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STOCK MARKET VOLATILITY AND THE SPREAD OF SPECULATIVE ATTACKS: EVIDENCE FROM WAVELET ANALYSIS

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Abstract

This paper investigates the effects of speculative-led attacks on volatility spillover through selected 20 stock markets over the period of January 03, 2013 and March 14, 2021, implementing a recently developed wavelet spectrum analysis. To assess the degree of speculation, the time scale of the study is divided into two parts as the pre-COVID-19 era and the COVID-19 pandemic. In addition, the potential effects of speculative-led attacks on stock markets are analyzed both through the income-based and region-based classifications. In that vein, the empirical results are built upon three parts. First, the volatility spillover is more common for the high-income economies than the rest of the other economies and it is much visible at the COVID-19 pandemic. Second, the regional differences of stock markets have also a crucial impact on the behaviors of financial investors in which the speculative-led attacks are intensified in the regions where the financial transactions are relatively much higher. Finally, the core reason behind the increase of speculative attacks in those stock markets is an ongoing stagnation in productive activities during the COVID-19 pandemic.

***Keywords**: Stock Market Volatility, Speculative Attack, Financial Instability, COVID-19 Pandemic, Wavelet Analysis.*
***JEL Classification**: D53, E44, G01.*

HİSSE SENEDİ PİYASASI OYNAKLIĞI VE SPEKÜLATİF ATAKLARIN YAYILIMI: DALGACIK ANALİZİNDEN KANITLAR

Öz

Bu çalışma spekülatif yönlü atakların seçili 20 hisse senedi piyasasında oynaklık yayılımına etkisini yakın zamanda geliştirilen dalgacık spektrum analizini uygulayarak 3 Ocak 2013 ve 14 Mart 2021 arası dönem için araştırmaktadır. Spekülasyon düzeyini değerlendirmek için çalışmanın zaman ölçeği COVID-19 öncesi dönem ve COVID-19 salgını olarak iki bölüme ayrılmaktadır. Bunun yanı sıra spekülatif yönlü atakların hisse senedi piyasaları üzerindeki potansiyel etkileri hem gelir bazlı hem de bölgesel bazlı sınıflandırmalarla analiz edilmektedir. Bu çerçevede, ampirik sonuçlar üç bölüm üzerine inşa edilmektedir. İlk olarak, oynaklığın yayılımı yüksek gelirli ekonomiler için diğer ekonomilere göre daha yaygın olup COVID-19 salgınında daha etkili bulunmaktadır. İkincisi, hisse senedi piyasalarının bölgesel farklılıkları finansal işlemlerin göreli olarak daha yüksek olduğu bölgelerde spekülatif atakların yoğunlaştığı ve finansal yatırımcıların davranışları üze-rinde önemli bir etkiye sahip olduğu görülmektedir. Son olarak, mevcut hisse senedi piyasalarındaki spekülatif atakların artmasının temel nedeninin COVID-19 salgını sırasında üretken faaliyetlerde devam eden durgunluk olduğu anlaşılmaktadır.

***Anahtar Kelimeler**: Hisse Senedi Piyasası Oynaklığı, Spekülatif Atak, Finansal İstikrarsızlık, COVID-19 Salgını, Dalgacık Analizi.*
***JEL Sınıflandırması**: D53, E44, G01.*

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1. Introduction

The COVID-19 pandemic has deeply shocked the economic units along with their unsolved problems that emerged in the 2007/2008 global crisis and thus led to an increase in uncertainty in various markets. One of the core negative changes has occurred in global stock markets during the outbreak of the COVID-19 pandemic in which the financial capital has largely flowed into speculative-led activities to mitigate their losses from the worldwide lockdowns and thereby the productivity losses. Although the ongoing COVID-19 crisis has hard hit several economies all over the world, it is not possible to argue that the countries have mostly adopted close to uniform policy packages against economic issues. For instance, the increasing number of infections and deaths caused some governments to implement strict rules and countermeasures, whereas the rest of the governments including Sweden, and South Korea carried out more imprecise policies together with being out of a lockdown. These different policy agenda settings imposed by different governments were also led to an increase in discussions towards the determination of which policies should be implemented in the economic structure. Indeed, after one year of the COVID-19 crisis, the governments have taken various paths on economic decision making although the political reactions of governments mostly differed from each other. However, the one-year performance of the world economy shows that a large part of the countries, including both developed and developing, have been confronted with a significant decrease in their domestic and international economic activities. Most importantly, the current strategies have passed away to become a way for solving the economic problems of the COVID-19 pandemic and thereby have exacerbated the panics of investors and consumers. In that vein, the same problems also led economic actors to change their traditional patterns and behaviors through consumption, and thus it has produced various market anomalies. One of those anomalies has been significantly effective in the financial sector where the financial investors have been mostly tended to get returns from the markets along with an increase in speculative-led attacks to specific instruments. In particular, most of the stock market indices have been plunged in response to the crisis-led problems of financial markets (McKibbin and Fernando, 2020).

In consideration of ongoing issues in financial markets and institutions, most of the studies have been put forward to analyze the specific fields of finance such that the stock markets. However, a large part of the literature concentrates on the effects of the COVID-19 pandemic on certain stock markets (Albulescu, 2020a; Ramelli and Wagner, 2020; Takahashi and Yamada, 2020). Therefore, a few of them consider the change in stock market indices during the COVID-19 pandemic from the global perspective (Albulescu, 2020b; Engelhardt et al., 2020; Engelhardt et al., 2021). For example, Alber (2020) indicates an increase in sensitivity of stock market returns to the COVID-19 cumulative cases in China, France, Germany, Italy, Spain, and the United States. Zhang et al. (2020) also find that the COVID-19 outbreak has stimulated a significant volatility increase in global markets. Moreover, Contessi and de Pace (2020) show that the outbreak has raised the rapid crashes of stock markets of 18 countries. Sansa (2020) finds that there is a positive and statistically significant correlation between the number of cases and the stock market indices in China and the United States. Similar to this outcome, Cepoi (2020) finds that there is an asymmetric dependence on stock market returns resulting from the negative news about the COVID-19 and the risk of contagion. Zaremba et al. (2020) show that an increase in return volatility is related to policy responses. According to Erdem (2020), the stock market returns in freer countries are less negative and volatility is highly responsive to the announcements of infection numbers. The other studies also analyze the correlation between societal trust and investor's behavior, and its effect on financial markets in general (Adams, 2020; Limbach et al., 2020; Engelhardt et al., 2021). Yan (2020) also investigates how Chinese stock markets were affected by the COVID-19 pandemic and finds that stock prices were significantly declined during the outbreak. Wang and Enilov (2020) show that there is a causality relationship between the number of cases and the stock market returns in Canada, France, Germany, Italy, and the United States, whereas the same linkage does not hold for the United Kingdom and Japan. Cox et al. (2020) explain that the market movements during the

COVID-19 pandemic have been more reflective of sentiment than substance. Furthermore, Ambros et al. (2020) find that the changes in COVID-19 news led to an increase in stock market volatility for European markets.

The turmoil in the financial system during the COVID-19 was also caused possible spillovers to the real economy (Utomo and Hanggraeni, 2021). Evidence from the analysis proposed by Fahlenbrach et al. (2021) document that there was significant heterogeneity in firms' resilience during the COVID-19 pandemic which was led to a stock market collapse in February and March 2020. According to their arguments, firms with greater financial flexibility can relatively have more power to find financial resources to close cash shortfalls in which they can be more protected from the COVID-19 crisis. Similar to that finding, in most countries, stock markets were hardly crashed due to a wide range of spread of the COVID-19 disease, especially where the small firms were hard hit since they had less flexibility for alternative channels to invest during any kind of shocks that occurred in the pandemic (Adenomon et al., 2020; Al-Awadhi et al., 2020; Elsayed and Abdelrhim, 2020; Gherghina et al., 2020; Kartal et., 2021). In addition to the financial flexibility problem, the stock markets were negatively affected by the policies implemented towards limitations and restrictions of the mobility of goods, inputs, and capital (Devi et al., 2020; Ozili and Arun, 2020; Chowdhury et al., 2021; Zoungrana et al., 2021). Another channel of influence of the pandemic on the stock markets is the ongoing uncertainties that have been occurred in the global economy (Contessi and de Pace, 2020; Fernandes, 2020; Feldkircher et al., 2021). In the international context, one focal investigation topic has received considerable precision which indicates the correlation between crude oil price volatility and stock markets. Related to a sharp increase in the degree of uncertainties in the global economy during the COVID-19 pandemic, a bulk of studies have examined the effects of a change in the price of crude oil on stock returns before and at the COVID-19 (Salisu et al., 2020; Wang and Yang, 2021; Zhang and Hamori, 2021; Zhang et al., 2021).

