UNIVERSITY OF CAPE COAST

GLOBAL SHOCKS AND STOCK MARKET RETURNS IN THE AUTOMOBILE SECTOR

MAXWELL KUMORDZIE

2025

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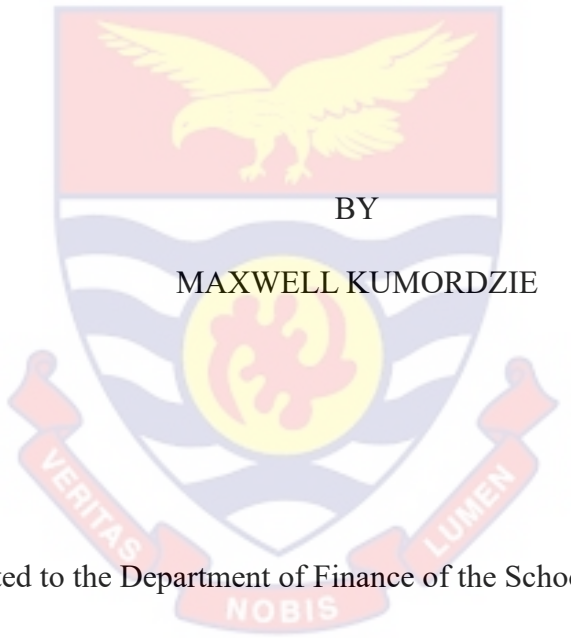

BY

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Thesis submitted to the Department of Finance of the School of Business, College of Humanities and Legal Studies, University of Cape Coast in partial fulfillment of the requirements for the award of Master of Commerce degree in Finance.

FEBRUARY 2025

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature …… Date ……

Name: Maxwell Kumordzie

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature ……. Date …….

Name: Dr. Patrick Kwashie Akorsu

Co-Supervisor's Signature ……... Date …….

Name: Prof. Samuel Kwaku Agyei

ABSTRACT

This study examined the connection between global shocks and stock returns in the automobile sector. The global shocks considered are the West Texas Intermediate (WTI) crude oil price shocks, the Russia-Ukraine war representing geopolitical risk, and COVID-19, which are modelled with selected automobile stocks to arrive at the findings of this study. Eight automobile stocks were employed with four selected from each market, thus the Shanghai Stock Exchange (SSE) and the New York Stock Exchange (NYSE). Wavelet coherence, Diks and Panchenko nonlinear causality test, and quantile regression analysis were employed in analysing time series daily data to arrive at the study's objectives. Findings revealed oil price shocks and automobile stock returns to be significantly connected. However, this co-movement varies in time and frequency as well as stock markets as SSE showed heightened levels of correlation compared to the NYSE. Results from the causality test also recorded a significant level of causality between COVID-19 and automobile stock returns. However, the Russia-Ukraine war reveals no significant relationship with automobile stock returns. It was recommended that investors, since black swan events, such as COVID-19, negatively impact some sectors, notably the automobile sector, investors should make portfolio investment decisions that will serve as risk diversification for their investment during such occurrences. Policymakers should implement measures that stabilize the price of oil by encouraging alternative sources of energy to reduce volatility and promote market stability. Also, automobile companies may consider diversified supply chains for key automobile materials to avoid effects posed by disruptions in a single region.

KEY WORDS

Automobile sector

COVID-19

Diks and Panchenko non-linear causality test

Global shocks

Quantile regression

Russia-Ukraine war

Stock returns

Wavelet

WTI crude oil prices

ACKNOWLEDGEMENTS

I sincerely thank my supervisors, Dr. Patrick Akorsu and Professor Samuel Kwaku Agyei, of the Department of Finance, for their unwavering direction and inspiration throughout this endeavour. I am truly appreciative of their valuable contributions.

I am also thankful to Miss Leah Nadia Acquah, for her unsparing efforts in making this study a success. Finally, I extend my heartfelt gratitude to my parent, Mr. and Mrs. Kumordzie, and my siblings Mavis and Felix Kumordzie.

DEDICATION

To my family and friends.

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LIST OF ACRONYMS

ACEA	European Automobile Manufacturers' Association
AMH	Adaptive Market Hypothesis
EMH	Efficient Market Hypothesis
GARCH	Generalized Autoregressive Correction Heteroskedasticity
GDP	Gross Domestic Product
GPR	Geopolitical Risk
HMH	Heterogenous Market Hypothesis
IEA	International Energy Agency
ILO	International Labour Organization
IMF	International Monetary Funds
NYSE	New York Stock Exchange
OECD	Organization for Economic Co-operation and Development
OICA	International Organization of Motor Vehicle Manufacturers
OPEC	Organization of Petroleum Exporting Countries
SDG	Sustainable Development Goals
SSE	Shanghai Stock Exchange
VAR	Vector Autoregression
VECM	Vector Error Correction Model
WCA	Wavelet Coherence Analysis
WHO	World Health Organization
WTI	West Texas Intermediate

CHAPTER ONE

INTRODUCTION

The behaviour of the stock market is salient to governments, corporate communities, and more especially market investors for decision-making. As revealed by Khositkulporn (2013), Global occurrences like political turmoil, oil price volatility, and catastrophic events affect the stock market. Recent oil price volatility has drawn a lot of interest because it has been shown that unanticipated shocks to the oil price have significantly impacted stock markets. According to Cui et al. (2021), abrupt fluctuations in oil prices affect stock markets in addition to economic policy. However, Pisani-Ferry (2022) reported that this volatility in oil prices is as a result of the ongoing Russia-Ukraine war.

COVID-19 is one major pandemic that crippled most sectors. The COVID-19 economic downturn caused the real-world economy to experience a shock, according to Adams-Prassl et al. (2020), hence, causing economic activities to slow down significantly. This affirms COVID-19 as one major global shock that affected the stock markets, more especially the automobile sector (He et al. 2020).

This study sought to analyze the interconnectedness between oil prices and stock market returns within the automotive sector. Additionally, it explores the impact of the COVID-19 pandemic on stock performance in the automobile industry and ultimately examines the relationship between stock returns in this sector and the Russia-Ukraine conflict.

Background to the Study

In this contemporary era, the growth of the automobile industry is essential to most countries' economic development due to the numerous industries the automobile sector is intertwined with. The sector consists of a wide range of businesses and institutions engaged in developing, producing, selling, and repairing automobiles. The International Organization of Motor Vehicle Manufacturers (OICA) estimated that the automotive sector in developing countries like China and India accounts for 7% of the Gross Domestic Product (GDP) of the respective countries. The global automobile sector generates more than €2.75 trillion annually on average, representing 3.65% of the global GDP (OICA, 2023)

The automotive industry has made significant strides in manufacturing clean and fuel-efficient vehicles in the quest to promote and attain the Sustainable Developmental Goals (IOCA, 2023). Modern emissions-control technology created by auto engineers is allowing for the widespread use of cleaner vehicles. International accords such as the Paris Agreement have driven several countries to implement more stringent emissions standards, thereby compelling automotive manufacturers to broaden their business portfolios by venturing into the electric vehicle sector leading to noticeable improvement in air quality as more and more new cars with contemporary exhaust emissions performance are produced (International Energy Agency, 2022).

Oil is a key component of the automotive industry and the most traded resource globally, contributing approximately 33% of all primary energy use worldwide (Ahmed, & Huo, 2021). According to Bashir et al. (2021), besides oil being the most common energy source, it also grants economic and political influence to nations with

large oil reserves. Oil is a major component of modern industries' raw materials and is important to the socioeconomic system's performance (Guo et al., 2021). Because oil has remained a valuable energy resource, it affects many industries, particularly those requiring a lot of energy, like the automotive sector. The sector is the third-largest consumer of oil globally (Du & Lin, 2017).

Oil prices influence the broader market through two principal mechanisms: supply-side and demand-side dynamics. An uptick in oil prices typically exerts a detrimental effect on stock returns by elevating production expenses and subsequently diminishing corporate profitability. As inflationary expectations rise, the macroeconomy as a whole is likewise impacted by rising oil prices. According to Driesprong et al. (2008) fluctuations in oil prices precipitate shifts in global equity market returns. Specifically, an increase in oil prices is associated with diminished future returns in equity markets. Concurrently, a rise in oil prices may signal heightened economic activity, driven by a surge in aggregate demand. Businesses are likely to make more profit and produce more returns when the economy is experiencing increased consumption.

Consumer demand is another means oil price shocks affect the automotive industry. As oil prices rise, consumer demand for oil-powered cars is expected to diminish, and when oil prices fall, customer demand for these vehicles is expected to climb as well (Du and Lin, 2017). As the cost of oil increases, consumers are inclined to reduce their automobile usage or opt for more fuel-efficient vehicles, in response to the escalating production costs encountered by manufacturers of conventional fuel-powered vehicles (Chen et al., 2021). The world is currently experiencing instability

in oil prices, which has been a major concern for many stock market participants. Instability in oil prices has an impact on stock markets by dint of their effects on corporate profitability, rising prices, and monetary policy. When a company's stock price falls due to rising oil prices, investors may decide to restructure their portfolios of investments, as stated by Jain et al. (2023),

Literature has demonstrated that wars and other violent events have historically exerted significant influences on both local and global economic systems (Jola-Sanchez, & Serpa, 2021). Stated differently, Khudaykulova et al. (2022), stated that geopolitical risks, threats, and uncertainties portray substantial negative effects on the process of deciding oil prices. The 1979 Iranian oil crisis is one of the most prominent instances of how the price of crude oil significantly affected automobile companies (Abdulrazzaq, 2018).

Among other things, the Russia-Ukraine conflict negatively impacted market returns, food and energy prices, and the world economy (Boungou and Yatié, 2022). There is a lot of economic turbulence as a result of the war, which started in 2022, and the harsh effects of financial sanctions on Russia. According to Wiseman and McHugh (2022), these impacts are not limited to Russia under President Vladimir Putin; they are also increasing global risks, upending the global economy, and destabilizing financial markets. This means that the economy of the world is impacted by war, not just the economies of the participating nations. Będowska-Sójka, Demir, and Zaremba (2022), revealed that the prolonged Russia-Ukraine war has significantly impacted several business sectors throughout the entire economy. Energy and commodity prices

have significantly increased as supply disruptions have grown increasingly frequent (Chepeliev et al., 2022).

An additional noteworthy worldwide disruption examined in this research is the COVID-19 pandemic, which had a profound effect on the world economy. COVID-19 is a serious public health emergency that has had a negative and long-lasting impact on the global economy (Iyke, 2020). With particularly dire repercussions for the automotive industry, the pandemic poses an unprecedented challenge to the world and is regarded as the most disruptive event since the previous three industrial revolutions. Due to concerns with supply and demand as well as halted production, the pandemic put businesses into a complete shutdown (Eldem et al., 2022).

The global automotive industry was exposed by COVID-19 to an unprecedented shock (Klein et al. 2021). The implementation measures in containing the pandemic have caused production and demand disruptions to the automakers and their sub-contractors. At the same time and more persistently, a demand shock marked reduced production across all assemblers (Klein et al., 2021). As stated by the European Automobile Manufacturers' Association (2020), the repercussions of the pandemic were swiftly evident in the Central and Eastern Europe (CEE) region, where automobile sales plummeted by approximately 32% during the first two quarters of 2020. Thus the demand side approach affects customer purchasing power and increases production cost as well, hence in the long run the profitability of automobile companies is affected.

The spread of foreign shocks and the vulnerability of the international stock market have drawn considerable attention in the literature on global economics. The automobile sector has seen disruption as a result of rising geopolitical unrest and a

string of exceptional catastrophes, where global businesses and supply chains have been severely damaged by these disruptions. Long-term regional and worldwide shutdowns as a result of COVID-19 presented turmoil in most sectors, especially the automobile sector, and the persistent Russia-Ukraine war, coupled with inflationary pressures, further complicated the situation. Financial crises and distress have regularly hit countries since the late 1990s, unexpectedly spreading to other countries and regions (Yu et al., 2022). Governments and investors need to understand how this link influences stock market returns, particularly the automobile sector, which is the key sector under examination for this study.

Numerous studies have looked into how different sectors are affected by global shocks (Chiang & Hughen, 2017; Kilian & Park, 2009; Narayan & Sharma, 2014; Nandha & Faff, 2008). Based on the discussions, the study considered three major global shocks that affect economic performance and transmit into global markets. These include oil price shocks, geopolitical risk represented by the Russia-Ukraine war, and COVID-19. To explore the interconnections between these factors, the shocks are modeled together with automobile stocks. This research focuses on the automotive sector, as prior studies have highlighted its particular susceptibility to fluctuations in oil prices and the impacts of the COVID-19 outbreak. Findings from this study will have important practical ramifications for risk control, policy formulation, capital allocation, and portfolio management.

Statement of the Problem

In line with justifications from previous studies, approximately 33% of all primary energy is consumed by the automobile industry which further infer that volatility in oil prices greatly impacts this industry in terms of operational costs and overall profitability. This justifies the need to examine how crude oil specifically influences the automobile industry in a quest to reveal how shocks are transmitted in these markets with the prospect of informing investor decisions. Shocks are transmitted into the automobile sector through three major channels: supply chain disruption, consumer demand fluctuations, and financing and credit breakdown. Supply chain disruptions can significantly impact production timelines and costs. Events like natural disasters, geopolitical conflicts, and global pandemics can halt the flow of essential components and materials. For example, shortages of semiconductors during the COVID-19 outbreak resulted in widespread production delays across many automakers. Also, the Russia-Ukraine war which led to bans against Russia has restricted the supply of oil from Russia to other countries. Such disruptions not only affect current manufacturing but can also lead to long-term changes in sourcing strategies.

Furthermore, financing and credit breakdown is basically about how shocks affect interest rates and credit availability affecting consumers' ability to finance vehicle purchases and impacting manufacturers' ability to invest. The automobile industry relies heavily on financing for both consumers and manufacturers. Changes in credit conditions can significantly impact sales and investments. When interest rates rise, the cost of financing a vehicle increases for consumers. Higher rates can lead to

reduced affordability and lower demand for new vehicles, particularly for higher-priced models. When banks tighten lending rules in response to shocks, it becomes more challenging for customers to secure loans or leases. This can result in a decline in vehicle sales.

Finally, the consumer demand fluctuations serve to translate shocks to the automobile sector. Economic shocks lead to shifts in consumer confidence and purchasing power, directly affecting demand for vehicles. During economic downturns, consumers may delay purchases or opt for used vehicles instead of new ones. Conversely, periods of economic growth can boost demand for new cars, especially for higher-end models. All these mediums connect and in times of global shocks, as we are currently experiencing, they translate and affect the global economy, specifically the automobile sector.

As estimated by OICA, 80 million and 85 million automobiles were produced worldwide in 2021 and 2022 respectively. Global auto sales decreased from the previous year's $75.63 million sales in 2019 to $65.52 million in 2020, the year when COVID-19's effects were felt the most. Nonetheless, after the COVID-19 pandemic, global auto sales increased but significantly decreased after 2021. Sales figures for 2021 indicated a rise to $70.01 million, an improvement over the industry's subpar performance in 2020. In the following year, the automobile sector experienced downturns in its sales operation in 2022, where sales fell by $1.02 million as 68.9 million sales were made globally (OICA, 2022). This downturn has drawn much concern from manufacturers and investors in the sector as this has affected sales negatively.

The Russia-Ukraine conflict is currently very concerning because it is said to have a detrimental effect on household spending, increase uncertainty, disrupt the supply chain, cause unstable stock movements, increase utility costs, discourage investment, and slow down growth in the economy (Chepeliev et al., 2022). Due to the war, there is a shortage of computer chips which has an impact on the auto industry. Both nations produce 30% of the palladium used in cars and cell phones globally, which further exacerbates the issue's effects on the global supply chain (Wiseman, & McHugh, 2022). In addition to the war affecting the Russian economy, the war will also affect the global stock market (Wiseman & McHugh).

Lately, the oil market has been experiencing volatility in prices which has been a major concern for most economies recently, and this has had an immense effect on the financial market (Dasauki et al., 2023). Oil prices become volatile as witnessed in 2022 to date whereas in January 2022 average oil price was 89.52 per barrel and an upward surge was experienced from February with the highest average price of 121.17 per barrel in June and currently 85.29 per barrel (International Energy Agency, 2022).

Much research examined the relationship and impact of such events as an important topic of interest. Many of these studies (Aloui, Hammoudeh, & Nguyen, 2013; Boungou, & Yatié, 2022; Xu, 2021; Huang et al. 2005; Jammazi et al., 2017; Mbah, & Wasum, 2022; Narayan & Sharma, 2011) employed the VECM, VAR, and the GARCH model to analyze the dynamic, time-varying connectivity among prices of oil, wars, and stocks market returns. Although these studies have examined the relationship of these variables, none have addressed the recent global shock, which includes the Russia-Ukraine war, oil price shocks, and the effects on stock markets,

particularly the automobile stock market. This study therefore covers the current global shocks that previous studies did not capture, to unmask the relevant relationship or dynamics that exist between such shocks (Russia and Ukraine war, oil price shocks, COVID-19) and stock performance in the automobile industry.

The correlation between fluctuations in oil prices and stock market performance has been extensively examined in various studies throughout the years (Cai et al., 2017; Mensi, 2019). However, none has considered the individual automobile stocks, but rather these studies considered the broad interaction among the oil price shocks and overall automobile stocks performance. Analyzing market-wide aggregate volatility spillovers has the disadvantage of potentially obscuring crucial information for risk mitigation and allocation of financial resources, hence the study takes into account the individual automobile stocks whose results will be considered more reliable concerning the stock's returns responsiveness to oil prices. This is to say the dynamics existing between the various automobile stocks (electric and gasoline vehicles) and stock markets (NYSE and SSE) will be unmasked.

Furthermore, research on how the continuing crisis between Russia and Ukraine affects stock performance, particularly in the automotive sector is relatively scarce. Russia is recognized as one of the preeminent oil producers worldwide, therefore, a war event involving such a country may affect oil supply, which in the long run may affect automobile stocks due to the oil price shocks that will translate into the various stock markets. This necessitates the assessment of the current war and its impacts on automobile stock performance which is not covered by previous studies.

Finally, this study sets itself apart from previous research by taking into account recent developments in the automotive sector. This includes the advent of electric vehicles and how they respond to global shocks, how the Russia-Ukraine war is affecting the automobile stock performance, and the COVID-19 effect on the various stock markets and individual automobile stocks, which are areas overlooked in prior investigations.

Purpose of the Study

The primary objective of the research is to examine the relationship between stock market returns within the automotive sector and global shocks. These international disruptions encompass the COVID-19 pandemic, the Russia-Ukraine war, and volatility in oil prices.

Research Objectives

1. To examine the co-movement between global oil prices and stock market returns in the automobile sector.
2. To examine the effect of COVID-19 on stock returns in the automobile sector.
3. To examine the relationship between the Russia-Ukraine war and stock market returns in the automobile sector.

