Investigating the Behavioral Pattern of Stock Market Index and Covid-19 Crisis: Case Study G20 Stock Market Indices

Egbe Agbortoko Agbortoko

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Approval of the Institute of Graduate Studies and Research

Prof. Dr. Ali Hakan Ulusoy
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science in Banking and Finance.

Prof. Dr. Nesrin Özataç
Chair, Department of Banking and Finance

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Banking and Finance.

Asst. Prof. Dr. Nigar Taşpınar
Supervisor

Examining Committee

1. Prof. Dr. Salih Katırcıoğlu

2. Asst. Prof. Dr. Hasan Rüstemoğlu

3. Asst. Prof. Dr. Nigar Taşpınar

ABSTRACT

This research focuses on investigating the behavioral patterns of stock market indices during the Covid-19 period, with the time period under assessment ranging from January 2015 to September 2022. The principal aim and objective of the research is to assess the volatility spillover of various stock market indices, with further derivations of both net transmitters and receivers of the volatility spillovers in the financial market. The principal econometric method used is the Diebold and Yilmaz approach (2012).

The results show a high rate of interconnectedness between the stock market indices in the financial market. The analysis reveals that the volatility in the market during the outbreak of the pandemic is due to its outburst, given that its total spillover index estimates are about 51%, and all observed series demonstrate stationarity at the level state I(0). These results emphasize the importance of information circulation in financial markets, as rational investment decisions by current and potential investors are backed by information adequacy. Additionally, the results demonstrate the relevance of health as an important factor in deriving the proficiency levels of stock market indices, with further illustrative evidence of a non-trading period as a result of the pandemic outbreak.

Keywords: volatility spillovers, stock market indices, Covid-19.

ÖZ

Bu araştırma, Ocak 2015'ten Eylül 2022'ye kadar değişen değerlendirme dönemi ile Covid-19 döneminde borsa endekslerinin davranış modellerini incelemeye odaklanmaktadır. Araştırmanın temel amacı, çeşitli hisse senetlerinin oynaklık yayılımını değerlendirmektir. Kullanılan başlıca ekonometrik yöntem Diebold ve Yılmaz yaklaşımıdır (2012).

Sonuçlar, finansal piyasada borsa endeksleri arasında yüksek oranda karşılıklı bağlantı olduğunu göstermektedir. Analiz, toplam yayılma endeksi tahminlerinin yaklaşık %51 olduğu ve gözlemlenen tüm serilerin I(0) seviye durumunda durağanlık gösterdiği göz önüne alındığında, pandeminin patlak vermesi sırasında piyasadaki dalgalanmanın salgının patlamasından kaynaklandığını ortaya koyuyor. Mevcut ve potansiyel yatırımcıların rasyonel yatırım kararları bilgi yeterliliği ile desteklendiğinden, bu sonuçlar finansal piyasalarda bilgi dolaşımının önemini vurgulamaktadır. Ek olarak, sonuçlar, pandemi salgınının bir sonucu olarak ticaret yapılmayan bir döneme ilişkin daha fazla açıklayıcı kanıtla birlikte, borsa endekslerinin yeterlilik düzeylerinin elde edilmesinde sağlığın önemli bir faktör olarak önemini göstermektedir.

Anahtar Kelimeler: volatilite yayılma etkileri, borsa endeksleri, Covid-19.

DEDICATION

To My Family

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LIST OF ABBREVIATIONS

ADF	Augmented-Dickey-Fuller Test
G20	Group 20
GFC	Global Financial Crisis
JB	Jarque-Bera Test
Kurt	Kurtosis
MAX	Maximum
MIN	Minimum
OBSERV	Observations
PP	Phillips-Perron Test
RQ	Research Question
SKEW	Skewness
STD	Standard Deviation
WHO	World Health Organization

Chapter 1

INTRODUCTION

1.1 Brief Overview

In the recent times, the world is tending towards the acknowledgement of technological advancement and awareness. This advancement in technology causes the world to be regarded as a global village. This further justifies the fact that the evolution in technology in the 19th century brings together countries all over the world closer than expected. These advancements have a seen the global integration and interconnectedness in the quest for auxiliary assets for possible in order to enhance market risk minimization (Adekoya & Oliyide, 2021). In most recent times, investors carryout optimal decision making relative to the follow up prices of commodities and stock prices in financial markets in order to minimize risk and enhance returns (Choi & Hammoudeh, 2010). These developments most especially in the financial field facilitates the exchange and movement of goods and services amongst the world's economies which enhance their economic growth.

The observed stock prices seen in the financial markets are based on the injection, circulation and availability of information. This scenario coincides with one of the variations of the efficient market hypothesis which happens to be the weak-form. This is of great importance as it helps policy formulations in terms of allocative functions (Choi, 2021). Hence, the prevailing prices of securities in the financial market are to

an extent the reflection of the responsiveness of the investors to the available information.

The variations in the stock prices of securities in the financial markets are somewhat normal given the economic and financial scenarios are not fixed given that the world is constantly advancing with new technologies and insertions of new information that causes these variations in the stock prices. These variations become a call for concern when its variations yield a net negative benefit to its holders and potential investors as such leading to the rise of financial crisis. Hence both endogenous and exogenous crisis play a role in the fluctuations and volatility in the financial markets. (Song, Shu & Zhu, 2022).

Endogenous shocks are failures that occur within the financial markets that leads to a structural breakdown causing a sharp and downfall of the existent and new stock prices in the financial markets with the most recent been the 2008 Global Financial Crisis (GFC) that led to the winding-up and disclosure of bankruptcy by many investment companies all over the world. Exogenous shocks are issues that occur out of the financial market whose impact be it positive or negative affect the stock prices of securities and the financial markets as a whole with the most recent occurrence be the outburst of Covid-19. Worthy of note here is the fact that the outburst of this ailment was and is still great shock given that its impacts where unforeseen as it gave rise to unplanned hardship as result of the unusual dispositions such as lockdowns whose long-term effects have recorded a mass down trend in economic prospects ranging from 3% to 6% (IMF, 2020).

This plague has led to an unprecedented fall in the equity, commodity and cryptocurrency value characterized by the negative returns on its portfolio been a resultant effect of the increase in its uncertainty and volatility (Ashraf, 2020). The world at large was brought to another era of global financial crisis backed by the high-risk spillover expectancy over different assets and market conditions (Ashraf, 2020). Government estimates to revitalize the economies in order to meet up with the deficiencies due to the outbreaks the pandemic about USD 3 Trillion with additional policies such as loan, equity injections and other guarantees which sum up to USD 5.5 Trillion. Furthermore, USD 700 Billion Quantitative Easy (QE) program was initiated with other policies such as zero interest rate policy which was declared on March 15th, 2020, coupled with other strategies used by the Central Bank amongst which were the following; the reduction in the interest rate policy, the reduction in the reserve requirements, additional financing injections, capital relaxation and countercyclical buffers for financial institutions (Congressional Research Service, 2020).

Hence this investigation is of utmost importance given the results will be of great relevance to both the regulatory institutions and to investors enabling them carry out well informed and optimal decisions for both micro and macro purposes. It should equally be noted that this too would go a long way to improve and increase available literature in this field of study.

1.2 Problem Statement

The fallbacks in the financial market operations as a result of the outburst of this global health pandemic happens to be a very broad and vast study area which has led to disparate controversies. Thus, there seem to be a school of thought which propounds that the resilient shocks in the stock prices movements is as a result of the pandemics

outbreak. It is as thus as result of this supposed causal relationship between Covid-19 and financial markets which propels us to investigate the impact the outbreak of Covid-19 has on the financial market. The decision to carry out the investigation for the G20 countries is justified by the fact that, these countries are the biggest countries in the world with regards to their transactions in the financial markets. The results obtained the G20 stock market indices would enable us understand the flow of volatility transmissions spillovers to its various trading partners and the extent to which the multiplier effect records in the financial sector and the world economies at large. This therefore accounts for the investigation of the constraints experienced in the financial markets as result of Covid-19 outbreak hence enabling us to ascertain the extent to which the volatility spillovers are as a result of the outbreak of the Covid-19 pandemic.

1.3 Objective of the Thesis

This thesis is focused on investigating the behavioral pattern of stock market indices are as a result of the Covid-19 outbreak. To this effect the primary aim and objective is to investigate the volatility spillovers existent between the G20 stock market indices during the Covid-19 outbreak.

1.4 Hypothesis of the Thesis

For an adequate analysis of our variables, we would take into consideration the following as our set null and alternative hypothesis;

H_0: Covid-19 does significantly enhance volatility in G20 stock market indices in the financial markets.

H_1: Covid-19 does not significantly enhance volatility G20 stock market indices in the financial markets.

1.5 Structure of the Study

The study is coherently organized into five chapter; the first chapter is centered on the introduction of the study; the second chapter entails the literature review associated to existing literature; the third chapter will focus on the methodology of the research, data source, definition of independent variables, analytical tools; the fourth chapter will entail the presentation of data results and discussion ; while the fifth chapter will cover the summary of findings, recommendations, policy implications and conclusions.

1.6 Significance of the Study

This relevance of this research is stated as follows:

1.6.1 Private Sector

This research would equally help aid the private sectors through the acquisition of the technological know-how that will enable them stabilize the prices of their securities which will reduce the fluctuations in the financial markets hence the maximization of the values of their securities.

1.6.2 Other Researchers

Conclusively, the research is of trivial importance in the academic milieu as it would serve as a basis for prospective further research papers and articles, not equally forgetting that it would equally serve as a reference as an addition to existing literature for future research works.

1.7 Scope of the Study

The research period as with regards to this study covers a 7 years period that is from 2015-2022.

Chapter 2

LITERATURE REVIEW

Health related concepts are closely linked to the production and provision of goods and services both domestically and internationally. It is of utmost importance to investigate the extent to which the outbreak of the pandemic has affected the trend of the G20 stock market indices. Thus, this chapter will illustrate how Covid-19 impacts stock price index with reference to use of both conceptual and empirical literature further enhanced by the use of varied data sources and econometric models.

2.1 Conceptual Issues

In an attempt to have a better understanding of the ravaging effects the Covid-19 outburst records on the behavioral pattern of stock market index; the following concepts are instrumental in easing our understanding giving us an upper hand in understanding the results of our investigation.

2.1.1 Health

This refers to both the metabolic and functional efficiency of living organisms. Pertaining to human beings, it refers to their capacity and their ability to self-adapt and equally manage the changes associated in their social, physical, psychological and mental environment. Health as defines by the World Health Organization (WHO) taking reference to the 1946 constitution defined health as “a state of complete physical, mental and social wellbeing and not merely the absence of disease and infirmity”. It should be noted here that the aforementioned definition has been subject to a lot of controversies as a result of the use of the “complete”, hence the upsurge and

rise of other definitions relating to the health concept with the most recent been suggestive of the fact that health is a correlation of personal satisfaction.