Following the complex relations among the economic units, especially right after the COVID-19 pandemic, a bulk of studies have used various alternative methods to detect the impact of current disease on stock markets. One of those methods has become increasingly popular in the literature which is called as wavelet analysis to capture the information on markets across different time frequencies without losing inputs from the time horizon. For instance, Gherghina and Simionescu (2021) explore the stock market returns-COVID-19 interdependence via wavelet coherence analysis for 15 affected countries over the period 1 January 2020 to 23 July 2020 and find that most of the stock market returns are in phase behavior (cyclical effects) with pandemic variables (e.g., COVID-19 new cases and new deaths), whereas a couple of stock index returns are exposed to out-of-phase behavior (anti-cyclical effects). Besides, Vo and Hung (2021) find that there exists strong dependency about the information spillovers between crude oil, S&P 500, and gold markets, which might conduct significant information for portfolio managers, investors, and government agencies. Sharma et al. (2021) also imply that COVID-19 cases have a significant long-term impact on stock markets returns as well as the exchange rate returns in which there are strong correlations at low frequencies of series. Kamaludin et al. (2021) mention significant insights on the drives of the ASEAN-5 equity markets and find that Malaysia, Indonesia, and Singapore equity markets reacted to COVID-19 cases at the initial phase of the pandemic, whereas Thailand and the Philippines exhibited coherency during the mid-period. According to Choi (2020), the COVID-19 effects of economic policy uncertainty have much influence on the sector volatility relative to the global financial crisis for all sectors.

As the recent literature highlights the fact that the investigation of the relationship between stock market volatility and the COVID-19 crisis needs further analyses to generalize the overall findings to detect whether the ongoing problems exacerbate the problems in financial markets or not. Indeed, the COVID-19 pandemic has brought about a significant drop in several economic indicators such as national income, employment, manufacturing, and retail sales. In addition to those indicators, the uncertainty that occurred during the COVID-19 pandemic was stimulated an unintended interruption in the global supply chain and world trade as well as the sudden decrease

in asset prices (Ayittey et al., 2020). In particular, some of the major sectors such as tourism, commodity trade, manufacturing, and transportation were relatively more affected by the ongoing lockdowns. In this regard, the economic effects of COVID-19 lockdowns and the crisis on production have led to an emergence of new burdens on several countries where the level of production contradicted, the stock markets became fluctuated, and the valuation of foreign exchange shaken up along with volatility. Therefore, the economic problems that most of the countries have experienced during the COVID-19 pandemic have deeply affected both the real and financial sectors. This, in turn, has led to an increase in economic instability all over the world due to a rise in macroeconomic disruptions.

Such kind of numerical investigation implies that the high variance in the spread rate of COVID-19 among different countries has statistically validated the significant cost effects of the virus on economic units. For instance, the estimates of Boissay and Rungcharoenkitful (2020) show that the maintenance of current problems would be resulted in a 4 percent decline in the global GDP of 2020, on average. This also indirectly renders a huge amount of global loss at the production level. As the other estimate, IMF (2020) emphasizes a 6 percent decline in aggregate global income. Therefore, if the ongoing expectations for the level of economic losses in global production hold for most of the countries, the cost of the COVID-19 pandemic would be exceeded the cost of the 2007/2008 global crisis, in which the global economy shrank by 3 percent, on average. Moreover, the oil markets were also shocked by the COVID-19 pandemic. At the initial phase of the pandemic, the oil prices were around $50 but dropped to $20 just after a short time due to a fall in aggregate demand. Therefore, oil-exporting countries such as Russia, Qatar, and Saudi Arabia have become more fragile to exogenous shocks. More importantly, the current decline in oil prices has also exacerbated the risk of a potential collapse in economic systems. Finally, the financial markets were also hard hit by the COVID-19 pandemic. One of the core impacts of the outbreak has emerged in the stock markets in which many of them faced a severe decline in terms of their indices. For instance, the Dow Jones index decreased by 2977 points in one business day on March 16, 2020, which was assumed as the biggest drop of all time. Since the losses from the financial instruments were evident for a large part of stock markets, it has led to an uncertain environment for financial investors. As a critical example, the size of loss resulting from an increase in uncertainty level was 37 percent in the UK stock market and 33 percent in the German stock market. The same negative movements in stock prices were also evident for the Brazilian stock market with a 48 percent decrease and the Polish stock exchange with a 38 percent decrease.

It can be argued that the globalization of financial services, instruments, motives, actors, institutions, and markets were largely investigated as one of the crucial issues to detect whether the process has a positive effect on domestic and international economies or not (Epstein, 2005). Indeed, the globalization of finance to a large extent can be accepted as a dynamic process in which it stimulates an increase in capital resources to manage firms and households, an increase in the production of investment goods, more diverse economic relations, more investment opportunities but along with higher complexity of risk and risk management problems (Račickas and Vasiliauskaitė, 2011). Hence, together with an increase in globalized financial relations, the spread effect of market disturbances has been diffused very rapidly from one unit to another, which is formally known as the financial contagion. This is explained as the spread of negative shocks that lead to trigger financial stability (Moser, 2003). One of the core results of the globalization process is an increase in the link among the financial sector, which in turn raises the excessive volatility in each financial transaction by way of increasing the contagion effect to occur in different markets. So that, the bubble formation in financial markets becomes more visible along with an increase in financial contagion effect and thus the prices of financial assets move away from their market values. The major result of explosive bubbles in financial markets leads to the occurrence of long-term disruptions in the financial sector. While the positive bubbles in financial markets tend to emerge an excessive demand towards the financial assets, the negative bubbles raise the

disproportionate sales of the same assets. Therefore, the most common result of explosive bubbles is a sudden decrease in asset prices and thereby a flight from the financial markets.

In this paper, we, therefore, analyze the speculative-led attacks on stock markets whether the speculation in the stock markets affects the rate of volatility during both the pre-COVID-19 era and COVID-19 pandemic. The rationale behind that the speculative attacks on financial assets significantly increase the degree of financial instability across different countries and thus affect the rate of volatility in stock markets. In that vein, speculative-led attacks are defined as signals that are based on the occurrence of a sharp increase in the degree of stock markets' volatility. For most financial investors, chasing volatile stocks is not feasible to follow as a financial strategy, because it has a high-risk level and thereby requires close monitoring. If the stocks are essentially faced with significant speculative movements and thus if the investors look for those stocks that are not expected to perform well, they can bet that their price may go up based on speculative demand. Therefore, it is assumed for most financial investors that there is no sound reason for the rise of stock prices other than artificially inflated demand, which result in some market volatility and lead investors to get a little bit more nervous about what may happen down the road along with a sharp increase in the volume of speculative trading. In addition, the financial investors should consider that there are different measures of price volatility such that conditional, historical, and implies and different types of speculation such that short-run, long-run, and excessive (Algieri, 2016; Brunetti et al., 2016; Haase et al., 2017; Thimmaraya and Masuna, 2017; Wellenreuther and Voelzke, 2018; Algieri and Leccadito, 2019; Auer and Tercero-Lucas, 2021; Baur and Dimpfl, 2021; Grobys and Junttila, 2021; Kyriazis, 2021; Zulfiqar and Gulzar, 2021). Therefore, the researchers should determine which type of conditional relationship between the market volatility and speculation should be implemented to analyze the correlation among those indicators. Using data from Yahoo Finance to proxy for stocks that cover a sample of 20 national stock markets from the developed economies, we find stock markets' volatility to be significantly higher in developed economies during the COVID-19 pandemic than in the pre-COVID-19 period. As one of the core reasons behind increased volatility in stock markets during the COVID-19 pandemic can be deduced from the raising degree of speculations due to the reduction of investors' gains in the production capacity. To test this argument, we use a very recently developed approach called as wavelet analysis (described in Section 3), which is limited to being implemented in the literature. The major aim for investigating the wavelet approach is due to the reason that wavelets capture all information about the asset returns, not only for a given time scale but also across different frequencies without losing any information from an aggregate time dimension.