Research Hypothesis

In light of the theory and literature, the following alternative hypotheses are raised and tested for this study.

1. H_1: There is a significant co-movement between global oil prices and stock market returns in the automobile sector.

2. H_1: There is a significant effect of COVID-19 on stock market returns in the automobile sector.
3. H_1: There is a significant relationship between the Russia-Ukraine war and stock market returns in the automobile sector.

Significance of the Study

The results of this study will offer vital information regarding the connection between the Russia-Ukraine war, COVID-19, oil prices, and stock performance in the automotive sector. Governments, corporate communities, stock market participants, and the larger academic researchers will all be significantly impacted. Each of the participants will be equipped to leverage the study's diverse conclusions to make informed decisions and sound policies. The study's findings will help the world market economy gain a better grasp of how oil prices and COVID-19 affect the climate for investing and how the Russia-Ukraine war influences stock returns in the automobile sector.

The study's findings will also be useful to investors in helping them monitor and control their portfolios and make critical investing decisions. The research's conclusions will be helpful to governments in terms of setting regulatory and policy priorities. As a result, the study will also be important to the research world because it will add to the body of literature by filling in the gaps that already exist.

Delimitations of the Study

The NYSE and SSE are the considered stock markets from which daily automobile stock prices are sourced. From each stock market considered for the study, four automobile daily stock prices are used, namely Honda, Tesla, Toyota,

and Volkswagen representing stocks from the NYSE and Chongqing, BYD, JAC, and SIAC representing stocks from the SSE.

The global oil prices which are modelled with the automobile stock prices to attain the first objectives of this study are the WTI crude oil prices.

Limitations of the Study

The study applied stock prices of Tesla, Toyota, Volkswagen, Chongqing, BYD, JAC, and SIAC automobiles which are sourced from the NYSE and SSE. Thus, the study is limited in this regard, as it considers only two stock markets where four automobile stock prices are retrieved from each market, thus, leaving out other automobile stocks as well as stock markets that can be studied. This implies that several automobile stock indexes whose operations are highly influenced by these global shocks were not considered in the study.

Additionally, the ability to exercise individual control over the data's quality is limited, given that the study utilized secondary data.

Definition of Terms

The following is a brief explanation of the keywords used in this study:

Global shocks

Refers to any unanticipated incident that significantly and unpredictably affects the world economy.

Stocks market

A stock market is an organized market where shares, stocks, and bonds are traded. It is a set of exchanges where companies issue shares and other securities for trading.

Global oil prices

Global oil prices reflect the price of crude oil on global markets and are impacted by several variables, including supply-demand dynamics, economic circumstances, and geopolitical developments.

Automobile sector

This refers to the sector that is involved in the design, manufacture, marketing, and distribution of motor vehicles, which include automobiles, trucks, and motorbikes.

Stock market returns

This simply refers to the amount of money that was earned or lost on an investment over time.

Organization of the Study

The study is structured into five chapters. The initial chapter provides an overview of the research, addressing the background, problem statement, objectives, hypothesis, significance, and scope and limitations of the study. The second chapter, thus the literature review, provides insight into the topic under investigation by analyzing past works in the field of this research. This comprised the conceptual, theoretical, and the empirical review. Topics including data and data sources, data collection methods, analytical models, and data processing and analysis are discussed in chapter three, which was devoted to research methods. Chapter four provides an in-depth analysis of the research's discoveries and outcomes. The fifth chapter, serving as the final section of the study, captures the study's overarching findings, conclusions, and recommendations. Consequently, the concepts discussed in this study, the findings of the research, and any suggested recommendations are all summarized in this chapter.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter conducts a comprehensive review of pertinent literature to underscore critical issues related to the COVID-19 pandemic, the Russia-Ukraine conflict, the performance of the automotive stock market, and the global oil price shock. It is organized into three principal sections, theoretical, conceptual, and empirical review. The chapter began by going over widely acknowledged theories that are salient to this study. In addition, key ideas regarding the study's subject matter and several empirical studies connected to it are discussed.

Theoretical Review

Numerous theories, hypotheses, and models have been developed to justify the effectiveness of the stock market indicators. For this study, the efficient market hypothesis, the catastrophe theory, the adaptive market hypothesis, and the heterogenous market hypothesis are among the key hypotheses resorted to.

Efficient Market Hypothesis (EMH)

The EMH is employed in this study as a theoretical framework to test how efficient the stock market for automobiles is and, thus how the price of auto automobile stocks adjusts to emerging market information. As the theory suggests, in an efficient market stock prices should quickly adjust to reflect shocks. Hence, delayed reactions may suggest inefficiency. Fama initially proposed the EMH in 1970, stating that stock prices appropriately reflect any relevant information in an efficient securities market (Fama, 1970). The market is said to be efficient when it is not feasible to achieve returns

above the market average. Investors cannot outperform the markets using any financial strategies, including selecting the best assets or utilizing a market timing strategy when market prices accurately represent all pertinent market data in an efficient market (Cheong et al., 2016).

According to the EMH, it is virtually difficult to outperform the stock market because stock prices already account for and represent all important information. Any investor who wants to make stock market investments should be highly aware of this fundamental idea. A diversified portfolio of individual stocks with equivalent risk yields higher returns for investors than one that relies solely on the dissemination of stock price information without conducting a technical and fundamental examination of the information (Malkiel, 2003).

"A market is said to be efficient with respect to an information set if the price fully reflects that information set, that is, if the price would be unaffected by revealing the information set to all market participants" (Sewell, 2011, pg. 12). In general, an efficient market is based on two tenets: investors cannot obtain a risk-weighted excess return in an efficient market, and all accessible information is already factored into stock prices. Fama (1970) asserts that in an efficient market, market competition causes the average stock price to reflect all of the information needed to make investment decisions. This is because new information swiftly circulates through the market and is immediately taken into account when calculating the price of financial assets. Because no one has access to private knowledge that is not widely known to the entire market, no market player has an advantage in predicting stock values, according to the EMH. Fama (1970) stated that financial asset prices must convey all information contained in

the past prices for weak form efficiency to materialize. It implies that no investor can continually make money by looking at past price trends. Thus, Fama's research indicated that it was impossible to predict future price movements.

When we consider market analysis from both a technical and a fundamental perspective, it indicates that elements like the price of oil, worldwide pandemics like COVID-19, and war can affect how stock prices perform. This occurs because the efficient market hypothesis takes into account how other macroeconomic factors affect asset valuations. This hypothesis clarifies the study's first goal, which is to evaluate the correlation between changes in global oil prices and returns on the automobile stock market at various points in time and frequency. The responsiveness of the automobile stocks to shocks or new information is assessed for both markets.

Heterogenous Market Hypothesis (HMH)

The HMH attributable to Müller et al. in 1997, contends that the stock markets are made up of heterogeneous market actors, implying that the same information can be understood distinctly by various market players based on their trading preferences and choices. Simply said, the primary cause of market heterogeneity is the presence of investors with a variety of investment perspectives, the uneven distribution of information in the market which is termed information asymmetry, diverse risk preferences, and regulatory and institutional differences among others.

These HMH principles were subsequently applied by Corsi (2009) to develop the HAR model, which effectively captures the long-memory characteristic within the given time series. Seeking immediate returns, short-term traders typically enter the market based on pertinent information. Conversely, investors with medium- to long-

term horizons, such as portfolio managers at financial institutions and pension funds, assess their holdings on a weekly or monthly basis, maintain longer investment durations, and exert a medium- to long-term influence on the market.

Diverse decision-making units in equity markets lead to different price movements throughout different periods. This discrepancy is mostly due to the variability of decision-making units, especially concerning their beliefs, risk tolerance, and market perspectives. This variation, which behavioral finance refers to as heterogeneity, is usually studied in the framework of HMH in financial literature. The fundamental idea of this hypothesis is that there are variations in the ways that investors behave, especially when it comes to trading on one's behalf and behalf of a particular stock market organization (Kahyaoglu & Kahyaoğlu, 2020). Considering the diversity in investors' reactions to stock behaviour, the response of stock returns to global shocks varies in different stock markets as the various markets consist of distinct participants. Considering that all the objectives for this study aim to achieve results from two different stock markets (NYSE and SSE), to ascertain how both market players respond to shocks the HMH best explains this phenomenon of heterogeneity in the market.

Catastrophe Theory

At times, a system within an economy may respond disproportionately to even a small external disturbance. This study, which looks at changes in the automotive industry due to shocks, demonstrates how catastrophe theory helps pinpoint the critical pressure points in the system where a crisis becomes inevitable. By analyzing the quantitative aspects of the system, and the scale of the system being analyzed, the

essential qualitative understanding necessary for informed decision-making can be derived from both macro and micro perspectives.

René Thom, a French mathematician, propounded the catastrophe theory during the 1960s. However, Christopher Zeeman's work in 1970, helped it gain widespread acceptance. The mathematical concept of catastrophe theory offers intriguing justifications for why seemingly steady relationships exhibit abrupt jumps-discontinuities known as catastrophe. Based on mathematical structure, this theory easily lends itself to applications in economics when issues with unstable links arise (Scott & Sattler, 1983).

In an economy, a system can occasionally become vulnerable to even a minor changing environment, which might cause an excessively large response. Using catastrophe theory, we may specify the key system pressure levels at which a crisis is unavoidable. Subject to the sizes of the examined system, analyzing the quantitative characteristics helps us obtain the qualitative results required for managerial decisions at the micro and macro levels. Small adjustments to a few nonlinear system parameters, according to Scott and Sattler (1983), can cause the equilibrium to emerge or to dissipate, or to switch from an attractive to a rejecting condition, or vice versa, causing the operations of the system to abruptly and substantially change.

The catastrophe theory is a technique for simulating phenomena that change abruptly and in "fits and starts" (Cobb & Watson, 1980). Rapid and sudden shifts in a behavioral variable can be aptly interpreted as the consequence of gradual, ongoing adjustments to one or more control variables. The theory justifies investigating the relationships between and impacts of macroeconomic indicators on the market for

stocks. This theory examines situations where systematically changing components have unexpected effects on other forces, with a particular focus on the interconnections between short and long-run dynamics (Birău, 2013). COVID-19 and global oil price effects on the performance of stocks in the automobile sector are well explained by this theory since the theory holds that some events affect the behaviour of stocks during global shocks.

Adaptive Market Hypothesis (AMH)

AMH combines behavioural finance with the well-known and frequently contentious EMH. The theory was propounded by Andrew Lo (2004) and holds that although most people are rational, they occasionally tend to overreact during times of increased market volatility. According to AMH, people have self-interested motivations and make mistakes that they usually learn from and adapt to.

The AMH, put out by Lo (2004), is a contemporary framework that can assist in explaining the observed temporal change in the level of market efficiency. The Adaptive Markets Hypothesis (AMH) integrates the notion of bounded rationality with the evolutionary framework (Simon, 1955). A rational investor, constrained by limitations, is described as acting satisfactorily rather than striving for an optimal solution. Given the potential costs of optimization, market participants with restricted access to, or proficiency in, information processing are primarily focused on attaining favorable outcomes. Lo (2004) contends that an evolutionary mechanism, encompassing natural selection and trial-and-error processes, produces superior results compared to purely analytical approaches. Natural selection guarantees the survival of

the most effective strategies by regulating both the number and the nature of market participants and their trading tactics.

Market participants devise strategies to guide their investment decisions while adapting to the constantly shifting conditions. The AMH has a significant aspect that returns predictability might occasionally become problematic due to shifting market circumstances. Hence, market efficiency may not fluctuate cyclically, being very context-dependent and dynamic, as predicted by proponents of the EMH, but rather may reflect a secular trend toward increasing efficiency (Lo, 2004). Henceforth, the realization of convergence towards market efficiency is by no means a foregone conclusion, nor is it endowed with a high probability of materializing, contingent upon the composition of market stakeholders and the prevailing market circumstances at that particular juncture. Amid global shocks that translate to stock markets, the reaction of market participants impacts stock prices.

Conceptual Review

Some fundamental concepts underpinning this study have been discussed in this section, taking into consideration the variables employed for the study.

The Global Automobile Sector

The automobile industry represents one of the world's largest industries, producing 60 million vehicles on average each year, which is around 50% of the world's oil use (Statista, 2022). Passenger automobiles constituted the predominant segment of global motor vehicle sales, representing nearly 68.21% of total transactions worldwide. In 2021, China and the United States emerged as the principal markets for this sector, primarily due to the expansive transportation infrastructures in both nations and the

deeply entrenched culture of motorization within American society. The production of automobiles for private, industrial, military, commercial, and emergency services is typically the sole objective of the automotive industry. Diesel, natural gas, gasoline, fuel cell electric cars, electric vehicles, and plug-in hybrid electric vehicles are the main divisions of the automobile market based on the types of cars produced. Despite the global transition to cleaner energy, diesel and gasoline vehicles will still be widely used among individuals at least through the end of the decade (Statista Research Department, 2022).

The global automotive sector has experienced a decline in demand and production disruptions since 2020, attributed to the COVID-19 pandemic and the scarcity of automotive semiconductors. The semiconductor deficit led to a contraction of 11.3 million units in global vehicle production in 2021. Following a downturn during the pandemic, automobile sales began to recover, ultimately reaching 66.7 million units sold worldwide in 2021. The global market for the manufacture of automobiles was projected to be worth $2.9 trillion by Statista (2022). This suggested a decline that happened more quickly than the entire economy's decline, which was a result of the COVID-19 pandemic.

Two top trending subjects in car production are becoming increasingly prevalent on a global scale. As the transportation sector contributes to approximately one-third of global carbon dioxide emissions, adopting electric vehicles has become an essential approach to mitigating environmental damage. In response, automotive companies have increasingly focused on creating advanced, emissions-free electric cars, with continual technological innovations emerging each year (OICA, 2022).

Global oil prices

The global economy depends heavily on crude oil, which is why investors and those who formulate policies are quite interested in tracking changes in the price of oil globally. Oil is one of the commodities with the most volatility, which has a major effect on how the global economy functions as a whole (Arezki et al., 2017). In support, Alekhina and Yoshino (2018) suggested that a shift in oil prices influences global monetary and fiscal policy in addition to contributing to macroeconomic oscillations. Microeconomic factors like production costs, investment choices, industry growth, and decline, as well as macroeconomic factors like inflation, national income levels, overall spending, and the balance of payments of various nations, have all been impacted by increased oil prices.

Brevik and Kind (2004), stated that the mobility of speculators has a smaller but still considerable impact on how much energy prices rise due to supply and demand. This shows that the three main factors driving instability in oil prices are supply, demand, and speculation. Kilian et al. (2009) illustrated through their research that the analysis of the collective impacts of both supply and demand disturbances on the global oil market incorporated a significant portion of contemporary shocks to global aggregate demand.

The accessibility of oil represents the second key determinant influencing oil prices. Efforts to regulate oil inventories and production volumes in a bid to govern both the supply and the associated economic ramifications of energy resources have been undertaken through pacts and collaborations, such as the Organization of Petroleum Exporting Countries (OPEC). The assortment of market participants,

comprising oil corporations, speculators, and refining entities, has precipitated the emergence of fresh market dynamics. Furthermore, the pricing of crude oil exhibits a recurrent susceptibility to global occurrences, encompassing armed conflicts, political disruptions, and comprehensive international embargoes. As an illustrative case, crude oil prices experienced a notable upswing during the conflict between Iraq and Iran, soaring from a modest USD 14 per barrel in 1978 to a considerably higher USD 35 per barrel by 1981, only to undergo a sharp descent to a mere USD 10 per barrel during the tumultuous phase of the Asian financial crisis. A limited energy supply may also result in excessive price volatility and producer dominance, according to Krichene (2006).

According to the insights presented by Brevik and Kind (2004), speculation is the final determinant impacting the fluctuations in oil prices. The presence of tangible limitations in supply, coupled with the looming threat of potential supply disruptions, particularly within the Middle Eastern region, and further compounded by the enormous demand for oil in the burgeoning markets of China and India, as well as the depreciation of the US dollar and the notable surge in worldwide consumption patterns, all appear to emerge as underlying drivers contributing to the escalation in oil prices, as outlined by Eckaus (2008). Eckaus discovered that in addition to demand and supply, speculation and hedging additionally contribute to the erratic swings of oil prices. According to Krichene (2006), when oil prices are highly volatile, there will be a rise in speculative demand for futures contracts, which will enhance volatility and clustering.

Figure. 1 depicts the pattern of WTI global oil prices from 2013 to 2023. The horizontal axis shows years, while the vertical axis represents global oil prices in USD

per barrel. General volatility is observed in the prices over the selected periods. Higher prices were noted in the latter part of 2013 into 2014. Consequently, prices began to drop in the latter period of 2014. Moderate levels of price changes or volatility were experienced from 2015 to the latter part of 2019, but a significant sharp fall in prices was recorded in the early part of 2020 which is connected to the COVID-19 pandemic outbreak. Price started to rise steadily getting to 2021 till the early part of 2022 when a surge in price is experienced. Literature has associated such a hike in prices with the Russia-Ukraine war which started in February 2022. Prices started falling in late 2022 into 2023, however, it has been volatile.

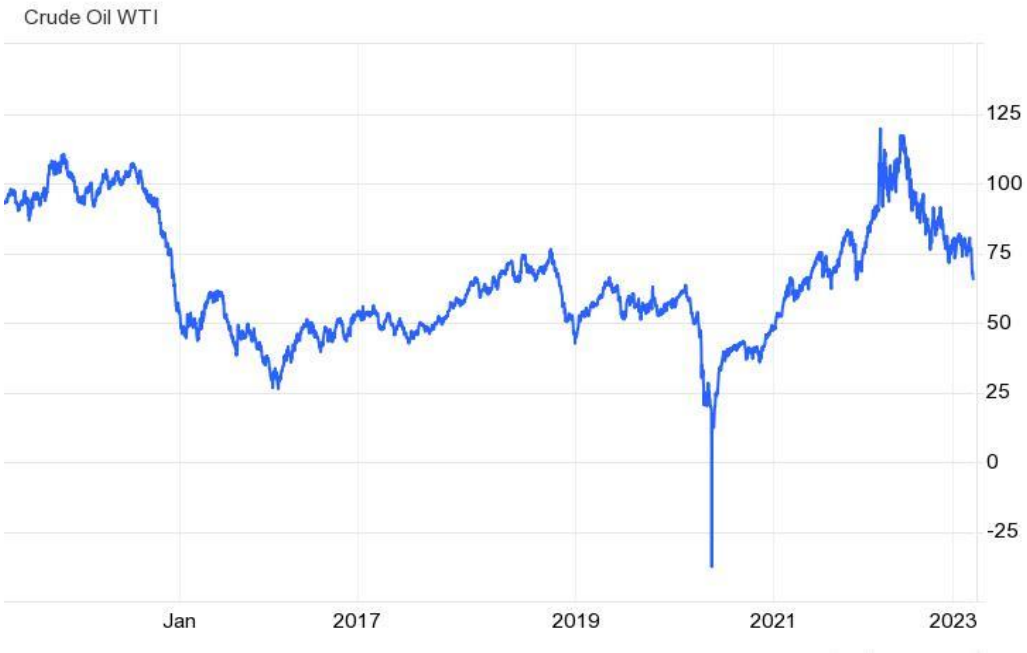


Figure 1: WTI global oil prices
Source: Tradingeconomics.com

Oil price and economic performance

Global oil price effects on economic performance have become a highly debated subject since the 1973 oil price shock, as demonstrated by Alekhina and

Yoshino (2018). According to Timilsina (2013), the world economy is significantly impacted by oil prices. This assertion is reinforced by the World Bank (2019), which emphasizes that variations in oil prices significantly affect economic growth, development, and societal welfare. Direct effects include prices and economic activity, while indirect effects include markets for commodities and commerce, reactions to fiscal and monetary policies, and uncertainty in investments. The growth and development process, particularly in emerging economies, is negatively impacted by higher oil prices because uncertainty is created. Oil price fluctuations can affect economic activities, as empirical research by Sadorsky (1999) demonstrated.

