive comovements with ROE and ROA, suggesting that these indicators move together with the GSEFI. The GSEFI still drives the ROE and ROA suggesting that the financial sector reform has made some indicators of the banking sector's financial soundness to become comparable with the GSEFI. At this point, a rise in the GSEFI is occasioned by a conforming rise in ROE and ROA. In this case, the dynamics of these indicators are relatively substitutes, and either of them can properly be used to assess the performance of the financial sector beyond the 2016 period. The outcome of the comovements between GSEFI with CLATA and CLASL is not far from the one obtained for ROE and ROA. Notwithstanding, CLATA and CLASL drive the GSEFI beyond 2016 in the short-, and medium-term. Thus, CLATA and CLASL lead the GSEFI to act as the first variables to respond to external shocks before GSEFI or as a transmitter of shocks to the remaining variables in the system. Accordingly, CLATA and CLASL are the only financial soundness indicators employed in this study that could drive GSEFI at a specific time and frequency. Statistically, CLATA and CLASL become relevant indicators in predicting fluctuations in GSEFI at all frequencies, except in the long term.

Moreover, we document negative comovements at most time-frequencies between GSEFI and credit to deposit (CD). The GSEFI positively drives CD in the short- and medium-term. In other words, GSEFI causes a negative change in CD at diverse investment horizons, except in the long term. This implies that investment in a market-based system within the financial sector reduces the amount of credit granted to customers but rather requires more deposits from the customers to undertake risky investments.

