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Article

Romanian Stock Market Integration with Europe: A Covid-19 Perspective

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Abstract: Understanding the interconnectedness of financial markets is essential for assessing market efficiency, risk transmission, and financial integration, particularly in the context of global shocks. While the COVID-19 pandemic has prompted numerous empirical investigations into international stock market co-movements, important gaps remain regarding the integration between developed and emerging European markets. This study explores the degree of integration between the Romanian stock market and major developed Western European markets, with a particular emphasis on Germany, Romania's largest trading partner. Employing partial wavelet coherence analysis, we analyze the co-movement between the German DAX and Romanian BET indices across three distinct periods: before, during, and after the COVID-19 pandemic. The findings reveal that the pandemic temporarily weakened market integration, but this effect was reversed in the post-pandemic period, with integration not only recovering but intensifying. These results carry important implications for investors, policymakers, and scholars concerned with financial contagion, regional integration, and the resilience of emerging markets in the European context.

Keywords: Financial Market Integration; Co-movement; Covid-19 Pandemic; Partial Wavelet Coherence,

JEL code: G10, G11, G18,

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INTRODUCTION

Understanding the interconnectedness of financial markets has become an essential area of investigation in modern economic research. In particular, studying why and how stock market indices across countries are linked offers valuable insights into market efficiency, risk transmission, portfolio diversification, and the broader dynamics of financial integration. Examining these connections is not only relevant for investors and policymakers but also plays a crucial role in assessing the stability and resilience of financial systems, especially in times of global uncertainty such as the Covid-19 pandemic.

In recent years – particularly since the outbreak of the COVID-19 pandemic – numerous empirical studies (for example Bekaert & Harvey (1995); Masih & Masih (2001); Berger et al., (2011); Ali et al. (2020); Cagliesi & Guidi (2021)) have examined stock market integration, co-movements and contagion effects across the globe. Although the number of empirical studies on market integration has increased in recent years, there are still notable research gaps where relevant investigations can be conducted. The comprehensive literature review conducted by Patel et al. (2022) highlights the lack of consensus regarding the level of market integration among developed, emerging, and frontier markets. It also emphasizes the importance of conducting such research across different geographic regions or countries that are part of economic, regional, and trade associations such as ASEAN, SAARC, and the EU.

In light of the above this research seeks to explore the extent to which the Romanian stock market is integrated with more developed Western European stock markets, with a particular focus on the German market – given that Germany is Romania's largest trading partner. Additionally, it investigates whether this relationship has changed in response to the impact of COVID-19. Specifically, the study employs partial wavelet coherence analysis to examine the co-movement between the Romanian stock index (BET) and the German stock index (DAX) across three distinct periods: before, during, and after the COVID-19 pandemic.

The remainder of the manuscript is structured as follows: Section 2 provides a brief literature review, followed by a presentation of the data and the applied methodology in Section 3. Section 4 contains the discussion and results, and the paper concludes with the final remarks in Section 5.

LITERATURE REVIEW

Recent decades have seen numerous studies (Bekaert & Harvey (1995); Masih & Masih (2001); Berger et al., (2011); Iyke (2020); Sharif et al. (2020); Zhang et al. (2020); Akbari et al., (2021); Cagliesi & Guidi (2021); Kizys et al. (2021), Okorie & Lin (2021)) investigating market integration and co-movement, highlighting that there is still no clear consensus regarding the nature and extent of market integration between developed and emerging economies. Similarly, studies – for example Caporale et al., (2005); Dias et al., (2019); Wang (2014) – point out that we still have a limited understanding of how crises and extraordinary events affect market linkages. While the present study does not aim to examine these questions on a global scale, a comprehensive overview of the topic can be found in the literature review by Patel et al. (2022). From a European perspective, however, it can be stated that the COVID-19 pandemic – similar to previous crises – triggered unprecedented disruptions in financial markets, raising questions about stock market cointegration and the co-movement between Eastern and Western European economies.