The worldwide crude crisis of 1973 to 1975, which saw a 157.05% rise in oil prices, caused a fall in global economic growth, from 6.57% in 1973 to 0.75% in 1975. Similarly, the world's growth declined by 55.09% in 1980 despite a 49.08% rise in global oil prices. The world market expanded by 4.63% in 1988, at the most rapid rate since 1980, when oil was only worth $14.87 per barrel (Yahoo Finance, 2020). When oil prices started to climb again in 1990, global growth dropped to 2.92%. According to research by Sanchez (2011), from 2002 to 2008, rising oil prices negatively impacted oil-importing countries by 23%.

Rising oil prices reduce production and drive-up inflation in countries that import oil. Additionally, they have a noticeable positive impact on export performance as well as government budget revenue in countries that export oil. Increasing oil prices lead to inflation and possess a negative effect on the productivity of nations that import oil. This suggests that oil importers suffer from increasing oil prices Timilsina (2013). On the other side, countries that export oil see their exports and government budget

income increase. These nations earn significant amounts of foreign currency, and their currencies are strengthening. Higher expenditures on government and exports boost an oil exporter's GDP.

COVID-19 and the global stock market

A rare degree of economic devastation was brought about by the COVID-19 epidemic, which took the entire economy off unexpectedly (Goodell, 2020). COVID-19 generally affected the world's economic pursuits, although its effects are not evenly felt by all sectors of the economy (Guerrieri et al., 2022). While most businesses would experience financial losses as a consequence of the economic fallout, some, such as the pharmaceutical industries, are anticipated to experience financial gains. Several international organizations changed their growth forecasts in light of the COVID-19 epidemic.

The Organization for Economic Cooperation and Development (2020) asserted that the coronavirus pandemic reduced worldwide economic development by 1.5% in 2020. Additionally, the International Labour Organization (ILO) reports that the COVID-19 pandemic has resulted in an additional 25 million jobless individuals globally. Several avenues could be used to spread the pandemic's impacts to stock markets. For instance, the spread of transmissible illnesses reduces economic activity and presents a significant challenge to business profitability and continuity in emergencies like lockdowns (Adda, 2016).

Additionally, an economic and financial shock brought on by a pandemic in one country quickly spreads to others, as a result of a significant degree of market connectedness, globalization, and economic interdependence. The COVID-19

pandemic has dramatically increased market volatility, according to recent research by Jahanshahi et al. (2020), with the degree of instability being related to how serious the outbreak is in each specific country. However, it is asserted that the impact varies by industry, suggesting that some sectors are more affected than others. Wen et al. (2021), discovered that the COVID-19 pandemic caused a dramatic increase in banking sector risks, which spread to other businesses. However, the pandemic affects various industries to diverse degrees, as does the reaction of those industries.

COVID-19 and the automobile sector

Every area of the economy, not only the automobile industry, was severely impacted by COVID-19. The primary, secondary, and tertiary industries are all further harmed by the catastrophic repercussions of circumstances (Nicola et al., 2020). Automobile sector prospects are subject to a great deal of uncertainty. Based on OECD outlook forecasts and an estimated correlation between car sales and GDP growth, it was stated that demand for cars made in Europe stays 8% below its pre-crisis level in 2021, with Europe and Germany still responsible for 67% and 30%, respectively. Since automobile sales are cyclical, the epidemic had long-term negative repercussions on economic growth in the CEE countries' primary trading partners (OECD, 2020).

Due to the automotive industry's extensive integration into global value chains, supply chain disruptions brought on by the epidemic possess a major detrimental effect on the automotive sector. A global shortage of auto parts began in China, prompting suppliers to halt or lockdown their manufacturing facilities. The scarcity of necessary components and the distribution of supplies was also made worse by legal and commercial restrictions, such as closed borders leading to a drop in sales of new cars.

Government-imposed measures to curb the virus, such as curfews, the shutdown of factories, offices, and dealerships, along with the subsequent termination of temporary employees, compounded by the apprehension of an impending recession, led to a decline in sales (Accenture, 2020).

Geopolitical risk and the global economy

In February 2022, the Russia-Ukraine conflict erupted, signifying a significant intensification of the eight-year dispute that commenced with Russia's annexation of Crimea and served as a critical juncture for European security. Numerous news reports have focused on the war due to the significantly negative effect it is expected to have on the world economy. Economic growth has stagnated, and more countries and goods are facing sustained high inflation. The shortage of energy supplies is contributing to rising costs. To curb inflation, interest rates need to be increased, which in turn heightens financial risks. The war is intensifying the threat of food shortages and worsening financial hardships in poorer nations.

The substantial and unparalleled energy upheaval brought on by the Russian-Ukrainian war, which is still fueling rising inflation, weakening optimism among consumers and the purchasing power of households, and raising uncertainties worldwide is anticipated to induce a marked deceleration in the global economy over the forthcoming year (OECD, 2022). The war, according to CBS News report, has led oil prices to rise to an all-time high. The war has exacerbated the dangers of recession and the upturn of the world economy, by causing high levels of uncertainty in the stock market (Boungou & Yatié, 2022). Globally speaking, Russia is significant in the energy sector, and Ukraine is significant in the production of commodities. In light of this, the

war poses a serious risk to the future of the energy and commodity markets, particularly in Europe, which is the area most impacted by it (Xing et al., 2023). Due to the European Union being one of China's major commercial partners, the Russia-Ukraine war has some indirect consequences on the Chinese economy, as conflict can instill anxiety throughout the world and have an impact on investor sentiment (Zhou & Lu, 2023).

Concern over potential global supply disruptions brought on by sanctions against Russia, a major exporter of crude, caused oil prices to decline after high increases. After reaching a peak of $101.98, the April Brent crude futures contract dropped $1.15, or 1.2%, to close at $97.93 a barrel. To reach $94.12 the more active May contract lost $1.30, or 1.4%. After reaching a session high of $95.64, U.S., WTI crude decreased $1.22, or 1.3%, to end at $91.59 per barrel. On Thursday, fueled by the conflict, oil prices surged above $100 per barrel, marking the first such occurrence since 2014. Brent reached a high of $105, but losses were pared before the end of trading (Yahoo Finance, 2022).

Empirical Review

The COVID-19 outbreak, the Russia-Ukraine war, and instability in the price of oil have all caused widespread alarm owing to their alleged effects on the functioning of the world economy. Previous global crises are said to influence returns in the stock market, and some of these researches are reviewed. The majority of studies have been done to look at the connections, effects, and dependencies between these variables, however, different findings have been made from previous studies. The empirical review is carried out in accordance with the objectives of this study.

Oil Prices and Stocks Market Returns in the Automobile Sector.

Firstly, considering studies on the relationship between global oil prices, and sectorial stocks market returns with particular attention to the automobile sector, Narayan and Sharma (2011) examined the interrelationship between oil prices and corporate profitability across 14 industries, their study examined 560 US companies that were listed on the NYSE. All 560 enterprises were subjected to GARCH (1, 1) models using daily time series data from January 5, 2000, to December 31, 2008. Findings showed that a company's return on investment was impacted by oil prices differently based on where it is positioned in the industry. The effects of oil prices are felt by some businesses (not the majority) in the majority of industries for up to eight delays, although the outcomes are variable in terms of direction. Among the firms that experience the persistent effect from shocks in the oil prices is the automobile sector.

In a related study, Nandha and Faff (2008) employed sectorial analysis in conjunction with a standard market model that was strengthened by the inclusion of the oil price element to analyze 35 global industrial indexes across the time frame from April 1983 to September 2005. Per their research results, escalating oil prices exert a significant adverse influence on the returns of all the sectors under the study, except for the oil and gas and mining sectors.

More recently, a comparable country-based analysis was carried out by Caporale et al. (2022). Using data from 2 January 2001 and 22 March 2021, The research explores the consequences of currency exchange rates and the cost of oil on sector-specific stock performance within the BRICS-T nations. In each instance, a benchmark linear model is estimated first, followed by tests for structural breaks by

Bai and Perron (2003). According to the results, all of the BRICS-T nations' energy sectors, with the exception of India, are significantly positively impacted by oil prices, but all nations' industrial sectors, except for Turkey, are negatively affected. Also, it was revealed Brazil, Russia, India, and South Africa's financial sector experienced a negative effect of oil price shocks, with Turkey and India experiencing the same impact in their transportation sector.

By exclusively concentrating on the automotive sector within a shared time-frequency domain, Pal and Mitra (2019) investigated the potential relationship between oil prices and the performance of automobile stocks. Using daily pricing data from August 1, 1996, to June 20, 2017, their study uncovered a substantial association between the two variables. In a more protracted examination, it becomes evident that the correlation becomes more pronounced, and the responsiveness of stock returns to elevated oil prices resulting from demand shocks becomes more apparent. However, as elucidated by Pal et al. (2019), this contradicts the prevailing notion that stock prices in the automotive sector consistently move in a negative direction to crude oil prices.

Cameron and Schnusenberg (2009) used the Fama-French three-factor model to include the oil price variable to investigate the relationship between oil prices and automobile stock prices. A four-factor model was developed as a result of this, which was accomplished by utilizing either the excess return of an energy exchange-traded fund (ETF) or the excess fluctuation in WTI crude oil prices. This analysis covered from 2001 to 2008. Their discoveries unveiled a concurrent decline in automotive stock values with rising oil prices. Also, the recession largely unaffected automobile manufacturers that concentrate on producing passenger automobiles.

Baur and Todorova (2018) also delved into an examination of how automobile stock prices react to changes in oil prices. Their analysis incorporated systematic variables, revealing that the responsiveness of the automotive sector to oil price fluctuations is not fixed but varies across different periods. Prior to the 2008 Global Financial Crisis, the responsiveness of the sector to oil price shifts had been relatively subdued, but it exhibited an increase during and after the crisis. Except for Tesla, all major automakers maintain a diverse range of lightweight and compact vehicles within their product portfolios. Notably, all these manufacturers exhibit negative conditional betas concerning oil prices. From a practical standpoint, this means that when oil prices fall, their stock values tend to rise, whereas when oil prices rise, they tend to fall. Interestingly, Tesla's stock price demonstrates a substantial positive reaction to changes in oil prices. The research by Baur and Todorova underscores that the relationship between conventional and electric vehicles, as influenced by the price of oil, is significantly discernible. Consequently, the study implies that persistent low levels of oil prices, coupled with an expanding market for less fuel-efficient vehicles, might potentially constrain the future growth prospects of electric vehicle producers. This implication, as outlined by Baur and Todorova, extends beyond environmental concerns to encompass a broader impact on the automotive industry.

In a study done in 2022, Wang et al. (2022) looked at the automotive industry in China to see how sales of electric, fuel, and plug-in hybrid electric vehicles react differently to various periods of oil price swings. The quantile-on-quantile regression and wavelet multiscale decomposition techniques were used. When empirical data were analyzed, it became clear that each automotive sector had its unique connection

between oil prices and sales of vehicles, and this relationship varied, with coefficients occasionally showing different directions at particular oil price quantiles and frequencies.

Numerous studies have also explored how global stocks react to changes in worldwide oil prices. To align the study's outcomes with established research, this correlation was examined within our literature review. In a study carried out by Park and Ratti in 2008, they applied a multivariate VAR analysis, taking into account both linear and non-linear assumptions, and evaluated how oil price shocks influenced actual stock returns in the United States and 13 European nations across the years spanning from 1986 to 2005. As revealed by their research outcomes, fluctuations in oil prices occurring either within the same month or over a one-month interval displayed a significant influence on stock returns. Contrary to the patterns observed in most countries under scrutiny, Norway, an oil-exporting nation, recorded a statistically significant upsurge in actual stock returns following oil price shocks.

Using wavelet analysis, Jiang and Yoon (2020), explored the correlation between oil prices and the stock markets of six countries. As revealed by the outcomes of the investigation, there exists a positive connection between oil price movements and stock markets in all six nations, specifically at the D4, D5, and D6 scales. The correlation between oil prices and stock market returns in oil-importing countries exhibited significant co-movement from 2007 to 2012, particularly during the 2008 global financial crisis. Furthermore, from 2007 to 2017, similar analytical approaches revealed a strong association between the oil and stock market returns in oil-exporting nations. Over periods ranging from 16 to 128 weeks, oil price returns outperformed the

stock market returns of Canada, Russia, and Saudi Arabia. The study concluded that oil prices exert a more pronounced influence on stock prices in oil-exporting countries compared to those that are net oil importers.

In 2017, Jammazi et al. (2017) conducted a study focusing on six major oil-importing countries (France, Germany, Italy, Spain, the UK, and the US). They explored the potential existence of fluctuating causal connections between changes in oil prices and fluctuations in stock returns using wavelet analysis. Their findings indicated a substantial mutual causal link between oil prices and stock markets across all these countries, across various time intervals.

Driesprong et al. (2008) assessed oil price effect on the overall stock market returns by utilizing monthly data for 48 industrialized and developing countries from October 1973 to April 2003. For 17 of the 18 developed countries included in the study, they found that the association was negatively significant, however, the majority of the relationships were discovered to be of no statistical significance, despite the fact that the association was still negative and significant for developing countries.

Lin et al. (2014) examined the financial markets and energy costs by investigating the evolving patterns of fluctuation transmission between oil prices and the returns of the Ghanaian stocks market within a multivariate context by employing the GARCH framework for this analysis. To provide a broader West African context, the study also extended its examination to include the Nigerian stock market. The results illustrated a significant interconnection between the understudied variables in both stock markets, accompanied by insignificant spillover volatility effects. Notably, in Ghana, there is a more explicit transfer of volatility from oil to stocks compared to

stock-to-stock transmission, with spillover effects more pronounced in Nigeria. Furthermore, the analysis revealed that contingent volatility escalates more rapidly due to the substantial impacts of preceding volatility rather than previous shocks.

COVID-19 and Stock Market Returns in the Automobile Sector

The impact of the COVID-19 pandemic on stock returns in the automotive sector is another important goal that this study aimed to achieve. Given this, literature in such regard has been looked at. In a groundbreaking study, Wen et al. (2021) conducted a study on the impact of COVID-19 on the electric vehicle industry of China. Analyzing emerging trends provides insights into the potential and limitations facing the growth of electric cars in China. It has been observed that the sales of electric vehicles experienced a temporary decline due to the COVID-19 outbreak. However, this crisis might lead to increased future demand, particularly for larger and more powerful electric models.

The travel restrictions resulting from COVID-19 disrupted the supply of materials for electric vehicles that relied on imports. This disruption prompted the adoption of domestic alternatives and stockpiling of crucial components. The study also points out that the extensive lockdowns implemented to control COVID-19 had a disruptive effect on operations and production. This disruption had the consequence of pushing smaller businesses out of the competitive market, leading to a consolidation of major brands within China's electric vehicle sector. Furthermore, the social distancing trend brought about by the pandemic is challenging the traditional distribution channels of electric vehicle dealers, pushing manufacturers to develop innovative online sales platforms.

Ramelli and Wagner (2020), focusing on the US equity market, explored the repercussions of the COVID-19 pandemic on stock performance. Employing the Capital Asset Pricing Model (CAPM), their analysis revealed that as the pandemic garnered greater attention, the adjusted returns of US firms with operations in China experienced a significant decline from January 20 to February 21, 2020. Moreover, they found that between February 24 and March 20, 2020, the adjusted returns for firms with higher debt levels and lower capitalizations deteriorated even further, exacerbated by growing concerns over the crisis. In a related investigation, Chan and Marsh (2020) analyzed the decline of the Dow Jones Industrial Average (DJIA) from February 21, 2020, to March 31, 2020, comparing it with downturns observed in previous market crashes and pandemics. Their findings revealed that during this period, the DJIA experienced a drop comparable to the one seen during the 1929 Great Depression, yet far more severe than the declines observed during earlier pandemics, such as the 1918 Spanish Flu. The significant downturn in 2020 was primarily attributed to the COVID-19 pandemic and its profound disruptions to global supply chains.

He et al. (2020) employed an event study methodology to assess the impact of the COVID-19 pandemic on the stock prices of key sectors in China. Their findings revealed that the pandemic adversely affected stock prices on the Shanghai Stock Exchange (SSE), particularly within the mining, transportation, electric and heating, and environmental industries. However, manufacturing, information technology, healthcare, and education sectors demonstrated a prompt and effective response to the crisis. The authors concluded that while the pandemic had a detrimental effect on certain SSE stocks, the impact varied significantly depending on the sector.

Rajamohan et al. (2020), investigated the effect of COVID-19 on the Indian stock market, with a focus on the automotive sector. GARCH (1,1) and RSI were applied in analyzing the data employed. The findings indicated that an increase in the number of undervalued stock sales in India had a considerable impact on the chosen sectoral index. According to the study, the return on the vehicle industry index was poor, hence, it may be established that COVID-19 had a detrimental impact on India's automobile sector over the study period. Ozili and Arun (2020) posited that the scope of economic activities was profoundly influenced by decisions regarding monetary policy, the duration of lockdown measures, and limitations imposed on international travel.

Eldem et al. (2022) also researched to ascertain COVID-19's effect on Turkish automotive manufacturers' supply chains and propose a framework for enhancing operational processes to thrive in an uncertain environment. The research meticulously examined the repercussions of the pandemic on the case study company, detailing the challenges it encountered throughout the crisis. Data for both qualitative and quantitative analyses were gathered through a diagnostic survey and semi-structured interviews. The results revealed that the pandemic severely disrupted the automotive sector, driven by several factors such as shortages of raw materials and spare parts, limited access to labor and transportation, fluctuations in demand, increased absenteeism due to illness, and the introduction of new health and safety protocols.