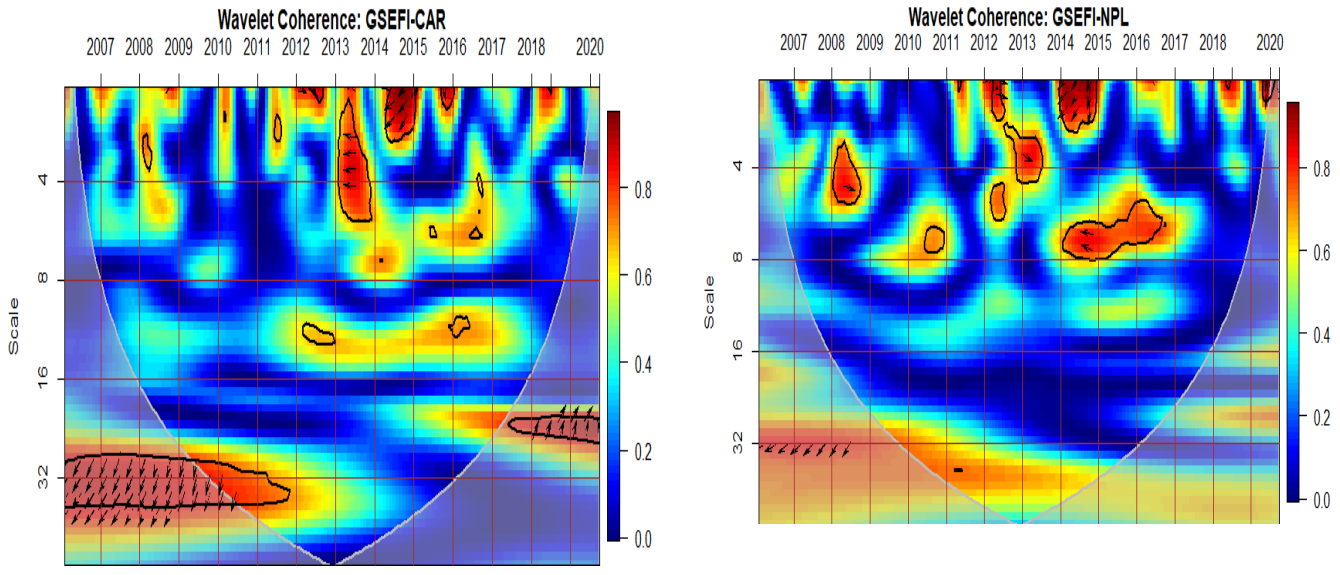


Figure 4. *Cont.*

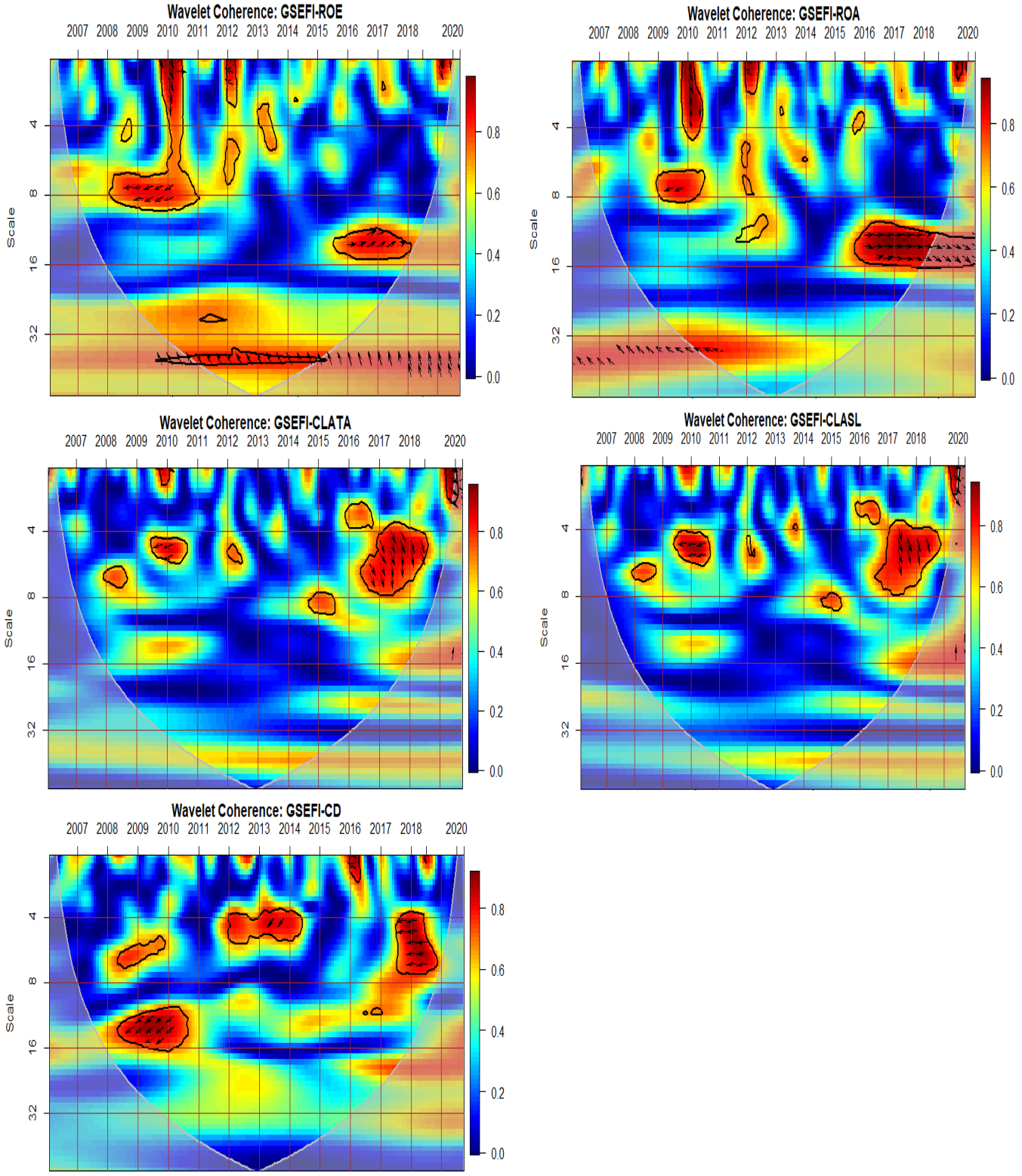


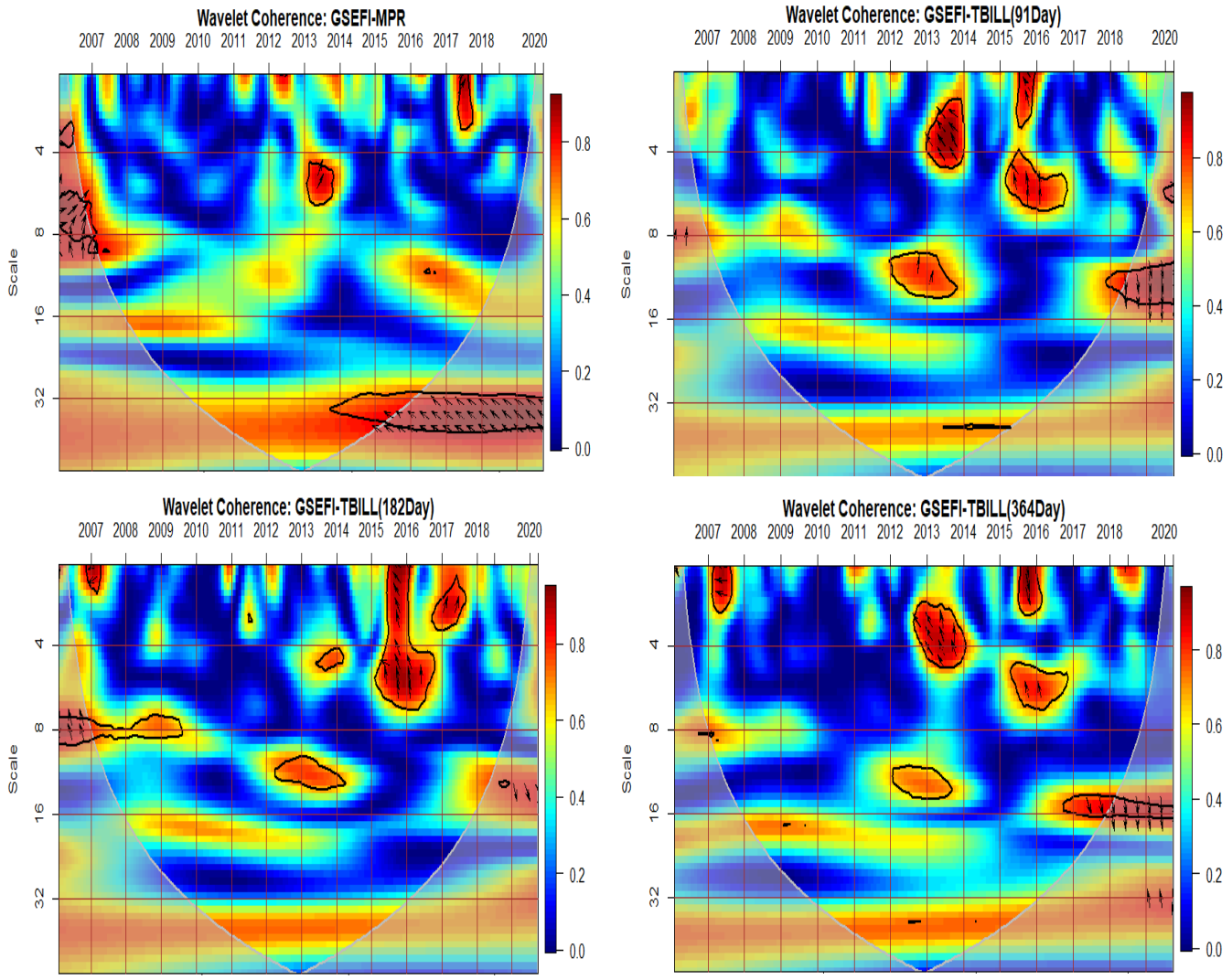
Figure 4. Comovements between GSEFI and banking sector financial soundness.

4.1.2. Interconnectedness between GSEFI and Interest Rates

Findings from Figure 5 divulge that comovements between GSEFI and interest rates are short-lived. This occurs in the short- and medium-term. Also, the comovements between GSEFI and the Treasury bill rates are negative. In most cases, the Treasury bill measures drive GSEFI negatively. This implies that a rise in Treasury bill rates induces

bonds to become attractive relative to stocks (Summers 1982; Panda 2008). Hence, asset allocation, therefore, alters against stock prices, leading to the latter's fall. This supports the dividend discount model, where a rise in interest rates plunges stock returns. However, the remaining interest rates depict positive comovements with the GSEFI, with the interest rate measures acting as drivers. This supports the idea that an increase in interest rates, in this case, IBWA, ACBLR, and ASCR, during mild economic situations is followed by a rise in corporate earnings and then stock prices (Gurley and Shaw 1967; Panda 2008), and does not overlap with the specific time-frequency in the case of comovements with the Treasury bill measures.

Relatively, the comovements between GSEFI and interest rates are not strong as compared to the comovements between the GSEFI and banking sector's financial soundness. Accordingly, most measures of the banking sector's financial soundness are highly interconnected with GSEFI as compared to the interest rate measures. That is, although the interest rate measures employed in this study have some linkages with the GSEFI, the banking sector financial soundness indicators better interconnect with the GSEFI.



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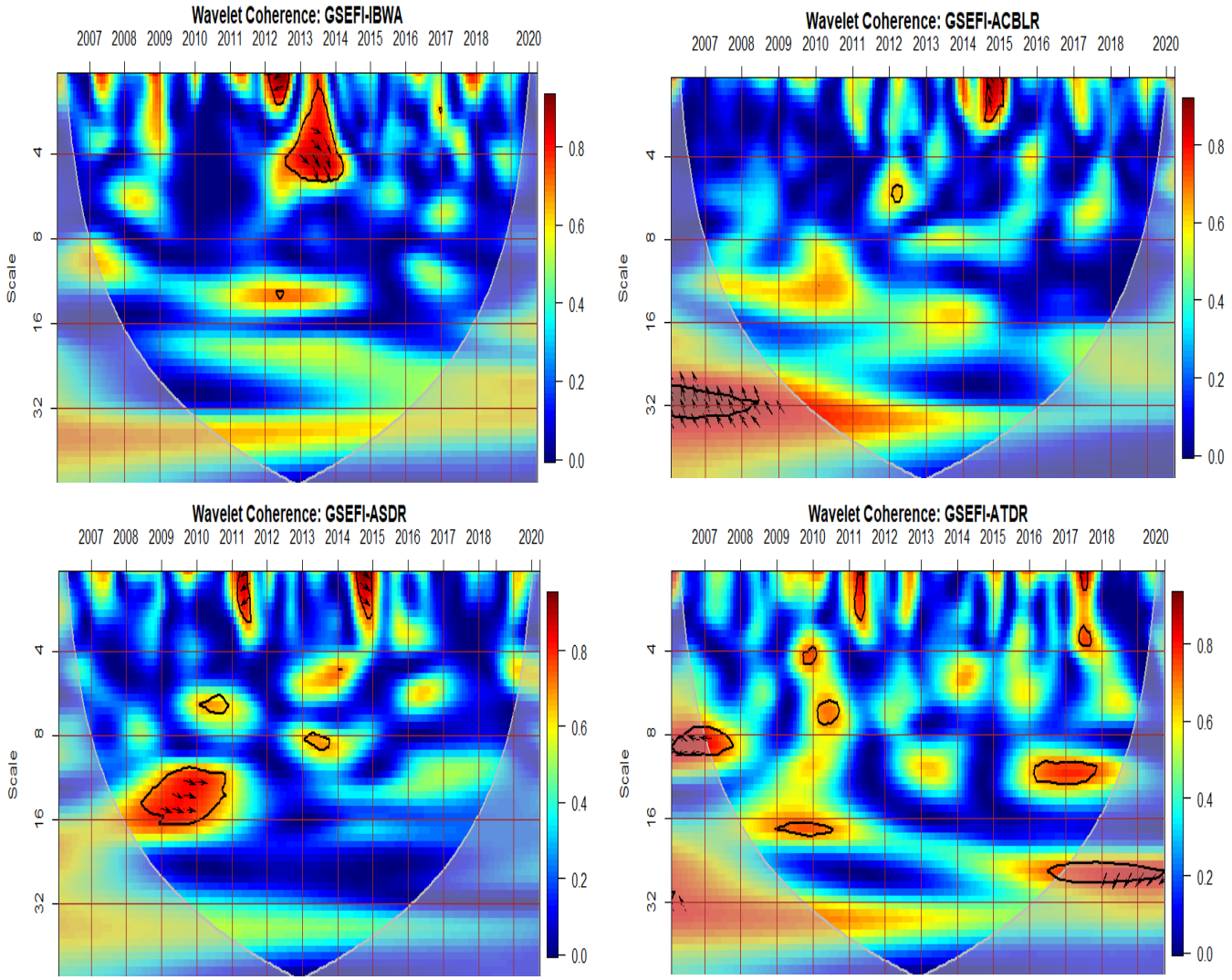


Figure 5. Comovements between GSEFI and interest rates.