Thus, with regards to this study, health is very essential as it either enhances either upward or downward movement of stock market indices. The Malthusian population growth theory further justifies this in situations where the use of birth control measures reduces population which enhances the provision of better medical facilities with a multiplier effect in the long-run enhancing economic growth and as such a healthier movement and behavioral pattern of the stock market indices.

2.1.2 Financial Markets

Financial markets generally refer to an environment in which the transactions relating to securities are been carried out that is both the sale and purchase of securities. These markets are of great relevance to capitalist economies not only because of the fact that they enhance their financial operations but equally of great importance as a result of the fact that it deals with the high-profile trading in securities such as Forex market, Derivative markets, Bond markets, Stock markets which serve as a point of contact to all other world economies hence linking them in all platforms (Bhide, 1993). The determinants of profitability and or viability of such securities is obtained from the value of market index. Thus, the price of any security over the financial market is obtained by assessing the behavioral patterns of its respective stock market index. It is worth noting here that behavioral patterns and movements of the market indices are basically in two directions that is either an upward movement which signifies its profitability, viability and efficiency and the downward movement very indicative of the fact the security in question is inefficient, not viable and very much less profitable and productive.

2.1.3 Relationship between Health and Stock Market Index

The primary objective of each and every firm is to maximize the value of their respective share prices through the enhancement of their market index. Hence, it is thus of utmost importance to consider how related health issues are to the behavioral pattern of company's stock price index. This aspect is most important because it witnesses negative returns during periods of both market crisis and negative health related issues. This tends to align with the national additional model with implicative tendencies on both stock prices and consumption (Cotti et al., 2015). This thus goes a long way to justify the assertion of the existence of a direct and positive relationship between health-related issues and the behavioral pattern of stock market indices.

2.2 Determinants of Stock Market Index

The stock market index concept has become a determinant factor in assessing the proficiency and viability of corporations. This is further buttressed by the fact that it not only demonstrates the viability and profitability of the its owned assets over the financial market but equally serves as a benchmark for its aggregate performance. A variety of key indicators exert a great influence in its assessment amongst which are some of the followings:

2.2.1 Foreign Investment

This is most often than not referring to as foreign direct investment. This generally refers to the investment on domestic corporations by foreign investors. This actually a great key indicator in the stock market index performance in that with an increase in such investment type, there will be an increase in capital plight which would in effect maximize the value of the corporation hence accounting for its profitability and increase in performance (Osadume & Etugbo, 2018).

2.2.2 Financial Intermediaries

These refers to institutions and or individuals who primary role is serving as mediators between third parties in order to enhance the conclusion of financial transactions. This in itself is trivial in that these records both positive and negative effects in the determination of stock market index. This point could be said to be a curse in situations where the absence of these mediators or their inadequacies causes the completion of financial transaction to become an arduous and herculean task while in same light could be said be said to be a blessing in situations of their availability its eases the conclusion of financial transactions which in the long-run improves both its proficiency and efficiency hence outperforms itself in terms of its stock market index (Odhiambo, 2011). It is worth noting that the financial intermediaries are not only restricted to this mediator role but carryout other functions such as advisory and provision of funds essential for the smooth conclusion of financial transaction which on their right exert a certain degree of influence in the determination of the performance of stock market index.

2.2.3 Stock Market Liquidity

This refers to the ability of financial markets to possess ready and available financial assets with abilities of quick cash conversion without a loss in its value. This is a key factor because corporations with these kinds of financial securities would attract a greater proportion of investors whose demand will lead to an increase in stock price illustrative of its performance hence account for the aggregate increase in the stock market index (Goyenko & Ukhov, 2009). This thus implies that its preferable to possess more of financial assets whose value is maintained when converted to cash than assets who value diminishes with regards to cash conversion in order to outperform its stock market index.

2.2.4 Interest Rates

This generally refers to the payments received by financial institutions as a reward for their loaning out of funds to potential and already existing investors. This factor is very complex in nature given it would impact the stock market index performance with inferences to the respective stand point of the policy maker. To begin with, this could have an adverse effect loan obtainability as a result of increase in interest rates, increase in the marginal propensity to save and hence a reduction in investments hence a fall in demand for financial assets and as such a downward trend in its performance (Aurangzeb et al., 2012). Hence with this increase in rates of interest would inadvertently lead to downward trend in terms of the stock market index performance.

2.2.5 Inflation Rates

This refers to the general increase in the prices of goods and services over a given period of time. This could either be cost-push inflation and or demand-pull inflation. In all macroeconomic scenarios the occurrence of this is usually devastative to the economy as a whole. Hence, it negatively impacts the determination of stock market index in that with its manifestation the it leads to a fall in the value of money which in itself leads to a fall in the ability to invest which equally leads to an increase in the propensity to save hence deterring investment financial assets hence the downward trend of the stock market index performance (Alzoubi, 2022).

2.2.6 Economic Growth

This refers to aggregate upward turnout in the production of both goods and services which in turn enhances the standards of living of present and future consumers and the economy as a whole. Pertaining to the stock market index, this would impact it positively in scenarios having to deal with the developed countries and economies given that an increase in economic growth would generate much more income giving

grounds for the acquisition and further investment in the financial markets hence leading to an increase in the price of stock market index thus, illustrative of a direct relationship between the aforementioned (Radke, 2021). A good example of such developed economies where the impact of economic growth is clearly is are the following markets; London Stock Exchange (LSE), New York Stock Exchange (NYSE), National Association of Securities Dealers Automated Quotations (NASDAQ).

The preceding examined determinants portray the anticipated effects on the behavioral pattern of the stock market index which in one way or the other accounts for the volatility if at all existent within the financial markets. It is worth noting that, these are our expectations on the impact the precedent determinants would have on the stock market index; in order to be certain of their earlier mentioned impacts, the following reviews with inferential to both systematics and scientific study will give us a clear picture of the extent to which our initial assertions be relevant or irrelevant.

Osadume and Etugbo (2018) carried out an extensive study on the effects Foreign Direct Investments exerts on stock market development and long-run with reference to Sub-Saharan African countries as their case study from 1984 to 2015. In order to carry out this research they made use of secondary data obtained from the Central Bank, Bureau of Statistics and the World Bank. They made use of Cointegration analytical methodology in a bit to test the effect the exogenous variable been Foreign Direct Investment had on the endogenous variables such as the number of listed shares, value of traded stocks, market capitalization. It is worth noting that a 5% significance level Foreign Direct investment impacts a statistically significant positive long-run effect on the stock market parameters of Nigeria, South Africa and Kenya while based

on the pool panel cointegration of Sub-Sahara African countries resulted in the fact that effect of the Foreign Direct Investment rho statistic and Philip-Perron were negatively significant but positively significant for the Johansen-Fisher statistic. This in effect suggest that Foreign Direct Investment exerts a long-run effect on stock market development as well as policies aimed at sustaining resultant spill-over effects follow suit.

Alzoubi (2022) investigated the reaction on interest rates and inflation on the stock market performance with reference to the Amman Stock Exchange performance over a period ranging from 1991to 2020. In order to carry out this research he made use of Auto-regressive distributive bound test (ARDL). In this study, the principal variable under analysis was the Consumer Price Index (CPI) and Interest rates. The results show relevant signs and of course statistically significant with implications of the fact that an increase in Consumer Price Index (CPI) and Indonesian Rupi (IDR). This is illustrative of an existent inverse relationship as per the long-run analysis. With reference to the short-run analysis, the model confirms the causality of both the dependent and independent variables. It further results in the statistical significance of the Error Correction Term confirming the long-run relationship between the variables.

Aurangzeb et al. (2012) investigated how stock market index is affected by rates of interest and inflationary rates with their case study been Pakistan with the use of KSE100 as the dependent variable while CPI (Consumer Price Index), REER (Real Effective Exchange Rate) and WALR (Weighted Average Lending Rate) as the independent variables. Their study showed the fact that Consumer Price Index (CPI) and Weighted Average Lending Rate (WALR) were found to statistically significant with a positive inflationary beta coefficient illustrative of the fact an increase in

inflationary rates would lead to an increase in KSE100 hence showcasing a direct and positive relationship. Nonetheless, the study further tells us that despite the existence of a positive relationship between the inflationary rates and the KSE100, a persistent and continuous of the inflationary rates will record a negative impact on KSE100 while the beta coefficient for Weighted Average Lending Rate (WALR) though statistically significant illustrated an inverse relationship as result of the negative sign attached to its beta coefficient. Hence, an increase in WALR would lead to a fall in KSE100.

Radke (2021) carried out this research in attempt to investigate the stock market and economic growth with more precision on the assessment on the level of existent dependence. In order to do this the relationship between the stock market situation and the real economy where measure by the strength of the correlation existent between the rates of returns of the stock market and the European capital market GDP (Gross Domestic Product) growth rates. This research was based on the hypothesis that the stock exchange situation precedes the change in the economic activities which is later used as basis for future forecasting. He further made use of quarterly data value of the stock index and Gross Domestic Product with results been that the observed changes in the stock exchange index and the changes in the Gross Domestic Product (GDP) growth rate yield a positive correlation hence and increase in one will inadvertently lead to an increase in the other.

2.3 Major Financial Crisis and Stock Market Index

There have been a series of financial crisis that have globally reshaped the face of the financial market. These financial crises have exerted varied ramifications on the stock market index hence influencing differential movements and relationships at the period of occurrence.

2.3.1 Global Financial Crisis (2007-2008)

The 2007-2008 global financial crisis is also referred to as the subprime mortgage crisis. This was mostly characterized by inadequate liquidity as a result of the fall in real estate markets. Worthy of note here is the fact that this fall in the housing posed a serious threat to the crumbling of the already set and established financial system (Blakenburg & Palma, 2009). This crisis alone is said to have been the greatest of its kind in terms of its recorded severity coupled with devastative effects when been compared to the impacts of the Great Depression 1929. The outburst of this crisis caused a lot of uncertainties in the financial markets given that it increased the volatilities in the stock market index and in the worst-case scenarios led to the winding up, closure and even the declaration of bankruptcy by major stakeholders in the financial markets. A good example of such repercussions was some of the findings carried out by the St. Louis Federal Reserve Bank whose estimates of American households declared a decline of about $17 trillion relative to the inflation adjusted terms that is 26% fall in their total net worth.