Before COVID-19, Central and Eastern European (CEE) stock markets had become increasingly interlinked with Western Europe, partly due to economic integration and EU expansion (Minović et al., 2023). The pandemic, however, significantly altered these linkages, as documented by multiple studies. For example, Davidescu et al. (2023), using volatility spillover analysis and a Markov-switching VAR, examined contagion from developed markets (Germany and the U.S.) to four emerging CEE markets (Romania, Poland, Hungary, Czech Republic). The authors found a high level of integration among CEE markets, with volatility transmissions intensifying during crisis periods. Notably, in normal times, the Bucharest index (BET), Prague's PX, and Warsaw's WIG were net transmitters of volatility, while Budapest's BUX was a net recipient. During the COVID-19 shock, BUX switched to transmitting volatility to the other CEE indices. A regime-switching

analysis confirmed a structural shift around the pandemic outbreak: CEE markets moved into a high-volatility regime, and contagion from developed markets to the CEE region increased significantly in the early phase of COVID-19. This indicates that Western European and U.S. market shocks were more strongly propagated into Romania and its regional peers during the pandemic.

Similarly, Rehman et al. (2022) analyzed 42 stock markets (both developed and emerging) to assess return connectedness during COVID-19 using various dependence measures, providing a global context that includes CEE markets. The authors reported that cross-market linkages surged amid the pandemic; for example, co-movements between CEE and G7 markets increased significantly during the COVID-19 period, supporting the notion of contagion. In other words, Central and Eastern European markets like Romania's became more tightly correlated with major Western markets when COVID-19 hit, reflecting a shift from pre-crisis interdependence to crisis-period contagion. Their findings highlight that the pandemic caused a higher synchronization of returns internationally, particularly between developed and emerging Europe, compared to pre-pandemic dynamics.

Aslam et al. (2021), focusing on high-frequency data, estimated intraday volatility spillovers among 12 European stock markets representing all regions of Europe during the initial COVID outbreak. Using a DCC-GARCH and Diebold–Yilmaz spillover index approach, the authors found that an astonishing 77.8% of the variance in intraday volatility across these markets could be attributed to cross-market spillovers during the pandemic period. This points to extremely high short-term interdependence. They also identified changes in the usual transmission roles: the largest net volatility transmitters were the developed markets of Germany and the Netherlands, whereas a CEE market (Poland) and Ireland showed the smallest spillover influence on others. These intraday results underscore how quickly European markets – both large and small – became intertwined due to COVID-19, with Western European markets driving volatility and CEE markets largely absorbing it.

In contrast to the studies presented so far, Radu and Poenaru (2021) observed that, unlike the more "resilient" Western European markets, the less liquid CEE markets displayed divergent reactions to pandemic developments. Specifically, news related to COVID-19 had differed effects in Romania, Poland, and Bulgaria compared to Western Europe, suggesting a temporary decoupling in how these stock markets responded to the pandemic shock. Similarly, Karkowska and Urjasz (2022), through their analysis of risk-transfer networks, found that Western European indices were more affected by COVID-19 shocks than their CEE counterparts. During the pandemic, Western markets exhibited the strongest co-movements (e.g., the S&P 500 with the UK's FTSE, France's CAC, and Germany's DAX), while correlations between the U.S. and CEE indices remained comparatively weaker. This suggests a lower level of integration between CEE markets and global financial contagion, as CEE stock indices were less affected and more decoupled from the initial COVID-induced turmoil. Supporting this, Škrinjarić (2021), in an event study of Central, Eastern, and Southeastern European stock markets, reported sharply negative initial reactions to COVID-19-related announcements, followed by opportunities for contrarian gains.

In the absence of common results in the literature presented above, the authors of the present study believe that it is worthwhile to further investigate the integration of the Romanian stock market with Western European markets, as well as to thoroughly examine the impact of COVID-19 on this co-movement and integration.

DATA AND METHODOLOGY

Data

The dataset used in this study covers the period from January 1, 2017, to November 4, 2024. For the purpose of the analysis, the full sample was divided into three distinct subperiods based on the timeline of the COVID-19 pandemic, as follows: (1) pre-COVID-19 period: January 1, 2017 – February 28, 2020; This period represents the time before the outbreak of COVID-19 pandemic, which is considered to have started in March 2020. (2) COVID-19 period: March 1, 2020 – April 30, 2023; This interval covers the outbreak and duration of the COVID-19 pandemic, ending with the official announcement by the European Union in late April 2023 declaring the end of the pandemic at the EU level. (3) post-COVID-19 period: May 1, 2023 –

November 4, 2024; This phase includes the period after the formal end of COVID-19 until the end of the observation window.

The main variables of interest are the following stock market indices: (1) Romanian Stock Market Index (BET): The benchmark index of the Bucharest Stock Exchange, reflecting the performance of the most liquid Romanian companies. (2) German Stock Market Index (DAX): Germany's leading stock index, comprising 40 major German blue-chip companies traded on the Frankfurt Stock Exchange.

