



T.C.

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**INVESTIGATION OF TIME-VARYING MARKET EFFICIENCY IN
ISLAMIC COOPERATION COUNTRIES: COMPARISON OF
GLOBAL FINANCIAL CRISIS AND COVID-19 PERIODS**

Doctor of Philosophy (Ph.D.)

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SCIENTIFIC ETHICS PAGE

According to the thesis writing guide of Tokat Gaziosmanpasa University Institute of Social Sciences, Graduate Education Institute, My Doctorate thesis titled “Investigation of Time Varying Market Efficiency in Islamic Cooperation Countries: Comparison of Global Financial Crisis And COVID-19 Periods” that I have prepared under the consultancy of “Prof. Dr. Mihriban COŞKUN ARSLAN” and 2nd supervisor Asst. Prof. Dr. Selim GÜNGÖR is based on scientific ethical values and rules. I hereby declare that it is an appropriate, original work, and I will accept any legal sanctions if it is determined otherwise.

/ / 2024

Muhammad REHAN

JURY ACCEPTANCE AND APPROVAL PAGES

Defense exam of the thesis study titled “**Investigation of Time Varying Market Efficiency in Islamic Cooperation Countries: Comparison of Global Financial Crisis and COVID-19 Periods**” prepared by Muhammad REHAN was held on 1st February 2024 it was accepted unanimously as a Doctor of Philosophy (Ph.D.) Thesis in Tokat Gaziosmanpaşa University Graduate Education Institute, Department of Business Administration-Accounting and Finance Department, by the jury given below.

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DEDICATION

I dedicate this thesis to the cherished memory of my late parents, Muhammad Farooq and Sakeena, who held steadfast dreams of witnessing my Ph.D. journey. Their enduring aspirations and unwavering support have been an everlasting source of inspiration. To my dear brothers, Muhammad Ahsan and Umair Lakhani, your continuous encouragement and support have been a pillar of strength throughout this pursuit. Additionally, I pay tribute to the loving memory of my late sister, whose presence and unwavering belief in my capabilities continue to guide and inspire me. This work stands as a testament to the dreams they carried, the unwavering support provided by my brothers, and the enduring spirit of my late sister.

ABSTRACT

INVESTIGATION OF TIME VARYING MARKET EFFICIENCY IN ISLAMIC COOPERATION COUNTRIES: COMPARISON OF GLOBAL FINANCIAL CRISIS AND COVID-19 PERIODS

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This research aims to examine the time-varying market efficiency of the stock markets of 15 member countries of the Organization of Islamic Cooperation (OIC), including Indonesia, Malaysia, Turkey, Pakistan, Jordan, Egypt, UAE, Kuwait, Morocco, Tunisia, Saudi Arabia, Lebanon, Qatar, Oman and Palestine, at the aggregate and sectoral (such as healthcare, real estate, consumer staples, banking, communication services and industrial indices) level during the COVID-19 and global financial crisis (GFC) periods i.e. from 1st January, 2020 to 31st December, 2021 and from 1st July, 2007 to 30 June, 2009 respectively within the framework of the adaptive market hypothesis. In this context, this research employs multifractal detrended fluctuation analysis to illustrate multifractality and short- and long-term dependence. The findings of the research highlight that most of the indices of OIC countries exhibited persistent behavior along with multifractal characteristics during COVID-19. In contrast, anti-persistence behavior has been seen during the GFC in most of the indices. Moreover, sectoral analyses show that for most countries, the highest persistence during the COVID-19 period was in the real estate sector, and unlike the persistence during COVID-19, there was no persistence in certain sectors during the GFC.

Conclusively, this research reveals the notable influence of fat-tailed distributions on multifractality across diverse sectors. The findings confirm the principles of the adaptive market hypothesis, which points to the fluctuation of arbitrage opportunities over time and provide vital information for shaping policies in anticipating future pandemic-induced economic crises. These findings will have several important implications for the asset allocations of investors in OIC stock markets.

When examine the most and least efficient countries during the COVID-19 and GFC periods, The results find that the most efficient countries in the GFC period are Palestine and Turkey with MDM values of 0.049 and 0.103, respectively, while the least efficient countries are Jordan and Lebanon with MDM values of 0.331 and 0.289, respectively. Furthermore, the research discovers that the most efficient countries in the COVID-19 period are Kuwait and Qatar, whereas the least efficient countries are Lebanon and Turkey.

Analyzing the market efficiency levels of countries from a sectoral perspective, the research observes that during the GFC, sectors such as healthcare in Egypt and communications in Jordan operated at the lowest level of efficiency; at the same time, the real estate sector stood out as the most efficient sector in many countries. In addition, it is concluded that the banking sectors in Morocco and the UAE struggled in both crises, reflecting consistent difficulties during economic downturns.

Keywords: COVID-19, MF-DFA, Organization of Islamic Cooperation, Financial Crisis, Market Efficiency, Global Financial Crisis.

ÖZET

İSLAM İŞBİRLİĞİ TEŞKİLATI'NA ÜYE ÜLKELERDE ZAMANLA DEĞİŞEN PİYASA ETKİNLİĞİNİN İNCELENMESİ: KÜRESEL FİNANSAL KRİZ İLE COVID-19 DÖNEMLERİNİN KARŞILAŞTIRILMASI

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Bu çalışmada, Endonezya, Malezya, Türkiye, Pakistan, Ürdün, Mısır, Birleşik Arap Emirlikleri-BAE, Kuveyt, Fas, Tunus, Suudi Arabistan, Lübnan, Katar, Umman ve Filistin'in de dahil olduğu İslam İşbirliği Teşkilatı'na (İİT'ye) üye 15 ülkenin hisse senedi piyasasının COVID-19 ve küresel finansal kriz (KFK) dönemlerindeki toplu ve sektörel (sağlık hizmetleri, gayrimenkul, tüketici temel ürünler, bankacılık, iletişim hizmetleri ve sanayi endeksleri gibi) düzeyde zamanla değişen piyasa etkinliğinin adaptif piyasa hipotezi çerçevesinde incelenmesi amaçlanmıştır. Bu bağlamda, bu araştırmada çoklu fraktallık ile kısa ve uzun dönem bağımlılığı ortaya koymak için çoklu fraktal eğimden arındırılmış dalgalanma analizi kullanılmıştır. Araştırmanın bulguları, KFK döneminde endekslerin çoğunda kalıcılık karşıtı davranışlar görülmesine rağmen İslam İşbirliği Teşkilatına üye ülke endekslerinin çoğunun, COVID-19 döneminde çoklu fraktal özelliklerin yanı sıra kalıcılık davranışları da sergilediğini vurgulamaktadır. Ayrıca, sektörel analizler, çoğu ülke için COVID-19 döneminde en yüksek kalıcılığın gayrimenkul sektöründe olduğunu ve COVID-19 dönemindeki kalıcılığın aksine, KFK döneminde belirli sektörlerde kalıcılığın olmadığını göstermiştir.

Son olarak, kalın kuyruklu dağılımın etkisinin bu sektörlerdeki çoklu fraktallık üzerinde önemli ölçüde etkilediğini gözlemlenmiştir. Bulgular, arbitraj fırsatlarının zaman

içerisindeki dalgalanmasına işaret eden adaptif piyasa hipotezinin ilkelerini doğrulamakta ve gelecekteki salgın kaynaklı ekonomik krizlerin öngörülmesinde politikaların şekillendirilmesi için hayati önem taşıyan bilgiler sunmaktadır. Ayrıca bu bulguların, İİT hisse senedi piyasalarındaki yatırımcıların varlık dağılımları üzerinde de birçok önemli sonucunun olacağına inanılmaktadır.

COVID-19 ve küresel finansal kriz dönemlerinde en çok ve en az etkin olan ülkeler incelendiğinde, KFK döneminde en etkin ülkelerin sırasıyla 0,049 ve 0,103 MDM değerleriyle Filistin ve Türkiye olduğunu, en az etkin olan ülkelerin ise sırasıyla 0,331 ve 0,289 MDM değerleriyle Ürdün ve Lübnan olduğu bulunmuştur. Ayrıca COVID-19 döneminde en etkin ülkelerin Kuveyt ve Katar, en az etkin ülkelerin ise Lübnan ve Türkiye olduğu belirlenmiştir. Ülkelerin piyasa etkinlik düzeyleri sektörel açıdan incelendiğinde, KFK döneminde Mısır'da sağlık ve Ürdün'de iletişim gibi sektörlerin en düşük etkinlik düzeyinde faaliyet gösterdiği; aynı zamanda gayrimenkul sektörünün birçok ülkede en etkin sektör olarak ön plana çıktığı gözlemlenmiştir. Öte yandan, COVID-19 döneminde Mısır'da sanayi ve Ürdün'de iletişim gibi sektörlerin düşük etkinlik düzeylerine tanık olduğu, gayrimenkul sektörünün ise yüksek etkinlik trendini koruduğu saptanmıştır. Buna ek olarak, Fas ve BAE'deki bankacılık sektörlerinin her iki krizde de zorlandığı ve bunun da ekonomik gerileme dönemlerindeki tutarlı zorlukları yansıttığı sonucuna varılmıştır.

Anahtar Kelimeler: COVID-19, MF-DFA, İslam İşbirliği Teşkilatı, Finansal Kriz, Piyasa Etkinliği, Küresel Finansal Kriz.

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ABBREVIATIONS

AMH	: Adaptive Market Hypothesis
COVID-19	: Coronavirus Disease 2019
DFA	: Detrended Fluctuation Analysis
EMH	: Efficient Market Hypothesis
FDI	: Foreign Direct Investment
FMH	: Fractal Market Hypothesis
GFC	: Global Financial Crisis
GDP	: Gross Domestic Product
IMF	: International Monetary Fund
MDM	: Market Deficiency Measure
MENA	: Middle East/North Africa
MF-DFA	: Multifractal Detrended Fluctuation Analysis
OIC	: Organization of Islamic Cooperation
PMPT	: Postmodern Portfolio Theory
SESRIC	: Statistical, Economic, and Social Research and Training Centre for Islamic Countries
UNCTAD	: United Nations Conference on Trade and Development
WHO	: World Health Organization

INTRODUCTION

Financial markets represent intricate systems crucial to society's prosperity and wealth accumulation. These markets involve a multitude of participants, including individuals, institutions, governments, and any entity seeking profit through investment-related buying and selling activities (Muellbauer & Murphy, 1997).

The primary function of financial markets is to allocate productive resources for optimal investment choices efficiently. These markets serve as a crucial link through which individuals can mobilize their funds and actively participate in the economic growth of a society, as emphasized by Henry. The significance of financial markets becomes evident when examining the fundamental functions, they fulfill. Firstly, they facilitate the transfer of funds from individuals who possess surplus capital but lack investment opportunities to those who have promising investment prospects Henry (1997).

Global financial data has compiled indices covering global markets from 1601 to 2023. In structuring this data, it became evident that the history of the stock market over the past four centuries can be categorized into four distinct periods where economic and political influences shaped the stock market's size and structure differently. Politics and economics delineate financial markets by dictating whether companies operate in the private or public sector, managing capital flow in financial markets, and determining the extent of regulation companies encounter to maximize their profits. The first epoch, spanning from 1600 to 1815, witnessed financial markets primarily financing government bonds and a limited number of government monopolies. The establishment of the British East India Company in 1600 marked the initiation of this period, characterized by a scarce trade in securities that resembled bonds more than equities after the bubbles of 1719-1720. Investors prioritized secure returns over potential capital gains (David & Elroy, 2016).

The subsequent era, from 1815 to 1914, experienced an expanding equity market, globalization, and a diminishing significance of government bonds compared to equities. This transformative shift was initiated in the 1790s with the advent of canals and later

railroads, fundamentally altering financial markets. Investors acknowledged transportation stocks as reliable sources of dividends and capital gains, presenting opportunities to invest in numerous companies for both capital appreciation and dividends. The global economy thrived due to financial globalization and the transportation revolution until World War I interrupted globalized financial markets on July 31, 1914. During the war, capital was redirected towards war expenditures. Efforts to reinstate globalized financial markets post-war were unsuccessful, leading to national-level market operations rather than international integration. While pre-war integrated markets delivered comparable returns, post-war national equity market returns diverged due to constrained capital flows toward countries with higher returns. Following World War II, Europe nationalized key industries, while the United States imposed regulations on industries. It was not until the 1980s, amid worldwide deregulation and privatization, that equity markets re-globalized. The OPEC Oil Crisis in the 1970s prompted scrutiny of government economic regulation, catalyzing privatization across capitalist economies and the inauguration of stock markets in former Communist countries. The research resulted in a significant surge in the global market capitalization/GDP ratio. The era that commenced from the 1981 bear market is considered the fourth, anticipating a potential fifth era contingent upon technological advancements. The envisioned fifth era would begin when financial markets achieve singularity, amalgamating national financial markets into a unified entity operating ceaselessly through global computer networks. The foreign exchange market has nearly reached this stage, indicating an inevitable progression towards the same for financial assets (David & Foray, 2016).

In the 21st century, the financial markets underwent significant upheaval during the pandemic era, marked by a notable surge in countries' risk premiums, resulting in substantial losses for investors within a brief timeframe and an unprecedented escalation in volatility. The World Health Organization (WHO) officially declared the coronavirus outbreak as a global pandemic on March 11, 2020, prompting numerous countries to enforce stringent quarantine measures, consequently leading to a substantial downturn in economic activities. Remarkably, the circuit breaker mechanism, which had been triggered only once in 1997 since its inception in 1987, was activated four times within the US stock market in March

2020. In a similar vein, the UK's primary index (FTSE) witnessed its most significant decline since 1987, plummeting by over 10% on March 12, 2020. Concurrently, the Japanese stock market experienced a decline of more than 20% by March 2020, compared to its standing in December 2019. In response to the financial market's fluctuations, the US Federal Reserve (FED) took action by announcing a zero percent interest rate policy and unveiling a \$700 billion quantitative development program on March 15, 2020 (Zhang et al., 2021).

The study focused on assessing the impact of COVID-19 on the financial markets in China and the USA within the timeframe of March 1 to March 25, 2020, utilizing data sourced from the Shanghai Stock Exchange and the New York Dow Jones stock market, respectively. The empirical analysis revealed a noteworthy and positive correlation between the occurrences of COVID-19 in both China and the USA and the performance of all financial markets examined (including the Shanghai Stock Exchange and New York Dow Jones). This correlation implies a substantial adverse effect of the epidemic on the financial markets of both China and the USA Sansa (2020).

Particularly when debating about the stock market development presently, the sheer multitude of exchanges presents a formidable landscape, and their future trajectory remains uncertain. However, a comparable surge in both the quantity and magnitude of global stock exchanges occurred during the emergence of the initial global financial markets from 1871 to 1914. As World War I loomed, an expert from the UK enumerated a total of 89 primary stock exchanges worldwide, with more than half situated in Europe, particularly Western Europe, and the remaining predominantly scattered across regions of European settlement (Lowenfeld, 1909).

Collectively, these markets facilitated trading for approximately 20 million investors dealing in securities valued at over \$160 billion in nominal terms. During that period, a French authority specializing in stock exchanges estimated that UK investors possessed 24%, Americans 21%, French 18%, and Germans 16% of the world's aggregate securities. The stock market holds a significant position in a country's economic advancement. Not only does it promote savings and investments, but it also fosters improved corporate governance and social

responsibility. Despite its inherent investment risks, the stock market offers extensive prospects for both local and global diversification through proficient asset allocation. Its absence would lead to underutilization of economic progress and productive efficiency. The stock market functions as a crucial platform, enabling companies to access long-term capital and facilitating their expansion and innovation. Simultaneously, it provides investors with a means to invest surplus funds. Enhanced savings mobilization contributes to an increased savings rate, subsequently driving investments and fostering economic prosperity (David & Elroy, 2016).

The accuracy of financial markets in predicting economic behavior has been a subject of extensive debate. Analyzing data gathered for the USA by the National Bureau of Economic Research revealed a consistent pattern. There is typically a decrease in the stock returns index either just before or immediately after the onset of a recession. Intriguingly, among the 41 recessions observed from 1802 to 1990, 38 instances were characterized by declines of 8% in the stock return index either preceding or coinciding with the economic downturn Siegel (1991).

The rise in foreign direct investment (FDI) within OIC member nations poses a challenge to their stock exchanges, questioning their capability to manage the surges in capital influx. Presently, the stock markets in OIC countries are characterized by developmental shortcomings and inefficiencies. Out of the member nations, only 33 maintain active stock exchanges, some of which are newly established, while others restrict foreign participation. Many OIC stock exchanges grapple with limited liquidity, leading to heightened market volatility. The research is evident in the sparse number of domestically listed companies, weak market capitalization, and low value traded. Ineffective and insufficient regulatory frameworks, a need for more effective information dissemination channels, high information costs, and a lack of product differentiation in these markets compound these challenges (COMCEC Financial Outlook 2022).

The concept of market efficiency has been a subject of ongoing debate in the past few decades, particularly since Eugene Fama introduced the renowned framework of "The

Efficient Market Hypothesis (EMH)" in 1970. During the initial years of the EMH, market efficiency was primarily founded on the notion of stochastic processes governing the movements of asset prices. The underlying principle of market efficiency suggested that in an efficient market, asset prices would exhibit a random walk pattern, as all relevant information pertaining to the asset would already be incorporated into its price. Consequently, it would not be possible to predict future changes in asset prices based on new information alone. Therefore, in an efficient market, the process of gathering information becomes futile as any new information would instantaneously affect the price of the asset. The existence of a perfectly functioning market is implausible because if prices accurately reflected all available information, traders would lack the incentive to invest in acquiring costly information. Market efficiency gauges the ability of markets to integrate and reflect all available information within stock prices swiftly. In efficient markets, stock prices are an accurate representation of available information, adjusting rapidly to new data. Numerous theories have attempted to explore and define market efficiency. In an efficient market, the opportunity for investors to gain abnormal returns from their investments is limited or non-existent. Consequently, investments in such markets would not yield additional returns beyond what is warranted by the risk taken. The topic of market efficiency has sparked numerous debates and theories Grossman and Stiglitz (1980).

The Postmodern Portfolio Theory (PMPT) emerged nearly four decades after Henry Markowitz introduced the Modern Portfolio Theory, both furnishing frameworks that consider risk and return for decision-making. These theories present contrasting facets regarding market efficiency, highlighting conflicting perspectives within this domain (Arshad & Arshad, 2017).

The scope of market efficiency involves how accurately, and swiftly financial markets absorb all available information into asset prices. It explores the speed and effectiveness with which markets incorporate information, aiding investors in making well-informed choices. This evaluation determines whether prices align with the intrinsic values of assets and how rapidly new information gets integrated. Market efficiency comprises weak, semi-strong, and strong forms, each representing distinct levels of information integration within markets. This

concept is pivotal in comprehending investor behavior, the efficacy of market regulations, and the dynamics of asset pricing. Furthermore, market efficiency's breadth extends to academic inquiry, financial modeling, and strategies for investment. Grasping market efficiency is vital for investors, policymakers, and analysts seeking to navigate and comprehend the behaviors of financial markets.

Numerous studies have demonstrated that asset prices do not adhere to random walks and that price variations, as well as returns, can be predicted (Fama & French, 1988). Consequently, this finding has given rise to a proliferation of research exploring the validity of the Efficient Market Hypothesis (EMH) in both developed and developing countries. Furthermore, these predictable variances in returns have opened avenues for the exploration of different trading strategies, as highlighted by (Jegadeesh and Titman (1993); Opong & Fox, 1999; Lim and Brook., 2011; Borges, 2010). Statistical tests are employed to assess the efficiency of a market within predefined periods. The results of these tests often categorize market efficiency as either present or absent, representing an all-or-nothing characterization of market efficiency. In recognizing the impracticality of achieving perfect efficiency, Campbell, Lo, MacKinlay, Adamek, and Viceira (1997) introduced the concept of relative efficiency. This conceptual shift has led to a transition from the binary notion of absolute market efficiency to a focus on measuring the varying degrees of market efficiency.

On the opposing side, some economists challenge the efficiency market hypothesis (EMH) and hold the belief that it is indeed possible to forecast future prices and outperform the market. Notable figures such as Nicholson (1968); Darrat & Zhong (2000); and Harrison et al. (2012) have expressed this viewpoint through their research and perspectives. Furthermore, a vast number of traders and investors employ diverse trading strategies and models in their quest to outperform the market. This widespread participation suggests that these market participants, to some extent, hold the belief that they can surpass market performance.

This study presents several significant contributions. Firstly, it investigates how the COVID-19 pandemic affects economic efficiency. With the pandemic impacting stock prices

differently across sectors, investors seek to forecast future returns within each industry. Thus, this study anticipates varied responses from different industries following the COVID-19 outbreak. Furthermore, it analyzes and compares the effects of the Global Financial Crisis (GFC) and the COVID-19 pandemic on stock market efficiency, aiming to emphasize the distinct characteristics of COVID-19's influence on the economy. The outcomes of this research offer valuable insights for shaping policies aimed at addressing potential future economic crises stemming from infectious diseases.

The purpose of this study is to explore the discrepancies between the impacts of the COVID-19 outbreak and the global financial crisis (GFC) on the economy. By utilizing time-varying techniques, the analysis aims to reveal market characteristics linked to significant structural changes. Additionally, this research employs the multifractal detrended fluctuation analysis (MF-DFA) model to assess and compare the effectiveness of both the overall market and specific sectors during crisis periods. The MF-DFA model, introduced by Kantelhardt et al. (2002), is applied to analyze non-stationary time series exhibiting multifractal attributes, allowing for the identification of long-term and short-term correlations. This method enables financial investors to evaluate the efficacy of each sector, providing valuable insights for their investment strategies. Furthermore, this study aims to elucidate the market efficiency of both the overall market and individual sectors within the framework of the Efficient Market Hypothesis (EMH).

This research utilized the MF-DFA approach to evaluate market efficiency, a method increasingly prevalent in examining the market efficiency hypothesis and multifractal properties of financial assets in recent studies (Miloş, et al., 2020; Choi, 2021; Yin & Wang, 2021; Pak & Choi, 2022; Gaio et al., 2022). Moreover, this study conducted static and rolling window analyses to appraise the market efficiency of worldwide stock markets. These analyses allowed to examine market efficiency across the entire sample period and discern fluctuations in market efficiency over time.

This research employed a methodological approach to examine the temporal changes in market efficiency within individual OIC countries, both in aggregated indices and sectoral

indices, utilizing rolling window analysis. Specifically, the study scrutinized and compared how distinct markets responded to systemic risks, such as the 2008 global financial crisis and the COVID-19 pandemic. While existing studies have explored the impact of the COVID-19 pandemic on stock market efficiency (Aslam et al., 2021; Mensi et al., 2022; Saâdaoui, 2023; and Erer, et al., 2023), these studies encompassed a narrower range of stock markets compared to the breadth covered in our research. Through the application of rolling window analysis, this study offers valuable insights into the dynamic evolution of market efficiency within individual countries over time.

Many studies have been done on time-varying market efficiency, but OIC countries need to get the attention of the researchers. While extensive research has been conducted on the Efficient Market Hypothesis (EMH) and the Adaptive Market Hypothesis (AMH) using the multifractal detrended fluctuation analysis (MF-DFA) method, researchers have largely overlooked the OIC countries. The motivation for this study is because, to the best of my knowledge, there has yet to be comprehensive research that encompasses all aggregate indices and sector indices during both the Global Financial Crisis and the COVID-19 pandemic in OIC member countries.

"This research structure is outlined as follows:

Chapter 1 provides the theoretical framework for market efficiency, encompassing the random walk hypothesis, efficient market hypothesis, fractals, multifractals, the Fractal Markets Hypothesis (FMH), and the Adaptive Market Hypothesis (AMH).

Chapter 2 explores the development of stock markets within the member states of the Organization of Islamic Cooperation, detailing the conditions both before and during crises.

Chapter 3 focuses on examining time-varying market efficiency in the economies of the Organization of Islamic Cooperation during the global financial crisis and COVID-19 periods. This chapter includes the problem statement, study objectives, significance, research questions, literature review, and research methodology. Additionally, it concludes with recommendations and references."

1. CHAPTER 1: THEORETICAL BACKGROUND ON MARKET EFFICIENCY

Within the realm of financial theory, a tapestry of hypotheses has emerged, seeking to unravel the complexities of market behaviors and asset price movements. This section delves into a mosaic of theories, ranging from the Random Walk Hypothesis to the Efficient Market Hypothesis (EMH), encompassing Fractals and Multifractals and culminating in the Adaptive Market Hypothesis (AMH). Each hypothesis represents a distinct vantage point, offering unique insights into the dynamics shaping financial markets. Understanding these theories not only unveils the evolution of thought in finance but also holds immense practical significance for investors, economists, and policymakers alike. By navigating through these hypotheses, this section aims to elucidate the interplay between market randomness, efficiency, self-similarity in price movements, and adaptive market behaviors, thus paving the way for a comprehensive understanding of the multifaceted nature of financial markets.

1.1. THE RANDOM WALK HYPOTHESIS

The random walk hypothesis and theory are closely and strongly linked with the weak form of market efficiency, which asserts that stock price movements do not exhibit any discernible patterns or trends. According to this hypothesis, the history of stock prices has no influence. The previous trajectory of stock prices does not impact future price movements and, therefore, cannot be utilized to make reliable predictions about future stock prices. Furthermore, explains the logic that the foundation of the random walk model suggests that if information is readily available and swiftly integrated into stock prices, the changes in tomorrow's prices will solely be influenced by tomorrow's news and will be unrelated to today's price changes. As news inherently lacks predictability, the subsequent price changes must also be unpredictable and occur randomly. The idea of stock prices evolving randomly emerges due to the competition among intelligent and rational investors seeking to gain access to pertinent information ahead of the market. In such a scenario, stock prices that fully reflect all current knowledge would naturally follow a random walk pattern. The predictability of stock price movements would indicate a deviation from market efficiency,

as it would suggest that not all available information has already been incorporated into equity prices. Therefore, if the random walk hypothesis is valid, it indicates that the weak form of market efficiency must also be upheld, and vice versa Malkiel (2003).

This model demonstrates that the value of an asset at time $t+1$ is established based on the price at the immediately preceding moment, an expected change term called drift, and an unpredictable error element. The coefficient of drift μ represents the average rate at which prices change, providing an estimation of the expected returns from holding the asset over time. By imposing certain restrictions on the error term ϵ_t , the random walk model can be derived using the martingale process. The characteristics of the error term ϵ_t are crucial, and certain limitations on its behavior give rise to three variations of the Random Walk Model, as described. The most robust form of the random walk model assumes that the changes in price P_t , represented by the error term ϵ_t , adhere to the same distribution (identically distributed) and are independent of each other. Generally, the original distribution is utilized, with the common assumption being that ϵ_t follows a normal distribution with a mean of zero and a constant variance σ^2 . Random Walk I (RW1) is even more stringent than the Martingale Model, as it suggests that the changes are nonlinearly uncorrelated, and any nonlinear combination of changes should also display no correlation. The run test can be used to assess the validity of RW1 (Campbell et al. 1997).

The random walk model (RWM1) is highly constraining and not suitable for analyzing real financial series because it needs to accommodate structural changes in the process of generating data, such as shifts in parameters, specifically alterations in volatility. Another suitable variant, recognized as RWM2 (Random walk model 2), relaxes this restriction by only requiring the increments to be independent without the necessity of originating from an identical distribution. This maintains the characteristic of linear randomness while allowing for changes in unconditional volatility. Filter rules can be used to assess the suitability of the RW2 model (Worthington and Higgs, 2003).

The most common version of the RWM is known as the RW3 model, which only requires that ϵ_t be uncorrelated over time. However, in this version, the squared increments

exhibit correlation, indicating a lack of independence. Consequently, linear forecasting techniques like regression analysis are not applicable to this process. RW3 model is the most commonly examined type of the RWM, with autocorrelation tests utilized for its evaluation. Lo and MacKinlay (1988) suggested a modification to RW3 to incorporate the dependence feature. This approach proved useful in capturing the nature and level of dependence in the noise process. They introduced specific types of heteroscedasticities in the noise process using the heteroscedasticity method developed (White and Domowitz, 1984).

1.2. THE EFFICIENT MARKET HYPOTHESIS (EMH)

Samuelson (1965) laid the groundwork for the Efficient Market Hypothesis (EMH) with his article called 'Proof that Properly Anticipated Prices Fluctuate Randomly.' In this publication, he presented the main concepts that form the basis of the EMH. According to Samuelson's hypothesis, in a market where information is effectively reflected in prices, it is not possible to predict price changes if they already encompass the expectations and information of all market participants. Since news and information are inherently unpredictable, prices are expected to fluctuate randomly. As a result, according to the Efficient Market Hypothesis (EMH), it is not feasible to use any information set to make precise predictions about future price changes (Campbell et al., 1997).

The term "Efficient Markets Hypothesis" was introduced by Harry Roberts (1959), who also distinguished between forms of EMH, i.e. (weak and strong); later, this classification was adopted as the standard in Fama's study (1970), becoming widely recognized in the field. Expanding on the ideas of Samuelson (1965), Fama (1970) published seminal research on the Efficient Markets Hypothesis, and that was the initial installment of three comprehensive review studies. Within this paper, Fama explored both the theoretical aspects and empirical findings concerning market efficiency up to that point. He defined an efficient market as a market where prices consistently and fully incorporate all accessible information. According to this definition, available information must appear unpredictably, and consequently, the resulting fluctuations in stock prices due to new information must also

be unforeseeable. Therefore, the market does not present any opportunities for abnormal profits Blackledge, J., & Lamphiere, M. (2021).

One crucial assumption in market efficiency is that investors possess complete certainty regarding the most effective models for predicting forthcoming profits. Nonetheless, when this assumption is loosened, and investors are no longer presumed to possess knowledge of the accurate forecasting model, the application of the mathematical expectation operator in market efficiency loses its attractiveness. Instead, it becomes significant to explain the markets as locally efficient over the period, considering the information available at specific points in time. Hence, this methodology proves valuable due to an increasing consensus in the literature that forecasting models can be effective for a specific duration, and there may exist time-dependent patterns in asset returns, as will be illustrated subsequently (Timmermann & Granger, 2004).

1.2.1. Underlying Principles of Market Efficiency

The Efficient Market Hypothesis (EMH) is built upon several underlying assumptions, as identified by Shleifer (2000):

- **Assumption of Investor Rationality:** It is postulated that investors act in a rational manner, meaning they evaluate securities in a logical manner and accurately revising their beliefs when new information emerges is a characteristic assumed of investors.
- **Arbitrage:** In cases where some investors are not rational, the assumption is that rational investors engage in arbitrage to exploit any mispricing caused by irrational trades. This arbitrage activity serves to eliminate these inefficiencies without affecting market prices.
- **Collective Rationality Assumption:** It is presumed that any random errors made by individual investors offset each other within the market. While some investors

may exhibit irrational behavior, their trades are random, leading to an overall neutralizing effect on prices.

- Costless information and trades: assumption of information accessibility and Costless trading, it is assumed that information is readily available to all investors in the market and that there are no transaction costs associated with trading securities.

These conditions guarantee that investors with access to available information cannot generate returns surpassing the expected returns in a competitive market. Nevertheless, it is essential to acknowledge that a breach of any of these conditions does not automatically indicate market inefficiency, as the absence of abnormal returns can persist. The paradox of efficient markets arises from the realization that if all investors were to adopt the belief that markets are efficient, it would result in the market becoming inefficient. If everyone believed in market efficiency, there would be no incentive for stock analysis or trading activities since no profits could be generated (Grossman & Stiglitz, 1980). Hence, the efficiency of a market hinges on the involvement of market participants who hold the belief that the market is inefficient and that trading stocks can result in substantial profits (Shleifer, 2000).

If the EMH holds in a stock market, it will indicate that the market prices of stocks serve as reasonable approximations of the intrinsic value of those stocks. Nevertheless, as Shiller subsequently highlights, prices do not serve as reasonable estimates of the underlying value of stocks. This does not imply that errors in prices do not occur or that they need to be corrected. Rather, it signifies that the errors in prices are randomly distributed around the true values. Prices may exhibit periods of being high or low, but the detection of a discernible trend is not feasible. As a result, we have a stock market that operates effectively. However, if the EMH is not valid, it opens the possibility of formulating profitable investment strategies that yield risk-adjusted returns above the average. Such a condition could have adverse implications for the future growth of the market while simultaneously driving the market toward greater efficiency. Consequently, market 'inefficiencies' indicate a transfer of wealth from inexperienced investors to knowledgeable and well-informed investors (Shiller 1984).

1.2.2. Market Efficiency Forms

Fama (1970) categorized the Efficient Market Hypothesis (EMH) into three distinct forms, each relying on diverse evidence and information collections to assess security prices:

- The concept of weak-form efficiency suggests that stock prices encompass all information obtained from analyzing market trading data, such as past price trends, trade volume, and short-selling interest. This version of the hypothesis proposes that any effort to forecast future performance based on trend analysis or technical analysis is pointless. The public can easily access historical data on stock prices at a low cost. If this data could consistently indicate future trends, all investors would have already acquired the knowledge to take advantage of these signals. As a result, once these signals become widely known, their effectiveness diminishes since a buy signal, for instance, would lead to an immediate rise in price.
- The concept of semi-strong-form efficiency states that the stock price reflects all information publicly accessible regarding a company's prospects. Consequently, fundamental analysis is ineffective in determining whether a stock is undervalued or overvalued. This category of information encompasses not only historical prices but also fundamental data relating to the factors considered in assessing a company, including its range of products, the caliber of its management team, the structure of its balance sheet, the patents it holds, its projected earnings, and its accounting practices. The semi-strong form of efficiency proposes that there is no delay in the distribution of public information, indicating that investors promptly receive and adjust their expectations based on such information.
- Strong-form efficiency goes beyond the semi-strong form by stating that stock prices encompass all information available, without any exceptions, including insider information accessible only to individuals within the company. According to this form of efficiency, even insiders who possess information

before it becomes public knowledge cannot earn any additional profits, rendering insider information useless for gaining an advantage. Evaluating the strong-form efficiency is exceptionally challenging since it is nearly impossible to measure or quantify the extent of insider information.

In the hierarchy of market efficiency, semi-strong efficiency encompasses weak efficiency, while strong efficiency encompasses both semi-strong and weak efficiency. Consequently, if weak efficiency is found to be violated, it would signify the rejection of both semi-strong and strong efficiency. In an efficiently functioning market, the present value of security incorporates all the information that is accessible. This guarantees that investors who have access to such information cannot consistently achieve returns higher than the average or expected returns. Extensive theoretical research has been conducted in the field of finance to recognize the behavior of equity prices and evaluate market efficiency (Fama, 1970, p.383).

A market is considered efficient when stock prices and returns are determined through the interplay of supply and demand in a competitive marketplace comprised of rational traders. These rational traders promptly adapt equity prices in reaction to any newly pertinent information. Consequently, investors are unable to consistently generate profits that exceed the overall market returns by obtaining fresh news and information once the risks and transaction charges have been considered (Jensen, 1978).

Throughout the development of the Efficient Market Hypothesis (EMH), various concepts have emerged, including the Martingale Model, which is known as (MM), and the Random Walk models (RWM), as researchers have sought to understand and explain the characteristics of market efficiency.

1.3. FRACTALS AND MULTIFRACTALS

Benoit Mandelbrot, a mathematician, is credited as the founder of the fractal theory, which was established in the 1960s. Since its inception, the theory has been further developed by Mandelbrot and other researchers. The application of fractal and multifractal analysis

spans across various disciplines, including physics, medicine, and social sciences. This multidisciplinary nature has contributed to its advancement. Examples of fractal and multifractal scaling can be observed in phenomena such as heartbeat rates, traffic speed series, blood pressure, ozone concentration, rainfall, river flows, and even language structures in linguistics. Fractal analysis has even been employed to analyze the paintings of artists like Jackson Pollock. When discussing empirical fractal analysis in an economic context, the term "econophysics" is often used, as it utilizes methods originally developed in physics. In addition to studying the scaling of fluctuations in finance, scaling has also been identified in the growth rate of companies (Blackledge et al., 2021)

Mandelbrot (1982) introduced the concept of fractal theory as a means of studying complex and rough patterns, in contrast to the familiar Euclidean measures. The purpose of this section is to provide an overview of fractal analysis without delving into a formal definition. Fractals exhibit a property called self-similarity, where the parts of an object resemble miniature versions of the whole. This means that similar or identical patterns can be observed at various scales. Self-similarity is visually intuitive and can be found in natural phenomena such as tree branches (repeatedly dividing into smaller branches following the same pattern), snowflakes, coastlines, and more (Mandelbrot, 2004). For additional examples, one can refer to Mandelbrot's renowned work, "The Fractal Geometry in Nature" (1982) or consult other sources such as (Brown et al., 2003). Unlike Euclidean geometric objects, which have integer dimensions (e.g., a straight line has a dimension of one, a plane has a dimension of two), fractals possess non-integer dimensions (Los, 2004). In the context of fractals, scientists analyze objects at different scales and search for similarities, which are expressed through scaling laws.

The following definition is derived from Kantelhardt (2008, p. 3):

Definition 2.1 (Scaling Law): A scaling law is characterized by a power law relationship with a scaling exponent (represented as α) that describes the behavior of a quantity F in relation to a scale parameter s , typically in an asymptotic manner: $F(s) \sim s^\alpha$.

The power law should hold over a wide range of scale values, such as spanning at least one order of magnitude.

A fractal system is characterized by a scaling law that exhibits a non-integer scaling exponent. Despite their apparent complexity, fractals possess a fundamental simplicity as a single scaling exponent can describe them. In contrast, multifractal systems are more intricate, and their scaling properties cannot be captured by a single value but require a function of scaling exponents for definition (Kantelhardt, 2008). It is important to note that the definition does not imply that the scaling law must apply to all scales, and caution must be exercised when estimating scaling exponents to avoid working with scales beyond a maximum threshold (Kantelhardt, 2008).

The concepts mentioned above can also be applied to time series analysis. Di Matteo highlights two approaches that are sometimes conflated. One approach, which is not the primary focus of our interest here, involves using different time intervals (e.g., daily, weekly, and monthly data) and examining how the distribution is affected. In the case of a self-similar or self-affine object, the distribution should remain the same. For instance, in financial data, as the time interval increases, the distribution of returns tends to have thinner tails. Another approach involves studying the behavior of a process's path by analyzing sample moments of increments while varying the time interval on which they are computed and searching for a power law relationship. In the empirical part of this study, they adopted the second approach, and thus, in the following section, they define multifractals from this perspective (Di Matteo 2007).

1.4. THE FRACTAL MARKET HYPOTHESIS

Mandelbrot initially introduced the fractal model to characterize a specific category of entities that display intricate behaviors. His approach involved examining objects across various scales and resolutions, comparing, and correlating the outcomes. Applied to financial time series, this method involves employing diverse timeframes ranging from hourly to daily, monthly, and yearly within a single analysis. This diverges significantly from conventional

time series analyses that concentrate on regularly spaced observations at fixed time intervals (Mandelbrot, 1963).

Edgar E. Peters introduced the fractal market hypothesis (FMH) in 1994 as a potential alternative to the Efficient Market Hypothesis (EMH). While the EMH presumes financial markets are in a state of equilibrium, the FMH proposes that markets are not in equilibrium but can attain stability when investors cover a wide range of investment horizons. In contrast to the EMH, the FMH posits that investors assign value to market information based on their specific investment horizons. This suggests that, at any given time, prices might not reflect all available information but only information relevant to a particular investment horizon. The core principles of the Fractal Market Hypothesis (FMH), as outlined by Edgar E. Peters in 1994, encompass several key tenets: (i) Market stability is achieved when investors encompass a broad spectrum of investment horizons. (ii) Short-term elements and market sentiment influence the information set, yet long-term aspects are primarily shaped by fundamental information. (iii) In instances where a market event raises uncertainties about fundamental information, long-term investors might resort to trading based on short-term information. (iv) Prices are reflective of a blend of technical and fundamental analyses. (v) Financial securities exhibit no correlation with the economic cycle, thus showing no discernible long-term trend (Peters, 1994).

The Fractal Market Hypothesis (FMH) emphasizes the significance of liquidity and the initiation of investment based on investor behavior. Its objective is to offer a model that captures investor conduct and market price shifts aligned with investor expectations. Unlike the Efficient Market Hypothesis (EMH) that necessitates Brownian motion for financial securities, the FMH diverges and suggests that price fluctuations adhere to fractional Brownian motion, gauged by the Hurst exponent. This exponent determines whether a fractal time series follows a random walk, maintains a persistent trend, or showcases mean reversion. By applying geometric fractional Brownian motion (GFBM) to interpret stock market index movements, one might infer that the market operates unpredictably, displays inefficiency, and adheres to fractal principles (FMH Ma, H., & Li, Y. 2020).

1.5. THE ADAPTIVE MARKET HYPOTHESIS

Lo (2004) presents a novel approach to address the dynamic nature of market efficiency by drawing inspiration from evolutionary principles. In this view, Lo suggests that incorporating insights from the field of biology can offer valuable perspectives, ultimately calling for an evolutionary alternative to the traditional concept of market efficiency. This proposed framework, known as the Adaptive Market Hypothesis (AMH), aims to reconcile the principles of the EMH and behavioral finance within a coherent intellectual framework. The development of the AMH was preceded by the work of Farmer and Lo (1999); Lo et al. (2002); Farmer (2002) before Lo formalized the hypothesis in 2004.

Lo (2004) asserts that the behavioral biases observed in finance align with the principles of an evolutionary framework, wherein individuals continuously learn and adapt in response to a changing environment. The efficiency of markets, as well as the performance of investments, businesses, and industries, is influenced by the evolutionary forces affecting financial institutions and market participants. Lo (2005) outlines the key principles underlying the Adaptive Market Hypothesis (AMH) as follows:

- Individuals are motivated by self-interest.
- Individuals are prone to making mistakes.
- Individuals have the capacity to learn and adapt.
- Competition drives adaptation and innovation.
- Market ecology is shaped by natural selection.
- Market dynamics are determined by the process of evolution.

Therefore, these principles have practical implications in the field of finance. One of these implications is that the risk premium, which represents the additional return investors demand for taking on risk, fluctuates over time. This variation is influenced by factors such as the prevailing stock market conditions and the demographic characteristics of investors participating in that market. For instance, in the United States, the recent absence of a significant downturn in the stock market has shaped the risk preferences of investors who have yet to experience a prolonged bear market. Consequently, regardless of whether stock

prices fully reflect all available information, the historical trajectory of market prices in recent years has an impact on the collective risk preferences of investors at present (Lo, 2004).