The remainder of this paper is organized as follows: Section 2 provides detail on the stock market indices. Section 3 explains the methodological framework. Section 4 presents the empirical findings. Section 5 concludes.

2. Data Description

The major aim of this study is to detect whether the financial contagion effect is significant only at the COVID-19 outbreak or it is a long-lasting issue over the sample period. In this regard, we use a daily dataset (5-day weeks) of the 20 most active stock market indices of selected economies. In particular, the core reason to select those indices is due to their high coverage of capitalization level in which they represent a large share of total stock exchanges in the world. Therefore, any kind of socio-economic shocks may have an ample effect on the volume of trading stocks in those markets and thus may lead to occur an increase in financial instability. The distinctive feature of this study from the others in the literature depends on the determination of the presence of contagion effect in the financial markets for two different time horizons, including the pre-COVID-19 period and COVID-19 pandemic. Besides, another feature of this study is to detect the financial contagion effect in stock markets using a wavelet approach to capture all information about the asset returns across various frequencies of data. We classify the stock market indices in consideration of two ways. On the one hand, the first classification is based on the income levels

of countries. On the other hand, the second classification considers the presence of regional differences among the sample countries. In that vein, the income-based classification of the selected stock market indices can be shown as follows:

1. **High-Income Economies:** *Australia* (S&P/ASX 200 Index-AXJO), *Belgium* (BEL 20 Index-BFX), *France* (CAC 40 Index-FCHI), *Germany* (DAX Performance Index-GDAXI), *Hong Kong* (Hang Seng Index-HSI), *Japan* (NIKKEI 225 Index-N225), *Italy* (FTSE MIB Index-FTSEMIB.MI), *South Korea* (KOSPI Composite Index-KS11), *Spain* (IBEX 35 Index-IBEX), *United Kingdom* (FTSE 100 Index-FTSE), *United States* (Dow Jones Composite Average-DJA) (NASDAQ Composite Index-IXIC) (NYSE Composite Index-NYA) (S&P 500-SPX)
2. **Upper Middle-Income Economies:** *Brazil* (BOVESPA Index-BVSP), *China* (Shanghai Composite Index-SCI), *Mexico* (S&P/BMV IPC Index-MXX), *Russia* (MOEX Russia Index-IMOEX.ME), *Turkey* (BIST 100 Index-BIST)
3. **Lower Middle-Income Economies:** *India* (NIFTY 50-NSEI)

In addition to income-based classification, the second type of classification can be made through the implementation of regional differences in countries as follows:

1. **East Asia and Pacific:** *Australia* (S&P/ASX 200 Index-AXJO), *China* (Shanghai Composite Index-SCI), *Hong Kong* (Hang Seng Index-HSI), *Japan* (NIKKEI 225 Index-N225), *South Korea* (KOSPI Composite Index-KS11)
2. **Europe:** *Belgium* (BEL 20 Index-BFX), *France* (CAC 40 Index-FCHI), *Germany* (DAX Performance Index-GDAXI), *Italy* (FTSE MIB Index-FTSEMIB.MI), *Russia* (MOEX Russia Index-IMOEX.ME), *Spain* (IBEX 35 Index-IBEX), *Turkey* (BIST 100 Index-BIST), *United Kingdom* (FTSE 100 Index-FTSE)
3. **North America:** *United States* (Dow Jones Composite Average-DJA) (NASDAQ Composite Index-IXIC) (NYSE Composite Index-NYA) (S&P 500-SPX)
4. **Latin America:** *Brazil* (BOVESPA Index-BVSP), *Mexico* (S&P/BMV IPC Index-MXX)
5. **South Asia:** *India* (NIFTY 50-NSEI)

Table 1 introduces the summary statistics of selected 20 stock market indices. One of the crucial outputs from the given values is the high volatility in stock markets across different countries where the gap between the maximum and the minimum values is significantly large. In addition, the standard deviations of the given stock market indices are relatively high for most of the countries.

The descriptive statistics are all formed among the period that covers January 03, 2013 and March 14, 2021 based on the weekly data. The wavelet power spectrum approach is employed on the series to detect whether they behave in explosive behavior. However, one of the major issues is to specify the starting date of the COVID-19 crisis. Therefore, we mostly consider a similar perspective from the current literature on COVID-19 or asset pricing in which the Wuhan Municipal Health Commission in China reported a cluster to the cases of pneumonia in Wuhan on January 01, 2020 (Contessi and de Pace, 2020). The major reason to adopt that day as the day of starting of the COVID-19 crisis depends on the fact that it is reported as the first official statement in Wuhan, Hubei Province. In other words, the use of an official statement to determine the starting date of the COVID-19 crisis is our basic strategy to classify and compare the pre-COVID-19 and COVID-19 periods, whereas it is also assumed that the unofficial cases and their effects on several economic units are effective. In this regard, the next section explains the empirical methodology – i.e., the wavelet power spectrum approach – that is used in the analysis to detect which period is confronted with the bubble formation.

Table 1: **Summary Statistics**

	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis	J-B
Australia (AXJO)	5726	5679	7139	4709	541.2	0.475	2.555	19.62
Belgium (BFX)	3456	3525	4189	2487	405.4	-0.594	2.580	28.31
Brazil (BVSP)	71026	62733	125075	38031	22088.8	0.638	2.133	42.41
China (SCI)	2934	2998	5174	1965	543.9	0.339	3.949	23.97
France (FCHI)	4840	4878	6093	3653	580.4	-0.029	2.111	14.15
Germany (GDAXI)	11100	11391	14519	7477	1659.1	-0.287	2.091	20.69
Hong Kong (HIS)	25051	24529	33335	18487	29.49	0.318	2.375	14.16
India (NSEI)	9228	8842	15270	5480	2145.1	0.246	2.583	7.41
Italy (FTSEMIB.MI)	20243	20494	24962	15133	2290.2	-0.299	2.126	19.98
Japan (N225)	19249	19514	30282	10743	3707.5	0.121	2.867	1.35
Mexico (MXX)	44060	44139	51526	33641	3552.6	-0.283	2.994	5.69
Russia (IMOEX.ME)	2083	1984	3563	1238	558.9	0.528	2.343	27.53
South Korea (KS11)	2137	2050	3162	1474	246.2	1.673	6.665	438.3
Spain (IBEX)	9371	9426	11762	6224	1142.1	-0.415	2.784	13.13
Turkey (BIST)	922	887	1563	617	184.2	1.108	4.438	124.5
United Kingdom (FTSE)	6808	6780	7779	5191	528.9	-0.215	2.343	10.98
United States (DJA)	7186	6962	10883	1730	1489.2	0.157	2.286	10.83
United States (IXIC)	6385	5705	14152	3089	2401.5	1.056	3.768	90.07
United States (NYA)	11486	11180	15715	8637	1440.1	0.316	2.549	10.72
United States (SPX)	2419	2292	3946	1466	569.2	0.549	2.598	24.40