In addition, to account for the dominant influence of the U.S. financial markets on global equity and stock markets, the S&P 500 Index (SP500) was included as a control variable, capturing the performance and efficiency of the U.S. stock market. Besides the U.S. stock market index, based on the assumption that the largest European economies also influence the BET index – and given that these economies are Romania's major trading partners – the study considered the performance of the Italian Stock Market Index (IT40), the French Stock Market Index (CAC40), the Dutch Stock Market Index (AEX), and the UK Stock Market Index (FTSE100), acknowledging that despite Brexit, the United Kingdom remains one of Romania's key trade partners. Together, these indices offer a comprehensive view of Romania's integration with both Western European and global stock markets, and their inclusion enables a robust examination of market interdependence and the dynamics of financial integration across different phases of the COVID-19 crisis.

Methodology

Wavelet techniques have long been applied in financial research, as seen in works like Ramsey & Lampart (1998), or more recently in Bouri et al., (2023). A newer tool derived from wavelet analysis – wavelet coherence – has also found applications in financial studies. For a detailed explanation of wavelet coherence, refer to Torrence & Compo (1998). An example of its current use in the context of co-movements during Covid-19 is provided by Goodell & Goutte (2021).

In this study, the authors argue that instead of relying on a multivariate linear regression model, nonlinear interrelations are better captured using partial wavelet coherence (PWC), which allow for a richer depiction of these relationships. While other nonlinear techniques (such as nonlinear autoregressive distributed lags, nonlinear Granger causality, or log-periodic oscillations) have been explored, they lack the depth of information – such as heatmaps and phase lags – offered by PWC. Importantly, this study employs partial wavelet coherence rather than general wavelet coherence, positioning the approach as a nonlinear counterpart to multivariate regression analysis.

The methodology builds on the work of Ghosh et al. (2023), but with a key advancement: whereas Ghosh's method is limited to a single excluded variable and lacks phase data, this study introduces a new PWC method that accommodates multiple excluded variables and preserves phase information. This is especially relevant since bivariate analyses can be misleading when both variables are influenced by third-party factors (Hu and Si, 2021).

Wavelets, which generalize the Fourier transform, function as bandpass filters that extract selected components from a time series. The continuous wavelet transform is generally represented as:

$$W_x(u,s) = \int_{-\infty}^{\infty} x(t)\frac{1}{\sqrt{s}}\psi^*\left(\frac{t-u}{s}\right)dt$$

where ψ* is the complex conjugate of ψ.

The wavelet coherence between two series, X and Y, is expressed as:

$$R_{xy} = \frac{S\left(W_{xy}(s,t)\right)}{\sqrt{S(|W_x(s,t)|^2)\,S\left(\left|W_y(s,t)\right|^2\right)}}$$

with S() as the smoothing function, $W_z(s,t)$ representing the Morlet wavelet transform of series x, and $W_{xy}(s,t)$ is the cross-wavelet transform between x and y. The Morlet wavelet itself is a complex exponential scaled by a Gaussian function:

$$\psi_0(t) = \frac{1}{\sqrt[4]{\pi}}e^{i\omega_0 t}e^{-t^2/2}$$

where ω_0 is the angular frequency, t is the time parameter, and i is the imaginary unit (Morlet et al., 1982).

To draw conclusions about causal connections, the coherence phase difference is used:

$$\phi_{XY} = Arctan \frac{Im\left(W_{XY}(s,t)\right)}{Re\left(W_{XY}(s,t)\right)}$$

which is essentially the argument of the complex scalar value, ϕ, with Im and Re representing the imaginary and real parts, respectively.

Partial wavelet coherence (PWC) extends wavelet coherence into a multivariate framework. Much like the partial correlation coefficient in Pearson's framework, PWC isolates the relationship between two variables while controlling for others, and it can handle nonlinearities. It is calculated using:

$$PWC_{X_i X_j} = -\frac{R_{ij}}{\sqrt{R_{ii} R_{jj}}}$$

where the determinant's cofactor comes from the smoothed cross-wavelet coherence matrix R.