The second implication, which contradicts the Efficient Market Hypothesis, is the existence of arbitrage opportunities in the market from time to time. Andrew Lo refers to Grossman and Stiglitz (1980), who argue that the presence of profit opportunities is necessary to incentivize the gathering of information and ensure the functioning of price discovery in financial markets. Therefore, from an evolutionary perspective, the existence of active and liquid financial markets suggests the presence of profit opportunities. However, as these opportunities are exploited, they diminish. Nonetheless, new opportunities continually arise as certain market conditions change. Instead of moving towards higher efficiency, the Adaptive Market Hypothesis suggests that complex market dynamics, such as trends, panics, bubbles, and crashes, are regularly observed in natural market environments (Lo, 2004)

The third implication is that the success of investment strategies is contingent upon specific market conditions. In contrast to the Efficient Market Hypothesis, the Adaptive Market Hypothesis suggests that these strategies may experience periods of decline only to regain profitability when environmental conditions become more favorable for such trades. Andrew provides an example of this phenomenon by examining the rolling first-order autocorrelation of monthly returns of the S&P Composite Index from January 1871 to April 2003. The study reveals that the level of market efficiency fluctuates cyclically over time, with certain periods in the 1950s exhibiting greater efficiency compared to the early 1990s (Lo, 2005)

While the Efficient Market Hypothesis (EMH) does not explicitly rule out the existence of cycles in theory, its empirical implementations have generally overlooked these dynamics and assumed a world where markets move inexorably toward efficiency. In contrast, the Adaptive Market Hypothesis (AMH) suggests that market efficiency is not a fixed state but rather a characteristic that can vary continuously over time and across different markets. One implication of the AMH is those certain characteristics, such as value and

growth, can behave like "risk factors" during specific periods. This means that stocks with these attributes may exhibit higher expected returns when those attributes are in favor. For instance, during the late 1990s US technology bubble, growth stocks yielded higher expected returns compared to value stocks, only to reverse course when the bubble eventually burst. Unlike the EMH, the AMH does not impose restrictions on what can be considered a risk factor. The presence of such non-stationarity poses challenges for the EMH, highlighting the dynamic nature of market efficiency according to the AMH. According to Lo (2005), the belief that financial markets will inevitably converge to a state of equilibrium characterized by perfect efficiency is flawed. Lo argues that such convergence is neither assured nor probable. Instead, the Adaptive Market Hypothesis (AMH) acknowledges the existence of intricate market dynamics, including cycles, trends, crashes, and bubbles. These phenomena play a significant role in shaping and influencing financial markets, highlighting the need for a more nuanced understanding of market behavior beyond the notion of a predetermined ideal state of efficiency.

The Adaptive Market Hypothesis (AMH) has garnered significant attention in recent academic literature. Neely et al. (2009) conducted a study exploring the AMH; however, their focus was on examining the declining returns of trading rules over time and the rate at which this decline occurs. Their implicit assumption was that if the returns decline at a slow rate, it could indicate evidence of the AMH. In contrast, Lo (2005) argues that in an adaptive market, trading strategies may experience periods of decline but can subsequently regain profitability when market conditions become more favorable for such trades. Lo suggests that trading rules not only decline but also have the potential to yield profits again when the environmental conditions are conducive. Therefore, while Neely et al. (2009) demonstrates the decline of specific trading rules, they do not provide evidence of an adaptive market as defined by Lo (2005).

Lim and Brooks (2006) conducted a study to examine the changing efficiency of developed and developing stock markets using the portmanteau bi-correlation test statistic. Employing a rolling sample approach, they discovered that the level of market efficiency undergoes cyclical fluctuations over time. Todea et al. (2009) investigated the profitability

of the moving average strategy over different time windows using linear and nonlinear tests from 1997 to 2008. They observed that returns are not consistent over time but rather exhibit episodic behavior, with sub-periods displaying both linear and nonlinear correlations. Based on their findings, they concluded that the degree of market efficiency varies cyclically over time, aligning with the propositions put forth by the AMH.

Ito and Sugiyama (2009) conducted a study to analyze the time-varying autocorrelation of monthly S&P500 returns. Their findings demonstrate that the level of market efficiency varies over time, with the market being least efficient during the late 1980s and most efficient around the year 2000. Similarly, Kim et al. (2011) investigated the AMH by examining the return predictability of daily and weekly DJIA from 1900 to 2009. They employed two autocorrelation tests (variance ratio and portmanteau) and a generalized spectral test to measure the monthly degree of stock return predictability using moving subsample windows. Their research provides strong evidence that return predictability fluctuates over time, which is consistent with the observations made by Lo. They also found that the US market has become more efficient after 1980.

Additionally, they utilized regression analysis to explore the relationship between changing market and economic conditions and return predictability over time. They discovered that there is no return predictability during market crashes, while economic and political crises are associated with a high degree of return predictability. Smith (2011) investigated the adaptive nature of fifteen European emerging stock markets and the developed markets of Greece, Portugal, and the UK. Using rolling window variance ratio tests from February 2000 to December 2009, they identified the Turkish, UK, Hungarian, and Polish markets as the most efficient, while the Ukrainian, Maltese, and Estonian markets were the least efficient. The results from all eighteen markets provide evidence of the time-varying nature of return predictability, aligning with the principles of the adaptive markets hypothesis.

Lim et al. (2013) conducted a study to investigate the return predictability of the three major US stock indices. They employed two data-driven tests, namely the automatic

portmanteau box Pierce test and the wild bootstrapped automatic variance ratio test. By utilizing a rolling window spanning from 1969 to 2008, they observed patterns in the time-varying nature of return predictability that align with the principles of the adaptive market's hypothesis. They found that significant return autocorrelations were prevalent during periods characterized by major exogenous events.

Moreover, recent empirical studies indicate that market efficiency is not constant and can vary across different periods (Lim & Brook, 2011). In response to this evolving understanding of market efficiency, Lo (2004) introduced a new framework called the Adaptive Market Hypothesis (AMH). Lo argues that the extensive body of research on market efficiency has sparked a debate among scholars, particularly in relation to the lens of rationality. The assumption of rational decision-making, a fundamental aspect of the Efficient Market Hypothesis (EMH), can be challenged, as individuals do not always strictly adhere to rational behavior, as evidenced by the field of behavioral finance. The Adaptive Market Hypothesis (AMH) integrates the concepts of rationality and behavioral biases within a heuristic evolutionary framework. The underlying premise of the AMH draws upon the sociobiological theory of evolutionary behaviors, connecting the realms of economics and finance with evolutionary perspectives. In this framework, individual optimization is not achieved through analytical means but rather through a process of trial and error akin to natural selection. The decision-making of individuals is influenced by past outcomes, with choices being shaped by negative or positive reinforcements.

During periods of the financial crisis and the COVID-19 pandemic, it is common for investors, brokers, and decision-makers to exhibit behaviors driven by the desire to avoid losses, often leading to irrational actions. Market sentiments can be manipulated by influential players, causing imbalances. Despite regulatory measures, there remains a disparity in knowledge among investors, resulting in information asymmetry. Market shifts reveal abnormal information, triggering panic among participants, which in turn can cause the market to reach excessive and unsustainable levels.

This study examines the market efficiency of OIC's stock market. The study includes 15 countries' stock indices¹ and sector indices² data from OIC members during the Global Financial crisis and COVID-19. The Organization of Islamic Cooperation (OIC) comprises 57 member states spanning four continents, making it the second largest organization globally, following the United Nations. The OIC serves as a unifying platform for the Muslim world, representing their collective voice. Its primary objective is to safeguard and uphold the interests of the Muslim community, with a strong commitment to fostering international peace and promoting harmony among diverse populations worldwide. The establishment of the Organization of Islamic Cooperation (OIC) dates to the significant summit held in Rabat, Kingdom of Morocco, on 12th Rajab 1389 Hijra (25 September 1969). This decision was prompted by the destructive act of arson committed against the Al-Aqsa Mosque in occupied Jerusalem. While extensive research has been conducted on the Efficient Market Hypothesis (EMH) and the Adaptive Market Hypothesis (AHM) using the multifractal detrended fluctuation analysis (MFDFA) method, it appears that the OIC countries have been largely overlooked by researchers. To the best of my knowledge, there has been no comprehensive research that encompasses all aggregate indices and sector indices during both the Global Financial Crisis and the COVID-19 pandemic for these countries.

Financial risk management has emerged as a crucial concern, particularly in the wake of the global financial crisis in 2007. Previous approaches to financial risk management primarily relied on simplistic time series models, such as the Gaussian model, to analyze the dynamics of the financial market. However, the reality of the financial market encompasses numerous complexities that cannot be adequately captured by these conventional models. Nevertheless, the dynamics of an actual financial market encompass various attributes that elude explanation through traditional simplistic time series models. One such manifestation is the presence of a thick tail in the probability distribution of returns, indicating the occurrence of extreme events with higher frequency than expected.

Additionally, the left tail of the negative return distribution exhibits an even greater degree of asymmetry, suggesting a more pronounced propensity for substantial losses. Furthermore, the financial market exhibits a jump phenomenon characterized by sudden and

substantial movements in stock prices. These abrupt shifts deviate significantly from the expected gradual changes. Additionally, a momentum phenomenon is observed, where the market displays a persistent trend in a particular direction, with changes occurring consistently in that same direction over a period.

The act of predicting and forecasting financial time series has long been prevalent in financial markets, as individuals aspire to outperform the market and achieve financial gain with minimal effort or time investment. There are multiple approaches to market analysis, with fundamental and technical analysis being the two prominent ones. Fundamental analysis centers on assessing the intrinsic value of an asset by examining its underlying factors and economic indicators. When it comes to stocks, fundamental analysis involves examining financial statements, such as a company's revenues, expenditures, and profits, as well as considering the overall economic conditions of the relevant industry. On the other hand, technical analysis focuses on predicting price movements based on historical patterns, trends, and sometimes seasonal factors. Technical traders utilize a range of technical indicators such as the Moving Average (MA), Relative Strength Index (RSI), Moving Average Convergence Divergence (MACD), and others. These indicators are used to analyze historical price and volume data, aiming to identify trends, potential turning points, or patterns in financial markets. Another technique in technical analysis involves using statistical or econometric models to estimate market behavior and make predictions. This approach utilizes the statistical properties of the data or employs econometric models to analyze market trends and make forecasts.

The financial crisis of 2008 inflicted significant economic turmoil in the United States, with potential spillover effects observed in other nations. In response, the US government and policymakers from various countries implemented bailouts and regulatory adjustments to mitigate the adverse impacts on their respective economies. Nevertheless, the extent to which the US financial crisis directly transmitted to other countries remains uncertain, and whether it can be classified as a contagion is a subject of debate. Past research has yielded contradictory results regarding the occurrence of international contagion. Forbes and Rigobon (2002) conducted a study analyzing financial crises spanning from the 1997

East Asian Crisis to the 1987 US Stock Market crash. They discovered that during these crises, there was an elevated level of co-movement among international stock markets, primarily driven by heightened volatility. Upon considering the amplified volatility, Forbes and Rigobon (2002) observed minimal indications of contagion. This implies that the effects of the 2008 financial crisis might be attributed more to interdependence among economies rather than a contagious spread of financial turmoil.

Financial theory has long sought to comprehend the inner workings of financial markets and establish models that can effectively capture the dynamics of financial data. The advancement of empirical research in examining the statistical characteristics of financial time series has played a vital role in enhancing the accuracy of models and forecasts. Of particular interest to this thesis is the concept of multi-scaling, which has recently emerged as a noteworthy property observed in financial series (Di Matteo et al., 2005)

Financial risk management is a critical concern that has gained heightened significance since the onset of the global financial crisis in 2007. Traditional theories of financial risk management have often relied on simplistic time series models, such as the Gaussian model, to analyze the complexities of financial markets. However, it has become evident that real financial markets possess numerous characteristics that cannot be adequately explained by these conventional models. One notable characteristic is the presence of a heavy-tailed probability distribution of returns, with a pronounced asymmetry in the left tail of the negative return distribution. Additionally, financial markets exhibit a jump phenomenon, where stock prices undergo sudden and significant movements, as well as a momentum phenomenon, where prices continue to change in a consistent direction. Moreover, the volatility of returns demonstrates heteroscedasticity, indicating varying levels of volatility over time and a mean reversion phenomenon, where returns tend to revert to their long-term average. Due to the presence of these distinctive characteristics, the traditional Gaussian time series model falls short in accurately explaining the dynamics of the real financial market, especially during significant events like the global financial crisis. To address this limitation, researchers have turned to econophysics theories, which offer

insights into the intricacies of financial markets. One such theory is multifractality, which captures the multifaceted nature observed in financial time series data (Morales et al., 2012).

The multifractal property refers to the occurrence of multiple simultaneous fractal dimensions within a time series. In contrast, when the fractal dimension remains constant, it is referred to as monofractal. Multifractal time series exhibit distinct characteristics such as heavy-tailed probability distributions, volatility clustering, and long-term memory effects. To quantify the long-term memory, which plays a crucial role in determining multifractality, the Hurst exponent is commonly employed. Multifractal analysis has been utilized in various studies to explore different aspects of the financial market. These include stock market prediction (Selvaratnam & Kirley, 2006; Domino, 2011), forecasting market collapses (Grech & Mazur, 2004; Grech & Pamuła, 2008), modeling financial time series (Tzouras et al., 2015), developing trading strategies (Dewandaru et al., 2015), examining market efficiency (Wang et al., 2009), and other related areas.

In the field of financial market research, there has been a growing focus on asymmetric correlations in recent years (Ding et al., 2011; Cao et al., 2014; Baruník et al., 2016). Investigating asymmetric correlations helps identify the distinctive features of asymmetric risks, which have practical applications in areas such as risk management and diversified investment strategies. Downside movements in international markets exhibit significantly higher correlations compared to upside movements, a phenomenon that amplifies the risk associated with market crashes. Consequently, market downturns pose greater threats to financial stability. Considering this, portfolio reallocation becomes crucial, as correlations may vary depending on the prevailing financial market conditions, requiring adjustments to ensure optimal risk management.

The efficient market hypothesis (EMH) serves as a framework for understanding information efficiency in financial markets, asserting that the stock market incorporates all relevant past information. Theoretically, the stock market is considered unpredictable; however, empirical evidence reveals the presence of long-range memory in real stock market data. The measurement of the generalized Hurst exponent provides a means to identify and

quantify this long-range memory phenomenon. Multifractal theory, while providing insights into overall market efficiency, has certain limitations when it comes to identifying the specific sources of inefficiency. These sources can stem from factors such as false optimism during periods of excessive bullishness in the market or extreme fears during phases of bearishness, typically observed during times of crisis. To overcome this limitation, the asymmetric long-range dependence and multifractality of each market trend are measured using an asymmetric generalized Hurst exponent derived from the price-based A-MFDFA (Asymmetric Multifractal Detrended Fluctuation Analysis) model. This approach aims to shed light on the factors contributing to market inefficiency by comparing the multifractal properties, including long-range dependence and multifractality, between uptrends and downtrends. The suggested test for asymmetric long-range dependence and multifractality is implemented across multiple countries, utilizing a moving-window approach to examine the impact of financial market crises on the asymmetric multifractal characteristics of the market.

The market efficiency information during the global crisis period, i.e., financial crisis or Pandemic like COVID-19, plays a vital role as it provides information regarding trading and strategic activity of the investor of the stock market related to the profitability outcomes generated during the inefficient market. The crux of this study is that it is appropriate to specify that if the market efficiency level improved (market inefficiency decreased), proposed that market returns and profit are less predictable and able to predict, and if the level of market efficiency decreased or reduced (increased inefficiency) proposed that market becomes more able to forecast and predictable to use the available information set and inversely.

The multifractal detrended fluctuation analysis (MFDFA) was conducted using different scaling windows, s while keeping the order parameter, q , constant. Like the approach taken by Ghazani and Khosravi (2020), the values of q were selected from the range of -10 to 10. This choice was made because q needs to encompass both positive and negative values to capture multifractality for both significant and minor fluctuations. Additionally, it is important for q to be large enough to cover a wide range of the singularity spectrum. Alternatively, an extremely large modulus, q , disrupts the accuracy of estimating the

singularity spectrum, $f(\alpha)$. As a result, this research restricts q within the range of ± 10 . Therefore, the study will help investors take appropriate strategic action to make some abnormal profits.



2. CHAPTER 2: DEVELOPMENT OF STOCK MARKETS OF THE ISLAMIC COOPERATION ORGANISATION MEMBER STATES

The Organization of Islamic Cooperation (OIC) comprises rapidly emerging markets and natural resources-rich nations, standing as the second largest regional bloc globally. However, among its 57 member countries, only 33 possess active stock exchanges, and these markets feature notably fewer domestically listed companies compared to other developing and emerging markets. The resulting lower liquidity contributes to heightened volatility, reflecting both market shallowness and limited integration with global markets, which stands as a primary challenge within OIC stock markets. The Organization of Islamic Cooperation (OIC) is recognized as the second largest inter-governmental body following the United Nations, boasting a membership of 57 nations spanning four continents. Its inception dates back to September 25th, 1969, originating from a summit decision in Rabat, Morocco, initially comprising 30 founding Members and later expanding to 57 countries by 2010 (Organization of Islamic Countries –OIC, 2010). However, the current OIC Charter, delineating the organization's objectives, principles, and core purposes to fortify solidarity and collaboration among its members, was ratified during the 11th Islamic Summit held in March 2008 in Dakar, Senegal. For a considerable time, economists have directed their focus toward understanding how financial development contributes to the economic growth of nations. The stock market is commonly perceived as a gauge of economic performance, given its role in allocating capital necessary for sustained economic expansion. With the aftermath of the recent global crisis, there has been amplified scrutiny on emerging and developing markets, assessing their resilience in handling capital inflows without facing market crashes. Despite its global presence and promising potential, the Organization of Islamic Cooperation (OIC) has faced criticism regarding its underdeveloped and illiquid stock markets (COMCEC Financial Outlook 2022).

2.1. THE STRUCTURE OF THE STOCK MARKETS OF THE ORGANISATION OF ISLAMIC COOPERATION ECONOMIES THE PRE-CRISIS PERIODS

Despite being home to some of the wealthiest nations with substantial oil and gas reserves, relatively limited research has focused on these countries. The Pew Research Center notes that Muslims constitute 23.2% of the global population, representing the fastest-growing religious group worldwide. However, only 20% of Muslims reside in the Middle East–North Africa (MENA) region, while the majority, 62%, are distributed across the Asia-Pacific region. Muslim-majority nations are making significant strides toward greater development. According to the Statistical, Economic and Social Research and Training Centre for Islamic Countries, countries like Indonesia, Saudi Arabia, Turkey, and Iran stood among the fastest-growing economies in 2015, showcasing substantial economic prominence. When discussing Islamic countries, the Organization of Islamic Cooperation (OIC) emerges as a pivotal entity, given its composition of Muslim or Muslim-majority nations. As per its charter, the OIC is dedicated to preserving Islamic social and economic values. In its pursuit of fostering economic growth among member countries, the organization endeavors to establish an Islamic Common Market, aiming to bolster intra-Islamic economic and trade collaboration to achieve economic integration (Organization of Islamic Cooperation, 2014). Serving as a regional bloc, the OIC holds substantial importance for Muslim nations globally, offering a platform for unity and fostering economic development among Muslims worldwide. Between 2010 and 2014, OIC countries experienced notable economic growth, with their gross domestic product (GDP) climbing from US\$ 13 trillion to US\$ 16.2 trillion. Concurrently, the average GDP per capita rose from US\$ 8,461 in 2010 to US\$ 9,884 in 2014. Despite a decline in the annual real GDP growth rate from 6.2% during 2005–2007 to 2.1% in 2009 due to the financial crisis, the OIC countries maintained positive growth throughout the crisis. Moreover, the collective average real GDP growth rate of OIC nations consistently surpassed the global and developed countries' averages. Although trade among OIC countries increased to US\$ 556 billion in 2008, it dipped to US\$ 421 billion during the global financial crisis period (Arshad, S. 2016). In the aftermath of the global crisis, the Organization of Islamic Cooperation (OIC) received

10% of the world's foreign direct investment (FDI) inflows, amounting to US\$ 132.3 billion in 2014. Among OIC members, notable recipients of FDIs in 2012 included Indonesia, Turkey, Saudi Arabia, Malaysia, UAE, and Nigeria. These countries collectively attracted 61% of the total FDI flows into the OIC (Arshad, 2016).

The surge in foreign direct investment (FDI) in OIC member nations raises concerns about the capacity of their stock exchanges to handle capital inflows. Presently, the stock markets in OIC countries suffer from underdevelopment and inefficiency. Only 33 member countries possess active stock exchanges, with some being recently established and others prohibiting foreign participation. Many of these exchanges experience low liquidity levels, resulting in heightened market volatility. This is evidenced by the limited number of domestically listed companies, weak market capitalization, and low-value traded. Challenges within OIC stock exchanges are further compounded by inadequate regulatory frameworks, ineffective information dissemination channels, high information costs, and a lack of product differentiation. The Organization of Islamic Cooperation (OIC) has encountered economic recessions, with instances like Malaysia and Indonesia significantly impacted by the 1997 Asian financial crisis. Over the past two decades, countries like Turkey, Pakistan, Kuwait, and others have faced internal crises, including bank runs, stock market crashes, and political instability. Additionally, there exists substantial disparity in financial development across OIC nations. Some countries—such as Malaysia, Turkey, Jordan, and the Gulf Cooperation Council (GCC) members—stand as advanced economies with well-established financial, banking, and insurance institutions. Conversely, other member nations are at varying stages of financial development, indicating considerable room for enhancing their institutional environments and financial sectors (COMCEC Financial Outlook 2022).

Previous literature indicates that stock markets in Islamic countries, spanning both the Middle East–North Africa (MENA) and Asia regions, exhibit characteristics such as smaller size, higher volatility, lower liquidity, and increased susceptibility to higher risk premiums, elevated funding costs, and inadequate legal and governance frameworks in contrast to the efficiency observed in developed nations' stock markets. These inefficiencies are often linked to poor information quality, elevated trading costs, disintermediation, and

limited trading activity due to investment barriers arising from protectionist measures and inadequate integration with global markets. Given the growing interest in the Organization of Islamic Cooperation (OIC), there arises a pressing need for enhanced infrastructural foundations within these markets to effectively accommodate and process increased investments. Consequently, there's an urgent requirement to assess stock market efficiency in light of rising foreign direct investments (FDIs) into these markets (Rizvi et al., 2014).

The study conducted by Arshad (2016) reveals variations in overall efficiency across countries concerning both short and long-term perspectives. In the short term, Turkey consistently emerged as the most efficient market throughout the observed period, while Egypt demonstrated the least efficiency. However, in the long term, Turkey's ranking declined to second place, with Kuwait identified as the least efficient market. Turkey's initial position as the most efficient stock market aligns with its market development stage, notably in terms of trading volume, market capitalization, and economic stability.

Arshad (2016) highlights that the Malaysian stock market exhibited higher efficiency during recessionary phases following the 2008 and 2010 recessions compared to subsequent boom periods. This phenomenon reflects the market's recovery after the global financial crisis of 2008. In the short term, the Malaysian market displayed peak efficiency during the 2007–2008 expansion, attributed to ample liquidity in the financial system, a robust reserve position, and a stable banking system. Notably, the market retained high efficiency in 2005, a year marked by the shift away from the fixed exchange regime. This alteration in fundamentals had a more profound impact on the market's long-term efficiency compared to its short-term implications.

During the recessionary period of 2006–2007, efficiency in Indonesia's market was higher than in the subsequent boom phase. This contrast can be attributed to increased volatility following the country's credit crunch in 2006. In the ensuing boom phase (2007–2008), Indonesia underwent substantial growth, fostering heightened short-term activity and speculation, consequently amplifying market volatility. Interestingly, Indonesia exhibited its highest short-term efficiency during the period of 2010–2014 (Arshad, 2016).

Butler and Malaikah (1992) conducted a study focusing on the Kuwaiti and Saudi Arabian stock markets. Their research delved into the behavior of individual stock returns within these markets spanning from 1985 to 1989. They observed that all 35 of the Saudi stocks displayed a substantial deviation from the random walk theory, indicating a lack of independence over the period studied. In the case of Kuwait stocks, they found a significant first lag of 36% in autocorrelation, with 14 out of 36 stocks violating the independence assumption at a 5% confidence level.

During the critical 2008–2010 phase in Pakistan's stock market, characterized as a business cycle boom, there was notably high inefficiency recorded at 8.22 in the short term. However, this data point is viewed as an anomaly and is subsequently disregarded. Despite this anomaly, in 2009, the economy experienced substantial inflows amounting to US\$ 7.8 billion, contributing to a significant surge in volatility. Pakistan faced a decrease in foreign investment, leading to a spike in short-term volatility. The Turkish market displayed its lowest efficiency during the 1998 recession period, registering 0.23 due to heightened stock market volatility stemming from capital inflows totaling US\$ 925 million. Notably, during this period, short-term efficiency was lower than long-term efficiency, primarily due to a surge in short-term capital inflows amounting to US\$ 2.9 billion. Similarly, long-term efficiency reached its nadir during the 1999–2000 recession, marked by a significant economic downturn in Turkey. This downturn correlated with the Russian crisis in mid-1998 and the Brazilian crisis in 1999, both of which severely impacted the Turkish economy and stock market (Arshad, 2016).

Study conducted by the Arshad (2016) which shows that the Turkey exhibited its highest long-term efficiency during the 2007–2008 recession, a notable period marked by substantial reforms within the country. This surge in efficiency can be attributed to Turkey's proactive measures in restructuring its financial framework, launching initiatives like the Banking Regulation and Supervision Agency and the Banking Sector Restructuring and Rehabilitation Program, popularly termed the Istanbul Approach. These endeavors aimed to fortify the financial sector. Consequently, the economy experienced growth, leading to a substantial increase in stock market efficiency compared to previous periods. Further the

study explored that Egyptian market exhibited higher efficiency during the boom phase of 2000–2001 compared to the subsequent recession, contrary to expectations. This anomaly can be attributed to increased volatility within the stock market during that period. The era was marked by trading frictions and challenges, including limited provision of information to market participants, compounded by restricted financial intermediation, thereby impairing market efficiency during the subsequent recession.

In addition, Arshad (2016) results show that Egyptian market demonstrated its highest efficiency in the post-recession phase of 2009–2010, recording a low of only 0.05 in the short term, contrary to expectations considering the significant impact of the crisis on the Egyptian economy due to its heavy reliance on the USA for exports. This unexpected efficiency during the crisis period could be attributed to the limited exposure of the Egyptian financial sector in the global arena, allowing the stock market to maintain stability. Conversely, in the long term, the stock market remained most efficient during the boom period of 2004–2008, registering 0.07.

The Kuwaiti market exhibited its highest short-term efficiency during the 2009–2010 period and its highest long-term efficiency between 2001 and 2005. These periods marked economic expansions, signifying significant growth in the economy, which positively impacted the stock market, enabling considerable growth. Conversely, Kuwait experienced its lowest efficiency, both in the short and long term, during the 1998–2001 phase. This decline in efficiency was primarily attributed to the political instability prevalent in Kuwait during that period. The country was involved in coalition-led military operations like Operation Desert Thunder and Operation Desert Fox, contributing to the instability affecting the stock market's efficiency. The UAE stock market exhibited its highest efficiency during the 2008–2009 recessionary phase in the short term while showing its least efficiency in the long term at 0.362. This period was marked by the UAE's close ties with US markets, leading to substantial portfolio losses of up to 42%, compounded by the Dubai debt crisis in 2009, which further impacted market performance. Conversely, during the recession in 2002, the short term displayed the highest inefficiency at 0.32. This heightened inefficiency during the period is reflected in the lower level of Foreign Direct Investments (FDIs) received despite

the market's anticipated attractiveness. Additionally, the market was still recuperating from the 2001 crisis and experiencing fluctuations in global oil prices, further contributing to its inefficiency. Indeed, the Saudi Arabian stock market displayed notable inefficiency during the 1998–1999 period. This coincided with a challenging phase for the Saudi Arabian economy due to the impact of low oil prices in 1997 and the simultaneous increase in oil production by non-OPEC countries. These factors contributed to heightened volatility and inefficiency within the stock market, marking it as the peak period of inefficiency for both short-term and long-term perspectives. The Tadawul, in an event referred to as Riyadh's Black Monday, experienced a drastic 20% plunge in 2006, resulting in a market collapse. The volatility primarily stemmed from an excess influx of investments. With the country benefiting from oil revenues, domestic investors opted to channel their funds into the stock market, leading to a speculative bubble that eventually burst. Although this surge in volatility occurred, the efficiency of the stock market remained intact during this period (Arshad, 2016).

Moreover, the study of Arshad (2016) revealed that the Qatar stock market displayed an anomaly in efficiency, rejecting values higher than 1.0 from the analysis. Consequently, the least efficient period for Qatar was during the 2005–2007 recession in the short term, as indicated in Table 5.15. Interestingly, Qatar implemented significant financial market liberalization in 2005, removing restrictions on foreign participation. Surprisingly, despite these changes, the market was recorded as inefficient during this period. This contrasts with prior studies suggesting that financial liberalization tends to have a positive impact on market efficiency. Also, she enlightens and examines the weak-form efficiency across 11 major OIC member countries, evaluating efficiency levels while considering various economic phases impacting each country. The analysis indicates an overall trend of improving efficiency across the sample period. Although the findings generally align with conventional economic intuition, which suggests better efficiency during economic booms than busts, there are instances where the data deviates from this trend. However, these deviations often align with specific economic, political, or contextual factors that could have influenced the stock market dynamics during those periods.

2.2. THE STRUCTURE OF THE STOCK MARKETS OF THE ORGANISATION OF ISLAMIC COOPERATION ECONOMIES DURING THE CRISIS PERIODS

In recent years, the impact of political instability (PI) on financial market performance has been a subject of extensive discussion and debate due to its significant implications. It is disheartening that those numerous conflicts—16 major wars, coups, ethnic insurgencies, revolutions, religious and political crises—have plagued Muslim countries, contributing to their current predicament despite their abundant, largely untapped natural resources. These nations, despite their potential, have lagged behind their global counterparts due to post-World War II conflicts, soaring levels of inflation and unemployment, political turbulence, inequality, and widespread corruption. While several Southeast Asian developing countries have transformed into developed economies, OIC member nations grapple with enduring political instability, economic and political suppression, and persistently high unemployment rates. This situation has sparked widespread Arab Spring movements, marked by extensive revolutions across many OIC countries. Recent empirical studies, especially following the latest financial crisis, have underscored the link between stock markets and political instability. Lehkonen and Heimonen (2015) suggested that reduced political risk could lead to higher portfolio and stock returns.

Conversely, Huang et al. (2015) discovered a positive correlation between government bond yields and international political risks. Political instability's impact extends to economic growth, evident in the declining growth rates experienced by several countries. For instance, there were negative growth rates of -0.74% in KSA in 2017 and correspondingly -1.5% and -4.7% in Qatar and Kuwait (World Development Indicators, WDI, 2020).

Despite an increase in investments, the proportion of OIC countries in global investments has not notably risen in recent years. In 2019, OIC nations represented 12.2% of global public investments, a modest uptick from 9.2% in 2000. Additionally, they

accounted for 12.5% of global capital stocks, slightly up from 11.6% in 2000. Among the OIC member countries, the top five collectively contributed 58.3% of the total public investment between 2010 and 2019, with Saudi Arabia leading the group, holding a substantial 22.7% share of total public investments within the OIC. Similarly, the share of OIC countries in global private investments increased from 9.7% in 2000 to 12.3% in 2019. Throughout the period of 2010-2019, three OIC nations jointly represented 55.8% of the total private investments within the OIC region. These countries were Indonesia (27.6%), Turkey (19.7%), and Saudi Arabia (8.5%), showcasing a notable concentration of private investments within a limited number of OIC countries. The latest available data indicates that OIC member countries had notably higher average unemployment rates compared to both the world and non-OIC developing countries between 2000 and 2015. Throughout this period, total unemployment rates in OIC countries fluctuated between 8.1% and 7.5%. Post the global financial crisis, developed countries witnessed a surge in unemployment rates from levels below 6% to over 8%. From 2009 to 2013, the average unemployment rate in developed countries remained higher than that in OIC countries. By 2015, OIC countries recorded a rate of 7.5%, while it was estimated at 6.8% in developed countries (COMCEC Financial Outlook 2022).

After the global financial crisis, real interest rates in the US plummeted to negative levels. Subsequently, from 2015 onwards, inflation rates began rising in tandem with interest rates. It is anticipated that this trend will lead to the real interest rate reaching a zero level by 2018. One of the pivotal financial developments that impacted global financial markets post the Global Financial Crisis was the adoption of unconventional monetary policy measures by major developed economies. This practice, known as quantitative easing, was implemented to address economic challenges and stabilize financial conditions (OIC Outlook, O. E. 2016).

The existing disparities in savings and technology within many developing and OIC countries accentuate the significance of multinational enterprises and Foreign Direct Investment (FDI) in fostering growth, innovation, job creation, and sustainable development. However, an analysis of FDI performance in OIC countries indicates that several are yet to

realize their full potential, with limited capacity to attract substantial FDI inflows. Between 2013 and 2019, FDI inflows to OIC countries decreased from US\$ 129.8 billion to US\$ 114.4 billion. The onset of the COVID-19 pandemic exacerbated this situation, leading to a decline in FDI inflows across most OIC countries. In 2020, FDI inflows further declined to US\$ 100 billion, marking a 12.6% reduction compared to 2019. Notably, a high level of concentration is observed in FDI within the OIC group, with the top 10 OIC countries receiving 73% of the total FDI flows in 2020. Moreover, cooperation among OIC countries regarding FDI remains below optimal levels, as indicated by limited available data, showing only a handful of countries benefiting significantly from intra-OIC FDI (SESRIIC OIC Investment Outlook 2022).

The prevailing investment environment significantly shapes both the quality and quantity of investments, influencing their developmental impacts. Consequently, identifying the primary obstacles to investment holds crucial significance within OIC countries. An analysis conducted using specific indicators and indices designed to evaluate countries' investment ecosystems comparatively highlighted that, on average, OIC nations face multiple barriers that deter investment. Consequently, these countries tend to attain comparatively less competitive scores, as observed in metrics like the Global Entrepreneurship Index (GEI) provided by the World Economic Forum. The study findings also shed light on efforts made by several OIC countries to enhance their investment ecosystems, primarily through the adoption of regulatory or institutional reforms. For example, across all dimensions of the World Bank's Ease of Doing Business Index (EDBI), OIC countries implemented a total of 1289 reforms between 2005 and 2020. However, the pace and extent of reforms vary significantly among these nations. In several OIC countries requiring more comprehensive reforms, the progress and scope of these reforms have been insufficient. The sluggish reform pace often correlates with higher country risks, leading to increased investment deterrents, elevated financing costs, and augmented insurance premiums for investments. Before the onset of the COVID-19 outbreak, the collective OIC countries were grappling with substantial investment shortfalls. This predicament stemmed from constrained savings, challenges within the investment ecosystem, and unutilized investment funds and savings.

The amplified uncertainties arising from the pandemic outbreak further aggravated these pre-existing investment gaps across numerous sectors. Consequently, the foreign direct investment (FDI) numbers within the OIC countries remained below the potential levels observed before the pandemic outbreak (COMCEC Financial Outlook 2022).

Furthermore, COMCEC Financial Outlook 2022) talk about the existing infrastructure gaps in OIC nations demand substantial investments, necessitating support from both regional and international institutions, alongside concerted efforts from the public and private sectors. However, it is crucial for OIC countries to create a conducive investment climate that offers equitable opportunities for all investor types. The research underscores the importance of implementing a series of policy measures and reforms aimed at enhancing the investment landscape in OIC countries, encouraging diverse forms of investments. Recognizing the significant synergies between public, private, and foreign investments in driving economic growth, increasing private involvement in public investments, such as through Public-Private Partnerships (PPPs), can yield notable efficiency improvements. Thoughtfully crafted economic policies can aid OIC countries in effectively allocating resources for varied investment requirements and fostering collaboration among different investor categories. The study underscores the pivotal role of political determination in attracting new investors and encouraging existing ones to amplify their investments. Overall, strategies like fortifying public investment, catalyzing private investment, augmenting FDI, refining the investment ecosystem, identifying priority sectors for investment, and mobilizing investment capital could substantially address investment gaps, stimulate economic growth, and promote sustainable development across the OIC region.

During the COVID-19 pandemic, financial constraints, and the necessity to prioritize resources for safeguarding both lives and livelihoods led many nations to pause domestically funded investment endeavors. Post-crisis, these countries aim to employ fiscal policies to reinvigorate their economies and boost overall demand through public investment. However,

their ability to do so is constrained by limited fiscal room, elevated debt levels, and substantial financing requirements post-pandemic. The IMF emphasizes the need for governments to escalate public investment to facilitate a successful economic resurgence, encourage growth and job creation, and adopt environmentally sustainable practices. While some financially robust nations have already allocated resources for initiatives beyond immediate emergency responses, those with weaker fiscal standings may encounter challenges in mobilizing resources for substantial public investment stimuli (IMF, 2020c)

In numerous low-income and emerging market economies, even those with fiscal capacity and financial access, the prompt expansion of investment endeavors post-pandemic might face limitations. Shifts in infrastructure development focus, scarcities in skilled labor, or inadequacies in accessing materials and equipment due to disrupted supply chains may hinder rapid scaling-up efforts. Thus, countries are compelled to reevaluate their investment priorities considering the post-pandemic landscape. Investments should prioritize projects aimed at mitigating the likelihood or severity of future crises, encompassing pandemics and climate change, while also fostering digitalization (COMCEC Financial Outlook 2022).

To mitigate the pandemic's impact on Foreign Direct Investment (FDI) inflows, numerous countries worldwide are expediting investment approval procedures, advocating the widespread use of online tools and e-platforms, and implementing incentive schemes for health-related Research and Development (R&D). These efforts aim to alleviate the effects on investment flows and local businesses. At the individual country level, some OIC countries successfully attracted increased FDI in 2020 compared to 2019, despite pandemic uncertainties. The United Arab Emirates led among OIC nations, drawing an additional US\$2 billion in FDI in 2020. Lebanon followed with an increase of US\$1 billion, alongside Kazakhstan and Saudi Arabia, each garnering an additional US\$1 billion and US\$0.9 billion, respectively. Conversely, several OIC countries experienced notable declines in FDI inflows in 2020 compared to 2019, such as Indonesia, with a decline of US\$5.3 billion; Malaysia, with a decrease of US\$4.3 billion; and Egypt, with a reduction of US\$3.2 billion (UNCTAD, 2020).

According to UNCTAD (2020) estimates, several OIC countries have significantly benefited from intra-OIC cooperation in terms of Foreign Direct Investment (FDI). For instance, in Palestine (95.6%), Bahrain (82.7%), Kuwait (43%), and Morocco (42%), over 40% of the inward FDI stocks were sourced from other OIC countries. At the country level, there is a notable concentration in specific nations. For instance, in Palestine, around 82.7% of the inward FDI stocks came from Jordanian investors. In Morocco, more than 36% of the inward FDI stocks originated from investors based in the UAE. Additionally, in Bahrain, investments from Kuwait accounted for over 30% in 2020. The data on intra-OIC FDI cooperation indicates a concentration in a few OIC countries, suggesting the necessity of measures to enhance intra-OIC FDI cooperation. Incentivizing and promoting intra-OIC FDI projects could be crucial in this regard.

Analyzing the sectoral breakdown of inward Foreign Direct Investment (FDI) stocks in OIC countries offers deeper insights into investor profiles and the evolving sectoral landscape within the region. In the past two decades, the global shift towards globalization has led to a relative decline in the shares of primary and manufacturing sectors, with a concurrent rise in the significance of the service sector due to the ascendance of global value chains. Technological advancements reducing transportation and communication costs have facilitated this transformation (UNCTAD, 2021).

Similar to developed and developing nations, many OIC countries have seen a surge in FDI projects directed toward the service sector. Consequently, the service sector's share in total inward FDI stocks in the OIC group escalated from 36% in 2000 to 57% in 2020. Conversely, the primary sector and manufacturing industry experienced a decline in their relative shares of total inward FDI stocks in OIC countries. Specifically, the primary sector's share decreased from 21% in 2000 to 8% in 2020, while the manufacturing sector declined from 44% in 2000 to 35% in 2020. The rise of automation, IT, and artificial intelligence technologies has propelled the globalization of the service sector after COVID-19, making it a pivotal growth driver in the global FDI landscape. Given this trend, OIC countries need to meticulously craft their FDI policies. Especially for OIC countries in Sub-Saharan Africa

striving for industrial transformation, understanding the services sector's role is crucial for sustainable development (COMCEC Financial Outlook 2022).

Similarly, Moody's Long-term Sovereign Ratings of OIC Countries in 2022 indicated that the majority of these nations carry a high-country risk. Specifically, 30 OIC countries, according to Moody's ratings, fall within the "non-investment-grade-speculative" category and below, encompassing designations such as extremely, highly speculative, and default risk. In these countries, borrowing costs are notably high, and certain investors may refrain from investing altogether due to the heightened risk exposure. Consequently, this situation leads to pronounced 'investment gaps', delineating the disparity between the country's potential and the actual investments made (SESRIC, 2014; SESRIC, 2015). Only seven OIC Countries—Indonesia, Kazakhstan, Kuwait, Malaysia, Qatar, Saudi Arabia, and the United Arab Emirates—have secured ratings above the non-investment-grade-speculative category (Moody's, 2022).

Despite the pandemic's impact on petrochemical demand in 2020, attributed to reduced downstream oil and gas activities, the sector experienced a resurgence in demand in 2021. Projections indicate that the petrochemical industry is slated for long-term growth, surpassing the \$2 trillion mark by 2030. This trajectory is anticipated due to rising income levels and the expanding global population. Certainly, some nations stand as global leaders in the petrochemical industry, while others are in the initial phases of industrial development. Tailoring strategies become crucial to enhance petrochemical value creation across all member countries within the OIC (IMF, 2022).