2.3.2 Eastern Asian Economic Crisis (1997-2001)

The manifestation of this crisis was experienced with the sudden fall in the currency exchange rates and a sequential series of depreciation in the valuation of the related currency which infiltrated into many Asian countries. This contagion led to the rise of government upheavals and as such a reduction in the generated inflows from imports and above all the witnessed down turn in terms of currency exchange rate prices of the other assets and stock market prices (Higgot, 1998). This in effect illustrates that in situations of financial crisis there is an inverse causal relationship between the stock market index behavioral pattern and the occurrence of the financial crisis which in the long-run enhances great volatility over the financial markets.

2.3.3 Russian Economic Crisis (1998)

This financial crisis is similarly referred to as the Rubble Crisis or the Russian Flu, with its principal triggering factor been the fact that both the Russian government and the Russian Central Bank devaluated the rubble which happens to be its currency which in effect led to its further debt default. It is worth noting here that this act did not hold the Russian economy at a stand-still but equally recorded a multiplier devastative effect on its neighboring countries. This plague recorded heavy and unpleasant shocks on both foreign exchange markets and capital markets in that it basically led to shift in terms of its Terms of Trade (TOT) to a deficit given that the devaluation caused imports to be more expensive and exports less expensive which in effect accounted for a loss in confidence amongst both foreign investors and domestic investors justified by a 60% fall in Foreign Direct Investment(FDI) and a decline in domestic stock market of about 70% accounting for monthly loss in capital flight of about $1.5 billion (Buchs, 1999).

2.4 Theoretical Framework Covid-19 and Stock Market Index

In order to grasp the connectedness of the global crisis be it endogenic or exogenic as the case maybe relative to the stock market index trend we refer to existing literature. The focal point here is investigating the occurrence of volatilities and its effects on the stock market index we would begin with generalities from which related literature pertaining to our investigation would be illustrated with further analysis of the associated literature and more. In order to do so, the generalities relating to volatility as a whole is shown in Table 1 below:

Table 1: Volatility literature

	Year	Authors	Title	Methodology	Variables	Results
Renewable Resources	2022	Rakesh S. and Anishka T.	Dynamic volatility behavior from crude to energy crop: Empirical evidence from India	GARCH (1,1), TGARCH (1) and AR (2)-EGARCH (1,1)	Crude prices (soya bean, wheat and sugar cane) and energy crops from January 1st 2016 to December 31st 2020	Returns on crude affects sugarcane and wheat with no impact on soya bean. Asymmetry for two crops (wheat and sugar cane) with positive shocks impacting crop volatility than negative and spillover from crude prices to both was negative hence shocks are not permanent.
	2022	Siraprapa Y., Roengchai T., and Woraphon Y.	Volatility spillovers between ethanol and corn prices: A Bayesian analysis	BEKK-GARCH (1,1)	Daily prices of United States, Brazil and China from January 1st 2015 to December 31st 2020	Significant bidirectional volatility between corn and ethanol for all countries with co-volatility movements is unstable between countries.
	2022	Te-ke M, Aoife M. F, Michael M. and Chia-lin C.	Impact of Covid-19 on returns-volatility spillovers in national and regional Carbon markets in China	DBEKK and DCC	Market indices (June 20th 2014 to 2021 Q3)	Larger amount of risk spillover due to pandemic outbreak
	2021	Shihong Z., Jingmin J., Bin S., Chunxia J. and Guowang Z.	The spillover effect of European Union (EU) carbon financial markets	BEKK-GARCH (1,1)	Future prices EUA (European Union Allowance) and CER (Certified Emission Reduction) (March 14th 2008 to July 27th 2014)	Existence of asymmetric volatility spillover between EUA and CER markets with its volatility spillover dropping in phase III due inadequate substitution of CER for EUA.
	2022	Coskun M. and Taspinar N.	Volatility spillovers between Turkish energy stocks and fossil fuel energy commodities based on time and frequency domain approach	Diebold and Yilmaz (2012 and Barunik and Krehlik approach (2018)	Firm-level data from July 18th 2006 to December 31st 2021	High linkages between fossil fuels and energy stocks. Recent crisis exerts more shocks than the previous.
	2022	Barbara B. and Joana G.	The lithium and oil markets-dependencies and volatility spillover	DCC-models (GARH family)	Stock market index from September 1st 2014 to January 31st 2022	American returns on mining stocks are weakly correlated to changes in oil prices but when compared to that of Chinese companies they are very much more correlated. No dependence is seen for oil and lithium producers.

	2022	Lin C., Fenghua W., Wanyang L., Hua Y. and Lili Z.	Extreme risk spillover of oil, exchange rate to Chinese stock market: Evidence from implied volatility indexes	AR(p)-GARCH (1,1) and CoVAR	Daily data from March 16th 2011 to September 9th 2019	The Chinese stock market is more sensitive to risk uncertainty fluctuation than its oil market; while the USD/CNY exhibits weak volatility.
	2020	Tangyong L. and Xu G.	Analysing time-varying volatility spillovers between the crude oil markets using a new method	Diebold and Yilmaz (2009, 2012, 2014) and GFEVD (TVP-VAR-SV model)	Daily spot prices from November 29th 2002 to July 13th 2018	Volatility between crude oil markets is gradually on the rise while the correlation and Granger causality shows that the volatility and volatility spillover are positively correlated and are two-way correlated as per the Granger causality test.
	2021	Zartasia H., Khuram S. and Anum N.	Volatility spillover between oil prices and foreign exchange markets	Diebold and Yilmaz (2012)	Future index and foreign exchange rates from January 4th 2011 to December 30th 2016	Oil prices have more volatility spillover effects on countries who do more of oil exportation than importation.
Cryptocurrency	2022	Michael D. and Ke X.	Covid-19 vaccine and post-pandemic recovery: Bitcoin cross-asset implied volatility spillover.	VAR and GFEVD (Generalized forecast error variance decomposition)	VXEEM and VXEFA from January 8th 2019 to January 20th 2022	Positive and negative relationship between both respectively due to the pandemic outbreak.
	2019	Anoop S. K. and S. Anandarao	Volatility spillover in crypto-currency market: Some evidence from GARCH and wavelet analysis	IGARCH (1,1), DCC-GARCH (1,1) and Wavelet analysis	Four bitcoins (crypto-currencies) (August 15th 2018 to January 18th 2018)	Statistically significant volatility spillover between Ethereum and Litecoin; moderate co-returns movements among crypto-currencies and persistent short-run correlation among crypto-currencies.
	2022	Olaluwa S. Y., Adewale F. L. and Xuan V. V.	Persistence and volatility spillover of bitcoin price to gold and silver price	CCC-VARMA-GARCH	Daily data sets from January 2nd 2018 to July 31st 2020	no spillover between bitcoin, gold and silver with existence of bi-direction volatility spillover
Stock Markets	2020	Seyfettin E., Ayfer G. and Emrah I. C.	Volatility spillover effects between Islamic stock exchange markets and exchange rates	MGARCH, GARCH (Chung and ng (1996) and Causality-in-variance test	Daily data for data for Islamic stock market and exchange rates from 2013 to 2019	Spillover from Islamic stock market to the Turkish foreign exchange market.

	2022	Xuequing G. and Kun G.	The spillover effect of VIX and oil price on the exchange rate volatility among Belt and Road countries	VAR and IRF (impulse respond function)	Exchange rate data Belt and Road countries and oil prices and VIX index from May 2007 to February 2020	Differential variation observed after the initiation Belt and Road initiative as an effect of VIX's spillover effect.
	2022	Giang Thi H. V., Manh H. N. and Anh N.Q.H	Volatility spillovers from the Chinese stock market to the U.S stock market	EGARCH (1,1) and ICSS	Daily data of the various stock market index from January 2001 to October 2020	Asymmetric volatility transmission from the Chinese stock market to the U.S stock market.
	2022	Dong w., Ping L. and Lixin H.	Time frequency volatility spillovers between major international financial markets during the Covid-19 pandemic	Garman and Klass, 1980 and Diebold and Yilmaz, 2015	Daily stock market indices from five major international markets (January 1st 2007 to December 31st 2019)	Both U.K and U.S markets are transmitters while others are the net receivers.
	2021	Yi Z. and Jiapeng L	Correlation and volatility spillovers between China and South East Asian Stock markets	Multivariate GARCH-models	Daily stock market indices (January 1st 1994 to August 30th 2019)	It illustrates that $1 long position is a better hedge for the Shanghai composite index.
	2022	Hamidreza H. and Hassan M.	Returns and volatility spillover across the Western and MENA countries.	Diebold and Yilmaz, (2009, 2012, 2014)	Daily nominal local currency price indices (January 2005 to December 2017)	Suggestion of similar pattern in both returns and spillovers. It further suggests that these markets are closely connected to Western markets hence can be volatility transmitters.
	2022	Yizhi W.	Volatility spillovers across NFTs news and financial markets	TVP-VAR and GARCH-MIDAS	NFTAIs (non-fungible attention index) and Market index	NFTAIs exert a significant prowess in explaining the returns of NFT fixed asset based on fixed effect perspective and equally a good tool in the volatility forecasting for both the short and long-run separately.
	2021	Fenghua W., Jiahui C., Zhen L. and Xiong W.	Dynamic volatility spillovers and investment strategies between the Chinese stock market and commodity market	TVP-VAR	Shanghai Composite index (May 25th 2009 to June 24th 2020)	Both commodity and stock markets highly depend on each other. The occurrence of the crisis greatly enhanced the volatility in the commodity market hence reducing its hedging abilities.
	2021	Eric M. E. A and Mbodja M.	Return and volatility spillovers to African currencies markets	Diebold and Yilmaz (2009,2012, 2014)	Daily exchange rate data (February 2nd 2000 to September 25th 2019)	African currencies are most responsive to their own their variable market than to regional or global volatility and returns with exceptions of BWP, MAD TND and

						ZAR given their integration to other currencies hence significant variations in both volatility and returns.
	2022	Choi S.	Volatility spillover among Northeast Asia and the U.S: Evidence from the global financial crisis and the Covid-19 pandemic	Diebold and Yilmaz (2012)	Weekly stock market index data (January 2000 to June 2001)	The U.S play a significant role as a net volatility shock transmitter with an observed increase in interdependence within the both periodic crises not forgetting the occurrence of varied volatility patterns with both periods.
	2022	Suleyman G. and Ahmet S.	Investigating the volatility spillover effect between derivative markets and spot markets via the wavelets: The case of Borsa Instanbul	M-GARCH and Wavelet analysis	Daily Bist 30 index from January 5th to September 27th 2017	Wavelet analysis tend to be more consistent than M-GARCH models with general volatility observed from derivative markets to stock markets.
	2020	Kamrul H., Ariful H., Muammer W. and Dominic G.	Islamic stocks, conventional stocks and crude oil: Directional volatility spillover analysis in BRICS	T-GARCH and GFEVD	Weekly data from June 2002 (first week) to March 2017 (second week)	Volatility is mostly driven by a long-term component. Volatility spillover substantially increases during financial crisis.
	2021	Md A., Sabri B. and Ahemt S.	Financial Contagion during Covid-19 Crisis (China and G7)	VARMA (1,1) DCC-GARCH	Stock market indexes from January 1st 2013 to March 20th 2020	China seen to be net spillover transmitters during the crisis and an increase in hedge costs.