In a distinct study, Xu (2021) utilized data from the United States and Canada to scrutinize the interplay between market returns and the COVID-19 pandemic. The research applied a bivariate structural GARCH and VAR model to investigate how

stock returns respond dynamically to unexpected fluctuations in the incidence of COVID-19 cases and the accompanying volatility. By analyzing daily data from both nations, the study revealed that stock markets were predominantly negatively influenced by an escalation in the number of COVID-19 cases. Additionally, there was asymmetry in how Canadian market returns responded to changes in the number of cases, which was indicative of the pandemic's detrimental effects. Additionally, the study discovered that although uncertainty had a negative influence on the United States stock market, this effect was rather mild.

Geopolitical Risk and Stock Market Returns in the Automobile Sector.

Geopolitical risks, threats, and uncertainties are well known to impact negatively on the international economy and the process of deciding oil prices (Mitsas et al., 2022). Pisani-Ferry (2022) asserted that the 2022 Russia-Ukraine war raised the cost of oil and gas, which in turn raised the price of gasoline worldwide. Due to the negative supply shock brought on by an increase in gas and oil prices, energy independence policies, the influx of migrants, and increased defense spending, the war will have a significant effect on the European Union's and its members' economic policies.

Liu et al. (2023) explored the ramifications of the Russia-Ukraine conflict on the sales of new energy vehicles in China and its subsequent influence on the energy composition within the country’s automotive industry. Their analysis, based on sales data from March 2016 to August 2022, employed the Chow test and Ordinary Least Squares (OLS) techniques to evaluate the impact. The findings showed that China's new energy vehicle sales structurally and suddenly increased in response to the Russia-

Ukraine crisis, which positively impacted the nation's automotive energy system. Secondly, plug-in hybrid electric vehicle sales are not as severely impacted as those of battery-powered vehicles because they can run on gasoline and electricity. Thirdly, the relative price shift between oil and electricity is primarily responsible for the boosting effect. Finally, the positive impact accelerates China's transition in the automotive energy and transportation sector, facilitating the nation's early progress towards achieving its dual carbon objectives. In summary, the study demonstrates that the Russia-Ukraine conflict has been advantageous for China's automotive energy transition.

In the study conducted by Agyei in 2023, an investigation was carried out into the imbalanced relationship between geopolitical risk and the stock market of the top seven emerging countries, known as the E7 nations. Utilizing daily data spanning from January 1, 2022, to July 25, 2022, the research employed the WCPD and SWC methods. The findings revealed distinct lead-lag patterns and market-specific coherence, showcasing variations in how geopolitical risk impacts the pricing of stocks in the E7 countries. These findings demonstrated how crucial it is to diversify assets or asset classes to reduce geopolitical risk shocks during continuous conflicts.

Boungou and Yatié (2022) analyzed stock return data from 94 countries between January 22 and March 24, 2022, to investigate the influence of the Russia-Ukraine conflict on global equity market performance. Their analysis indicated that the conflict had a substantial adverse impact on stock returns worldwide. While tensions between Ukraine and Russia had persisted for some time, the issue escalated significantly when Russia initiated its invasion. However, in the subsequent weeks

following the invasion, the global stock markets exhibited less favorable responses. Additionally, it was observed that the stock market indices of countries sharing borders with Russia and Ukraine, as well as those of United Nations member states that called for an end to the Russian incursion in Ukraine, experienced poor performance.

Using international statistics and data from the Euro Area, Ozili (2022) investigated the economic impact of the Russia and Ukraine conflict on a worldwide scale during the month of the invasion. Several significant tendencies were revealed by their findings. As the global Purchasing Managers' Index (PMI) ascended, food prices concurrently surged. In the month subsequent to the invasion, the manufacturing PMI for the Euro Area deteriorated. Moreover, it was disclosed that the transportation sector within the consumer price index had risen from the preceding month, largely due to energy and fuel scarcities, which precipitated an increase in gasoline prices across the Euro Area. Relative to both Russia and the broader Eurozone, Ukraine endured a disproportionately more severe impact from the invasion. During the invasion period, a notable relationship was observed between core consumer prices in Ukraine and the Eurozone. At the same time, food inflation rates displayed a marked correlation between Russia and the Euro Area. As a result, a substantial and positive linkage was evident among the global food price index, global oil price index, global dairy price index, and global cereal price index throughout this period.

Several studies have undertaken empirical examinations of the financial implications associated with armed conflicts. For instance, Koubi (2005) observed how war affects the economic development of a wide range of nations using data spanning the period from 1960 to 1989. The analysis unearthed a consistent link between the

existence and character of conflicts and the disparities in economic growth across nations. The study revealed that both the intensity and duration of conflicts exhibited positive correlations with economic performance in the post-war period. However, it was also observed that the advantages of growth exhibited an inverse relationship with the level of economic advancement within a nation. Similarly, in a related context, Kang and Meernik (2005) identified that wars exert adverse effects on economic fundamentals. Furthermore, their research highlighted that the manner in which nations respond to civil wars has a substantial influence on their subsequent economic growth.

Hoffmann and Neuenkirch (2017) explored the effect of the pro-Russian uprising on stock market returns in Russia and Ukraine during the period from November 2013 to September 2014. Using an online search for conflict-related news, they developed four new indicators to assess the level of escalation. Their analysis revealed that an intensification of the conflict negatively impacted stock returns in both countries. Specifically, Russian stock returns could decrease by as much as 21 basis points (bps), while Ukrainian returns could drop by up to 30 bps following a one percentage point increase in escalation.

Simeunovic (2016) analyzed data spanning from October 1960 to September 2015 to examine the influence of the Iraq War on stock returns within the US financial markets. The research primarily concentrated on the quarterly fluctuations in the Dow Jones Industrial Average index. The findings indicated that the conflict had a positive effect on the quarterly returns of the Dow Jones Industrial Average. They also discovered that companies that produce military products have lower stock volatility as a result of defense spending.

Federle et al. (2022) contended that significant geopolitical events precipitate widespread global consequences. Their analysis of the reaction of the stock market to the Russia and Ukraine conflict revealed a pronounced "proximity penalty" effect, wherein neighbouring nations situated near Ukraine experienced an anomalous 23.1% drop in equity indices within a mere four weeks following the onset of the war. This finding suggests that countries geographically proximate to a warring nation often endure substantial economic repercussions during times of war.

The numerous empirical research that was reviewed produced a range of findings. COVID-19, the Russia and Ukraine war, the price of oil globally, and stock returns have been found to have significant positive links for the distinctive paired variables and in some studies, weak positive relationships are observed. Different findings are reported by various researchers. This range of results and conclusions results from variations in the research methodology, the variables used, and the time frame.

Research Gaps

Among the numerous studies reviewed, it is noted that some studies have been conducted to examine the relationship and impact of such events (oil price shocks, war, and COVID-19) on stock performance. Many of these studies (Aloui et al., 2013; Boungou, & Yatié, 2022; Xu, 2021; Huang et al., 2005; Jammazi, Ferrer et al., 2017; Mbah, & Wasum, 2022; Narayan & Sharma, 2011) employed the Vector Error Correction Model (VECM), the Vector Autoregression (VAR) model, and the Generalized Autoregressive Conditional Heteroskedastic (GARCH) model to study the dynamic, time-varying connectivity among prices of oil, Russia-Ukraine war, and

stocks market returns. Although these studies have explored the dynamics of these variables, none covers the recent global shock, thus the Russia and Ukraine war, oil price shocks, and impact on the stock market, specifically the automobile stock market.

This study, therefore covers the current global shocks which previous studies did not capture, to unmask the relevant relationship or dynamics that exist between such shocks (Russia and Ukraine war, oil price shocks) and the stock performance in the automobile sector. Wavelet analysis is a technique employed to assess the co-movement between oil price shocks and automobile stock returns, integrating information from both the time and frequency domains, to allow for the simultaneous evaluation of the co-movement at various frequencies over time.

Moreover, although empirical studies have examined the connection between oil price shocks and the performance of automobile stocks over time, the overall relationship between oil price fluctuations and the collective performance of the automobile sector has garnered more focus than the performance of individual automobile stocks. Meanwhile, analyzing market-wide aggregate volatility spillovers has the disadvantage of potentially obscuring crucial information required for risk management and capital allocation, hence the study considers the individual automobile stocks whose results will be considered more reliable concerning the stock returns responsiveness to oil prices. This is to say the dynamics existing between the various automobile stocks (electric and gasoline vehicles) and stock markets NYSE and SSE will be unmasked.

Furthermore, the existing literature examining the effect of the ongoing Russia-Ukraine war on stock performance, especially in the automotive industry, is relatively

scarce. Considering Russia is among the top producers of oil globally, war events involving such a country may affect oil supply, which in the long run may affect automobile stocks due to the oil price shocks that will translate into the various stock markets. This necessitates the assessment of the current war and its impacts on automobile stock performance which is not covered by previous studies.

Finally, this study sets itself apart from previous research by taking into account recent developments in the automotive sector. This includes the advent of electric vehicles and how they respond to global shocks, how the Russia and Ukraine war is affecting the automobile stock performance, and the COVID-19 effect on the various stock markets and individual automobile stocks, which are areas overlooked in prior investigations.

Chapter Summary

This chapter looked at the studies relating to the relationship among stock market performance, global oil prices, COVID-19, and the Russia-Ukraine war. The chapter commenced by pointing out relevant theories and hypotheses that support this study. Underlying concepts and empirical works were further reviewed to throw light on the direction and focus of the previous studies. Based on the literature reviewed, gaps concerning the study period, the stock markets under study, variables left out, and the methodologies deployed are noted which this study will fill by factoring all these gaps.

CHAPTER THREE

RESEARCH METHODS

Introduction

The method used for the study is presented in this chapter. The chapter commences with an exploration of the research paradigm, research approach, and research design. Following that, it covers the process of collecting and handling data, detailing the model specifications, the estimation approach employed, and finally, the analytical tools utilized for the research.

Research Paradigm

The positivist paradigm is employed for the study. The positivist paradigm's theorists argue that this paradigm entails analyzing a societal phenomenon that is observable and deriving inferences and broader generalizations (Cooper & Schindler, 2008). Positivists evaluate the validity, reliability, generalizability, precision, and objectivity of quantitative investigations to define, forecast, and confirm empirical correlations in comparatively controlled environments (Johnson & Onwuegbuzie, 2004). By quantifying social phenomena and elucidating how various factors relate to one another, positivism enables researchers to analyze social processes objectively (Patton, 1975). Moreover, positivist philosophy adapts itself well to the creation of mathematical models that explore the connection between quantitative measures. This paradigm is used because quantitative methods are employed to objectively assess the relationship between the variables being investigated.

Research Design

The study employs an explanatory research methodology. To identify the true reasons for a phenomenon, an explanatory study builds on descriptive and exploratory research. It aims to define causes and motivations and provides information that can be utilized to support or refute a theory or prediction. The objective of this research design is to explore a specific condition or issue, to clarify the connections between different variables, or to determine if one event can be attributed as the causal factor of another, as outlined by Creswell (2003). It is done to find and record links between different parts of the phenomenon being studied.

The research goals as indicated in the preceding section are to examine the link between the study variables (Russia-Ukraine war, global oil prices, COVID-19, and automobile stocks market returns) and any causal relationship that exists among them. The study derives statistical and quantitative findings to reach these goals and further aims to offer explanations for the observed correlation. As a result, the appropriate study design is undoubtedly one that provides explanations for both the how and why parts of the problem under study. To tackle the problems and inquiries posed by this study, the selection of a research design should align with the study's objectives, as emphasized by Crotty (1998). Therefore, in pursuit of the study's primary objectives, the explanatory design stands out as the most suitable research approach.

Research Approach

A quantitative research approach is used for the study. This methodology prioritizes the acquisition of exact measurements, the computational analysis of pre-existing data through advanced statistical techniques, and the statistical, mathematical,

or numerical evaluation of information derived from surveys, polls, and various research instruments. The central objective of quantitative research is the collection of numerical data, which is then utilized to gain insights into a specific phenomenon or to generalize findings to broader populations.

This method has the advantage of articulating the study topic in very specific words, removing or limiting subjectivity of judgment, and steadily adhering to the initial set of research aims, leading to more objective conclusions (Saunders & Townsend, 2016). While attempting to explain, forecast, or regulate occurrences, the quantitative approach is utilized to address concerns relating to connections among measured variables (Saunders et al., 2010). Thus, the study used a quantitative technique to quantify the variables for this study and look at their relationships.

Data Sources and Description

The research examined the connection between global shocks (oil price shocks, COVID-19, Russia-Ukraine war) and stock market returns in the automobile sector. The research utilizes daily WTI crude oil prices for which data was sourced from Yahoo Finance, and the automobile stocks market data covering the same time frame (January 2013 to December 2022). This is an attempt to achieve objective 1 of the study. The selection of the research periods is driven by the aim to encompass both the economic downturn and the issue of energy at their current levels. This would make it easier to spot any fluctuations in the co-movement's strength during a time of crisis. To assess the various subsectors of the automobile industry, Tesla, Toyota, Volkswagen, Honda, Chongqing, BYD, JAC, and SAIC, are the automobile stock prices sourced from both the NYSE and the SSE. These represent electric vehicles and those that run on gasoline.

The second objective of this study is to investigate the impact of COVID-19 on the stock market returns in the automobile sector. The COVID-19 daily data used for the study was obtained from the World Health Organization (WHO) website, covering January 1, 2020, to December 31, 2021.

Finally, the study examines the relationship between the Russia-Ukraine war and stock market returns in the automobile sector. The data representing the war, as used in achieving this objective is retrieved from EquityRT and is based on the daily GPR index computed by Caldara and Lacoviello (2022). The data period covers February 2022 to December 2022 which represents the period for the start of the war and the current available data.

Models Specification

The study adopted the Wavelet Coherence Analysis (WCA) to examine the co-movement among the global prices of oil and the automotive industry stocks market returns, which is objective 1 of this study. The wavelet analysis is thought to be the most appropriate for achieving this objective since it offers vital information about potential dependencies on various scales. Since wavelet analysis uses time-series spectral bands as a function of time to extract information for both the frequency and time dimensions, it is a more useful tool than other conventional techniques. It is a useful analytical method because economic decision-making time horizons and the strength of correlations between variables are both subject to frequent and long-term changes (Ramsey, 2002).

Wavelet coherence analysis is unique in that it can break down time series data into a time-frequency domain. This unique approach enables it to capture fluctuations

between different frequencies and identify localized events over time, enabling the differentiation of long and short-term phenomena. Wavelet analysis is fundamentally built upon two key components: time or location (μ) and frequency (ν), which are presented as follows:

$$\psi_{\mu,\nu}(t) = \sqrt{\nu}^{-1}\psi(t-\mu)(\nu^{-1}), \psi(\cdot) \in L^2(R) \quad (1)$$

Here $\sqrt{\nu}^{-1}$ represents the normalization constant, ensuring that the wavelet $|| \psi_{\mu,\nu}(t) ||^2$ has a unit variance, with the location factor indicating the precise position of the wavelet coherence, and ν denotes the scale dilation factor, characterizing the expansion of the wavelet. The evaluation of a specific wavelet $\psi(.)$ in relation to the time series $\chi(t) \in L^2(R)$ results in the wavelet transform $W_x(\mu,\nu)$ expressed as:

$$W_x(\mu,\nu) = \int_{-\infty}^{\infty} \chi(t)\sqrt{\nu}^{-1}\psi * \left(\frac{t-\mu}{s}\right) dt \quad (2)$$

Continuous wavelet transformations' capacity to break down and then rebuild as a time series $\chi(t) \in L^2(R)$ is considered one of its fundamental features, expressed as:

$$\chi(t) = \frac{1}{c_\psi}\int_0^{\infty}\left[\int_0^{\infty} W_X(\mu,\nu)\psi_{\mu,\nu}(t)d\gamma\right]\frac{d\nu}{V^2}, V > 0 \quad (3)$$

Wavelet Transform Coherence (WTC)

The bivariate structure called WC assesses the connection existing among two time series variables. The Cross Wavelet Transform (CWT) and Cross Wavelet Power

(CWP) are specified first to provide an acceptable description of WC. This two-time sequence $\chi(t)$ and $y(t)$ can explain the CWT as:

$$W_{xy}(\mu,\nu) = W_x(\mu,\nu)W_y^*(\mu,\nu) \quad (4)$$

where the WTI oil price is represented by $x(t)$ and $y(t)$ is the automobile stock returns, with $W_x(\mu,\nu)$ and $W_y^*(\mu,\nu)$ showing successive transformations. In line with the aforementioned equation, while ν denotes the scale, and μ denotes the position index. Where the complex conjugate is indicated by *.

The WTC is a well-known measure of the coherence of a wavelet transform, which is the squared absolute value of a wavelet cross-spectrum normalization to a single spectrum of wavelet power (Torrence & Compo, 1998). Consequently, the squared wavelet coefficient is defined as:

$$R^2(\mu,\nu) = \frac{|V(\nu^{-1}W_{xy}(\mu,\nu)|^2}{V(\nu^{-1}|W_x(\mu,\nu)|^2)V(\nu^{-1}|W_y(\mu,\nu)|^2)} \quad (5)$$

The smoothing parameter V regulates the trade-off between significance and resolution, with $0 \leq R^2(\mu,\nu) \leq 1$. A strong co-movement between the variables is indicated when the value approaches 1, while a weak or absent relationship is suggested when the value nears 0.

Wavelet Transform Coherence Phase Difference

Inconsistencies in the observed time series' fluctuation are shown by the wavelet transform coherence phase difference. As outlined by Torrence and Compo (1998), the phase difference between $x(t)$ and $y(t)$, is described as follows:

$$\Omega_{xy}(\mu,\nu) = tan^{-1}\left(\frac{\Im\{V(\nu^{-1}W_{xy}(\mu,\nu)\}}{\Re\{V(\nu^{-1}W_{xy}(\mu,\nu)\}}\right);\ \Omega_{xy} \in [-\pi,\pi] \qquad (6)$$

Here, the symbols $\Im$ and $\Re$ represent the imaginary and real operators, respectively. Directional arrows are utilized in the wavelet coherence map to indicate phase relationships within the WC disparity. When $x(t)$ and $y(t)$ are in-phase or out-of-phase, the arrow points to the right or left; if it points downward or upward, it signifies that $y(t)$ (or $x(t)$ is leading (Asafo-Adjei et al., 2020; Frimpong et al. 2021).

Diks and Panchenko Non-linear Causality Test

Evaluating the effect of COVID-19 on stock returns in the automobile industry is the second goal of this study. In this instance, the Diks and Panchenko (2006) non-linear causality test was utilized, even though the Granger causality test is frequently utilized in numerous investigations. The goal of the Granger causality test is to ascertain whether information from one time series can improve the accuracy of predicting another time series, both now and in the future. However, it may have some drawbacks since the economic cycle, technical advancement, the oil crisis, industrial reorganization, and other things can readily alter it (Nadal et al., 2017; Bouri et al., 2017). The stock market performance and oil price may have a significant, nonlinear relationship that changes over time, as a result, this work utilizes the nonparametric test approach to investigate such a relationship.

