

REPUBLIC OF TURKEY
ÇUKUROVA UNIVERSITY
INSTITUTE OF SOCIAL SCIENCES
DEPARTMENT OF BUSINESS ADMINISTRATION

**TESTING THE WEAK AND SEMI-STRONG FORM OF STOCK MARKET
EFFICIENCY: EVIDENCE FROM DEVELOPED AND DEVELOPING
COUNTRIES' STOCK MARKETS INDEXES**

SUADIQ MEHAMMED HAILU

PhD. THESIS

ADANA / 2022

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PhD. THESIS

ADANA / 2022

To the Directorate of Çukurova University Institute of Social Sciences;
This study has been accepted as a DOCTORAL THESIS in the Department of
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Suadiq Mehammed HAILU

ABSTRACT**TESTING THE WEAK AND SEMI-STRONG FORM OF STOCK MARKET
EFFICIENCY: EVIDENCE FROM DEVELOPED AND DEVELOPING
COUNTRIES` STOCK MARKETS INDEXES****Suadiq Mehammed HAILU****Ph.D. Thesis, Department of Business Administration****Supervisor: Prof. Dr. Hatice DOĞUKANLI****July 2022, 154 pages**

This study aims to investigate the weak and semi-strong forms of stock market efficiency for developed (Australia, German, Japan, U.K., and the USA), developing upper-middle-income (Brazil, China, Malaysia, South Africa, and Turkey), and developing-lower-middle-income (Egypt, India, Kenya, Sri Lanka, and Tunisia) countries.

The weak form of stock market efficiency was examined using weekly observations of sample stock index returns for the period spanning from January 8, 2000, to December 28, 2019, and for the three sub-periods (1/ 8/2000 -8/ 26/2006, 9/1/ 2006 – 4/27/2013, and 5/ 5/2013 – 12/ 28/2019). Autocorrelation test, Run test, unit root tests (the Augmented Dickey-Fuller (ADF) tests, the Phillips-Perron (PP) test, and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test), and Lo and MacKinlay variance ratio tests are applied to examine the weak form of stock market efficiency.

The semi-strong form of efficiency was investigated using the monthly observations of the stock market indexes and selected macroeconomic factors (inflation, money supply, exchange rates, interest rates, industrial production index, and crude oil price) for the period from January 2000 to December 2019. Cointegration analysis and Granger causality tests are employed to examine the semi-strong form of efficiency.

The autocorrelation and run test results indicate that in the third sub-period, all stock indexes become weak-form efficient except stock indexes in developing-lower-middle-income countries. On the contrary, the unit root and variance ratio test results show that all stock indexes were weak-form inefficient in the entire and all sub-study

periods. The cointegration test results reveal that only developed and developing-upper-middle income countries' indexes seem efficient in the semi-strong form of efficiency. Further, the Granger causality test result indicates that all developed and developing countries' stock markets are efficient in the semi-strong form of efficiency. The inconsistency of results among applied methodologies suggests that future research should focus on the methods used to test stock market efficiency.

Keywords: Weak-form of efficiency, semi-strong form of efficiency, stock market indexes



ÖZET

ZAYIF VE YARI GÜÇLÜ FORMDA PIYASA ETKİNLİĞİNİN GELİŞMİŞ VE GELİŞMEKTE OLAN ÜLKELERİN BORSA ENDEKSLERİ ÜZERİNDE ARAŞTIRILMASI

Suadiq Mehammed HAILU

Doktora Tezi, İşletme Ana Bilim Dalı

Danışman: Prof. Dr. Hatice DOĞUKANLI

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Bu çalışma, gelişmiş (Avustralya, Almanya, Japonya, Birleşik Krallık ve ABD), gelişmekte olan üst-orta gelirli (Brezilya, Çin, Malezya, Güney Afrika ve Türkiye), ve gelişmekte olan alt-orta gelirli (Mısır, Hindistan, Kenya, Sri Lanka ve Tunus) ülkelerin hisse senedi piyasası etkinliğinin zayıf ve yarı güçlü formlarını araştırmayı amaçlamaktadır.

Hisse senedi piyasası etkinliğinin zayıf formu, 8 Ocak 2000'den 28 Aralık 2019'a kadar olan dönem ve üç alt dönem için (1/8/2000 -8/ 26/2006, 9/1/2006 – 27/04/2013 ve 5/5/2013 – 12/31/2019) örnek hisse senedi endeksi getirilerinin haftalık gözlemi kullanılarak incelenmiştir. Otokorelasyon testi, Koşu testi, birim kök testleri (Artırılmış Dickey-Fuller (ADF) testleri, Phillips-Perron (PP) testi ve Kwiatkowski, Phillips, Schmidt ve Shin (KPSS) testi) ve Lo ve MacKinlay varyans oranı testi hisse senedi piyasası etkinliğinin zayıf formunu incelemek için uygulanmıştır.

Yarı güçlü etkinlik formu, Ocak 2000'den Aralık 2019'a kadar olan dönem için hisse senedi piyasası endekslerinin ve seçilen makroekonomik faktörlerin (enflasyon, para arzı, döviz kurları, faiz oranları, sanayi üretim endeksi ve ham petrol fiyatı) aylık gözlemleri kullanılarak araştırılmıştır. Yarı güçlü etkinlik formunu incelemek için eşbütünleşme analizi ve Granger nedensellik testleri kullanılmıştır.

Otokorelasyon ve Koşu testi sonuçları, üçüncü alt dönemde gelişmekte olan-alt-orta gelirli ülkelerde hisse senedi endeksleri dışındaki tüm hisse senedi endekslerinin zayıf formda etkin hale geldiğini göstermektedir. Aksine, birim kök ve varyans oranı test sonuçları, tüm hisse senedi endekslerinin tüm ve alt çalışma dönemlerinde zayıf formda

etkin olmadığını göstermektedir. Eşbütünleşme testi sonuçları, yarı güçlü etkinlik biçiminde yalnızca gelişmiş ve gelişmekte olan üst-orta gelirli ülke endekslerinin etkin görüldüğünü ortaya koymaktadır. Ayrıca Granger nedensellik testi sonucu, gelişmiş ve gelişmekte olan tüm ülke hisse senedi piyasalarının yarı güçlü etkinlik biçiminde etkin olduğunu göstermektedir. Uygulanan metodolojiler arasındaki sonuçların tutarsızlığı, gelecekteki araştırmaların borsa etkinliğini test etmek için kullanılan yöntemlere odaklanması gerektiğini göstermektedir.

Anahtar kelimeler: Zayıf-formda etkinlik, yarı-güçlü formda etkinlik, borsa endeksleri



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ABBREVIATIONS

AC	: Autocorrelation Coefficient
ADF	: Augmented Dickey-Fuller
ARDL	: Autoregressive distributed Lag
CFO	: Chief financial officer
CPI	: Consumer Price Index
CSE	: Colombo Stock Exchange
DUMI	: Developing-Upper-Middle-Income
DLMI	: Developing-Lower-Middle-Income
DJIA	: Dow Jones Industrial Average
ER	: Exchange Rates
ECM	: Error Correction Model
EMH	: Efficient Market Hypothesis
GARCH	: Generalized Autoregressive Conditional Heteroscedasticity
GDP	: Gross Domestic Product
IPI	: Industrial Production Index
IR	: Interest Rates
JSE	: Johannesburg Stock Exchange
KPSS	: Kwiatkowski, Phillips, Schmidt, and Shin
OLS	: Ordinary Least Squares
OP	: Oil Price
PP	: Phillips-Perron
UK	: United Kingdom
USA	: United States of America
VAR	: Vector Auto Regressive
VECM	: Vector Error Correction Model
WESP	: World Economic Situation and Prospects

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CHAPTER I

INTRODUCTION

1.1. Background of The Study

A well-performing stock market may help a country's economic development through increasing savings, efficient and effective allocation of financing funds, and well employment of existing funds (Leigh, 1997). By quickly buying and selling shares in the stock market, companies can access capital easily, and investors can keep the liquidity of their savings. In doing so, stock markets can spur capital allocation and economic growth (Levine, 1966). According to Pagano (1993), capital markets improve economic development by channeling savings to investment, bettering capital allocation, and promoting saving. Bekaert and Harvey (1998) stated that capital markets foster economic growth by appealing to overseas and local investors to invest further. Stock markets also have an essential function for the economy by expanding capital ownership structure to broaden society and play as an economic indicator. Also, Bekaert and Harvey (1998) state that stock markets play an essential role in economic growth by expanding investors' portfolios and encouraging entrepreneurship. Investors can diversify their risk by investing in several stocks and further inspiring investing in firms. An entrepreneur with a business idea can solve the capital problem by selling the venture's share to the public. The role of stock markets in enhancing economic development can achieve when the stock markets are efficient. Bekaert and Harvey (1998) stated that inefficient stock markets may discourage investment by creating liquidity problem; frighten foreign investors, and create expensive transaction costs. Consequently, an inefficient stock market leads down economic growth.