3. Empirical Methodology

The empirical specification is based on a multiscale correlation procedure using the wavelet power spectrum approach. One of the core features of wavelet models is their technical advantage for investigating the relationship among several stock market indices both at different time horizons and frequency bands. Hence, the wavelet models provide to follow investors' operations in stock markets at different time scales. Besides, those models yield an advantage to grasp the low- and high-scale effects of any shock that may emerge within and across stock markets. In this regard, the wavelet approach is employed to decompose time series into their frequencies without any loss in the time dimension. Therefore, the wavelet methods lead us to grasp volatility spillover and speculative-led attacks in the stock markets in terms of different time scales. In essence, a wavelet (i.e., $\psi_{u,s}(t)$) can be represented as real-valued square-integrable function:

$$\psi_{u,s}(t) = \psi \frac{(t - u)}{\sqrt{s}} \tag{1}$$

where u denotes the location, s is the scale which includes both low- and high-scales, and t is the time dimension. The wavelet formation is featured by the zero-mean assumption, i.e., $\int_{-\infty}^{\infty} \psi(t)dt=0$. However, the usual way to transform the wavelet formation is to normalize it equal to one, i.e., $\int_{0}^{\infty} \psi^2(t)dt=1$. In that vein, the wavelet formation can be transformed into a time series if the following condition holds as represented in Equation (2):

$$C_{\psi}(t)= \int_{0}^{\infty} \frac{|\psi(f)|^2}{f} df<+\infty \tag{2}$$

where $\psi(f)$ is the Fourier transform of a given wavelet. The Morlet wavelet transformation can also be used to denote wavelet power spectrum along with the implication of Equation (3):

$$\psi(t)=\pi^{-\frac{1}{4}}e^{-i\omega_0 t}e^{\frac{-t^2}{4}} \quad (3)$$

where ω_0 is the central frequency. In this regard, the wavelet transformation of time series x(t) and y(t) can be measured by employing Equations (4) and (5):

$$W_x(\tau,s)=\int_{-\infty}^{\infty} x(t)\frac{1}{\sqrt{|s|}}\psi^*\left(\frac{t-\tau}{s}\right)dt \quad (4)$$

$$W_y(\tau,s)=\int_{-\infty}^{\infty} y(t)\frac{1}{\sqrt{|s|}}\psi^*\left(\frac{t-\tau}{s}\right)dt \quad (5)$$

In consideration of a recent technique that is measured by the wavelet power spectrum approach, the changes in the financial markets can be significantly tracked without losing any information from the data. So that, the differences in time frequencies or time scales are now considered not to be a serious problem to detect the volatilities or speculations in financial markets since all the information from the markets is obtained by the financial investors. The next section represents the empirical findings based on the implication of the wavelet power spectrum approach to grasp which periods are faced with speculative attacks in stock markets over the given period.

4. Empirical Findings

The empirical specification based on the wavelet power spectrum approach is classified for the stock markets in terms of countries' income levels and geographical positions. On the one hand, Figures 1-3 show the wavelet power spectrum for the stock market indices based on income differences of countries. The Y-axis shows the frequency/time horizon, whereas the X-axis represents the time. Also, the colors in graphs imply that from blue to red, the heat map indicates that both the volatility spillover and the speculative attacks are concentrated in the stock markets. In this regard, the blue color represents the weak effect, while the red color denotes the concentration of volatility spillover and the speculative-led attacks in the stock markets. The results imply that most of the power is concentrated within the early periods of the COVID-19 pandemic in several stock markets, although there is appreciable power in longer periods. In consideration of the results obtained from the wavelet power spectrum approach, it is possible to state that the variations in the frequency of emergence and amplitude of the COVID-19 outbreak are common for most of the stock markets. Although the reasons can change across the countries, the global lockdowns and the decline in supply chains can be specified as the core factors to detect the current high frequencies through the stock markets in the COVID-19 pandemic. It also directly refers to the case that the stock markets are highly volatile throughout the COVID-19 crisis. Meanwhile, the results from the power spectrum analysis point out that the volatility spilled from high frequency (low-scales) to low frequency (high-frequency) during the early phases of the COVID-19 pandemic and the beginning of the first global lockdown. Therefore, the fluctuations of stock markets are highly effective on the asset investment horizons of financial investors.

Some of the core remarks can be deduced from the relevant results in the case of income classification of selected countries and their corresponding stock market indices. First, Figure 1 shows that the speculative-led attacks are concentrated on European countries and the United States as a case for high-income classifications. However, the other countries covering Hong Kong, Japan, and South Korea are also faced with speculative-led attacks on their stock markets, but the effects are relatively much later emerged in those countries. Second, Figure 2 indicates that the speculative-led attacks towards the stock markets for selected upper-middle-income economies are not clear-cut as the high-income economies. For instance, the results of wavelet power spectrum analysis imply that the speculative-led attacks are relatively more effective at the pre-

COVID-19 period in China than the COVID-19 period. Also, Brazil faces several attacks on its stock markets at each period although the durations are many thumbnails for the pre-COVID-19 period. Moreover, while Turkey and Russia experience the same problems in their stock markets, the weights of those problems can be neglected compared to the other stock markets. In consideration of lower-middle-income classifications, the only significant impact of speculative-led attacks on stock markets at the COVID-19 period emerges in Mexico where the duration of those attacks is also long-term. Third, Figure 3 refers that as the only country, the wavelet power spectrum indices start to turn blue to red just before the COVID-19 pandemic and get more effective at the COVID-19 period. However, the results imply that the speculative-led attacks in India's stock market are not so profound and thus they fade throughout time.