Non-parametric T_n (a test statistic) was suggested by Diks and Panchenko (2006) to examine the possibility of a non-linear causal link among variables. Moreover, the non-parametric testing approach inherently adjusts for changes in the conditional distribution through bandwidth control, preventing the issue of excessive

rejection during the evaluation process. This results in a more reliable and robust conclusion. The core principle of the non-parametric T_n test method is described below. Considering the two delay vector matrices, $X_t^{l_x}$, which represents the global COVID-19 index, and $Y_t^{l_y}$ which reflects car stock returns, under the null hypothesis of no causal connection, previous values $X_t^{l_x}$ provide no meaningful insight into $Y_t^{l_y}$.

$$H_0 = Y(t+1) \left| \left(X_t^{l_x};\ Y_t^{l_y} \right) \sim Y(t+1) \right| Y_t^{l_y} \tag{7}$$

Let $W_t = (X_t^{l_x},\ Y_t^{l_y},\ Z_t)$, where $Z_t = Y_{t+1}$. Equation (7) implies that the distribution of $(X_t^{l_x},\ Y_t^{l_y},\ Z_t)$ will remain unchanged, so it is assumed that $L_x = L_y = 1$ and eliminate the time subscript. When (X, Y) = (x, y), the conditional distribution of Z is identical to the conditional distribution of Z given Y = y, according to the null hypothesis (Peng, Chen, Wei, & Yu, 2020). The joint probability density function can be used to rephrase the null hypothesis in equation (7) in terms of the ratios between joint distributions, and its marginal distribution needs to follow the underlying connection:

$$\frac{f_{X,Y,Z(x,y,z)}}{f_Y(y)} = \frac{f_{X,Y}(x,y)}{f_Y(y)} \times \frac{f_{Y,Z}(y,z)}{f_Y(y)} \tag{8}$$

The real hypothesis H_0 according to Diks and Panchenko (2006), denotes the following relationship:

$$q = E\left[f_{X,Y,Z(x,y,z)} f_y(y) - f_{X,Y}(x,y) f_{Y,Z}(y,z) \right] = 0 \tag{9}$$

Then the local density estimator of a $d_w - variate$ random vector W at W_i can be presented as:

$$\hat{f}_w(w_i) = (2_{\varepsilon_n})^{-d} w \,/(n-1) \sum_{JJ \neq i} I_{ij}^w \qquad (10)$$

Based on the computed value of the local density function, an additional test statistic for non-linear Granger causality can be derived, where the bandwidth $\mathcal{E}_n$ is contingent on the sample size n, and the indicator function is expressed as $I_{ij}^w =$ $\mathrm{I}(\left|\left|-w_j\right|\right| < \mathcal{E}_n)$:

$$T_n(\mathcal{E}_n) = \frac{n-1}{n(n-2)} \sum_i (\hat{f}_{X,Y,Z}(X_i Y_i Z_i)\hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i, Y_i)\hat{f}_{Y,Z}(Y_i, Z_i) \qquad (11)$$

Quantile Regression Model

To achieve objective 3 of the study, which examines the connections between the Russian-Ukrainian war and stock market performance in the automotive industry, the Quantile Regression (QR) technique is applied. Koenker and Bassett (1978) introduced the QR approach, which serves as an expansion of the conventional Ordinary Least Squares (OLS) regression technique.

Unlike OLS, which imposes limitations on the scope of data analysis, QR, as noted by Mensi, Hammoudeh et al. (2014), offers a more extensive range for data analysis. For instance, in traditional OLS, the conditional mean of the dependent variable represents the average connection between the dependent variable and the different independent variables. However, according to Mosteller and Tukey (1977), standard OLS results partially explain the relationship between the dependent and

independent variable(s). This is accomplished by simulating the correlation between one or more independent variables and specific quantiles of the dependent variable.

Generally speaking, the QR approach can be employed to handle skewness, heterogeneity within the regressand, non-normal errors, and the existence of outliers in the data set (Zhu et al., 2016). The method allows for the varied impacts of independent variables at various points along the dependent variable's distribution. The model can be briefly elucidated as follows:

$$Y_t = X_t^i \beta + \varepsilon_t \tag{12}$$

Where Y_t is the dependent variable in this case the automobile stock returns, X_t^i is the vector of explanatory variables which is constant, β is the coefficient, and ε_t is the error term.

The approach of the OLS is to estimate the mean. Let the conditional mean of Y be $\mu(x) = X\beta$,

$$\min_{\mu \epsilon R} \sum_{t=1}^{n} (Y_t - \mu)^2 \tag{13}$$

That is:

$$\min_{\beta \epsilon R^p} \sum_{t=1}^{n} (Y_t - X_t^i \beta)^2 \tag{14}$$

The median function can be estimated by solving equation (14). The quantile variables for other quantiles can be defined using τ. One way to express the conditional quantile function is:

$$Q_y(\tau|X) = X^i\beta(\tau) \quad (15)$$

Where $Q_y(\tau|X)$ is the conditional quantile of the dependent variable y thus, automobile stock returns at quantile level τ. X represents the independent variable thus COVID-19.

The value of $\beta(\tau)$ measures how each independent variable affects the specified quantile of the dependent variable. To estimate the conditional quantile functions, the following equation must be solved:

$$\min_{\beta \epsilon R^p} \sum_{t-1}^{n} Pt(Y_T - X_T^i\beta) \quad (16)$$

Minimizing the following equation:

$$\min_{\beta}[\tau \sum Y_t \geq \hat{\beta}X_t|Y_t - \hat{\beta}X_t| + (1-\tau)\sum Y_t < \hat{\beta}X_t|Y_t - \hat{\beta}X_t|] \quad (17)$$

Where $\hat{\beta}X_t$ is an approximation of the τ^{th} conditional quantile of Y. $\hat{\beta}X_t$ characterizes the behaviour of Y at the left or right tail of the conditional distribution.

Data Processing and Analysis

Daily calculations of stock price returns were performed, and the entire dataset was cleaned using the Microsoft Excel application to remove all unobserved data. Data was further processed using R statistical software to compute the wavelet and quantile regression results for the study. The Diks and Panchenko non-linear causality test was also employed in processing data to arrive at the second objective of this study. The study used daily returns:

$$r_t = \ln ƥ_t - \ln ƥ_{t-1} \quad (18)$$

where $ƥ_t$ and $ƥ_{t-1}$ represent the current and historical indexes and prices, respectively, and r_t represents the continuously increased return. Daily frequency data were employed in the study because they permit a large number of observations, which enables more thorough and in-depth insights (Bouri et al., 2021).

Chapter Summary

This chapter addresses the study's methodology and techniques. It specifies that the study adopts the positivism paradigm, explanatory approach, and quantitative design for the entire research. The data and data sources, as well as the variables used, are well discussed. It ends by specifying the models and techniques that are used in arriving at the objectives of the study

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This investigation evaluates the interplay between international shocks and equity market returns within the automotive sector. This chapter outlines the results extracted from the data analysis, along with a discussion of the outcomes of the chosen models that were employed. Results from the wavelet analysis, Diks and Panchenko (2006) causality test, and the quantile regression analysis, which were employed in arriving at the study's objectives are presented, coupled with a detailed discussion.

Descriptive Statistics

The summary statistics for variables incorporated in this analysis are presented in Table 1. These are the automobile stock returns (Honda, Toyota, Tesla, Volkswagen, Chongqing, JAC, BYD, SAIC) and WTI crude oil prices. The table illustrates the results for the summary statistics, encompassing the mean, standard deviation, skewness, kurtosis, normality, and stationarity, among others, aimed at facilitating the adoption of an appropriate model and assessing stationarity along with structural breaks.

Table 1: Descriptive Statistics for the Stock Returns

	Mean	SD	SKW	KTS	Norm.W*	LBQ	ADF with Trend	ZVA (t-test)	Break date
HONDA	-0.0001	0.0150	0.0001	4.0983	0.9609	21.731**	-35.821***	-29.329**	20-04-2020
TOYOTA	0.0002	0.0135	-0.0087	3.7533	0.9632	30.491***	-35.659***	-29.631**	22-05-2015
TESLA	0.0016	0.0359	0.0060	5.0126	0.9346	13.086	-34.426***	-28.298**	15-04-2020
VOLKSWAGEN	-0.0001	0.0230	-0.1124	13.231	0.9032	33.040***	-36.421***	-29.497**	17-04-2020
BYD	0.0011	0.0305	0.3006	2.5973	0.9548	30.956***	-35.852***	-30.276**	30-10-2019
JAC	0.0003	0.0327	0.1784	1.9909	0.9545	30.961***	-35.139***	-28.203**	24-05-2021
CHONGQING	0.0006	0.0294	0.2817	2.3580	0.9518	19.054	-34.901***	-30.025**	24-05-2021
SAIC	0.0001	0.0209	0.1115	3.2224	0.9566	18.429	-37.636***	-30.479**	01-12-2014
WTI	0.0002	0.0284	0.1038	24.676	0.8255	50.227***	-35.621***	-32.410**	15-05-2020

Note: Levels of significance [***, **, *] suggest significance at 1%, 5%, and 10% respectively.
Source: Author's construct (2023)

Results as depicted in Table 1, reveal that, except for Honda and Volkswagen, most markets exhibit positive mean returns. In terms of variations, the average deviations surpass the mean returns, indicating heightened market instability. Skewness tends towards right-sidedness predominantly, with some instances of left-skewness, indicating an asymmetric distribution. Excess kurtosis highlights the peaked nature of distribution, confirming non-normality in market dynamics, consistent with normality test outcomes. Autocorrelation levels were evaluated within each dataset, with few exceptions, affirming autocorrelations in most returns. Additionally, Zivot and Andrew (1992) and augmented Dicky-Fuller unit root tests, considering structural breakpoints, were employed to assess stationarity, revealing adherence to stationarity constraints with structural breaks observed across all series. However, employing a dynamic model in the context of WCA precludes dissecting the dataset to capture these breaks, as discussed by Woode et al. (2024).

Trend Analysis

Figures 2a, and 2b respectively present the return series of the sample crude oil, NYSE automotive equities, and SSE equities. The rationale was to identify the prevailing patterns in oil prices and automobile stock returns throughout the duration of the analysis, which will further enhance relative inference to be drawn from the various markets.

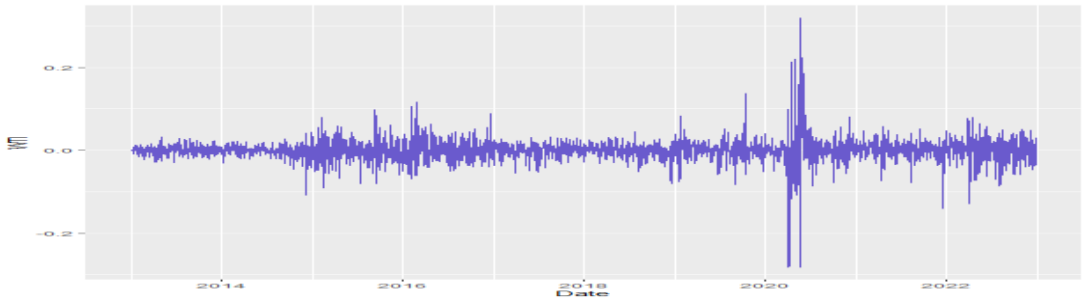


Figure 2a: Returns series plot of WTI crude oil prices.
Source: Author's construct (2023)

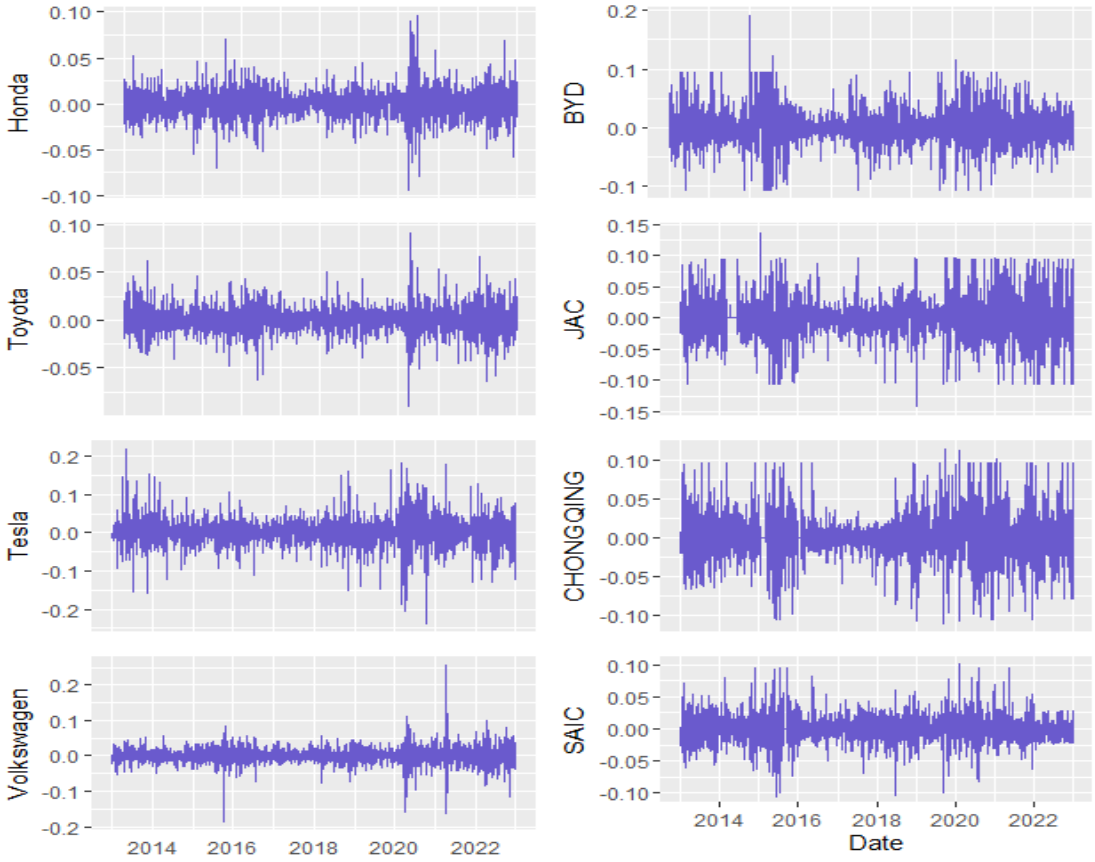


Figure 2b. Returns series plot of NYSE and SSE automobile Stocks.

Source Author's construct (2023)

From Figure 2a, contrary to the price series which mostly exhibits a series of incessant upward and downward spirals, those of the return series in the case of WTI exhibited stationarity across all periods with the difference being a single structural break observed during 2020. This breakpoint is not surprising since the recent global health crisis affected all markets with the crude oil markets even largely affected given the supply shocks due to several transport-based restrictions imposed by numerous economies in a quest to control the virus from spreading (Liu et al., 2020). Thus, the observed breakpoint indicated a sharp simultaneous increase and decrease during the period which validates these assertions. The period characterised by the political polarisation between Russia and Ukraine further exhibited minor breaks yet the effect was not as severe as those of the coronavirus.

The visualisations highlighted on the left side of Figure 1b represent the return series of equities traded on the NYSE which include Honda, Toyota, Tesla, and Volkswagen. Similar to the pattern observed in the case of WTI, those of all automotive equities mentioned above exhibit a mixture of upward and downward series despite the observed stationarity. Nevertheless, the case of Volkswagen equity returns was found to follow a diverse pattern with somewhat stability despite the observed volatility clustering during the COVID-19 crisis (2020-2022) and Brexit (2016) era. Also, the volatility is found to be extreme during the pandemic and polarisation period given the reported contributions of these crises towards increasing global shocks.

Those of the automotive equities traded on the SSE which are on the right side of Figure 1b, followed a similar pattern with the only variations exhibited during the early periods preceding the European banking crisis (2013-2014). Nevertheless, the

periods of health crisis and conflict possessed a similar pattern of clustering while SSE was found to exhibit a higher volatility compared to the NYSE. Subject to the sporadic disruptions observed exclusively among the sample markets, there is a need to assess.

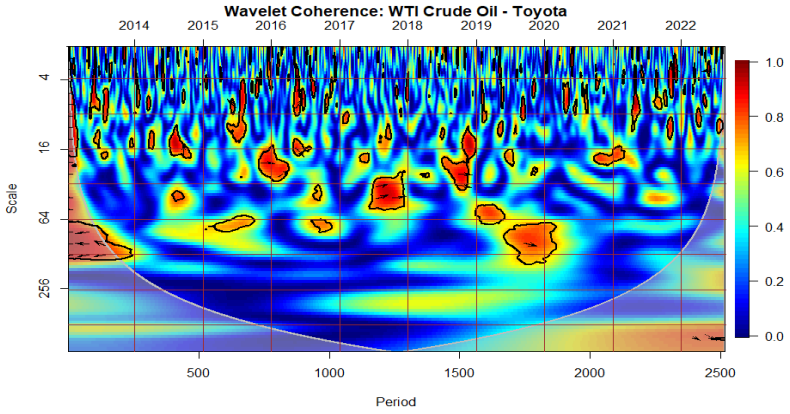
Results

Research Objective 1: To examine the co-movement between oil prices and stock market returns in the automobile sector.

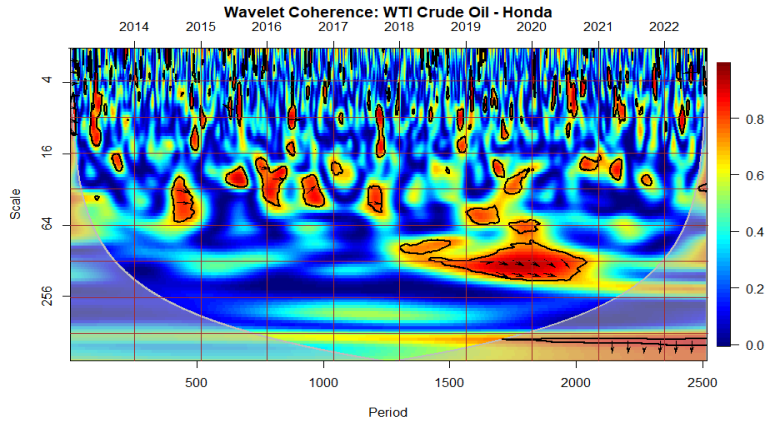
Analyzing the correlation between global oil prices and stock returns within the automotive sector, a wavelet analysis of the daily returns of eight automobile stocks along with WTI crude oil price was carried out, and results are displayed in Figures 3 and 4. The wavelet coherence analysis results in Figure 3, represent the co-movement between global oil prices and automobile stock returns from the NYSE. Also, Figure 4 presents the results for the co-movements between oil prices and automobile stock returns sourced from the SSE. This is purposely carried out to compare the co-movement in the two markets.