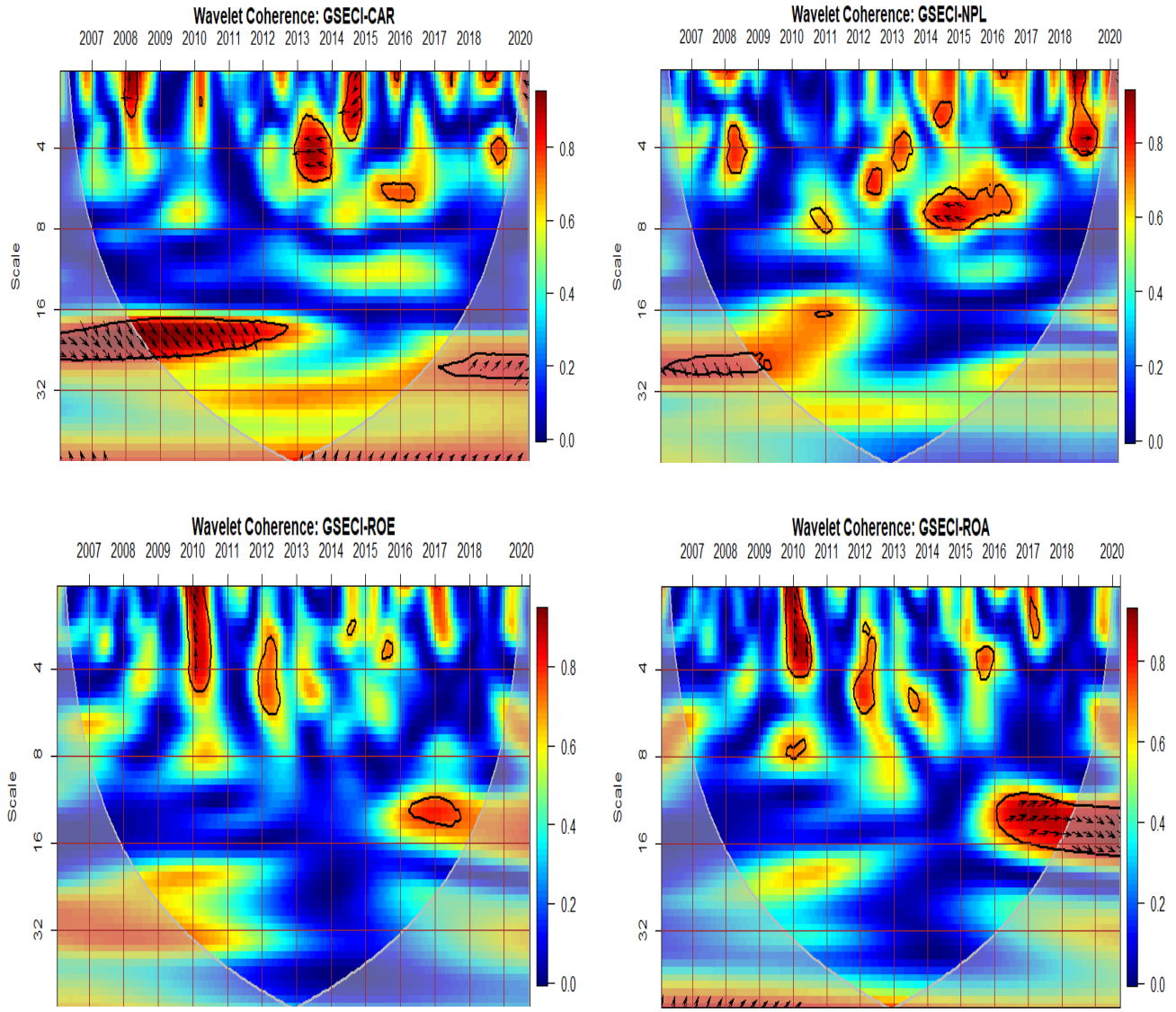
4.1.3. Interconnectedness between GSECI and Banking Sector Financial Soundness

The comovements between GSECI and banking sector financial soundness are shown in Figure 6. It can be seen that the comovements of GSECI with CAR and NPL are strong in the short-term beyond 2012. Comovements between GSECI, and CAR and NPL are negative suggestions that a rise in one variable changes the corresponding variable. Specifically, for the comovements between GSECI and CAR, the left-pointing arrows downwards indicate that changes in GSECI cause CAR to fall in the short-term beyond 2012. On the other hand, in the long term, CAR drives GSECI upwards, but this was before 2017. This may be a result of inadequate capital kept by banks, which opened the opportunity for more funds to be channelled to other sectors other than only financial institutions by banks. Consequently, the GSECI became a relevant indicator in responding to the excess fluctuations in CAR during this period.

The GSECI commoves with ROE and ROA mostly in the short- and medium-terms. We find that the comovements are negative with left-pointing arrows upwards before 2012. This implies that ROE and ROA drive the performance of the GSECI downwards, and this was before the banking sector clean-up in Ghana. That is, a rise in ROE and ROA leads to a corresponding fall in GSECI. Accordingly, we notice that beyond 2016, there are traces of positive comovements with ROE, suggesting that GSECI commoves with ROE. Thus, a rise in the GSECI is occasioned by a conforming rise in ROE. As a result, the

GSECI and ROE are relatively substitutes, and they can be used as appropriate performance indicators interchangeably beyond the 2016 period. Also, we find that the comovements between GSECI, and CLATA and CLASL are strong in the short- and medium-terms with few in-phase. Contrarily, as found for the GSEFI, CLATA and CLASL could not predict the patterns of fluctuations in GSECI. However, the few right-pointing arrows upwards and left-pointing arrows downwards suggest that GSECI drives CLATA and CLASL at most time frequencies.

On the other hand, we document negative comovements at most time frequencies between GSECI and credit to deposit (CD) beyond 2012. Notwithstanding, the GSECI and CD drive each other positively in the medium-, and long-term beyond 2008. Specifically, CD causes a significant change in GSECI beyond 2017 except in the long-term, and beyond 2008 in the long-term. This provides that CD has a long-term positive impact on the GSECI. Comparatively, the GSECI is more robust in responding to the fluctuations in CD in the long term than the GSEFI. Thus, the GSECI can capture hidden relationships not captured by the GSEFI alone. Accordingly, due to the increased financial integration, financial sectors have high potentials to be interconnected, and as such, in this study, the synergistic impact of most sectors adequately responds to fluctuations in CD.