The MENA region witnessed a reevaluation of the role of its stock markets during the 1990s, marked by the revival of longstanding markets like Egypt, Saudi Arabia, Kuwait, and Amman, alongside the establishment of new markets such as Dubai and Abu Dhabi. However, the growth trajectory of these markets has typically been gradual and sluggish. Authorities in these countries have implemented institutional and organizational reforms within their stock markets to bolster their financial systems. This includes extensive privatization programs and initiatives like electronic trading systems, laws for investor

protection, and reductions in stock holding taxes, all aimed at enhancing market liquidity and transparency. Moreover, various financial liberalization efforts have been pursued to facilitate international integration and encourage the entry of foreign investors. Despite these efforts, the degree of market emergence across the MENA region remains diverse. In an assessment by Lagoarde-Segot and Lucey (2008b), they observed that "while Turkey, Israel, Jordan, and Egypt are progressing closer to the standards of developed countries, Lebanon, Tunisia, and Morocco still exhibit characteristics akin to frontier markets" (Lagoarde-Segot & Lucey, 2008b, p. 68).

The financial markets in the MENA region continue to be largely dominated by the banking system. Despite this, the region experienced substantial growth, surpassing 5% for the fifth consecutive year in 2007. This growth was noteworthy given the prevailing concerns in the global economy at that time, including escalating oil prices, turbulence in global financial markets due to mortgage-backed securities' decline, and surging prices of commodities like oil, metals, and basic food items. However, the markets in the MENA region are often perceived as small, lacking in liquidity and transparency, and exhibiting low transaction volumes (Chordia et al., 2005). Their structure remains distinct from that of developed economies (El-Erian & Kumar, 1995). Moreover, these markets generally appear less developed compared to emerging markets in Asia and Latin America. In a comparative analysis, Lagoarde-Segot and Lucey (2008b) positioned the degree of market emergence in the MENA region as second-most developed, following Asia and preceding Latin America and Eastern Europe (Lagoarde-Segot & Lucey, 2008b, p. 80).

3. CHAPTER 3: TESTING TIME-VARYING MARKET EFFICIENCY IN THE ORGANISATION OF ISLAMIC COOPERATION ECONOMIES DURING THE GLOBAL FINANCIAL CRISIS AND COVID-19 PERIODS

Chapter 3 serves as an expansive canvas, navigating through critical elements of this study with precision and depth. Addressing the problem statement and delving into the significance of the research, this chapter aligns its objectives with a rigorous exploration of research questions, an in-depth review of relevant literature, meticulous research methodologies, and a profound analysis of discussions and results. By weaving together these intricate threads, Chapter 3 aims to illuminate multifaceted dimensions within the realm of financial dynamics, offering comprehensive insights that extend beyond theoretical constructs, aiming to resonate profoundly within the landscape of financial academia and practice.

3.1. PROBLEM STATEMENT

Numerous studies have focused on investigating market efficiency, with a majority adopting the perspective of the Efficient Market Hypothesis (EMH) and examining whether stock markets exhibit random walk behavior over extended periods of time. The conventional approach of assessing market efficiency as a binary condition faces limitations, as noted by Campbell et al. (1997). Accurately identifying the attributes of changes in securities prices is fundamental to comprehending the principles behind how the securities market functions. This understanding serves as a foundation for effectively distributing assets to optimize returns and managing systematic risks. The concept of the efficient market hypothesis (EMH) originated from the idea that securities prices move in a manner like Brownian motion and random walk, with outcomes following a normal distribution (Fama, 1965, 1970). Consequently, the securities market displays traits of being linear, continuous, static, and independent. These characteristics facilitate the estimation and control of investment risks.

Advancements in technology are leading to the integration of various fields like computer science, communication engineering, and big data. This is driving the emergence of interdisciplinary subjects like financial physics, which are exploring the complexities of securities price fluctuations and market operations. Evidence shows that securities price fluctuations are not consistently moderate, indicating potential traits of discontinuity, nonlinearity, and complexity in the securities market. To understand these intricate matters, a comprehensive and integrated approach is crucial, involving various disciplines. The fractal market hypothesis (FMH), rooted in Fractal Geometry, is significantly shaping modern securities investment theories and practices (Peters, 1994). Similarly, Lim and Brook (2011) and Lo (2004) suggest that market efficiency is not a static concept but rather varies with changing market conditions, aligning with the Adaptive Market Hypothesis (AMH). Additionally, testing the Efficient Market Hypothesis (EMH) proves challenging due to the lack of consensus on the specific form of market efficiency to be evaluated (Titan, 2015).

The Adaptive Market Hypothesis (AMH) incorporates the notion of market dynamics, suggesting that the level of market efficiency varies over time, influenced by factors such as market participants, prevailing market conditions, adaptability of participants, and the level of competition in the market. In line with this perspective, Ito et al. (2016) conducted a study to examine the changing degree of market efficiency over time, focusing on two major Japanese stock indices. The study assesses the Adaptive Market Hypothesis (AMH) on four prominent stock exchanges. They examined the relationship between the level of return predictability and various market conditions. The findings revealed that there were periods of statistically significant predictability in certain time periods, while in other periods, predictability was not observed. Additionally, they discovered that the predictability of returns was statistically significantly associated with different market conditions (Urquhart and McGoarty 2016).

Different events exert different levels of impact on stock market efficiency. Instances that induce widespread panic and instability, including exchange rate shocks, economic and financial crises, bubbles, and pandemics, often exacerbate the challenges faced by the Efficient Market Hypothesis (EMH). These events cause financial asset prices to deviate

from their fundamental values. Researchers such as Kim et al. (2011), Niemczak and Smith (2013), Rodriguez et al. (2014), Charfeddine and Khediri (2016), Lalwani and Meshram (2020), Ozkan (2021), Erer et al. (2023) have highlighted the impact of such events on stock market efficiency. This study focuses on examining the efficiency of both aggregate and sectoral markets in OIC (Organization of Islamic Cooperation) countries, specifically during the Global Financial Crisis (GFC) and the COVID-19 outbreak. The analysis will be conducted within the framework of the Adaptive Market Hypothesis (AMH).

3.2. OBJECTIVES OF THE STUDY

The market efficiency information during the global crisis period, i.e., financial crisis or Pandemic like COVID-19, plays a vital role as it provides information regarding trading and strategic activity of the investor of the stock market related to the profitability outcomes generated during the inefficient market.

The study investigates the impact of the financial crisis on the level of market information efficiency for Islamic Cooperation countries' stock indices. The core question of this debate is whether stock market movements are predictable. The research will do a detailed examination of the behavior of Islamic Cooperation Countries' stock market aggregate and sectoral indices during the COVID-19 and GFC. In addition, the thesis will compare the market indices of the Islamic Cooperation Countries during the financial crisis, i.e., GFC and COVID-19, for the OIC aggregate stock market and sectorial indices.

Another objective of this study is to assess the efficiency of stock market indices in Islamic Cooperation countries during the financial crisis. This analysis is particularly relevant in the ongoing debate between Thaler and Fama regarding the Efficient Market Hypothesis (EMH) and behavioral finance. Thaler emphasizes the distinction between predictable behaviors within a rational model.

3.3. SIGNIFICANT OF STUDY

This study makes several key contributions. Firstly, it examines the impact of the COVID-19 pandemic on economic efficiency. Given the differential effect of the pandemic on stock prices at the sector level, investors are interested in predicting the future returns of each industry. Hence, this study anticipates diverse reactions from each industry in response to the outbreak of COVID-19.

Additionally, it examines and contrasts the effects of the Global Financial Crisis (GFC) and the COVID-19 pandemic on stock market efficiency, aiming to highlight the unique characteristics of COVID-19's impact on the economy. The findings of this research can provide valuable insights for policy formulation in addressing future economic crises resulting from infectious diseases.

This study aims to make several contributions to the literature on market efficiency. Firstly, it examines market efficiency on both aggregate and sectoral levels, considering the varying degrees of efficiency over time. This analysis is conducted for two distinct crisis periods: the outbreak of COVID-19 and the Global Financial Crisis (GFC), focusing specifically on countries belonging to the Organization of Islamic Cooperation (OIC). Given the differential impact of the COVID-19 outbreak on various sectors of the economy, investors have a keen interest in predicting the future returns of each sector. Consequently, this study aims to investigate the divergences between the effects of the COVID-19 outbreak and the Global Financial Crisis (GFC) on the economy. By employing time-varying techniques, the analysis seeks to uncover market properties associated with significant structural shifts. Secondly, this study utilizes the multifractal detrended fluctuation analysis (MF-DFA) model to evaluate and compare the efficiency of both the aggregate market and individual sectors during periods of crisis. The MF-DFA model, introduced by Kantelhardt et al. (2002), is employed to analyze non-stationary time series with multifractal characteristics, enabling the identification of long-range and short-range dependencies. This approach allows financial investors to assess the efficiency of each sector, providing valuable insights for their investment strategies. Thirdly, this study aims to clarify the market

efficiency of both the aggregate market and individual sectors within the framework of the efficient market hypothesis (AMH).

3.4. RESEARCH QUESTIONS

In the context of the AMH framework, following research questions has been formulated:

What is the impact of the COVID-19 pandemic and Global Finance Crisis on the overall efficiency of the market of OIC countries?

Do different sub-sectors within the AMH framework show varying impacts of the COVID-19 and GFC outbreak on market efficiency?

Among the sectors, which one experiences the most significant loss in efficiency during GFC and during COVID?

Does the differentiation of sectoral market efficiency occur between the periods of the Global Financial Crisis (GFC) and the COVID-19 outbreak?

3.5. LITERATURE REVIEW

The significance of stock market efficiency within the finance industry cannot be emphasized enough, as a properly operating stock market is crucial for promoting a competitive economy. The notion of market efficiency was initially introduced to describe a market where the prices of financial assets incorporate all relevant information. Fama provides an explanation of this concept, stating that it envisions a market where prices accurately indicate how resources should be allocated. In other words, it is a market where companies can make informed decisions regarding production and investment. Investors can make their security selections with the understanding that security prices incorporate all accessible information at any given moment. As a result, prices play a significant role in influencing allocation decisions that rely on the trading prices of stocks (Fama 1970).

Louis Bachelier (1900) established the foundational principles of the Efficient Market Hypothesis (EMH) and the Random Walk Theory through his work. In his 1900 doctoral thesis titled 'The Theory of Speculation,' Bachelier initially analyzed market prices under the assumption that discernible patterns would emerge in the time series. However, he soon discovered that price changes followed a random pattern instead. Bachelier noted that although some historical, existing, and even awaited forthcoming events were influenced by stock market prices, they did not exhibit any apparent relationship to subsequent price changes. Consequently, he concluded that the mathematical expectation of a speculator's gains or losses would be zero. Similarly, Cowles (1933) discovered no evidence to substantiate the capacity for market prediction. Nonetheless, this idea was largely ignored until Kendall (1953) reexamined the concept.

Kendall (1953) thoroughly examined 22 price series of stocks and commodities in the United Kingdom, and his findings were unexpected. He discovered that in price series noted at comparatively close intervals, the fluctuations were random from one period to the next and were so substantial that they overshadowed any discernible systematic effects that might exist. This closest-to-zero serial correlation in the change in price contradicted the prevailing beliefs of economists during that time. Furthermore, the scholar who noted the time

dependence of the empirical variance was Kendall (1953); he also indicates nonstationarity. At first, economists interpreted this finding as proof of the irrationality of the market.

Conversely, it quickly became evident that it backed and supported the model, namely the random walk model. If stock prices meander in a random manner, it implies that financial and market experts and analysts will be unable to forecast the future direction of the stock market. Additionally, Roberts (1959) illustrated that a time series created from an order of random numbers closely mirrored a log of US stock prices. Osborne (1959) examined the data of the US stock market and found common stock prices exhibit characteristics like the motion of particles.

Although there was substantial evidence in favor of price fluctuations for randomness of stock, there were rare cases where certain series seemed to exhibit foreseeable patterns. In 1960, it was acknowledged that autocorrelation could be introduced into return series by employing time-averaged security prices. However, Alexander (1961) revealed that the stock return fluctuates randomly when the stock return series belongs to the end-of-period prices. Similarly, working (1960)'s research shows the same. The recognition of the time-averaging problem by Working (1960) initiated the examination of thin trading and paved the way for further research on market microstructure (Working 1960).

The study about the random nature of stock prices took a significant shift in the mid-1960s. Cootner (1964) published a compilation of research on the subject, while Fama (1965) reprinted his doctoral dissertation, in which he reached a conclusion that "it can be confidently stated that research has introduced strong and extensive sign for supporting the random walk hypothesis." Subsequently, the Efficient Market Hypothesis (EMH) was extensively scrutinized in the next section of the literature, yielding conflicting results in many studies. The next section furnishes a more comprehensive enlightenment on the EMH and the random walk model.

It's widely acknowledged that Bachelier (1900) laid the groundwork for the Efficient Market Hypothesis (EMH). He initially observed that securities prices adhere to Brownian motion and an "irregular" random walk in speculative financial markets, indicating that

investors couldn't gain additional returns by predicting price fluctuations. Following Cowles (1933); Kendall (1953); and Cootner (1964) conducted subsequent empirical studies, contributing to the understanding of price fluctuation and return distribution in securities. Notably, Samuelson (1965) introduced a comprehensive mathematical analysis, marking a significant step in establishing a more scientific approach to researching securities markets.

Roberts (1967) and Fama (1965, 1970), a recipient of the 2013 Nobel Prize in Economics, made significant academic contributions to information classification. Fama's formal proposition of the Efficient Market Hypothesis (EMH), derived from these contributions, delineated three distinct levels of securities market efficiency: (1) weak form efficiency, (2) semi-strong form efficiency, and (3) strong form efficiency. Fama (1965, 1970) specifically noted that in a strongly efficient market, securities prices embody all available information, devoid of any discernible statistical short-term or long-term "memory" in their yield sequences. This implies that there are no inherent advantages or "free lunches" for investors within the securities market, as historical, public, or insider information cannot yield excess returns.

However, the Efficient Market Hypothesis (EMH) remains far from achieving absolute perfection and universality. Numerous scholars cast doubt on its assumption that the distribution of return rates follows a linear pattern within the securities market (Mandelbrot, 1970; Peters, 1994). Consequently, its scientific validity faces theoretical challenges due to persistent financial anomalies like the P/E effect and calendar effect mentioned earlier. Additionally, the enduring and unresolved disparities between fundamental analysis and technical analysis, such as the belief that historical price movements can be replicated, hinder its application in guiding investment practices (Mandelbrot, 1970). These challenges have spurred the academic community to continuously refine and enhance classical theory, striving to align it more closely with reality. This pursuit aims to augment its interpretative value and improve its practical guidance, as highlighted in the works (Mandelbrot 1970, 1997; Mandelbrot & Taylor 1967; Peters 1994).

3.5.1. Random Walk and Efficient Market Hypotheses

Maurice Kendall introduced the random walk hypothesis in 1953, initially anticipating the presence of price cycles within the stock market. However, his research yielded unexpected results contrary to his expectations (Brealey et al., 2010, p. 342). Kendall's study, spanning from 1883 to 1914 and between 1921 and 1934, surprisingly revealed an absence of evidence indicating any correlation between a stock's price in one week and its subsequent price. Instead, the prices appeared to adhere to what he termed a "random walk."

Lo and MacKinlay (1988)'s examination of the CRSP index provided evidence of price correlation, thereby refuting the random walk hypothesis. Their study encompassed a sample comprising 1216 weekly observations spanning from September 6, 1962, to December 26, 1985. Notably, the test employed variance estimators derived from data across various time periods for their analysis.

Urrutia (1995)'s investigation into the Latin American market, encompassing Argentina, Brazil, Chile, and Mexico, led to the rejection of the random walk hypothesis. Employing a Variance Ratio test on monthly data spanning from December 1975 to March 1991, Urrutia was able to reject the notion of a random walk, observing correlated prices across different time periods. However, a more recent study analyzing data from May 1, 1996, to March 1, 2011, in the Brazilian stock market presented contrasting findings. Chen and Metghalchi (2012, p. 22) found evidence supporting the random walk hypothesis in this more contemporary analysis.

Chan et al. (1997) conducted a test on weak-form efficiency across 18 developed markets, which notably included Sweden. Their analysis covered data from January 1961 to December 1992. Employing a unit root test on monthly data, they investigated price autocorrelation. The findings indicated an absence of autocorrelation among prices in any of the markets examined. Consequently, these results suggest that the prices in these 18 markets adhered to a random walk pattern during this period. This outcome implies that deriving abnormal returns based on past price analysis may not be feasible, given the lack of discernible long-term patterns in these markets.

The extensive financial literature surrounding the random walk hypothesis presents a challenge in capturing its comprehensive overview. Considering the literature review, particularly regarding the investigation of price autocorrelation, this study sought to gather evidence both supporting and contradicting the random walk theory across various periods and diverse markets. Despite fluctuations in outcomes, this study contends that most research leans towards rejecting the random walk hypothesis. Noteworthy references such as Summers (1986); Fama and French (1988); Lo and MacKinlay (1988); Urrutia (1995) contribute to this perspective. These findings imply that numerous markets over time have demonstrated a lack of weak-form efficiency, displaying correlated prices and detectable patterns, potentially enabling investors to generate abnormal returns through technical analysis across multiple markets and timeframes. Their research focuses on the intriguing observation of market inefficiencies. Previous studies have suggested patterns in prices across various markets, prompting their interest in investigating whether companies with relatively active insiders exhibit stocks that deviate from weak-form efficiency. Specifically, they aim to explore whether these stocks display higher or lower autocorrelation between prices. Aktas et al. (2008) conducted a study indicating that insider trading enhances efficiency levels. They aim to extend this investigation to the Swedish financial market, exploring a similar impact.

Numerous studies have highlighted the futility of attempting to resolve these issues within the confines of linear science (Mandelbrot & Hudson, 2009; Peters, 1991). Consequently, scholars endeavored to construct a more expansive and comprehensive analytical framework operating at a broader horizon, leading to the emergence of the Fractal Market Hypothesis (FMH) (Mandelbrot, 1997; Mandelbrot & Van Ness, 1968; Peters, 1991, 1994).

3.5.2. Fractal Market Hypothesis

The emergence of the Fractal Market Hypothesis (FMH) was prompted by two significant historical events: (1) the emergence of interdisciplinary sciences like Econophysics and (2) the groundbreaking contributions of Mandelbrot in Fractal Geometry

and Multifractal Geometry (Mandelbrot, 1967, 1999; Mandelbrot & Hudson, 2009; Mantegna & Stanley, 1997).

The Fractal Market Hypothesis (FMH) encompasses two primary modes: monofractal analysis and multifractal analysis. Research on FMH at the local level began in the late 1990s (Fan & Zhang, 2002; Xu, 1999). Some studies systematically investigated the FMH's emergence, development, and its current research status, focusing on its potential application within the securities market. Moreover, both domestic and international studies have confirmed the fractal dynamics present in various markets such as stocks, bonds, currencies, foreign exchange, commodity futures, stock index futures, P2P, and cryptocurrencies, noting asymmetrical disruptions among these markets (Cao & Shi, 2007; Mantegna & Stanley, 1995; Shi et al., 2014). The unique characteristics of these localized studies are thoroughly discussed in the subsequent sections.

The qualitative confirmation of the complementary nature of the relationship between the Efficient Market Hypothesis (EMH) and the Fractal Market Hypothesis (FMH) has been established in prior studies. However, there remains a lack of in-depth and mathematical exploration into the microscopic mechanisms governing their relationship. This absence can lead to misunderstandings and errors in fundamental concepts and methodologies associated with these hypotheses (Mantegna & Stanley, 2000; Peters, 1994).

Furthermore, Mandelbrot (1967) highlighted the association between the fractal nature of the securities market and its tumultuous, discontinuous price fluctuations. He suggested that the volatility of securities prices is not mild but exhibits what he termed the "Noah effect," attributed to volatility clustering, and the "Joseph effect," arising from long-term persistence and irregular circulation. The Noah effect signifies sporadic and sudden significant jumps in stock prices, where substantial jumps are often followed by similar movements, forming volatility clustering. Meanwhile, the Joseph effect refers to the prolonged and non-cyclical movement (long memory) of stock prices. Unfortunately, the analysis of the underlying causes of these effects was largely abandoned at that time. Subsequent studies have remained primarily at this stage, lacking substantial theoretical

breakthroughs. Evidently, despite decades passing, the fundamental laws and characteristics governing price volatility have yet to be profoundly and comprehensively understood Mandelbrot (1967).

Fractal geometry, a crucial discipline and methodology within nonlinear science, is not solely employed in discerning the volatility patterns of securities prices but is also utilized in constructing optimal portfolios and mitigating investment risk (Mandelbrot & Hudson, 2009). While international studies have underscored the significance of fractal geometry (Mandelbrot & Van Ness, 1968; Mantegna & Stanley, 2006), local research is still in its early stages and predominantly comprises imitative studies. Ultimately, while the Fractal Market Hypothesis (FMH) might offer a relatively better depiction of the securities market compared to the Efficient Market Hypothesis (EMH), it encounters limitations concerning the psychological aspects and behavioral decision-making processes of market participants. These constraints restrict its application. Moving forward, the FMH requires further development by assimilating insights from emerging disciplines and fostering continuous integration to refine its explanatory power (Fan & Zhang, 2002; Liu & Song, 2013).

In comparative analyses between neoclassical and emerging finance, the examination of similarities and differences between the Efficient Market Hypothesis (EMH) and the Fractal Market Hypothesis (FMH) is frequently included (Ying & Xin-tian, 2006). Neoclassical finance has historically rested upon the premise of market linearity, yet it has not entirely dismissed the non-linearity and intricacies inherent in the securities market. Previous studies exploring the interplay of financial theories have often depicted the EMH and the FMH as intertwined rather than distinctly separate. Instead of stark differentiation, these theories are observed to evolve in tandem, displaying mutual permeation and cross-merging (refer to Figure 1). Notably, Mandelbrot, a key figure in advancing the FMH, was a student of mathematician Von Neumann and probability theory expert Lévy. In a reciprocal connection, another prominent scholar, Fama, the architect of the EMH, was a student of Mandelbrot (Liu et al. 2022).

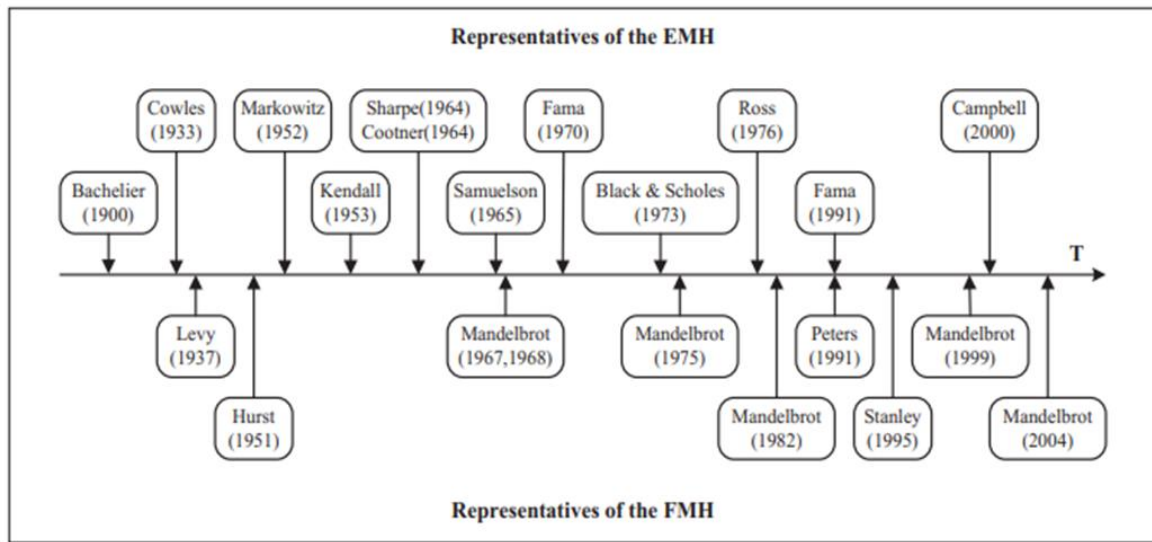


Figure 1: Representative figures and chronicles of the EMH and the FMH (Liu et al. 2022).

3.5.3. Adaptive Market Hypothesis

Andrew Lo (2004) argues that market efficiency is a relative concept, diverging from Fama's explanation of market efficiency confined to three levels. In contrast to the Efficient Market Hypothesis (EMH), which suggests three distinct levels of market efficiency, the Adaptive Market Hypothesis (AMH) depicts a financial landscape where market efficiency is not strictly categorized within these levels. Instead, markets exhibit tendencies to incorporate price information more significantly in certain areas than in others. Lo further presents evidence indicating that the level of market efficiency is subject to variation over time (Lo, 2004, p. 25).

The perspective that market efficiency is a variable explicitly outlined in the Adaptive Market Hypothesis (AMH) emerges as an alternative and offshoot of the Efficient Market Hypothesis (Neely et al., 2009, p. 468). This theory incorporates behavioral finance in efficiency assessments and has thereby identified the capacity to elucidate deviations from market efficiency observed across various markets (Lim & Brooks, 2010, p. 71). Factors like

psychological biases, noise trading, and the presence of market imperfections are highlighted to illustrate instances where the market diverges from operating as an efficient market.

Kahneman and Tversky (1979, p. 265–267) performed a test illustrating investors' varying responses to losses and gains. Andrew Lo further developed this test with a slight alteration in his article on The Adaptive Market Hypothesis (2004, p. 17). Both scenarios presented the same probabilities and amounts, differing only in whether they depicted losses or gains. Participants were offered a choice between a certain smaller loss or gain (100% probability) and a larger loss or gain (75% probability). The study's outcome is notable, indicating a significant finding: Individuals tend to exhibit more risk-seeking behavior when faced with expected losses and more risk-averse behavior when dealing with expected gains. This highlights an instance where individuals engage in irrational behavior, contradicting the Efficient Market Hypothesis (EMH) assumption that all investors act rationally.

Grossman (1976, p. 573) and Grossman and Stiglitz (1980, p. 405) have emphasized the impossibility of achieving perfectly informationally efficient markets. This notion challenges the quantitative models of efficient markets, as one of their foundational assumptions is fundamentally violated. In a perfectly informationally efficient market, where all relevant information is already incorporated into security prices, there would be no potential for profit by possessing additional information. Consequently, trading in such markets would lose its purpose, as no one could gain further profit through trading. Behavioralists argue that in a market of this nature, where no incentives exist for investors to trade, the market would eventually collapse (Lo, 2004, pp. 17-18).

3.5.4. MF-DFA Approach

In this section, they introduce a more sophisticated method known as multifractal detrended fluctuation analysis (Kwapień et al., 2005). Kantelhardt et al. (2002) demonstrated in their groundbreaking paper that MFDFA has the capability to identify multifractal scaling patterns within time series data. The rationale behind utilizing MFDFA stems from its

foundation in DFA, which helps to mitigate correlations that arise as artifacts of non-stationarities present in the time series data.

As per the theory, multifractality can arise from two factors: a wide probability density function and long-range correlations between small and large fluctuations in time. In scenarios where multifractality stems from a broad probability density function, shuffling the data does not eliminate multifractality. However, if multifractality is a result of long-range correlations, shuffling the series should lead to unifractality, as the long-range correlations are disrupted by shuffling (Barunik et al., 2012). In Zhou (2009)'s research, he compares return series with both shuffled and surrogate data, ultimately concluding that the presence of fat-tailed distributions plays a more pivotal role than the temporal structure in this context.

Sun et al. (2001) and Wei and Huang (2005) highlight the utility of multifractal analysis in predicting market index movements, particularly during periods of substantial return fluctuations. However, this predictive correlation tends to weaken over time. Additionally, Wang et al. (2011) demonstrated the presence of multifractality in the gold market both before and after 1999 across various time scales. Their findings revealed persistent fluctuations in the short term, while large fluctuations exhibited anti-persistence, and small fluctuations displayed persistence over the long term. Similarly, Telesca and Lapenna (2006), employing MFDFA, observed a seismic phenomenon transitioning from heterogeneity to homogeneity during the aftershock period. This transition indicated a potential loss of multifractality compared to the primary seismic event. The study's significant aspect lies in the substantial number of total observations, amounting to 7520, providing a robust foundation for estimating reliable exponents. Among these exponents, one crucial measure is the width of the multifractal spectrum, representing the breadth of the range of exponents. A broader spectrum indicates richer multifractality within the system. Additionally, $\alpha_0 \max$, equivalent to the value of α when $f(\alpha)$ reaches its maximum value, serves as an indicator of the regularity within the process. A larger α_0 suggests a more orderly or regular process.

Hasan et al. (2015) conducted a study investigating the influence of the Great Recession in the US on the multifractality of two developed and five emerging Asian stock markets, encompassing China and Hong Kong. An interesting observation from the analysis of the Chinese stock market during the crisis period was that the $r(q)$ vs. q plot for the return series showed only marginal divergence from the shuffled series for negative q values. This indicates the presence of weak correlations in minor fluctuations. Amid the 2007-2008 crisis, five out of the seven markets—Hong Kong, the US, South Korea, Indonesia, and Japan—displayed robust multifractality for $q > 0$, reflecting significant impact due to the Great Recession. Conversely, the Chinese and Indian markets demonstrated comparatively less susceptibility to the US crisis during that period.

Lim et al. (2008) investigated the impact of the 1997 extreme event on eight Asian stock markets, evaluating their efficiency using a rolling bicornelation test statistic. Their findings indicated that Hong Kong's efficiency was notably impacted, experiencing the greatest effects over the 14-year full sample period. Contrarily, Jiang (2008) proposed that the perceived multifractality in stock market indices might be illusory, arguing that both real and shuffled indices did not exhibit significant multifractal properties. Similarly, Bouchaud (2000) expressed uncertainty regarding the differentiation between financial time series demonstrating monofractal and multifractal behavior, suggesting a lack of clarity in discerning such distinctions.

In their publication, Kantelhardt et al. (2002) describe the procedural steps of the method in the following manner: The multifractal detrended fluctuation analysis (MF-DFA) operates on a time series denoted as $x(k)$, where $k = 1, 2, \dots, N$, and N represents the length of the series. They assume that $x(k)$ represents increments of a random walk process centered around the average ($\bar{x}$), and the profile is established by integrating the signal.

3.5.5. Applied Research

In the realm of finance, the concept of market efficiency serves as a cornerstone for models, strategies, and policies within stock markets. Since its inception in the 1960s, market

efficiency has been a subject of substantial empirical and theoretical deliberation, encompassing hypotheses like the random walk hypothesis, the Efficient Market Hypothesis (EMH), the Fractal Market Hypothesis, and the Adaptive Market Hypothesis (AMH). These hypotheses have been pivotal in shaping discussions and analyses within this domain. The EMH has been a crucial area of research aimed at enhancing the understanding and improving the quality of stock markets. Consequently, numerous studies have been conducted to gain deeper insights into and test the EMH.

Abraham et al. (2001) examined markets in the Middle East and found that in thinly traded equity markets, the index might not accurately represent the genuine fundamental index value. Additionally, they identified a consistent inclination toward refuting the Efficient Market Hypothesis (EMH). The three emerging Gulf equity markets exhibit irregular trading patterns, which significantly impact the outcomes of market efficiency and random walk assessments.

Reilly's (2002) study of EMH categorizes tests into two groups: one contrasting risk-return outcomes for trading based on historical market data versus buy-and-hold strategies, and the other involving statistical examinations of the rate of return independence. Widely used tools like Autocorrelation and Run tests are employed for this purpose. This issue has gained significant attention globally, with studies conducted on individual and regional markets, such as Urrutia (1995)'s study on Latin America (specifically Brazil and Mexico), which supports the random walk hypothesis. A similar study on African markets by Magnusson and Wydick (2002) also favors the random walk hypothesis across all markets. Groenewold and Ariff (1998) analyzed the impact of liberalization on market efficiency in ten Asia-Pacific countries, finding that deregulation did not significantly alter many efficiency measures. However, regression and autocorrelation-based methods suggest increased predictability post-deregulation, both domestically and internationally. While greater international predictability may be linked to global equity market integration, the reasons for this phenomenon at the domestic level remain unclear.

Milionis and Moschos (2000) engaged in a study involving the empirical investigation and analysis of the findings presented by Al-Loughani and Chappell (1997). Contrary to the conclusions drawn by the authors, this analysis asserts that despite the rejection of the random walk hypothesis, it remains argued that the weak-form market efficiency hypothesis (WFME) for the London Stock Exchange cannot be discarded based on the reported results. Additional commentary is provided regarding the weak-form market efficiency hypothesis in the context of conditional heteroscedasticity. This evidence implies the possibility of predictability, leading researchers to reconsider weak-form market efficiency through the application of statistical tests capable of identifying nonlinear trends in financial time sequences (Panagiotidis, 2010; Saadi et al., 2006).

Lim, K. P. et al. (2008) conducted research on the weak-form efficiency of ten emerging Asian stock markets. Using various nonlinearity tests, the results show consistent, predictable nonlinear patterns in return series, even after removing linear sequential connections in the data. Analyzing sub-samples with the Hinich bicomrelation test, the study finds that these Asian markets demonstrate periods of pure randomness over extended periods punctuated by brief episodes of notable nonlinear interdependence. Country variations in nonlinear efficiency deviations seem linked to market size and trading activity, while sporadic nonlinear phases within individual markets are mainly attributed to economic and political events.

Pele, & Voineagu (2008) explore market efficiency through a model that breaks down stock returns into two parts: a random trend and a noise element. The Romanian Capital Market is analyzed using this model, focusing on the BET (Bucharest Exchange Trade) Index time series. The findings indicate that, based on our dataset, they do not have grounds to refute the efficient market hypothesis for the Romanian Capital Market.

Borges (2010) conducted an investigation into the equity markets of France, Germany, the UK, Greece, Portugal, and Spain, spanning from January 1993 to December 2007. The study utilized a series of statistical tests, including a serial correlation test, an augmented Dickey-Fuller test, a runs test, and the Lo and MacKinlay (1988) multiple

variance ratio test to evaluate whether a random walk pattern existed in these equity markets. The findings indicated a lack of significant evidence supporting the adherence of monthly prices and returns to the Random Walk Model (RWM) across all six equity markets. Daily returns exhibited non-normal distribution, indicated by their negative skewness and leptokurtosis. France, Germany, the UK, and Spain adhered to the random walk hypothesis with daily data, whereas this hypothesis was rejected for Greece and Portugal due to positive serial correlation. However, after 2003, these two countries also exhibited behavior aligned with the random walk theory.

Worthington and Higgs (2009) conducted a study examining the weak-form market efficiency of the Australian stock market. Their analysis encompassed daily returns from January 6, 1958, to April 12, 2006, and monthly returns from February 1875 to December 2005. Utilizing a range of statistical tests, such as the serial correlation coefficient, runs tests, unit root tests, and multiple variance ratio tests, the research aimed to investigate the presence of random walks. The results from the serial correlation tests suggested inefficiency in daily returns and a modest level of efficiency in monthly returns. Moreover, run tests indicated weak-form inefficiency in both the daily and monthly series. Unit root tests further supported the presence of weak-form inefficiency in both sets of return data. The more rigorous variance ratio tests revealed that while monthly returns adhered consistently to a random walk pattern, daily returns diverged from weak-form efficiency primarily due to short-term autocorrelation.

Hamid et al. (2010) examined the weak-form market efficiency of stock market returns across several Asian-Pacific countries, encompassing Pakistan, India, Sri Lanka, China, Korea, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, Thailand, Taiwan, Japan, and Australia. The study spanned from January 2004 to December 2009. It employed a battery of tests, including Autocorrelation, Ljung-Box Q-statistic Test, Runs Test, Unit Root Test, and Variance Ratio, aiming to determine if the stock market exhibited a random walk pattern. Findings indicate that monthly returns show a non-normal distribution with negative skewness and leptokurtosis. In summary, the research concludes that monthly stock prices in the Asian-Pacific region do not adhere to random walk behavior across the

examined countries. This suggests potential arbitrage opportunities for investors to exploit profitable disparities within these markets.

Guidi et al. (2011) employed methods such as autocorrelation analysis, the runs test, the variance ratio test, and GARCH-M techniques spanning a decade (1999–2009) to provide empirical evidence that the seven Central and Eastern European (CEE) stock markets under examination did not conform to a random walk pattern. However, the authors noted a positive shift in stock market efficiency among CEE countries after their accession to the European Union in 2004. Among the seven markets studied, the random walk hypothesis was refuted for the Bulgarian and Slovak markets.

Karadagli and Omay (2012) explored the weak form of market efficiency in emerging economies, which also encompassed some of the countries examined in our analysis. They employed both linear and nonlinear unit root tests on monthly data spanning 2002 to 2010, leading to conflicting outcomes. The results from nonlinear unit root tests indicated that the Romanian and Polish markets were not weak-form efficient, in contrast to the linear tests that suggested otherwise. Similar conflicting results were observed for other Central and Eastern European (CEE) stock markets like Bulgaria, Hungary, and Slovenia. However, when taken together as a whole, the authors concluded that the studied countries did not demonstrate efficiency.

In a study by Smith (2012), support was discovered for weak form efficiency through examination of the Martingale hypothesis across 15 European emerging stock markets during an extended timeframe of almost nine years (from February 2000 to December 2009). The investigator employed a moving window variance ratio method to monitor efficiency shifts and assess market inefficiency rankings. The outcome of this investigation revealed a considerable disparity in return predictability among the countries. Among the markets scrutinized the Hungarian and Polish markets exhibited the highest levels of efficiency, while Estonia demonstrated lower efficiency.

Andrianto and Mirza (2016) conducted a study focusing on the assessment of market efficiency in the context of Indonesia's stock market. They utilized daily stock price data

extracted from the LQ45 Index, Jakarta Islamic Index (JII), and Kompas 100 Index for the period spanning from 2013 to 2014. The evaluation of weak-form efficiency was carried out through statistical tests, specifically the run test and serial correlation test. The outcomes of their findings indicate that the Indonesian stock market falls under the category of weak-form efficiency. The conducted statistical tests yield two key results: 1) the daily movement of stock prices follows a random walk pattern, and 2) there is no discernible correlation between the price movements of the present day and those of the previous day.

Botoc (2015) conducted an investigation into the weak form of market efficiency spanning from 1997 to 2014, particularly examining five Central and Eastern European (CEE) stock markets, namely Croatia, Czech Republic, Hungary, Romania, and Poland. The study employed unit root tests, a non-parametric runs test, and joint variance tests. The findings suggested that, except for Poland, Hungary, and Croatia, the examined CEE markets did not demonstrate indications of weak-form market efficiency.

Awan et al. (2016) conducted research where conflict findings prompted an exploration of Gulf Stock Markets due to shifts in the current market conditions. Data from six Gulf Stock Exchanges over a five-year period was collected. The study utilized daily closing stock indices for Oman, UAE, Kuwait, Saudi Arabia, Bahrain, and Qatar from January 1, 2011, to December 31, 2015. Auto-correlation and run tests were conducted to evaluate Weak Form Market Efficiency. The Parametric Tests (both Autocorrelation and Runs tests) revealed outcomes indicating that stock prices across all Gulf Markets did not adhere to the random walk model. The identification of notable auto-correlation coefficients at different lags resulted in rejecting the null hypothesis of Weak Form Efficiency.

Sánchez-Granero et al. (2020) conducted a research endeavor focused on the efficiency of Latin America Stock Markets. This assessment was carried out through the application of a statistical arbitrage technique named Pairs trading. Pairs trading is a relative value trading strategy where a long position is taken in one stock and a short position in another stock within a pair chosen for their similar characteristics. To conduct this analysis, an approach introduced by Ramos et al. (2007) was employed, which involves tracking the

evolution of the Hurst Exponent of a given pair. The findings reveal a profitable outcome of this trading strategy in emerging markets. In contrast, the same strategy is not profitable in developed markets, aligning with the principles of weak-form efficiency.

Kang et al. (2022) carried out a research endeavor to assess the efficient-market hypothesis (EMH) within the cryptocurrency market, aiming to evaluate information effectiveness. The study employed three random walk tests to validate the weak-form EMH, and the event study method was utilized to examine the semi-strong-form EMH. The analysis outcomes revealed that out of the total 893 cryptocurrency units, 54 units (6.04%) adhered to the weak-form EMH, while 24 units (2.695%) aligned with the semi-strong market hypothesis. Additionally, the investigation found that among cryptocurrency exchanges established before November 2017, exchanges of larger size displayed a greater likelihood of complying with both weak-form and semi-strong-form EMHs.

In response to the Efficient Market Hypothesis (EMH) and the Random Walk Hypothesis (RWH), the field of econophysics introduced fractal theory, initially proposed by Benoit Mandelbrot and further expounded upon (Mandelbrot et al., 1997; Mandelbrot, 1967). Stemming from the realm of mathematics, this theory defines fractals as intricate geometric shapes that exhibit self-similar patterns across various scales. This viewpoint has emerged as an alternative to conventional tools and methods used in finance, encompassing both the wider financial landscape and, specifically, financial markets. This transition arises from the shortcomings observed in GARCH processes and Brownian motion, which have proven insufficient in adequately modeling all essential attributes of financial markets (Mandelbrot, 1967).

Over time, the comprehension of fractal characteristics has directed scholarly focus toward market efficiency, as explored by Kristoufek and Vosvrda (2012). Peters, a prominent academic, also emphasized in his research that the Hurst index maintains a relationship with return series. When correlations exist within asset return sequences, investors might anticipate alterations in asset prices using specific methods. This implies that asset prices do

not comprehensively encompass their historical information, making the Hurst index a tool for indirectly gauging market efficiency, as discussed by (David et al., 2020).

The Hurst index effectively quantifies how adeptly asset prices incorporate historical data, a point on which earlier research has mostly concurred. Specifically, when the Hurst value stands at 0.5, denoting zero correlation in the asset return series, asset price changes become utterly arbitrary. At this juncture, the performance of the capital market aligns with the efficient market theory, rendering predictions of asset price shifts impracticable. The immediate reflection of historical asset information in market prices characterizes peak market efficiency. The proximity of the Hurst index to 0.5 signifies weaker correlations among asset returns, leading to more erratic price movements. In contrast, deviations of the Hurst index from 0.5 signify heightened correlations in asset returns, resulting in longer time lags before historical asset data influence market prices. This suggests a decrease in market efficiency, as discussed by (David et al., 2020A).

Additionally, much of the literature has scrutinized deviations of the Hurst index from 0.5 through the lens of behavioral finance, with research indicating a potential connection to herd behavior, as highlighted by Li et al. (2022). Prolonged irrational investment behaviors, such as blindly following trends and hasty selling, have been observed, as discussed by (Yalamova and McKelvey, 2011).