Farrell (1957) initially commenced the concept of efficiency. He defines efficiency in the context of technical efficiency as the capability of a company or stock exchange to achieve maximum yield from a given combination of inputs. Schmiedel (2004) illustrated Farrell's efficiency concept for the stock market as "a stock exchange may achieve higher profits at lower costs than other stock exchanges if it can better combine its inputs and transform them into outputs at lower cost" (p.22). The literature in

the field indicates that market efficiency presents three forms of efficiency, i.e., allocational efficiency, operational efficiency, and informational efficiency (Balaban, 1995). These three components of market efficiencies are connected through their rank of efficiency. A market to be allocational efficient; initially, it should be informational and operationally efficient. Therefore, a market cannot be allocational efficient without informational and operational efficiency (Kennedy, 2004). On the contrary, a market can be informationally efficient without operational and allocational efficiency.

According to Financial Glossary, allocational efficiency is "the effectiveness with which a market channels capital toward its most productive uses." The allocational efficiency concerns how capital markets allocate scarce resources between market participants (Pilbeam, 2005). In an allocational efficient market, the marginal rate of return is identical to all market participants, i.e., borrowers and savers. Thus, this means savers volunteer to finance projects with maximum net present value and all good projects with positive net present value (Bauer, 2004). On the other hand, a market will be operationally efficient when market participants conduct their transactions at a reasonable minimum cost (Hendry & King, 2004). The third type of market efficiency is informational efficiency. This paper focused only on the informational efficient market, and the phrase "efficient market" throughout the paper refers to informational efficiency.

The turning point for Efficient Market Hypothesis (EMH) regarding the stock market is back in the 1960s when Fama (1965) and Samuelson (1965) indicated the efficiency of the stock market. Fama (1965) stated that in an efficient market, the current price of single security reflects all available information about an event. Thus, this means the current security price represents the security's intrinsic value. Samuelson (1965) indicated that in a competitive market, prices "perform a random walk with no predictable bias" (p.25).

According to Fama (1970), an efficient market is "a market in which prices always fully reflect available information" (p.383). And he classified the efficient market into weak-form, semi-strong form, and a strong form of efficiency. The weak form of stock market efficiency proposes that a stock's market prices do not relate to its historical price. Instead, the stock's current price is spontaneously adjusted for the historical price information. Therefore, if a stock market is efficient at a weak form of efficiency, investors cannot realize abnormal returns through technical analysis of historical price information. The semi-strong form of market efficiency implies that stock prices are

quickly adjusted for historical price information and publicly available information. Accordingly, investors cannot gain an above-average return using technical and fundamental analysis (Potocki & Swist, 2015). Finally, the strong form of market efficiency stipulates that the stock prices are already adjusted, including publicly unavailable information or insider information. Therefore, investors cannot "beat the market" even using insider information.

The EMH has a solid theoretical foundation in economics and finance research and is supported by several researchers. Jensen (1978) stated that:

"I believe there is no other proposition in economics which has more solid empirical evidence supporting it than the Efficient Market Hypothesis." He also defines efficient as "A market is efficient with respect to information set θ_t , if it is impossible to make economic profits by trading based on the information set θ_t " (p.96).

Samuelson (1965) has proposed two types of stock market efficiency: micro efficient and macro inefficient. Jung and Shiller (2005) named Samuelson's statement as stock markets are "micro efficient" but "macro inefficient." Micro efficiency is a dictum used to express the efficiency of individual stocks, whereas macro efficiency denotes the efficiency of the aggregate stock market. Accordingly, stock market efficiency can be investigated at the single-stock level, at the indexed stock level, at the industry level, at the state level, or, in some circumstances, at the international level (Baker, Bradley, & Taliaferro, 2014).

Since the 1970s, several studies have been conducted to test the stock market's efficiency using different methods, data, and securities covering multiple periods. Examining the level of stock market efficiency has significant benefits for regulatory bodies and investors (Cooray & Wickremasinghe, 2007). If the market is efficient, the security prices reflect the intrinsic value, and the security valuation process can justify the market price. Ma (2018) indicated that "it has been frequently documented in the finance literature that an inefficient market cannot benefit the economy as much as an efficient market." Due to these reasons, testing the three forms of market efficiency has been a central place for finance researchers.

To test the efficiency of the stock market, researchers did numerous empirical analyses using diverse methods. The communal techniques applied to test the weak form of stock market efficiency are auto-correlation tests; runs tests; unit root tests (Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski, Phillips, Schmidt, and

Shin (KPSS) tests); and variance-ratio tests (Conrad & Jüttner, 1973; Ntim, Opong, Danbolt, & Dewotor, 2011; Worthington & Higgs, 2003). On the other hand, the Granger causality test, regression, Ordinary Least Squares (OLS), and cointegration tests are the frequently employed techniques to test the semi-strong form of stock market efficiency (Hancock, 1989; Hanousek & Filer, 2000; Kraft & Kraft, 1977; Torun & Kurt, 2008). Finally, the strong form of stock market efficiency can be tested by analyzing the abnormal returns of insiders (corporate officers, directors, and significant stockholders), large portfolio managers, mutual fund managers, and brokerage-firm analysts from their buying and selling of stock based on their publicly unavailable information (Brown, Richardson, & Trzcinka, 1990; Gupta, Anand, & Singh, 2008; Jaffe, 1974; Kara & Denning, 1998; Khan & Ikram, 2011).

Using stock's daily, weekly, and monthly historical prices, the randomness of the stock price fluctuation can be tested through different statistical methods. The Semi-strong form of stock market efficiency can be tested using macroeconomic data like inflation, money supply, and exchange rates or company-specific microeconomic data such as stock splits, dividend announcements, annual reports, bonus issues, and new security issues (Groenewold & Kang, 1993). The information used to test the strong form of market efficiency is insider information or publicly unavailable information. These three relevant information types, i.e., historical price, publicly available information, and insider information, were identified by Fama (1970), which are used to test stock market efficiency levels.

Numerous researches were conducted to test the efficiency of the stock market in its three forms using different variables and methods. Among them, Dickinson and Muragu (1994), Hudson, Dempsey, and Keasey (1996), Abrosimova, Dissanaik, and Linowski (2002), Buguk and Brorsen (2003), Asiri (2008), Khan and Ikram (2011), and Chiwira and Muyambiri (2012) are assessed a single country's stock market at the weak form of efficiency.

Fama (1965), Fama (1970), Muradoglu and Metin (1996), Hussin, Ahmed, and Ying (2010), Olweny (2012), Sheefeni (2015), Hasan and Wadud (2015), and Ayodele and Maxwell (2017) investigate the efficiency of a single country's stock market at the semi-strong form of efficiency. Likewise, Groenewold and Kang (1993), Cooray and Wickremasinghe (2007), and Torun and Kurt (2008) analyze the weak and semi-strong forms of stock market efficiency together.

Furthermore, scholars such as Urrutia (1995), Palac-McMiken (1997), Worthington and Higgs (2003), Elango and Hussein (2008), Stasiulis (2009), Borges (2010), Ntim et al. (2011), Salameh (2011) and Hamid, Suleman, Shah, and Akash (2017) analyze a group of countries' stock market efficiency level based on either similar economic level countries, member countries of economic associations or similar geographic locations. Besides, Jaffe (1974), Finnerty (1976), Gupta et al. (2008), Khan and Ikram (2011) and Potocki and Swist (2015) examines the stock markets efficiency at strong form.

Generally, it is possible to summarize the implications of studies conducted to test the efficiency of stock markets worldwide as follows: First, there is a general expectation of the efficiency of stock markets in developed countries in the weak form. Second, there is no consensus on the efficiency of developing countries' stock markets at the weak-form of efficiency. Third, the efficiency of developed countries' stock markets in the semi-strong form is still in question. Fourth, some developed countries' stock markets are efficient at a semi-strong level, and some are not efficient. Lastly, the strong form of efficiency of stock markets is not the case even in developed countries.

1.2. Statement of The Problem

Even though several studies investigated the efficiency level of developed and developing countries' stock markets, researchers have no common perception in the area (Leković, 2018; Sewell, 2012). Since the 1970s, much research has been done using different methods, data, and securities to test the efficiency level of stock markets worldwide. There is a general expectation by economics and finance researchers regarding the efficiency of developed countries' stock markets at the weak form of efficiency. On the contrary, there is no universal consensus regarding the semi-strong form of market efficiency even in the developed world (Malkiel, 1989).