Huynh et al. (2022) carried out a study on the spillover originating from the Chinese stock market to that of the United States. In order to effectively do this, they made use of the variant form of EGARCH (1,1) alongside the ICSS algorithm in order to model the resultant excessive volatility breakpoints. The empirical results show that there is an asymmetric volatility transmission from the Chinese stock market to that of United States.

Huang, Li and Wang (2022) assessed the spillover volatilities on major international financial markets during the Covid-19 pandemic based on time-varying frequency. In an attempt to do this, they made use of five top capitalization market indices and associated proxies on which daily volatilities were obtained based on the Garman and Klass (1980), with further utilization of the Diebold and Yilmaz (2015). The illustration from empirical results show that all are volatility receivers with the exception of America and Britain as volatility transmitters.

Wang et al. (2021) investigated volatility spillovers of G20 stock market indices relative to their level of connectedness. They made use of the associated stock market index daily data o which GARCH-BEKK was used in order to estimate the volatility spillover and dynamic network respectively. They further introduced the quadratic assignment procedure (QAP) aimed at identifying the factors that enhance spatial linkages of the volatility spillover. The results obtained showed that the geographical factor enhances spatial volatility correlation differently over the economic cycles and the QAP analysis illustrating the fact that at least 50% of spatial correlation variation over the international financial market volatility spillover is explained by the influencing factors.

Zhang, Hu and et Ji (2020) analyzed the exerted impacts of the global pandemic on the financial markets with the use of statistical analysis which resulted in the unprecedented upsurge movements of financial markets with policy implications been that market returns for individual are directly linked to the pandemic outbreak resulting in an increase risk, uncertainty, volatility and above all the stochastic movements of the stock market index in the financial markets.

Ashraf (2020) with the use of daily confirmed cases of Covid-19 and market returns of 64 countries with the period of study from January 22nd 2020 to April 17th 2020, discovered the existence of an inverse relationship between both variables which in effect implies that as the Covid-19 cases increased the aggregate stock market returns experienced a sharp and perpetual decline. The study aggregately suggest that stock market returns are sensitive to the number of Covid-19 cases which further implies that intended response to this outbreak would with reference to the phase at which the pandemic finds itself.

Izzeldin et al. (2021) investigated the variations in G7 stock as a result of the occurrence of Covid-19. They made use of daily value weighted aggregate price couple with ST-HAR model. The results obtained demonstrated that minimal effects were witnessed in the technological sector with grave effects witnessed in both consumer and medical sectors. This in effect implies that on average there is a positive relationship between the Covid-19 outbreak and the all the variables that is the health, technology and consumer sectors of the economy. Hence, an assume increase in Covid-19 rates leads to an average increase health cost, cost of living and stimulates technological innovations in order to meet up with the impromptu measures to curb the pandemic.

Al-Awadhi et al. (2020) examined the nature of the relationship existent between the outbreak of the Covid-19 pandemic and the market returns with data type been panel data with case study been the Chinese stock market. They discovered that there is an existent inverse relationship between the Covid-19 pandemic and the market returns with further suggestions of a constant fall in market returns with the increase or continuous progression of the pandemic.

Dong et al. (2021) carried a multidimensional analysis on the impacts Covid-19 has on the stock markets of G20 countries. In order to carry out the research they made use of cross-market linkages in order to effectively examine the transmission rates of risk and its pathway among G20 stock markets not forgetting the par wise volatility connectedness among the G20 stock markets. They concluded that the G20 total market volatility significantly increases during the Covid-19 with developed markets been the principal spillover transmitters and the emerging markets the prime receivers of the emitted spillovers.

Sethi and Halda (2021) in their study of the effects of global financial market volatility by Covid-19 made use of EGARCH model with further use of both bivariate time series and random-effects panel with indicative results of an inverse stock returns accruals, further enhancing volatility within the stock markets hence demonstrating the existence on inverse relationship between the analyzed variables.

Nguyen et al. (2021) in their study of the changes in the global equity market as a result of the outburst of Covid-19 with case study been the both the United States equity market and China’s equity market obtained results illustrative of the fact that the contagion in itself showed multiplier flow effects originating from the United States

to China's equity market. They further suggested that coupled with occurrence of a no change in stock index's nature the was little or no volatility within the pandemic period.

Yagli (2020) with reference to Borsa Instanbul as its case study carried out comparative analysis of various industries registered within it before the advent of Corona virus and with the pandemic. One of the major findings from this research was the fact that most firms experience a high rate of deterioration as with regards to the volatility of stock market indices during the pandemic and also found out that an increase in the Covid-19 cases considerably increased the rate of volatility for most industries with the exceptions of the following industries; food and beverage industries, insurance industries, non-mineral product industries and whole and retail trade industries. His research further went to suggest that credit defaults (CD) and exchange rates greatly enhance volatility in the stock markets relative the level of occurrence of the both aforementioned.

Oliyide and Adekoya (2021) in their research examined the ramifications of the pandemic Covid-19 with reference to market connectedness that is how connected stock markets are. In order to effectively carryout this research, they made use of Time-varying parameter (TVP-VAR) technique which to an extent enabled them determine the extent to which volatility exists between financial assets and commodity assets with further utilization of the Granger-causality test which was aimed determining a possible long-run relationship. The results of the Granger-causality test illustrated the existence of a significant causal relationship with aggregate results illustrative of the fact that Covid-19 is greatly responsible for the risk transmission between the financial asset markets and the commodity markets.

Gupta et al. (2020) investigated the volatility in the international stock markets during outburst of the pandemic. In their research, they made use of GARCH with the prime and main objective of examining the volatility of stock market indices based of the Gross Domestic Product (GDP) with the exogeneous variance regressor coefficient in GARCH been Covid-19 been positive and very much significant for all the stock market indices under analysis which implies that there is a direct and positive relationship between the stock market indices and the rates of stock market volatility. Hence, a perpetual increase in one enhances an increase in the other by the same proportion.

Vo et al. (2021) analyzed the spillover effect of the outbreak between the United States and Chinese stock sectorial analysis. They made use of Copula and Conditional Value at Risk approach. The empirical results show evidence of bi-directional asymmetric risk spillover from the American stock markets to that of the Chinese and vice versa. This implies that a greater proportion of the risk spillover flows from the American stock markets to that of the Chinese before and after the pandemic outbreak.

Echaust and Malgortazarta (2020) investigated the correlation volatility in the stock markets during Covid-19 with use of the two-regime Markov switching model. The results of this research show that there is a degree of close interdependence between the returns accrued and the volatility. It is thus worth noting here that the aforementioned research shows that there is no existent correlation with liquidity.

Chaudary, Bakshi and Gupta (2020) carried out an empirical study on the volatility occurrent in the international stock market as a result of the prevalence of Covid-19. They aimed at assessing the effect of Covid-19 records on the stock returns and the

volatility of 10 market indices with reference to GDP. In order to do this, they made use of econometric models such the GARCH (Generalized Autoregressive Conditional Heteroscedasticity) model with further use of daily returns obtained from market indices from January 2019 to January 2019. This research demonstrated negative returns during the pandemic precisely from January 2020 to June 2020 while the second half reflected the re-bounce of the market indices characterized by bearish tendencies and very high volatility than normally observed.

Ngwakwe (2020) carried an extensive study in order to decipher the effects Covid-19 has had on the stock market values. To this effect, he made use of market indices such as SSE Composite Index, Euronext100 and the Dow Jones Industrial Average (DJIA) with the purpose of determining the extent and direction to which the pandemic ramifies the aforementioned indices. The data used were obtained fifty days to the outburst and fifty days after the outburst of the pandemic. The research suggested that the occurrence of the pandemic has diversified impacts on the market indices that is with regards to the DJIA, it witnessed a massive fall in the mean stock value during the pandemic while the Chinese Stock Exchange Composite Index experience a boost during the pandemic higher than the occurrence of the pandemic. Other indices such as S&P500 and Euronext100 manifested no great change in their respective stock prices.

Adekoya and Nti (2020) carried out and extensive research in order to get an understanding of the expected effects the major indices would have as a result of the outbreak of Covid-19. In order to meetup with the set goal, they made use of random sampling techniques enabling them obtain 30 world market indices from different countries affected by the pandemic from December 31st 2019 to March 25th 2020. The

results suggest the fact that the shock generated with reference to the manifestation of the pandemic are last long in the financial markets. Hence, the validity of this research as it enables us explore measures that enable us hedge against uncertainties most precisely portfolio diversification.

Liu et al. (2020) analyzed the market response of countries in terms of their differentiated stock levels as a relation to the Covid-19 outbreak. In this study they made use of both event study and regression analysis with results been that areas characterized by Covid-19 contamination were subject to significant negative returns. This in effect demonstrates that there is on average an existent inverse relationship between the outbreak of this disease and the market response of the countries.

Chaudhary, Bakshi and Gupta (2020) in their article tried to assess the performance of the Indian stock market during the pandemic with the sole aim of assessing its effects with reference to two composite indices that is BSE500 and BSE SENSEX with further comparisons with three other composite indices that is S&P500, Nikkei500 and FTSE100. They made use of daily data to which the generalized least square regression alongside varied volatility measures such as standard deviation, skewness and kurtosis. The research suggested the following: the standard deviation for all indices experienced and upward movement, skewness became more negative and kurtosis was exceptionally large. It is worth noting that the research further suggested that low returns accrual but most especially it illustrated the negative during the pandemic period.

Gil-Alana and Claudio-Quiroga (2020) researched the Covid-19 outbreak on the behavioral patterns of stock markets with Asia as their case study. They did this with

the aid of the analysis of the statistical properties of the three financial market indices that is Kopsi, Nikkei225 and the Shenzhen CSI. They made use of fractional integration methodology with the use of daily data. The research hence suggested that Kopsi and the Shenzhen indices rejected the hypothesis of shocks been permanent while the Nikkei225 illustrated mean reversion that is returning to their long-term mean value.

Scherf, Matschke and Rieger (2020) investigated the reactions stock markets as a result of the lock-down. They did so with the use of sample stock market indices obtained from both OECD (Organization for Economic Co-operation and Development) and BRIC (Brazil, Russia, India and China) with keen emphasizes on the reaction of the indices as a result of the announcement of the lock-down. The research suggested that a negative effect was observed on the market indices as a result of the strict lock-down and restriction characterized by underreaction; this was directly followed by corrected measures of overreaction. It should however be noted that the aforementioned reactions were mostly observed during the first half of the outbreak with a slight change in the stock market indices that is a tilt towards positivity as a result of the relaxed lock-down and restriction policies.