The concept of fractal theory, often referred to as the theory of "roughness and self-similarity," has been employed to study the conduct of financial markets in relation to market efficiency, offering a nonlinear perspective. Kantelhardt et al. (2001, 2002) introduced the multifractal detrended fluctuation analysis (MF-DFA) as a technique for scrutinizing non-stationary time series.

The empirical exploration of financial market behavior has established that multifractal attributes in financial time series can be attributed to two primary factors: nonlinear temporal connections between past and present occurrences and the presence of heavy-tailed probability distributions (Li & Lu, 2011). Extensive empirical research has confirmed the existence of multifractality within stock market indices. The Hurst exponent

is commonly utilized to identify periods of heightened volatility in financial time series (Mandelbrot et al., 1997) or to gauge the short and long-term memory exhibited by the stock market, which reflects the level of market efficiency (Jagric, et al. 2005; Kristoufek & Vosvrda, 2013; Zunino et al., 2008).

Dar et al. (2017) conducted a study to investigate the applicability of the Fractal Market Hypothesis regarding the prevalence of specific frequencies during financial crises in global stock markets. Utilizing the continuous wavelet framework proposed by Kristoufek (2013), they employed wavelet power spectra to examine this hypothesis. The findings revealed that stock markets worldwide demonstrate an increased prevalence of higher frequencies during crisis periods, aligning with the propositions of the Fractal Market Hypothesis. These results were consistent across multiple countries and different crises, underscoring their robustness and validity.

Arashi & Rounaghi (2022) conducted a comprehensive study employing multifractal analysis to explore various dimensions of the financial market, encompassing market efficiency, financial crises, risk assessment, and crash prediction. The focus of their investigation centered on analyzing the daily return patterns of the NASDAQ stock exchange index. Distinguishing itself from previous studies that primarily rely on statistical technical analysis methods, this research delves into the efficient market hypothesis and the fractal characteristics of the NASDAQ stock exchange. Acknowledging the intricate interplay of political, economic, and psychological factors in the nonlinear and chaotic nature of the stock market, the study utilizes the ARMA-GARCH model to analyze daily stock index data spanning from 2000 to 2016. Remarkably, the model forecasts stock index values for 2017 with an exceptional 1% error rate. The findings reveal a correlation between stock price indexes across various time scales, affirming the efficiency and non-fractal nature of the NASDAQ stock exchange, as observed in this study.

Jagric et al. (2005) employed wavelet analysis and calculated the Hurst exponent over a moving time window to assess the presence of long-range dependence (LRD) across six transition economies. Their findings were categorized into two clusters: markets displaying

pronounced LRD (Czech Republic, Hungary, Russia, and Slovenia) and markets exhibiting a more subtle form of LRD (Poland, Slovakia). Additionally, their investigation revealed indications of time-dependent variations in the Hurst coefficient.

Domino (2011) conducted an examination of an extensive array of stocks listed on the Warsaw Stock Exchange (126 companies) spanning the timeframe of 1991 to 2008. The objective was to calculate the Hurst exponent, aiming to identify the juncture at which alterations in the long-term return rate of an investment were prone to transpire, potentially informing investment strategies. The outcome of this analysis suggested that a declining Hurst exponent could be interpreted as an indicator signaling a potential shift in either the trend or the return of an investment.

Pleșoianu et al. (2012) utilized the MF-DFA technique to evaluate the informational efficiency of the Romanian stock market. Their research focused on the blue-chip Bucharest Exchange Trading (BET) and the composite BET-C index alongside ten individual stocks listed on the Bucharest Stock Exchange. By analyzing daily time series data from January 2001 to May 2012 and intraday time series data spanning January 2011 to December 2011, the study affirmed the existence of multifractality within the market and identified inherent predictability within it.

Caraiani (2012) explored multifractality within three key CEE stock markets: Poland, the Czech Republic, and Hungary. Employing the MF-DFA method, the study analyzed original return time-series for the blue-chip indexes WIG, BUX, and PX up to December 2010, as well as reshuffled time series. The results revealed the presence of long-term dependence in these markets. Furthermore, the research investigated whether multifractality underwent changes during the financial crisis period. Interestingly, although the study did not find an increase in the strength of multifractality during this period, it did observe alterations in its shape.

On the other hand, Rejichi and Aloui (2012) used the Hurst exponent method to assess stock market efficiency in the MENA region. Their findings highlighted Iran as exhibiting

the highest degree of inefficiency in this context, while Israel, Turkey, and Egypt showcased the lowest levels of inefficiency.

Rizvi and Arshad (2014) utilized MF-DFA to investigate the efficiency of East Asian stock markets during economic upturns and downturns. Their research concluded that economic booms had varying effects on each market, leading to decreased efficiency during recessionary periods and increased efficiency during economic booms. Notably, Singapore's market efficiency was the only one to improve during these events. In a detailed examination of financial crises, Horta et al. (2014) delved into the aftermath of the 2008 and 2010 crises on stock markets. Their analysis unveiled the existence of dynamic market efficiency and financial contagion during these tumultuous periods.

Furthermore, the study highlighted the relative resilience of developed markets in the face of financial crises, contrasting with the substantial impacts experienced by less-developed markets. Other researchers, i.e., Ito et al. (2014), employed a non-Bayesian model for time-varying vector autoregression to make a case about the efficiency of markets in G7 nations and the changing nature of global interconnections. Their results indicate that the efficiency of markets and global interconnections undergo fluctuations over time. They also note a positive correlation between these behaviors and historical events related to the international financial system.

Kumar (2014) conducted an empirical study using DFA and local Whittle techniques to examine the applicability of the Efficient Market Hypothesis (EMH) in the primary industry indices of India. The results highlight the dynamic nature of the efficiency attributes observed in Indian industrial indices. Furthermore, Gozbasi et al. (2014) employed ESTAR unit root tests to investigate the validity of the Efficient Market Hypothesis (EMH) in the context of the Turkish stock market. Their findings revealed that the stock prices in Borsa Istanbul adhere to a random walk pattern, indicating that the Turkish stock market exhibits weak-form efficiency.

Sensoy and Tabak (2015) conducted research and utilized the generalized Hurst exponent technique to provide empirical evidence of varying inefficiency in stock markets

within the European Union. Their results indicate that the Eurozone sovereign debt crisis has a detrimental effect on the stock markets of France, Spain, and Greece. At the same time, the Global Financial Crisis (GFC) adversely affects nearly all stock markets. Arshad et al. (2016) utilized the MFDFA method to assess the efficiency of stock markets in countries belonging to the Organization of Islamic Conference. Their results indicate a rise in efficiency over the past decade.

Charfeddine and Khediri (2016) utilized a combination of the generalized autoregressive conditional heteroskedasticity (GARCH) within the mean framework and DFA (Detrended Fluctuation Analysis) methods to evaluate the time-varying efficiency in the weak-form for stock markets within the Gulf Cooperation Council. They discovered that the efficiency of these markets fluctuates notably during periods of financial instability, such as the Arab Spring and the subprime crisis.

Ferreira (2018) undertook an examination of 18 Eastern European stock markets through the application of a sliding window DFA, utilizing data up to March 2017. The study's outcomes suggested that a significant number of the markets investigated exhibited long-range dependence, indicating a degree of market inefficiency. The paper highlighted a crucial aspect regarding the temporal evolution of dependency levels within the Czech, Hungarian, and Polish stock markets. Intriguingly, these dependency levels showed a declining trend, surpassing even the benchmark indexes for developed markets. Following this analysis, the markets were ranked using an efficiency index structured based on the methodology introduced by Kristoufek and Vosvrda (2013). This ranking established the Czech Republic, Hungary, and Poland as the most efficient markets in the group.

Wen et al. (2019) investigated how the attention of retail investors influences the risk of stock price crashes in China. Their study revealed that heightened attention from retail investors is linked to a reduction in crash risk and has an impact on the level of information asymmetry. Li et al. (2022) pointed out that financial data exhibit intricate patterns attributed to human behavior and evolving economic circumstances. They introduced a novel method, an improved SVDD model, to effectively ascertain the count of clusters within financial data.

Their findings demonstrated the successful identification of sub-patterns within financial series using this model.

Numerous studies have employed MFDFA to explore market efficiency and to specifically test the Adaptive Market Hypothesis, especially during times of crisis and pandemics.

Liu et al. (2010) investigated the evolution of market efficiency in the Shanghai stock market utilizing the model-free approach called multifractal detrended fluctuation analysis. By examining the alterations in scale-related behavior, the research observed that the reforms associated with price limitations led to enhanced efficiency over extended periods, yet their immediate impact was negligible. Employing a moving window technique and employing three distinct metrics, they ascertain a progressive increase in efficiency in the Shanghai stock market post-reform. Similarly, they apply the same analysis to volatility data and identify indications of inefficiency.

In the realm of academic literature, multifractal detrended fluctuation analysis (MF-DFA) has emerged as a valuable tool for assessing the efficiency of asset returns. This method, frequently applied in the field of econophysics, allows for the examination of various factors in financial time series, including multifractality, long-memory dependence, asymmetry, and persistence, all of which are associated with market inefficiency (Al-Yahyaee et al., 2020). Unlike the traditional rescaled range analysis (R/S) that gauges time series variability, MF-DFA circumvents spurious outcomes caused by nonstationarity and short-term dependencies in time series data, making it a more robust approach for characterizing long-range autocorrelations in these data (Zhuang et al., 2015; Ali et al. 2018).

It is worth noting that conventional nonlinear variance ratio tests or autocorrelation functions are ill-suited to identify multifractal structures in time series data. Multifractality in time series typically arises from two sources: long-range correlation and the properties of fat-tailed distributions (He & Wang, 2017; Han et al., 2019). Given that these features are commonly observed in financial asset price returns, often referred to as stylized facts, the utilization of MF-DFA for quantifying multifractality in time series becomes a suitable

technique for evaluating the presence of random walk properties and dependencies, as acknowledged in the econophysics literature (Arshad et al., 2016; Ali et al., 2018; Tiwari et al., 2019).

Numerous advancements have arisen in utilizing MFDFA within the stock market context. Thompson and Wilson (2016) exemplify this, while Cai and Hong (2019) employed MFDFA to explore the link between trading volume in the stock market and the investor fear index. The empirical findings indicate that the evolving connection between trading volume volatility and various forms of investor fear indicators displays multifractal traits, and this dynamic relationship exhibits pronounced anti-persistence.

The research conducted by Shahzad et al. (2018) affirmed that both full and rolling window analyses revealed a superior level of efficiency in the Japanese Yen (JPY) and the Swiss Franc (CHF) exchange rates. Conversely, the findings pointed to the British Pound (GBP) being the least efficient, with the Euro (EUR) following as the next least efficient. Tiwari et al. (2019) employed the MFDFA utilizing the generalized Hurst index to contrast the effectiveness of stock markets between developed and emerging nations. Their study demonstrates that most stock markets display multifractal characteristics, with long-term efficiency surpassing short-term efficiency levels.

Patil and Rastogi (2020) utilized MFDFA analysis, which revealed that the price series displays persistence in minor fluctuations and anti-persistence in significant fluctuations across all structural segments. This implies that the series maintains long memory behavior consistently, even with structural breaks. In contrast, both volume and price-volume cross-correlation exhibit anti-persistence across all structural segments, indicating that volume mainly conveys information in stable market conditions. The differing Hurst exponent among the structural segments points to varying levels of persistence, highlighting periods of market volatility. These findings carry significance in understanding the practical implications of the Adaptive Market Hypothesis (AMH).

In their research, Aslam et al. (2020a) investigated the influence of the COVID-19 pandemic on the intraday multifractal characteristics of eight European stock markets. They

utilized five-minute index data covering the period from January 1, 2020, to March 23, 2020, and calculated Hurst exponents using multifractal detrended fluctuation analysis (MFDFA). Their collective findings confirmed the existence of multifractality within European stock markets during the COVID-19 outbreak. Furthermore, market efficiency varies across these markets based on multifractal properties, with the Spanish stock market being the most efficient and Austria's market displaying the lowest efficiency. Belgium, Italy, and Germany fall in between. Given the widespread impact of this outbreak, policymakers should consider comprehensive measures to enhance market efficiency during similar epidemics.

Aslam et al. (2020b) explored the existence of long-range dependence and multifractal characteristics within the stock indices of nine emerging Asian economies tracked by MSCI. To ensure the reliability of their results, they utilized multifractal detrended fluctuation analysis (MFDFA) in combination with the Seasonal and Trend Decomposition using the Loess (STL) method, which effectively separates distinct time series components and eliminates seasonal fluctuations. The results unveil varying levels of multifractality observed across these markets, implying the existence of long-range correlations, which could lend support to the fractal market hypothesis. This symmetry in multifractality trends within financial time series parameters holds implications for portfolio management strategies. Notably, the Chinese and South Korean markets exhibit the lowest degrees of long-range dependence, trailed by Pakistan, Indonesia, and Thailand. In contrast, the Indian and Malaysian stock markets demonstrate the highest levels of dependence, potentially signifying market inefficiencies and avenues for profitable institutional trading strategies.

Miloş et al. (2020) employed MFDFA to conduct a comparative analysis of multifractal characteristics across various Central and Eastern European (CEE) markets. Their findings provided evidence of extended-term dependencies within these markets, leading to the conclusion that the markets under investigation were likely inefficient. This inefficiency could be attributed to their insufficient level of maturity at the time of the study.

Using MFDFA, Zhang and Fang (2021) noted that certain researchers have identified multifractal traits in both Chinese and American stock markets both prior to and following

the COVID-19 outbreak. Additionally, they delved into the origins of these multifractal attributes and concluded that the primary factor behind such characteristics in the stock market was long memory. In a study by Suh et al. (2021), their findings indicate that a novel technique known as the asymmetric multifractal detrended fluctuation analysis (A-MFDFA) has been developed. This method serves to investigate the asymmetric attributes of multifractals. Regarded as an extension of MFDFA, the A-MFDFA is notably adept at identifying the presence of asymmetric multifractal traits in intricate signal sequences. Likewise, numerous researchers have corroborated the presence of asymmetric effects within the capital market.

Choi (2021) examines the Efficient Market Hypothesis (EMH) across US stock market sectors during the COVID-19 pandemic. They analyzed 11 S&P 500 sectors using multifractal detrended fluctuation analysis, also exploring sector efficiency during the global financial crisis (GFC). Results reveal non-persistent behavior during the GFC and persistent behavior during the pandemic. Consumer discretionary sectors exhibited the highest efficiency, while utility sectors showed the lowest during both crises. Multifractality derives from long-range correlations and fat-tailed distribution, with the latter as the primary driver. Sectors with lower efficiency rankings are more affected by fat-tailed distribution. The study categorizes sectors with low market efficiency during both crises, offering insights for optimizing asset allocation strategies in US stock markets.

Frezza et al. (2021) investigated how the effectiveness of fifteen financial markets across Europe, the United States, and Asia was affected by the COVID-19 pandemic. To model price dynamics, the research employed multifractional Brownian motion. The outcomes reaffirmed prior research, indicating that markets did not maintain efficiency during the COVID-19 crisis. Notably, the results were intriguing as they revealed that Asian markets fully restored their efficiency to pre-crisis levels. In contrast, European and American markets had not yet regained their pre-crisis efficiency levels.

Xu & Hui (2021) conducted an extensive assessment of multifractal characteristics across ten sectors within the Shanghai Stock Exchange, aiming to gauge the repercussions of

the COVID-19 pandemic on China's stock market. Their approach involved the utilization of intra-day 5-minute transaction data and the application of multifractal detrended fluctuation analysis (MF-DFA). The results unveiled a common trend across all sectors during the COVID-19 period, characterized by heightened multifractality and diminished market efficiency. Notably, MHII stood out as the best-performing sector, exhibiting lower multifractal properties and higher market efficiency, while ITII, TBII, and EII were identified as the least efficient sectors. Intriguingly, ITII, TBII, MCII, and UII emerged as the four sectors that rebounded most swiftly from the pandemic impact, marked by reduced multifractal intensity and substantial enhancements in market efficiency. Furthermore, the time-varying MF-DFA outcomes affirmed that the Chinese stock market was influenced not only by the domestic ramifications of the COVID-19 epidemic but also by the ripple effects of the US stock market crash in March, which subsequently triggered fluctuations in sectors sensitive to market dynamics.

Okorie and Lin (2021) scrutinized the adaptive market efficiency across the economies of Brazil, India, Russia, and the US during the COVID-19 outbreak. Their results revealed that there were no substantial alterations in the long-, medium-, or short-term market efficiency levels within the Brazilian and US stock markets. However, they observed that the Russian stock market displayed heightened information efficiency in the long run in comparison to the Indian stock market.

Ozkan (2021) employed wild bootstrap automatic VR and automatic portmanteau tests to explore the stock market efficiency within six developed economies—namely, the United Kingdom, the United States, Spain, Italy, Germany, and France—all significantly impacted by the COVID-19 outbreak. The results suggest that deviations from market efficiency during the outbreak are more pronounced in the UK and US stock markets compared to the other markets under study.

In a separate study, Xu et al. (2022) conducted an analysis of the multifractal properties of ten sectors listed on the Shanghai Stock Exchange. Their findings suggest that

throughout the COVID-19 period, all sectors demonstrated low market efficiency and exhibited higher levels of multifractality.

Gaio, Luiz Eduardo, et al. (2022) conducted a study to explore how the Russia-Ukraine conflict influenced the stock market efficiency of six developed countries. The dataset encompassed daily stock index data from the United States (US), the United Kingdom, Germany, France, Italy, and Spain. Market efficiency was assessed by examining the multifractal nature of the return series across four distinct periods (the entire series, the COVID-19 outbreak, pre-conflict, and post-conflict). The findings illuminated the existence of multifractality within the return series of these indices during crisis periods. This evidence challenges the market efficiency hypothesis and suggests the potential for predicting asset prices during times of instability and global financial turmoil. These results hold valuable implications for fund managers, institutional investors, and the broader investment community, aiding them in decision-making related to asset allocation during crisis scenarios.

Mensi et al. (2022) identify distinct multifractal patterns in stock markets in both the rising and falling phases. Inefficiency tends to be higher during the rising market, except during financial crises when it reverses. The Turkish stock market is notably less inefficient in both trends. As the scale increases, asymmetric multifractality (A-MF) intensifies. The progression of extreme A-MF in MENA stock market returns varies widely. Mostly, markets exhibit greater inefficiency during a COVID-19 pandemic crisis in contrast to instances of oil crashes and past financial crises. Notably, the markets in Saudi Arabia and Qatar are particularly sensitive to oil price crashes. Inefficiency levels fluctuate across trends, scales, markets, and over time. These findings offer valuable insights for investors and policymakers, assisting in the development of investment strategies, risk management, and the promotion of financial stability.

Ogunjo (2023) conducted a research study that delved into the efficiency of stock markets across various global regions, with a specific focus on underexplored markets like Nigeria. This investigation centered on the application of multifractal formalism to analyze

the end-of-day stock prices spanning various sectors within the NGX (Nigerian Stock Exchange), covering the timeframe from January 2000 to November 2015. The findings unveiled the presence of multifractal characteristics in these stocks, primarily driven by long-range correlations and distributions with fat tails. A noteworthy discovery was the manifestation of anti-persistence behavior across all the stocks, indicated by a generalized Hurst exponent ($h(2)$) consistently below 0.5. Furthermore, the study assessed the multifractality of these stocks preceding, during, and later the 2007–2008 global financial crisis. The crisis period notably heightened the multifractality of the stocks in question, and in most instances, this heightened multifractality did not revert to pre-crisis levels. The insights gleaned from this research hold significant implications for regulatory policy formulation and provide valuable information for both local and international investors.

Erer et al. (2023) investigated the Turkish stock market's efficiency alongside different sectors amid the COVID-19 outbreak and the global financial crisis. Employing multifractal detrended fluctuation analysis, their findings indicate heightened persistence in sectoral returns during the COVID-19 outbreak compared to the global financial crisis. Notably, the real estate and information technology sectors consistently demonstrate lower efficiency levels in both crises, and the presence of fat-tailed distribution affects their multifractality. These findings support the adaptive market hypothesis and provide insights for policy formulation in managing future economic crises caused by outbreaks.

Maciel (2023)'s study applied multifractal detrended fluctuation analysis to evaluate price efficiency dynamics within the Brazilian equity market and its correlation with stock price predictability. The study's key findings include (i) Confirmation of multifractality in both pre and post the coronavirus disease (COVID-19) outbreak, contradicting the random walk hypothesis. (ii) Stock returns generally display anti-persistence, indicating a tendency for significant returns to be succeeded by smaller ones and vice versa. (iii) A decline in stock market efficiency observed post the COVID-19 pandemic within the Brazilian market. (iv) Identification of a link between efficiency and predictability, with less efficient assets displaying higher predictability.

Mensi et al. (2023)'s study findings indicate that there are distinct patterns of multifractality (MF) during upward and downward trends. In most stock markets, inefficiency is greater during upward trends and lower during financial crises. The Turkish stock market stands out as the least inefficient in both types of trends. Additionally, the absolute multifractality (A-MF) becomes stronger as the scales increase. The evolution of excessive A-MF varies among MENA stock returns. During a pandemic crisis, most stock markets experience higher levels of inefficiency compared to oil crashes and other financial crises. However, the inefficiency of the Saudi Arabia and Qatar stock markets is highly influenced by oil price crashes. Overall, the level of inefficiency varies across market trends, scales, and individual stock markets over time. These findings provide valuable insights for investors and policymakers in terms of effective investment strategies, risk management, and maintaining financial stability.

In summary, this section of the study presents findings obtained through the utilization of MF-DFA and various conventional tools to assess the weak-form market efficiency during periods of financial crises and pandemics. These examinations reveal that, apart from a few instances, these stock exchanges generally manifest inefficiency. These anomalies might arise from variations in approach or the duration of analysis. However, it is crucial to approach these empirical outcomes cautiously, as market efficiency can oscillate over time—a phenomenon often termed as time-varying market efficiency due to a range of factors, including the level of development in the stock market (Hull & McGroarty, 2014). Moreover, despite MF-DFA being a well-established methodology, its application in the context of financial crises and pandemics within individual countries remains somewhat limited. As a result, there is substantial room for comprehensive testing to attain a deeper comprehension of market behavior.

3.6. RESEARCH METHODOLOGY

3.6.1. Research Philosophy

Research on the following bases either there is any reasoning (theory) or has some observation, i.e., data or information; hence, philosophy helps to simplify the design and approaches of the research, and further, this will help to understand the data collection and analysis (Blumberg et al., 2005). There are three main elements of the research philosophy, i.e., axiological, ontology, and epistemology. These three main elements should be considered while talking about research philosophy. Further, three-epistemology is concerned with creating knowledge that is acceptable, ontology deals with nature and reality, and axiology is the study of value (Collis & Hussey, 2009).

In scientific research, there are many different ideas, and for knowledge development in research, philosophy is mandatory to guide the research idea. There are three main research processes that influence literature, namely positivism, interpretive, and realism (Saunders et al. (2003). In the positivism research philosophy, the research work is like the natural scientist.

There are constantly varying theories when we conduct scientific inquiry. We require a research philosophy to direct our ideas to advance knowledge. Literature is dominated by three perspectives on the research process: positivism, interpretivism, and realism (Saunders et al., 2003).

If someone manages their job like a natural scientist, then they must follow the positivist research philosophy. They will find it more satisfying to engage with observable social reality. A study of this kind can result in generalizations that resemble laws, much like those created by physical and natural scientists (Remenyi et al., 1998). The task for the investors is to gather some ostensibly valueless data, analyze it using statistical tools, and then replicate the reality. Normal positivism should be emotion-free and objective.

In contrast to the natural sciences, the social world of business and management is excessively complex. Therefore, it is not practical to define law using the same methodology

as natural science. If the world's complexity is reduced to a set of generalizations resembling laws, rich insights into the world's complexity are lost. It is the interpretive principle of numbers. The foundation of realism is the conviction that reality is distinct from human perception and belief. Realism seeks to bridge objective elements within society while recognizing the inherent challenge of studying people in a purely objective manner, blending principles from both positivism and interpretivism. The philosophy this study adopts for research depends on the subject matter's needs. Hence, this study goes with positivism. I believe that the study must base our analysis and conclusions on a vast number of facts; nonetheless, the outcome of the computation will reveal the answer. The study must utilize a statistical tool, and our solution cannot be based on human reasoning; all that is left for us to deal with is the numbers. As a result, positivism informs an approach to study (Saunders et al., 2003).

3.6.2. Ontological Assumption

This study is considered ontological by an objectivist. It is the mind of independent researchers that the social reality is exterior to the researchers, and meanings of the social phenomena are existent independent social actors (Sarantakos, 1998; Bell & Bryman, 2007). This research aims to explore market efficiency during the financial and pandemic crisis of Organization of Islamic Cooperation stock market indices and sectors indices, which are related outside the scholar's mind, which means objectivism is suitable over constructionism. All factors under consideration influence the decision in this study.

3.6.3. Epistemological Assumption

This research believes in the positivism area, and the focus of the study is market efficiency during the financial crisis and pandemic, which makes a general law that one may generalize for the entire population instead of clarifying and understanding the significance of such a decision.

Indeed, epistemology procedures and principles should be governed and taken from the study of reality. 02 (two) conflict areas are positivism and interpretivism. Social reality

study is related to the method of natural sciences, and positivism is directly backed by the natural sciences (Bell & Bryman, 2007).

The subject of the research does not affect the researchers. According to the positivism idea, the research has been carried out in a well-neutral manner, i.e., the structure of the research data has been collected from stock markets. There is no effect of the researcher on the data. The current concepts and research have been implemented to secondary time series data and trading data collection of stock markets from websites, and the hypotheses tested are all accordingly suggested by positivism (Saunders et al., 2003).

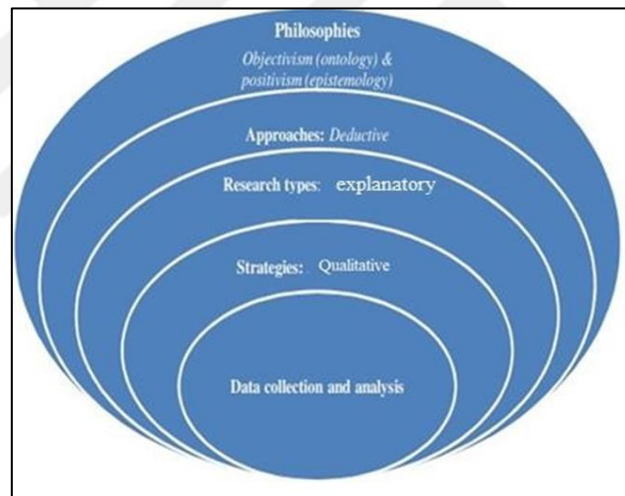


Figure 2: Research methodology took from “Research Onion”

Source: Saunders, et al. 2003

3.6.4. Research Approach

There are two approaches to theory that can be tested and built on the basis of these approaches, i.e., induction and deduction; the deductive approach is applicable when the researcher’s research is based on already existing theory and only the researcher contributes empirical evidence of the research whereas the inductive research is the type of research where researcher developed new theory through observations and practical reality (Bell & Bryman, 2007; Saunder et al., 2009; Ghauri & Gronhaug, 2020).

This research aims to find out the market efficiency during the financial crisis and the pandemic market efficiency theory already exists. This research does not build or develop any new theory that indicates that the deduction approach is best and most appropriate; further, this study belongs to theories that are on market efficiency in general and specifically related to the stock market.

The deductive approach is also connected with quantitative research, which includes the collection of quantitative data and the implementation of statistical models for analysis. Both research approaches have been explained step by step in Figure 3.

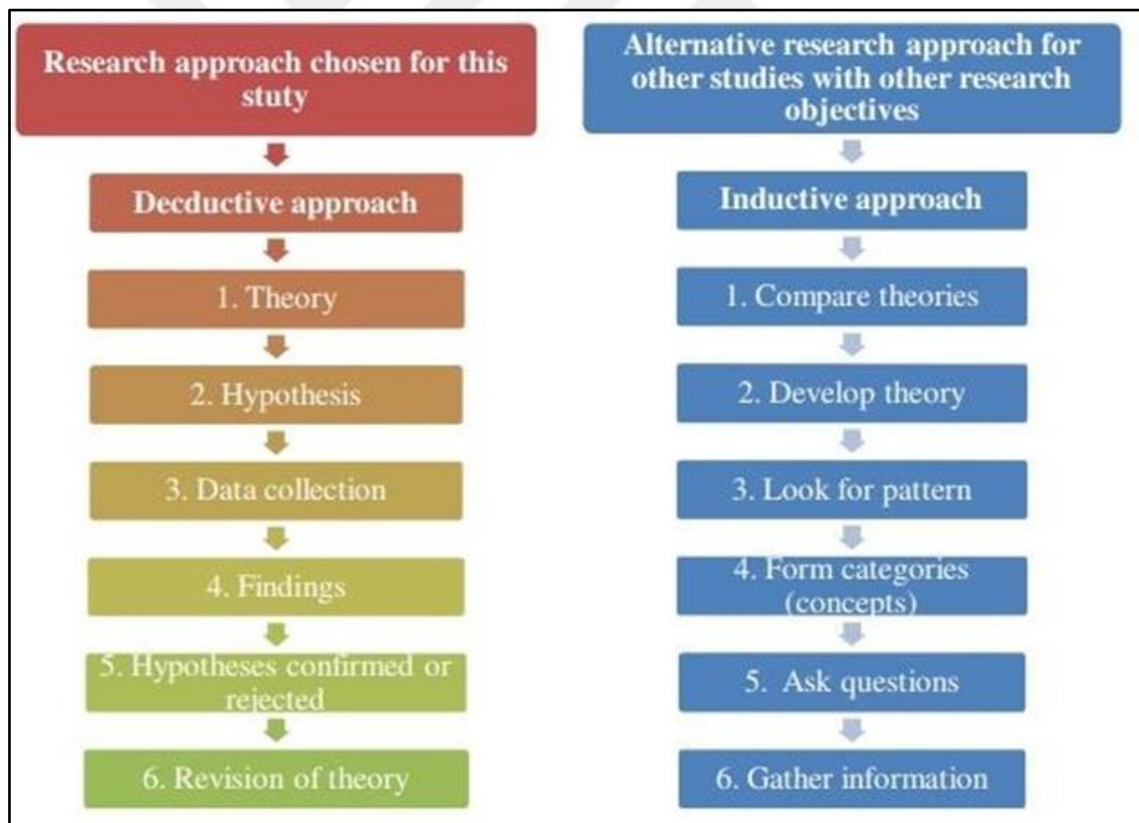


Figure 3: Research Approach step by step

3.6.5. The Type of Research

The answers to the research questions can be explanatory, exploratory, or descriptive (Saunders et al., 2009). Exploratory research is research for something new and what is currently happening. Further it helps to clear the unsure problems has described this research (Blumberg et al., 2005; Saunders et al., 2009; Ghauri & Gronhaug, 2020).

This study belongs to explanatory research is best for this research and it has been done very by a few researchers previously. Explanatory research will help to understand the market efficiency during the financial crisis and pandemic as very limited understanding among the people.

3.6.6. Research Strategy

This study is purely based on quantitative research. Moreover, the main point of the study is to identify the market efficiency during the financial crisis and during the pandemic, for which quantitative research is the only approach that can be done effectively as quantitative research was introduced to establish a relationship between variables for descriptions and identifications (Garner et al., 2009). Positivism is based on hard facts and is often linked to quantitative research.

Through the quantitative research strategy, researchers can use statistical models to analyze their research results with the help of computer software. Most of the research that has been published in the top journals also uses the quantitative research approach, and they also applied advanced-level statistical methods with the help of computer software to analyze their research results (Sarantakos, 1998). The quantitative research approach must be focused on the digits and statistics, so this method is not able to differentiate between people and institutions. Further, it has been scientifically proved that this approach is considered superficial (Bell & Bryman, 2007).

The thesis utilized quantitative research methods that relied on share price data, and it is presumed that the outcomes can be applied to similar markets. As a result, the thesis was

determined to be aligned with the functionalist paradigm. The researcher also believes that changes in share prices in emerging stock markets in South Asia represent a crucial reality rather than being influenced by social constructs, which is in line with the thesis's objective.

3.6.7. Research Design

Research design gives direction or structure for the collection of data and its analysis Ghauri & Gronhaug, (2010); Bell & Bryman (2007). To understand the market efficiency through time series data of the stock market the longitudinal research designs are appropriate that are measured again and again on daily intervals over time (Velicer, 2010).

Whereas Case study refers to the study and analysis of only cases (Collis & Hussey, 2009), and longitudinal study is the study and observation of the multiple times or changes that occurred over time. A cross-sectional study is the study of multiple cases collected and analyzed at a single time (Saunders et al., 2009).

In view of the above-mentioned research and reference, the following aspects are relevant to this research: first, in this research, the research describes market efficiency instead of a single person or case, the data has been collected for different periods, and this study is the longitudinal research design.

3.6.8. Limitations

The study strongly believes in the methodological approach used, but there are still a few limitations. The study used an MFDFA test to identify the level of market efficiency, which is only one of the best methods to check market efficiency. The unavailability of data was a big problem in this study, as the thesis belongs to OIC countries. Most of the countries belong to emerging markets and developing markets. Hence, the availability of data was a big issue as the thesis is time-bound, so time was another limitation in this study. It can summarize the limitations and say that there were mainly three limitations: unavailability of data, time constraints, and availability of resources.

3.6.9. Multifractal Detrended Fluctuation Analysis (MF-DFA)

Benoit Mandelbrot, a mathematician, is credited as the founder of fractal theory. This theory was established in the 1960s and has since been further developed by Mandelbrot and other researchers. The application of fractal and multifractal analysis spans various fields, such as physics, medicine, and social sciences, contributing to its advancement. Fractal and multifractal scaling have been observed in diverse phenomena, including heartbeat rate (Arevalo et al., 2007), traffic speed series (Shang et al., 2008), blood pressure (Marrone et al., 1999), ozone concentration (Lee et al., 2006), rainfall and river flows (Tessier et al., 1996), and language structures in linguistics (Berners-Lee & Kagal, 2008). In the economic context, when discussing empirical fractal analysis, the term "Econophysics" is often employed, as it utilizes methods originally developed in physics.

There exist various approaches for analyzing the fractal properties of time series data. Among them are the Wavelet Transform Modulus Maxima (WTMM) method proposed by Eichner et al. (2006) and Bogachev et al. (2007), as well as the multifractal detrended fluctuation analysis (MFDFA) introduced by Muzy et al. (1994) and Von Storch and Zwiers (2002). Studies have indicated that when the true fractal structure of the data is unknown, MF-DFA is the recommended method between the two, as it exhibits less bias and a lower likelihood of yielding false positive results (Oświęcimka et al., 2006; Schumann & Kantelhardt, 2011).

In this section, the study introduces an enhanced DFA technique known as multifractal detrended fluctuation analysis (Kwapień, 2005). The seminal study by Kantelhardt et al. (2002) demonstrated that MFDFA can capture the multifractal scaling characteristics of time series. The rationale behind incorporating DFA into MFDFA is to mitigate spurious correlations arising from non-stationarities in the time series data.

The MF-DFA method, utilized to represent multifractal properties within a financial time series, serves as a means to gauge and rank market efficiency. Kantelhardt et al. (2002) delineate the MF-DFA procedure into five sequential steps:

Let $\{x_k, k = 1, \dots, N\}$ be a time series, where N is the length of the series.

Stage 1. Determine the profile $Y(i)$ ($i = 1, 2, \dots, N$)

$$Y(i) = \sum_{k=1}^n (x(k) - \bar{x}) \quad (2)$$

Where:

$$\bar{x} = \sum_{k=1}^n x(k)/N \quad (3)$$

Step 2 involves partitioning the profile $\{Y(i)\}$ ($i = 1, 2, \dots, N$) into $N_s \equiv \text{int}(N/s)$ non-overlapping segments, each sharing equal length denoted as s . To ensure the entire sample is covered, this process is reiterated from the end of the sample. Consequently, a total of $2N_s$ segments are obtained collectively.

$$\{Y[(v-1)s + i]\}_{i=1, v=1, 2, \dots, N_s} \quad (4)$$

$$\{Y[N - (v - N_s)s + i]\}_{i=1, v = N_s + 1, N_s + 2, \dots, 2N_s} \quad (5)$$

Step 3 involves computing the local trend for each of the $2N_s$ segments. The local trend estimation for each segment is achieved through a least-square fitting polynomial. Subsequently, the variance is calculated based on these local trends.

$$F^2(s, v) = \begin{cases} \frac{1}{s} \sum_{i=1}^s \{Y[(v-1)s + i] - \hat{Y}_v^m(i)\}^2, & v = 1, 2, \dots, 2N_s \end{cases} \quad (6)$$

$$\frac{1}{s} \sum_{i=1}^s \{Y[N - (v - N_s)s + i] - \hat{Y}_v^m(i)\}^2, \quad v = N_s + 1, N_s + 2, \dots, 2N_s. \quad (7)$$

Here, $\hat{Y}_m^v(i)$ represents the fitting polynomial with an order denoted as m within segment v . Typically, linear ($m = 1$), quadratic ($m = 2$), or cubic ($m = 3$) polynomials are employed for this purpose. However, for this study, to prevent overfitting and streamline computation Jiang et al. (2009), a linear polynomial ($m = 1$) is utilized.

Step 4. Average over all the segments. Then, the study obtain the q th order fluctuation function:

$$F_q(s) = \begin{cases} \left[\frac{1}{2N_s} \sum_{v=i}^{2N_s} (F^2(s, v))^{q/2} \right]^{1/q} & q \neq 0 \\ \exp \left[\frac{1}{4N_s} \sum_{v=i}^{2N_s} \ln(F^2(s, v)) \right] & q = 0 \end{cases} \quad (8)$$

Step 5 involves assessing the scaling behavior of the fluctuation functions. This evaluation entails comparing the log–log plots of $F_q(s)$ against s for each specific value of q . If the series exhibit long-range power-law correlations, there should be an increase in $F_q(s)$ for larger s values. The power law can be expressed as follows in mathematical terms.

$$F_q(s) \propto s^{h(q)} \quad (9)$$

The function $h(q)$, which depends on the parameter q , plays a crucial role. In the case of a stationary time series, $h(2)$ is commonly referred to as the Hurst exponent. Consequently, $h(q)$ is known as the generalized Hurst exponent. When $h(2)$ equals 0.5, it signifies that the series lacks correlation and follows a random walk pattern. If $0.5 < h(2) < 1$, it indicates the presence of long memory. Conversely, if $0 < h(2) < 0.5$, it suggests a tendency toward a mean-reverting process.

$$\Delta h = h(q_{\min}) - h(q_{\max}) \quad (10)$$

The degree of multifractality can be determined by observing the decreasing trend of $h(q)$ as q increases. When Δh values are higher, it indicates greater levels of multifractality within the timeseries (Zunino et al., 2008; Aslam et al., 2020).

3.6.10. Overlap Moving Window

To tackle the discontinuity problem in data segmentation, the OMW-based algorithm, as proposed by Zhang et al. (2019), is employed. This algorithm involves estimating the moving window size from the fault signal of length L and establishing the step size (s) for each iteration. The algorithm iterates through the signal for numerous iterations, the count of which depends on the signal length or total samples, as illustrated in Fig. 1. The calculation for these iterations can be expressed as follows:

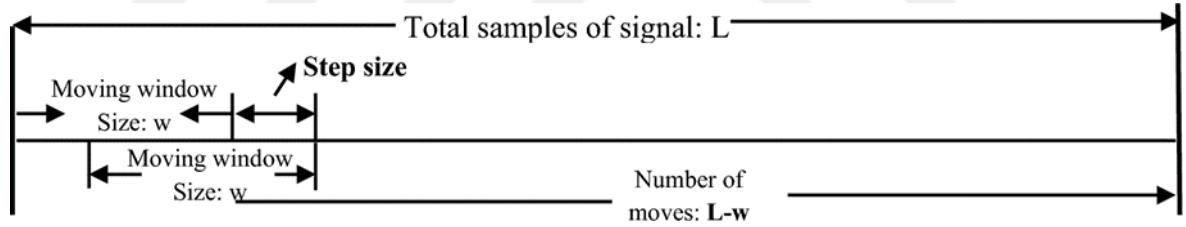


Figure 4: Overlap moving window architecture (Zhang et al., 2019)

The inclusion of overlapping moving windows in this library serves a different purpose than detrending. Instead, it is intended for analyzing relatively short time series or for dealing with very large scales in longer time series (Zhou and Leung 2019). In the literature, various applications of moving average windows have been proposed to remove trends and ensure stationarity, typically achieved by subtracting a windowed average from the time series, as described by Zhou and Leung (2019), as well as (Lai et al., 2019). However, this study adopted the approach here differs, which replaces the non-overlapping segmentation of a moving window with a single moving window of each segment size applied over the entire time series, following the method introduced by Y. Zhou and Y. Leung

in 2019. This becomes particularly important when analyzing short time series, as using larger lags can result in a limited number of segments, leading to insufficient statistics for scaling at larger lags.

3.6.11. Ranking efficiency of the sector ETF markets:

This thesis employed the MF-DFA method to evaluate the market efficiency ranking of both stock markets and sectors within the countries belonging to the Organization of Islamic Cooperation (OIC). In order to scrutinize the fluctuations in market efficiency levels during both the Global Financial Crisis (GFC) and the COVID-19 pandemic, a market deficiency measure (MDM) is calculated utilizing the following method:

$$\text{MDM} = \frac{1}{2} (|\underline{h}(-5) - 0.5| + |h(5) - 0.5|) = \frac{1}{2} \Delta h \quad (11)$$

In an efficient sector ETF market, all types of fluctuations, whether small ($Q=-5$) or large ($Q=+5$), adhere to a random walk process.

Hence, in an efficient market, the value of "MDM" is zero, indicating a high level of efficiency. Conversely, for a market with lower efficiency, the "MDM" value is high.

3.7. DATA

3.7.1. Countries Indices Data

The study has focused on the Organization of Islamic Cooperation (OIC), comprising 57 countries, from which 15 countries have been selected for the study due to the availability of data. Daily data for the primary indices of chosen countries has been gathered from DataStream Thomson Reuters and investing.com. The table provided in section 3.1 outlines the specifics, including the calculated average return from this data.

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}} \quad (1)$$

Where:

R_m = Daily Market returns of the index for day t

R_t = closing value of the share Price Index for day t .