There is also a difference between the developing and developed countries' stock market efficiency levels. In this concern, Harvey (1993) and (1995) indicated high-level predictability of developing countries' markets compared with developed ones. Therefore, there is still a need to study developing and developed countries' stock market efficiency characteristics.

This study investigates the weak and semi-strong forms of stock market efficiency for 15 developing and developed countries' stock markets. First, by trying to take a

sample from all corners of the world, five countries: Australia, Germany, Japan, the UK, and the USA are selected to represent developed or high-income countries. Then, on behalf of developing countries, five countries such as China, Malaysia, Brazil, South Africa, and Turkey from Developing-Upper-Middle-Income (DUMI), and finally, five countries such as Egypt, Kenya, India, Sri Lanka, and Tunisia from Developing-Lower-Middle-Income(DLMI) countries are selected. Once selecting countries to be included in this study, the next step is determining the stock market index for each country. The criterion for choosing the index is identifying the index that highly represents each country's stock market or the primary stock index of each country. Consequently, the major stock indexes of each sample country are selected to test the efficiency level of the sample countries' stock markets.

The weekly closing price for each sample index from January 2000 to December 2019 was collected to examine the weak form of stock market efficiency. The collected data is analyzed using autocorrelation, unit root, run, and variance ratio tests. The weak form of efficiency was also conducted by dividing the sample period into three sub-periods to explore the dynamics of stock market efficiency over time. Macroeconomic variables such as inflation, money supply, exchange rates, interest rates, GDP, and crude oil prices are selected to investigate the semi-strong form of stock market efficiency. The monthly data of all the variables covering from January 2000 to December 2019 is analyzed using cointegration and Granger causality tests.

1.3. Objectives of The Study

The main objective of this study is to investigate the weak and semi-strong forms of stock market efficiency for ten developing and five developed countries.

This study tries to accomplish the following specific objectives:

- I. To assess whether or not the selected countries' stock markets are efficient at the weak form of efficiency level.
- II. To investigate the dynamics of the Stock market's weak form of efficiency over time.
- III. To examine whether the selected countries' stock markets are efficient at the semi-strong form of efficiency.

- IV. To analyze whether there is a similarity in the stock market's efficiency depending on the sample countries' economic levels.

1.4. Significance of The Study

The empirical findings of this research will have important implications for investors and policymakers concerned with selected countries' stock markets. It will significantly contribute to investors, financial market analysts, market makers, and policy issuers for better capital allocation and correct market conditions. Additionally, the results of this study will help financial analysts in underlying countries to make good decisions informing investment portfolios.

The findings of this study will add value to the existing literature by testing the weak and semi-strong forms of efficiency for ten developing and five developed countries' stock markets. Furthermore, this research will allow readers to understand the efficient market hypothesis better.

1.5. Limitations of The Study

The strong form of stock market efficiency hypothesis states that the current stock market price reflects the historical price, publicly available information, and insider information. Therefore, this research will not investigate the strong form of stock market efficiency. In this study, the researcher will test only the weak and semi-strong forms of stock market efficiency for selected countries' stock indexes. Collecting trading data from insiders is necessary to examine the strong form of EMH. As the sample countries are from different continents, finding information on insider traders' decisions in each country is impossible. Due to this reason, this research will test only the weak and semi-strong forms of EMH.

1.6. Organization of the Paper

This study consists of seven chapters. The first chapter is the introduction chapter and encompasses the background, problem statement, objective, significance, limitation, and study organization. The second chapter presents the theoretical foundation of the efficient market hypothesis. The third chapter reviewed the literature on the weak and semi-strong efficiency forms. The methodologies of the study are explained in chapter

four. The empirical analysis of the study is presented in chapter five. Chapter six is devoted to discussing the finding of the study in line with the literature. Finally, the conclusion, recommendation, limitation, and further research suggestions are labelled in chapter seven.



CHAPTER II

THEORETICAL BACKGROUND

The notion behind the efficient market hypothesis (EMH) is clearly illustrated in the introduction chapter of this study. This chapter summarizes the history and development of EMH, the concept of random walk theory, the deficiency of EMH, and the idea of behavioral finance.

2.1. Introduction

Investors participating in financial instrument trading have been trying to beat the market by constructing different methods. Technical and fundamental analyses are the main approaches that investors have applied to gain abnormal returns (Alexander, 1961; Malkiel, 2003). Technical analysts try to earn abnormal returns by analyzing securities' historical prices and trading volume information (Mandelbrot, 1966). On the other hand, fundamental analysts are trying to beat the market by analyzing firm-specific micro and country-level macro details. Since 1900, statistics and financial economics researchers have been trying to answer important questions like: is the historical price useful in predicting future prices? Do price changes follow a specific pattern? , etc.

Three perspectives, such as classical economic theory, efficient market hypothesis, and behavioral finance theory, were developed to explain the association between stock price and information (De Bondt, 2000; Ruhani, Islam, & Ahmad, 2018). First, the classical supply and demand theory explains the link between availability and need for a product like financial instruments and price. Whelan and Msefer (1996) stated that the supply and demand theory assumes that a market should be perfectly competitive and that investors should be rational. And also, entry and exit into the market should be free. According to this theory, the price reaches equilibrium by the interaction of demand and supply.

The efficient market hypothesis and behavioral finance theory are the most supported perspectives by empirical research. Behavioral finance theory states that investors may beat the market as their behavior affects investors' decisions. On the other hand, the EMH says that security prices reflect all available information, and it is

impossible to predict future prices by analyzing historical prices and publicly available and insider information.

2.2. History of Efficient Market Hypothesis

The historical development of the efficient market hypothesis can be classified into three phases. The first phase covers the studies done before 1965, which tried to explain time-series behaviors like price. This phase is the foundation phase of the efficient market hypothesis. The second phase is the launching and improvement phase of the Efficient Market Hypothesis. Finally, the third phase in the history of the efficient market hypothesis is when different challenges arise against the efficient market hypothesis.

2.1.1. The Foundation Phase of EMH

The origin of market efficiency dates back to the 1900s when French mathematician Louis Bachelier wrote his Ph.D. thesis entitled “The Theory of Speculation.” His thesis commenced mathematical finance of Brownian motion to the world. Bachelier stated in his thesis, “past, present and even discounted future events are reflected in market price, but often show no apparent relation to price changes.” (Savoiu, 2013). It is the recognition of market efficiency by Bachelier at that time. Unfortunately, Bachelier's contribution to modern finance was not given attention until the 1950s (Bernstein, 1993).

Cowles (1933) wrote an article entitled “Can Stock Market Forecasters Forecast?” He assessed the forecasting efforts of 45 investment professionals who have attempted to gain an abnormal return or forecast the future stock price. He concluded that stock market forecasters could not predict future price movement, and their little forecast performance has probably resulted from chance. Therefore, according to Cowles, trying to gain an anomalous return or to predict future price movements are relied on luck instead of different techniques and strategies. Working (1934) stated, “I find that to the important extent that wheat prices resemble a random-difference series....” He used the phrase “random-difference series” to describe the randomness and unpredictability of a series. Cowles and Working continued their study and reported evidence regarding the non-predictability of prices. Cowles (1944) investigated the forecasting ability of 11 investment forecasters. He again wrote that forecasters could not predict future stock

market prices successfully. Working (1949) also concluded that future market expectations were inaccurate.

Following the previous studies regarding the predictability of future prices, in 1953, Maurice Kendall examined the weekly and monthly data for 22 economic series; 19 stock groups for the period from 1928 to 1938, and the monthly average price of wheat in the Chicago commodity markets from 1883 to 1934, the monthly average price of wheat from 1883 to 1934 (excluding 1915 to 1920) and monthly spot cotton at New York commodity markets from 1816 to 1951 (excluding 1861-1866 and 1914-1920). Kendall's study confirmed that the series of prices are observed random changes from one term to the next (Kendall & Hill, 1953). Hence, Kendall's empirical examinations are called the "random walk theory" (Dimson & Mussavian, 1998).

Harry Roberts did a similar study to Kendall's paper using the American individual firms and stocks index. His result was identical to Kendall's conclusion (Roberts, 1959). In the meantime, Osborne indicated that the movement of logarithms of stock prices seems like "coordinates of a large number of molecules," i.e., Brownian motion (Osborne, 1959). Finally, Alexander (1961) investigated the properties of Dow Jones and S&P industrial average from 1897 to 1959. He concluded that their price movements follow a random walk.