The cone of influence, which denotes the point at which wavelet power decreases, is represented by the white curve in Figures 3 and 4. Higher scales on the visualization indicate lower frequencies, whereas the horizontal axis represents time and the vertical axis denotes frequency. The degree of correlation between the oil price and the related auto stock is shown by the wavelet coherence. Colder colors, depicted as blue, signify a weaker connection between the series, whereas warmer colors, shown as red, indicate significant correlation areas. Whether the matched series are in phase or out of phase is shown by the arrows' direction, along with any lead/lag phase relationships between the variables under examination.

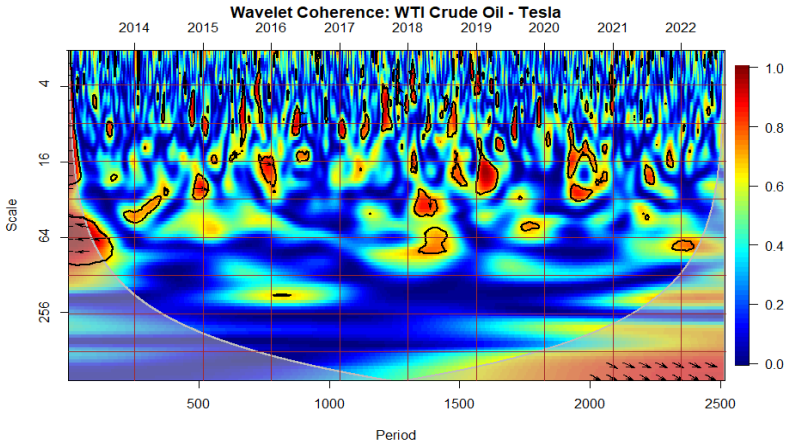
a.



b.



c.



d.

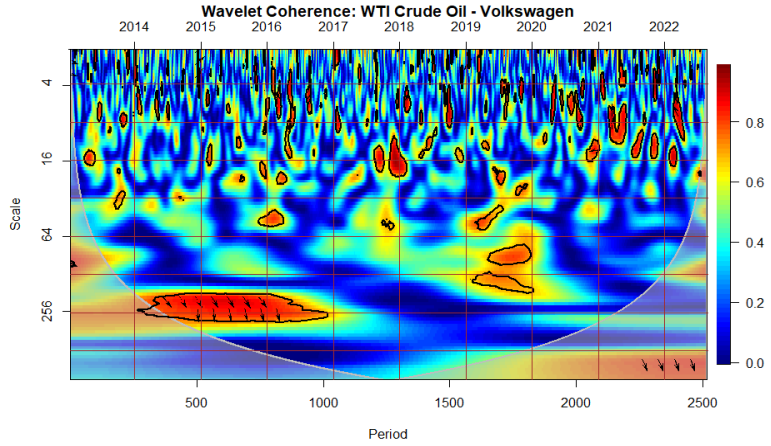


Figure 3. Co-movement between Crude oil (WTI) prices and automobile stock returns from the NYSE.
Source: Author's construct (2023)

The first plot labeled (a) above, specifically focuses on WTI crude oil and Toyota automobile equity co-movement. The analysis revealed a notable and significant nexus between oil returns and Toyota's returns, particularly at 64 days and beyond (representing low-frequency movements) during 2013. The direction of the arrows indicates that both series are out of phase. However, the predictive capacity between these asset classes becomes indeterminate. Subsequently, the nexus between these variables weakens starting from the beginning of 2014 and continues through the early periods of 2017. However, in the medium- to long-term of 2017, an in-phase nexus and a lead-lag dynamic emerged between these paired variables. During this particular period, it was observed that WTI crude oil led the fluctuations in Toyota's stock returns at a middle frequency. The right-oriented arrows suggest a positive integration between crude oil and Toyota's automobile returns.

The latter part of 2018 also revealed an out-phase coherence between the variables at the medium frequency, approximately between the scales of 16 and 64, with no precise predictiveness. These findings are consistent with that of Arouri et al. (2012), which examined the transmission of shocks from crude oil prices to the equities of the Europe 600 vehicles and components index but failed to uncover evidence of such cross-volatility spillover with only cross-asset integration observed. It is crucial to highlight that the risk management strategies employed within the automotive industry could be responsible for the absence of cross-volatility. For instance, Pal and Mitra (2019) underscored that the management of this industry acknowledges the sensitive nature of their market to oil-related shocks and therefore employs robust risk management strategies as a safeguard

against these potential shocks. Contrary to the consistent level of coherence observed in the pre-health crisis era, the period characterised by heightened global health crises and polarisations (2020–2022) rather recorded a blend of moderate and weak levels of coherence, which infers that the nexus between Toyota vehicles and crude oil fluctuations is not driven by turmoil. This implies that during periods of crisis, investors in the automobile industry can rather fall on equities from Toyota in a quest to mitigate against oil-related shocks. Nevertheless, it is relevant to acknowledge that this luxury is time-varying and therefore must be considered within the limits of time.

The results of the horizon- and frequency-dependent pairwise integration between crude oil and Honda automobile stock are depicted in the second visualization of Figure 3 labelled (b). The display of red (warm) colours in specific segments of the illustrations connotes a robust integration between the sample assets. Throughout the study periods, the WTI crude oil-Honda pair's findings showed a combination of strong, moderate, and weak levels of integration. The levels of coherence between crude oil returns and those of Honda automobile returns were found to be completely feeble over the early years of the study period (2013–mid-2014). In the latter months of 2014, an in-phase direction was observed at a relatively medium-term (approximately scale 64) with an indeterminate predictive capacity. A similar observation was made across the short and medium terms (scale 4-64) in the period preceding the global health crisis. Nevertheless, between 2016 and 2017, at approximately scale 32–64, the crude oil market was found to drive those of Honda with a positive nexus shared. The crude oil-Honda integration found a consistently heightened degree of coherence during the early

periods of the global health crisis (2019–2020). Even though the visualization highlighted a moderate level of integration in the short and very medium terms (4–32 scales), those in the very long term were marred with near-perfect adverse levels of coherence given the out-phase directional arrows.

The out-phase arrows indicate that, contrary to the revelations regarding Toyota, which observed a positive nexus, crude oil moved in the opposite direction with Honda, which infers a dual implication for market participants. In one vein, the out-phase arrow indicates that investors seeking to diversify their portfolios to avoid losses, especially during periods of crisis, can do so by merging crude oil and Honda. Thus, the negative relationship between these assets shows that in a single portfolio, these assets will hardly face simultaneous depletion since their returns move inversely. On the other hand, the direction of the arrow further demonstrates that crude oil-related shocks rather drive Honda equities negatively. This suggests that, in times of crisis, adverse shocks in the crude oil market will have a similar influence on Honda equities.

It is relevant to acknowledge that the weak and moderate levels of integration observed between the returns of Honda and crude oil during the short and medium terms of the COVID-19 era indicate the prospect of a safe haven, even though these luxuries are not sustaining given the consistent variations in the level of coherence. The above revelations can be explored by short-term speculators since their investment horizons permit such a diversification strategy. Nevertheless, the heightened integration observed in the very long term further infers that long-term investors in the Honda markets are at a loss since all approaches will not materialize during such an era. In one vein, combining crude

oil with Honda equities will not provide the necessary diversification benefit since these variables share a strong level of integration. However, fluctuations in the crude oil market tend to adversely influence Honda equities. It can be presupposed that the best alternative for such investors will be to avoid such an option altogether, especially during periods of heightened chaos in the crude oil markets.

In light of these heightened integrations, Pal and Mitra (2019) further asserted that contrary to common belief, the equity values within the automotive sector do not consistently exhibit an inverse relationship with crude oil prices. This assertion stems from the findings of their research, which reveal fluctuating correlations throughout the study's duration. Specifically, their findings regarding variational coherence across the period of crisis (2021–2022) align with the current study, with crude oil leading at lower frequencies.

The results of the horizon- and frequency-dependent pairwise integration between crude oil and Tesla automobile stock returns are depicted in the third visualization of Figure 3 labelled (c). The inconsistent display of red (warm) colours in a few segments of the illustrations, approximately at 8–64 scales across all periods, connotes a robust integration between the crude oil and Tesla automobile equities, while the period marred with numerous blue colours depicts weak integration. The general observation within the Tesla-crude oil integration can be concluded as a moderate level of integration with few levels of significance, indicating that the volatility in crude oil prices has less impact on Tesla's stock returns. In a similar investigation, Cameron and Schulenburg (2009) also identified a limited connection between the returns on European automotive stocks and crude oil prices. They attributed this to European regulations as well as the development

of fuel-efficient cars. Practically, Tesla being an electric vehicle is, according to the literature, less prone to oil price fluctuations, which corroborates the weak integration recorded. The period preceding the global health crisis (2013–2018) saw a blend of weak (scale 4, 64–256), moderate (scale 32–64), and patchy strong (scale 8–16) correlations between the paired variables. Nevertheless, the period lacks predictiveness with flat-edged arrows. This indicates that despite the presence of a few integrations, the level is not enough to expose Tesla automobile equities to the shocks from the crude oil markets.

Contrary to the above observation, the period, 2019-2021, which is notable for the COVID-19 crisis, recorded strong coherence, with the exception being the short and medium terms of mid-2021 and 2022. It is relevant to acknowledge that the entire long-term (128–256) integration between Tesla and crude oil can be characterised as feeble, which contradicts the observations in the case of Toyota. The long-term, poor correlation that was noted indicates that investors with a long-term investment horizon can diversify their portfolios across all periods by merging crude oil and Tesla automobile stocks.

The long-term weak integration in the normal period (2013–2018) indicates that investments in Tesla can act as a hedge against crude oil-based shocks, while those related to the period marred by crises (2019–2022) reveal the safe haven prospect of Tesla equities. On the other hand, the weak integration further indicates that, in the very long term, Tesla automobile equities are not influenced by shocks in the crude oil sector. Contrary to the inconsistent safe haven prospect observed in the case of Honda, it is relevant to acknowledge that those related to Tesla are sustaining since this weak integration was persistent across the very long term.

This luxury can be explored by long-term speculators since their investment horizons permit such a diversification strategy. Nevertheless, the observance of heightened integration in the very short and medium term further infers that speculators with such horizons in the Tesla markets are partially at a loss despite the indeterminate levels of predictiveness.

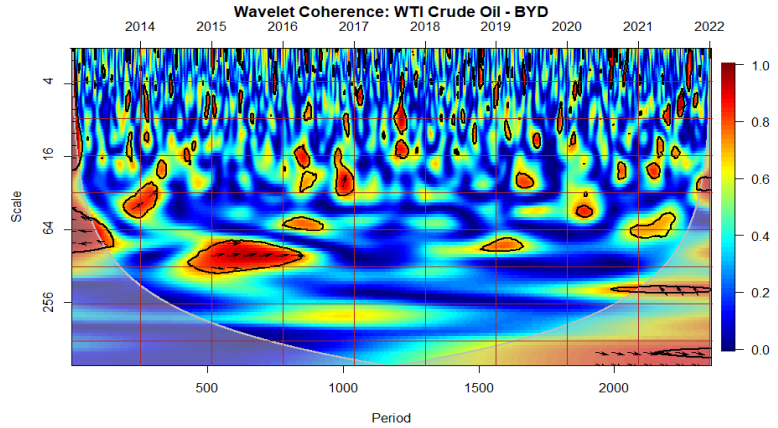
The pairwise integration between crude oil and Volkswagen automobile stock returns is depicted in the fourth visualization of Figure 3 labelled (d). The consistent display of yellowish and the few red colorizations observed across the sample periods, respectively, indicate moderate and strong correlations, while the period marred with numerous blue colours depicts weak integration. Similar to the previously paired variable, an inconsistently strong coherence was observed during the very short and medium terms (4–16) of the time frame before COVID-19. The medium-to-long term (32-128 scales) observed mild connection, while the very long term (approximately 256 scales) further revealed a near-perfect coherence. The rightward-down arrows on the 256 scales confirm that Volkswagen returns were leading crude oil returns over the period. Contrary to the above observation, the short-term (approximately 4–16 scales) period characterised by the health crisis (2020–2021) and political polarisation (2022) recorded strong coherence, with few exceptions observed in early 2022 prior to the Russia–Ukraine conflicts.

The heightened integration infers that the Volkswagen-crude oil integration is mostly driven by global shocks, with geopolitical conflicts being at the height of these crises. This revelation affirms the findings of (Caporale et al., 2022; Ftiti et al., 2016; Jola-Sanchez & Serpa, 2021; Khudaykulova et al., 2022; Hamdi et al., 2019) investigations on the influence of conflicts on the equity markets as well as

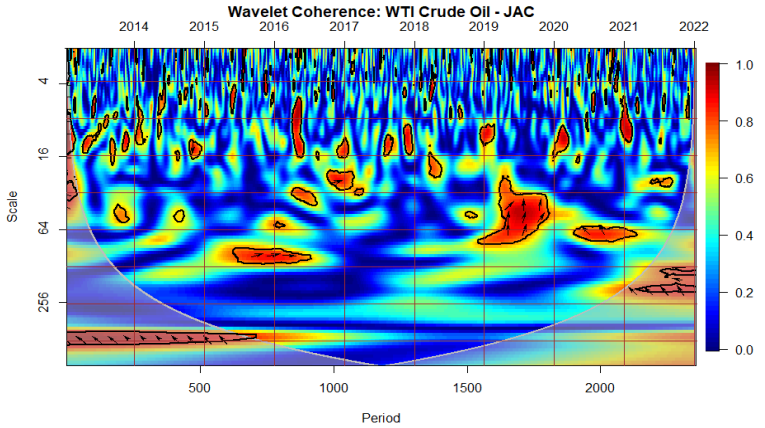
those related to the automotive industry. The moderate level of coherence observed across scales 32-128 from 2013–2020 further indicates the lack of diversification across these periods since the prospect of such luxury is limited by the consistent variations in the levels of integration. However, the medium- and long-term weak integration seen in the 2020–2022 period indicates that Volkswagen auto stocks are not impacted by shocks in the crude oil industry and can serve as a safe haven in times of crisis. Similar to the case of Tesla, these luxuries are also sustainable despite being limited to only the crisis era.

Figure 4 below presents the wavelet coherence analysis results between the WTI crude oil prices and automobile stock traded on the SSE. These automobile stocks include BYD, JAC, Chongqing, and SAIC automobiles.

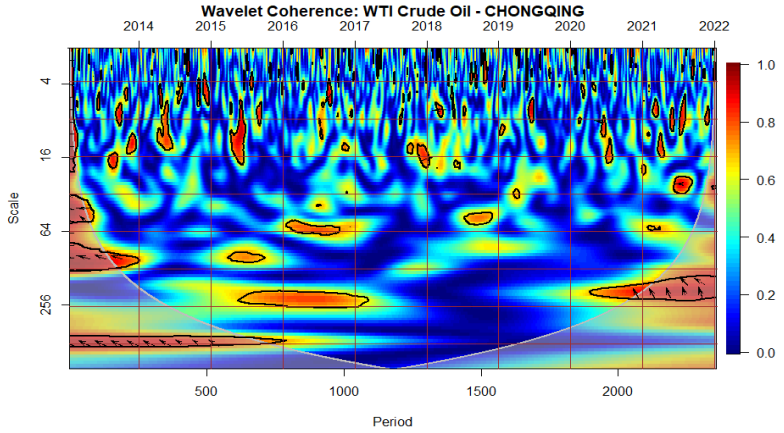
a.



b.



c.



d.

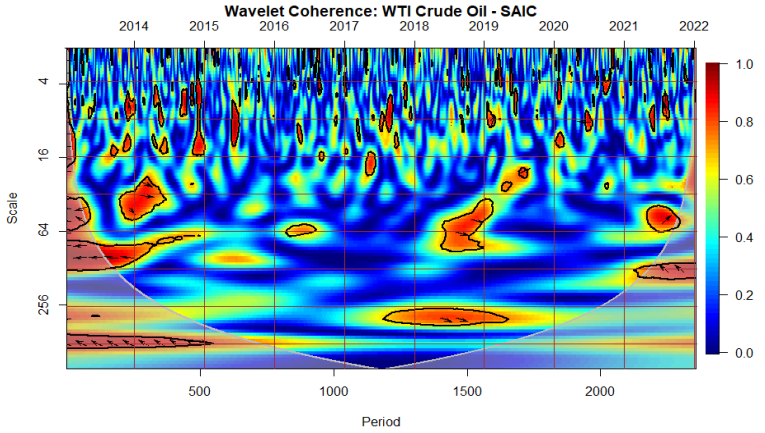


Figure 4. Wavelet analysis: Crude oil (WTI) prices and automobile stock returns from the Shanghai Stock Exchange(SSE). Sourced: Author's construct (2023

The pairwise integration between crude oil and BYD automobile stock returns is depicted in the first visualization of Figure 4 labelled (a). The consistent display of bluish, yellowish, and inconsistent red colorization observed, especially during the medium and long terms of periods, respectively, indicate weak, moderate, and strong correlations. A weak to moderate coherence is noted during the short and medium terms of the early years of the study period, ranging from 2013 to 2016. This is similar to the latter part of 2020–2022. However, the long-term of the same period observed a near-perfect integration between BYD and crude oil, which suggests that the strength of the BYD-crude oil integration is dependent on the investment horizon, with the very long-term characterizing a stout integration. The right-upward arrows exhibited across the normal periods (2013–2016) indicate a positive nexus between the paired assets. This infers that in one sense, crude oil drives the BYD automobile returns, while in another vein, it reflects the simultaneous changes in their values. Comparatively, the period preceding the notable crisis can be considered to possess heightened integration, while those of the crisis era rather demonstrate a frail level of integration with weak and moderate coherence. This indicates that BYD-crude oil integration is not crisis-driven.

It is relevant to acknowledge that the very long-term (128–256) integration between BYD and crude oil can be characterised as feeble, which corroborates the case of Tesla. This further affirms that investors with a long-term investment horizon can diversify their portfolios across all periods by merging crude oil, BYD, and Tesla automobile stocks since they both share weak integration. The long-term weak integration in the normal period (2013–2018) indicates that investments in

BYD can act as a hedge against crude oil-based shocks, while those related to the crisis period (2019–2022) reveal the safe haven prospect of BYD equities. On the other hand, the weak integration further indicates that, in the very long term, BYD automobile equities are not impacted by shocks in the crude oil sector. Contrary to the inconsistent safe haven prospect observed in the cases of Honda and Volkswagen, it is relevant to acknowledge that those related to BYD, similar to Tesla, are sustaining since their observed weak integration was persistent.