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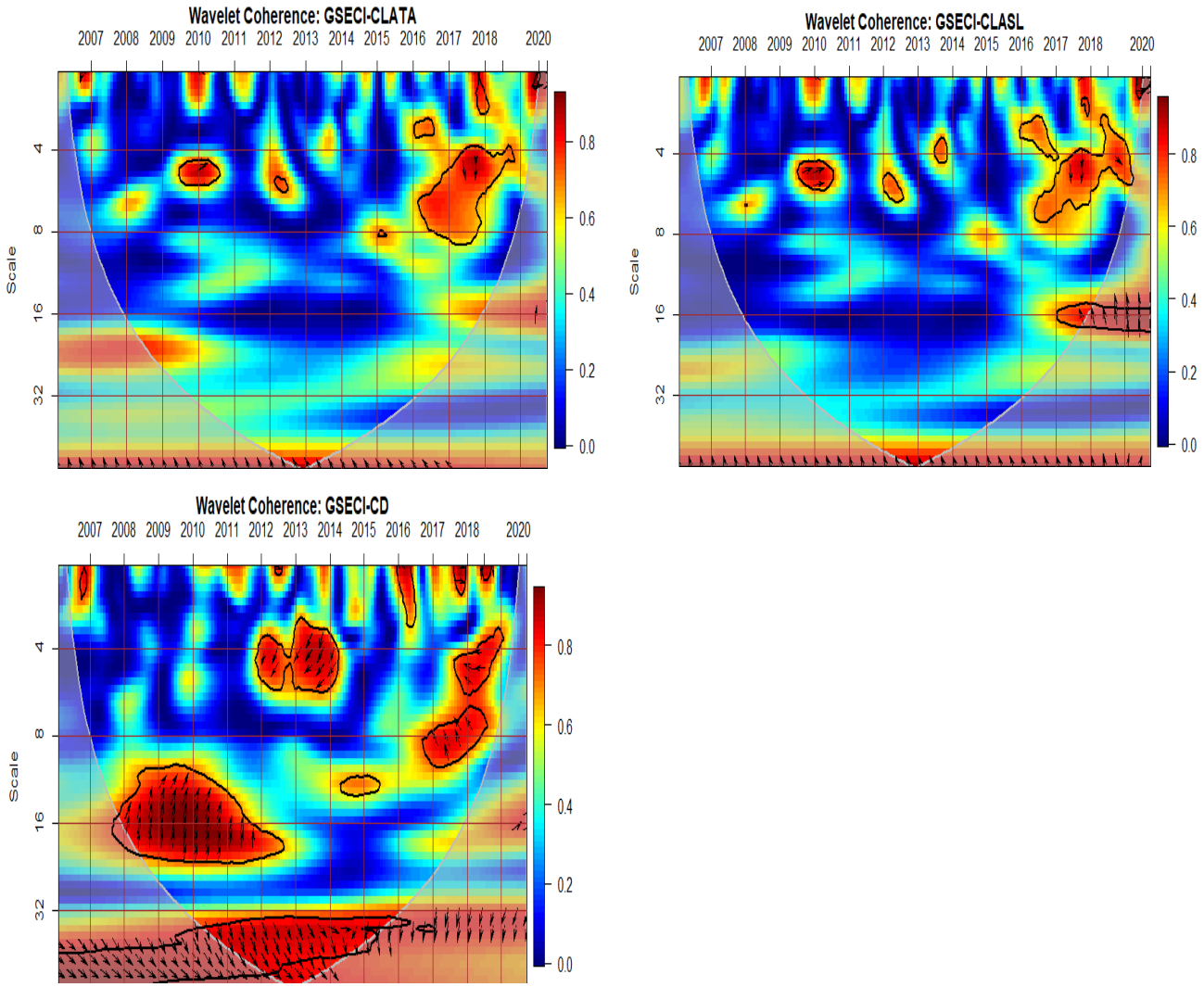
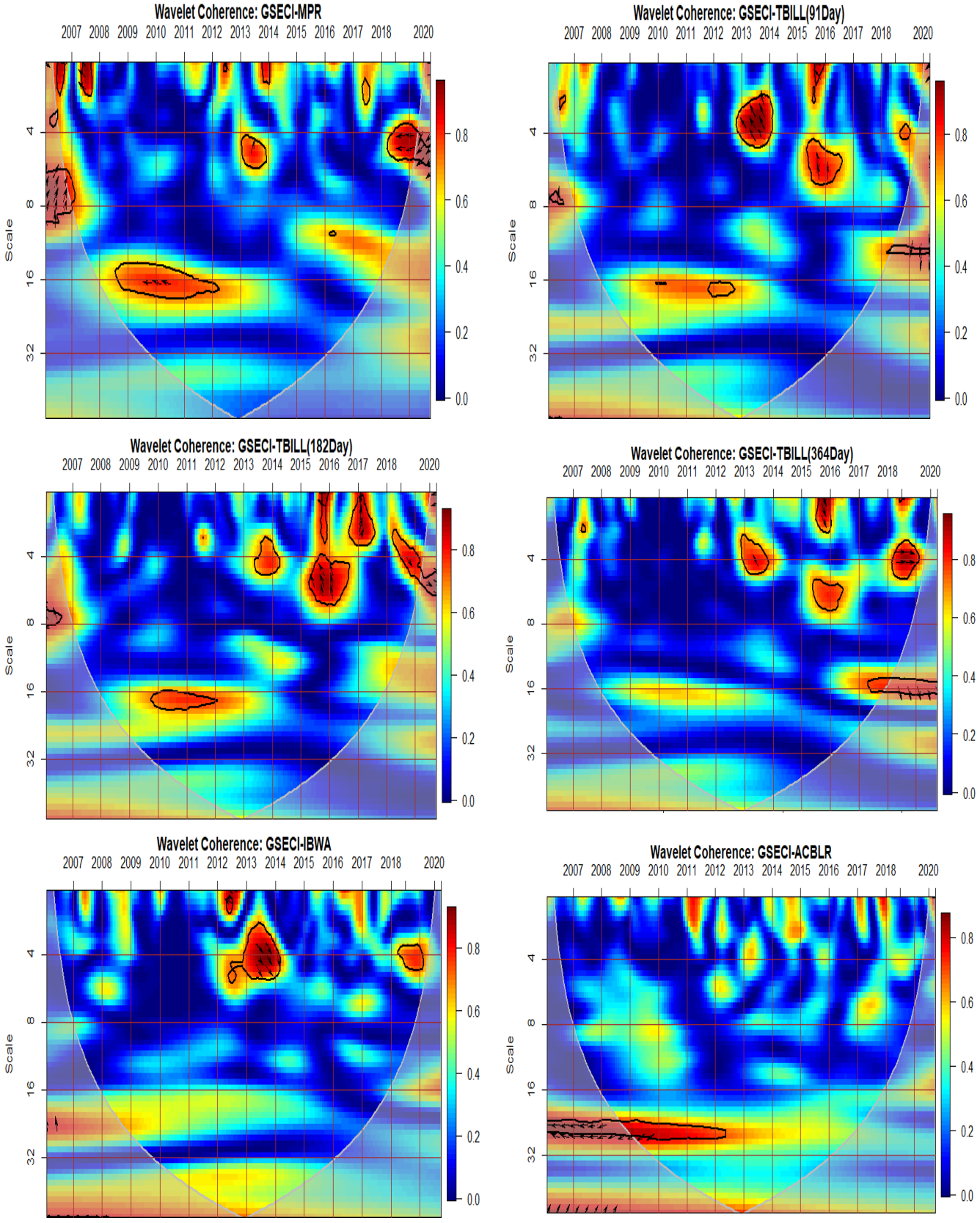


Figure 6. Comovements between GSECPI and banking sector financial soundness.

4.1.4. Interconnectedness between GSECI and Interest Rates

From Figure 7, we find that the comovements between GSECI and interest rates are strong, except in the long term. Also, the comovements between GSECI, the Treasury bill rates, and the average time deposits rate (ATDR) are negative. In most cases, the Treasury bill and ATDR measures drive GSECI. Relatively, the comovements between GSECI and interest rates are not strong as compared to the comovements between the GSECI and the banking sector's financial soundness. Accordingly, most measures of the banking sector's financial soundness are highly interconnected with GSECI as compared to the interest rate measures. This outcome is also similar to the one obtained for comovements with the GSEFI.



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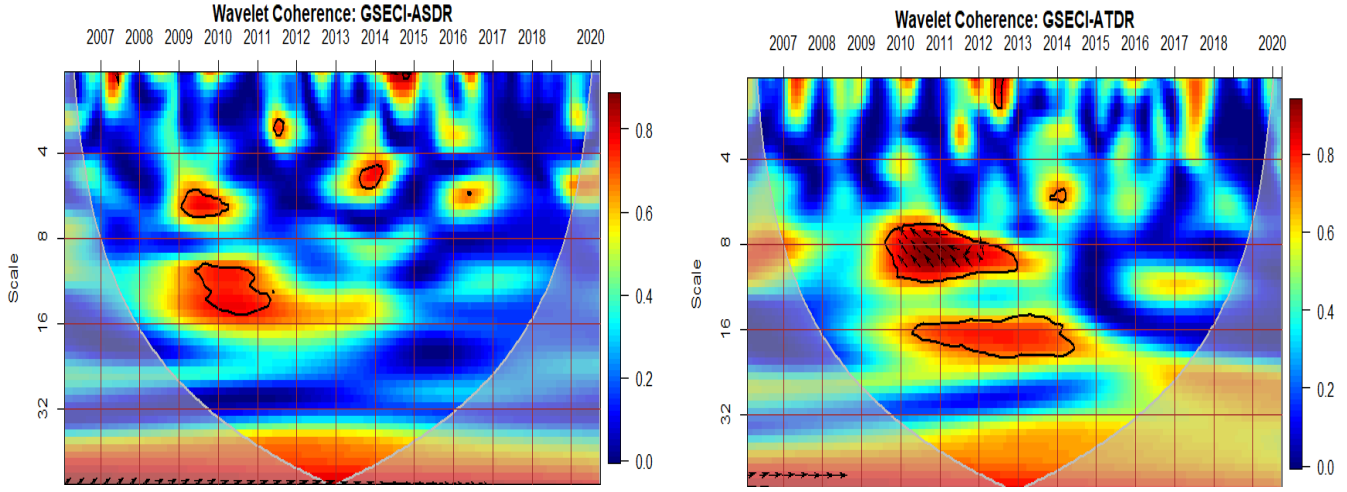

Figure 7. Comovements between GSECI and interest rates.

4.2. Frequency Domain

The wavelet multiple correlations (WMC) for the MODWTs localization of variables into frequencies is discussed below (Fernández-Macho 2012). Without actually exhibiting leading or lagging variables, it implies the degree of integration between the variables (see, Asafo-Adjei et al. 2021; Boateng et al. 2022a; Owusu Junior et al. 2021a).

Moreover, we present the wavelet multiple cross-correlation (WMCC) coefficients for four wavelet scales. The scales on the *y*-axis have identical connotations to those mentioned before in the wavelet multiple analysis discussion. The *x*-axis depicts the series' lag length. In this situation, the positive and negative lags are separated by 12 months. Positive lag indicates a lagging variable at the corresponding scales, whereas negative lag indicates a leading variable. Both a lead and a lag are absent at the localization's zero-lag. The dashed lines inside of the dotted lines represent localization, which is the term for the highest values in the linear combination of all variables at the wavelet scales (at all lags). The potential exists for a variable that is listed on a scale to either lead or lag all of the other variables. It denotes that it has the highest value among all the variables at the relevant scales in a linear combination at that scale. The economic significance of the WMCC is that it selects the variable with the greatest influence at a given wavelet scale to act as either a leading (first mover to respond to shocks) or a lagging (last variable to respond to shocks after the remaining variables) variable and to reveal the degree of interdependence between the variables.