At the beginning of the 1960s, researchers like Houthakker (1961), Cootner (1962), and Osborne (1962) presented evidence against the random walk theory. Houthakker (1961) identified a particular nonrandomness pattern using the "stop order" method. Cootner (1962) analyzed the randomness of 45 sample stocks from the New York Stock Exchange for the period covered from 1956 to 1960 and concluded that weekly stock price changes did not follow a random walk theory.

Using spectral analysis, Granger and Morgenstern (1963) investigated the New York stock price series. They stated that short-run price movements follow the simple random walk hypothesis but not the long-run price movements. Mandelbrot (1972) investigated the typical distribution characteristics of the random walk model that researchers neglected. He called the model "stable Paretian probability laws" in place of Gaussian distributions. Fama (1963) reviewed Mandelbrot's 'stable Paretian probability laws' and stated that tested logarithms of stock and cotton prices follow the statistical distributions.

Godfrey, Granger, and Morgenstern (1964) described the random walk hypothesis, and they tested the random walk hypothesis for the London and New York Markets data. They concluded that “observed changes in the price of a stock are not correlated with the observed volume of transactions.”

2.1.2. The Launching and Improvement Phase of the EMH

The attempts of several researchers to identify the behavior of the security price movement from 1900 to 1964 resulted in the birth of the EMH in 1965. “The Behavior of Stock-Market Price” by Fama (1965) initiated researchers to direct their studies on the random walk hypothesis. Fama (1965) described the random walk model and also empirically tested its validity of the model. He stated that the random walk model in stock price should fulfill two distinct hypotheses, such as “(1) successive price changes are independent, and (2) the price changes conform to some probability distribution”. As impossible to find perfect independence features in a time series, Fama accepted the independence of consecutive stock price changes with a certain “minimum acceptable” level.

Fama (1965) published another paper named “Random walks in stock market prices” and came up with the “Efficient Market” concept for the first time. He interpreted the Efficient Market Hypothesis as “a market where there are large numbers of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants.” He also stated that; in an efficient market, the current price of single security reflects all information about an event that happened and the event that will occur in the future. This means the current security price represents the intrinsic value of the security. Therefore, the turning point for the Efficient Market Hypothesis in finance was 1965, when Fama (1965b) and Samuelson (1965) indicated the efficiency of the capital market in their study.

Samuelson (1965) described the behaviors of price changes in his paper entitled “proof that properly anticipated prices fluctuate randomly.” He expressed price changes by Martingale models instead of random walk models. He defined the martingale property of price changes as “next period's price differences are uncorrelated with previous period's price differences.” Deng (2009) states that Samuelson's study is “a milestone

for forming the Efficient Market Hypothesis.” After that, the random walk model was replaced by Martingale for financial economists to explain the stock price property.

Fama and Blume (1966) conducted a study to test the random walk model for each of the specific securities of the Dow-Jones Industrial Average, covering the period from January 1956 to April 1958. They applied Alexander's filter technique and serial correlation mode. They concluded that “for measuring the direction and degree of dependence in price changes, the serial correlation model is probably as powerful as the Alexandrian filter rules.” Benoit Mandelbrot (1966) describes how future prices are unpredictable in an unbiased market, and he proves that prices follow a martingale model. In his paper, Roberts (1967) used the term efficient markets hypothesis, “Statistical versus clinical prediction of the stock market,” and classified the efficient market in weak and strong forms for the test.

For the first time, Ball and Brown (1968) tested the efficiency of the capital market using accounting information. They concluded, "Of all the information about an individual firm which becomes available during a year, one-half or more is captured in that year's income number." They indicated that the capital market's efficiency mainly depends on the sufficiency of the data source. Fama, Fisher, Jensen, and Roll (1969) conducted an event study test for the first time to test the efficient market hypothesis. They investigated the effects of stock split on stock return. For this purpose, they select 940 splits from January 1927 to December 1959. Their finding indicated that stock split information was fully reflected in stock prices as soon as after the split announcement. They concluded that “the stock market is efficient in the sense that stock prices adjust very rapidly to new information.”

Fama (1970) published a paper entitled “efficient capital markets: A review of theory and empirical work.” He reviewed all related studies and theories, such as fair game models, sub-martingale models, and random walk models. He defined an efficient market as “prices always fully reflect available information.” Depending on Roberts's (1967) weak and strong form taxonomy of efficient market, Fama classified efficient market tests into three forms, i.e., weak form, semi-strong, and strong form tests. Further, Fama (1970) identified the sufficient conditions for an efficient capital market, such as (1) unavailability of transaction cost in trading of financial instruments, (2) all existing information is freely accessible for all market participants, and (3) all market participants are consent on the impact of available information on the current price and future price

of each financial instrument. He concluded that there is no strong evidence contrary to weak and semi-strong form tests; however, there is only limited proof in contradiction of strong form tests. He asserts that “the evidence supporting the efficient markets model is extensive, and (somewhat uniquely in economics) contradictory evidence spars.”

Most previous studies regarding stock market price behavior employed American data. Kemp and Reid (1971) tested the random walk hypothesis for British data. They conclude that stock price movements did not follow the random walk hypothesis. Scholes (1972) investigated the effects of secondary distribution of shares on the stock price for companies listed on the New York Stock Exchange covering January 1947 to December 1965. He examined for a total of 345 and 1,207 daily and monthly secondary distribution, respectively. His finding indicated no significant abnormal return on daily and monthly secondary distributions. This finding concurred with the efficient market hypotheses.

Samuelson (1973) published the “Mathematics of speculative price” study. Samuelson reviewed mathematical methods applied in financial economics for speculative pricing in this study, starting from Bachelier’s 1900 ‘Brownian motion’ to Markowitz’s 1959 portfolio optimization model. In the same year, Lorie and Hamilton (1973) and Malkiel (1973) published the book “The Stock Market: Theories and Evidence” and “A Random Walk Down Wall Street,” respectively. LeRoy (1973) investigated the validity of martingale property under the risk aversion condition. He concludes that martingale property confirmed only a minimal context under the risk aversion rate of return on the stock market. Therefore, LeRoy’s result is against the efficient market hypothesis under the risk version condition. Deng (2009) stated that the development of an efficient market hypothesis plays a significant theoretical role for capital market theories such as Markowitz’s Portfolio Selection theory, Sharpe’s Capital Asset Pricing Model, Black-Scholes’ Option Pricing Model, and Ross’s Arbitrage Pricing Theory.

Fama (1976) published the book “Foundations of Finance.” The book contains nine chapters, and the first four consecutive chapters describe primary statistical material to understand empirical finance. The last five chapters summarize concepts concerning “Efficient Capital Markets, Short-Term Interest Rates as Predictors of Inflation, The Two Parameter-Portfolio Model, Capital Market Equilibrium in a Two Parameter World, and The Two-Parameter Model: Empirical Tests’ respectively.” In this book, Fama tried strengthening his previous definition of the efficient market hypothesis in 1970. Logue

(1977) reviewed Fama's book and concluded that Fama's Foundations of Finance is a simple introduction to the efficient market hypothesis and security pricing, the approach to test these concepts, and empirical studies in these fields.

In the meantime, the efficient market hypothesis has become the leading research topic in finance. Ball (1978) and Lucas (1978) challenged the theory in certain circumstances. Ball (1978) conducted a survey paper and concluded that there is a possibility of gaining abnormal returns after a firm's earnings announcement. This finding is against the postulation of the semi-strong form of EMH. Lucas (1978) also investigated whether price changes track Martingale property. He developed a model and revealed that actual price series do not follow the Martingale property of the efficient market hypothesis.

In his paper, Jensen (1978), "Some Anomalous Evidence Regarding Market Efficiency," assessed studies that provide inconsistent evidence regarding the efficient market hypothesis. He states, "I believe there is no other economic proposition that has more solid empirical evidence supporting it than the Efficient Market Hypothesis" (p.1). After reviewing studies that came with results inconsistent with the efficient market hypothesis, Jensen (1978) concludes, "I have little doubt that we will document further anomalies and begin to sort out and understand their causes in the next several years. However, the result will not abandon the 'efficiency' concept or asset, pricing models".

Radner (1979) tried to demonstrate the informational efficiency of rational expectations equilibrium. He indicates that "in a particular model of asset trading, if the number of alternative states of initial information is finite then, generically, rational expectations equilibrium exists that reveal all of their initial information."

In conclusion, from 1965, when Fama and Samuelson put the base of the efficient market hypothesis to 1979, the notion of the efficient market hypothesis was extensively tested, discussed, and developed.

2.1.3. The Challenging Phase for EMH

The phase from the 1980s to the present is characterized as a challenging period, and opposing theories developed to describe the behavior of financial instruments' prices. This section summarizes studies supporting and opposing the efficient market hypothesis from the 1980s to the present.