Figure 1: **Results for Wavelet Power Spectrum (High-Income Economies)**

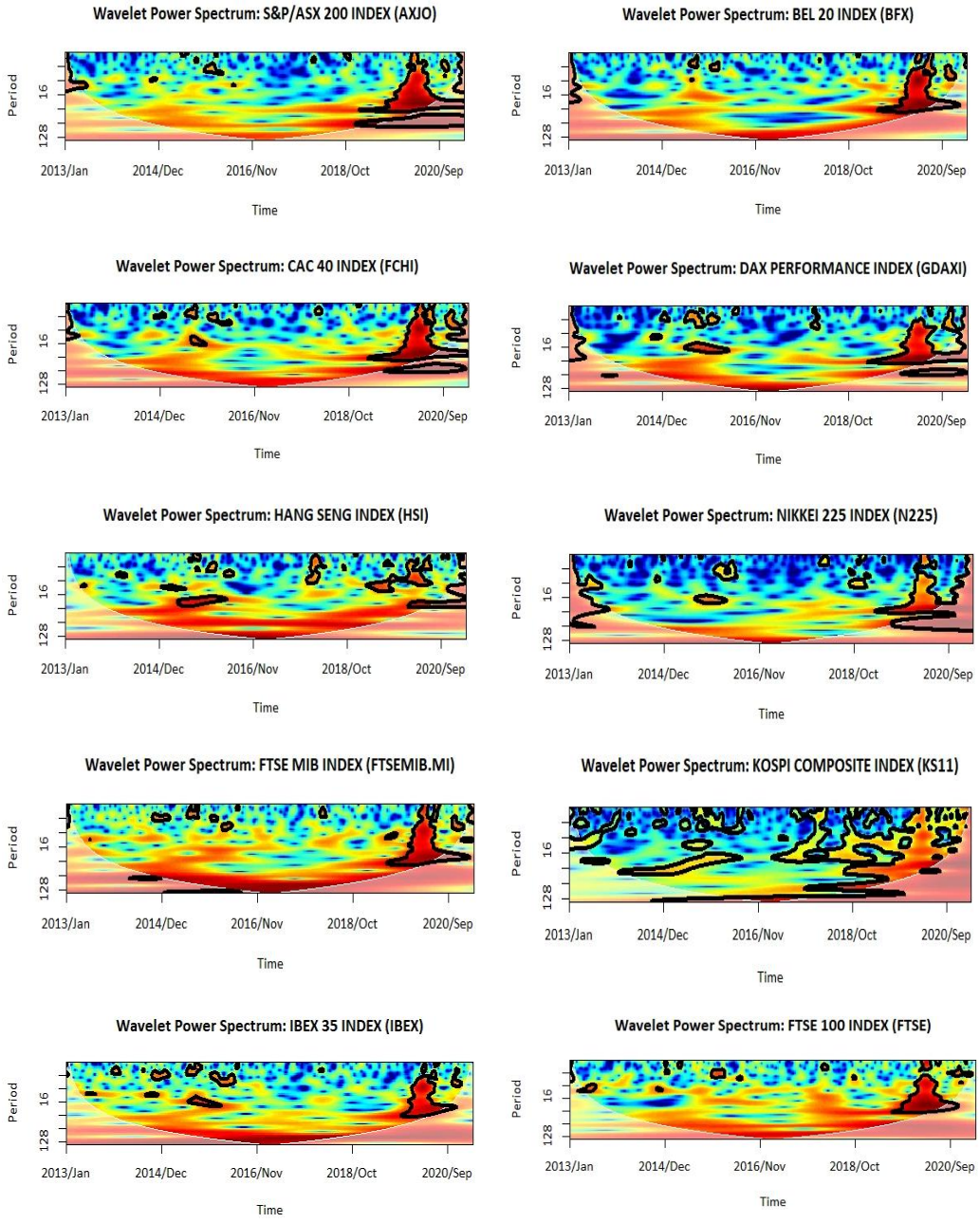


Figure 1 (Continued): **Results for Wavelet Power Spectrum (High-Income Economies)**

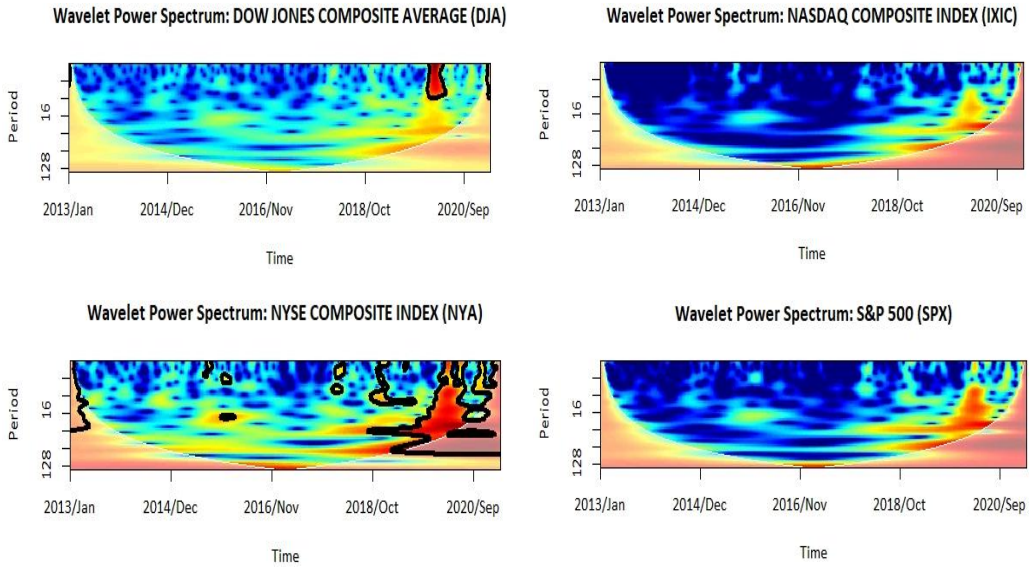


Figure 2: **Results for Wavelet Power Spectrum (Upper Middle-Income Economies)**

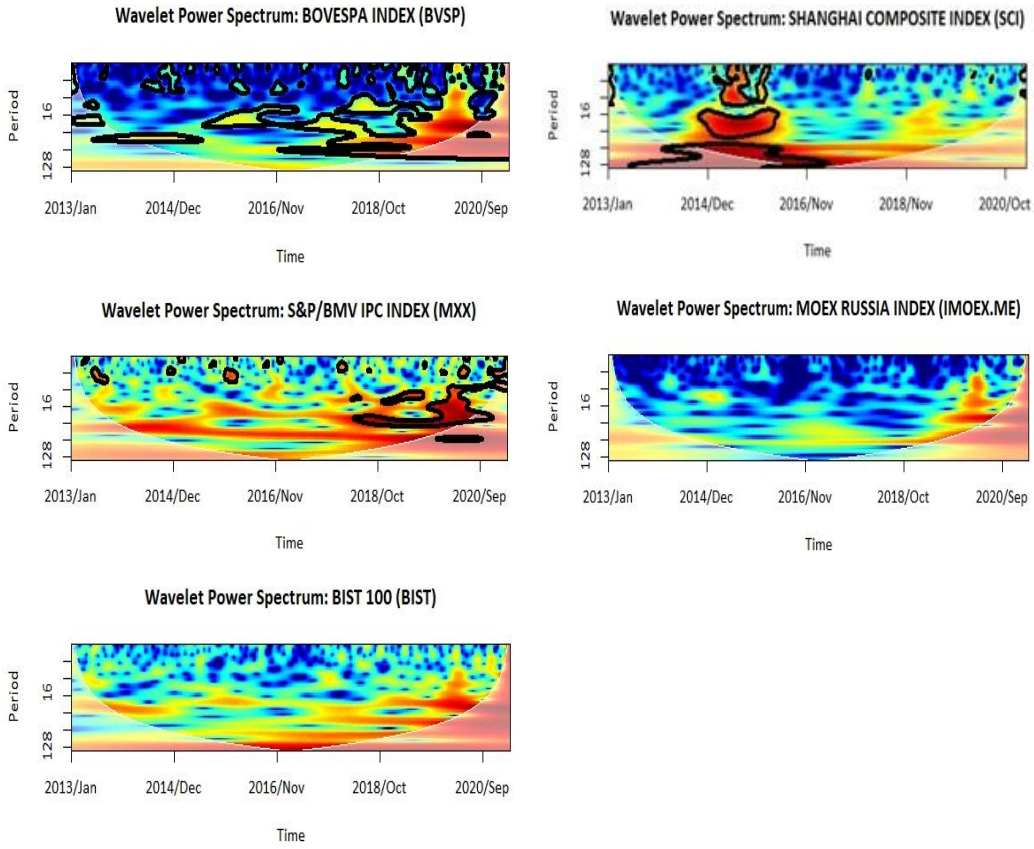
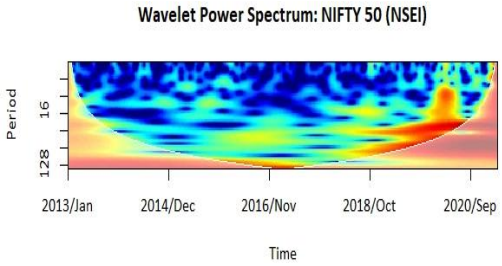


Figure 3: **Results for Wavelet Power Spectrum (Lower Middle-Income Economies)**



On the other hand, Figures 4-8 represent the results for the wavelet power spectrum in terms of the regional differences in stock markets to detect the volatility spillover and the speculative-led attacks. First, the weekly data for stock markets show that both volatility spillover and speculative attacks are concentrated on the COVID-19 period although the effects are varied across the regions. Second, the empirical outputs show that the most intensive attacks are concentrated at the COVID-19 pandemic compared to the pre-COVID-19 era. The results are also compatible with the results produced in wavelet power spectrum analysis based on income classifications of countries. While the speculative-led attacks in East Asia and Pacific region are visible for most of the selected stock exchanges such as the S&P/ASX 200 Index (AXJO), Hang Seng Index (HIS), and Nikkei 225 Index (N225) the highest weight for the volatility in European stock exchanges can be more visible for many selected ones such as BEL 20 Index (BFX), CAC 40 Index (FCHI), DAX Performance Index (GDAXI), FTSE MIB Index (FTSEMIB.MI), IBEX 35 Index (IBEX), and FTSE 100 Index (FTSE). Those stock exchanges can also be evaluated based on the countries where the effects of the COVID-19 pandemic have been highly perceived in terms of both economic and social ingredients. In particular, the productive activities in those countries have almost come to a halt and thus most of the small-scale firms have faced serious problems regarding compensating for their costs in the short- and long-run. In addition, since the trade activities have largely been restricted all over the world, the decline in transportation volumes of raw materials and intermediate goods, which were used as the core tools of the final goods, have stimulated such firms to shut down their production process. Third, the distinctive feature of the region-based analysis, the selected stock exchanges in North America have been confronted with speculative-led attacks only in NYSE Composite Index (NYA). The rest of the other stock exchange markets were relatively stable in the pre- and post-COVID-19 eras. Finally, the selected stock exchanges in Latin America have revealed an increase in volatility attacks where the countries have also faced strict problems about the pandemic.