4.2.1. Integration among the Indicators of GSE and Banking Sector Financial Soundness

The degree of integration among the GSEFI, GSECI, and banking sector financial soundness over various time horizons (short-, medium-, and long-term) is established in Figure 8 and Table 2 continuously. The monthly return series has a relatively high degree of integration, with values around 0.999307602 for the WMC, 0.996957065 for the lower panel, and 0.999842593 for the upper panel. Over the horizon, there is an unbroken swell in the WMC. As a result, the remaining variables can account for the monthly returns of one variable to a degree of about 99.9%, up to a scale of 16 months of interdependence.

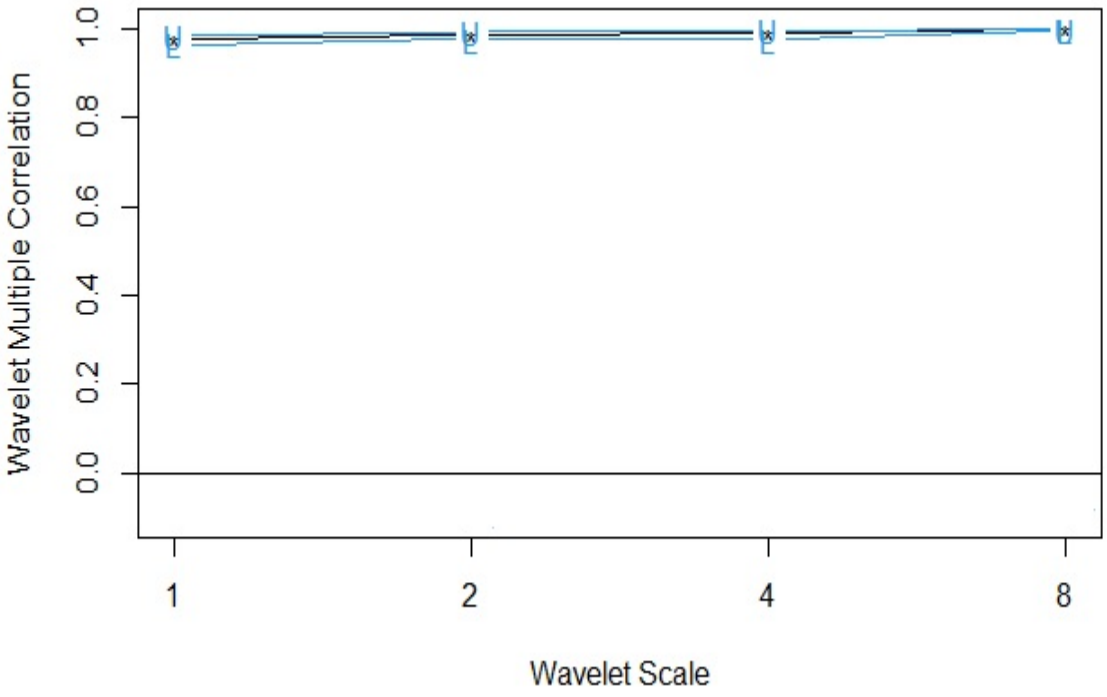

Figure 8. Wavelet multiple correlations between GSE and banking sector financial soundness. U—upper limits, L—lower (at 95% confidence interval), *—plots of actual WMC values.

Table 2. Wavelet multiple correlations between GSE and banking sector financial soundness.

Scale	WMC "Lower"	Correlation	WMC "Upper"
1	0.964951927	0.977309113	0.985341926
2	0.976548349	0.987514383	0.99336988
3	0.975745533	0.990556308	0.99633977
4	0.996957065	0.999307602	0.999842593

Figure 9 (Table 3) depicts interdependencies among all the variables—GSEFI, GSECI, and banking sector financial soundness indicators. We find that core liquid assets to total assets (CLATA) and core liquid assets to short-term liabilities (CLASL) are the most influential variables for maximising the WMCC. Specifically, CLATA has the potential to lead or lag in the short- and medium-term. Additionally, CLASL leads or lags the remaining variables only in the long term. In other words, the CLATA and CLASL act as either first movers to receive or predict shocks in other variables, specifically, GSE indicators. They also have the potential to be the last banking sector financial soundness indicator to respond to shocks depending on investment horizons.

Table 3. WMCC GSE and banking sector financial soundness.

Scale	Localizations	Time Lag (months)	Leading/Lagging Variable
1	0.977309113	0	CLATA
2	0.987514383	0	CLATA
3	0.990556308	0	CLATA
4	0.999307602	0	CLASL

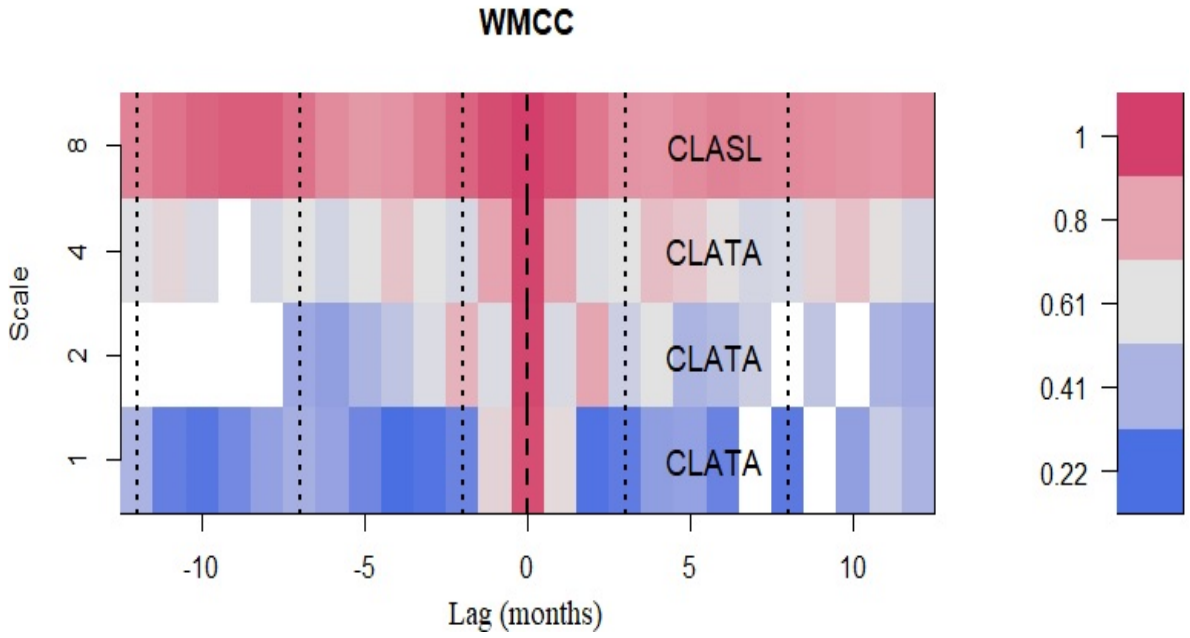

Figure 9. WMCC GSE and banking sector financial soundness.

4.2.2. Integration among the Indicators of GSE and Interest Rates

Figure 10 and Table 4 establish the degree of integration among the GSEFI, GSECI, and interest rates over diverse horizons (short-, medium-, and long-term) in a continuous fashion. The monthly return series has a rather high degree of integration, with values around 0.997779582 for the WMC, 0.990267007 for the lower panel, and 0.999494921 for the upper panel. There is an uninterrupted surge in the WMC over the horizon. As a result, the other variables can account for the monthly returns of one variable to a degree of roughly 99% monthly, resulting in a scale of 16 months of interdependence.