Grossman and Stiglitz (1980) showed that an informationally efficient market could exist when information is costless. They tried redefining the efficient market hypothesis: "when information is very inexpensive, or when informed traders get exact information, then equilibrium exists, and the market price will reveal most of the informed traders' information." Further, they stated that as in the actual world, information is not accessible, and security prices are not demonstrating all available information.

LeRoy and Porter (1981) tested an efficient market hypothesis using U.S. corporations' aggregated and disaggregated price and earnings data. They concluded that stock prices on aggregated and disaggregated data were "more volatile," and they rejected the efficient markets hypothesis. Shiller (1981) conducted a study entitled "Do stock prices move too much to be justified by subsequent changes in dividends?" and indicated that assumed actual dividend is given; the analyzed data was inconsistent with the efficient market hypothesis. Roll (1984) also tested the informational efficiency of US orange juice futures prices and concluded that orange juice futures prices are informationally inefficient.

DeBondt and Thaler (1985) investigated a new behavioral theory, i.e., overreaction, for the first time, using monthly return data from the New York Stock Exchange from January 1926 to December 1982. They concluded that stock prices overreact to unpredicted and extraordinary new events. Accordingly, they discovered a weak form of market inefficiency. According to Sewell (2012), De Bondt and Thaler's study indicated the birth of behavioral finance contrary to the efficient market hypothesis.

In his discussion paper "Does the Stock Market Overreact? Discussion" Bernstein (1985) assessed the inconsistency between the efficient market hypothesis and the overreaction anomaly identified by DeBondt and Thaler (1985). He argued that stock markets are highly efficient in the short run while some abnormalities result in the long run. As long-run inefficiencies created arbitrage opportunities, markets would become efficient. Finally, Bernstein concluded that "let us give the Efficient Market Hypothesis its due as an explanation of how markets work in the short run, even if we can probably reject the hypothesis for the long run."

Marsh and Merton (1986) assessed the efficient market hypothesis using the "variance-bound" method that was applied by Shiller (1981). Contrary to Shiller's finding, they concluded that the variance-bound method could not be utilized to test the efficient market hypothesis. Black (1986) came up with the concept of "noise" and

defined it as “a large number of small events are often a causal factor much more powerful than a small number of large events can be.” Concerning the effect of noise on the efficient market hypothesis, Black stated, “Noise causes markets to be somewhat inefficient, but often prevents us from taking advantage of inefficiencies”. Summers (1986) examines the methodologies applying to test market efficiency and concluded that evidences regarding market efficiency does not demonstrated the fundamental values of financial instruments due to the low power of commonly applies statistical methods to test efficiency.

The 1987 world stock market crash is one of the significant challenges faced efficient market hypothesis. The stock market crash started in Hong Kong, expanded to Europe, and struck the United States stock market. As a result, the Dow Jones Industrial Average (DJIA) price falls almost 31% in 4 trading days. The crash resulted in around one thousand billion in US\$ loss in the US stock markets ((Deng, 2009; Sewell, 2012). Regarding the 1987 stock market crash, the Yale University Nobel laureate economist James Tobin commented that “the effect that no tangible factors do not exist could cause the stock value to change by 30%” (Samuelson & Nordhaus, 1998). Therefore, the opponent of the efficient market hypothesis blames the hypothesis due to the inability to justify this great stock market crash.

Fama and French (1988) found negative autocorrelation for a short-term period, gradually reaching a minimum of 3 and 5 years. Finally, the autocorrelation became zero for a long time horizon. Lo and MacKinlay (1988) tested the random walk hypothesis using the variance-ratio test. They concluded that their data did not follow the random walk model and firmly rejected the model. Finally, Poterba and Summers (1988) analyzed the data from the United States and seventeen other countries using the variance ratio test. They indicated that stock returns are positively autocorrelated over short periods and negatively autocorrelated over long periods.

Cutler, Poterba, and Summers (1988) examined the impact of macro and non-macro-economic news on stock price movement and found that news does not sufficiently describe the stock price movement. This finding is against the notion of a semi-strong form of stock market efficiency. Finally, LeRoy (1989) illustrated the concept behind efficient capital market doctrine and its relation with martingale. He stated that “the transition between the intuitive idea of market efficiency and the martingale model is far from direct.”

Among researches conducted in 1990 regarding efficient market hypotheses, such as Laffont and Maskin (1990), Lehmann (1990), and Jegadeesh (1990) documented evidence against the efficient market hypothesis. Laffont and Maskin (1990) tested the strong form of stock market efficiency using insider trading information. They concluded that if imperfect competition appears in the market, the efficient market hypothesis may not accept. Lehmann (1990) also found a result against the efficient market hypothesis and saw a weekly stock return reversal. Finally, Jegadeesh (1990) rejected the assumption that stock prices follow a random walk and found the foreseeable property of security prices.

Fama (1991) wrote his second review paper called “Efficient Capital Markets: II” to reconcile the efficient market hypothesis with the hypothesis's empirical studies. He stated that:

“The empirical literature on efficiency and asset-pricing models passes the acid test of scientific usefulness. It has changed our views about the behavior of returns, across securities and through time. Indeed, academics largely agree on the facts that emerge from the tests, even when they disagree about their implications for efficiency. The empirical work on market efficiency and asset-pricing models has also changed the views and practices of market professionals.” (p. 1576).

Fama (1991) restructured his 1970 three-categories capital market efficiency tests. The weak form test concerned only the forecast ability of past returns is replaced by a broader area of “tests for return predictability.” The semi-strong form test previously tested by publicly available information gives a general name called “event studies.” He gave a more descriptive name for a strong-form test of market efficiency, “tests for private information.” Chopra, Lakonishok, and Ritter (1992) showed a significant overreaction effect. Bekaert and Hodrick (1992) found a predictable component in excess return in the stock and foreign exchange market.

Malkiel (1992) published an essay entitled “Efficient Market Hypothesis, one famous advocator of efficient market hypothesis.” He described the notion behind the efficient market hypothesis and summarized studies that criticized the theory. He tried to magnify the position of the approach. He said, “the empirical evidence in favor of EMH is powerful. Probably no other hypothesis in economics or finance has been more extensively tested” (p.133).

Jegadeesh and Titman (1993) documented the underreaction anomaly, i.e., “Buying Winners and Selling Losers,” for the first time. In the paper presented as the Keynote Address at the Annual Meeting of the Financial Management Association in Toronto, Ontario, on 13 October 1993, Roll (1994) addressed some fundamental issues in financial economics every CFO should know. The efficient market hypothesis is among the five topics he gave priority to. He stated: “After spending 25 years looking at particular allegations about market inefficiencies and ten years attempting to exploit them as a practicing money manager, I have become convinced that every CFO ought to learn the concept of the efficient market. Market efficiency is categorically the first approximation to reality, and perhaps more important is a constructive organizing paradigm of thought” (p.71).

Roll (1994) defined the efficient market hypothesis as “an absence of a marginal incentive to study, analyze, or spend on the information.” Considering seasonal anomalies found against the efficient market hypothesis in the 1980s, he indicated that “Many of these effects are surprisingly strong in the reported empirical work, but I have never yet found one that worked in practice, in the sense that it returned more after cost than a buy-and-hold strategy” (p.71). Generally, Roll (1994) perceived that gaining abnormal returns from market inefficiencies is very difficult.

Metcalf and Malkiel (1994) tested the efficient market hypothesis by analyzing portfolios selected by experts. They found that constructing portfolios chosen by experts does not always help beat the market. Dow and Gorton (1997) examined the association between stock market efficiency and economic efficiency. They concluded that stock market efficiency is insufficient for financial and investment efficiency.

Dimson and Mussavian (1998) reviewed high-quality studies which advocated and criticized efficient market hypotheses. As continued studies found different anomalies against market efficiency, Fama (1998) published an article entitled “Market efficiency, long-term returns, and behavioral finance” to show the endurance of his hypothesis. He concluded that: “Market efficiency survives the challenge from the literature on long-term return anomalies. Consistent with the market efficiency hypothesis that the anomalies are chance results, apparent overreaction to information is about as common as underreaction, and post-event continuation of pre-event abnormal returns is about as frequent as post-event reversal” (p. 283).

Bernstein (1999) assessed the efficient market hypothesis and claims that:

“The reality that thousands of individuals in the capital market spend so much time in gaining access to information, evaluating the information, and translating the evaluation into investment decisions must suggest that the marginal benefits of acting on information exceed the marginal costs.”