Figure 4: **Results for Wavelet Power Spectrum (East Asia and Pacific)**

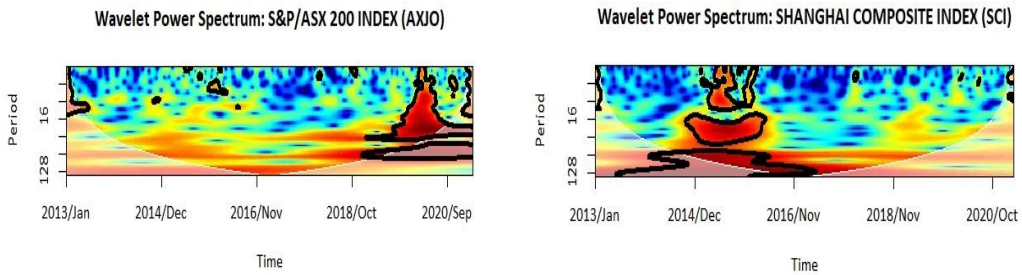


Figure 4 (continued): **Results for Wavelet Power Spectrum (East Asia and Pacific)**

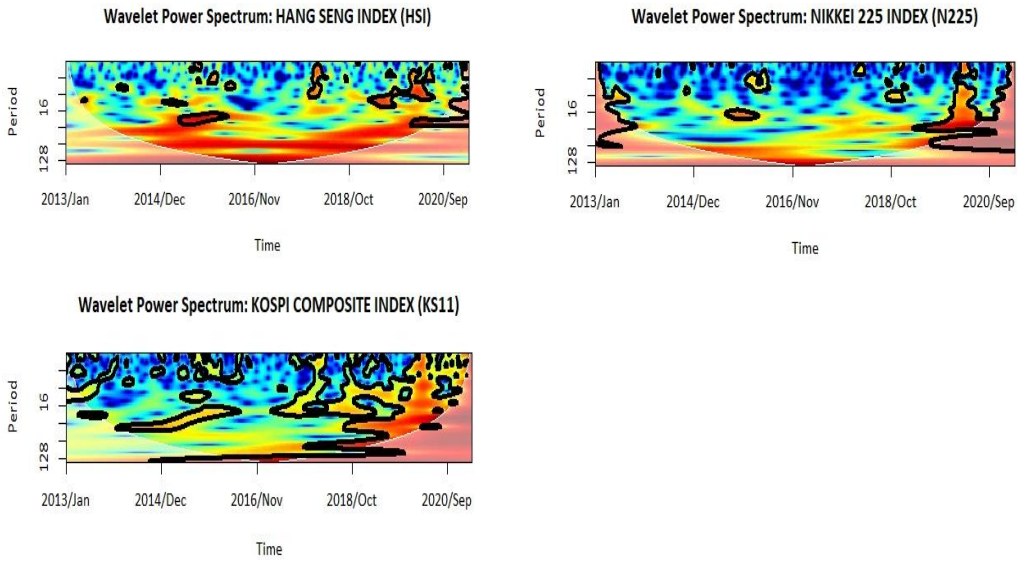


Figure 5: **Results for Wavelet Power Spectrum (Europe)**

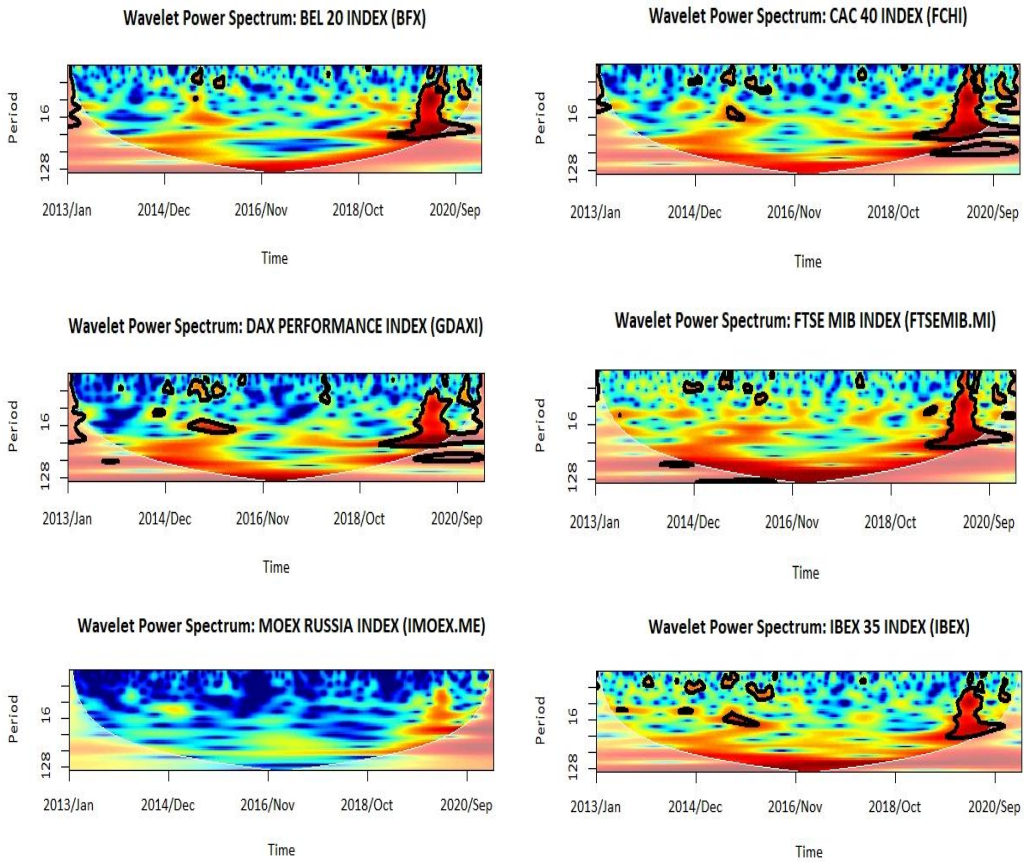


Figure 5 (continued): **Results for Wavelet Power Spectrum (Europe)**

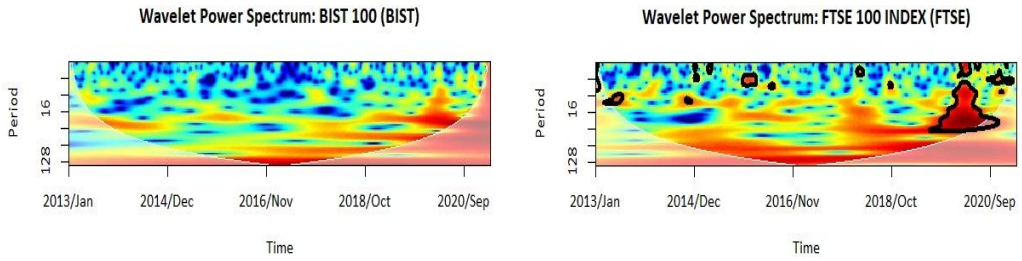
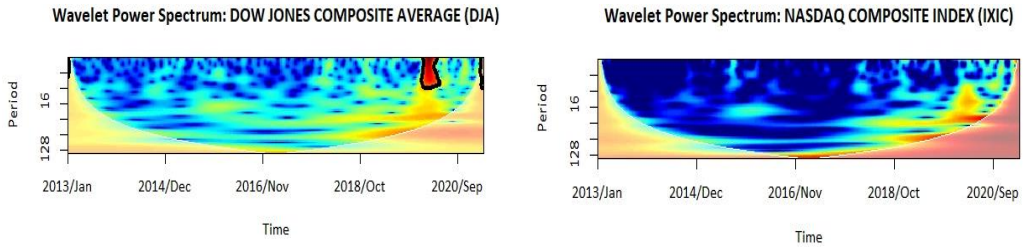