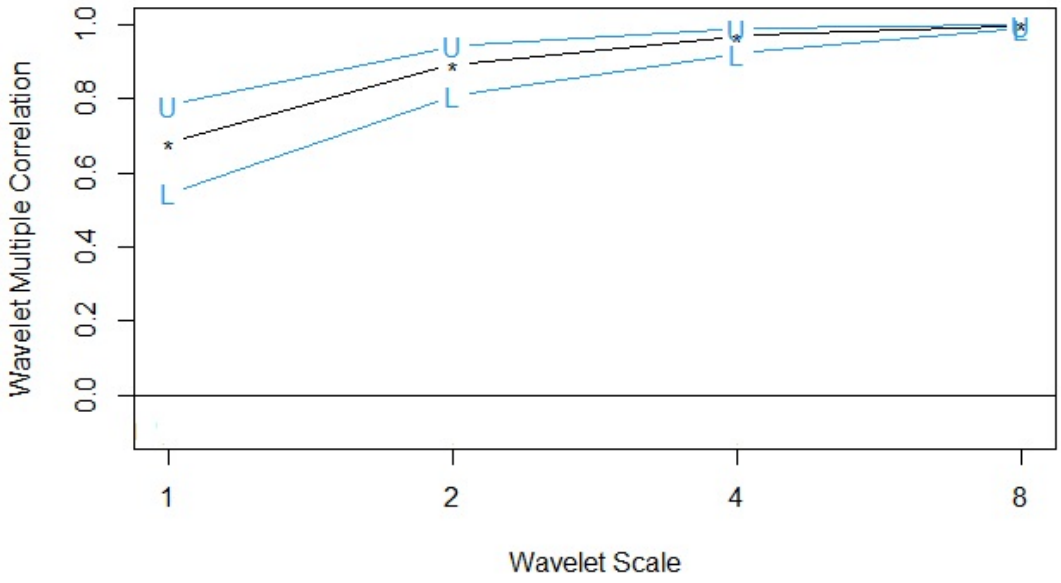

Figure 10. WMC among the indicators of GSE and interest rates. U—upper limits, L—lower (at 95% confidence interval), *—plots of actual WMC values.

Table 4. WMC among the indicators of GSE and interest rates.

Scale	WMC "Lower"	Correlation	WMC "Upper"
1	0.545483715	0.681785289	0.782952777
2	0.808482582	0.893814518	0.942338444
3	0.922916484	0.969488667	0.988097124
4	0.990267007	0.997779582	0.999494921

Figure 11 (Table 5) depicts that the integration among GSEFI, GSECI, and interest rate indicators has Treasury bill rates to be the most influential variable to maximise the WMCC. Specifically, the 182-day Treasury bill has the potential to lead or lag in the short- and medium-term. Moreover, the 91-day Treasury bill leads or lags in the medium- and long-term. In other words, the 91-day and 182-day Treasury bills act as either first movers to receive or predict shocks in other variables, specifically, GSE indicators. They also have the potential to be the last economic indicator to respond to shocks, depending on investment horizons. The potential for the Treasury bill measures to lead implies that a rise in these measures invests in bonds more preferred to stocks across investment horizons within the system of GSE and interest rates, and vice versa with a potential to lag. Investors can therefore form reliable portfolios between government securities and stocks depending on the dynamics of Treasury bill measures.

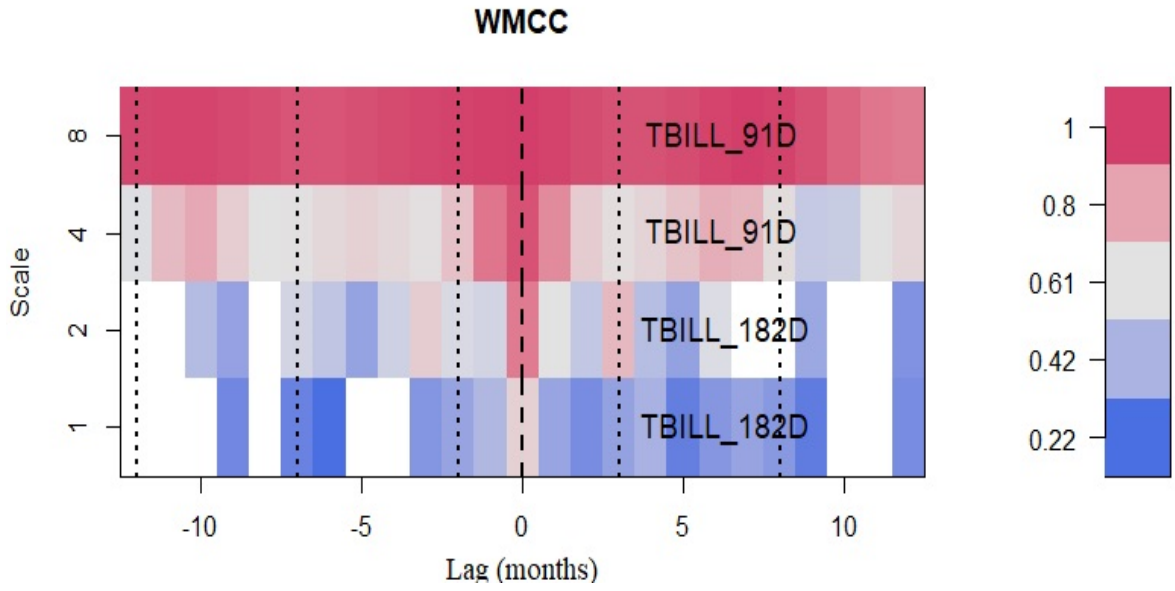

Figure 11. WMCC among the indicators of GSE and interest rates.

Table 5. WMCC among the indicators of GSE and interest rates.

Scale	Localizations	Time Lag (months)	Leading/Lagging Variable
1	0.681785289	0	TBILL_182D
2	0.893814518	0	TBILL_182D
3	0.969488667	0	TBILL_91D
4	0.997779582	0	TBILL_91D

4.2.3. Integration among GSE, Banking Sector Financial Soundness, and Interest Rates

The degree of integration between the GSEFI, GSECI, and banking sector financial soundness over various time horizons (short-, medium-, and long-term) is established in Figure 12 and Table 6 continuously. The monthly return series has a rather high degree of integration, with values averaging around 0.999738675 for the WMC, 0.998850695 for the lower panel, and 0.999940601 for the upper panel. Over the horizon, there is an unbroken

swell in the WMC. As a result, the other variables may account for the monthly returns of one variable to a degree of around 99.97%, up to a scale of 16 months of dependency.

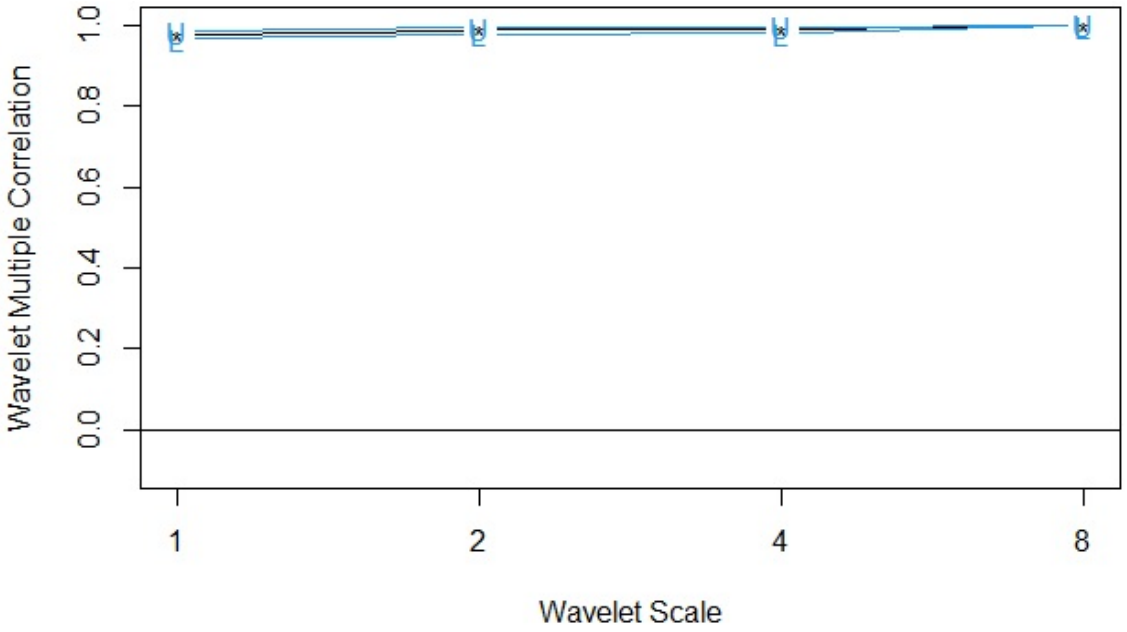

Figure 12. WMC among GSE, banking sector financial soundness, and interest rates. U—upper limits, L—lower (at 95% confidence interval), *—plots of actual WMC values.

Table 6. WMC among GSE, banking sector financial soundness, and interest rates.

Scale	WMC "Lower"	Correlation	WMC "Upper"
1	0.96691929	0.978590385	0.986172786
2	0.978994009	0.988822915	0.99406657
3	0.980472831	0.992408016	0.997059139
4	0.998850695	0.999738675	0.999940601

We find from Figure 13 (Table 7) that core liquid assets to total assets (CLATA) and core liquid assets to short-term liabilities (CLASL) are the most influential variables to maximise the WMCC for all the variables included in this study. Thus, CLATA has the potential to lead or lag in the short-, and medium-terms. Additionally, CLASL leads or lags the remaining variables only in the long term. This suggests that CLATA and CLASL are the most influential variables in the interconnectedness among GSEFSI, GSECI, interest rates, and the remaining banking sector financial soundness indicators. As a result, both CLATA and CLASL should be monitored by regulators, policymakers, investors, and among other interested parties with care at various intrinsic times.