Zhang (1999) claims that market inefficiencies cannot eliminate by arbitrage opportunity and introduced a theory of marginally efficient markets. Shleifer (2000) challenges investor rationality and perfect arbitrage assumptions of the efficient market hypothesis. He claimed that various empirical challenges of the efficient market hypothesis created a new theory, i.e., behavioral finance, to explain the behavior of markets. Beechey, Gruen, and Vickery (2000) examined empirical evidence focused on stock and foreign exchange markets. They concluded that: “The efficient market hypothesis is almost certainly the right place to start when thinking about asset price formation. However, academic research and asset market experience suggest that it does not explain some important and worrying features of asset market behavior”.

In his paper “Rational Markets: Yes, or No? The Affirmative Case” Rubinstein (2001) examines studies with significant results against market rationality and concludes that markets are rational. Lewellen and Shanken (2002) investigated the asset-pricing effects of parameter uncertainty and figured that “parameter uncertainty can be important for characterizing and testing market efficiency.”

Malkiel (2003) examined studies that challenged the efficient market hypothesis and claimed the partial predictability of stock market prices. He concludes that “our stock markets are far more efficient and far less predictable than some recent academic papers would have us believe.” Further, he asserts that investors cannot earn abnormal risk-adjusted returns by creating anomalies-based portfolios.

Schwert (2003), in his study “Anomalies and Market Efficiency,” examines whether empirical anomalies against the efficient market hypothesis are a profitable investment strategy for practitioners or not. He concludes that familiar anomalies in financial literature do not exist in different sample periods, and some anomalies disappeared after their details were published to the public. Further, he states that even if anomalies existed in the sample period, the actions of practitioners to take advantage of anomalous behaviors could cause anomalies to disappear, and the market becomes efficient.

The famous proponent of the efficient market hypothesis, Malkiel (2005), in his study “Reflections on the Efficient Market Hypothesis: 30 Years Later,” shows that “professional investment managers, both in The U.S. and abroad, do not outperform their index benchmarks and provides evidence that by and large market prices do seem to reflect all available information.”

Tóth and Kertész (2006) analyzed the cross-correlations of returns on the New York Stock Exchange and concluded that markets are increasingly efficient. Wilson and Marashdeh (2007) examined whether co-integrated stock prices are harmonious with the efficient market hypothesis and showed that co-integrated stock prices are consistent with an efficient market hypothesis in the long run but not in the short run. Accordingly, they argued that market inefficiencies in the short run ensure market efficiency in the long run through equilibrating corrections.

In his second edition survey paper, “efficient markets hypothesis,” Lo (2008) examines the historical development and the continuing challenges of the efficient market hypothesis. He asserted the main enduring challenges come from that behavioral finance theory. Regarding the current status of the efficient market hypothesis, Lo states that the debate between opponents and proponents of an efficient market is expected to continue. Further, he says, “despite the lack of consensus in academia and industry, the ongoing dialogue has given us many new insights into the economic structure of financial markets.”

In their survey paper “Efficient Market Hypothesis: Past, Present and Future,” Yen and Lee (2008) examine empirical findings by classifying them into three categories “supporting empirical findings” as documented from the 1960s to 1990s, “mixed empirical findings,” from 1970s to 1980s” and “challenging empirical findings” occurred in 1990s. After reviewed several empirical studies in these three categories, they supposed that “the EMH is here to stay and will continue to play an important role in modern finance for years to come.”

Ball (2009), in his paper “The Global Financial Crisis and the Efficient Market Hypothesis: What Have We Learned?” discussed several comments which put the efficient market hypothesis responsible for the 2008 global financial crisis. First, he stated that the blame of the efficient market hypothesis for the global financial crisis looks extensively exaggerated. Finally, he concludes that “the impact of the theory of efficient

markets has proven to be durable, and seems likely to continue to be so, despite its inevitable and painfully obvious limitations.”

In his report paper “Death of the Efficient Market Hypothesis,” Deng (2009) deeply investigated the essence of the efficient market hypothesis and concluded that “with the fact that Efficient Market Theory is far from a reasonably close approximation to the stock market realities, and its scientific content is close to zero.” Finally, Lee, Lee, and Lee (2010) examine whether the efficient market hypothesis sustains in stock markets for 32 developed and 26 developing countries from January 1999 to May 2007. Their finding indicated that investigated countries' stock markets are not efficient.

In his paper “History of the Efficient Market Hypothesis,” Sewell (2012) reviewed notable literature on the efficient market hypothesis chronologically from the 16th century and concluded that “Strictly speaking, the EMH is false, but in spirit is profoundly true. Besides, science concerns seeking the best hypothesis, and criticism is of limited value until a better hypothesis replaces a flawed one”. When the 2008-2009 global financial crisis outbreaks and many academicians were responsible for the EMH crisis, Malkiel (2011) continued his usual support for the efficient market hypothesis in his paper “The Efficient-Market Hypothesis and the Financial Crisis.” He argues that the criticism of EMH resulted from a misunderstanding what EMH means.

In 2013, Fama shared the Nobel Prize in Economic Sciences equally with Lars Peter Hansen and Robert Shiller, for his empirical analysis of efficient market hypothesis and asset prices. On 26 October 2013, Shiller addressed his concern regarding the Nobel Prize to The New York Times and stated, “Actually, I do not completely oppose the efficient market theory. I have been calling it a half-truth”. On the other hand, Fama (2013), in his lecture for Nobel Foundation, states that the behavioral finance literature mainly criticized the efficient market hypothesis and attacked the behavioral finance theory for lacking a testable model for prices and returns.

Degutis and Novickytė (2014) analyzed the current status of the efficient market hypothesis. They stated the ambiguous position of EMH as follows: “The EMH fails to explain excess volatility in stock prices, investor overreaction, seasonality in returns, asset bubbles, etc. But, on the other hand, stock returns are often found random, and investors are not capable of constantly earning an excess return”.

In his review study, Tığan (2015) examines specialized literature and empirical research on the efficient market hypothesis and concludes that testing for market

efficiency is complex because market / economic situation changes. Further, he recommends continuing testing whether capital markets are informationally efficient or not. Naseer and Bin Tariq (2015) reviewed works of literature and concluded that “Essentially, though the markets may often be efficient, they are not necessarily always efficient.”

Fakhry (2016), in his review study “A Literature Review of the Efficient Market Hypothesis,” critically evaluates the status of efficient market hypotheses and argues that despite testing difficulties and mixed empirical results, EMH is beneficial as a benchmark for policymakers and central bankers. Then, Bird, Du, and Willett (2017) investigated whether the Eurozone crisis between 2009 and 2015 is attributed to the efficient market hypothesis or behavioral finance theory characteristics. They concluded that the efficient market hypothesis and behavioral finance theory are essential to understanding how markets perform.

Recently, Woo, Mai, McAleer, and Wong (2020), in their review paper “Review on Efficiency and Anomalies in Stock Markets,” revised the theory and literature on market efficiency and market anomalies. They concluded that “when EMH, anomalies and Behavioral Finance are used to explain the impacts of investor behavior on stock price movements, it is invaluable to policymakers, when reviewing their policies, to avoid excessive fluctuations in stock markets.”

Since the 1980s, it has been characterized by practical and theoretical challenges against the efficient market hypothesis. However, although several studies claimed the death of the efficient market hypothesis, it is still applicable to describe the characteristics of asset prices.

2.2. Conclusion

This section discusses the efficient market hypothesis's historical development and current status. In this study, the historical background of EMH is divided into three categories: the foundation phase of the efficient market hypothesis, the launching and improvement phase of the Efficient market hypothesis, and the challenging phase of the efficient market hypothesis.

The foundation stage covers the period from 1900 to 1965. In this period, several studies were conducted to explain the behavior of prices in the market. Brownian motion, random-difference series, random walk theory, and stable Paretian probability laws are

among the models developed to describe the randomness or unpredictability of security prices. These different models played a significant role at the beginning of EMH.

The launching and improvement phase covers the period from 1965 to 1980. In this stage, the EMH was introduced to explain the characteristics of security price fluctuation by Eugene F Fama (1965) and Samuelson (1965). In this phase, EMH was extensively tested by financial and economic researchers, and the notion of EMH was also revised and improved.

The third phase covers from 1981 to the present and is characterized as a challenging period for EMH due to practical and theoretical challenges faced by EMH. Empirically, different market anomalies which contradict the concept of EMH are discovered, and to describe these anomalies, a new theory, i.e., behavioral finance theory, emerged.