R_{t-1} = closing value of the Share Price Index for day $t-1$

To measure the market efficiency, data has been divided into two sub-periods: (i) during GFC 1 July 2007 to 30 June 2009 consisting of 521 observations (ii) During COVID 1 January 2020 to 31 December 2021 with 521 observations, after the outbreak COVID pandemic by public health emergency of international concern (PHIEC) on 1 January 2020 the period has been considered for COVID. Further, data sorted and removed holidays and mismatched dates from the data, only data considered which has been found in all the stock markets. Descriptive analysis and the MF-DFA technique are employed for the examination of multifractal characteristics (or prolonged memory) within non-stationary financial time series and for assessing financial market efficiency, as indicated by studies conducted by Kantelhardt et al. (2002), Mensi et al. (2017), and Choi (2021). This method enables the assessment of the degree of persistence, long-term memory, and random walk tendencies present in the prices of financial assets, as highlighted in the research conducted by Mensi et al. (2017) with the help of R Programming.

Table 1:Source of Data Collection during GFC and COVID Pandemic.

Country	Source of Data	Country	Source of Data
Egypt	DataStream	Indonesia	DataStream
Jordan	DataStream	Kuwait	DataStream
Lebanon	DataStream	Malaysia	DataStream
Morocco	DataStream	Oman	Investing.com
Pakistan	DataStream	Palestine	Investing.com
Qatar	Investing.com	Saudi Arabia	DataStream
Tunisia	DataStream		

Source: Author Generate

Table: 1 shows source of data collection the mostly data has been collected through Thomson Reuter Data Stream expect for three countries i.e., Qatar, Oman, and Palestine which has been collected from Investing.com.

3.7.2. Sector Indices Data

The sectors selected from the 15 countries are mentioned in Table 3.1; only six countries, i.e., Egypt, Jordan, Morocco, Saudi Arabia, Turkey, and UAE, have been selected based on the availability of data and similarity of sectors between countries, further, the Bloomberg classification has been used to select the sector in table 3.2. Only the sectors selected are similar in all countries, and the data available, sector indices divided into two sub-period (i) GFC period covered from 1st July 2007 to 30th June 2009 consists of 502 observations, (ii) COVID period considered from 1st January 2020 to 1st January 2022 with 502 observations, the return of the sector indices calculated which are previously defined in the countries stock indices and descriptive analysis and MF-DFA applied for sector indices, data has been collected from investing.com for sector indices.

Table 2: Bloomberg Classification of the Sectors

S.No.	Sectors	Bloomberg Classification	Included
01	Health Care	Health Care	Health Care Equipment & Services Pharmaceuticals, Biotechnology & Life Sciences
02	Real Estate	Real Estate	Real Estate
03	Consumer Staples	Consumer Staples	Food & Staples Retailing Household & Personal Products Food Beverage & Tobacco
04	Bank	Financial	InsuranceBanks Diversified Financials
05	CommunicationServices	Communication Services	Telecommunication Services Media & Entertainment
06	Industrial	Industrial	Commercial & Professional Services Transportation Capital Goods

Source: Author Generate

Table 2 shows the Bloomberg market classification. The sector indices data collected for different countries and have different names through the Bloomberg classification data has been collected, and the sector has given names accordingly.

Table 3: Descriptive Statistic for Country Major Indices during COVID-19 and GFC Period

	Mean	Min	Max	Std. dev.	Skewness	Kurtosis	Jarque-Bera	obs.
COVID-19 period								
Egypt	.0000142	-.0865	.0559	.012308	-1.279503	12.48223	2094.013	521
Indonesia	.0002927	-.0658	.1019	.0128123	.3799758	13.50788	2409.474	521
Jordan	.0004704	-.0448	.0275	.0063178	-.2335236	10.16428	1118.959	521
Kuwait	-.017148	-.4959	.4919	.2148502	.0083061	2.677574	2.262761	521
Lebanon	.0007334	-.1197	.0566	.0130272	-2.152732	26.73162	12628.32	521
Malaysia	.0000217	-.0526	.0685	.0096372	.0131097	10.98844	1385.338	521
Morocco	.0002382	-.0882	.0545	.0093019	-2.36858	29.63052	15882.36	521
Oman	.0101236	-.0557	.0823	.0218797	1.692121	5.128086	346.9391	521
Pakistan	.0002395	-.0686	.048	.0122061	-1.035386	9.75745	1084.358	521
Palestine	.0148858	-.0222	.0986	.0277073	1.754862	4.81946	339.2709	521
Qatar	.0118511	-.097	.0985	.0259597	1.599318	5.947333	410.6794	521
Saudi Arabia	.0007102	-.08	.07	.0118514	-1.427897	16.03858	3867.559	521
Tunisia	.0000154	-.041	.0192	.0051285	-2.261724	19.07891	6056.469	521
Turkey	.0011353	-.0979	.0598	.0164496	-1.478119	10.21155	1318.69	521
UAE	.0011094	-.0806	.0841	.0134058	-.2689922	17.31022	4451.77	521

GFC period								
Egypt	-.0003789	-.158	.0593	.0198334	-1.401602	11.7733	1841.489	521
Indonesia	.0001223	-.1038	.0792	.0209418	-.3086815	6.902547	338.889	521
Jordan	.0002296	-.1857	.2199	.0195134	.9947255	48.13302	44305.57	521
Kuwait	-.0008929	-.0724	.0774	.014824	.2110691	8.035646	554.3424	521
Lebanon	.0004764	-.0633	.0818	.0145529	1.085553	10.91893	1463.645	521
Malaysia	-.0003731	-.095	.0435	.0118284	-.9405296	11.44645	1625.54	521
Morocco	.0000779	-.0456	.0456	.010092	-.2835465	7.225169	394.5195	521
Oman	.0098693	-.0833	.0837	.0272892	.4002132	4.288219	49.93329	521
Pakistan	-.0080975	-.3686	.4414	.2078632	-.0051926	1.719217	35.61283	521
Palestine	.0116288	-.0834	.0972	.0278213	.982699	4.205247	115.3887	521
Qatar	.0099121	-.0875	.0988	.0295586	.5753406	4.45939	74.97809	521
Saudi Arabia	-.0008829	-.1000	.0800	.0182606	-.6089851	6.366028	278.1618	521
Tunisia	.0007553	-.0488	.0324	.0065299	-.4887083	13.92194	2610.298	521
Turkey	-.0001898	-.0862	.1289	.0236933	.2415382	5.648361	157.3241	521
UAE	-.0003908	-.0683	.0753	.0168377	.004412	7.005277	348.252	521

Source: Author Generate

Table 3 presents a descriptive analysis of the return series of major indices of selected countries for the thesis, which is mentioned in Table 1 during the GFC and COVID-19 periods. As results shown in Table 3, the Palestine stock index showed the highest return during COVID-19; moreover, all other indices had positive mean returns except Kuwait. Palestine stock shows the highest mean return during the GFC, and Pakistan has the lowest negative mean return. In addition, the negative mean return was observed for Turkey, Malaysia, Egypt, UAE, Saudi Arabia, Pakistan, and Kuwait during GFC. The standard deviation shows that the Kuwait stock market was highly fluctuating during GFC, while the Pakistan stock market was a riskier market during COVID-19.

The skewness and kurtosis show that all the values are greater than 0 and 3, respectively, which shows that the data is not normally distributed. Furthermore, only the UAE stock index skewness value is near zero, but the kurtosis value is above the critical value, i.e., 3. At a significant level of 5%, the null hypothesis that the returns follow a normal distribution according to the Jarque- Bera test is not accepted for both periods, i.e., COVID-19 and GFC. Furthermore, the skewness shows a positive value for Egypt, Jordan, Lebanon, Morocco, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Tunisia, Turkey, and UAE stock markets during the COVID-19 period. Their distribution is right-skewed, while Indonesia, Kuwait, Malaysia, Oman, Palestine, and Qatar stock markets show positive skewness values, which means these stock markets are distributed left-skewed. During GFC, the skewness values have been found negative for Egypt, Indonesia, Malaysia, Morocco, Pakistan, Saudi Arabia, and Tunisia and positive for Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Turkey, and UAE, which suggests that distribution was right skewed for negative value and left skewed for positive value of skewness.

Table 4: Descriptive Statistic Sector Indices of Egypt during COVID-19 and GFC

COVID Period								
	Mean	Min	Max	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Obs.
Health Care	.0010159	-.1	.05	.0153458	-1.557518	11.11371	1579.956	502
Real Estate	.0011952	-.11	.07	.0202126	-1.008162	7.394352	488.9456	502
Consumer Staples	.0009562	-.09	.05	.0171957	-1.282352	8.586392	790.3461	502
Bank	.0002191	-.1	.1	.0221713	-.1112592	6.496679	256.7788	502
Communication Service	.0008167	-.1	.09	.0201177	-.6876125	7.527888	468.3870	502
Industrial	.0019323	-.1	.06	.0170724	-1.355175	9.526974	1044.733	502
GFC Period								
Health Care	.0002006	-.068	.1051	.0198737	.2634865	5.37887	124.1764	502
Real Estate	-.0009602	-.083	.0882	.0205379	-.2789691	5.218042	109.4152	502
Consumer Staples	.0001594	-.084	.0896	.0221326	-.1179649	4.907262	77.25180	502
Bank	.0001857	-.105	.1687	.0312629	.3590995	5.117855	104.6068	502
Communication Service	.0004388	-.138	.1262	.0284417	.0969523	5.358369	117.1230	502
Industrial	-.0004337	-.077	.0875	.0191258	-.2608177	5.583058	145.2514	502

Source: Author Generate

Table 4 presents a descriptive analysis of Egypt's return series of sector indices during the COVID-19 and GFC periods. As the results shown in Table 4 show, the industrial sector had the highest return during the COVID-19. Moreover, all other indexes had positive mean returns; on the other side, the communication service sector showed the highest mean return during the GFC, and the real estate sector had the lowest mean return; the Industrial and Real Estate sectors had negative mean returns. The standard deviation shows that the banking sector fluctuated and was risky during both the GFC crisis and COVID-19.

The skewness and kurtosis show that all the values are greater than 0 and 3, which, respectively, shows that the data is not normally distributed. At a significant level of 5%, the null hypothesis that the returns follow a normal distribution according to the Jarque-Bera test is not accepted for both periods, i.e., COVID-19 and GFC. Furthermore, the skewness shows negative value for all the sectors during the COVID-19 period, which means their distribution is left-skewed, while the healthcare, banking, and Communication sectors show positive skewness value during GFC, which means these stock markets are distributed right-skewed.



Table 5: Descriptive Statistic Sector Indices of Jordan During COVID-19 and GFC

COVID period								
	Mean	Min	Max	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Obs.
Health Care	.0001394	-.02	.02	.0067888	.0213243	3.413564	3.615523	502
Real Estate	-.0003785	-.08	.07	.0115148	-.1067159	9.97807	1019.458	502
Consumer Staples	.0009163	-.04	.05	.0127918	.3553383	3.87097	26.43133	502
Bank	.000102	-.049	.0353	.0071294	.1870131	11.41587	1484.390	502
Communication Service	.0008765	-.04	.05	.0129188	.3649269	3.759144	23.19631	502
Industrial	.000239	-.03	.03	.0077087	-.2240025	4.224568	35.56410	502
GFC Period								
Health Care	-.0016733	-.04	.04	.014071	-.1102287	3.712164	11.62504	502
Real Estate	.0516135	0	.1	.0284108	-.0711493	1.880255	26.64945	502
Consumer Staples	.0144024	-.03	.1	.0275178	1.549689	4.47958	246.7185	502
Bank	.0489243	0	.1	.0291811	.0195681	1.811808	29.56220	502
Communication Service	.0341434	-.05	.1	.0333846	.3205454	1.957667	31.32180	502
Industrial	-.0003984	-.05	.05	.0160787	-.0505485	3.244693	1.466154	502

Source: Author Generate

Table 5 presents a descriptive analysis of the return series of sector indices of Jordan during the COVID-19 and GFC periods. As the results shown in Table 5 indicate, the Consumer Staples sector had the highest return during the COVID-19. Moreover, all other indexes had positive mean returns except the Real Estate sector; on the other hand, the Real

Estate sector shows the highest mean return during the GFC, and the Health Care sector has the lowest mean return, while the industrial, health care and real estate sector has a negative mean return. The standard deviation shows that the Communication Service sector is highly fluctuated and risky, and the Health Care sector shows less fluctuation during both crises, GFC and COVID.

The skewness and kurtosis show that all the values are greater than 0 and 3, respectively, showing that the data is not normally distributed. At a significant level of 5%, the null hypothesis that the returns follow a normal distribution according to the Jarque-Bera test is not accepted for both periods, i.e., COVID-19 and GFC. Furthermore, the skewness shows a positive value for all the sectors during the COVID-19 period, which means their distribution is right-skewed except for the Real Estate and Industrial sectors as these sectors are left-skewed distributed, while Health Care and Real Estate sectors show negative skewness value during the GFC, which means these stock markets are distributed left-skewed and other sectors are positive and right-skewed distribution.

Table 6: Descriptive Statistic Sector Indices of Morocco during COVID-19 and GFC

	COVID Period							
	Mean	Min	Max	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Obs.
Health Care	-.000517	-.1	.1	.021148	-.0016437	4.886719	74.45743	502
Real Estate	.000338	-.08	.06	.0116881	-.8240512	13.0543	2171.258	502
Consumer Staples	.000278	-.07	.07	.0110489	-.4816884	13.68502	2407.462	502
Bank	-.000338	-.1	.06	.0120082	-1.44419	19.78049	6064.317	502
Communication Service	-.000358	-.1	.06	.0180117	-.3443647	6.18964	222.7238	502
Industrial	-.000488	-.0953	.0608	.0171841	-.4095063	6.229684	232.2093	502
	GFC Period							
	Mean	Min	Max	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Obs.
Health Care	.000498	-.06	.06	.0192045	-.082686	4.964408	81.28731	502
Real Estate	.000517	-.04	.04	.0107842	-.0455644	4.442851	43.71841	502
Consumer Staples	-.000099	-.06	.05	.0128631	-.1391539	6.649858	280.2606	502
Bank	.000398	-.07	.05	.0133523	-.0879514	6.585548	269.5550	502
Communication Service	-.000019	-.06	.06	.0208071	.0026532	3.752718	11.85166	502
Industrial	.017828	-.05	.1	.0321714	.8297383	3.055854	57.66688	502

Source: Author Generate

Table 6 presents a descriptive analysis of Morocco's return series of sector indices during the COVID-19 and GFC periods. As the results shown in Table 6 indicate, the real estate sector had the highest return during the COVID-19. Moreover, all other indexes had negative mean returns except the Real Estate and consumer staple sectors; on the other side, the Industrial sector showed the highest mean return during the GFC communication services, and consumer staple showed a negative mean return and the lowest value. The standard deviation value shows that the healthcare care sector is highly fluctuating and risky,

and the consumer staples sector shows less fluctuation during the COVID-19 period, while the Industrial sector remains highly risky during the GFC. Real Estate values show that it was a less fluctuating sector.

The skewness and kurtosis show that all the values are greater than 0 and 3, which are respectively expected for Industrial during GFC, which shows that the data is not normally distributed. At a significant level of 5%, the null hypothesis that the returns follow a normal distribution according to the Jarque-Bera test is not accepted for both periods, i.e., COVID-19 and GFC. Furthermore, the skewness shows a negative value for all the sectors during the COVID-19 and GFC period, which means their distribution is left-skewed, except the Communication and Industrial sectors have a positive value for skewness means these sectors are right-skewed distribution.

Table 7: Descriptive Statistic Sector Indices of Saudi Arabia during COVID-19 and GFC

	COVID Period							Obs.
	Mean	Min	Max	Std. dev.	Skewness	Kurtosis	Jarque-Bera	
Health Care	.0003984	-.06	.08	.0129578	.2015063	8.586094	656.0902	502
Real Estate	.0012749	-.08	.08	.0142395	-.1464082	10.63059	1219.686	502
Consumer Staples	.0004183	-.05	.05	.0091136	-.6843145	10.71511	1284.201	502
Bank	.0003386	-.08	.09	.0131961	-.5787721	12.81188	2041.737	502
Communication Service	.000996	-.09	.06	.0139647	-1.304772	12.02839	1847.391	502
Industrial	.0003785	-.1	.07	.0168253	-1.562162	11.69515	1785.593	502
	GFC Period							Obs.
	Mean	Min	Max	Std. dev.	Skewness	Kurtosis	Jarque-Bera	
Health Care	-.0002456	-.0997	.0988	.0221124	-.1143937	7.611115	445.8330	502
Real Estate	.0496663	.002	.0986	.0279279	-.011573	1.827245	28.77903	502
Consumer Staples	-.0013771	-.0979	.0986	.0262112	-.4554289	5.969964	201.8531	502
Bank	.0000865	-.0962	.0952	.022283	-.2632085	7.378469	406.7895	502
Communication Service	-.0002251	-.0977	.0912	.0224193	-.0539788	6.645188	278.1718	502
Industrial	.0001199	-.0989	.0976	.0279832	-.0009449	5.485611	129.2287	502

Source: Author Generate

Table 7 presents a descriptive analysis of the return series of Saudi Arabia's sector indices during the COVID-19 and GFC periods. As results show in Table 7, the Real Estate sector has the highest return during the GFC and COVID-19; moreover, all other indices have positive mean returns during the COVID-19 period, and the Health Care and Consumer Staples have negative mean returns during the GFC. Standard deviation values show that the industrial sector is highly fluctuating and risky, and the healthcare sector shows less

fluctuation during both crises, i.e., the GFC and COVID-19 periods. In contrast, the Industrial sector remained highly risky during the GFC, and Real Estate values show that it was a less fluctuating sector.

The skewness and kurtosis show that all the values greater than 0 and 3 are actively expected for Real Estate during GFC, which shows that the data is not normally distributed. At a significant level of 5%, the null hypothesis that the returns follow a normal distribution according to the Jarque-Bera test is not accepted for both periods, i.e., COVID-19 and GFC. Furthermore, the skewness shows a negative value for all the sectors during the COVID-19 and GFC period, which means their distribution is left-skewed, except the healthcare sector has a positive value for skewness, which means that the sector has a right-skewed distribution during the GFC.

Table 8. Descriptive Statistic Sector Indices of Turkey during COVID-19 and GFC

COVID Period								
	Mean	Min	Max	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Obs.
Health Care	.0010159	-.1	.05	.0153458	-1.55751	11.11371	1579.956	502
Real Estate	.0011952	-.11	.07	.0202126	-1.00816	7.394352	488.9456	502
Consumer Staples	.0009562	-.09	.05	.0171957	-1.28235	8.586392	790.3461	502
Bank	.0002191	-.1	.1	.0221713	-.111259	6.496679	256.7788	502
Communication Service	.0008167	-.1	.09	.0201177	-.687612	7.527888	468.3870	502
Industrial	.0019323	-.1	.06	.0170724	-1.35517	9.526974	1044.733	502
GFC Period								
Health Care	.0002006	-.0687	.1051	.0198737	.263486	5.37887	124.1764	502
Real Estate	-.0009602	-.0836	.0882	.0205379	-.278969	5.218042	109.4152	502
Consumer Staples	.0001594	-.0848	.0896	.0221326	-.117964	4.907262	77.25180	502
Bank	.0001857	-.1054	.1687	.0312629	.359099	5.117855	104.6068	502
Communication Service	.0004388	-.1387	.1262	.0284417	.096952	5.358369	117.1230	502
Industrial	-.0004337	-.0777	.0875	.0191258	-.260817	5.583058	145.2514	502

Source: Author Generate

Table 8 presents a descriptive analysis of the return series of sector indices of Turkey during the COVID-19 and GFC periods. As results shown in Table 8 indicate, the industrial sector had the highest return during COVID-19, and the communication service sector had the highest return during the GFC. Moreover, all other indexes had positive mean returns during the GFC and the period, except Real Estate and Industrial, which had negative mean returns during the GFC. Standard deviation values show that the banking sector is highly

fluctuating and risky, and the industrial sector showed less fluctuation during both crises, i.e., the GFC and COVID-19 periods.

The skewness and kurtosis show that all the values are greater than 0 and 3, respectively, showing that the data is not normally distributed. At a significant level of 5%, the null hypothesis that the returns follow a normal distribution according to the Jarque-Bera test is not accepted for both periods, i.e., COVID-19 and GFC. Furthermore, the skewness shows a negative value for all the sectors during the COVID-19 and GFC periods, which means their distribution is left-skewed, except that the Health Care, Bank, and Communication sectors have positive values for skewness, which means that the sector is right-skewed distribution during GFC.

Table 9: Descriptive Statistic Sector Indices of UAE during COVID-19 and GFC

COVID Period								
	Mean	Min	Max	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Obs.
Health Care	.0001195	-.09	.08	.0149379	-.6102607	11.59306	1575.659	502
Real Estate	.0006375	-.06	.09	.015808	.535349	7.457785	439.6315	502
Consumer Staples	.0006175	-.09	.11	.0208554	-.1085484	9.062791	769.8286	502
Bank	.0000996	-.0856	.075	.0145028	-.6608596	11.496	1546.349	502
Communication Service	.0003785	-.08	.15	.0169199	1.579013	18.8122	5438.309	502
Industrial	.0002988	-.09	.14	.0178066	.5812701	14.63892	2861.732	502
GFC Period								
Health Care	-.0016371	-.0682	.0759	.0169668	.0156787	5.561752	137.2878	502
Real Estate	-.0013436	-.1395	.1493	.0383325	.6350488	6.292089	260.4334	502
Consumer Staples	-.0019562	-.1111	.149	.0362236	.3831401	6.532819	273.3390	502
Bank	.0495884	.002	.0986	.0278948	.0900157	1.872889	27.25003	502
Communication Service	-.0006518	-.1198	.1496	.0327414	.6607709	8.539729	678.4335	502
Industrial	-.0003048	-.1065	.1472	.0304497	.9158659	9.499626	953.8081	502

Source: Author Generate

Table 9 presents a descriptive analysis of the return series of sector indices of UAE during the COVID-19 and GFC periods. As the results show in Table 9, the Real Estate sector had the highest return during COVID-19, and all other sectors had positive mean returns. The banking sector had the highest return during the GFC, and all other sectors had negative mean returns. Standard deviation values show that the Consumer Staples sector is highly fluctuating and risky during COVID-19. In contrast, Real Estate value shows the sector

remained highly risky during the GFC, and Health Care and the banking sectors remained less fluctuating during both crises.

The skewness and kurtosis show that all the values are greater than 0 and 3, respectively, showing that the data is not normally distributed. At a significant level of 5%, the null hypothesis that the returns follow a normal distribution according to the Jarque-Bera test is not accepted for both periods, i.e., COVID-19 and GFC. Furthermore, the skewness shows a positive value for all the sectors during the COVID-19 and GFC period, which means their distribution is right-skewed except Health Care, Bank, and Consumer Staple sectors have a positive value for skewness, which means that the left-skewed distribution during COVID-19.

3.8. EMPIRICAL RESULTS AND DISCUSSION

In this chapter, the thesis embarks on a comprehensive examination of the data, aiming to uncover valuable insights and contribute to the broader understanding of market efficiency during the COVID-19 and GFC. Building upon the foundation laid in the previous chapters. This study delves deep into the empirical evidence and findings to address the research questions posed in this study. This chapter not only presents the results of the investigation but also interprets their significance in the context of existing literature, thus paving the way for a more profound understanding of the subject matter.

Table 10:Nonlinearity Test for Stock Indices

Index Country	Terasvirta	White	Keenan	Tsay	LR
During COVID-19					
Indonesia	6.16 (0.045)	11.52 (0.001)	5.8 (0.001)	2.53 (0.000)	82.83 (0.000)
Malaysia	13.51 (0.001)	7.92 (0.029)	5.52 (0.01)	6.97 (0.000)	5.20 (0.33)
Turkey	7.29 (0.026)	3.025 (0.05)	5.92 (0.02)	2.67 (0.000)	28.72 (0.01)
Pakistan	13.49 (0.001)	3.527 (0.05)	7.71 (0.005)	3.91 (0.000)	73.46 (0.000)
Jordan	4.14 (0.05)	6.97 (0.03)	9.8 (0.004)	2.88 (0.000)	43.94 (0.000)
Egypt	11.22 (0.003)	6.03 (0.04)	4.32 (0.01)	2.07 (0.000)	73.91 (0.000)
UAE	8.41 (0.014)	11.38 (0.001)	5.73 (0.05)	8.41 (0.000)	198.51 (0.00)
Kuwait	25.13 (0.000)	7.32 (0.025)	4.33 (0.03)	1.07 (0.29)	29.00 (0.01)
Morocco	18.60 (0.000)	5.26 (0.051)	15.87 (0.00)	7.50 (0.000)	92.09 (0.000)
Tunisia	13.53 (0.001)	22.42 (0.000)	4.35 (0.02)	13.02 (0.000)	31.29 (0.000)
Saudia Arabia	11.94 (0.0025)	19.9 (0.003)	13.02 (0.0003)	4.149 (0.000)	60.27 (0.000)
Lebanon	15.07 (0.0005)	0.60 (0.73)	4.65 (0.03)	14.96 (0.000)	116.44 (0.000)
Qatar	15.25 (0.000)	27.76 (0.000)	7.65 (0.004)	2.339 (0.000)	69.96 (0.000)
Oman	5.60 (0.050)	11.8 (0.005)	5.14 (0.04)	2.745 (0.000)	27.93 (0.000)
Palestine	1.14 (0.56)	5.82 (0.05)	5.76 (0.016)	2.438 (0.000)	137.27 (0.000)
During GFC					
Indonesia	4.26 (0.03)	8.02 (0.028)	6.78 (0.03)	6.78 (0.005)	13.4 (0.023)
Malaysia	12.27 (0.002)	11.80 (0.002)	8.79 (0.003)	8.78 (0.003)	14.83 (0.011)
Turkey	15.33 (0.001)	5.05 (0.010)	3.73 (0.053)	4.31 (0.02)	7238.0 (0.000)
Pakistan	4.600 (0.010)	5.54 (0.012)	4.03 (0.035)	2.10 (0.035)	40.17 (0.000)
Jordan	90.54 (0.000)	52.98 (0.000)	550.65 (0.000)	7.64 (0.005)	3083.80 (0.00)
Egypt	23.26 (0.000)	20.61 (0.000)	13526 (0.000)	22.32 (0.000)	62.404 (0.00)
UAE	230.05 (0.000)	19.80 (0.000)	102.22(0.000)	102.2 (0.000)	157.3 (0.000)
Kuwait	7.546 (0.000)	14.37 (0.000)	11.24 (0.000)	11.24 (0.000)	13.06 (0.023)
Morocco	6.499 (0.038)	7.14 (0.0281)	5.61 (0.018)	4.04 (0.007)	17.43 (0.010)
Tunisia	53.48 (0.000)	32.21 (0.000)	3.91 (0.051)	2.78 (0.000)	53.09 (0.000)
Saudia Arabia	10.27 (0.005)	12.42 (0.002)	1282.7 (0.000)	10.25 (0.001)	81.48 (0.000)
Lebanon	12.16 (0.002)	9.07 (0.010)	3960.6 (0.000)	3.92 (0.048)	495.96 (0.000)
Qatar	440.9 (0.000)	501.7 (0.000)	23.37 (0.000)	401.9 (0.000)	11.50 (0.044)
Oman	1.102 (0.57)	1.10 (0.57)	32238 (0.000)	1.02 (0.31)	467.06 (0.000)
Palestine	16.55 (0.000)	10.34 (0.005)	2843.7 (0.000)	13.81 (0.000)	481.32 (0.000)

Source: Author Generate

Table 10 presents the series of nonlinear tests for the stock indices of OIC countries during COVID-19 and GFC period. The non-linear arrangement of the series is evaluated using a battery of tests, including Terasvirta, White, Keenan, Tsay, and likelihood ratio tests, to examine what is referred to as the "return series". The findings are summarized in Table

10. Most of the p-values are less than 5% which show that hypothesis of linearity is rejected for all the series, implying that their structure is confirmed non-linear.



Table 11: Results of Long Memory and Nonlinear Unit Root Tests for Major Country Indices

Index Country	Geweke, Porter and Hudak (1983) test		Robinson and Henry (1999) test		KSS unit root test	
	D	P value	D	P value	Statistic	Critical value (%5)
During COVID-19						
Indonesia	0.17	0.03	0.073	0.017	-4.424	-1.9651
Malaysia	0.101	0.012	0.126	0.013	-2.313	-1.9651
Turkey	0.10	0.004	0.10	0.003	-3.841	-1.9651
Pakistan	0.11	0.014	0.088	0.004	-2.176	-1.9651
Jordan	0.20	0.000	0.181	0.000	-5.361	-1.9651
Egypt	0.21	0.000	0.171	0.000	-3.201	-1.9651
UAE	0.22	0.000	0.156	0.006	-4.964	-1.9651
Kuwait	0.085	0.029	0.11	0.000	-2.476	-1.9651
Morocco	0.17	0.000	0.122	0.000	-4.650	-1.9651
Tunisia	0.25	0.000	0.306	0.000	-2.379	-1.9651
Saudi Arabia	0.169	0.032	0.11	0.055	-3.332	-1.9651
Lebanon	0.092	0.024	0.118	0.021	-2.416	-1.9651
Qatar	0.181	0.03	0.071	0.05	-6.297	-1.9651
Oman	0.094	0.012	0.094	0.012	-3.095	-1.9651
Palestine	0.098	0.054	0.084	0.026	-4.021	-1.9651
During GFC						
Indonesia	0.109	0.017	0.108	0.000	-7.508	-1.964
Malaysia	0.091	0.047	0.066	0.031	-5.601	-1.964
Turkey	0.125	0.009	0.607	0.029	-2.858	-1.964
Pakistan	0.242	0.000	0.195	0.000	-2.560	-1.964
Jordan	0.155	0.003	0.230	0.000	-6.459	-1.964
Egypt	0.169	0.001	0.154	0.000	-3.192	-1.964
UAE	-0.216	0.000	0.068	0.026	-4.850	-1.964
Kuwait	0.1489	0.001	0.136	0.000	-6.856	-1.964
Morocco	0.1675	0.000	0.197	0.000	-4.471	-1.964
Tunisia	0.1027	0.025	0.101	0.001	-11.30	-1.964
Saudi Arabia	0.0913	0.015	0.078	0.011	-2.030	-1.964
Lebanon	0.089	0.050	0.118	0.000	-3.939	-1.964
Qatar	0.883	0.000	0.848	0.000	-2.927	-1.964
Oman	0.173	0.035	0.147	0.000	-12.72	-1.964
Palestine	0.116	0.015	0.108	0.000	-5.634	-1.964

Source: Author Generate

Table 11 show cases the results obtained from evaluations regarding long-memory and asymmetric unit root properties. Long-memory tests conducted by Geweke and Porter-Hudak (1983) and Robinson and Henry (1999) reveal d values within the range of 0 to 0.5 for all variables during both the Global Financial Crisis (GFC) and the COVID-19 pandemic periods. This suggests a manifestation of long-memory characteristics across all return data. Additionally, statistics derived from the KSS (2003) nonlinear unit root test, utilizing the ESTAR (Exponential Smooth Transition Autoregressive) process, indicate that all return series are identified as globally stationary ESTAR processes at a 5% significance level.

Table 12: Nonlinearity Test for Egypt Sectors Index

Index Country	Terasvirta	White	Keenan	Tsay	LR
During GFC					
Health Care	8.49 (0.01)	19.42(0.00)	0.577(0.4)	1.97 (0.00)	56.09(0.00)
Real Estate	6.07 (0.01)	5.07 (0.03)	0.84(0.35)	8.40 (0.00)	45.45 (0.00)
Consumer Staples	11.3 (0.003)	4.40 (0.03)	1.26(0.26)	1.26 (0.00)	39.45 (0.00)
Bank	8.66 (0.013)	15.77 (0.00)	9.90 (0.0)	2.87 (0.00)	49.96 (0.00)
Communication Services	9.21 (0.011)	6.83 (0.02)	1.39 (0.23)	1.98 (0.00)	37.9 (0.00)
Industrial	8.12 (0.017)	9.50 (0.008)	2.16 (0.14)	2.66 (0.00)	47.7 (0.002)
During COVID					
Health Care	7.32 (0.02)	7.88 (0.04)	3.19 (0.05)	11.88 (0.00)	49.76 (0.00)
Real Estate	9.22 (0.01)	5.69 (0.05)	5.23 (0.02)	3.17 (0.00)	27.31 (0.05)
Consumer Staples	6.92 (0.003)	16.38 (0.00)	8.61 (0.00)	21.53 (0.00)	452.7 (0.00)
Bank	8.33 (0.013)	13.59 (0.00)	4.95 (0.03)	5.65 (0.00)	14.54 (0.00)
Communication Services	9.97 (0.01)	13.77 (0.00)	1.33 (0.24)	13.32 (0.00)	17.5 (0.00)
Industrial	7.86 (0.01)	7.46 (0.003)	3.34 (0.05)	2.95 (0.03)	13.03 (0.05)

Source: Author Generate

Table 13:Nonlinearity Test for Jordan Sectors Index

Index Country	Terasvirta	White	Keenan	Tsay	LR
During GFC					
Health Care	15.84 (0.00)	13.69 (0.00)	10.8 (0.00)	5.73 (0.00)	16.7 (0.00)
Real Estate	8.72 (0.012)	8.24 (0.01)	8.54 (0.00)	8.54 (0.00)	19.5 (0.00)
Consumer Staples	10.77 (0.00)	9.14 (0.01)	21.1 (0.00)	2.88 (0.03)	12.32 (0.05)
Bank	4.91 (0.00)	13.02 (0.00)	12.6 (0.00)	19.10 (0.00)	177.2 (0.00)
Communication Services	9.52 (0.00)	9.33 (0.00)	9.43 (0.00)	1.73 (0.00)	28.03 (0.00)
Industrial	20.07 (0.00)	10.27 (0.00)	23.5 (0.00)	2.35 (0.03)	39.2 (0.00)
During COVID					
Health Care	24.04 (0.00)	25.8 (0.00)	16.6 (0.00)	2.42 (0.00)	18.75 (0.05)
Real Estate	123.4 (0.00)	120.9 (0.00)	121 (0.00)	11.95 (0.00)	211.9 (0.00)
Consumer Staples	15.19 (0.00)	17.29 (0.00)	4.47 (0.03)	2.78 (0.041)	13.48 (0.04)
Bank	18.67 (0.00)	11.8 (0.002)	12.80 (0.0)	9.07 (0.002)	377.3 (0.00)
Communication Services	40.9 (0.00)	37.9 (0.00)	22.2 (0.00)	2.93 (0.040)	5.67 (0.27)
Industrial	101.9 (0.00)	88.93 (0.00)	91.6 (0.00)	16.43 (0.00)	104.0 (0.00)

Source: Author Generate

Table 14:Nonlinearity Test for Morocco Sectors Index

Index Country	Terasvirta	White	Keenan	Tsay	LR
During GFC					
Health Care	30.68 (0.00)	37.93(0.00)	54.1 (0.00)	1.845 (0.00)	58.1 (0.00)
Real Estate	19.2 (0.00)	51.59 (0.00)	13.8 (0.00)	1.38 (0.001)	16.7 (0.00)
Consumer Staples	4.92 (0.03)	35.01 (0.00)	4.98 (0.026)	1.877 (0.00)	67.6 (0.00)
Bank	25.5 (0.00)	25.6 (0.00)	25.01 (0.00)	2.50 (0.00)	39.9 (0.00)
Communication Services	18.9 (0.00)	36.66 (0.00)	33.3 (0.00)	1.85 (0.00)	256.9 (0.00)
Industrial	10.61 (0.00)	8.84 (0.012)	6.658 (0.00)	3.29 (0.020)	16.16 (0.017)
During COVID					
Health Care	42.89 (0.000)	41.30 (0.00)	41.9 (0.00)	3.428 (0.00)	123.2 (0.00)
Real Estate	12.24 (0.002)	16.59 (0.00)	11.42 (0.00)	11.42 (0.00)	16.86 (0.00)
Consumer Staples	5.402 (0.051)	30.6 (0.00)	25.40 (0.00)	10.9 (0.00)	2378.5 (0.00)
Bank	7.20 (0.021)	9.28 (0.01)	38.39 (0.00)	9.86 (0.00)	126.9 (0.00)
Communication Services	6.48 (0.039)	23.8 (0.00)	4.62 (0.033)	3.60 (0.00)	147.58 (0.00)
Industrial	4.255 (0.05)	38.5 (0.00)	6.80 (0.023)	3.36 (0.05)	348.7 (0.00)

Source: Author Generate

Table 15:Nonlinearity Test for Saudia Arabia Sectors Index

Index Country	Terasvirta	White	Keenan	Tsay	LR
During GFC					
Health Care	5.45 (0.041)	7.10 (0.00)	4.90 (0.021)	7.90 (0.000)	143.3 (0.00)
Real Estate	3.914 (0.050)	22.84 (0.00)	19.03 (0.00)	9.34 (0.000)	75.00 (0.00)
Consumer Staples	5.42 (0.046)	5.97 (0.050)	8.33 (0.044)	3.52 (0.000)	61.76 (0.00)
Bank	6.62 (0.036)	8.02 (0.000)	6.05 (0.05)	2.67 (0.000)	24.21 (0.00)
Communication Services	6.62 (0.036)	4.53 (0.000)	9.39 (0.00)	2.74 (0.000)	26.86 (0.00)
Industrial	7.80 (0.020)	5.31 (0.051)	2.35 (0.12)	2.34 (0.000)	44.13 (0.00)
During COVID					
Health Care	10.75 (0.00)	15.83 (0.00)	5.19 (0.023)	6.409 (0.00)	37.91 (0.00)
Real Estate	29.67 (0.00)	21.16 (0.00)	13.67 (0.00)	24.45 (0.00)	2053.3 (0.00)
Consumer Staples	10.69 (0.00)	8.053 (0.01)	2.99 (0.050)	7.433 (0.00)	32.80 (0.00)
Bank	6.150 (0.00)	16.38 (0.00)	20.89 (0.00)	6.823 (0.00)	63.00 (0.00)
Communication Services	4.814 (0.04)	21.53 (0.00)	12.04 (0.00)	4.707 (0.00)	20.81 (0.00)
Industrial	19.29 (0.00)	6.366 (0.02)	23.01 (0.00)	5.296 (0.00)	52.44 (0.00)

Source: Author Generate

Table 16:Nonlinearity Test for Turkey Sector Index

Index Country	Terasvirta	White	Keenan	Tsay	LR
During GFC					
Health Care	11.59 (0.00)	9.16 (0.00)	8.50 (0.00)	1.84 (0.00)	169.3 (0.00)
Real Estate	10.17 (0.00)	5.66 (0.02)	8.59 (0.00)	1.69 (0.00)	29.09 (0.05)
Consumer Staples	31.40 (0.00)	3.69 (0.03)	6.71 (0.00)	1.70 (0.00)	140.1 (0.00)
Bank	4.499 (0.01)	3.39 (0.03)	6.08 (0.00)	1.87 (0.00)	470.4 (0.00)
Communication Services	22.78 (0.00)	9.15 (0.00)	15.77 (0.00)	1.57 (0.01)	110.2 (0.00)
Industrial	25.52 (0.00)	8.61 (0.00)	6.72 (0.00)	1.78 (0.00)	73.10 (0.00)
During COVID					
Health Care	17.04 (0.00)	11.52 (0.00)	9.80 (0.00)	2.93 (0.00)	16.64 (0.014)
Real Estate	12.12 (0.00)	12.30 (0.00)	7.53 (0.00)	1.70 (0.00)	15.53 (0.022)
Consumer Staples	23.47 (0.00)	6.532 (0.03)	14.75 (0.00)	1.56 (0.00)	12.19 (0.054)
Bank	5.199 (0.02)	4.868 (0.04)	6.680 (0.01)	1.69 (0.00)	15.00 (0.025)
Communication Services	9.299 (0.00)	9.343 (0.00)	16.97 (0.00)	4.11 (0.00)	1172 (0.00)
Industrial	7.646 (0.00)	9.655 (0.00)	9.09 (0.01)	3.92 (0.00)	15.68 (0.045)

Source: Author Generate

Table 17: Nonlinearity Test for UAE Sector Index

Index Country	Terasvirta	White	Keenan	Tsay	LR
During GFC					
Health Care	4.32 (0.04)	6.85 (0.03)	5.25 (0.00)	1.80 (0.00)	1019.8 (0.00)
Real Estate	8.57 (0.01)	10.24 (0.00)	11.78 (0.00)	2.49 (0.00)	57.44 (0.00)
Consumer Staples	5.93 (0.03)	15.78 (0.00)	3.02 (0.01)	1.76 (0.00)	422.9 (0.00)
Bank	8.90 (0.01)	9.22 (0.00)	11.35 (0.00)	2.27 (0.00)	50.20 (0.00)
Communication Services	6.96 (0.03)	6.06 (0.03)	22.36 (0.00)	2.45 (0.00)	43.98 (0.00)
Industrial	12.26 (0.00)	16.57 (0.00)	14.39 (0.00)	1.78 (0.00)	75.61 (0.00)
During COVID					
Health Care	9.12 (0.010)	6.00 (0.049)	7.50 (0.00)	6.52 (0.00)	105.22 (0.00)
Real Estate	6.11 (0.047)	12.49 (0.00)	9.10 (0.00)	3.08 (0.00)	68.20 (0.00)
Consumer Staples	10.97 (0.00)	9.73 (0.00)	7.11 (0.00)	2.05 (0.05)	23.19 (0.00)
Bank	25.08 (0.00)	13.2 (0.00)	6.90 (0.00)	4.97 (0.00)	63.70 (0.00)
Communication Services	8.770 (0.01)	5.36 (0.05)	5.18 (0.04)	3.76 (0.00)	13.42 (0.00)
Industrial	9.86 (0.00)	17.8 (0.00)	15.17 (0.00)	5.28 (0.00)	28.47 (0.01)

Source: Author Generate

Table 12 to Table 17 presents the series of nonlinear tests for the sector indices of Egypt, Jordan, Morocco, Saudi Arabia, Turkey, and UAE during the COVID-19 and GFC periods. The following sectors are included for both period analyses, i.e., health care, real estate, consumer staples, bank, communication services, and industrial. The nonlinear arrangement of the sectors is evaluated using a battery of tests, including Terasvirta, White, Keenan, Tsay, and likelihood ratio tests, to examine what is referred to as the return series. The findings are summarized in Tables 12 to 17. Most of the p-values are less than 5%, which shows that the hypothesis of linearity is rejected for all the series, implying that their structure is confirmed nonlinear.