Figure 6: **Results for Wavelet Power Spectrum (North America)**



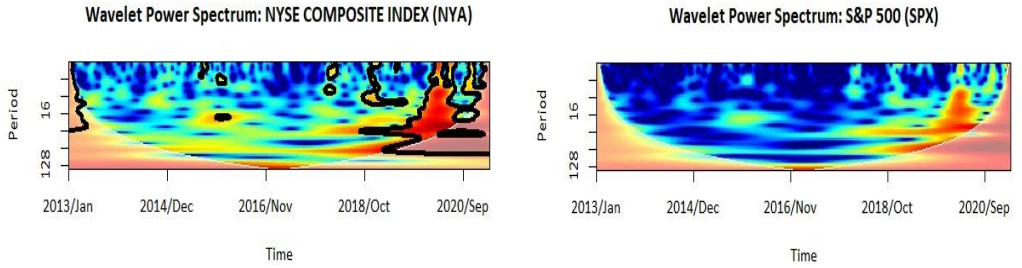


Figure 7: **Results for Wavelet Power Spectrum (Latin America)**

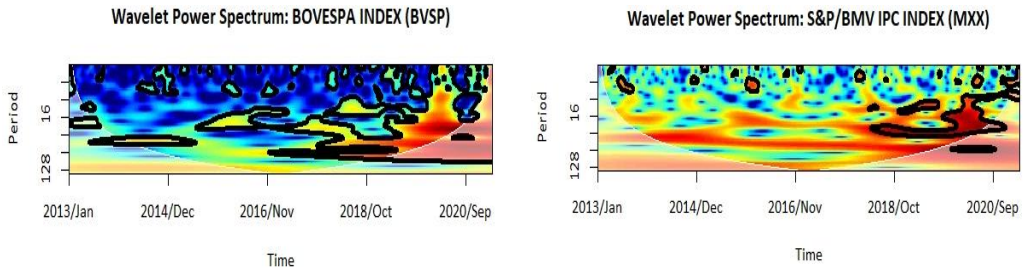
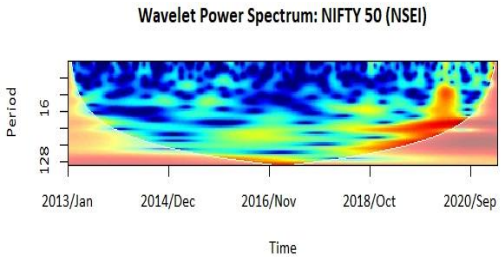


Figure 8: **Results for Wavelet Power Spectrum (South Asia)**



5. Conclusion

This paper investigated the presence of speculative-led attacks on stock markets selected based on their daily transaction volumes to show whether the speculation in those stock markets affects the rate of volatility spillover during both the pre-COVID-19 era and the COVID-19 pandemic. The comparison of two different time scales revealed that the speculative attacks on most of the top stock exchanges were increased at the COVID-19 pandemic. In addition, the empirical results showed that the financial motives and transactions were highly intensified during that period in which many financial investors were involved in risky buying and selling transactions of financial assets. Therefore, it directly led us to think that the post-COVID-19 period may face jeopardous issues that emerged in financial markets to be solved for the health of the overall economy. To get a grasp about the presence of speculative-led attacks in stock markets, the recently produced wavelet spectrum analysis was implemented for the selected stock markets to find out the potential effects of speculative-led attacks on financial assets which may confront a significant increase in financial instability across different countries and thus the volatility spillover in stock markets. Using data from Yahoo Finance, the empirical results show that the rate of volatility in most of the selected stock markets has been significantly increased during the COVID-19 pandemic. The second distinctive feature of the empirical results depends on the case that the volatility spillover is more common for the stock markets of developed economies. Since those and the other extensive results produced from the wavelet analysis indicate a significant rise in the degree of speculation over the selected stock markets, it leads us to refer to the fact that the speculations were increased largely due to the reduction of investors' gains in the productive capacity and thereby the ongoing loss in their accounts. Therefore, as the financial investors highly tend to buy risky assets during the COVID-19 pandemic, the background of such behavior should be investigated through the reasons for stagnant productive activities.

References

Adams, R. B. (2020). Trust in finance: Values matter. *Working Paper*, Oxford: University of Oxford.

Adenomon, M. O., Maijamaa, B. and John, D. O. (2020). On the effects of COVID-19 outbreak on the Nigerian Stock Exchange performance: Evidence from GARCH models. *Preprints* 2020, 2020040444.

Al-Awadhi, A. M., Alsaifi, K., Al-Awadhi, A. and Alhammadi, S. (2020). Death and contagious infectious diseases: Impact of the COVID-19 virus on stock market return. *Journal of Behavioral and Experimental Finance*, 27, 100326.

Alber, N. (2020). The effect of coronavirus spread on stock markets: The case of the worst 6 countries. *SSRN Electronic Journal*, Available at: https://ssrn.com/abstract=3578080.

Albulescu, C. T. (2020a). Covid-19 and the United States financial markets' volatility. *Finance Research Letters*, 38, 101699.

Albulescu, C. T. (2020b). Coronavirus and financial volatility: 40 days of fasting and fear. Working Papers hal-02501814, HAL.

Algieri, B. (2016). Price volatility, speculation and excessive speculation in commodity markets: Sheep or shepherd behaviour? *International Review of Applied Economics*, 30(2), 210-237.

Algieri, B. and Leccadito, A. (2019). Price volatility and speculative activities in futures commodity markets: A combination of combinations of p-values test. *Journal of Commodity Markets*, 13, 40-54.

Ambros, M., Frenkel, M., Huynh, T. L. D. and Kilinc, M. (2020). COVID-19 pandemic news and stock market reaction during the onset of the crisis: Evidence from high-frequency data. *Applied Economics Letters*, 28(19), 1686-1689.

Auer, R. and Tercero-Lucas, D. (2021). Distrust or speculation? The socioeconomic drivers of US cryptocurrency investments. *BIS Working Paper*, No. 951.

Ayittey, F. K., Ayittey, M. K., Chiwero, N. B., Kamasah, J. S. and Dzuvor, C. (2020). Economic impacts of Wuhan 2019-nCoV on China and the World. *Journal of Medical Virology*, 92, 473-475.

Baur, D. G. and Dimpfl, T. (2021). Price discovery in Bitcoin spot or futures? *Journal of Futures Markets*, 39(7), 803-817.

Boissay, F. and Rungcharoenkitkul, P. (2020). Macroeconomic effects of COVID-19: An early review. *BIS Bulletin*, No. 7.

Brunetti, C., Büyükşahin, B. and Harris, J. H. (2016). Speculators, prices, and market volatility. *The Journal of Financial and Quantitative Analysis*, 51(5), 1545-1574.

Cepoi, C-O. (2020). Asymmetric dependence between stock market returns and news during COVID-19 financial turmoil. *Finance Research Letters*, 36, 101658.

Choi, S-Y. (2020). Industry volatility and economic uncertainty due to the COVID-19 pandemic: Evidence from wavelet coherence analysis. *Finance Research Letters*, 37, 101783.

Chowdhury, E. K., Khan, I. I. and Dhar, B. K. (2021). Catastrophic impact of Covid-19 on the global stock markets and economic activities. *Business and Society Review*, 2021, doi: 10.1111/basr.12219.

Contessi, S. and de Pace, P. (2020). The international spread of COVID-19 stock market collapses. *Pomona Economics*, 9.