Yu, Xiao and Liu (2020) with the use of two pandemic anxiety indexes examined the dynamic co-movement between anxiety and stock market returns in BRIC and G7 countries. The article suggested that there is a resultant downward trend given that the anxiety indexes are very volatile and went ahead to suggest that the correlation becomes weaker and smaller as a result of the mRNA-based Covid-19 vaccine.

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Chowhury, Dhar and Stasi (2022) in their study of the volatility of the US stock market and business strategy during the Covid-19 assessed the impact of the pandemic and the impacts it records on the resultant changes in the Economic Policy Uncertainty (EPU). This research made use of both event study and vector autoregression (VAR) models. The results of the research suggest that there is a negative cumulative abnormal return as a result of the deaths from the pandemic hence the resultant financial bailout. The research also suggests that EPU is positively significant to the resultant volatilities in the US stock markets hence the EPU, Covid-19 and volatility variables cointegrated move in a unidirectional pattern.

Abuzayed et al. (2021) in this research analyzed the resultant systemic risk spillover existent between the individual and global stock market affected by the Covid-19 virus. Conditional Value at Risk (CoVAR) and Delta Conditional VAR and the conditional autoregressive heteroscedastic model were used. The research suggests that there is a high level of integration amongst both markets that is the individual and global stock markets especially during the relative to financial crisis with inferences the connectedness analysis based on the value at risk. The results further suggest and illustrates the existence of bivariate systemic spillover which was aggravated during the outbreak of the pandemic.

Hatmanu and Cautisanu (2021) made use of the autoregressive distributed lag (ARDL) bound cointegration as an analytical tool in order to assess and examine the impact of Covid-19 in Romania. They made use of the Bucharest Trading Index (BET) alongside other variables such as; number of new cases, number of deaths, measures taken by the government and the international economic context. The research suggests that

there is existent inverse relationship between the pandemic and BET index while a direct relationship was observed with the European economic context.

Bora and Basistha (2021) investigated how the volatility of the Indian stock prices is affected by the occurrence of Covid-19. The generalized autoregressive conditional heteroscedasticity model was used with daily closing prices for Nifty and Sensex accompanied with comparative studies of pre-Covid-19, Covid-19 and post-Covid-19 scenarios. The article suggests that the Indian stock market is characterized by high volatility with an increase of such volatility observed during the pandemic outbreak based on the comparative analysis carried out.

From the above review, ample write-ups show that the behavioral pattern of stock market indices is affected by the pandemic outbreak. The write-ups essentially focus on the assessment of relationship between the without much attention paid to the existent volatility and interconnectedness if any among market indices, and as such inadequate time varying analysis on the trending behavior of the stock market indices.

Chapter 3

DATA AND METHODOLOGY

This section of the research solely focuses on the presentation of data used to in the analysis and its nature not equally forgetting the outlining of the proposed parameters for further analysis. This equally centers on the presentation of the econometric models having as objectives the identification of the various test to be used and mentioning both the merits and the demerits of the aforementioned econometric methodological analytic procedures.

3.1 Data and Sampling

The data made use of in this research comprises of the adjusted closing price indices for those obtained from yahoo finance and closing prices for those obtained from stooq.com with the period under study been from January 2015 to September 2022. The case study of this research is G20 stock market indices relative to top 10 most performant based on market capitalization. Market value or capitalization, refers to sum total of the outstanding stock shares. It is worth noting here that the calculations of the volatility are be based on absolute returns retrieved from the logarithmic transformation of the respective closing prices of the returns series for the countries mentioned in the Table 2 below. The period chosen for the analysis enables us assess the behavioral pattern of the said stock market indices before, within and after the outburst of the Covid-19 pandemic.

Table 2: Market Capitalization Ranking (1975-2020)

S/N	Country	Market Capitalization ($Billion)	Period
1	United States of America	40719.66	1975-2020
2	China	12214.47	1975-2020
3	Japan	6718.22	1975-2020
4	Canada	2641.45	1975-2020
5	India	2595.47	1975-2020
6	South Arabia	2429.1	1975-2020
7	Germany	2284.11	1975-2020
8	South Korea	2176.19	1975-2020
9	Australia	1720.56	1975-2020
10	Brazil	988.37	1975-2020

Table 3: Data Description

S/N	Country	Stock Market Index	Data Source
1	United State of America	NASDAQ (IXIC)	Yahoo finance
2	China	SZSE	Yahoo finance
3	Japan	Nikkei (N225)	Yahoo finance
4	Canada	S&P/TSX	Yahoo finance
5	India	Nifty 50 (NSEI)	Yahoo finance
6	Saudi Arabia	Tadawul (TASI)	Stooq.com
7	Germany	DAX (GDAXI)	Yahoo finance
8	Republic of Korea	Kospi Comp. Index (KS11)	Yahoo finance
9	Australia	S&P/ASX 100	Yahoo finance
10	Brazil	Ibovespa (BSVP)	Yahoo finance

The return series under investigation and its respective pictorial statistics are illustrated below in Table 4. Based on our findings shown in Table.4 below, we observe that all return series have coefficients above zero (0). This is illustrative of the fact that all the series are rightly-skewed with its largest been observed in the Canadian stock market index (GSPTSE). With reference to kurtosis, we observe that all the return series under investigation have coefficients largely greater than three (3) very much implicative of the fact that tails in the returns series are heavily peaked and fat hence, the aforementioned are highly leptokurtotic in nature with its highest observed in the Canadian stock market index (GSPTSE) averagely followed by the German stock market index (GDAXI). With regards to the normality test propounded by Jarque-Bera, we are able to reject the null hypothesis of the existence of normal distribution in the returns series at 1% level of significance all of the stock market index suggestive of the fact they are not normally distributed. It is worth noting that the nature of data used is weekly data.

Table 4: Descriptive Statistics Returns Series

	IXIC	SZ	N225	GSPTSE	NSEI	TASI	GDAXI	KS11	ATOI	BSVP
Mean	0.2065	0.0886	0.0983	0.0558	0.1798	0.0663	0.0569	0.0278	0.0486	0.2069
Median	0.3513	0.2555	0.2232	0.1903	0.3586	0.4538	0.2869	0.1665	0.1822	0.3684
Max.	10.0621	11.5682	15.8171	9.0695	11.9719	8.7293	10.3521	9.2573	6.0427	16.5621
Min.	-13.5129	-17.6758	-17.4281	-16.4881	-12.9561	-13.2271	-22.3296	-14.1264	-14.0796	-20.9231
Std.	2.7651	3.6093	2.8626	2.1088	2.3607	2.7823	2.9076	2.3713	2.1117	3.2909
Skew.	-0.5130	-0.7900	-0.5038	-2.1901	-0.4194	-0.8391	-1.4171	-0.8648	-1.5065	-0.7643
Kurt.	5.6934	5.9909	9.3212	18.9222	7.8333	6.1115	13.1175	8.8772	10.7907	9.7152
JB	143.8748*	192.1367*	688.0154*	4579.151*	404.0892*	209.8679*	1853.767*	630.2720*	1171.640*	796.4623*
Observ	403	403	403	403	403	403	403	403	403	403

Note: (*) indicates the rejection of the null hypothesis of the volatility series following a normal distribution at 1% levels of significance with reference to the Jarque-Bera (JB) test (1980).

3.2 Methodology

3.2.1 Unit Root Test

Prior to the retrieval of the empirical results the conventional unit root test is carried out in order to determine the stationary level. The unit root of a series refers to the stochastic trend in the series. This test is of essence given that series in question is a returns series which is stationary in nature. The stationarity of returns series is characterized by constant variance, constant mean and constant autocovariance relative to its given lags. In order to do this, we would make use of the Augmented-Dickey-Fuller and the Phillips-Perron unit root test (Dickey and Fuller, 1981; Phillips and Perron, 1988). The null hypothesis for both test states the existence of unit root. The general ADF model is generally based on that which is characterized by the intercept and trend. The ADF model is mathematically as follows;

$$\Delta Y_t = \alpha_0 + \alpha_2 t + \delta Y_{t-1} + 2\sum_{j=1}^{p}\left(1 - \frac{j}{\alpha+1}\right)\beta_j \Delta Y_{t-i-1} + \epsilon_t \qquad (1)$$

Where y represents the variables in the model; α shows the intercept; t represents the indicated trend; ϵ_t shows the white noise and p shows the lag level that is the optimum lags based on the results obtained from the information criterion in order to reduce and or eliminate serial correlations in the error terms (Dickey and Fuller, 1981). Worthy of note is the fact that both the ADF and PP unit root test make use of t-test in estimating δ.

Phillips-Perron test suggest a nonparametric approach to find serial correlation in the errors through lag addition for a possible heterogenous distributed data. (Philips and Perron, 1988). The most popular method used in this method is the Newey-West method which is further estimated as follows;

$$\omega^2 = Y_0 + 2 \sum_{j=1}^{q} \left(1 - \frac{j}{\alpha+1}\right) Y_j \quad (2)$$

$$Y_j = \frac{1}{T}\sum_{t=j+1}^{T} \mathcal{E}_t \mathcal{E}_{t-j}$$

Where q is the lag truncation; Y_t illustrates the estimated covariance of both the j-lag and T in the model.