Table 18: The Results of Long Memory and Nonlinear Unit Root Tests for Egypt
Sector Index

Index Country	Geweke, Porter and Hudak (1983) test		Robinson and Henry (1999) test		KSS unit root test	
	D	P value	D	P value	Statistic	Critical value (%5)
During GFC						
Health Care	0.124	0.033	0.0894	0.005	-3.918	-1.965
Real Estate	0.1996	0.000	0.171	0.000	-2.325	-1.965
Consumer Staples	0.144	0.050	0.197	0.008	-6.541	-1.965
Bank	0.144	0.002	0.158	0.000	-2.483	-1.965
Communication Services	0.113	0.017	0.121	0.000	-2.627	-1.965
Industrial	0.160	0.000	0.135	0.000	-3.644	-1.965
During COVID-19						
Health Care	0.1584	0.000	0.1793	0.000	-4.429	-1.965
Real Estate	0.1940	0.000	0.1677	0.000	-2.424	-1.965
Consumer Staples	0.1253	0.008	0.1080	0.000	-6.704	-1.965
Bank	0.4023	0.015	0.1181	0.040	-4.597	-1.965
Communication Services	0.1618	0.000	0.1316	0.000	-2.153	-1.965
Industrial	0.1206	0.011	0.0911	0.004	-3.255	-1.965

Source: Author Generate

Table 19: The Results of Long Memory and Nonlinear Unit Root Tests for Jordan
Sector Index

Index Country	Geweke, Porter and Hudak (1983) test		Robinson and Henry (1999) test		KSS unit root test	
	D	P value	D	P value	Statistic	Critical value (%5)
During GFC						
Health Care	0.1349	0.036	0.1124	0.011	-3.269	-1.965
Real Estate	0.1155	0.015	0.1469	0.000	-5.732	-1.965
Consumer Staples	0.1353	0.004	0.0900	0.004	-4.692	-1.965
Bank	0.0915	0.024	0.1619	0.040	-8.558	-1.965
Communication Services	0.1531	0.047	0.1423	0.050	-4.692	-1.965
Industrial	0.1567	0.001	0.0962	0.002	-5.451	-1.965
During COVID period						
Health Care	0.0882	0.054	0.07111	0.0314	-3.251	-1.965
Real Estate	0.1899	0.000	0.1503	0.000	-3.936	-1.965
Consumer Staples	0.2987	0.000	0.2389	0.000	-4.070	-1.965
Bank	0.3226	0.000	0.2420	0.000	-2.690	-1.965
Communication Services	0.0989	0.052	0.0758	0.021	-3.741	-1.965
Industrial	0.1779	0.000	0.1370	0.000	-4.286	-1.965

Source: Author Generate

Table 20: The Results of Long Memory and Nonlinear Unit Root Tests for Morocco
Sector Index

	Geweke, Porter and Hudak (1983) test		Robinson and Henry (1999) test		KSS unit root test	
Index Country	D	P value	D	P value	Statistic	Critical value (%5)
During GFC						
Health Care	0.3132	0.000	0.3407	0.000	-3.307	-1.965
Real Estate	0.2439	0.000	0.2224	0.000	-3.940	-1.965
Consumer Staples	0.112	0.006	0.0890	0.005	-2.152	-1.965
Bank	0.1375	0.003	0.1269	0.000	-7.326	-1.965
Communication Services	0.1564	0.002	0.1796	0.000	-3.177	-1.965
Industrial	0.29720	0.021	0.1575	0.000	-3.461	-1.965
During COVID-19						
Health Care	0.288	0.000	0.2061	0.000	-6.998	-1.965
Real Estate	0.146	0.001	0.1587	0.000	-4.939	-1.965
Consumer Staples	0.1041	0.054	0.1006	0.000	-2.652	-1.965
Bank	0.1003	0.032	0.0767	0.015	-3.942	-1.965
Communication Services	0.403	0.021	0.1949	0.051	-4.389	-1.965
Industrial	0.4668	0.010	0.3556	0.001	-3.270	-1.965

Source: Author Generate

Table 21: The Results of Long Memory and Nonlinear Unit Root Tests for Saudi Arabia Sector Index

Index Country	Geweke, Porter and Hudak (1983) test		Robinson and Henry (1999) test		KSS unit root test	
	D	P value	D	P value	Statistic	Critical value (%5)
During GFC						
Health Care	0.0946	0.051	0.0642	0.045	-2.652	-1.965
Real Estate	0.1372	0.003	0.0888	0.004	-3.023	-1.965
Consumer Staples	0.1156	0.019	0.0622	0.048	-2.985	-1.965
Bank	0.0942	0.044	0.0849	0.007	-2.453	-1.965
Communication Services	0.0805	0.050	0.685	0.002	-3.254	-1.965
Industrial	0.467	0.023	0.2403	0.042	-2.738	-1.965
During COVID-19						
Health Care	0.1508	0.037	0.2861	0.026	-4.021	-1.965
Real Estate	0.6907	0.045	0.1715	0.042	-6.748	-1.965
Consumer Staples	0.1020	0.043	0.1154	0.000	-4.067	-1.965
Bank	0.1234	0.008	0.0794	0.011	-2.470	-1.965
Communication Services	0.1784	0.000	0.2742	0.005	-3.976	-1.965
Industrial	0.1300	0.005	0.0936	0.003	-3.766	-1.965

Source: Author Generate

Table 22: The Results of Long Memory and Nonlinear Unit Root Tests for Turkey
Sector Index

	Geweke, Porter and Hudak (1983) test		Robinson and Henry (1999) test		KSS unit root test	
Index Country	D	P value	D	P value	Statistic	Critical value (%5)
During GFC						
Health Care	0.0918	0.051	0.1813	0.005	-2.709	-1.965
Real Estate	0.3505	0.006	0.08272	0.008	-3.146	-1.965
Consumer Staples	0.1353	0.049	0.1032	0.034	-4.860	-1.965
Bank	0.1403	0.043	0.2085	0.045	-2.550	-1.965
Communication Services	0.2080	0.000	0.0856	0.006	-2.604	-1.965
Industrial	0.0929	0.047	0.0930	0.003	-5.801	-1.965
During COVID-19						
Health Care	0.11389	0.023	0.06046	0.051	-3.099	-1.965
Real Estate	0.12502	0.007	0.06796	0.031	-5.329	-1.965
Consumer Staples	0.09286	0.049	0.09076	0.004	-5.910	-1.965
Bank	0.09882	0.051	0.07339	0.035	-2.226	-1.965
Communication Services	0.4579	0.006	0.0496	0.012	-2.510	-1.965
Industrial	0.10283	0.028	0.07285	0.021	-2.581	-1.965

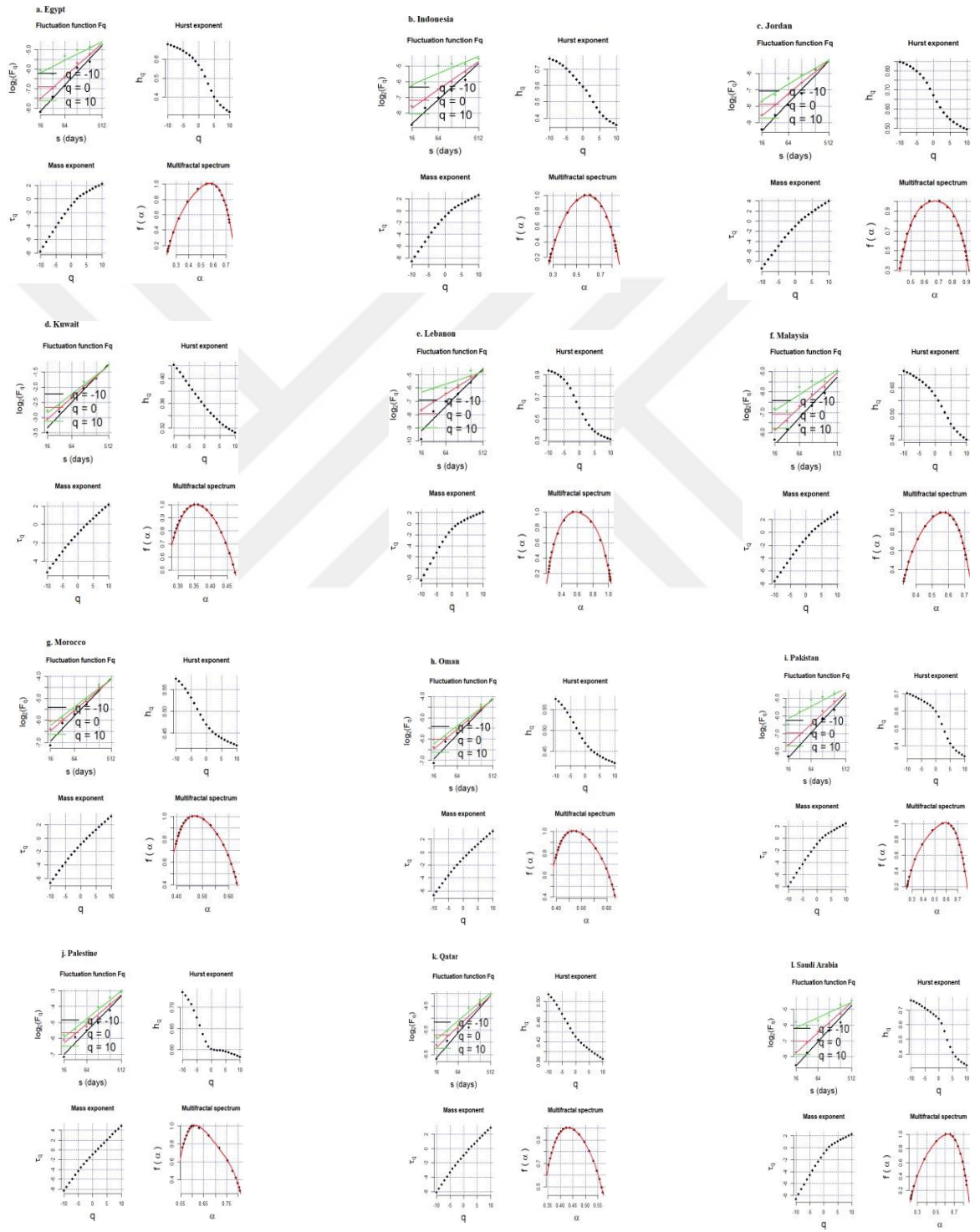
Source: Author Generate

Table 23: The Results of Long Memory and Nonlinear Unit Root Tests for UAE**Sector Index**

Index Country	Geweke, Porter and Hudak (1983) test		Robinson and Henry (1999) test		KSS unit root test	
	D	P value	D	P value	Statistic	Critical value (%5)
During GFC						
Health Care	0.5029	0.021	0.3684	0.010	-4.960	-1.965
Real Estate	0.6391	0.018	0.0669	0.053	-6.728	-1.965
Consumer Staples	0.1199	0.006	0.2552	0.048	-2.073	-1.965
Bank	0.1348	0.004	0.1208	0.000	-2.871	-1.965
Communication Services	0.1711	0.029	0.0670	0.048	-7.411	-1.965
Industrial	0.5394	0.047	0.07406	0.019	-7.552	-1.965
During COVID-19						
Health Care	0.1441	0.002	0.1276	0.000	-5.036	-1.965
Real Estate	0.1069	0.022	0.0897	0.004	-3.339	-1.965
Consumer Staples	0.0988	0.035	0.1153	0.000	-2.984	-1.965
Bank	0.1158	0.013	0.0876	0.005	-2.326	-1.965
Communication Services	0.1181	0.014	0.2225	0.041	-3.496	-1.965
Industrial	0.1292	0.005	0.1026	0.001	-5.809	-1.965

Source: Author Generate

Table 18 to Table 23 presents the series of long memory and nonlinear tests for the sector indices of Egypt, Jordan, Morocco, Saudi Arabia, Turkey, and UAE during the COVID-19 and GFC period; the following sectors are included for both period analyses, i.e., health care, real estate, consumer staples, bank, communication services, and industrial. The evaluations concerning long-memory and asymmetric unit root properties yielded notable findings. Long-memory tests conducted by Geweke, Porter and Hudak (1983) and Robinson and Henry (1999) revealed d values between 0 and 0.5 for all variables during both the periods encompassing the Global Financial Crisis (GFC) and the COVID-19 pandemic. This pattern indicates the presence of long-memory characteristics across all return data. Moreover, the statistics derived from the KSS (2003) nonlinear unit root test, utilizing the ESTAR (Exponential Smooth Transition Autoregressive) process, indicated that all return series were identified as globally stationary ESTAR processes, maintaining significance at the 5% level.



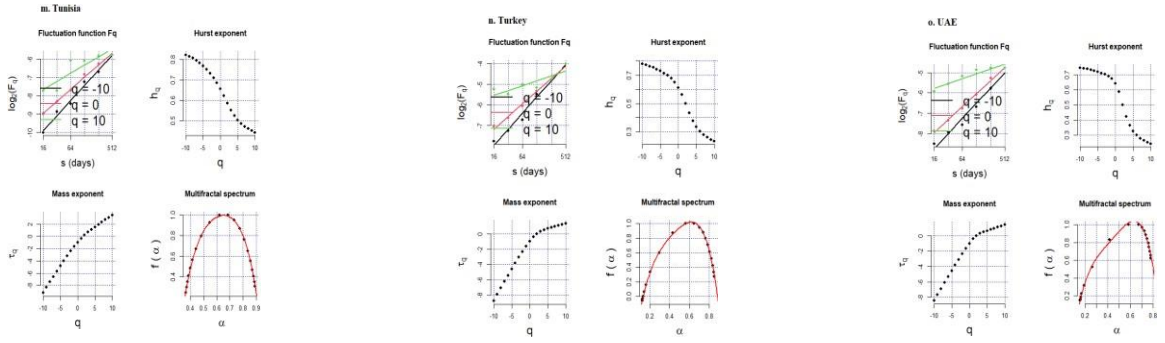
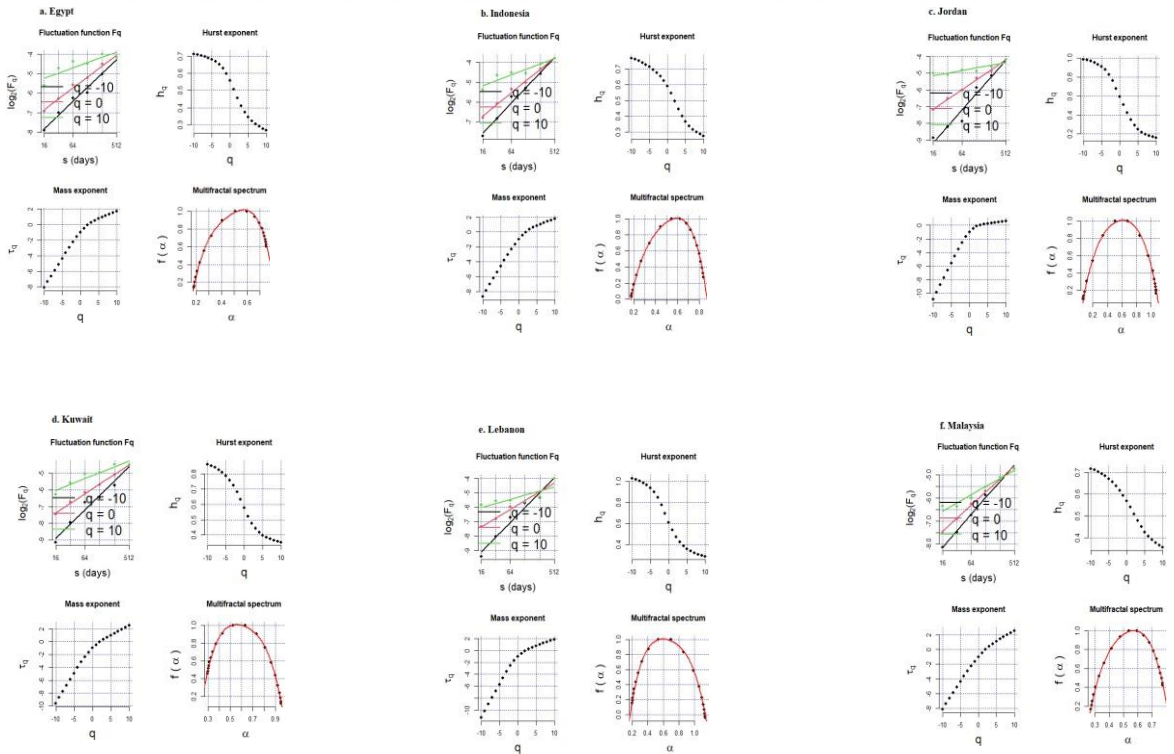


Figure 5: show cases the MF-DFA results for the return time series of prominent stock indices from OIC countries during the COVID-19 period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.



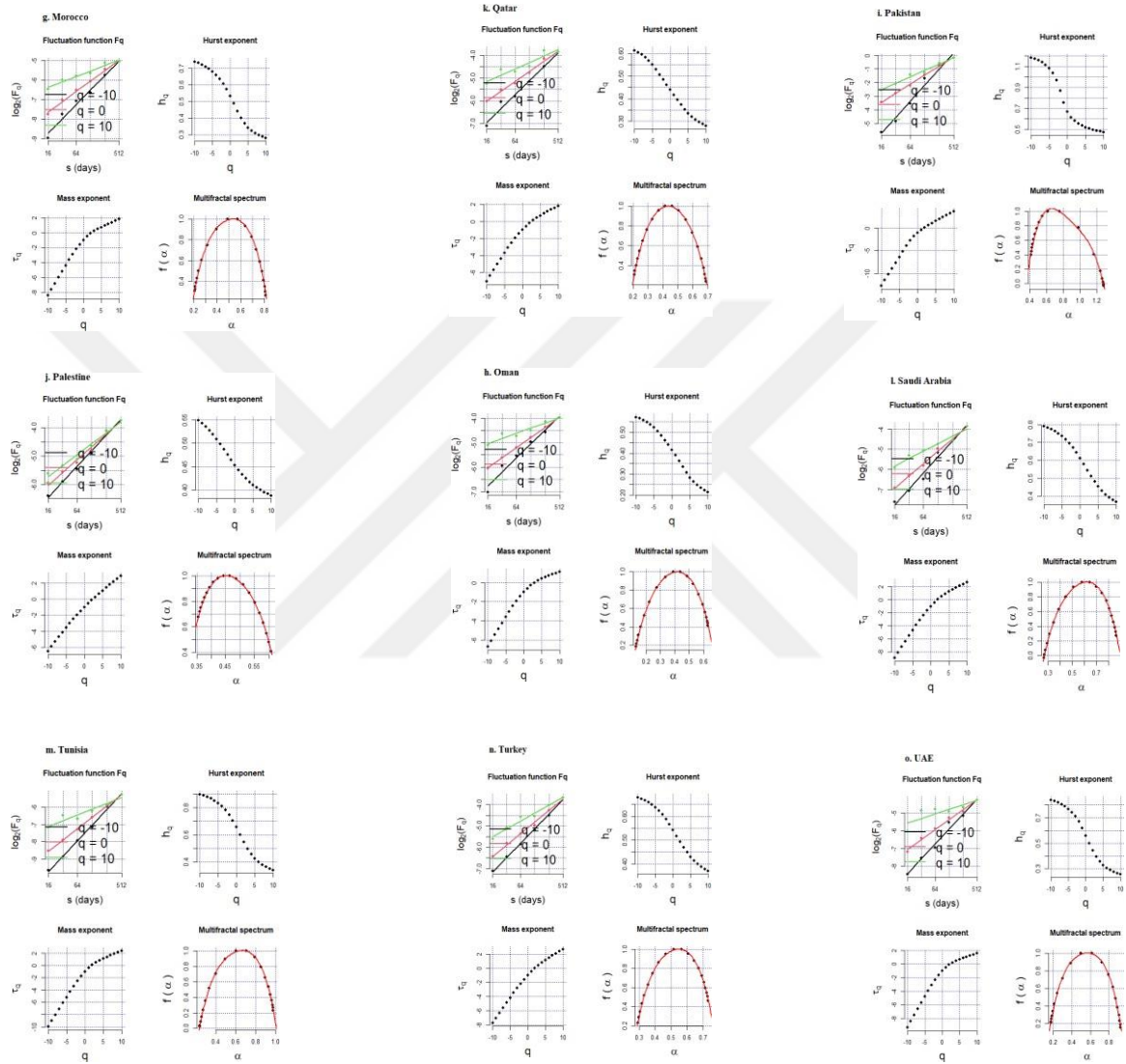


Figure 6: show cases the MF-DFA results for the return time series of prominent stock indices from OIC countries during the GFC period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

The multifractal detrended fluctuation analysis (MF-DFA) was conducted using different scaling windows, s while keeping the order parameter, q , constant. Like the approach taken by Ghazani and Khosravi (2020), the values of q were selected from the range of -10 to 10. This choice was made because q needs to encompass both positive and negative values to capture multifractality for both significant and minor fluctuations. Additionally, it is important for q to be large enough to cover a wide range of the singularity spectrum. Alternatively, an extremely large modulus, q , disrupts the accuracy of estimating the singularity spectrum, $f(\alpha)$. As a result, this thesis restricts q within the range of ± 10 .

Figures 5 and 6 display the findings obtained through MF-DFA (Multifractal Detrended Fluctuation Analysis) for the remaining components of major stock indices in OIC countries. In panel (i), the logarithmic plot of the fluctuation function (F_q) is shown with s for q values of -10, 0, and 10, exhibiting a well-shaped form and possibly represented by a straight line. Panel (ii) presents the values of the generalized Hurst Exponent, $h(q)$, across the range of q from -10 to +10, revealing a decreasing trend. This declining trend provides confirmation of the existence of multifractal patterns in the time fluctuations of the remaining stock markets in OIC countries. Panel (iii) presents the Renyi exponent, $\tau(q)$, which serves as an indicator of nonlinearity in multifractal time series.

Meanwhile, panel (iv) illustrates the multifractal spectrum, $f(\alpha)$, characterized by a singular peak, reinforcing the presence of multifractality. One approach to evaluating the multifractality of a financial series involves analyzing the singularity spectrum, $f(\alpha)$. This spectrum provides insights into the fractal dimension within specific subsets of a financial series, with α representing the singularity's strength. A narrower multifractal spectrum in a financial series indicates higher efficiency, suggesting reduced heterogeneity and market risk, as discussed by Zunino et al. (2008). The right side of the spectrum, depicting the relationship between $f(\alpha)$ and α , pertains to minor fluctuations, while the left side represents more significant fluctuations. The multifractal spectrum, representing the power law exponent in a financial series, highlights that the spectrum's width and shape influence financial series across various scales, as emphasized by Zhang et al. (2018). Throughout both the Global Financial Crisis (GFC) and the COVID-19 outbreak periods, return spectra

illustrate that minor fluctuations demonstrate persistence and exhibit positive long-term memory. Conversely, major fluctuations tend to regress to the mean and display an anti-persistent structure over the long term.

During the GFC, the spectrum for Egypt, Indonesia, Jordan, Kuwait, Malaysia, Morocco, Oman, Palestine, Qatar, Turkey, and UAE is centered at 0.5 to 0.6, which shows small fluctuation and lower risk in the market, while the spectrum for Lebanon, Pakistan, Saudi Arabia, and Tunisia is between 0.7 to 0.8 shows highest spectra and present the higher multifractal behavior and market risk. In contrast, during COVID-19, the spectrum for Egypt, Indonesia, Jordan, Lebanon, Malaysia, Morocco, Oman, Palestine, and Qatar was found to be centered between 0.5 and 0.6. The spectrum for Kuwait was found to be very low, i.e. 0.35, which is a sign of small fluctuation; on the other hand, the spectrum for Jordan, Pakistan, Saudi Arabia, Turkey, and UAE is between 0.7 and 0.8, which shows high fluctuation in the market and market risk.

During both the GFC and the COVID-19 outbreak, the $h(q)$ values for all returns, with $q \leq 0$, surpassed 0.5. This indicates that even for the smallest fluctuations observed during these crisis periods, all returns exhibit long-term persistence. Kuwait, Oman, and Qatar's values were less than 0.5 during COVID-19, and Oman, Palestine, and Qatar's values were lower than 0.5 during GFC. When examining $q \leq 2$, the values of $h(q)$ are above 0.5 except for Kuwait, Oman, Qatar, and Turkey stock markets during the COVID-19, and q values for Malaysia, Pakistan, Saudi Arabia, and Tunisia stock markets are greater than 0.5 during the GFC outbreak. All other stock market values were less than 0.5 during the GFC.

Nonetheless, due to the distinctive characteristics of each crisis, the levels of persistence in stock market returns differ between the two crisis periods. GFC related to the financial crisis and the crisis raised because of banking mortgage, Reinhart, C. M., & Rogoff, K. S. (2008); Demyanyk, Y., & Van Hemert, O. (2011); Choi, S. Y. (2021), while the COVID-19 related to the pandemic. During the Global Financial Crisis (GFC), the Hurst exponents for all sectors were below 0.5, whereas during the COVID-19 pandemic, they were above 0.5. This implies that the average return series for all stock markets demonstrates anti-

persistence during the GFC except for Malaysia's, Pakistan's, Saudi Arabia's, and Tunisia's stock markets. The behavior observed during the Global Financial Crisis (GFC) reflects anti-persistence, indicating negative autocorrelation. This means that a positive or negative change in the previous period is likely to be followed by an opposite change in the subsequent period. However, during the COVID-19 pandemic, the behavior is generally persistent, except for Kuwait, Lebanon, Oman, Qatar, and Turkey when $h(q)$ equals 2.



Table 24: The Generalized Hurst Exponents, Which Pertain OIC Stock Countries Stock Market Returns, During COVID-19 a Range of q Values Spanning from -5 to 5.

COVID-19							
	Egypt	Indonesia	Jordan	Kuwait	Lebanon	Malaysia	Morocco
-5	0.6439	0.7038	0.7980	0.3889	0.8556	0.6294	0.7378
-4	0.6333	0.6833	0.7817	0.3819	0.8210	0.6201	0.7194
-3	0.6212	0.6600	0.7613	0.3750	0.7734	0.6098	0.6999
-2	0.6072	0.6361	0.7359	0.3684	0.7128	0.5982	0.6810
-1	0.5906	0.6139	0.7052	0.3619	0.6507	0.5849	0.6640
0	0.5700	0.5925	0.6711	0.3557	0.5953	0.5693	0.6459
1	0.5435	0.5674	0.6371	0.3498	0.5405	0.5506	0.6160
2	0.5096	0.5346	0.6067	0.3442	0.4861	0.5288	0.5649
3	0.4707	0.4976	0.5814	0.3389	0.4398	0.5051	0.5029
4	0.4330	0.4629	0.5609	0.3341	0.4045	0.4819	0.4485
5	0.4014	0.4340	0.5442	0.3296	0.3783	0.4612	0.4074
	Oman	Pakistan	Palestine	Qatar	SA	Tunisia	Turkey
-5	0.5306	0.6634	0.6759	0.4757	0.7131	0.7673	0.7283
-4	0.5180	0.6539	0.6565	0.4658	0.6992	0.7500	0.7137
-3	0.5048	0.6437	0.6361	0.4559	0.6851	0.7303	0.6968
-2	0.4917	0.6325	0.6184	0.4464	0.6713	0.7084	0.6760
-1	0.4796	0.6185	0.6066	0.4376	0.6573	0.6840	0.6489
0	0.4691	0.5981	0.6007	0.4299	0.6391	0.6557	0.6119
1	0.4603	0.5667	0.5987	0.4233	0.6077	0.6222	0.5612
2	0.4530	0.5245	0.5983	0.4177	0.5562	0.5857	0.4973
3	0.4470	0.4801	0.5980	0.4127	0.4967	0.5522	0.4311
4	0.4419	0.4420	0.5971	0.4082	0.4467	0.5248	0.3754
5	0.4375	0.4122	0.5954	0.4039	0.4096	0.5030	0.3332

Source: Author Generate

Table 25: The Generalized Hurst Exponents, Which Pertain OIC Stock Countries Stock Market Returns, During GFC a Range of q Values Spanning from -5 to 5.

GFC							
	Egypt	Indonesia	Jordan	Kuwait	Lebanon	Malaysia	Morocco
-5	0.6793	0.7108	0.9114	0.7857	0.9384	0.6714	0.6783
-4	0.6672	0.6941	0.8777	0.7575	0.8997	0.6563	0.6578
-3	0.6511	0.6747	0.8297	0.7229	0.8474	0.6386	0.6334
-2	0.6290	0.6519	0.7629	0.6814	0.7782	0.6181	0.6049
-1	0.5983	0.6242	0.6796	0.6323	0.6959	0.5949	0.5718
0	0.5572	0.5894	0.5924	0.5771	0.6122	0.5689	0.5327
1	0.5078	0.5460	0.5083	0.5221	0.5366	0.5401	0.4875
2	0.4565	0.4955	0.4247	0.4761	0.4738	0.5091	0.4407
3	0.4108	0.4448	0.3485	0.4417	0.4249	0.4780	0.3991
4	0.3737	0.4007	0.2903	0.4168	0.3876	0.4495	0.3660
5	0.3448	0.3655	0.2493	0.3985	0.3592	0.4253	0.3409
	Oman	Pakistan	Palestine	Qatar	SA	Tunisia	Turkey
-5	0.5224	1.0841	0.5088	0.5496	0.7354	0.8336	0.6369
-4	0.5046	1.0374	0.4983	0.5290	0.7175	0.8105	0.6230
-3	0.4841	0.9685	0.4873	0.5065	0.6964	0.7820	0.6065
-2	0.4620	0.8695	0.4758	0.4834	0.6718	0.7473	0.5871
-1	0.4395	0.7565	0.4643	0.4608	0.6436	0.7053	0.5651
0	0.4164	0.6700	0.4531	0.4386	0.6123	0.6560	0.5414
1	0.3911	0.6171	0.4427	0.4164	0.5789	0.6015	0.5168
2	0.3631	0.5827	0.4331	0.3941	0.5449	0.5468	0.4924
3	0.3341	0.5575	0.4247	0.3725	0.5119	0.4978	0.4692
4	0.3068	0.5378	0.4172	0.3526	0.4811	0.4574	0.4480
5	0.2829	0.5219	0.4106	0.3349	0.4536	0.4252	0.4295

Source: Author Generate

Tables 24 and 25 display the slopes of $h(q)$, which illustrate the characteristics of scales ranging from -5 to 5, corresponding to the COVID-19 and GFC outbreaks. When the value of $h(q)$ falls within the range of 0 to 0.5, it indicates fractal characteristics in the series and suggests that achieving market efficiency is not possible. In such situations, the series tends to revert to its mean, resulting in increased risk for investors. Moreover, the returns demonstrate a negative or anti-persistent long memory, indicating that the observed movements in the series deviate significantly from what would be expected in a random series. Conversely, when $h(q)$ reaches 0.5, it indicates randomness in the series, implying market efficiency. This suggests that returns lack long-term memory, and investors are unable to consistently outperform the market.

In contrast, if $h(q)$ lies between 0.5 and 1, it indicates a persistent and fractal structure in the series, which contradicts market efficiency. Furthermore, the returns exhibit a long memory. These findings were examined by Patil and Rastogi in 2020.

Tables 24 and 25 demonstrate that the $h(q)$ values differ across various indices, implying that all return series display multifractal characteristics. Furthermore, in all indices, the $h(q)$ values for small fluctuations are higher compared to those for large fluctuations. This suggests that the dynamics of the relevant markets demonstrate greater persistence and a more pronounced long-memory characteristic in small fluctuations. During the COVID-19 outbreak, the Lebanon and Jordan stock markets exhibit the highest persistence for $q=-5$, while the Kuwait stock market demonstrates the lowest persistence. Conversely, during the GFC outbreak, the Pakistan stock market displayed the strongest persistence for $q=-5$, whereas the Qatar stock market exhibited the weakest persistence. These findings indicate that the Pakistan stock market during the GFC and the Lebanon and Jordan stock markets during the COVID-19 outbreak display long-range dependence specifically for the smallest fluctuations. Further, the multifractal results can also be confirmed through Δh as results in Tables 1 and 2 show that Lebanon has the highest, and Kuwait has the lowest Δh during COVID. In contrast, Jordan has the highest, and Palestine has the lowest Δh during GFC.

Table 26: Presents the MF-DFA Rankings for the Stock Markets of OIC Countries, Comparing the GFC and COVID-19 Periods.

During GFC			During COVID-19		
Ranking	Country	MDM	Ranking	Country	MDM
01	Palestine	0.0491	01	Kuwait	0.02965
02	Turkey	0.1037	02	Qatar	0.0359
03	Qatar	0.10735	03	Palestine	0.04025
04	Oman	0.11975	04	Oman	0.04655
05	Malaysia	0.12305	05	Malaysia	0.0841
06	SA	0.1409	06	Egypt	0.12125
07	Egypt	0.16725	07	Pakistan	0.1256
08	Morocco	0.1687	08	Jordan	0.1269
09	Indonesia	0.17265	09	Tunisia	0.13215
10	Kuwait	0.1936	10	Indonesia	0.1349
11	Tunisia	0.2042	11	SA	0.15175
12	Pakistan	0.2811	12	Morocco	0.1652
13	Lebanon	0.2896	13	Turkey	0.19755
14	Jordan	0.33105	14	Lebanon	0.23865

Source: Author Generate

Table 26 presents the market deficiency measure (MDM) rule of thumb that states that if the value is zero or near zero, the market is efficient. If the value of MDM is high, the market is less efficient. The result shows Palestine was the most efficient market, followed by Turkey and Qatar. At the same time, Jordan was the less efficient market during GFC, while during COVID-19, Kuwait, Qatar, Palestine, Oman, and Malaysia stock markets were more efficient. In contrast, Lebanon and Turkey's stock markets are the least efficient. The variations in market efficiency levels stem from differences in the extent of persistence and enhancement. These variations should be considered by investors when making decisions regarding portfolio risk management and asset allocation.

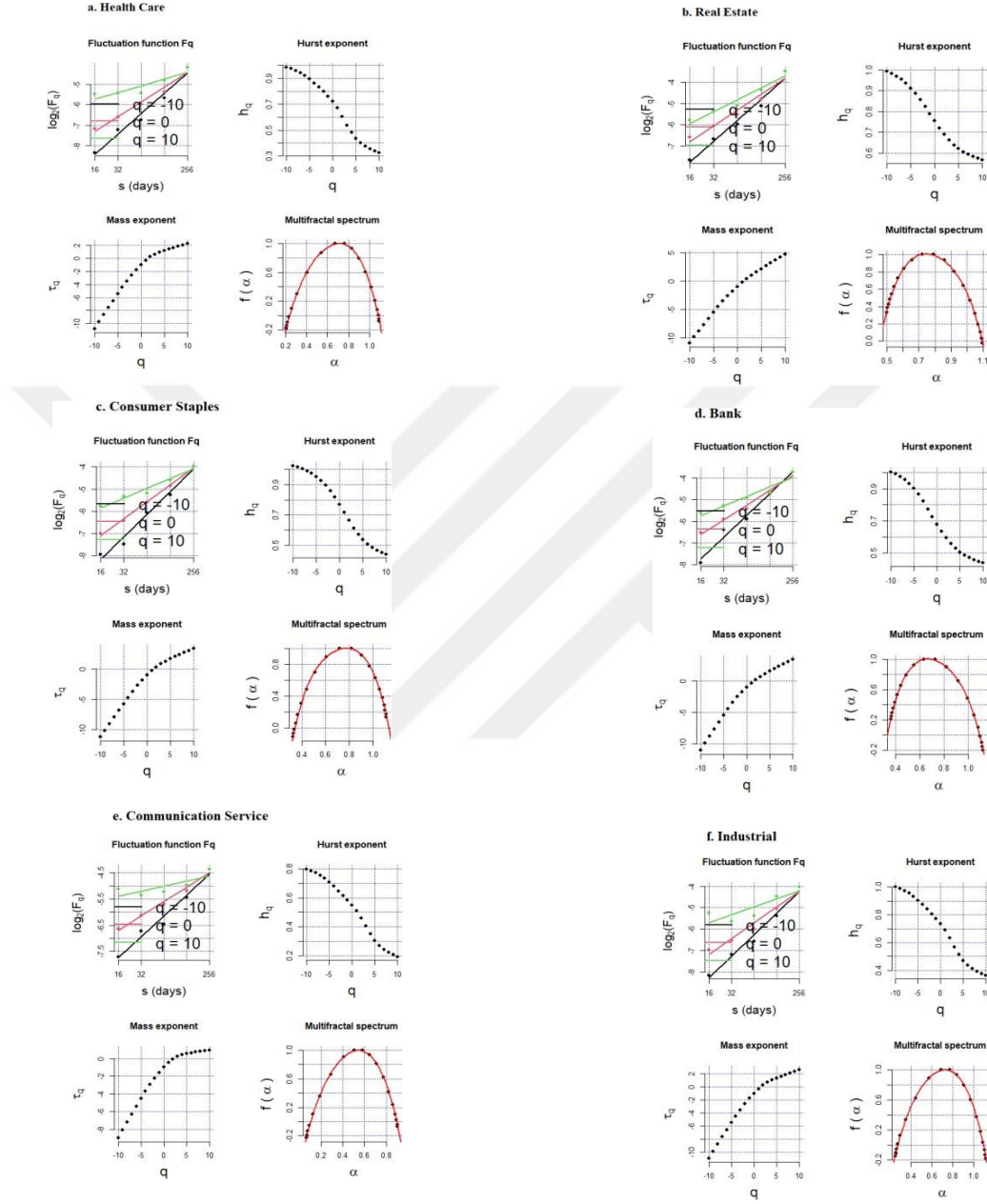


Figure 7: show cases the MF-DFA results for the return time series of prominent Egypt sector indices from OIC countries during the COVID-19 period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

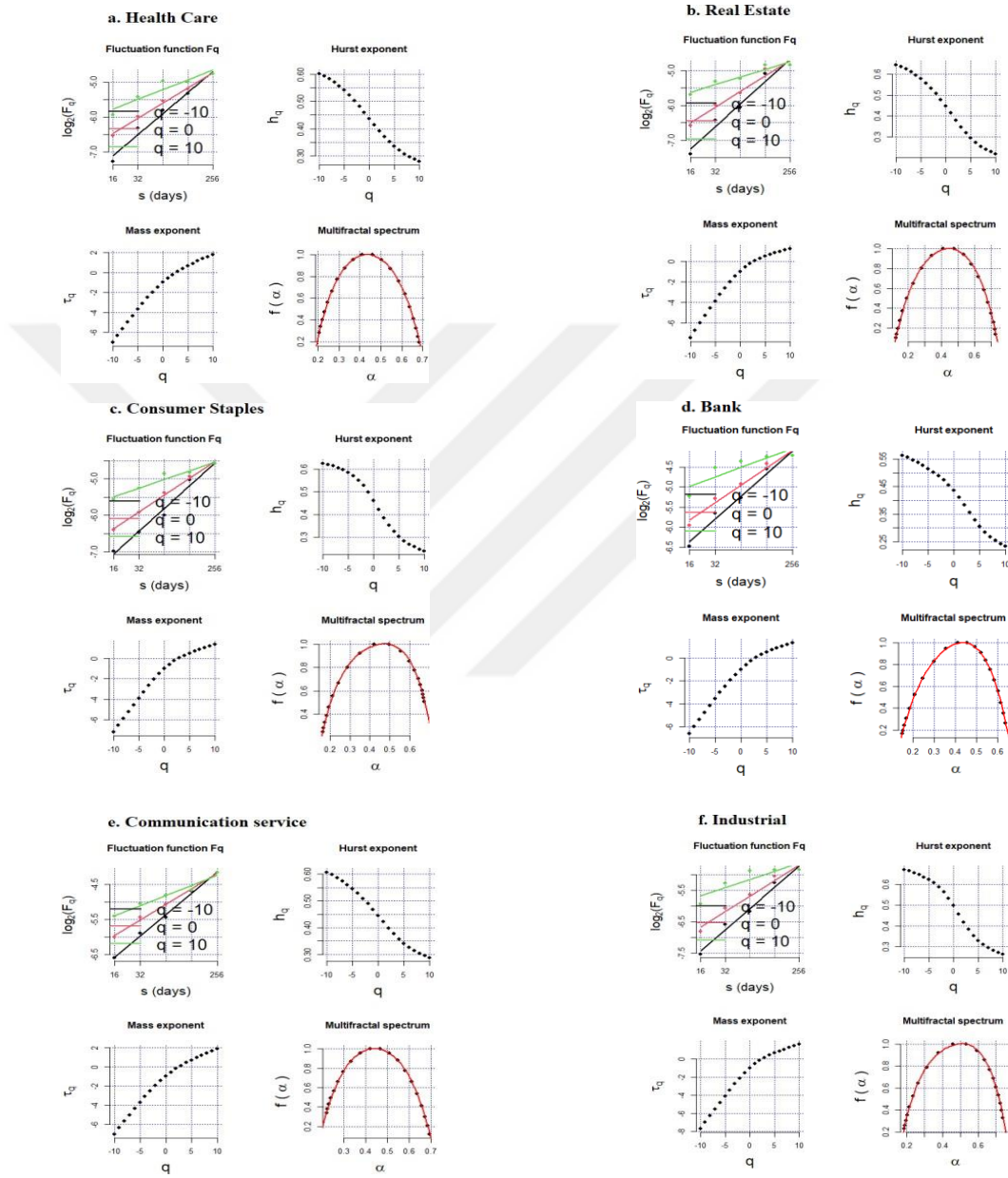


Figure 8: show cases the MF-DFA results for the return time series of prominent Egypt sector indices from OIC countries during the GFC period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

In Panel (i), the logarithm of the fluctuation function (F_q) is plotted against the scaling factor (s) for different values of q , namely -10, 0, and 10. The graph displays a well-defined shape and exhibits a linear relationship. In Panel (ii), the generalized Hurst exponent $h(q)$ is illustrated with q values ranging from -10 to +10. The plot reveals a decreasing trend in the values of $h(q)$ as q increases. The decreasing pattern observed provides evidence for the existence of multifractal patterns within the temporal fluctuations. Panel (iii) displays the nonlinear Renyi exponent, $\tau(q)$, indicating the nonlinearity of multifractal time series. Lastly, Panel (iv) presents the multifractal spectrum, f_α , characterized by a single-humped form, providing further confirmation of the existence of multifractality. One approach to assess the multifractality of a financial dataset involves studying the singularity spectrum, $f(\alpha)$. The singularity spectrum, $f(\alpha)$, offers insights into the fractal dimension of a specific subset within the financial series, with α representing the magnitude of the singularity. According to Zunino et al. (2008), a financial series that demonstrates a narrower multifractal spectrum is regarded as more efficient since it indicates lower levels of heterogeneity and market risk. The right portion of the spectrum, which depicts the connection between $f(\alpha)$ and α , signifies minor fluctuations, while the left portion indicates significant fluctuations. The multifractal spectrum, representing the power law exponent of a financial series, reveals that the breadth and form of the spectrum can influence financial series across various scales, as observed by Zhang et al. (2018). During the global financial crisis (GFC), the return spectra indicates that small fluctuations display persistence and possess a positive long-term memory. During COVID-19, the results indicate large fluctuation; on the other hand, larger fluctuations tend to revert to the average and demonstrate an anti-persistent pattern over an extended period.