Concerning the current status of EMH, there is no common conclusion among academicians. Researchers such as Grossman and Stiglitz (1980), DeBondt and Thaler (1985), Jegadeesh (1990), Jegadeesh and Titman (1993), Shleifer (2000), Deng (2009), Lee et al. (2010), and Degutis and Novickytė (2014) stated that EMH is not an accurate hypothesis and replaced by behavioral finance. On the contrary, researchers such as Schwert (2003), Malkiel (2005), Malkiel (2011), Fama (2013), Fakhry (2016), Bird et al. (2017), and Woo et al. (2020) claim that EMH is still applicable as a benchmark for describing the characteristics of security price movements. It is helpful for policymakers along with behavioral finance theory.

CHAPTER III

EMPIRICAL LITERATURE REVIEW

This chapter is devoted to presenting the review of previous empirical studies conducted on sample countries' stock market indexes to test weak and semi-strong form efficient market hypotheses. The chapter has three main sections. The first section reviews studies conducted to test each sample country's weak form of stock market efficiency in three categories: developed, developing upper-middle-income, and developing lower-middle-income countries. Then, the second section presents the literature review on testing the semi-strong form of stock market efficiency for sample countries. Finally, concluding remarks are forwarded in the third section based on the studies explored in the first and second sections.

3.1. Literature Review On Weak Form of Stock Market Efficiency

This section reviews empirical studies conducted to examine the weak form of efficiency for sample developed, DUMI, and DLMI countries. In addition, studies were done to investigate a group of countries' efficiency and reviewed in a table.

3.1.1. Weak Form Efficiency Test for Developed Countries' Stock Market

In this study, Australia, Japan, German, the UK, and the USA are the sample countries selected as a proxy for developed countries. Accordingly, studies done to test the weak form efficiency of these sample countries' stock markets are reviewed in this section.

Employing the mean-variance efficiency test, Stokie (1982) investigated the weak-form efficiency of Australian Stock Market indexes for the period between 1958 to 1973. His finding indicated that sample indexes had not followed the random walk hypothesis. Groenewold and Kang (1993) also investigated the weak-form efficiency of the Australian Stock Market index for a sample period from 1982(8)-1988(6) using the Autocorrelation test of the Box-Ljung portmanteau statistic (Q) and Phillips-Perron unit root test. The result shows that the data were consistent with the weak form of EMH. Further, Worthington and Higgs (2006a) and Worthington and Higgs (2009) investigated the long-run weak form of efficiency using daily (from 6 January 1958 to 12 April 2006) and monthly (from February 1875 to December 2005) data. The finding shows that the monthly data was consistent with

EMH; on the contrary, the daily observation was violet EMH. Furthermore, Hamid et al. (2017) examined the weak-form efficiency of the Australian stock market with their Asia-Pacific sample countries. Their finding indicated that the Asia-Pacific markets, including Australia, did not follow the random walk hypothesis.

Conrad and Juttner's (1973) study is one of the earlier research that examined the weak-form efficiency of Germany's stock market. They investigated the efficiency of Germany's stock market using parametric and non-parametric tests. Their finding shows that Germany's stock market was not following EMH between 1968 and 1971. On the contrary; Cuthbertson and Hyde (2002), Worthington and Higgs (2003), Stanley and Kinsman (2009), Kristoufek and Vosvrda (2014), and Rossi and Gunardi (2018) showed that Germany's stock market is efficient in the weak form of stock market efficiency.

Studies conducted to examine the efficiency of the Japanese stock market provide conflicting evidence. For instance, Nagayasu (2003), Kanojia and Mahajan (2017), and Hamid et al. (2017) claim that the Japanese Stock markets are weak for inefficient. On the other hand, Studies such as Pettway (1984), Kim and Shamsuddin (2008), Samaratunga (2009), Nisar and Hanif (2012), and Ryaly, Kumar, and Urlankula (2014) indicated that the Japanese stock markets are following the random walk hypothesis.

Al-Loughani and Chappell (1997) examined the weak form of efficiency for FTSE 30 index using unit root tests and the Generalized Autoregressive Conditional Heteroscedasticity (GARCH-M) model for the period between 30 June 1983 and 16 November 1989. Their finding indicated that FTSE 30 does not fulfill the criteria to be efficient in the weak form of efficiency during the examined period. Similarly, Opong, Mulholland, Fox, and Farahmand (1999) investigated the UK stock market indexes at the weak-form efficiency. They concluded that the UK's stock indexes did not follow a random walk hypothesis. In the opposite to the above studies, Milionis and Moschos (2000), Konak and Şeker (2014), and Rounaghi and Nassir Zadeh (2016) states that the UK stock markets are efficient in the weak form.

On the weak-form efficiency of the US stock markets, Chan, Gup, and Pan (1992), Lim (2007), and Rounaghi and Nassir Zadeh (2016) indicated that the US stock markets are weak-form efficient. On the contrary, employing Box–Pierce and automatic variance ratio tests, Lim, Luo, and Kim (2013) investigated the predictability of the US stock index returns covering from 31 December 1969 to 31 December 2008. Their finding indicated that they found varying predictability patterns during the study period. Likewise, Urquhart and

McGroarty (2016) and Ferreira and Dionísio (2016) exhibited a certain predictability and memory pattern for the US stock market.

Table 1.

Selected Studies on the Weak Form Efficiency of Developed Countries

Author(s)	Sample countries	Method	Sample period	Results
Ko and Lee (1991)	Including Japan and the US	Serial Correlation Test, Runs Test,	1981:12- 1988:12	Efficient market (Only the US)
U. Lee (1992)	Ten industrialized countries	Variance ratio test	1967–1988	Efficient market
Choudhry (1994)	The US, Japan, Germany	Unit root tests	1953-1989	Efficient market
Sadique and Silvapulle (2001)	Including the USA, the UK, and Japan	Rescaled Range Analysis, The GPH Test, and Frequency and Time Domain Score Test	1983(1)-1998(12)	Efficient market
Cooray (2003)	The US, Japan, Germany, the UK, Hong Kong, and Australia	Unit root tests and spectral analysis	1991(4) - 2003(2)	Efficient market
Andrew C Worthington and Higgs (2005)	Including Australia and Japan	Autocorrelation runs tests, Unit root and multiple variance ratio tests	1987:12 to 2003:5	Japan: Efficient Australia: Inefficient
Borges (2010)	Including the UK and Germany	Runs test and joint variance ratio tests	1993–2007	Mixed Result
P. Mishra (2011)	Including Germany, US and UK	Unit root test and GARCH (1, 1)	2007(1)-2010 (12)	Inefficient market
Nisar and Hanif (2012)	Including Australia and Japan	Runs test and variance ratio test	1997:7 to 2011:6	Efficient market
P. Singh, Deepak, and Kumar (2015)	Australia, German, Japan, the UK, and the US	Unit root and Variance ratio tests	2003:4 to 2014:12	Efficient market
Erdem and Ulucak (2016)	G7 countries	Unit root tests and Bootstrap causality	2003:7 -2014:10	Efficient market
Hamid et al. (2017)	Including Australia and Japan	Autocorrelation, Runs Test, Unit Root Test, and Variance Ratio Tests	2004(1)-2009(12)	Inefficient market
Tiwari, Aye, and Gupta (2019)	Eight Developed countries	Multifractal Detrended Fluctuation Analysis	1693 to 2017	Inefficient market

3.1.2. Weak Form Test of Efficiency For DUMI Countries' Stock Market

Brazil, China, Malaysia, South Africa, and Turkey are the sample countries selected as a proxy for developing upper-middle-income countries. This section has reviewed the literature to examine the weak form efficiency of developing upper-middle-income countries.

Employing the variance ratio tests, Urrutia (1995) examined the weak form of stock market efficiency for emerging Latin American countries, namely Argentina, Brazil, Chile, and Mexico. He used monthly data from sample indexes from December 1975 to March 199. The finding indicated that stock markets in the sample country are weak-form efficient. In the same way, Ojah and Karemera (1999), Capobianco, Cister, and Maceio (2002), and . Chen and Metghalchi (2012) argue that the efficiency of the Brazilian stock market in the weak-form of efficiency. However, Andrew C Worthington

and Helen Higgs (2003) and De Carvalho, Suen, and Gallo (2016) present evidence against the efficiency of the Brazilian stock market in the weak form.

Martin Miles Laurence, Cai, and Qian (1997) studied the weak-form efficiency of “A” and “B” group shares of the Chinese stock market for the period between 8 March 1993 and 31 October 1996. The finding indicated that “A” group shares of the Chinese stock market became efficient in the weak form, while the “B” group was not efficient. Similarly, Groenewold, Tang, and Wu (2001), Araújo Lima and Tabak (2004), Zhang and Xindan (2008), Charles and Darné (2009), and Hung (2009) came with mixed results. On the opposite, Seddighi and Nian (2004), Niblock and Sloan (2007), Qu and Li (2014), and Malafeyev, Awasthi, and Kambekar (2017) indicated that still, the Chinese stock market is not efficient in the weak form.