RESULTS AND DISCUSSION

As stated in the introduction, the main purpose of this study was to examine the integration and co-movement of the Romanian stock market index, the BET, and the German stock market index, the DAX, under different market conditions. To ensure that the research findings are meaningful and accurately reflect reality, it is not sufficient to analyze only the returns of the BET and DAX indices and their co-movements using partial wavelet coherency analysis. This is because the Romanian stock market index, the BET, is influenced by numerous other factors. Therefore, in this study, alongside the BET and DAX indices, we also included the U.S. stock market index, the S&P 500, as well as the stock market indices of the four largest European economies. These economies are not only the most significant in Europe but also represent Romania's main trading partners. Consequently, it is reasonable to assume that the Italian, French, Dutch, and UK stock market indices – namely, the IT40, CAC40, AEX, and FTSE100 – also exert an influence on the Bucharest Stock Exchange. In light of this, we generated partial wavelet coherency analysis heatmaps to examine the co-movement between the BET and DAX indices while controlling for the potential effects of all other stock market indices. These results are presented in Figure 1.

Based on the three heatmaps shown in Figure 1, it can be observed that market integration and co-movement indeed vary across the examined sub-periods. For example, when comparing the left-hand heatmap of Figure 1, representing the pre-COVID period, with the central heatmap, corresponding to the COVID period, it is apparent that the COVID-period heatmap displays significantly more blue areas. This suggests that market co-movement weakened considerably during the COVID period. When comparing the central heatmap (COVID period) with the right-hand heatmap (post-COVID period), it is evident that the post-COVID period contains considerably more red areas, indicating that market co-movement – and thus capital market integration – strengthened notably after COVID. Moreover, when comparing the pre-COVID and post-COVID periods, that is, the left-hand and right-hand heatmaps of Figure 1, it can be observed that the post-COVID period shows even more red areas compared to the pre-COVID period. This implies that although stock market co-movements weakened during the COVID period, in the subsequent post-COVID period, they not only recovered to pre-COVID levels but even surpassed them, indicating that the stock market linkages and co-movements between the BET and DAX indices became stronger after COVID compared to the pre-pandemic period.

In order to address the research question outlined in the introduction – namely, to what extent the Romanian capital market is integrated with the more developed Western European capital markets, and whether this relationship changed as a result of the COVID-19 pandemic – the authors conducted an additional analysis to ensure the reliability of the findings. As a robustness check, the authors extended the previously presented analysis to include the relationship between the BET index and the Standard & Poor's 500 (S&P 500) index, as shown in Figure 2, as well as the relationship between the BET index and the aforementioned Western European stock market indices. For example, the co-movement between the Romanian BET index and the Italian stock market index, IT40, is presented in Figure 3. The results show that in both Figure 2 and Figure 3, very similar patterns emerge as in Figure 1. In both cases, the central heatmaps display a

significantly larger blue area, indicating that co-movement weakened during the COVID period. Furthermore, in the post-COVID period, the co-movement between the Romanian stock market and the examined Western European and U.S. stock indices not only recovered to the levels observed in the pre-COVID period but even strengthened beyond them.

CONCLUSIONS

The results obtained from the partial wavelet coherency analysis reveal that there are fundamental differences across the examined sub-periods. Based on the results, the following conclusions can be drawn. First, there is clear evidence of stock market integration and co-movement between the Romanian stock index and the German stock index. Second, this integration and co-movement vary across the different analyzed periods, the COVID-19 affecting (weakening) stock market integration. Third, when comparing the pre-COVID and post-COVID periods, it can be established that in the post-COVID period, stock market integration and co-movement not just returned to the pre-pandemic levels but intensified, meaning that the Romanian stock market became even more closely connected to the German stock market. Fourth, the same pattern – that is, a weakening of stock market integration during the COVID period, followed by not only a recovery to pre-COVID levels but a further strengthening afterward – can also be observed between the Romanian stock index and the capital markets of other developed economies, such as the United States or Italy.

From an economic and financial implications perspective, the following conclusion can be drawn: the Romanian economy is becoming increasingly interconnected with the developed Western European economies and their capital markets. Although this interconnectedness was somewhat disrupted during the COVID period, it has since been strengthening again. Therefore, policymakers should always anticipate that any external shock affecting Western European economies is likely to spill over rapidly into the Romanian economy as well.

Naturally, this research is not without limitations. It would be worthwhile to incorporate additional factors that influence stock markets into the model, such as the dynamics of oil or gold prices, or perhaps energy prices. Furthermore, the application of other non-linear models, such as dynamic copulas, could be explored. It might also be valuable to examine Granger causality, as wavelet coherency analysis only captures co-movement but does not address causal relationships. In addition, extending the research to other European Union member states that have not yet adopted the euro – for example, conducting similar analyses on the Hungarian, Polish, or even Czech stock indices and their integration with more developed Western European stock indices – would offer important further insights.