The values of $h(q)$ gradients for both the global financial crisis (GFC) and COVID-19 outbreaks span from -5 to 5. When the value of $h(q)$ falls between 0 and 0.5, This suggests that the series exhibits fractal characteristics, indicating a lack of market efficiency. In such cases, the series tends to return to its average (mean) value, which increases the level of risk in the market for investors. The returns demonstrate a form of negative or anti-persistent long memory, indicating that the patterns observed in the series deviate significantly from those typically observed in a random series. When the value of $h(q)$ is 0.5, it suggests that the series

is random, indicating market efficiency. This implies that the returns do not display long-term patterns, and investors are unable to achieve superior performance compared to the overall market. Conversely, if the value of $h(q)$ falls within the range of 0.5 to 1, it indicates that the series exhibits a persistent and fractal structure, which is inconsistent with market efficiency. In this scenario, the returns display long-term patterns, as noted by Patil and Rastogi (2020).

Figures 7 and 8 present the outcomes derived from the multifractal detrended fluctuation analysis (MF-DFA) conducted for the Health Care, Real Estate, Consumer Staples, Banking, Communication Services, and Industrial sectors of Egypt's stock market during COVID-19 and GFC. During the GFC, the spectrum for all the sectors at 0.4 to 0.6, which shows small fluctuation and lower risk in the market, while the spectrum during the COVID-19 for all the sectors is between 0.8 to 0.9, which shows the highest spectra and presents the higher multifractal behavior and market risk expect communication services which show 0.6.

Table 27: The Generalized Hurst Exponents, Which Pertain to Sector Indices for Egypt Stock Market Returns, During COVID-19 and GFC a Range of Q Values Spanning from -5 to 5.

COVID-19 period						
	Health Care	Real estate	Consumer Staples	Bank	Communication Services	Industrial
-5	0.8934	0.9131	0.9528	0.9012	0.7072	0.9044
-4	0.8630	0.8864	0.9272	0.8643	0.6780	0.8733
-3	0.8302	0.8562	0.8962	0.8210	0.6467	0.8400
-2	0.7966	0.8235	0.8596	0.7736	0.6149	0.8063
-1	0.7617	0.7893	0.8172	0.7254	0.5828	0.7722
0	0.7216	0.7545	0.7690	0.6784	0.5486	0.7347
1	0.6701	0.7204	0.7161	0.6340	0.5087	0.6887
2	0.6057	0.6889	0.6621	0.5938	0.4598	0.6309
3	0.5385	0.6613	0.6121	0.5591	0.4040	0.5682
4	0.4806	0.6384	0.5695	0.5302	0.3502	0.5127
5	0.4356	0.6197	0.5348	0.5067	0.3054	0.4691
Δh	0.4578	0.2934	0.418	0.3945	0.4018	0.4353
GFC period						
-5	0.5419	0.5764	0.5840	0.5145	0.5449	0.6230
-4	0.5237	0.5558	0.5692	0.5021	0.5279	0.6074
-3	0.5034	0.5325	0.5505	0.4886	0.5093	0.5881
-2	0.4816	0.5066	0.5265	0.4734	0.4892	0.5639
-1	0.4588	0.4781	0.4966	0.4558	0.4676	0.5336
0	0.4357	0.4470	0.4611	0.4352	0.4448	0.4973
1	0.4127	0.4137	0.4226	0.4109	0.4214	0.4571
2	0.3904	0.3798	0.3852	0.3835	0.3982	0.4174
3	0.3696	0.3475	0.3521	0.3550	0.3765	0.3819
4	0.3506	0.3185	0.3244	0.3279	0.3570	0.3523
5	0.3338	0.2936	0.3021	0.3040	0.3400	0.3285
Δh	0.2081	0.2828	0.2819	0.2105	0.2049	0.2945

Source: Author Generate

Table 27 presents an analysis of $h(q)$ during the COVID-19 period; the $h(q)$ values for all returns are above 0.5 for q values ranging from -5 to 5, indicating a strong persistence in the observed data, all returns have long-term persistence during the GFC, the $h(q)$ values for all sectors are below 0.5, indicating anti-persistence in the data. For q values up to 2, the $h(q)$ values exceed 0.5 except for the Communication Service sector during COVID-19, and q

values for all the sectors are below 0.5 during the GFC outbreak. However, due to the distinct characteristics of each crisis, the levels of persistence in sector returns vary between the two periods of crisis. GFC related to the financial crisis and the crisis raised because of banking mortgage, Reinhart & Rogoff (2008); Demyanyk, & Van Hemert (2011); Choi (2021), while the COVID-19 related to the pandemic. During the global financial crisis (GFC), the Hurst exponents of all sectors are below 0.5, indicating a lower level of persistence. However, during the COVID-19 pandemic, the Hurst exponents are above 0.5, indicating a higher level of persistence. To put it differently, the average return series of all sectors exhibit anti-persistence during the global financial crisis (GFC), which is characterized by negative autocorrelation. This means that a positive/negative change in the previous time period is likely to be followed by a negative/positive change in the subsequent period. However, during the COVID-19 pandemic, the average return series shows persistence, except for the Communication Service sector when considering the $h_q=2$ value.

As depicted in Table 13, the $h(q)$ values demonstrate variation across different indices, suggesting that all return series exhibit multifractal characteristics. Furthermore, the values of $h(q)$ are higher for small fluctuations compared to large fluctuations across all indices. This observation indicates that the dynamics of the analyzed markets exhibit stronger persistence and a more pronounced long-memory characteristic in the realm of small fluctuations. For the value of q equal to -5, the Consumer Staples sector demonstrates the highest level of persistence. In contrast, the communication service sector exhibited the lowest level of persistence during the COVID-19 period. In contrast, during the GFC outbreak, the industrial sector displayed the strongest persistence for q equal to -5, while the banking sector showed the weakest persistence. These findings indicate that when examining the smallest fluctuations, certain sectors maintain consistent patterns in their returns.

Table 28: Displays the MF-DFA Rankings for the Sector of the Egyptian Stock Market, Comparing the GFC and COVID-19 Periods.

Ranking	Country	MDM	Ranking	Country	MDM
During GFC			During COVID-19		
01	Real estate	0.1467	01	Communication Services	0.10245
02	Bank	0.19725	02	Health Care	0.10405
03	Communication Services	0.2009	03	Bank	0.10525
04	Consumer Staples	0.209	04	Consumer Staples	0.14095
05	Industrial	0.21765	05	Real estate	0.1414
06	Health Care	0.2289	06	Industrial	0.14725

Source: Author Generate

Table 28 presents the results of MDM for Egypt's stock market sectors; the Real Estate market demonstrates a high level of efficiency, followed by the Banking and Communication Services Sector, while Health Care is the less efficient market during GFC while during COVID-19 Communication Services, Health Care, and banking sectors are more efficient while Industrial show least efficient. These differences in market efficiency levels arise from varying degrees of persistent improvement, and these findings should be considered by investors when making their investment decisions regarding portfolio risk management and asset allocation.

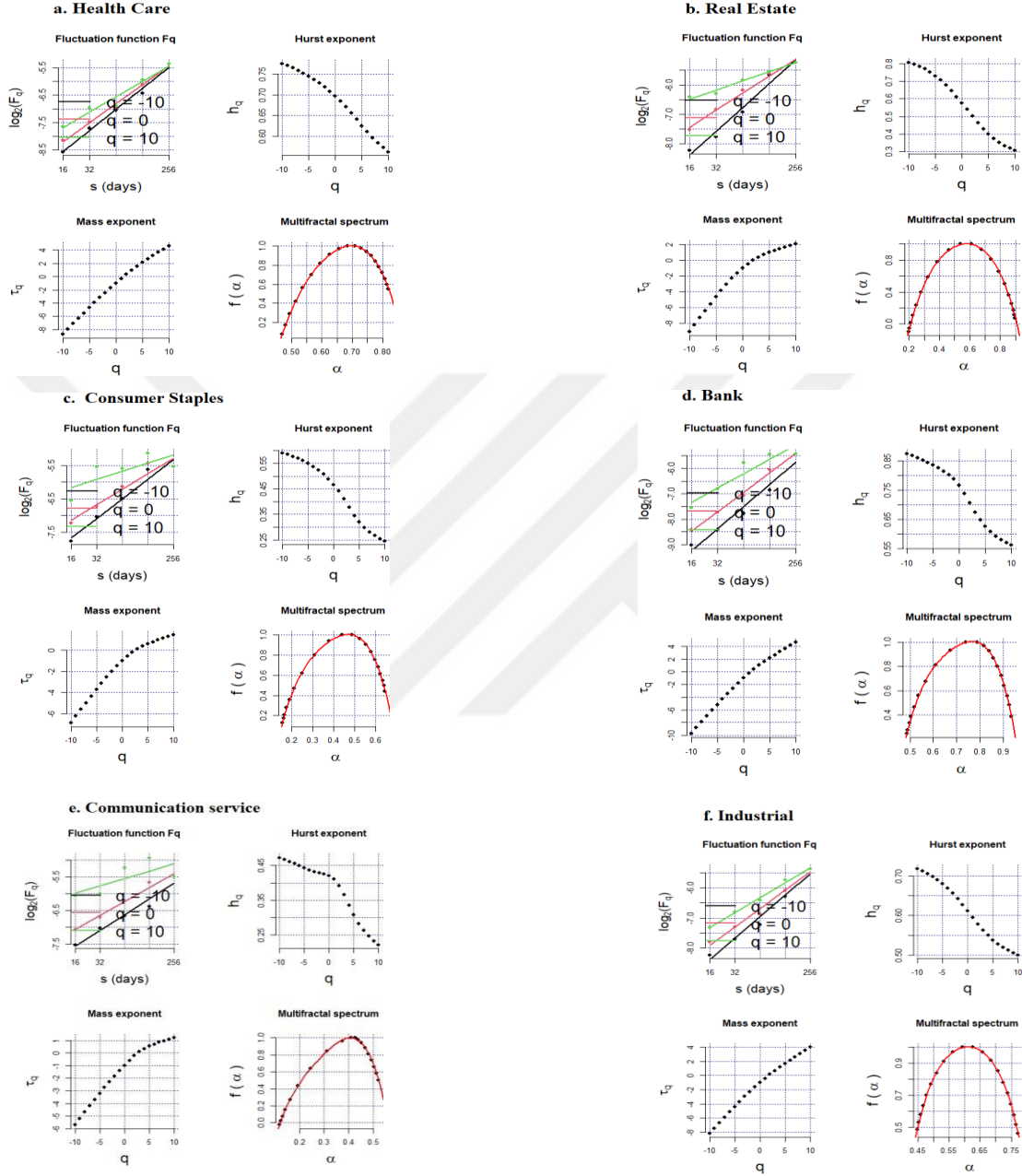


Figure 9: show cases the MF-DFA results for the return time series of prominent Jordan sector indices during the COVID period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

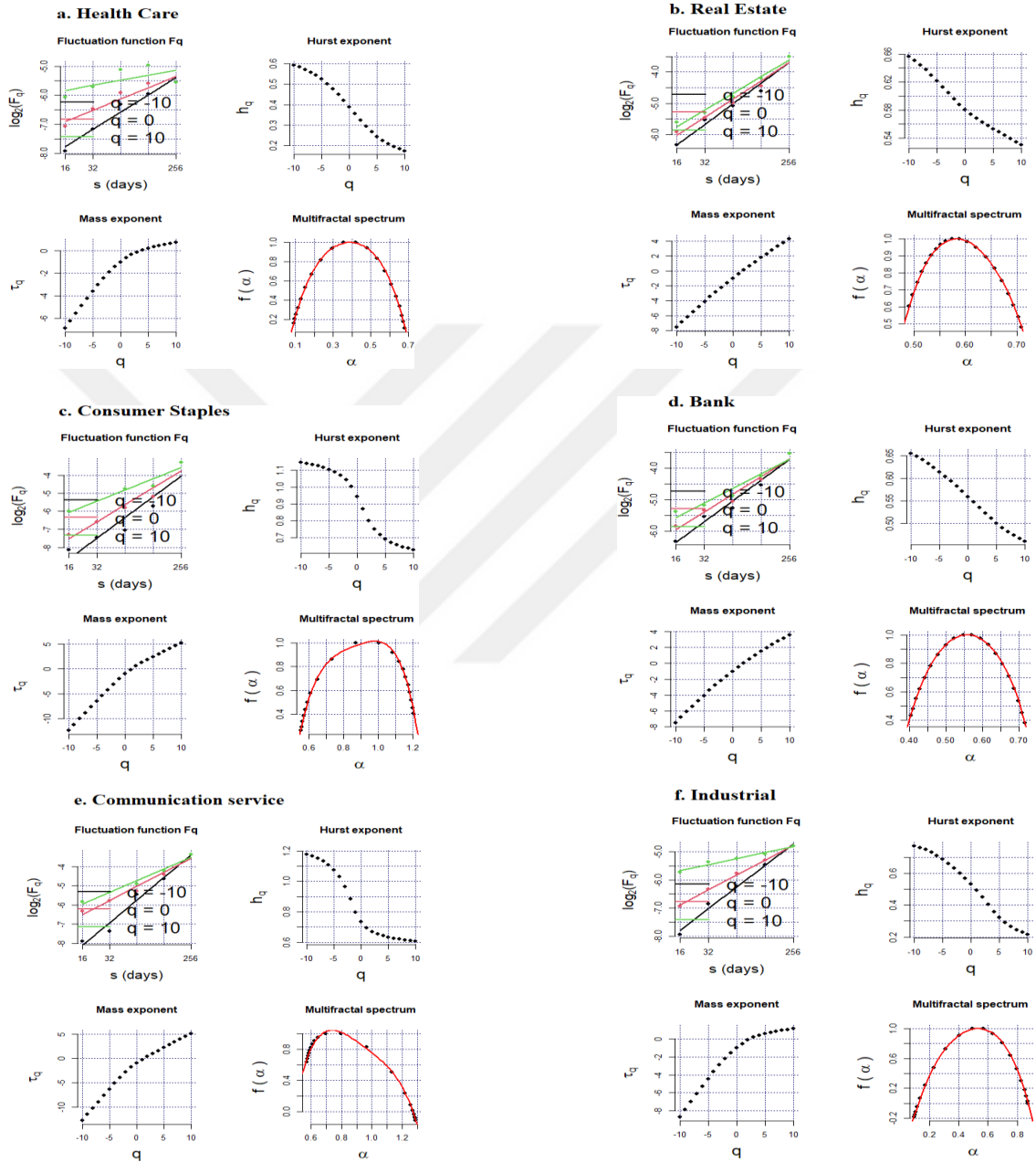


Figure 10: show cases the MF-DFA results for the return time series of prominent Jordan sector indices during the GFC period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

Figures 9 and 10 present findings obtained from the MF-DFA analysis conducted for the Health Care, Real Estate, Consumer Staples, Banking, Communication Services, and Industrial sectors of the Jordan stock market during COVID-19 and GFC. During the GFC, the spectrum for all the sectors is at 0.5 to 0.6, which shows small fluctuation and lower risk in the market except Consumer Staples and Communication Services, which are at one and show large fluctuation and high risk in the market, while the spectrum during the COVID-19 for all the sectors is between 0.5 to 0.6 and in the centered which shows the small fluctuation and low risk in the market, expect for the banking and health care sectors which presents the higher multifractal behavior and market risk.

Table 29: The Generalized Hurst Exponents, which Pertain to Sector Indices for Jordan Stock Market Returns, During COVID-19 and GFC a Range of q Values Spanning from -5 to 5.

Covid-19 period						
	Health Care	Real estate	Consumer Staples	Bank	Communication Services	Industrial
-5	0.7442	0.7302	0.5493	0.8354	0.4424	0.6801
-4	0.7363	0.7052	0.5371	0.8255	0.4366	0.6691
-3	0.7277	0.6767	0.5231	0.8148	0.4315	0.6567
-2	0.7183	0.6454	0.5069	0.8027	0.4276	0.6428
-1	0.7080	0.6121	0.4883	0.7876	0.4245	0.6273
0	0.6966	0.5768	0.4667	0.7667	0.4202	0.6108
1	0.6841	0.5396	0.4408	0.7383	0.4105	0.5940
2	0.6703	0.5012	0.4102	0.7058	0.3918	0.5778
3	0.6556	0.4635	0.3769	0.6744	0.3651	0.5628
4	0.6404	0.4289	0.3455	0.6474	0.3353	0.5494
5	0.6253	0.3988	0.3191	0.6253	0.3070	0.5378
Δh	0.1189	0.3314	0.2302	0.2101	0.1354	0.1423
GFC Period						
-5	0.5234	0.6217	1.1034	0.6144	1.0742	0.6887
-4	0.5018	0.6131	1.0890	0.6042	1.0286	0.6618
-3	0.4772	0.6043	1.0704	0.5934	0.9651	0.6322
-2	0.4497	0.5959	1.0441	0.5823	0.8827	0.6010
-1	0.4201	0.5879	1.0041	0.5709	0.7973	0.5682
0	0.3889	0.5806	0.9442	0.5592	0.7327	0.5327
1	0.3569	0.5741	0.8698	0.5472	0.6929	0.4931
2	0.3250	0.5683	0.8010	0.5350	0.6689	0.4493
3	0.2946	0.5630	0.7499	0.5230	0.6532	0.4034
4	0.2673	0.5581	0.7145	0.5114	0.6420	0.3598
5	0.2439	0.5533	0.6894	0.5005	0.6332	0.3218
Δh	0.2795	0.0684	0.414	0.1139	0.441	0.3669

Source: Author Generate

Table 29 presents the findings for q values ranging from -5 to 5, particularly for q values less than or equal to 2, revealing that the $h(q)$ values surpass 0.5. This indicates that regardless of the small fluctuations, all returns exhibit long-term persistence, except for the Communication Service and Consumer staples sectors during the COVID-19 these two sectors have lower values below 0.5, and q values for all the sectors are higher than 0.5 during the GFC outbreak which shows that the small fluctuation and market is long term persistence. To put it differently, the average return series of all sectors demonstrate persistence both during the global financial crisis (GFC) and the COVID-19 period.

As depicted in Table 15, the $h(q)$ values demonstrate variability across different indices, suggesting that all return series display characteristics of multifractal behavior. Furthermore, it can be observed that in all indices, the $h(q)$ values are higher for small fluctuations compared to large fluctuations. This implies that the dynamics of the studied markets demonstrate greater persistence and a more pronounced long-memory characteristic when it comes to small fluctuations. During the COVID-19 period, the banking sector exhibited the highest level of persistence for $q = -5$, while the communication service sector showed the lowest level of persistence. Conversely, during the GFC outbreak, the Communication Services sector demonstrated the strongest persistence for $q = -5$, while the Health Care sector exhibited the weakest persistence. These findings suggest that for the smallest fluctuations, the sectors display varying levels of persistence.

Table 30: Table 30 Presents the MF-DFA Rankings for the Sector of the Jordanian Stock Market, Comparing the GFC and COVID-19 Periods.

During GFC			During COVID-19		
Ranking	Country	MDM	Ranking	Country	MDM
01	Real estate	0.0342	01	Health Care	0.05945
02	Bank	0.05695	02	Communication Services	0.0677
03	Health Care	0.13975	03	Industrial	0.07115
04	Industrial	0.18345	04	Bank	0.10505
05	Consumer Staples	0.207	05	Consumer Staples	0.1151
06	Communication Services	0.2205	06	Real estate	0.1657

Source: Author Generate

Table 30 presents the results of MDM for Jordan's stock market sectors, Real Estate is the most efficient market, followed by Banking and Health Care sectors, while Communication Services is the less efficient market during GFC while during COVID-19 Health Care, Communication Services, and Industrial sectors are more efficient, while Real Estate show least efficient. The discrepancies in market efficiency levels arise due to differences in the degree of persistence and improvement. Investors can take these variations into account when making decisions regarding portfolio risk management and asset allocation.

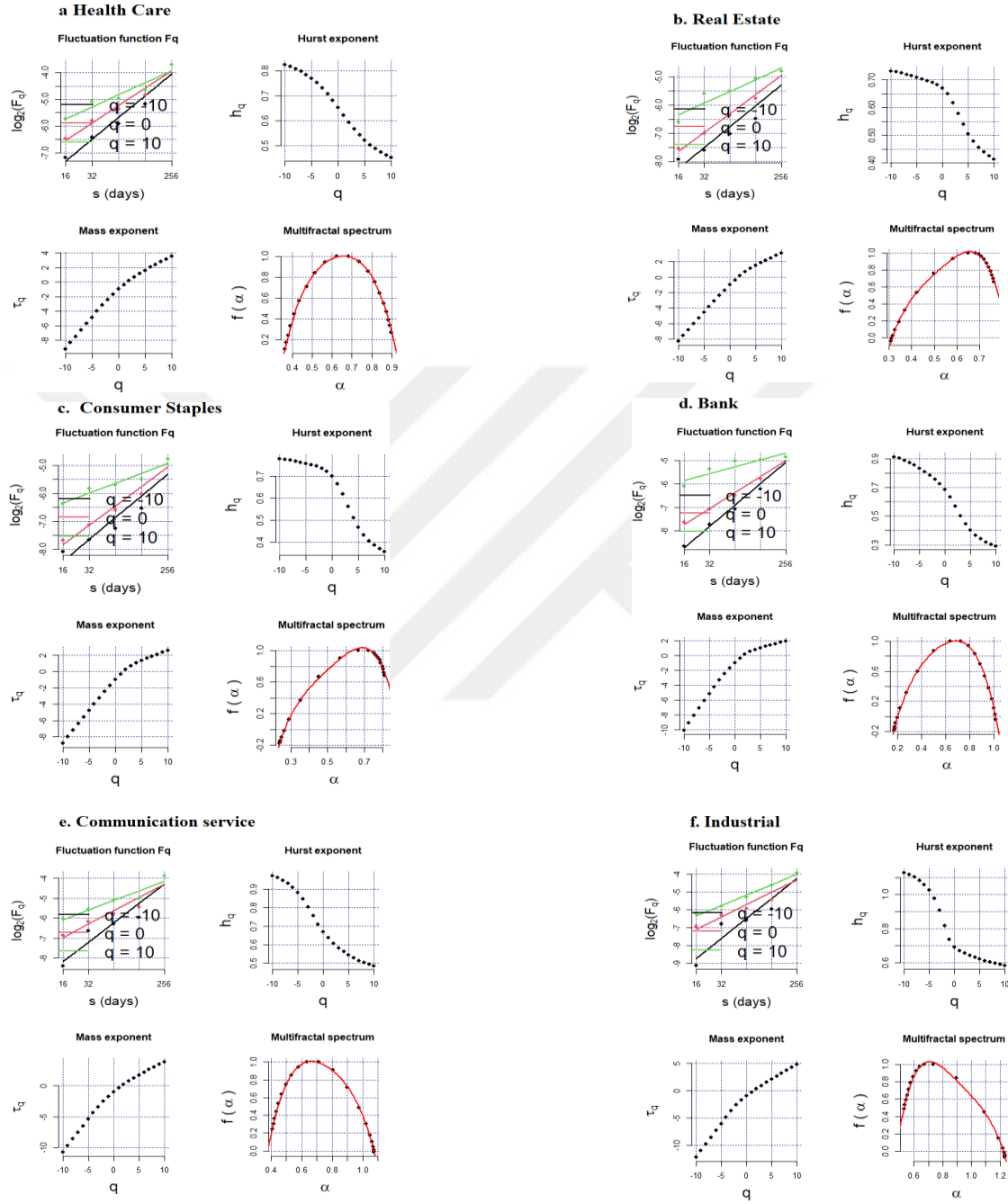


Figure 11: show cases the MF-DFA results for the return time series of prominent Moroccan sector indices during the COVID-19 period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

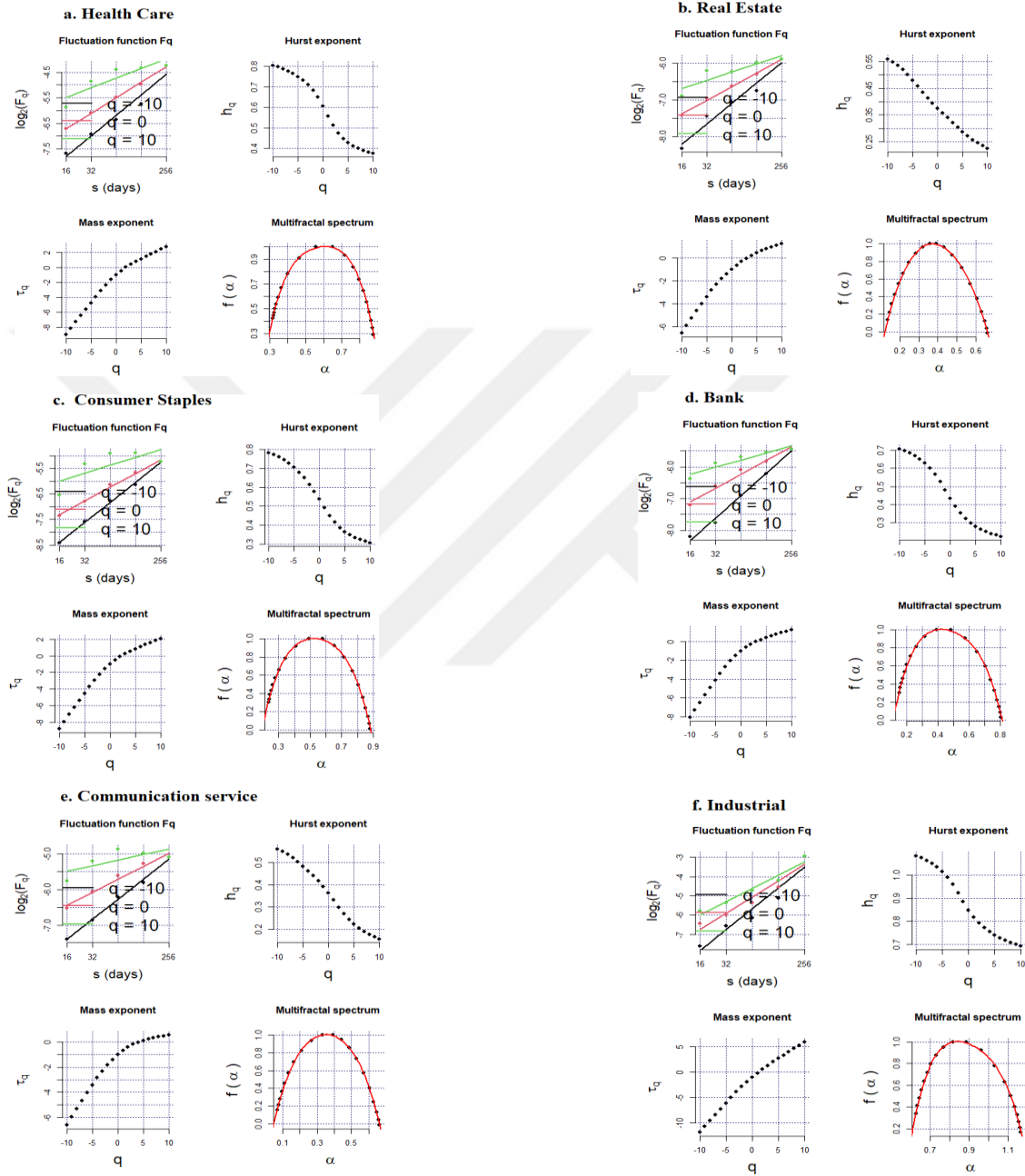


Figure 12: show cases the MF-DFA results for the return time series of prominent Moroccan sector indices during the GFC period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

Figures 11 and 12 present outcomes obtained from the multifractal detrended fluctuation analysis (MF-DFA) conducted for Health Care, Real Estate, Consumer Staples, Banking, Communication Services, and Industrial sectors of the Morocco stock market during the COVID-19 period and the global financial crisis (GFC) are examined. During the GFC, the spectrum for all the sectors is at 0.5 to 0.6, which shows small fluctuation and lower risk in the market except Industrial, which is at 0.9 and shows large fluctuation and high risk in the market, while the spectrum during the COVID-19 for all the sectors is between 0.7 to 0.8 and which shows high fluctuation and high risk in the market, in other words, it is the higher multifractal behavior and market risk is also high.

Table 31: The Generalized Hurst Exponents, Which Pertain to Sector Indices for Morocco Stock Market Returns, During COVID-19 and GFC a Range of q Values Spanning from -5 to 5.

COVID-19 Period						
	Health Care	Real estate	Consumer Staples	Bank	Communication Services	Industrial
-5	0.7699	0.7084	0.7583	0.8320	0.8832	1.0242
-4	0.7523	0.7025	0.7522	0.8088	0.8483	0.9758
-3	0.7317	0.6964	0.7450	0.7834	0.8055	0.9053
-2	0.7080	0.6899	0.7356	0.7556	0.7577	0.8142
-1	0.6813	0.6823	0.7219	0.7241	0.7113	0.7351
0	0.6525	0.6704	0.7002	0.6854	0.6708	0.6913
1	0.6230	0.6495	0.6657	0.6336	0.6368	0.6690
2	0.5943	0.6168	0.6175	0.5682	0.6081	0.6544
3	0.5677	0.5770	0.5622	0.5011	0.5833	0.6418
4	0.5437	0.5380	0.5096	0.4441	0.5620	0.6301
5	0.5224	0.5044	0.4659	0.3997	0.5437	0.6194
Δh	0.2475	0.204	0.2924	0.4323	0.3395	0.4048
GFC Period						
-5	0.7493	0.4795	0.7040	0.6286	0.4832	1.0146
-4	0.7315	0.4569	0.6786	0.6011	0.4618	0.9898
-3	0.7097	0.4341	0.6489	0.5675	0.4397	0.9591
-2	0.6828	0.4127	0.6149	0.5273	0.4164	0.9229
-1	0.6486	0.3933	0.5772	0.4817	0.3910	0.8843
0	0.6057	0.3752	0.5363	0.4346	0.3622	0.8480
1	0.5572	0.3574	0.4927	0.3908	0.3307	0.8170
2	0.5116	0.3392	0.4502	0.3531	0.2989	0.7918
3	0.4749	0.3207	0.4142	0.3224	0.2695	0.7712
4	0.4474	0.3027	0.3860	0.2980	0.2439	0.7543
5	0.4270	0.2859	0.3644	0.2787	0.2223	0.7401
Δh	0.3223	0.1936	0.3396	0.3499	0.2609	0.2745

Source: Author Generate

Table 31 presents the results for values of q ranging from -5 to 5; it is observed that for $q \leq 2$, the values of $h(q)$ are greater than 0.5, indicating that all returns exhibit long-term persistence during the COVID-19 period. Conversely, during the global financial crisis (GFC) outbreak, the values of q for all sectors are below 0.5, suggesting a different pattern. Put simply, the average return series of all sectors demonstrates persistence during the COVID-19 period, whereas during the global financial crisis (GFC), they exhibited anti-persistence. To put it differently, during the global financial crisis (GFC), the average return series of all sectors exhibited anti-persistence, characterized by negative autocorrelation. This means that a positive or negative change in the previous time period is likely to be followed by an opposite change in the subsequent period. However, during the COVID-19 pandemic, the average return series remains persistent, except for the Communication Service sector.

As shown in Table 31, the $h(q)$ values display variation across different values of q for all indices, suggesting that all return series demonstrate multifractal behavior. Furthermore, it is observed that the $h(q)$ values for small fluctuations are higher compared to the $h(q)$ values for large fluctuations across all indices. This indicates that the dynamics of the analyzed markets display stronger persistence and exhibit a more pronounced long-memory characteristic when it comes to smaller fluctuations. During both the COVID-19 period and the global financial crisis (GFC), the industrial sector demonstrated the highest level of persistence when q was set to -5. On the other hand, the real estate sector exhibited the lowest level of persistence during these periods.

Table 32: Displays the MF-DFA Rankings for The Sector of The Moroccan Stock Market, Comparing the GFC and COVID-19 Periods.

During GFC			During COVID-19		
Ranking	Country	MDM	Ranking	Country	MDM
01	Real estate	0.0968	01	Real estate	0.102
02	Communication Services	0.13045	02	Health Care	0.12375
03	Industrial	0.13725	03	Consumer Staples	0.1462
04	Health Care	0.16115	04	Communication Services	0.16975
05	Consumer Staples	0.1698	05	Industrial	0.2024
06	Bank	0.17495	06	Bank	0.21615

Source: Author Generate

Table 32 presents the results of MDM for Morocco's stock market sectors, Real Estate is the most efficient market, while the Banking sector is the less efficient market during both crisis i.e. GFC and COVID-19. The differences in market efficiency levels arise due to varying degrees of persistent improvement. Investors can take these variations into consideration when making decisions regarding portfolio risk management and asset allocation.

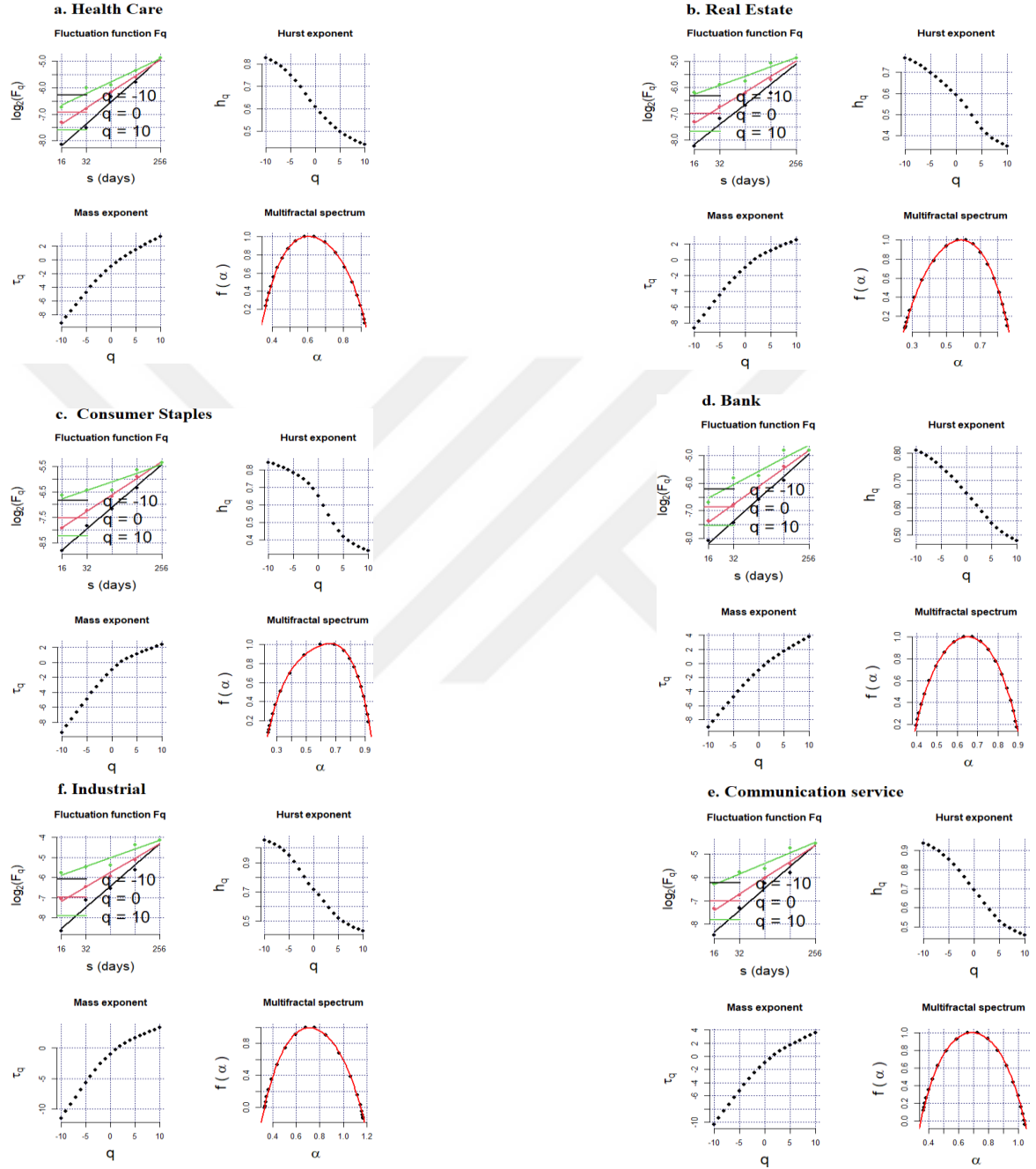


Figure 13: show cases the MF-DFA results for the return time series of prominent Saudi Arabia sector indices during the COVID-19 period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10 , (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

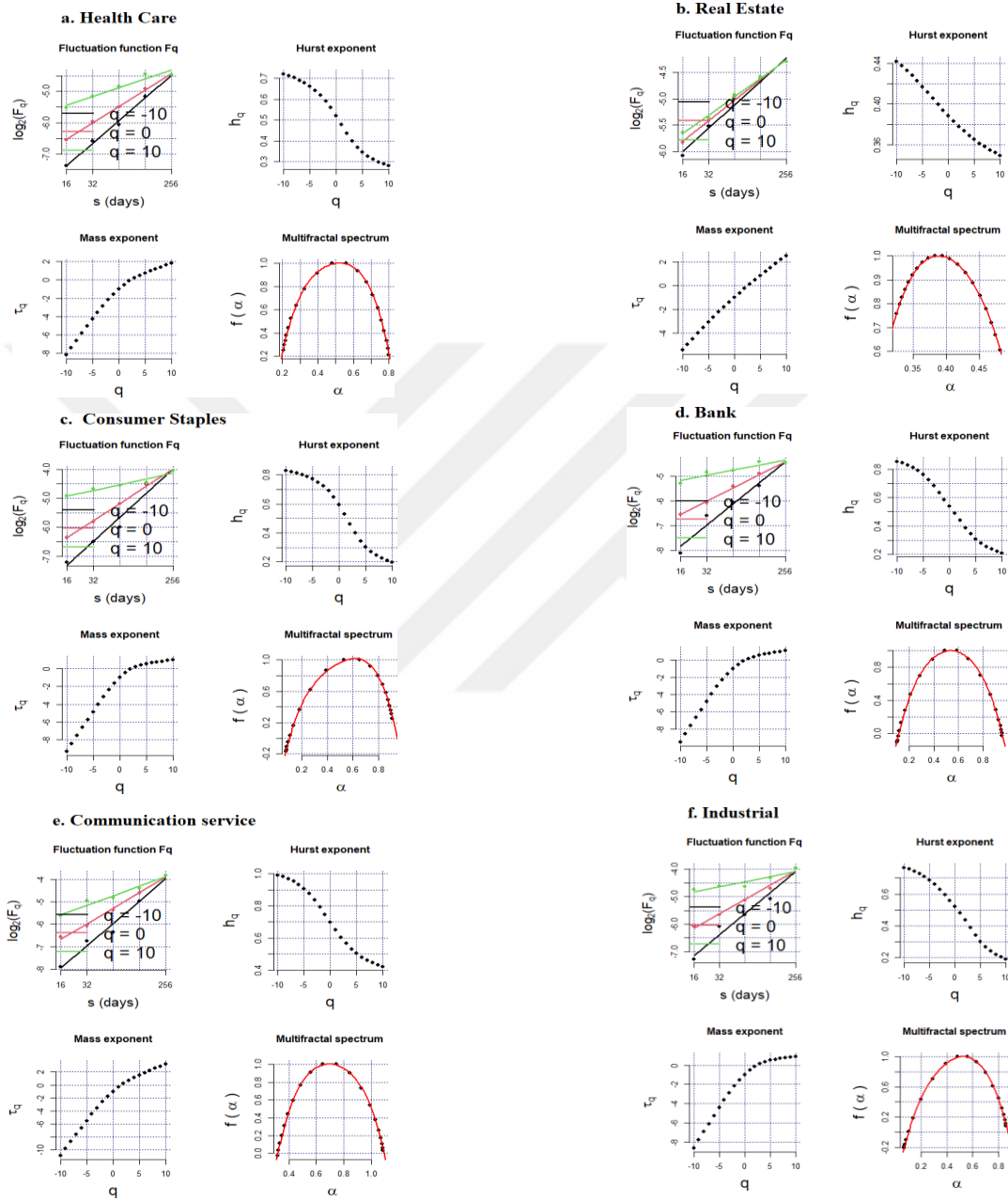


Figure 14: show cases the MF-DFA results for the return time series of prominent Saudi Arabia sector indices during the GFC period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

Figures 13 and 14 present the outcomes derived from the MF-DFA analysis conducted for the Health Care, Real Estate, Consumer Staples, Banking, Communication Services, and Industrial sectors of the Saudi Arabia stock market during COVID-19 and GFC. During the GFC, the spectrum for all the sectors is at 0.5 to 0.6, which shows small fluctuation and lower risk in the market except Industrial, which is at 0.9 and shows large fluctuation and high risk in the market, while the spectrum during the COVID-19 for all the sectors is between 0.7 to 0.8 and which shows high fluctuation and high risk in the market, in other words, it is the higher multifractal behavior and market risk is also high.

Table 33: The Generalized Hurst Exponents, Which Pertain to Sector Indices for Saudi Arabia Stock Market Returns, During COVID-19 and GFC a Range of q Values Spanning from -5 to 5.