3.2.2 Volatility Spillovers Analysis

The investigation on the ascertainment of the supposed behavioral pattern of G20 stock market index will essentially be based on the use of the Diebold and Yilmaz (2012) approach. This model is based on the generalized forecast error variance decomposition (GFEVD) of a vector autoregressive (VAR) model initially propounded by Sims (1980). With the first step been the construction of a basic stationary VAR model estimated as follows;

$$y_t = \sum_{i=1}^{M} \omega_1 y_{t-1} + \varepsilon_t \quad (3)$$

Where Y_t refers to the endogenous variables of t (N-dimensional vector); w_1 refers to the coefficients of the matrices (N*M) and ε_t representing the independent and identically distributed error term. The in-depth understanding of the dynamic pertaining the changes observed within a system is relative to the coefficients of the moving average which tend to be very determinant component in understanding this concept, hence the use of the forecast error decomposition VAR framework to overcome this issue (Koop, Peasaran and Potter,1996; Pesaran and Shin, 1998). This step is mostly referred to as the H-step mathematically illustrated below as follows;

$$\emptyset_{cd}^{i}(H) = \frac{\partial_{dd}^{-1} \sum_{h=0}^{H-1} (\propto_c^1 X_h \sum \propto_d)2}{\sum_{h=1}^{H-1} (\propto_c^1 X_h \sum X_h^1 \propto_c} \quad (4)$$

Where ∂_{dd} denotes the standard deviation for the error term relative to the b^{th} equation; $\sum$ denotes the error vector variance matrix; α_c denotes the vector selection of values of 1 and otherwise 0 for the α^{th} term. It is worth noting that the sum of the elements on

each row of the variance decomposition table is not and will never be equal to one (1) hence its further normalization which illustrated below as follows;

$$\emptyset_{cd}^{i}(H) = \frac{\emptyset_{cd}^{i}(H)}{\sum_{d=1}^{N} \emptyset_{cd}^{i}(H)} \quad (5)$$

Where $\sum_{d=1}^{N} \emptyset_{cd}^{i}\ (H)$=1 and $\sum_{c,d=1}^{N} \emptyset_{cd}^{i}\ (H)$=N

Hence, the total volatility spillover index with inferential to the described aforementioned elements can be expressed as follows;

$$S^{i}(H) = \frac{\sum_{c,d=1\ (c\neq d)}^{N} \emptyset_{cd}^{i}\ (H)}{\sum_{c,d=1}^{N} \emptyset_{cd}^{i}\ (H)} . 100 = \frac{\sum_{c,d=1\ (c\neq d)}^{N} \emptyset_{cd}^{i}(H)}{N} . 100 \quad (6)$$

By obtaining the total volatility index, it enables us assess the level and extent to which the volatility spillover and its associated shocks affect the G20 stock market index. Hence, it gives us the ability to be able to forecast the total error variance.

This spillover methodology does not only enable us obtain the total volatility index but it also enables us ascertain the spillover volatility effects too equation (8) and from equation (7) the markets with the aid of directional volatility illustrated as follows;

$$S_{\propto.}^{i}(H) = \frac{\sum_{c,d=1\ (c\neq d)}^{N} \emptyset_{cd}^{i}\ (H)}{\sum_{c,d=1}^{N} \emptyset_{cd}^{i}\ (H)} . 100 = \frac{\sum_{c,d=1\ (c\neq d)}^{N} \emptyset_{cd}^{i}(H)}{N} . 100 \quad (7)$$

$$S_{.\propto}^{i}(H) = \frac{\sum_{c,d=1\ (c\neq d)}^{N} \emptyset_{cd}^{i}\ (H)}{\sum_{c,d=1}^{N} \emptyset_{cd}^{i}\ (H)} . 100 = \frac{\sum_{c,d=1\ (c\neq d)}^{N} \emptyset_{cd}^{i}(H)}{N} . 100 \quad (8)$$

The net volatility spillover from any of the aforementioned is obtained from the resultant difference arising from the gross volatility shocks sent to the markets and the gross volatility received as shown the following mathematical illustration;

$$S^{i}(H) = S_{.\propto}^{i}(H) - S_{\propto.}^{i}(H) \quad (9)$$

Chapter 4

DATA PRESENTATION AND RESULT ANALYSES

This section of the thesis focuses on the presentation of the empirical results as well as the discussion and analysis of the results. The presentation of the results would essentially those obtained from two models that is the results obtained from the unit root test (ADF and PP) aimed at testing for the occurrence of unit roots and that of that Diebold and Yilmaz aimed at examining the existent volatility spillover amongst the G20 stock market indices.

4.1 Unit Root Test

As disclosed in the methodology, purpose of the test that is ADF(Augmented-Dickey-Fuller) test and PP(Phillips-Perron) test is to ascertain the occurrence of unit root in the series. These tests are of great importance given that the analytical methodology in examining the volatility spillover is based on the Diebold and Yilmaz's 2012 approach which further relies on the stationarity assumption of the vector auto-regressive model. The unit root test shows the results relative to the integration order. The findings of the test illustrate that at a 1% level of significance we are unable to reject the null hypothesis for both tests hence occurrence of the unit root and thus stationarity in the series at all levels. It should be noted that this is confirmatory of the fact that returns series are stationary in nature. The results illustrative of the affirmations above are illustrated below in Table 5 as follows;

Table 5: ADF and PP Unit Root Test

Statistics (Level)	IXIC.	SZ	N225	GSPTSE	NSEI	TASI	GDAXI	KSII	ATOI	BSVP
τ_T (ADF)	-20.898*	-17.590*	-20.857*	-18.139*	-19.267*	-17.838*	-20.034*	-19.505*	-18.588*	-12.079*
τ_μ (ADF)	-20.906*	17.599*	-20.881*	-18.164*	19.272*	-17.820*	-20.034*	-19.494*	-18.611*	-12.088*
τ (ADF)	-20.807*	-17.613*	-20.879*	-18.172*	-19.185*	-17.828-*	-20.051*	-19.516*	-18.626*	-12.042*
τ_T (PP)	-20.932*	-17.669*	-20.933*	-18.064*	-19.287*	-17.770*	-20.041*	-19.523*	-18.552*	-19.326*
τ_μ (PP)	-20.938*	-17.679-*	20.959*	-18.094*	-19.297*	-17.769*	-20.040*	-19.513*	-18.576*	-19.342*
τ (PP)	-20.803*	-17.693*	-20946*	-18.098*	-19.229*	-17.780*	-20.057*	-19.535*	-18.593*	19.307*

Note: All the data made use of the above series are in their logarithmic forms. With τ_T indicative of the consisting of that with trend and intercept; τ_μ illustrative of the model consisting of the intercept without trend; τ further indicative of the limited model consisting that without intercept and without trend. The * represents the levels at which the null assumption (H_0) is rejected at a 1% level of significance.

4.2 Diebold and Yilmaz (2012) Results

4.2.1 Static Results

The first set of results from the running of the data are those which refer to the time-in-varying volatility transmission among the stock market index (atoi, bsvp, gsptse, sz, gdaxi, nsei, n225, tasi, ks11 and ixic). The results obtained relative to the aforementioned market indices are further illustrated in Table 6. that is the showcasing of the existent static analytic inferences between the stock market index under examination.

Table.6. below illustrate values in each of the rows show the spillover volatility transmitted to other markets further denoted by TO while the correspondent values on the each of the respective columns represent the spillover volatility received other markets inclusive of its own, this is denoted by FROM. The resultant net volatility from the from the volatility returns series is the difference from the spillovers transmitted to and from other markets (TO-FROM). The total spillover index from the above is estimated to be about 51% which is illustrated at the lower extreme right corner illustrated in Table. 6. This index illustrates the average summary of the all contributions of the spillovers existent within the market that is TO and FROM respectively. It is gotten by the taking the summation of the all the FROM values and dividing by the number of markets with inferential to its percentage (ten markets x100%=1000%). The resultant effect of the total spillover index estimated at about 51% is high and mostly accounts for the variations and fluctuations witnessed in the markets. It's worth noting that despite the evidence above, the results are not very much reliable given that financial data are dynamic and not static in nature given the constant evolutions in the financial sector characteristic of changes in the trade cycle.

With reference to the net directional volatility analysis as per the static analysis, the largest are observed from the South Korean stock market index (ks11) with a net spillover of about 82.9% resulting from the differences between 117.9% and 35%, which closely followed by the Japanese stock market index (n225) estimated at about 21% the resultant difference from 68.5% and 47.5% which illustrate the fact there the aforementioned are net spillovers transmitters and as such showcase the existence of long lasting shocks existent within the markets which is thus in accordance with Gul-Alana and Claudio-Quiroga, 2020. Hence, relative to static analysis we observe that gsptse, n225, ks11 and gdaxi corresponding to the Canadian, Japanese, South Korean and German stock market indices are the net spillover volatility transmitters while the others such as atoi, bsvp, sz, nsei tasi and ixic corresponding to the Australian, Brazilian, Chinese, Indian, Saudi Arabian and American stock market indices are the net spillover volatility receivers as per this study.

Table 6: Volatility Spillovers among the Various Stock Market Indices

	atoi	**bsvp**	**gsptse**	**sz**	**gdaxi**	**nsei**	**n225**	**tasi**	**ks11**	**ixic**	**FROM**	**Net Spillovers**
atoi	35.77	4.96	12.18	0.68	9.97	5.23	7.79	0.84	17.09	5.49	64.2	-1.3
bsvp	9.69	41.06	10.07	0.54	7.25	5.87	8.40	0.50	14.04	2.58	58.9	-32.2
gsptse	11.44	6.15	29.22	0.39	10.22	5.53	8.20	0.62	17.98	10.24	70.8	2.6
sz	3.35	1.28	1.03	88.79	1.69	1.26	1.32	0.46	0.62	0.19	11.2	-4.2
gdaxi	7.83	3.71	10.24	1.38	39.06	4.46	9.70	0.60	15.54	7.46	60.9	7.7
nsei	7.36	3.67	10.87	0.91	7.62	38.46	7.74	0.53	16.72	6.12	61.5	-25.7
n225	5.74	1.06	5.21	0.58	8.59	2.10	52.48	1.19	19.23	3.80	47.5	21.0
tasi	7.56	1.93	5.56	1.44	7.94	3.39	5.90	58.25	4.94	3.10	41.8	-36.3
ks11	3.68	1.32	3.40	0.92	5.84	1.96	14.43	0.39	65.01	3.06	35.0	82.9
ixic	6.29	2.58	14.88	0.15	9.45	5.98	5.00	0.36	11.72	43.60	56.4	-14.4
TO	62.9	26.7	73.4	7.0	68.6	35.8	68.5	5.5	117.9	42.0	508.2	**Total Volatility index=50.8%≈51%**

4.2.2 Dynamic Volatility Results

The aforementioned is equally referred to as moving-window analysis. The moving-window for this study is illustrated below is the graphical representation in Figure.1. The moving-window analysis relative to the is research article is based on the analysis relative the behavioral pattern of G20 stock market indices relative to ten (10) of its most performant indices comprising of the following; atoi, bsvp, gsptse, gdaxi, n225, nsei, ks11, tasi, sz and ixic corresponding to the stock market indices of the following member countries; Australia, Brazil, Canada, Germany, Japan, India, South Korea, South Arabia, China and USA with the period under analysis ranging from January,1st 2015 to September,19th 2022.

The analysis is based on the 100-day rolling with the total spillover index ranging from about 45% to 75%, with the relative total volatility index based on the static premise estimated at about 50% illustrative of the fact that time-varying analysis are more viable and reliable to a greater extent given that they take into consideration the resultant economic changes with an estimate reflection in their results in term of the resultant volatilities in the respective markets. Figure. 1. which shows the total volatility pattern based on the moving-windows analysis gives us an overview of such tendencies.