The pairwise integration between WTI crude oil and JAC automobile stock returns is depicted in the second visualization of Figure 4 labelled (b). The consistent display of bluish, yellowish, and inconsistent red colorization observed, especially during the medium and long terms of the periods, respectively, indicates weak, moderate, and strong correlations. Similar to the case of BYD, a blend of moderate, weak, and strong coherence is recorded across the sample period, with the levels shared across the horizons. For instance, the very short-term (approximately scale 4) period preceding the health crisis and conflicts (2013–2018) recorded a very weak coherence with minor exceptions. Contrary to the short-term, the medium terms (8–32) scales further observed a consistent moderate with inconsistently strong integration between the paired sample with a right-upward arrow. The pairing was discovered to be in phase throughout the sample period, with crude oil leading JAC automobile equities. This further demonstrates a simultaneous movement between the value of JAC and that of crude oil. Thus, a rise in the value of WTI crude oil will initiate a simultaneous increase in JAC automobile equities. Crude oil prices predominated in the intermediate-frequency

range in 2019, and a positive link was found between the returns of WTI crude oil prices and the stock returns of JAC Automotive. However, an out-phase coherence is recorded between the pair variables in the years 2021–2022, with the price returns of JAC automobiles leading crude oil price returns.

The out-phase arrows indicate that contrary to the earlier revelations where a positive nexus was observed, crude oil moves in the opposite direction with JAC, which infers a dual implication for market participants. In one vein, the out-phase arrow indicates that investors seeking to diversify their portfolios to avoid losses, especially during periods of crisis, can do so by merging crude oil and JAC. Thus, the negative relationship between these assets shows that in a single portfolio, these assets will hardly face simultaneous depletion since their returns inversely correlate. On the other hand, the direction of the arrow further demonstrates that crude oil-related shocks rather drive JAC equities negatively. This suggests that, in times of turmoil, adverse shocks in the crude oil market will have a similar influence on JAC equities. Nevertheless, this trait cannot be deemed exhaustive since most of the periods observed positive coherence. It is relevant to acknowledge that the weak levels of integration observed between the returns of JAC and crude oil during the very long terms of all the sample periods demonstrate a hedge (2013–2018) and safe haven (2019–2022) prospect. Nevertheless, the heightened integration observed in the short and medium terms infers the absence of such a luxury since fluctuations in the crude oil market tend to adversely influence JAC equities during such periods. It can be presupposed that the best alternative for such

investors will be to avoid such an option altogether, especially during the early days of periods characterised by heightened chaos.

The time- and frequency-dependent pairwise correlation between crude oil and Chongqing automobile stock returns is depicted in the third visualization of Figure 4 labelled (c). The majority of the observed coherence can be deemed feeble given the numerous bluish colorizations with few yellowish (moderate) and red (strong) integrations. The level of integration can be characterised as one with limited predictiveness, given the few observed arrows. The period between 2013 and 2015 recorded an out-of-phase coherence in the very short term, which infers an adverse relationship between Chongqing automobiles and crude oil returns. A similar pattern is detected in the period spanning from 2020 to 2022. Similar to the above observation, the global health crisis period (2019–2021) recorded weak coherence with minor inconsistent strong coherence, especially across the medium terms.

The blended weak and strong integration across the sample period is a signal that investors cannot rely on these dynamics, with this swift shifting pattern indicating the non-sustaining nature of any diversification prospects that investors will seek to depend on. It is relevant to acknowledge that investors seeking to diversify their portfolios with Chongqing equities should trade with caution since such luxury seems to be sustained only during the very long term (128–26) of the period between 2018 and 2022. The varying nature of the integration between Chongqing further affirms the heterogeneous nature of the investment horizon as well as the adaptive nature of the market participants. The inconsistent

diversification prospects in the case of Chongqing corroborate those of Honda, indicating the non-sustaining nature of such luxuries.

The time- and frequency-dependent pairwise correlation between crude oil and SAIC stock returns is depicted in the fourth visualization of Figure 4 labelled (d). Similar to the case of the JAC, the wavelet between SAIC automobile stock returns and WTI crude oil returns exhibit a significant co-movement at high, medium, and low frequencies. The consistent display of bluish, yellowish, and inconsistent red colorization observed across all periods, respectively, indicates weak, moderate, and strong correlations. Similar to the case of JAC, a blend of moderate, weak, and strong coherence is recorded across the sample period, with the levels shared across the horizons. For instance, the very short-term (approximately scale 4) period preceding the health crisis and conflicts (2013–2018) recorded a very weak coherence with minor exceptions. Contrary to the short-term, the medium-term (8–16) scales of the period between 2013 and 2018, except for 2016, further observed an inconsistent blend of strong and moderate integration between the paired sample, with a flat arrow indicating the indeterminate nature of the integrations. A similar finding was observed during the crisis period (2020–2022), which indicates that the crude oil-SAIC integration is not conditioned by the crisis. The most notable coherence between 2014 and 2015 was observed at approximately 64–128 scales, while those of the crisis era were recorded at both 64 and 256 scales. There was an observed in phase in the majority of the visualisations, with a minor exception. This demonstrates a simultaneous movement between the value of SAIC and crude oil. The implication is that a rise

in the value of crude oil will initiate a simultaneous increase in SAIC automobile equities. The minor out-phase arrows observed during the long term of 2019 indicate that, contrary to the earlier revelations where a positive nexus was observed, crude oil moved in the opposite direction with SAIC, which infers several implications for market participants, as highlighted in the case of JAC.

The combined weak, medium, and strong connection for crude oil and SAIC during the data period, similar to those of JAC, signals a possible threat in terms of diversification given the consistent shifting dynamics. Thus, the shifting pattern indicates that any prospect of diversification (hedge or safe haven) cannot be deemed sustaining. Also, the fact that the level of coherence between the sample pairs in both the period preceding the crisis and those with a crisis indicates that these levels of integration are not conditional and should be considered as such.

Non-linear causal relationship between WTI crude oil prices and automobile stock returns.

Given the inherent limitations in the WCA regarding lack of access to actual coefficients and the need to provide robust tests to mitigate these limitations, the study further examined the causal nexus between the WTI and the sample automobile equities via the Diks and Panchenko (2006) nonlinear causality test. To overcome the heterogeneous traits of the co-movement as established in the WCA, we also decomposed the data using the variational decomposition mode. The results of the causal nexus across the short, medium, and long-term are respectively presented in panels A, B, and C of Table 2. The null hypothesis in this analysis posits that there are no nonlinear causal relationships, while the alternative hypothesis suggests the presence of such relationships.

Table 2. Summary results for Diks and Panchenko causality test across the short, medium, and long term

Co-movements	Short-term		Medium-term		Long-term	
	$\chi \rightarrow \gamma$	$\gamma \rightarrow \chi$	$\chi \rightarrow \gamma$	$\gamma \rightarrow \chi$	$\chi \rightarrow \gamma$	$\gamma \rightarrow \chi$
WTI↔Honda	2.317**	3.367***	1.998**	0.867	3.084***	1.546*
WTI↔Toyota	1.949**	2.000**	2.272**	1.597*	3.349***	-0.102
WTI↔Tesla	1.093	1.766**	0.891	1.671*	0.615	-0.350
WTI↔Volkswagen	1.260	2.859***	2.093**	2.608***	2.595***	3.767***
WTI↔BYD	1.458	1.883**	0.481	-0.995	0.139	1.755**
WTI↔JAC	1.458*	1.883**	-0.186	1.229	0.139	0.124
WTI↔CHONGQING	1.297*	0.995	1.133	0.679	-0.548	0.658
WTI↔SAIC	0.149	0.009	0.797	0.123	0.551	-0.047

Note: The test is bidirectional; $\chi \rightarrow \gamma$ represent WTI Granger-causes variable automobile equities, and $\gamma \rightarrow \chi$ demonstrates that the automobile equity variable Granger-causes variable WTI respectively. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.
Source: Author's construct (2023)

The results from panel A revealed a blend of bi-and-unidirectional causal nexus between the automobile equities during the short-term with the only exception found in the case of WTI and SAIC where none of the directional causality was found to be significant. For instance, the paired causal nexus between WTI and automobile equities (Honda, Toyota, and JAC) shows a bidirectional effect with both markets having a causal effect on each other with a 5% significance level used to reject the null hypothesis, which asserted that there was no causal relationship. In the case of Saudi Arabia, the study by Arouri and Rault (2012), which looked at the causative correlation between crude oil prices and stock prices in the GCC countries, shows evidence of a bidirectional causal relationship, which is consistent with the findings of this investigation. The causality between WTI and Tesla, Volkswagen, and BYD, on the other hand, was found to be unidirectional. The bidirectional results found in Tesla's case validate the findings of Baur and

Todorova (2018) regarding the favourable influence of oil price variations on Tesla equities. This suggests that surging oil prices influence the equity markets of Tesla vehicles favorably while falling oil prices have the opposite effect. However, it is noteworthy that Volkswagen appears to influence oil prices, similar to the causality observed between oil prices and Tesla in the preceding result. Additionally, as demonstrated by the WCA, the SSE instance implies that oil prices have little effect on auto stocks, particularly in the near period. Moreover, the null hypothesis is accepted for both the Chongqing and SAIC automobile stocks, demonstrating that changes in oil prices have a significant impact on the stock market performance of both companies. Conversely, the returns on the SAIC and Chongqing automotive stocks do not exert a substantial influence on oil prices.

The results of the causal nexus for the medium-term as highlighted on the second panel further follow a somewhat similar trend with slight variations. Similar to the results of the short-term, a significant causal nexus is identified between crude oil and Honda, implying that oil prices impact Honda's equity returns across varying periods as established in the WCA. The majority of the unidirectional causal nexus as well as the non-significant nexus validates those of the WCA regarding the numerous nondirectional co-movements observed. The causal nexus between WTI and SSE equities (BYD, JAC, CHONGQING, and SAIC) was found to be insignificant which corroborates the earlier submission regarding the weak influence that WTI has on these equities, especially in the medium term. The results of the long-term causal nexus presented in panel C of Table 2 revealed a similar trend. Accordingly, WTI and NYSE equities (Honda and Volkswagen) was found

to be significant and bidirectional while those between WTI, Toyota, and BYD were unidirectional. Similar to the medium-term results regarding WTI and SSE equities (JAC, CHONGQING, and SAIC) further showing the lack of causal nexus. Regarding the equities from SSE, it was determined that there was no causal relationship. Generally, the outcomes of the causality test validate those of the WCA with a blend of significant and insignificant causal nexus across varying periods. Furthermore, the analysis uncovered a stronger causal linkage between oil prices and automobile returns on the NYSE. This finding aligns with the conclusions of Jammazi, Ferrer, Jareo, and Shahzad (2017), who identified substantial bidirectional causal relationships between oil and stock markets across various countries and timeframes. Additionally, based on Hamilton's findings, Mork (1989) found that the US economy was disproportionately affected by global oil market prices. Similar effects on the NYSE's auto industry are also noted by this study.

In contrast to the NYSE, the SSE market demonstrates a comparatively limited effect of oil prices on automobile stocks, and any effect of the automobile industry's stock on oil prices remains statistically insignificant. This finding diverges from the observations made by Cong, Wei, Jiao, and Fan (2008), who reported that changes in oil prices significantly affect the Chinese stock market. Furthermore, Zhang and Shang (2023) noted the presence of asymmetric effects stemming from both anticipated and unforeseen oil shocks, with the exception of the auto service sector. Given the asymmetrical impact of global oil returns, it is apparent that various shocks exert differing effects on distinct sectors. This research emphasizes that there is a stronger causal association between oil prices and car

stock values over the medium term than there is over the short and long term. The observed asymmetry in influence is intricately linked to the behaviour of agents, particularly investors, and how this behaviour manifests itself in affecting the returns of automobile markets. Similarly, further validate the results of Caporale et al. (2022) regarding the negative influence of oil in the BRICS-T countries on the transportation sector across the majority of the countries examined.

Objective 2: To examine the effect of COVID-19 on the stock market returns in the automobile sector

To determine the impact of COVID-19 on the selected auto stocks, a causality test is conducted using the Diks and Panchenko (2006) nonlinear causality test. This seeks to accomplish the second objective, which is to assess how COVID-19 has affected stock market returns in the automobile industry. The results are shown below in Table 3.

Table 3. Results for Diks and Panchenko nonlinear causality test between COVID-19 and automobile stocks

Co-movement	$\chi \rightarrow \gamma$	$\chi \rightarrow \gamma$
COVID-19 ↔ Honda	1.317*	0.657
COVID-19 ↔ Toyota	1.947**	0.981
COVID-19 ↔ Tesla	1.998**	0.867
COVID-19 ↔ Volkswagen	1.145***	0.738
COVID-19 ↔ BYD	2.012**	0.894
COVID-19 ↔ JAC	1.756**	0.142
COVID-19 ↔ CHONGQING	1.857*	0.995
COVID-19 ↔ SAIC	1.984**	0.796

Note: The test is bidirectional; $\chi \rightarrow \gamma$ represent COVID-19 Granger-causes variable automobile equities, and $\gamma \rightarrow \chi$ demonstrates that the automobile equity variable Granger-causes variable COVID-19 respectively. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.
Source: Author's construct (2023)

The results from Table 3 revealed causality between COVID-19 and the returns on auto stocks on the NYSE and SSE. In both stock markets included in this study, a substantial causal relationship is found when considering the transmission of shocks caused by COVID-19 into the returns of automobile stocks. This leads to the conclusion that COVID-19 significantly affected stock market returns in the auto industry. However, although there is a causal link the automobile stocks do not exert any significant impact on the COVID-19 cases, hence a unidirectional significant causality result is obtained for this study.

The findings are consistent with the research by Rajamohan et al. (2020) which found that the return on the automobile industry index was low during the COVID-19 period. This led to the conclusion that COVID-19 had a negative effect on the automobile sector in India during the study period. Similarly, He et al.

(2020), revealed that COVID-19 significantly affected the automobile industry in China. Considering these negative impacts investors need to make key decisions during and after such a downturn involving strategies to manage risk, protect investment, and find opportunities amidst uncertainty.

Objective 3: To examine the relationship between the Russia-Ukraine war and stock market returns in the automobile sector.

Table 4 presents the estimation results for the quantile regression analysis for the selected quantiles $\tau \in \{0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90\}$. To investigate the connection between the performance of auto stocks and the Russia-Ukraine war, which serves as the fourth objective of this study, the lower quantiles, middle quantiles, and upper quantiles are computed. Shown in Table 4, the quantiles ($Q_{0.10}$, $Q_{0.20}$, $Q_{0.30}$) represents the lower quantiles, ($Q_{0.40}$, $Q_{0.50}$, $Q_{0.60}$) represents the middle quantiles, and ($Q_{0.70}$, $Q_{0.80}$, $Q_{0.90}$) represents the upper quantiles. Simple linear quantile regression is carried out for each paired variable, that is the GPR index representing the Russia-Ukraine war and the selected automobile stocks from each market.

The quantile regression effectively illustrates how the connection between automobile stock returns and the Russia-Ukraine war varies under specific market conditions, including bearish, normal, and bullish markets, at defined quantiles. The most notable finding is how the intercept and regressive coefficient behave differently across the various quantiles.

Table 4. The estimation results of quantile regression coefficient for GPR and automobile stock returns

Variables		Lower Quantiles			Middle Quantiles			Upper Quantiles		
		$Q_{0.10}$	$Q_{0.20}$	$Q_{0.30}$	$Q_{0.40}$	$Q_{0.50}$	$Q_{0.60}$	$Q_{0.70}$	$Q_{0.80}$	$Q_{0.90}$
HONDA	β_1	0.00894	-0.00774	-0.00484	-0.01070***	0.00902	-0.01091	-0.00631	-0.00992	-0.00825
	$t-stats$	1.2542	-1.1321	-1.2215	-2.6891	1.0016	-1.2228	-1.1136	-0.3569	-1.0012
TOYOTA	β_1	-0.00381	-0.00494	-0.00417	-0.00417	-0.00713	-0.00641	-0.00577	-0.00611	-0.00714
	$t-stats$	-0.6241	-0.7132	-0.3245	-0.4489	-1.0136	-0.3852	-0.8829	-0.1269	-0.8996
TESLA	β_1	-0.00631	-0.02947	-0.01500	-0.02042	-0.00876	-0.00795	-0.01981**	-0.01863**	-0.04005**
	$t-stats$	-0.7256	-1.1169	-0.3582	-1.0162	-0.6523	-0.4652	-1.9886	-1.9978	-2.0097
VOLKSWAGEN	β_1	0.02701	-0.00929	-0.00378	-0.00341	-0.00706	-0.00672	-0.00415	-0.01359	-0.01259
	$t-stats$	0.5689	-0.6987	-0.1356	-0.1265	0.3652	-0.1236	-0.2546	-0.2718	-1.2451
BYD	β_1	-0.00722	0.01076	0.01350	0.01060	0.00826	0.00646	-0.00256	-0.00697	-0.00450
	$t-stats$	-0.6897	0.9897	1.1258	1.1225	0.8994	1.1245	-0.2546	-0.3452	-0.3245
JAC	β_1	-0.00722	0.01076	0.01350	0.01060	0.00826	0.00646	-0.00256	-0.00697	-0.00450
	$t-stats$	-0.6523	0.9978	1.1123	0.8996	0.2316	0.8896	-0.3245	-0.1254	-0.2456
CHONGQING	β_1	0.02822	0.01959**	0.00730	0.00713	0.00997	0.00869	0.01515	0.00784	0.00626
	$t-stats$	1.1354	1.8992	0.6231	0.5469	0.3459	0.6542	1.1246	0.8947	0.6542
SAIC	β_1	0.00104	0.00751	0.00732	0.00308	0.00242	0.00365	0.00395	0.00708	0.00500
	$t-stats$	0.1286	0.3652	0.4569	0.2365	0.1265	0.2336	0.6598	0.6548	0.6589

*Note: *, **, and *** denote rejection of the null hypothesis at 10%, 5%, and 1% level of significance respectively.*
Source: Author's Construct (2023)

Apart from Q0.20 in Chongqing automobile stock, the results of the quantile regression analysis of the connection between the Russia-Ukraine war and the returns of automobile stocks in both stock markets (NYSE, SSE) at the lower quantiles indicate that shocks resulting from the conflict do not significantly affect the returns of automobile stocks in either stock market. This suggests that with the exception of Chongqing automobile, which has a strong correlation with GPR, the shock caused by the Russia-Ukraine war does not have an impact on the automotive industry. This relationship however is positive, meaning under poor or inefficient market conditions, shocks resulting from the Russia-Ukraine war translate or impact such automobile stock price returns.