SA. Covid-19 Period						
Q	Health Care	Real estate	Consumer Staples	Bank	Communication Services	Industrial
-5	0.7505	0.6994	0.7843	0.7500	0.8537	0.9495
-4	0.7255	0.6792	0.7675	0.7328	0.8258	0.9073
-3	0.6975	0.6580	0.7476	0.7142	0.7946	0.8560
-2	0.6676	0.6367	0.7231	0.6947	0.7617	0.8025
-1	0.6375	0.6155	0.6913	0.6746	0.7284	0.7561
0	0.6086	0.5927	0.6494	0.6538	0.6946	0.7168
1	0.5818	0.5657	0.5975	0.6320	0.6594	0.6782
2	0.5574	0.5329	0.5419	0.6089	0.6233	0.6363
3	0.5354	0.4966	0.4914	0.5854	0.5884	0.5933
4	0.5158	0.4616	0.4506	0.5630	0.5573	0.5542
5	0.4986	0.4314	0.4190	0.5429	0.5311	0.5217
Δh	0.2519	0.268	0.3653	0.2071	0.3226	0.4278
GFC						
-5	0.6601	0.4171	0.7716	0.7619	0.9071	0.6876
-4	0.6408	0.4114	0.7507	0.7261	0.8761	0.6601
-3	0.6182	0.4055	0.7244	0.6819	0.8380	0.6280
-2	0.5912	0.3997	0.6909	0.6327	0.7933	0.5931
-1	0.5590	0.3939	0.6483	0.5842	0.7448	0.5574
0	0.5210	0.3884	0.5948	0.5377	0.6959	0.5208
1	0.4789	0.3831	0.5310	0.4895	0.6486	0.4809
2	0.4368	0.3780	0.4624	0.4382	0.6044	0.4358
3	0.3994	0.3734	0.3984	0.3879	0.5649	0.3871
4	0.3690	0.3690	0.3452	0.3437	0.5313	0.3401
5	0.3451	0.3650	0.3035	0.3075	0.5033	0.2992
Δh	0.315	0.0521	0.4681	0.4544	0.4038	0.3884

Source: Author Generate

Table 33 The Generalized Hurst exponents, which pertain to sector indices for Saudi Arabia stock market returns during COVID-19 and GFC, a range of q values spanning from -5 to 5. Table 33 presents the results of the COVID-19 period, the values of $h(q)$ exceeding 0.5, indicating that all returns exhibit long-term persistence. On the other hand, during the global financial crisis (GFC), the values of q for all sectors are below 0.5. In simpler terms, the average return series of all sectors demonstrates persistence during the COVID-19 period while showing anti-persistence during the global financial crisis (GFC). To provide further precision, the average return series of all sectors exhibit anti-persistence during the GFC, which implies negative autocorrelation. This anti-persistence behavior suggests that a positive or negative change in the previous time period is likely to be followed by an opposite (negative or positive) change in the subsequent period. However, during the COVID-19 pandemic, the average return series remains persistent, except for the Communication Service sector.

As shown in Table 33, The values of $h(q)$ exhibit variation across different values of q for all indices, indicating that all return series demonstrate multifractal behavior. Furthermore, the $h(q)$ values for small fluctuations are higher than those for large fluctuations across all indices, signifying that the dynamics of the analyzed markets exhibit greater persistence and a more pronounced long-memory characteristic in smaller fluctuations. During the COVID-19 period, the industrial sector exhibited the highest level of persistence for $q = -5$, while the real estate sector displayed the lowest level of persistence. Additionally, the Communication Services sector demonstrates the highest persistence, while the Real Estate sector exhibits the lowest persistence.

Table 34: Presents the MF-DFA Rankings for The Sector of The Saudi Arabian Stock Market, Comparing the GFC and COVID-19 Periods.

During GFC			During COVID-19		
Ranking	Country	MDM	Ranking	Country	MDM
01	Real estate	0.02605	01	Bank	0.10355
02	Health Care	0.1575	02	Health Care	0.12595
03	Industrial	0.1942	03	Real estate	0.134
04	Communication Services	0.2019	04	Communication Services	0.1613
05	Bank	0.2272	05	Consumer Staples	0.18265
06	Consumer Staples	0.23405	06	Industrial	0.2139

Source: Author Generate

Table 34 presents the results of MDM for Saudi Arabia's stock market sectors, real estate is the most efficient market, while the Consumer staples sector was the most efficient market during GFC, the banking sector was the most efficient, and the Industrial sector was less efficient during the COVID-19. The discrepancies in market efficiency stages stem from differences in the extent of persistence and enhancement. Investors can take these variations into account when making decisions regarding portfolio risk management and asset allocation.

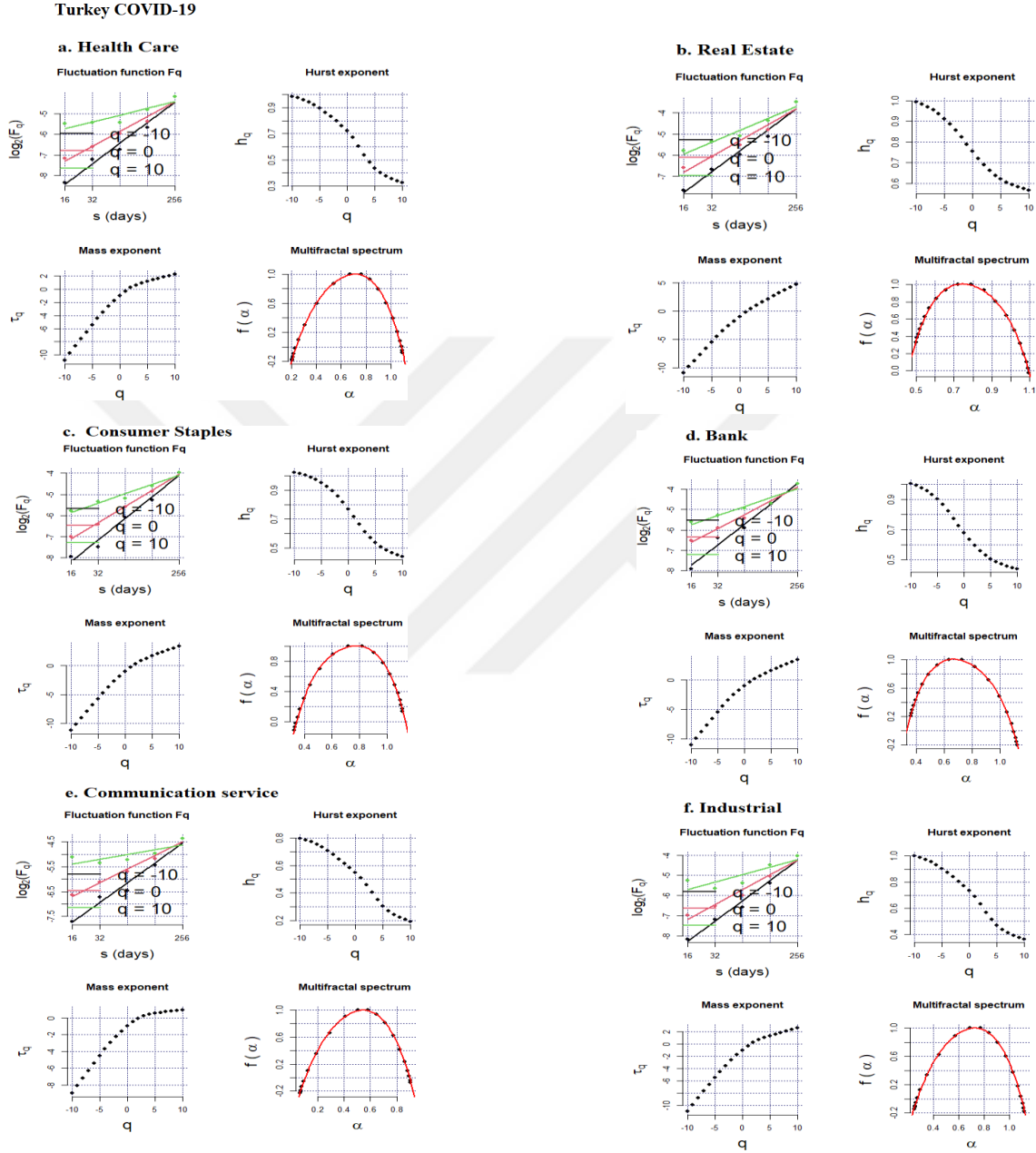


Figure 15: show cases the MF-DFA results for the return time series of prominent Turkish sector indices during the COVID-19 period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

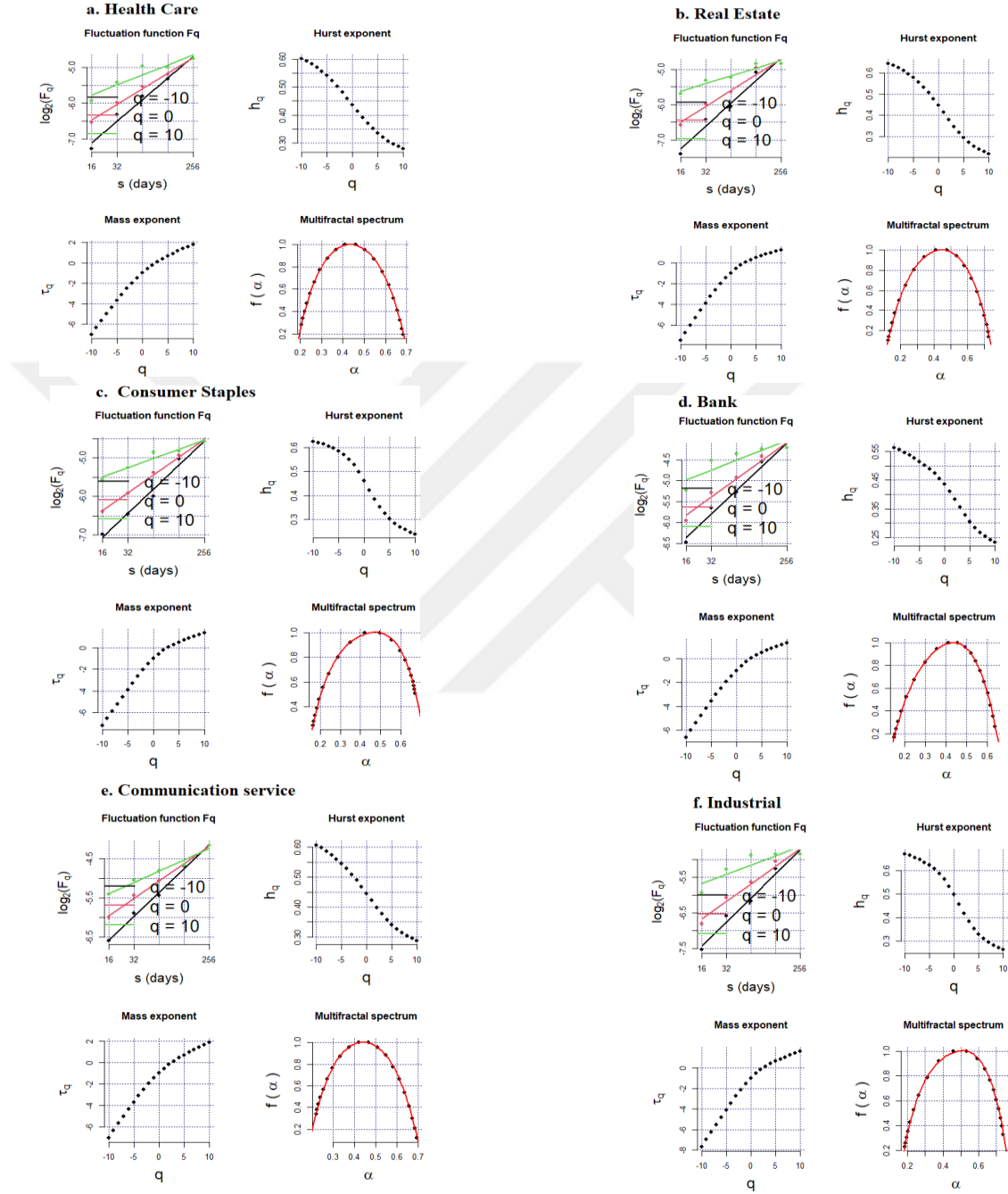


Figure 16: show cases the MF-DFA results for the return time series of prominent Turkish sector indices during the GFC period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

Figures 15 and 16 present the outcomes derived from MF-DFA analysis conducted for the Real Estate, Consumer Staples, Banking, Communication Services, and Industrial sectors of the Turkish stock market during the COVID-19 and global financial crisis (GFC) periods. During the GFC, the spectrum for all the sectors is at 0.5, which shows small fluctuation and lower risk in the market, while the spectrum during the COVID-19 for all the sectors is between 0.8 to 0.9 which shows high fluctuation and high risk in the market, in other words, it is the higher multifractal behavior, and market risk is also high expect communication services which is at 0.6.

Table 35: The Generalized Hurst Exponents, Which Pertain to Sector Indices for Turkish Stock Market Returns, During COVID-19 and GFC a Range of q Values Spanning from -5 to 5.

Turkey Covid-19 Period						
Q	Health Care	Real estate	Consumer Staples	Bank	Communicatio n Services	Industrial
-5	0.8934	0.9131	0.9528	0.9012	0.7072	0.9044
-4	0.8630	0.8864	0.9272	0.8643	0.6780	0.8733
-3	0.8302	0.8562	0.8962	0.8210	0.6467	0.8400
-2	0.7966	0.8235	0.8596	0.7736	0.6149	0.8063
-1	0.7617	0.7893	0.8172	0.7254	0.5828	0.7722
0	0.7216	0.7545	0.7690	0.6784	0.5486	0.7347
1	0.6701	0.7204	0.7161	0.6340	0.5087	0.6887
2	0.6057	0.6889	0.6621	0.5938	0.4598	0.6309
3	0.5385	0.6613	0.6121	0.5591	0.4040	0.5682
4	0.4806	0.6384	0.5695	0.5302	0.3502	0.5127
5	0.4356	0.6197	0.5348	0.5067	0.3054	0.4691
Δh	0.4578	0.2934	0.418	0.3945	0.4018	0.4353
GFC Period						
-5	0.5419	0.5764	0.5840	0.5145	0.5449	0.6230
-4	0.5237	0.5558	0.5692	0.5021	0.5279	0.6074
-3	0.5034	0.5325	0.5505	0.4886	0.5093	0.5881
-2	0.4816	0.5066	0.5265	0.4734	0.4892	0.5639
-1	0.4588	0.4781	0.4966	0.4558	0.4676	0.5336
0	0.4357	0.4470	0.4611	0.4352	0.4448	0.4973
1	0.4127	0.4137	0.4226	0.4109	0.4214	0.4571
2	0.3904	0.3798	0.3852	0.3835	0.3982	0.4174
3	0.3696	0.3475	0.3521	0.3550	0.3765	0.3819
4	0.3506	0.3185	0.3244	0.3279	0.3570	0.3523
5	0.3338	0.2936	0.3021	0.3040	0.3400	0.3285
Δh	0.2081	0.2828	0.2819	0.2105	0.2049	0.2945

Source: Author Generate

Table 35 presents the results of q (-5 to 5) during the COVID-19 period, all returns exhibit long-term persistence, as indicated by the values of $h(q)$ being greater than 0.5 for q values less than or equal to 2 except for communication services sector and q values for all the sectors are below 0.5 during the GFC outbreak which shows. To put it differently, the average return series of all sectors demonstrates persistence during the COVID-19 period while displaying anti-persistence during the global financial crisis (GFC). To provide greater clarity, the average return series of all sectors exhibits anti-persistence during the global financial crisis (GFC). This anti-persistence behavior, characterized by negative autocorrelation, implies that a positive or negative change in the previous time period is likely to be followed by an opposite (negative or positive) change in the subsequent period but persistent during the COVID-19 pandemic except for Communication Service sector. During the COVID-19 period, the consumer staples sector demonstrates the highest level of persistence for $q = -5$, while the communication services sector exhibits the lowest level of persistence, the industrial sector has the highest persistence, and the banking sector shows the lowest persistence.

Table 36: Displays the MF-DFA Rankings for The Sector of The Turkish Stock Market, Comparing the GFC and COVID-19 Periods.

During GFC			During COVID-19		
Ranking	Country	MDM	Ranking	Country	MDM
01	Communication Services	0.10245	01	Real estate	0.1467
02	Health Care	0.10405	02	Bank	0.19725
03	Bank	0.10525	03	Communication Services	0.2009
04	Consumer Staples	0.14095	04	Consumer Staples	0.209
05	Real estate	0.1414	05	Industrial	0.21765
06	Industrial	0.14725	06	Health Care	0.2289

Source: Author Generate

Table 36 presents the results of MDM for Turkey's stock market sectors; Communication Services are the most efficient market, the Industrial sector is the less efficient market during GFC, the Real Estate sector is the most efficient, and Health Care is less efficient during COVID-19. These differences in market efficiency stages arise from deviations in the degree of persistence and improvement, which investors are able to take into account when making decisions about portfolio risk management and asset allocation.

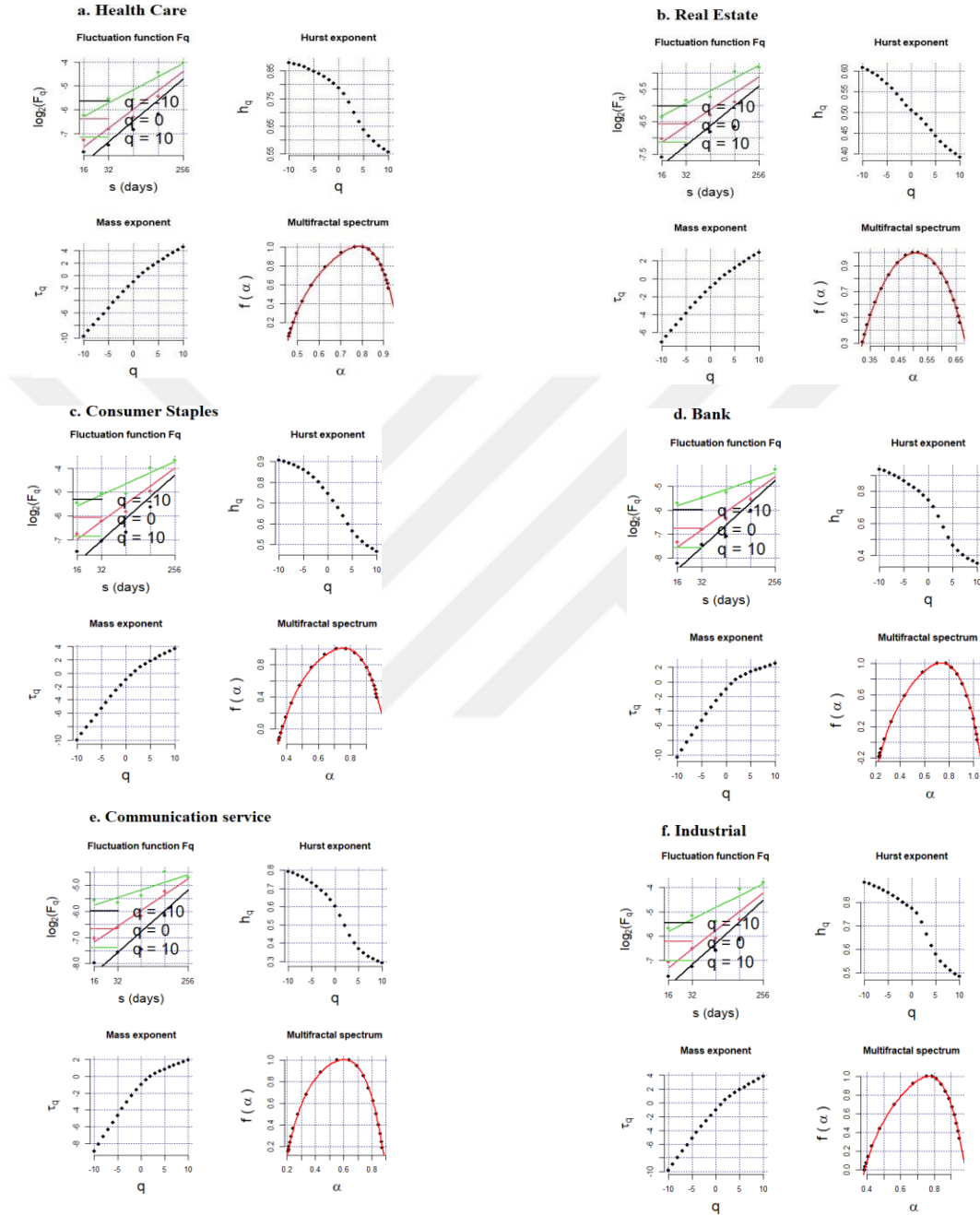


Figure 17: show cases the MF-DFA results for the return time series of prominent UAE Sector indices during the COVID-19 period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized

Hurst exponent corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

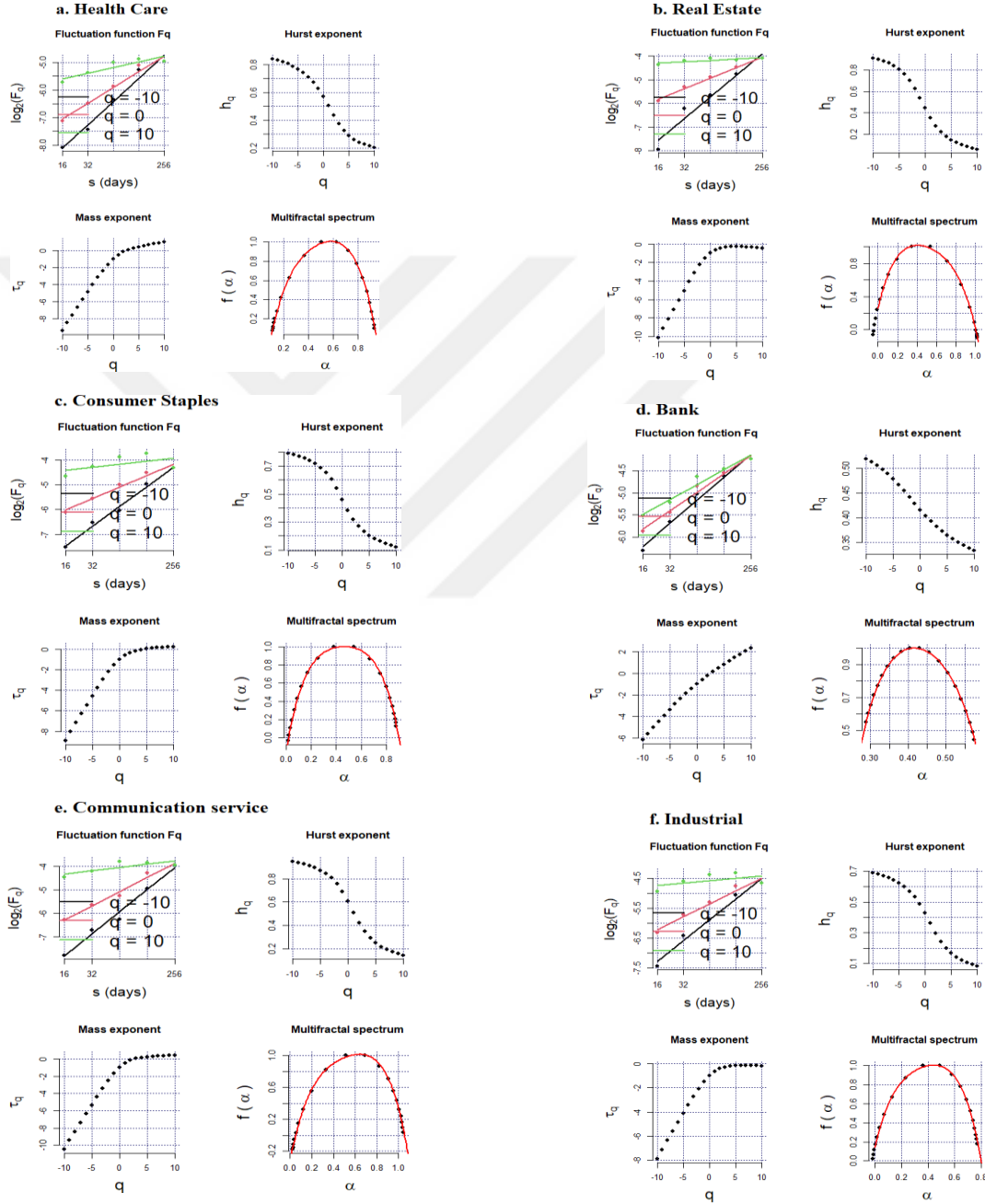


Figure 18: show cases the MF-DFA results for the return time series of prominent UAE sector indices during the GFC period. It includes various elements such as (i) fluctuation functions for different values of q ranging from -10 to 10, (ii) the generalized Hurst exponent

corresponding to different q values, (iii) the mass exponent τ , and (iv) the multifractal spectrum.

Figures 17 and 18 present the results from the MFDFA, calculated for the Health Care, Real Estate, Consumer Staples, Banking, Communication Services, and Industrial sectors of the UAE stock market during COVID-19 and GFC. During the GFC, the spectrum for all the sectors is between 0.5 to 0.6, which shows small fluctuation and lower risk in the market, while the spectrum during the COVID-19 for all the sectors is between 0.7 to 0.8, which shows high fluctuation and high risk in the market, in other words, the presence of increased multifractal behavior coincides with elevated market risk, except for communication services, which is at 0.6, except for the real estate sector, which is at 0.60.

Table 37: The Generalized Hurst Exponents, Which Pertain to Sector Indices for UAE Stock Market Returns, During COVID-19 and GFC a Range of q Values Spanning from -5 to 5.

Q	Health Care	Real estate	Consumer Staples	Bank	Communication Services	Industrial
COVID-19 period						
-5	0.8488	0.5698	0.8602	0.8648	0.7307	0.8388
-4	0.8396	0.5582	0.8442	0.8442	0.7117	0.8268
-3	0.8291	0.5450	0.8246	0.8224	0.6902	0.8136
-2	0.8174	0.5307	0.8010	0.7996	0.6662	0.7995
-1	0.8046	0.5170	0.7740	0.7749	0.6383	0.7857
0	0.7892	0.5056	0.7449	0.7447	0.6021	0.7728
1	0.7672	0.4960	0.7135	0.7024	0.5528	0.7527
2	0.7360	0.4849	0.6775	0.6434	0.4956	0.7137
3	0.7005	0.4715	0.6380	0.5751	0.4427	0.6635
4	0.6669	0.4571	0.5995	0.5132	0.4009	0.6168
5	0.6382	0.4432	0.5656	0.4650	0.3694	0.5794
Δh	0.2106	0.1266	0.2946	0.3998	0.3613	0.2594
GFC						
-5	0.7672	0.8097	0.7175	0.4786	0.8719	0.6230
-4	0.7414	0.7641	0.6895	0.4671	0.8435	0.5991
-3	0.7101	0.7032	0.6530	0.4547	0.8067	0.5695
-2	0.6723	0.6275	0.6044	0.4418	0.7575	0.5327
-1	0.6267	0.5404	0.5395	0.4286	0.6911	0.4868
0	0.5710	0.4446	0.4601	0.4158	0.6062	0.4297
1	0.5050	0.3509	0.3808	0.4036	0.5112	0.3635
2	0.4352	0.2744	0.3166	0.3923	0.4214	0.2979
3	0.3729	0.2178	0.2687	0.3821	0.3477	0.2424
4	0.3244	0.1761	0.2324	0.3728	0.2911	0.1995
5	0.2884	0.1441	0.2038	0.3644	0.2485	0.1669
Δh	0.4334	0.5161	0.4154	0.1746	0.5319	0.2945

Source: Author Generate

Table 37 presents the results of q (-5 to 5). For values of q less than or equal to 2, the values of $h(q)$ exceed 0.5, indicating that all returns exhibit long-term persistence for COVID-19 except for real estate and communication services sectors, and q values for all the sectors are below 0.5 during the GFC outbreak which shows. To put it differently, the average return series of all sectors demonstrates persistence during the COVID-19 period while exhibiting anti-persistence during the global financial crisis (GFC). To provide further clarification, the average return series of all sectors displays anti-persistence during the global financial crisis (GFC), characterized by negative autocorrelation. This means that a positive or negative change in the previous time period is likely to be followed by an opposite (negative or positive) change in the subsequent period. However, during the COVID-19 period, the average return series exhibited persistence except for the real estate and communication service sectors. For $q = -5$, the banking sector shows the utmost persistence, while the real estate sector has the lowest persistence for the period of COVID-19. In contrast, the communication services sector has the highest persistence, and the banking sector shows the lowest persistence.

Table 38: Presents the MF-DFA Rankings for the Sector of the UAE Stock Market, Comparing the GFC and COVID-19 Periods.

GFC Period			COVID-19 Period		
Ranking	Country	MDM	Ranking	Country	MDM
01	Bank	0.0873	01	Real estate	0.0633
02	Industrial	0.14725	02	Health Care	0.1053
03	Consumer Staples	0.2077	03	Industrial	0.1297
04	Health Care	0.2167	04	Consumer Staples	0.1473
05	Real estate	0.25805	05	Communication Services	0.18065
06	Communication Services	0.26595	06	Bank	0.1999

Source: Author Generate

Table 38 presents the results of MDM for UAE's stock market sectors; banking is the most efficient market, the communication services sector was the less efficient market during GFC, the real estate sector was the most efficient, and banking was less efficient during COVID-19. The discrepancies in market efficiency stages arise from changes in the degree of persistent improvement. Investors can take these variations into account when making decisions regarding portfolio risk management and asset allocation.

Table 39: Lowest and Highest Efficiency during GFC and COVID-19 Sectors Indices

Country	GFC		COVID	
	Lowest Efficiency	High Efficiency	Lowest Efficiency	High Efficiency
Egypt	Health Care	Real Estate	Industrial	Communication
Jordan	Communication	Real Estate	Real Estate	Health Care
Morocco	Bank	Real Estate	Bank	Real Estate
Saudi Arabia	Consumer Staples	Real Estate	Industrial	Bank
Turkey	Industrial	Communication	Health Care	Real Estate
UAE	Bank	Real Estate	Bank	Real Estate

Source: Author Generate

Table 39 shows results regarding the lowest and highest efficiency in the sector indices. It is notable that the real estate sector for most countries is the highly efficient index which shows that the market is efficient and there is no abnormal profit for the investment in the real estate sector. In addition, the sectors with the lowest efficiency have opportunities to make abnormal profits, and with time, the market will be efficient. Regarding policy stance, the effectiveness of a market is crucial for fostering economic development as it supports the generation of capital, allocation of resources, and distribution of wealth. Fluctuations in market efficiency can also impact how investors perceive future economic conditions. Recent financial and economic crises, such as the global financial crisis (GFC) and the COVID-19 pandemic, have demonstrated the detrimental effects of an inefficient stock market on economic growth. Consequently, our findings could offer valuable insights to policymakers and regulators seeking to reduce economic disruptions through revising existing measures. As for portfolio management, investors might want to consider a diversification strategy that considers the varying efficiency levels of different sectoral markets within an efficient market with changing structures.

The most efficient sector was communication during the GFC, and the least efficient was health care during COVID-19 for Turkey. During the global financial crisis, Turkey's communications sector likely thrived due to tech advancements, rising demand for connectivity, and firms' resilience to market shifts. Government support and consumer prioritization of communication services may also have boosted the sector's efficiency amidst economic challenges. The main reasons behind the healthcare sector's lower efficiency during COVID-19 include overwhelmed systems, resource strain, supply chain disruptions, pandemic response challenges, staffing issues, and increased demand and pressures.

The research investigates the impact of the financial crisis on the level of market information efficiency for Islamic Cooperation countries' stock indices. The core question of this debate is whether stock market movements are predictable. The thesis will do a detailed examination of the behavior of Islamic Cooperation Countries' stock market aggregate and sectoral indices during the COVID-19 and GFC. In addition, the thesis will compare the market indices of the Islamic Cooperation Countries during the financial crisis, i.e., GFC and COVID-19, for the OIC aggregate stock market and sectorial indices.

Another objective of this study is to assess the efficiency of stock market indices in Islamic Cooperation countries during the financial crisis. This analysis is particularly relevant in the ongoing debate between Thaler and Fama regarding the Efficient Market Hypothesis (EMH) and behavioral finance. Thaler emphasizes the distinction between predictable behaviors within a rational model.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The core objective of this research is to investigate the impact of the financial crisis on the level of market information efficiency for Islamic Cooperation countries' stock indices and sectoral indices during the COVID-19 and GFC.

Market efficiency serves as a critical determinant of an investor's ability to generate returns. Intriguingly, specific investments maintained their significance even in times of economic crisis. Depending on the underlying rationale, the study endeavors to investigate the dynamic nature of market efficiency within sectoral markets. This is achieved through the application of the MF-DFA (Multifractal Detrended Fluctuation Analysis), which allows us to discern the characteristics of market periods, including structural shifts observed during both the global financial crisis (GFC) and the COVID-19 pandemic. Consequently, this research aspires to enhance the existing body of knowledge regarding the Adoptive Market Hypothesis (AMH) by employing the MF-DFA technique on the combined and sector-specific markets of major indices within OIC (Organization of Islamic Cooperation) countries. This analysis extends to sector indices, examining these financial dynamics in the context of the GFC and the COVID-19 outbreak.

The results have many intriguing implications for policymakers and investors. First, the findings show that all indices of OIC countries exhibit persistent behavior and multifractal characteristics during COVID-19, implying that arbitrage opportunities increased during COVID-19. The changing Hurst exponents at various time scales validate the AMH, in which arbitrage opportunities vary over time. This result supports the empirical findings of Choi (2021), Mensi et al. (2021), and Erer et. al. (2023). Except for Kuwait, Lebanon, Oman, Qatar, and Turkey, Stock indices, as a result, show $h(q) < 0.5$, which exhibits anti-persistent behavior; the anti-persistent findings are supported by the following studies Aslam et al. (2020) and Sipra et al. (2021).

The changing Hurst exponents at different time scales can indeed support the Adaptive Market Hypothesis (AMH). The AMH posits that market dynamics change over time and across different scales due to varying factors, such as investor behavior, technological advancements, or economic conditions. The fluctuating Hurst exponents suggest multifractality, indicating that the market's behavior is not only persistent or anti-persistent but also exhibits different levels of persistence across various time scales. The AMH implies that market participants adapt their strategies based on changing market conditions. Fluctuating Hurst exponents could signify adaptive behavior, indicating that the market's behavior is not static but continuously adapting to new information or changing circumstances. The varying Hurst exponents at different time scales suggest time-varying efficiency. This aligns with AMH, which asserts that market efficiency fluctuates over time. It implies that the degree of predictability or randomness in the market changes across different time frames.

The AMH proposes that market environments are not constant but evolve dynamically. Changing Hurst exponents indicate that the market is not uniformly efficient or inefficient but adapts to different conditions, supporting the idea of a dynamic and adaptive market environment. The fluctuating Hurst exponents observed at various time scales can be indicative of adaptive, multifractal market behavior, aligning with the principles of the Adaptive Market Hypothesis.

Furthermore, all indices of OIC countries exhibit anti-persistent behavior and multifractal characteristics during the GFC period the finding supported by the following research Hasan & Mohammad (2015), Lee et al. (2018); Aslam et al. (2020), Sipra et al. (2021); furthermore, the following studies Morales & Callaghan (2012), Thao & Daly (2012) show that the Asian stock market does not affect by the global financial crisis. In addition, Malaysia, Pakistan, and Saudi Arabia have shown persistence during the GFC. The findings support the studies of (Choi 2021; Mensi et al. 2021; Erer et al. 2023).

The presence of anti-persistence implies that subsequent price movements display a negative correlation with preceding ones, suggesting that markets don't strictly follow a

random walk pattern. This aligns with AMH, which emphasizes that markets might not always incorporate information instantly and efficiently but can exhibit patterns and behaviors that adapt to changing circumstances and information.

The health care, real estate, consumer staples, bank, communication services, and industrial sectors included Egypt, Jordan, Morocco, Saudi Arabia, Turkey, and UAE; the results show that sectoral indices for all the countries exhibit anti-persistent behavioral and multifractal characteristics during the GFC period, except for the Jordan, the finding support by the following research Lye & Hooy (2012), Hasan & Mohammad (2015), Ali et al. (2021), Sadhukhan & Sadhukhan (2022) while the market has been found persistent during the COVID-19 period the study support Choi (2021), Erer et al. (2023), furthermore, the study of held by the Choi (2021) in the USA stock market sectors are also supported our results his study shows that the market was anti-persistent during GFC and the persistent during COVID-19.

Another result is about market efficiency. It has been found that Turkey and Palestine were the most efficient sectors, while Lebanon and the Jordan stock markets showed the lowest efficiency during the GFC; furthermore, Kuwait and Qatar were the most efficient stock markets during COVID-19, while Lebanon and Turkey were the lowest efficient market, it is to mentioned here lowest efficiency means investors have the potential to create exceptional returns by using trading strategies in these markets due to arbitrage opportunities. Enhancing information flow to boost transparency, adopting more dynamic investment strategies responsive to changing efficiency levels, and strengthening regulatory institutions can further improve market efficiency. Nevertheless, these factors also serve as indicators of economic performance.

The third set of results reveals that all the major stock indices exhibit multifractal behavior and long memory. Amid the global financial crisis (GFC) and the COVID-19 pandemic, the stock markets of Palestine and Kuwait demonstrated the highest degree of persistence. At the same time, Jordan and Lebanon exhibited the lowest levels of persistence, respectively.

Move to the sector indices, the real estate sector shows the highest persistence for Egypt, Jordan, Morocco, and Saudi Arab during GFC, and during COVID-19 for Morocco, Turkey, and UAE, as many types of research show that the real estate was the most affected sector during the GFC for most of the countries, i.e., USA, Choi (2021) and Turkey Erer et al. (2023) there are several reasons that the real estate sector is more efficient for these countries, the investor may consider the real estate investment more stable than investments in the other sectors, the rapid growing population in the OIC countries are caused to increase the demand for real estate therefore, the real estate sector may remain the stable despite of the crisis, Government policy may support the real estate sector, real estate is the long term investment may investor adopted more patient approach during crisis.

The banking sector was found to be the less efficient during GFC and COVID-19 in Morocco and UAE, as the banking sector is the key sector for any country, and due to a financial crisis may cause a liquidity crunch, landing crunch unable to pay the loan by the individuals and businesses 57% of Morocco economy rely on tourism and UAE economy rely on Oil and Gas due to COVID there was no tourism business as well as the oil and gas price was also almost declined business were unable to pay their loan which hit the banking sector.

Healthcare and industrial sectors were the least efficient sectors for Egypt during GFC and COVID-19, respectively. At the same time, communication was a highly efficient sector; during the crisis, the government may reduce spending on health care. Furthermore, foreign investment has been withdrawn from the sector due to the financial crisis, and the industrial sector was the least efficient sector during COVID-19; as everything was closed, industrial work may suffer, which is why the sector was the least efficient during COVID-19. The communication sector was highly efficient during COVID-19 due to the increase in demand due to the lockdown; people use different communication channels and the entertainment industry.

During the GFC, the communication sector was the lowest efficient, while health care was the highly efficient sector during the COVID-19 for Jordan; the service sector

contributed 60% of the GDP in Jordan, including foreign investment, according to the US Department of State mentioned that 20% of investment are non-Jordan in the service sector due to financial crisis many investors withdraw their investment from the sector, the health care sector was the most attractive sector during the COVID-19, the health care sector got high demand, investment in innovation, Government support to the health care, and remote healthcare services.

The results show that for Saudi Arabia, the most efficient sector was banking, while the least efficient sector was industrial during COVID-19. The main reason for the lowest efficiency was the lockdown due to restrictions, the supply chain was disturbed, and demand was reduced. Social distancing measures and health concerns might have affected workforce productivity and efficiency within industrial facilities. Labor shortages or reduced operational capacities due to safety protocols. The banking sector in Saudi Arabia was the most efficient sector for several reasons. The banking sector is the daily need of humans in this era and the only sector that functions with protocols. Furthermore, the banking sector adopted an online banking system for smooth running and social distancing. Additionally, Government initiatives and regulatory support, such as stimulus packages, loan moratoriums, and financial aid to businesses, helped maintain stability and liquidity within the banking sector as well as Saudi Arabia's financial system is strong; therefore, the financial sector might have played a role in maintaining confidence among investors and customers even during uncertain times.

It can be asserted that past prices from the global financial crisis (GFC) era have an impact on the current price formation in the sectors with the highest persistence, primarily because of their prolonged memory characteristics. In the context of policy, regulatory measures can be implemented by policymakers to enhance market prediction and draw diverse investors to these sectors. Conversely, in the sectors that have the lowest persistence, price fluctuations are not influenced by historical price trends due to their exceptional efficiency, especially during the COVID-19 pandemic.

Enhancing market efficiency might involve bolstering the legal framework, promoting economic liberty, and strengthening financial intermediaries, as proposed by Dewandaru et al. (2014). These measures could potentially address multifractality within stock markets.

Recommendations/ Suggestions

The study proposes recommendations for policymakers, governmental bodies, and investors aimed at enhancing economic development. Emphasizing convenient portfolio allocation, risk diversification, and the adoption of hedging strategies is suggested to contribute to this development. Essentially, prioritizing sustainable economic development across various sectors, coupled with promoting advancements in the stock market, is recommended to foster a dynamic and sustainable market.

Moreover, strategic utilization of market mechanisms is advised to mitigate the impact of external events on market efficiency. Optimizing the investor structure within the stock market and enhancing the investment value of companies are identified as potentially advantageous compared to relying solely on financial intermediation. Implementation of these measures is anticipated to bolster market confidence, stabilize market sentiment, and facilitate sustained improvements in the stock market over the long term.

Future Study Recommendations

This study recommends scholars embark on a comparative study encompassing a broad spectrum of economies, including but not limited to G20, G7, and the European Union, and comparative analyses between China and the USA, BRICS nations, developed and developing economies, as well as European-Asian and Islamic countries. Such an inclusive approach would offer a novel perspective on the varied responses of diverse economies to events like the global financial crisis (GFC), the COVID-19 pandemic, the Russia-Ukraine, and Israel-Palestine conflict, particularly in relation to the Efficient Market Hypothesis (EMH), and multifractal detrended fluctuation analysis (MF-DFA).

While the current study centers on the stock markets and sectors of OIC countries, it's essential to acknowledge the unique responses of each market during crises such as the GFC and COVID-19. Therefore, we suggest focusing on a specific stock market for a more comprehensive analysis, potentially delving into sectors like health, hospitality, tourism, and telecommunications for a deeper exploration.



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