From Figure 1 below, we observe that the period pre-Covid-19 the fluctuations are certainly low but suddenly witness and upward trend from 2016 to 2017 with high volatility estimates about 67%. The manifestations of events such as the Brexit in 2016, the institutions of the 2016 OPEC policies such as the supply cuts by the end of 2017, and the increase the prices of both coal and natural gas accounts for the high

volatilities. Schmidbauer and Rosch (2012), Zhang et al., (2020), Filis, Degiannakis and Floros (2011) and Li (2020) further corroborate this fact in their respective publications. The Covid-19 period ranging from late 2019 to the early 2021 witness's high volatility index of about 73%. The high level of investment degradation and uncertainties account for the breaks in the flow of the trend.

The recovery period slated as the later of 2021 to 2022 witnesses a decline in the spillover transmission index with the production, administration of the vaccines and the overruling of lockdown policies. The slight increase in 2022 in spillover index of about 55% and fall of about 50% is as a result of the outbreak of the Covid-19 variant (Omicron) and the administration of its vaccine (Booster).

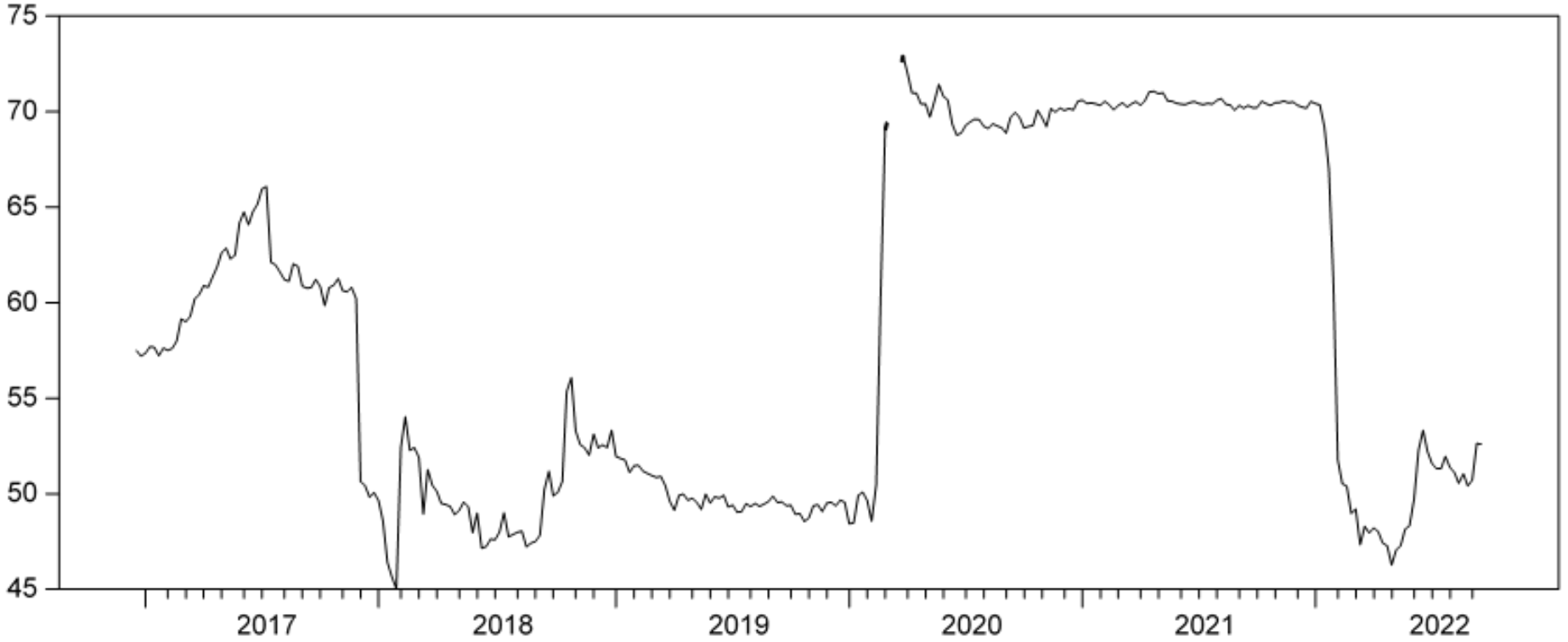

Figure 1; Total Volatility Spillovers

Figure.2 below illustrates the long-term decomposed directional spillover effects FROM stock market indices on a 100-day rolling day analysis. From Figure 2 below we observe that prior to the outbreak of the pandemic (Covid-19), the total spillover ranges from 0% to 80% index with its highest estimates of about 60%, 80% during the pandemic and 40% after the pandemic. It is worth noting here that, the scenario is seemingly true for nine of the above indices with the exception of the Chinese stock index(sz) estimated to have its highest spillover index at about 70% lower total spillover index estimated at about 40% during the pandemic and averagely during the recovery phase mostly as a result of the fact that most of its private sector is labor-intensive hence the outbreak of the pandemic greatly reduce its momentum for economic growth (Bowman, 2019) Generally, we observe a similar pattern in the trend of the various stock market indices illustrative of the fact that there exists some degree of connectedness in them despite divergence in spillover index relative to the various stock market indices.

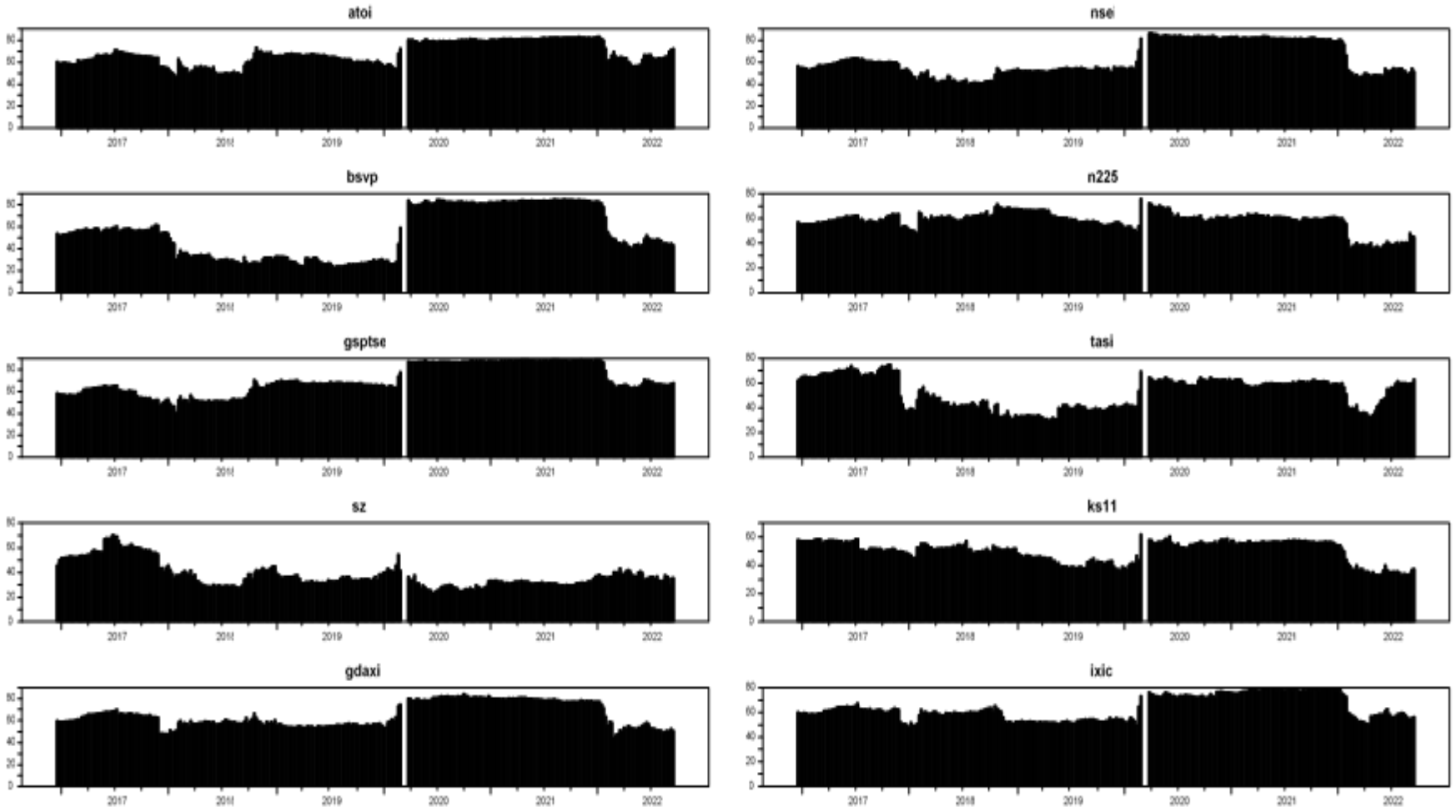

Figure 2: Directional Volatility Spillovers, FROM

Figure.3 below with references to a 100-rolling day effects reflects the decomposed directional volatility TO the stock market indices from itself. It is generally seen here as well that the existential gap from the late 2019 to 2020 is as result of the reduction in the marginal propensity to invest and the existing uncertainties as result of the Covid-19 outbreak. This shows that there exists some degree of connectedness amongst market indices. Figure.3 below illustrates the total volatility index for the various market index ranging from 0% to 200%.

From the illustration below, we observe that the ixic, atoi, sz, nsei and tasi which are all stock market indices corresponding to America, Australia, China, India and Saudi Arabia with volatility spillover index estimates of about 80%,110%, 120% 79% and 58% represent the peak indices are all occur at time interval ranging from 2017 to 2018. The peak indices we see here are the impacts of the major events such as the Brexit and OPEC policies on the respective market indices. Hence, the volatility spillover indices for these market indices are greater than prior to the outbreak of Covid-19 than during the Covid-19 crisis.

From Figure.3 below, we see that the following stock market indices; ks11, n225, gdaxi, and gsptse corresponding to South Korea, Japan, Germany, Brazil and Canada with the total spillover index estimated at about 160%, 160%, 100%,and 100% seem to manifest themselves at almost same time frame that is late 2019 to the early 2020s principally due to the outburst of the pandemic and we are equally able to see that despite the fact the these indices recorded high indices prior to the outbreak the pandemic its greatest volatilities are see are witnessed during the pandemics outbreaks. It is however not the case of bsvp which corresponds to the Italian stock market index. This is because of the increase in its index in 2021 with estimates of about 80%. This

increase is as result of the combine influence of both the Covid-19 and its variant (Omicron) outbreak.