Table 7. WMCC among the indicators of GSE, banking sector financial Soundness, and interest rates.

Scale	Localizations	Time Lag (months)	Leading/Lagging Variable
1	0.978590385	0	CLATA
2	0.988822915	0	CLATA
3	0.992408016	0	CLATA
4	0.999738675	0	CLASL

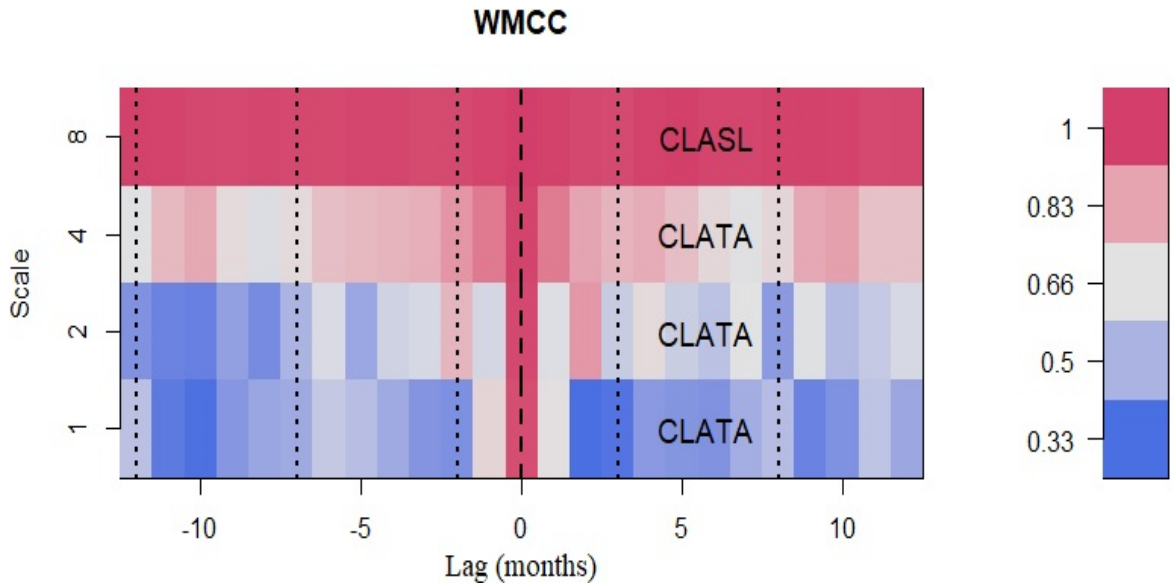

Figure 13. WMCC among the indicators of GSE, banking sector financial Soundness, and interest rates.

4.3. Robustness Check

The network interconnected structure among the indicators of the GSE, financial soundness indicators and interest rates is presented in Figure 14. It specifically shows the net pairwise directional connectedness obtained through the DCC-GARCH connectedness approach. It is noticeable from Figure 12 that, aside from RoE and ASDR, the remaining measures of banking sector financial soundness are potential net receivers of shocks. The 91-Day and 182-Day Treasury bill rates are net transmitters of shocks to the 364-Day Treasury bill. This is not surprising because the dynamics of both the 91-Day and 182-Day Treasury bills would have been reflected in the 364-Day Treasury bill, upon maturity considering the liquidity position in the Ghanaian economy. The interbank weighted average (IBWA) transmits shocks to MPR, ACBLR, CAR, and CLATA. Also, ATDR receives shocks from ASDR and the 182-Day Treasury bill. For the indicators of the GSE, the GSEFI drives the GSECI. This explains that the GSEFI acts as a first mover to cause a change in the GSECI. Hence, addressing the important role of the financial system in a market-based system within the connectedness of several macroeconomic indicators. Moreover, we find no linkages between the market-based measures and the selected macroeconomic variables, rendering a static approach less effective in providing the true picture of the nexus.

We present additional research on the nexus between the GSEFI and GSECI in Figure 15 to partly reiterate the findings of Osei and Adam (2020) on the significant role of the financial sector as a constituent in enhancing the overall market structure toward economic development. We find a positive comovement between the GSEFI and GSECI from 2007 to 2009. This suggests similar behaviour of both indices, rendering redeployment of the portfolio within the entire market structure concerning the financial sector less likely. Conversely, in the aftermath of the 2008 Global Financial Crisis (GFC), an inverse nexus is found to induce diversification strategies by existing and potential investors in the GSE regarding both the GSEFI and GSECI. The sudden change in the directional connectedness can be attributed to the rebasing of the economic statistics of the country in 2010, which led the economy into the middle-income group. Accordingly, following the aftermath of the 2008 GFC, the diversification opportunity observed across calendar times accentuates the DVMCES hypothesis put forward by Asafo-Adjei et al. (2022c). The reverse in the directional comovements (i.e., positive) is noticeable beyond 2012.

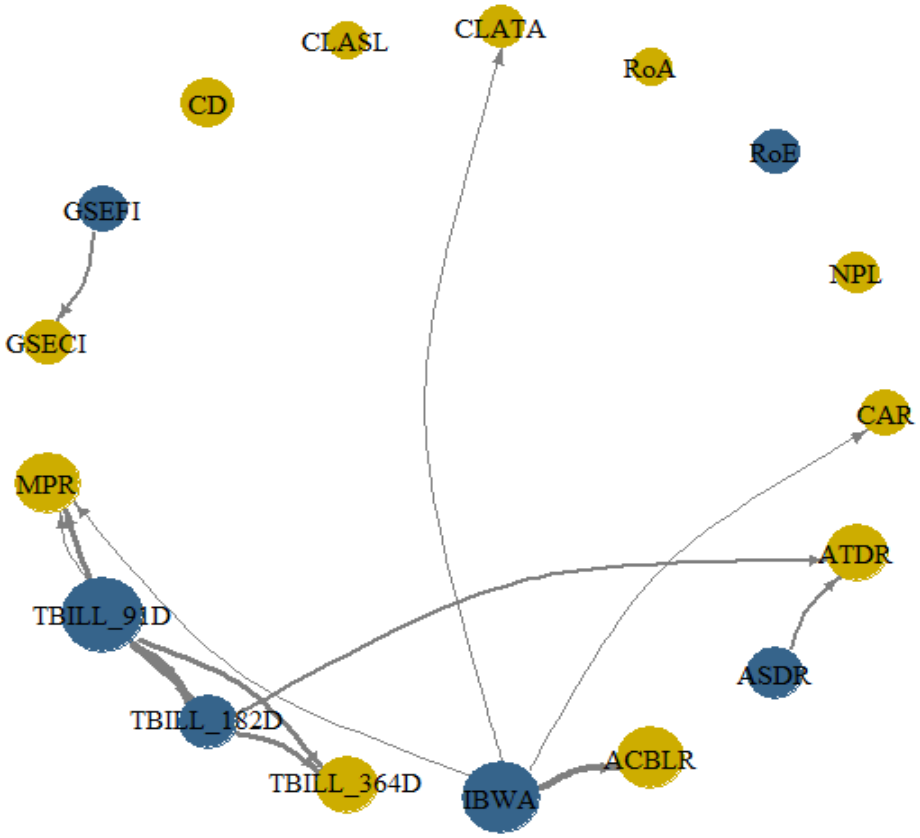

Figure 14. Net pairwise directional connectedness among indicators of GSE, financial soundness indicators and interest rates obtained through the DCC-GARCH connectedness approach. Notes: The arrows show net directional connectivity between two variables. The blue nodes illustrate net transmitters of shocks whereas brown nodes specify net receivers of shocks. The nodes' size depicts weighted average net total directional connectedness.