The results from the middle quantiles just like those of the lower quantiles show no significant relationship between the variables GPR and automobile stocks across all distributions with the exception of Honda automobile which shows a significant value in the middle quantiles of $Q_{0.40}$. The relationship shown between the GPR index representing the Russia-Ukraine war and Honda automobile stock returns is negatively significant. Thus, increasing cases of the war index translate into a lower return in the Honda automobile stocks. However, the remaining automobile stocks (Toyota, Tesla, Volkswagen, BYD, JAC, Chongqing, SAIC) which do not show a significant correlation with GPR imply there may be no existence of translations of shocks from the war to the aforementioned stock returns.

In the upper quantiles, Tesla automobile stock returns present a noteworthy upward correlation with the GPR index across various quantiles ($Q_{0.70,}$ $Q_{0.80,}$ $Q_{0.90,}$).

Nevertheless, the co-movement lacks significance with regard to the remaining automobile stocks. This suggests that shocks resulting from the Russia-Ukraine war may not be conveyed to these stocks in the upper quantiles.

Discussion of Results

The co-movement between WTI crude oil prices and stock market returns in the automobile sector.

The findings obtained from the wavelet coherence analysis reveal that the relationship between global oil prices and stock returns from the NYSE and SSE fluctuates across time and frequency. Auto stock returns and WTI crude oil have a sporadic but persistent link that is stronger at longer timescales, especially at 256 and 64-day periods. In contrast, at shorter time scales, such as 16 days (high-frequency), the correlation is relatively weaker. This implies that the benefits of diversification over extended time frames may be limited due to the heightened correlation at lower frequencies. For instance, Volkswagen and Toyota returns demonstrated a positive correlation with WTI returns, contrasting with Tesla, BYD, JAC, and SAIC, which displayed weaker integration with crude oil returns. These dynamic integrations align with the research conducted by Pal and Mitra (2018), with equity returns showing a greater susceptibility to rising oil prices brought on by demand-induced disruptions, it was seen that the long-standing correlation between crude oil prices and vehicle stock returns becomes increasingly apparent over time, a finding that was affirmed by Jiang and Yoon (2020), who noted similar patterns. Notably, apart from sporadic instances, particularly in 2018, the association between WTI returns and Toyota appeared unaffected by the global

health crisis, while Tesla and BYD equity markets exhibited resilience to crisis-induced shocks, especially amidst the global health crisis. During the crisis period, Honda and Volkswagen returns exhibited a robust correlation, with WTI returns driving both markets.

Conversely, JAC and SAIC displayed weak ties in the short term before the global health crisis but exhibited moderate to strong interactions in the medium term. Chongqing returns displayed limited predictability compared to WTI returns, maintaining a weak relationship throughout the health crisis period with minor strengths and coherence. The aforementioned results find credence in the research carried out by Akoum et al. (2012), who considered OPEC basket oil returns and stock market returns for the GCC countries and indicated that, in the long run, oil and stock returns tend to move in tandem, whereas their relationship is notably weaker over shorter time frames. Considering the predictiveness, it can be inferred that crude oil has led to higher returns on automobile stocks, which implies the interdependence of the latter on the former as well as the more sensitive nature of the crude oil markets towards processing information than the automobile equity market. Regarding diversification opportunities, Toyota and BYD returns acted as a refuge for WTI returns in the long run, while Tesla, Volkswagen, and JAC returns served as both hedge and safe haven assets over the same horizon. Although Honda's returns initially acted as a safe haven in the short and medium term, this effect was unsustainable in the long term. In contrast, Chongqing and SAIC returns did not exhibit safe haven or hedge properties for WTI returns due to persistent fluctuations in integration levels. Overall, SSE automobile stocks showed greater

susceptibility to influence from WTI crude oil returns compared to their NYSE counterparts.

From a theoretical perspective, the diverse integration patterns concerning frequency and horizon between automobile equities and crude oil reflect the heterogeneous market hypothesis, corroborating previous research findings (Caporale et al., 2022; Ftiti et al., 2016; Hamdi et al., 2019; Jiang & Yoon, 2020; Pal & Mitra, 2019) on the varied coherence levels between equities and crude oil returns. Conversely, the presence of differing coherence degrees across multiple market scenarios underscores the adaptable behaviour of market participants. For example, the observed weak integration between Toyota returns and crude oil amid the pandemic era illustrates how investors strategically manage their investments to mitigate losses during periods of turmoil (Baur & Todorova, 2018; Owusu Junior et al., 2021; Woode et al., 2024). These findings are also consistent with the insights of Cameron and Schnusenberg (2009) regarding the simultaneous decline in automotive stock values alongside oil price surges, underscoring the competitive dynamics within these markets.

The impact of COVID-19 on stock market returns in the automobile sector.

Evaluating how COVID-19 has affected the stock return in the automotive industry, the findings showed a significant impact between the paired variables with COVID-19 affecting the automobile stock returns significantly. As noted earlier, the stock market experienced a profound adverse impact due to the COVID-19 pandemic., causing sharp declines, increased volatility, and economic uncertainty. This study's results also conform with the results by Eldem et al. (2022), who

studied how the COVID-19 pandemic has affected the Turkish automotive industry's distribution network and observed a significant disruption in the automobile sector. In a separate study, Xu (2021) also discovered an admittedly detrimental effect of COVID-19 on the US stock market. Nonetheless, the majority of the research found outcomes consistent with this study, which found that COVID-19 had a detrimental effect on the automotive industry.

The tenets of behavioral finance theory assert that crises exert a substantial influence on stock prices by not only altering the intrinsic value of firms but also reshaping the psychological and behavioral tendencies of investors. According to Lee and Jiang (2002), an increase in investor optimism typically mitigates profit volatility, while a surge in investor pessimism raises it. Thus, it was anticipated that the pandemic would affect the broader economy, affect investor attitude, and thus affect changes in stock prices.

The catastrophe theory propounded by René Thom in the 1960s best explains the phenomenon of the impact of COVID-19 on the financial performance of automobile stocks., as the theory elucidates that in an economy, a system can occasionally become vulnerable to even a minor changing environment which might cause an excessively large response. Although a major impact of COVID-19 on automobile stock price returns is recorded for this study in both markets, the SSE exhibits a stronger significant effect between the paired variables compared to the NYSE. This may be associated with the fact that the pandemic was more pronounced in China. The implication of the findings to investors and the business fraternity as a whole is that events like COVID-19 negatively impact the

automobile market, hence in the event of similar occurrences, investors may divert their portfolio to sectors (manufacturing, information technology, education, healthcare industry) which are less affected by such pandemic, according to He et al. (2020). Diversifying across asset classes, sectors, and geographies can help reduce risk as different investments react differently to economic events.

The impact of the Russia-Ukraine war on stock market returns in the automobile sector.

The general intuition behind the findings of the quantile regression suggests that automobile stocks responsive to the Russia-Ukraine war shocks are insignificant, although a significant relationship is recorded at the upper quantiles for some stocks, thus a strong market environment, in the case of Tesla automobiles. In a similar study Hudson and Urquhart (2015), their study in the same vein found a minimal impact of war on UK stocks. Due to differences in market efficiency according to Ramiah et al. (2012), stock markets would respond to shocks more leisurely than they would under the EMH, which asserts that markets have to immediately take into account all pertinent information. For this research, the war's impact on automobile stock returns is negligible and unimportant.

In contrast to our findings, Bougou and Yatie (2022) discovered that the Russia-Ukraine war had a significant detrimental impact on the return on global stocks. The correlation between the Russia-Ukraine war and automobile stock returns, however, shows a high degree of consistency between the NYSE and the SSE, according to our data. Most pairs of variables exhibit a weak association. Investors can venture into oil and automobile stocks amid the war, where there are

low returns on stocks. The absence of an adverse connection between GPR and automobile stocks can be interpreted as economic stability despite the war. Also, this is a result of limited direct exposure, where many automobile companies may have limited direct exposure to the Russian or Ukrainian markets. If these regions represent a small portion of their sales, production, or supply chain, then the impact of the war on these companies would be minimal as seen from our result. Investors knowing that the market can withstand certain events without adverse effects may encourage investors to commit more confidently to long-term investment strategies, reducing the temptation to react to external events. Further, knowledge from the study's results will guide investors in prioritizing growth opportunities, looking for sectors or companies that could benefit from the event rather than merely withstanding it.

Chapter Summary

The chapter covers findings from the analysis and discussions related to achieving the study's objectives. Results for the study variables are presented and intuitively described after descriptive statistics, wavelet coherence analysis, quantile regression analysis, and Diks and Panchenko causality test were carried out. The outcomes of the WCA revealed oil prices and automobile stock returns to exhibit synchronized movements. Furthermore, the results obtained from the Diks and Panchenko causality test indicate the presence of a causality between oil prices and the returns of automobile stocks, as well as a causal link between COVID-19 and these returns. Finally, the QR analysis unveiled an insignificant correlation between the Russia-Ukraine war and stock returns within the automobile industry.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter lays out the overall discussion undertaken in the previous chapters. First of all, the chapter summarizes all the issues under study, the research objectives, data analysis methods, and key observations from the study. The chapter also includes conclusions drawn from the study's findings per its predetermined objectives. Further, discerning recommendations for financial market stakeholders as to how to make optimum investment decisions are provided. The chapter draws to a close by pointing out areas that the study could not touch on and thus, providing suggestions for further study.

Assessing how global shocks affect stock market returns in the automotive sector was the primary objective of this study. This is initiated out of the need to address financial market players' concerns about the current fluctuations in global oil prices, falling sales in automobile stocks, and the rising cases of the Russian-Ukraine conflict. The study covers eight major automobile companies' stock prices, namely, Honda, Toyota, Tesla, Volkswagen, Chongqing, BYD, JAC, and SAIC. On the other hand, the global shocks considered are COVID-19, the Russia-Ukraine war, and WTI crude oil price shocks.

The first objective is to investigate the co-movement between global oil prices and returns on automobile stocks using data from January 2013 through December 2022. The research employed wavelet coherence analysis, a technique that evaluates co-movement in the time and frequency domain. Using the same data

period as in objective one, the study's second objective was how automobile stock returns are affected by COVID-19. To achieve this objective, the Diks and Panchenko causality test was used.

The final objective of the study was to examine the relationship between the stock market performance within the automotive industry and the Russia-Ukraine conflict through applying quantile regression analysis. The GPR index, developed by Caldara and Lacoviello (2022), represents the ongoing conflict in this analysis.

Summary of Findings

The first objective examined the relationship between global oil prices and stock returns within the automobile sector. The findings indicated a reciprocal relationship and highlighted that the correlation between oil price fluctuations and stock returns in the automobile industry fluctuates across varying time intervals and frequencies. Notably, oil price returns generally exhibit a dominant influence in the lead-lag dynamic between the two variables during most periods. Furthermore, this pattern of co-movement also varies across different stock markets. As a result, different markets have different levels of relevance and correlation between global oil prices and returns on vehicle stocks, with the correlation in the SSE being more pronounced than that of the NYSE.

Additionally, a comprehensive evaluation of the short, medium, and long-term trends demonstrated a distinct causal connection between oil prices and automotive stock prices over all periods. However, the causal connection was particularly pronounced in the medium-term, surpassing the strength observed in the short and long-term periods.

The impact of COVID-19 on stock market returns in the automobile sector was examined in the second goal. The results of the study show that the pandemic significantly affected the performance of the industry's stock returns, with a notably stronger and more substantial causal effect observed in the SSE. Although a bidirectional causal link between COVID-19 and automobile stock returns was found, the causal influence from automobile stock returns to COVID-19 case numbers was found to be negligible.

Finally, the third objective of the study examined the relationship between the Russia-Ukraine war and stock market returns in the automobile sector. As revealed by the study, the Russia-Ukraine war represented by the GPR index did not show a significant relationship with the stock market returns in the automobile sector, although some selected stocks (Honda, Toyota, BYD, SAIC) exhibit a relationship in the upper quantiles.

Conclusion

Several significant inferences can be made from the research's findings. Firstly, from objective one, this study establishes that there exists a significant level of co-movement, both in the positive and negative directions, between the returns of global oil prices and automobile stock prices. Hence, the research alternative hypothesis for the first objective: There is significant co-movement between global oil prices and automobile stock returns, is accepted.

Furthermore, it can be concluded from objective 2 that, the global economic impact of COVID-19, substantially affected the performance of stocks in the automobile industry. The alternative hypothesis: There is a significant effect of

COVID-19 on automobile stock returns is accepted. This is attributable to the number of sanctions implemented during the period of the pandemic to control its spread. This limited the operation of most businesses, especially the automobile sector. However, a bidirectional relationship is revealed where a causal link is translated from automobile stocks to COVID-19 cases. This result of the causal effect emanating from the automobile market to the COVID-19 case can be associated with market sentiment and public behaviour. This means during periods of rising stock returns, optimism can lead to increased public confidence and risk-taking, potentially affecting social behaviour, such as a willingness to engage in activities that could influence COVID-19 transmission rates and vice versa.

Moreover, the Russia-Ukraine war although having a relationship with the performance of stocks in the automobile sector, this relationship is not significant, hence a weak causal link between the war and stock performance in the automobile industry. Given this, the study fails to accept the alternative hypothesis for the final objective: There is a significant relationship between the Russia-Ukraine war and stock returns in the automobile sector. This result can be due to diversified supply chains, where in a situation where companies in the sector have diversified their sources of key materials and components, they may be less affected by disruptions in any single region, including Russia and Ukraine. Moreover, some automobile companies have significant pricing power and strong demand for their products. If demands remain robust, companies can maintain sales and profitability despite global political tensions, mitigating the war's indirect effects.

Recommendations

Some noteworthy recommendations emerge from the findings and conclusions of this research, particularly in the context of investment decisions and policy implications. To begin with, the significant co-movement observed between oil prices and automobile stock returns, along with the counter-cyclical connection between these variables, underscores the significance of recognizing that fluctuations in oil prices are all not of equivalent magnitude or impact. Consequently, investors should develop cross-sector hedging strategies by keeping track of market-specific characteristics throughout a range of time scales and frequency levels, given that market stocks differ from one another despite sharing some similarities. In essence, stocks with strong performance and potentially pose a contagion risk can be effectively managed through diversification or hedging strategies by acquiring assets that are experiencing weaker performance.

Additionally, understanding the correlation between oil prices and stock performance in the automobile industry will help policy-making decisions on the side of government and policymakers. Policymakers can employ this insight to implement measures that stabilize oil prices, which include encouraging alternative sources of energy to reduce volatility and promote market stability.

Moreover, businesses in the automobile sector which is noted to be heavily influenced by oil prices and COVID-19, should implement risk management practices to handle shocks. This could be improving operational efficiency, seeking alternative energy sources, or adjusting pricing strategies to manage costs effectively.

Finally, automobile companies may consider diversified supply chains for key automobile materials. Doing this will reduce the effect posed by disruptions in a single region since supply chains will not be entirely affected.

Suggestions for Further Research

This study focuses on only two stock markets (SSE, NYSE), which are all for developed economies. For this reason, it is recommended that future studies consider other markets, more especially that of developing economies such as the Johannesburg Stock Exchange. Also, future studies can examine current global shocks and how they impact a particular country's economic performance. Finally, employing other econometric methods in assessing this relationship between the variables for this study, is recommendable for future studies.

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Appendix A: Co-movement between global oil prices and stocks market returns in the automobile sector.

Table 1. Summary results for co-movement between WTI crude oil and automobile stocks

Co-movements	Sub-period	D_4	D_{16}	D_{32}	D_{64}	D_{128}	D_{256}
WTI→Honda	Pre-GLHCE	(↔) medium	(↔) strong	(+) strong	(±) strong	(↔) weak	(↔) weak
	GHLCE	(↔) medium	(↔) strong	(↔) strong	(—) strong	(±) strong	(↔) medium
	GEOPORE	(↔) medium	(↔) strong	(↔) medium	(↔) medium	(↔) medium	(↔) weak
WTI→Toyota	Pre-GLHCE	(↔) medium	(↔) strong	(+) strong	(↔) medium	(↔) weak	(↔) weak
	GHLCE	(↔) medium	(↔) strong	(+) strong	(—) strong	(↔) medium	(↔) medium
	GEOPORE	(↔) strong	(↔) medium	(↔) strong	(↔) medium	(↔) weak	(↔) weak
WTI→Tesla	Pre-GLHCE	(↔) medium	(↔) strong	(↔) strong	(↔) weak	(↔) medium	(↔) weak
	GHLCE	(↔) strong	(↔) strong	(—) strong	(↔) medium	(↔) weak	(↔) weak
	GEOPORE	(↔) medium	(↔) medium	(↔) medium	(↔) weak	(↔) weak	(↔) weak
WTI→Volkswagen	Pre-GLHCE	(+) strong	(↔) strong	(↔) medium	(↔) medium	(↔) medium	(—) strong
	GHLCE	(↔) strong	(—) strong	(↔) strong	(↔) medium	(↔) medium	(↔) weak
	GEOPORE	(↔) strong	(↔) strong	(↔) medium	(↔) weak	(↔) weak	(↔) weak
WTI→BYD	Pre-GLHCE	(↔) weak	(↔) medium	(+) strong	(+) strong	(±) strong	(↔) medium
	GHLCE	(↔) medium	(↔) strong	(↔) medium	(↔) medium	(↔) medium	(↔) weak
	GEOPORE	(↔) strong	(↔) strong	(↔) strong	(↔) medium	(↔) weak	(↔) weak
WTI→JAC	Pre-GLHCE	(↔) weak	(↔) medium	(↔) medium	(↔) medium	(↔) weak	(↔) weak
	GHLCE	(↔) medium	(↔) strong	(+) strong	(±) strong	(↔) medium	(↔) weak
	GEOPORE	(↔) medium	(↔) strong	(±) strong	(—) strong	(↔) medium	(↔) weak
WTI→CHONGQING	Pre-GLHCE	(↔) weak	(↔) strong	(↔) medium	(↔) weak	(—) medium	(↔) strong

	GHLCE	(↔) medium	(↔) medium	(↔) medium	(↔) medium	(↔) weak	(↔) weak
	GEOPORE	(↔) medium	(↔) strong	(—) strong	(↔) weak	(↔) weak	(—) strong
WTI→SAIC	Pre-GLHCE	(↔) weak	(—) strong	(±) strong	(±) strong	(±) strong	(↔) weak
	GHLCE	(↔) medium	(↔) strong	(↔) medium	(±) strong	(↔) weak	(±) strong
	GEOPORE	(↔) medium	(↔) medium	(+) strong	(↔) medium	(↔) weak	(↔) weak

Note: Table 2 is the summary results of the bivariate WCA for the sample automobile equities and WTI crude oil. GLHC and GEOPOR respectively represent the global health crisis (COVID-19 pandemic) and the Geopolitical Risk era from the Russia-Ukraine conflict. D_4, D_{16}, D_{32}, D_{64}, D_{128}, D_{256} Weak, Moderate, and Strong respectively indicate the extent of co-movement in the pairwise while (-), (+), and (↔) respectively indicate the positive, negative and non-directional pattern of co-movement.