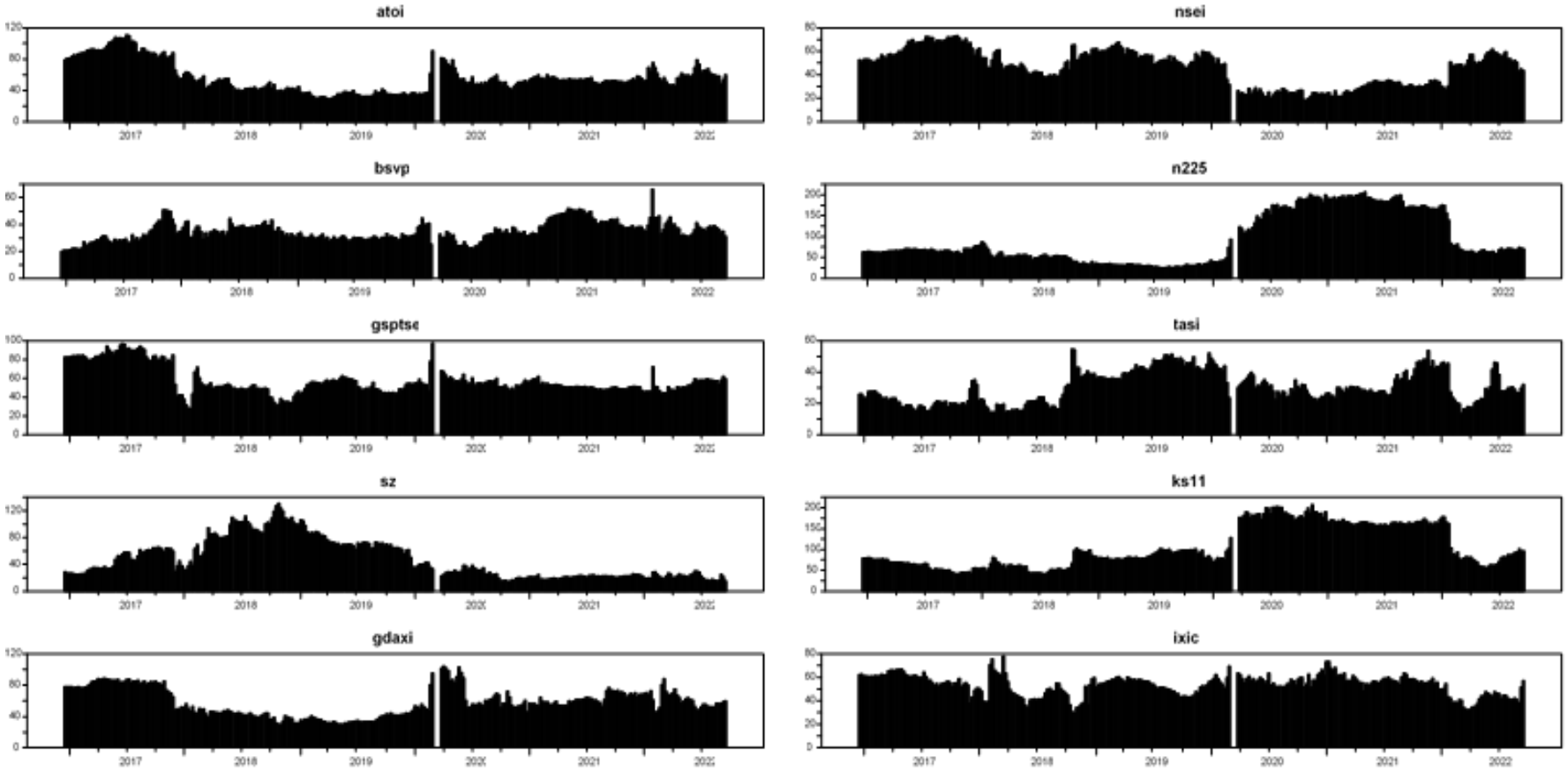

Figure 3: Directional Spillovers, TO

Figure.4. illustrates the situation of the net volatility spillovers resulting from the between TO and FROM the stock market indices. Relative to the aforementioned stock market indices, we are able to deduce that the following stock market indices exhibits attribute of been net volatility receivers given that their coefficients are negative in nature; atoi, nsei, bsvp, gsptse, tasi, gdaxi and ixic which correspond to Australia, India, Brazil, Canada, Saudi Arabia, Germany and United States of America while the following stock market indices exhibit features of net volatility spillover transmitters; n225,sz and ks11 which correspond to Japan, China and South Korea.

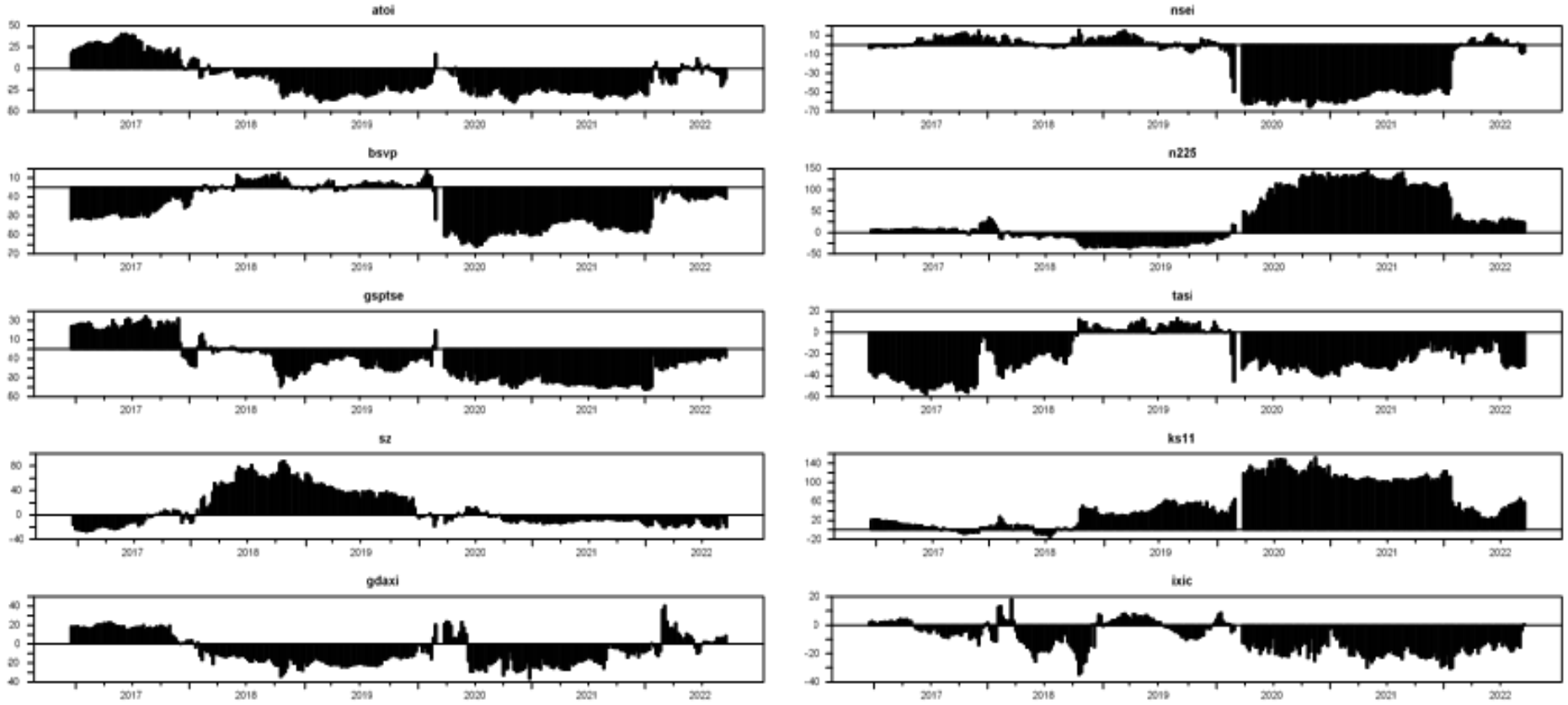

Figure 4: Net Volatility Spillovers

Chapter 5

CONCLUSION

This chapter essentially focuses on the general review and purpose of this research with inference to the obtained empirical results. With this in mind, the primary objective is to assess the impact of the outbreak of the pandemic (Covid-19) on the behavioral pattern of G20 stock market indices relative to 10 of its most performant indices based on market capitalization from January 1st 2015 to September 19th 2022.

In an attempt to do this, the conventional unit root test (ADF and PP) coupled with the use of Diebold and Yilmaz approach (2012) in order to determine the stationarity order and carryout volatility analysis. The outcome of the result from the unit root test with use of the conventional test illustrates that all the series are stationary in nature hence the existence unit root. It should be noted that the stationarity of the series is very important given all returns series are stationary.

The empirical results illustrate the fact that Covid-19 significantly affects the behavioral pattern of the stock market index hence our inability to the reject the null hypothesis of our research. The results show the existent to which the pandemic ramified the performance and behavioral pattern in terms of its volatility. The results equally demonstrate contradictory results in terms of the determination of both net volatility receivers and the net volatility transmitters with reference to both the static and moving-window analysis.

A comparative view of both the static and the dynamic analysis illustrates the fact that four variables are net volatility transmitters while six are net volatility receivers and three are net volatility transmitters and seven net volatility receivers respectively. Our conclusive results is drawn from the moving-window analysis given it takes into consideration the resultant change in the financial sectors. Hence, based on the results illustrated by the moving-window analysis we are able to assert that South Korea, Japan and China are net volatility transmitters while Germany, Brazil, Australia, Canada, India, Saudi Arabia and the United States of America are net volatility receivers. It should be noted that, the aspect of China been a net volatility transmitter and the United States of America been a net volatility receiver is consistent with the already existing literature provided by Huynh et al., (2022).

According to the results, this research strongly recommends that health related issues and concepts be considered as one of the determinant factors in the derivation of both the proficiency and performance of stock market index for any economy and country given that stock markets could be referred as the skeletal structure that supports the smooth functioning of the financial markets. Thus, as health is trivial for the survival of every human being as propounded by the definition of health by the World Health Organization in the 1948 constitution, so too it should be considered in the derivation, assessment and proficiency of stock market indices.

Furthermore, with reference to this study, it amplifies the necessity and the importance of the flow of information which further goes to enhance the Efficient Market Hypothesis further justified by the fact that the degradation in the investment of pattern in the later parts of 2019 and the early 2020s was based on reigning uncertainty and hence the increase in the volatility indices. This is equally backed up by the major

financial events relative to the previous volatilities with reference to the endogenous events occurrent from 2016 to 2017.

The principal limitation in this study was the use of only 10 most proficient stock market indices relative to market capitalization. It is thus suggested that prospective publications and articles follow new horizons enabling the general assessment of the entire set of G20 countries and not specifics in order to obtain with certainty the true extent to which the pandemic outburst has impacted the behavioral pattern of the stock market indices.

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