Cox, J., Greenwald, D. L. and Ludvigson, S. C. (2020). What explains the COVID-19 stock market? National Bureau of Economic Research, *NBER Working Paper Series*, No. 27784.

Devi, S. Warasniasih, N. M. S. and Masdiantini, P. R. (2020). The impact of COVID-19 pandemic on the financial performance of firms on the Indonesia stock exchange. *Journal of Economics, Business, & Accountancy Ventura*, 23(2), 226-242.

Elsayed, A. and Abdelrhim, M. (2020). The effect of COVID-19 spread on Egyptian stock market sectors. *SSRN Electronic Journal*, Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3608734.

Engelhardt, N., Krause, M., Neukirchen, D. and Posch, P. (2020). What drives stock during the corona-crash? News attention vs. rational expectation. *Sustainability*, 12(12).

Engelhardt, N., Krause, M., Neukirchen, D. and Posch, P. (2021). Trust and stock market volatility during the COVID-19 crisis. *Finance Research Letters*, 38, 101873.

Epstein, G. (2005). Introduction: Financialization and the World Economy. In: G. Epstein (Ed.), *Financialization and the World Economy*, 3-16, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.

Erdem, O. (2020). Freedom and stock market performance during COVID-19 outbreak. *Finance Research Letters*, 36, 101671.

Fahlenbrach, R., Rageth, K. and Stulz, R. M. (2021). How valuable is financial flexibility when revenue stops? Evidence from the COVID-19 crisis. *The Review of Financial Studies*, 34, 5474-5521.

Feldkircher, M., Huber, F. and Pharrhofer, M. (2021). Measuring the effectiveness of US monetary policy during the COVID-19 recession. *Scottish Journal of Political Economy*, 68(3), 287-297.

Fernandes, N. (2020). Economic effects of coronavirus outbreak (COVID-19) on the world economy. *IESE Business School Working Paper*, No. WP-1240-E.

Gherghina, Ş. C., Armeanu, D. Ş. and Joldeş, C. C. (2020). Stock market reactions to COVID-19 pandemic outbreak: Quantitative evidence from ARDL Bounds Tests and Granger Causality Analysis. *International Journal of Environmental Research and Public Health*, 17(18).

Gherghina, Ş. C. and Simionescu, L. N. (2021). Exploring the co-movements between stock market returns and COVID-19 pandemic: Evidence from wavelet coherence analysis. *Applied Economics Letters*, doi.org/10.1080/13504851.2021.1937034.

Grobys, K. and Junttila, J. (2021). Speculation and lottery-like demand in cryptocurrency markets. *Journal of International Financial Markets, Institutions and Money*, 71, 101289.

Haase, M., Zimmermann, Y. S. and Zimmermann, H. (2021). Commodity returns and their volatility in relation to speculation: A consistent empirical approach. *The Journal of Alternative Investments*, 20(2), 76-91.

IMF (2020). *World economic outlook*. Chapter 1, the Great Lockdown, April.

Kamaludin, K., Sundarasen, S. D. D. and Ibrahim, I. (2021). Covid-19, Dow Jones and equity market movement in ASEAN-5 countries: Evidence from wavelet analyses. *Heliyon*, 7(1), e05851.

Kartal, M. T., Depren, S. K. and Depren, Ö. (2021). How main stock exchange indices react to Covid-19 pandemic: Daily evidence from East Asian countries. *Global Economic Review*, 50, 54-71.

Kyriazis, N. A. (2021). A survey on volatility fluctuations in the decentralized cryptocurrency financial assets. *Journal of Risk and Financial Management*, 14(7), 293.

Limbach, P., Rau, P. R. and Schürmann, H. (2020). The death of trust across the finance industry. *SSRN Electronic Journal*, Available at: https://doi.org/10.2139/ssrn.3559047.

McKibbin, W. J. and Fernando, R. (2020). The global macroeconomic impacts of COVID-19: Seven scenarios. *CAMA Working Paper*, No. 19/2020.

Moser, T. (2003). What is international financial contagion? *International Finance*, 6(2), 157-178.

Ozili, P. K. and Arun, T. (2020). Spillover of COVID-19: Impact on the global economy. *SSRN Electronic Journal*, Available at: http://dx.doi.org/10.2139/ssrn.3562570.

Račickas, E. and Vasiliauskaitė, A. (2011). Channels of financial risk contagion in the global financial markets. *Economics and Management*, 16.

Ramelli, S. and Wagner, A. F. (2020). Feverish stock price reactions to COVID-19. *The Review of Corporate Finance Studies*, 9(3), 622-655.

Salisu, A. A., Ebuh, G. U. and Usman, N. (2020). Revisiting oil-stock nexus during COVID-19 pandemic: Some preliminary results. *International Review of Economics and Finance*, 69, 280-294.

Sansa, N. A. (2020). The impact of the COVID-19 on the financial markets: Evidence from China and USA. *Electronic Research Journal of Social Sciences and Humanities*, 2(2), 29-39.

Sharma, G. D., Tiwari, A., Jain, M., Yadav, A. and Erkut, B. (2021). Unconditional and conditional analysis between COVID-19 cases, temperature, exchange rate and stock markets using wavelet coherence and wavelet partial coherence approaches. *Heliyon*, 7(2), e06181.

Takahashi, H. and Yamada, K. (2020). When the Japanese stock market meets COVID-19: Impact of ownership, China and US exposure, and ESG channels. *SSRN Electronic Journal*, Available at: https://doi.org/10.2139/ssrn.3577424.

Thimmaraya, R. and Masuna, V. (2017). Implied volatility and stock market speculation. *SSRN Electronic Journal*, Available at: http://dx.doi.org/10.2139/ssrn.3040470.

Utomo, C. D. and Hanggraeni, D. (2021). The impact of COVID-19 pandemic on stock market performance in Indonesia. *The Journal of Asian Finance, Economics and Business*, 8(5), 777-784.

Vo, X. V. and Hung, N. T. (2021). Directional spillover effects and time-frequency bexus between oil, gold and stock markets: Evidence from pre and during COVID-19 outbreak. *International Review of Financial Analysis*, 76, 101730.

Wang, W. and Enilov, M. (2020). The global impact of COVID-19 on financial markets. *SSRN Electronic Journal*, Available at: https://ssrn.com/abstract=3588021.

Wang Y. and Yang X. (2019). Asymmetric response to PMI announcements in China's stock returns. Accessed on 23 December 2021, Available on: https://arxiv.org/ftp/arxiv/papers/1806/1806.04347.pdf.

Wellenreuther, C. and Voelzke, J. (2018). Speculation and volatility – a time-varying approach applied on Chinese commodity futures markets. *Journal of Futures Markets*, 39(4), 405-417.

Yan, C. (2020). Outbreak and stock prices: Evidence from China. *SSRN Electronic Journal*, Available at: https://ssrn.com/abstract=3574374.

Zaremba, A., Kizys, R., Aharon, D. Y. and Demir, E. (2020). Infected markets: Novel coronavirus, government interventions, and stock return volatility around the globe. *Finance Research Letters*, 35, 101597.

Zhang, D., Hu, M. and Ji, Q. (2020). Financial markets under the global pandemic of COVID-19. *Finance Research Letters*, 36, 101528.

Zhang, W. and Hamori, S. (2021). Crude oil market and stock markets during the COVID-19 pandemic: Evidence from the US, Japan, and Germany. *International Review of Financial Analysis*, 74, 101702.

Zhang, F., Narayan, P. K. and Devpura, N. (2021). Has COVID-19 changed the stock return-oil price predictability pattern? *Financial Innovation*, 7, 61.

Zoungrana, T. D., Toé, D. L. T. and Toé, M. (2021). Covid-19 outbreak and stock return on the West African Economic and Monetary Union's stock market: An empirical analysis of the relationship through the event study approach. *International Journal of Finance & Economics*, 2021, doi.org/10.1002/ijfe.2484.

Zulfiqar, N. and Gulzar, S. (2021). Implied volatility estimation of Bitcoin options and the stylized facts of option pricing. *Financial Innovation*, 7, 67.