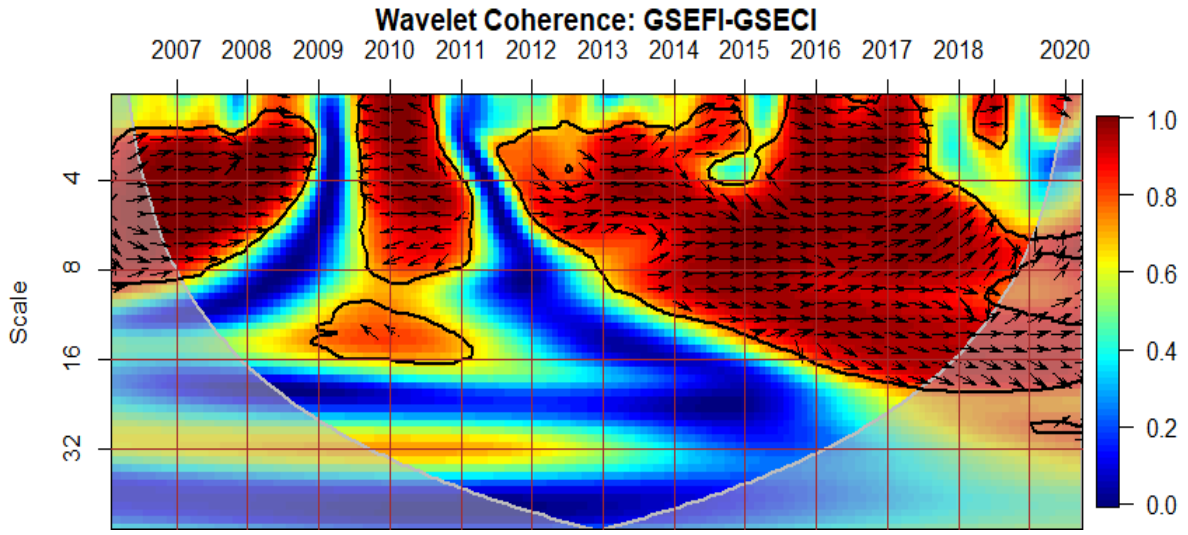

Figure 15. Comovements between the indicators of the GSE.

It is instructive to note two possible outcomes from the nexus, in addition to the directional comovements. First, the comovements are significant only in the short- and medium-terms, suggesting a saturated market in the long-term with an unpredictable pattern of an efficient market. The insignificant comovements, in this case, are not ideal for speculative investors who seek to predict the market but only to the extent of uncorre-

lated asset returns, which may be ideal for portfolio diversification (Baur and Lucey 2010). Second, we find a bicausality between the GSEFI and GSECI but with the GSEFI being the dominant driver, especially in the short term. Reverse dominant causality is found (causality from the GSECI to the GSEFI) in the medium-term at the point when the behaviour of the GSEFI has already been captured/observed by the GSECI (coupled with impacts from several other sectors), necessitating a new course of causality. The finding partly supports the outcome obtained by Osei and Adam (2020) on the significant information transfer from the financial sector as a constituent to the GSECI and the argument of Asafo-Adjei et al. (2021) on the significant role of the financial sector index as an appropriate proxy for a market-based system.

5. Practical Implications

It must be noted that lead-lag relationships among the indicators of the GSE, banking sector financial soundness, and interest rates are heterogeneous and adaptive, as revealed in the study of Boateng et al. (2022a) when commodities in Ghana and macroeconomic variables were considered. The findings of Shahbaz et al. (2019), Abaidoo et al. (2021), Flori et al. (2021), Kinda et al. (2018), and Asafo-Adjei et al. (2021) conducted outside Ghana are of no exception to the extent of the heterogeneous and/or adaptive dynamics. Hence, relevant stakeholders such as policymakers, investors, investors, and asset managers should encourage adaptive strategies across time and frequency. Nonetheless, we provide a unique contribution to the Ghanaian economy by addressing the sustainability of the financial system's susceptibility to other macroeconomic fundamentals, which have been ignored by recent studies in the quest of providing policy directions or strategies, It is instructive to suggest that the development of strategies for enhanced macroeconomic stability of nations demands a deeper comprehension and appraisal of the integrative dynamics of monetary and fiscal policy measures with their impact on the economy. The financial market system and economic activities could be affected by destabilising factors both internal and external. Resuscitation of the economy is probable through the intervention of state authorities such as the government and the Central Bank to fine-tune both fiscal and monetary policies.

To begin with, the positive impact found between the indicators of the GSE and banking sector financial soundness measures informs policymakers that the strength and weaknesses of the financial system are reflective of each other. Hence, in times of significant economic shocks or poor performance of either the indicators of the GSE or the banking sector's financial soundness measures may have a contagion effect on the other. This calls for critical monitoring of the financial system to induce productive investment in the real sector, which could drive a positive change in other macroeconomic conditions across time and frequency (Asafo-Adjei et al. 2021; Ozenbas et al. 2022). In this regard, there should be a gradual readjustment of government spending and taxes geared toward enhancing productive investments in the real sector to improve the asset prices of businesses.

Moreover, policymakers with the quest of putting Ghana's economy on a sustainable path should fine-tune or regulate Treasury bill rates to enhance competitiveness between the bond market and stock market for a progressive financial system. This is particularly pertinent because we found the interest rate indicators, especially the Treasury bill measures, leading the two GSE indicators in the short- and medium-term as found from both the biwavelet and wavelet multiple techniques. The directional impact was then found to be negative at most times, suggesting that a rise in Treasury bill measures is inimical to growth or a rise in the stock market in favour of the bond market. This assertion is in line with the dividend discount model, where an increase in interest rates diminishes the value of the stock market, making it less attractive. However, the outcome of the negative nexus between interest rates and stock returns is not surprising due to the growth constraints in times of poorly performing macroeconomic indicators in the Ghanaian economy (Owusu-Ankamah and Sakyi 2021; Amegavi et al. 2022; Obeng et al. 2022). This requires immediate attention by the government to initiate policies to revamp the economy into a sustainable one, and also policies that are adaptive to the changing circumstances of the economy across

time and frequency. Most specifically, interest rates, such as the Treasury bill measures, could be reduced to face-lift the current value of the stock market in the short- and medium-term to enhance competitiveness where the stock market becomes less attractive. This action to monetary policy would then make it cheaper to borrow to encourage spending and investment, leading to higher economic growth. As a result, consumer and business spending will increase, which can boost asset prices. However, lowering the interest rate should be adaptive enough not to undermine its effectiveness in withstanding inflationary pressures and liquidity traps.

6. Conclusions

The study sought to assess the degree of integration between GSE and banking sector financial soundness indicators and interest rates, as well as among all the variables suggesting a complex system. In addition, we investigate the tendencies to which each variable drives the other in time and frequency or frequency-dependent approach to reveal the level of heterogeneity and adaptiveness within these economic indicators. Specifically, we examine whether it is the GSE that drives the banking sector's financial soundness and interest rates or otherwise. The GSEFI and GSECI are employed as reliable proxies for GSE to facilitate effective comparison. To achieve the main purpose of the study, we utilized the wavelet techniques, which take care of both time and/or frequency. Specifically, the biwavelet and wavelet multiple techniques were used. The main contribution to the empirical literature is the assessment of integration among GSEFI, GSECI, banking sector financial soundness indicators, and interest rates using wavelet techniques. The closest study to ours is the one by Boateng et al. (2022a), who employed three commodities and economic drivers relevant to Ghana with wavelet as the estimation technique.

We found high interconnectedness between the indicators of GSE and banking sector financial soundness relative to the interest rates. Notwithstanding, the Treasury bill measures drive the two GSE indicators in the short-, and medium-terms as found from both the biwavelet and wavelet multiple techniques. Specifically, from the wavelet multiple correlations, there are very high integrations among GSEFI, GSECI, and banking sector financial soundness relative to the integration among GSEFI, GSECI, and interest rates. That is, interest rates act as a possible setback or constraint in the comovements between GSE and banking sector financial soundness. We advocate that the comovements among the indicators of GSE, banking sector financial soundness, and interest rates are heterogeneous and adaptive, especially during crises of significant comovements. Hence, time and frequency approaches provide a true picture of the nexus relative to techniques that reveal average responses.

Comparatively, the study underscores that stronger comovements existed between the GSEFI and the two broad macroeconomic variables (banking sector financial soundness and interest rate measures) relative to the GSECI. This shows that it is not exaggerated to use the performance and expansion of the GSE, which includes a stream of businesses providing financial services, as a proxy for financial development (Bagehot 1873; Levine 2005; Asafo-Adjei et al. 2021).

The first research hypothesis of a lead-lag relationship between the indicators of the GSE and macroeconomic variables across time and frequency was supported. We further provided full support for the second research hypothesis of a significant integration among the indicators of the GSE and macroeconomic variables across investment horizons. Also, the significant positive nexus between the indicators of the GSE and banking sector financial soundness measures was partially supported since comovements were found to be bidirectional. Similar to the comovements with the interest rate measures, the negative nexus was revealed in addition to the positive. Moreover, it was confirmed that the baking sector's financial soundness measures had the potential to lead or lag amid the indicators of the GSE and interest rates. To end with, the GSEFI was confirmed to be a significant leader or laggard with macroeconomic fundamentals in comparison with the GSECI.

Findings from this study have serious implications for relevant stakeholders such as the government of Ghana, the Bank of Ghana, security regulators, portfolio managers, risk managers, and investors. They need to consistently monitor the nexus between the stock markets and the banking sector indicators in light of general macroeconomic factors such as interest rates and inflation, regarding monetary policy. Further studies can consider the partial impact of interest rates on the comovements between the GSE and the banking sector's financial soundness. Inflation rates can also be considered to enhance monetary policy decisions.

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