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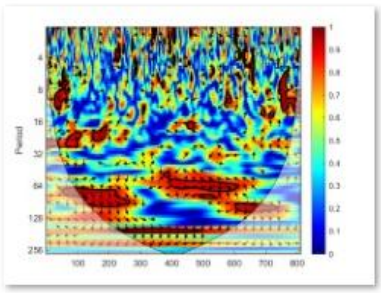
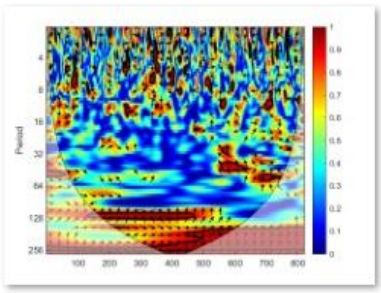

BET and DAX excluding ALL OTHERS (pre covid period).png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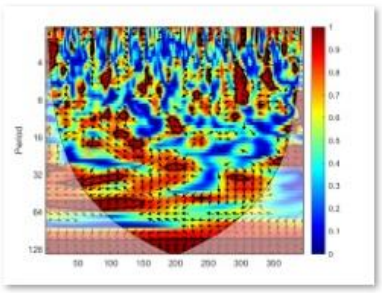
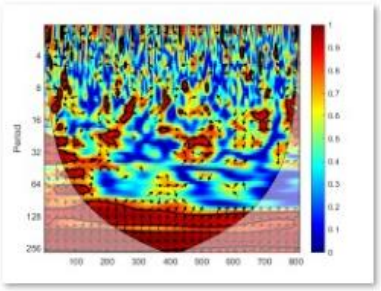
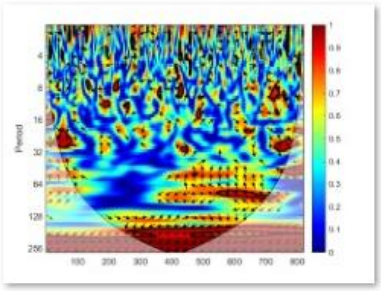

BET and DAX excluding ALL OTHERS (aft covid period).png

Figure 1.
The effect of the DAX index on the BET index returns during the examined periods, controlling for the influence of all other stock market indices


BET and SP500 excluding ALL OTHERS (pre covid period).png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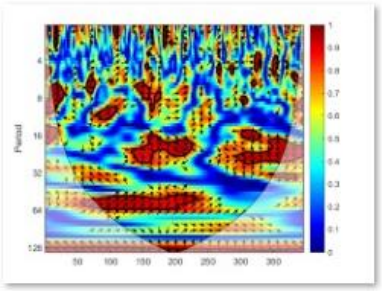
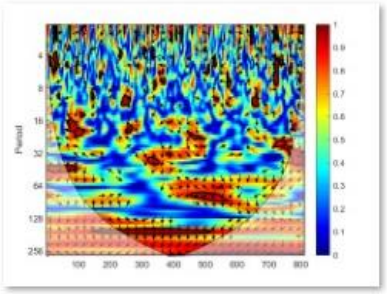
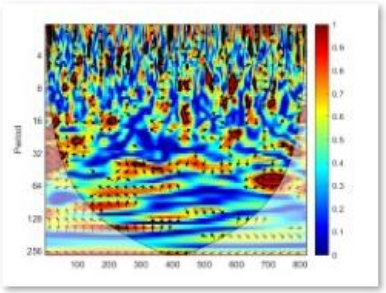

BET and SP500 excluding ALL OTHERS (aft covid period).png

Figure 2.
The effect of the S&P500 index on the BET index returns during the examined periods, controlling for the influence of all other stock market indices


BET and IT40 excluding ALL OTHERS (pre covid period).png


BET and IT40 excluding ALL OTHERS (covid period).png

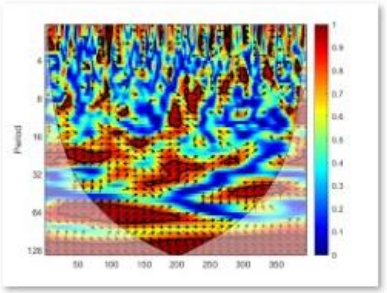

BET and IT40 excluding ALL OTHERS (aft covid period).png

Figure 3.
The effect of the IT40 index on the BET index returns during the examined periods, controlling for the influence of all other stock market indices