Previous studies which examined the efficiency of the Malaysian stock market came with mixed results. Laurence (1986) looked at the weak-form efficiency of the Kuala Lumpur Stock Exchange (KLSE) using individual stock price observations from June 1, 1973, to December 31, 1978. He employs an autocorrelation test, run test, and distributional statistics to examine the weak form of efficiency of LKSE. The finding indicated a slight deviation from the weak-form of efficiency. Yong (1987) also investigate the efficiency of the Kuala Lumpur Stock Exchange for only major stock exchange in Malaysia, using weekly observation from January 1977 to May 1985. Again, serial correlation, runs, Kolmogorov-Smirnov, and Spearman rank correlation tests are employed to investigate the weak form of efficiency. The finding indicated that major stocks in Malaysian stock markets were less efficient compared to developed stock markets.

Employing unit root analysis and serial correlation test, Nassir, Ariff, and Mohamad (1993) examined the weak form efficiency of KLSE from January 1977 to May 1989. Their finding indicated that most sample indexes were efficient except for some indexes during the study period. Further, Lian and Leng (1994) examined the short and long-run efficiency of the Malaysian stock market from 1984 to 1991. They concluded that different methods came up with mixed results; however, the efficiency of the Malaysian stock market showed an improvement from year to year.

Lai, Balachandher, and Nor (2002) investigated the randomness of KLSE covering the period from January 1977 to December 1999, employing the variance ratio test and moving average method. The finding shows that successive price changes were

not random during the sample period. Furthermore, Sadique and Silvapulle (2001), Balkiz (2003), Cheong (2008), Ahmed and Hossain (2018), and Singh and Kumar (2018) studied the weak form of efficiency of the Malaysian stock market. They concluded that the Malaysian stock market is not efficient in the weak-form efficiency. On the contrary, Munir and Mansur (2009), Kok and Munir (2015), Ching, Munir, and Bahron (2016), and Tuyon and Ahmad (2016) reported the efficiency of the Malaysian stock market is a weak form of efficiency.

Studies conducted to test the weak-form efficiency of the South African stock market mainly reported two types of results. First, studies such as Jefferis and Smith (2004), Phiri (2015), and Heymans and Santana (2018) reported mixed results. On the other hand, the majority of reviewed studies, such as Jefferis and Smith (2005), Simons and Laryea (2006), Enowbi, Guidi, and Mlambo (2010), Bonga-Bonga (2012), Van Heerden et al. (2013), Chitenderu, Maredza, and Sibanda (2014), Fusthane and Kapingura (2017), and Abakah, Alagidede, Mensah, and Ohene-Asare (2018) claimed that the South African stock market is weak-form efficient.

Similar to other emerging stock markets, the efficiency of the Turkish stock market in its weak form of efficiency is not unanimously agreed upon by researchers. Empirical studies that examined the efficiency of Borsa Istanbul came with the result of either efficient or inefficient. Accordingly, Balaban (1995), Oktay and Atac (2005), Büyükşalvarcı and Abdioğlu (2011), Kapusuzoglu (2013), Al-Jafari (2013), Akgun and Sahin (2017), Aliyev (2019), and Hailu and Vural (2020) reported the inefficiency of Borsa Istanbul in the weak form of efficiency. However, Smith and Ryoo (2003), Aga and Kocaman (2008), Buguk and Wade Brorsen (2003), Ozdemir (2008), Korkmaz and Akman (2010), Gozbasi, Kucukkaplan, and Nazlioglu (2014), Bektur and Aydin (2019), and Karademir and Evci (2020) claimed that Borsa Istanbul is efficient in the weak form of efficiency.

Table 2.

Selected Studies on the Weak Form Efficiency of DUMI Countries

Author(s)	Sample countries	Method	Sample period	Results
M. I. Alam, Hasan, and Kadapakkam (1999)	Asian Stock Markets, including Malaysia	Variance-ratio tests	1986(11)-1995 (12)	Efficient market
Karemera, Ojah, and Cole (1999)	15 emerging markets	Variance ratio tests	1987:12 to 1997:5	Efficient market
(Andrew C Worthington & Higgs, 2005)	10 Asian emerging markets	Autocorrelation, run tests, Unit root, and multiple variance ratio tests	1987:12 to 2003:5	Inefficient market
P. Mishra (2011)	Including Brazil and China	Unit root test and GARCH (1, 1)	2007(1)-2010 (12)	Inefficient market
Mobarek and Fiorante (2014)	BRIC	Variance ratio test	1995(10) -2010(3)	Efficient market
P. Singh et al. (2015)	Including Brazil, China, and S.Africa	Unit root and Variance ratio tests	2003(4)-2014(12)	Efficient market
Hamid et al. (2017)	China and Malaysia	Autocorrelation, Runs Test, Unit Root Test, and Variance Ratio Tests	2004(1)-2009(12)	Inefficient market

3.1.3. Weak Form Test of Efficiency For DLMI Countries' Stock Market

Egypt, India, Kenya, Sri Lanka, and Tunisia are the sample countries selected to represent developing lower-income countries. In this section, the review of empirical studies testing the weak form efficiency of these sample countries.

Hegazy (1998) examined the weak-form efficiency of the Egyptian stock market (ESM), employing unit root tests and variance-ratio tests from January 1, 1994, to December 31, 1996. The finding indicated that ESM was inefficient in the weak form of efficiency. By examining random walk, serial correlation, and Q-statistics tests, Asal (1998) studied the efficiency of ESM using daily observation from 1992 to 1997. The result shows that ESM was inefficient. Simons and Laryea (2006) examined the efficiency of ESM using weekly data from Alexandria Exchange for a sample period ranging from 1997 to 2002. They used the Kolmogorov-Smirnov (KS) Goodness of Fit Test, Runs Test, Auto-Correlation, and Variance Ratio Test. The result indicated that ESM was inefficient in the study period. Moreover, Al-Jafari and Altaee (2011), Ahmed (2013), Nwosu, Orji, and Anagwu (2013), and El-Ansary and Mohssen (2017) argued that ESM is an inefficient market. Contrary to the above studies, Ahmed and Ahmed (2016) and Abakah et al. (2018) claimed that ESM is efficient in the weak form of efficiency.

Several empirical studies were conducted to examine whether the Indian stock market is efficient. For instance, Barua (1981) investigated the weak-form efficiency of

the Indian stock market by employing autocorrelation and run tests for the period spanning from July 1977 to June 1979. The result indicated that the Indian stock market was efficient in the weak form of efficiency. Further, Vaidyanathan and Gali (1994) investigated the efficiency of the Indian stock market by applying run tests, autocorrelation, and filter tests. They claimed that the result of the study supported the weak-form efficient market hypothesis.

Samanta (2004) examined the daily price observations from 4 January 1993 to 31 December 2001 by classifying them into 18 sub-periods to explore the changes in efficiency over time for the Indian stock market. The result indicated a fluctuation in efficiency from period to period, and there was an improvement in efficiency in the last sub-periods. Jain and Jain (2013) examine the weak-form efficiency of the Indian stock exchange for the period spanning from 1993 to 2013 using the runs test, autocorrelation, and unit root test. They also present a result in the efficiency of the Indian stock exchange in the weak form of efficiency. Similar to the results of the above studies, Srivastava (2010), P. Jain, Vyas, and Roy (2013), Chavannavar and Patel (2016), and Ryaly, Raju, and Urlankula (2017) presented evidence about the weak form efficiency of Indian stock market.

Contrary to studies claiming the weak-form efficiency of the Indian stock market, several studies depicted evidence of the inefficiency of the Indian Stock market. For example, Poshakwale (1996) examined the weak-form efficiency of the Bombay Stock Exchange from 1987 to 1994. He employed frequency distribution, Kolmogorov–Smirnov, runs, and autocorrelation tests. The finding indicated that the Bombay Stock Exchange did not fulfill the weak-form efficient market hypothesis criteria. Khan Masood, Shahid, and Shahid (2006) also studied whether the Indian stock market is efficient or not in the weak form efficiency for the period from 1999 to 2004. They employed the Unit Root test, Autocorrelation, GARCH Model, and Kolmogorov–Smirnov test, and the result indicated that the Indiana stock market was inefficient. Likewise, A. Khan, Ikram, and Mehtab (2011) conducted a study on the efficiency of the Indian stock market using daily closing stock prices from the National Stock Exchange (NSE) and Bombay Stock Exchange (BSE) covering the period from 1 April 2000 to 31 March 2010. They conclude that the Indian stock market was weak for inefficient.

Gupta (2014) also examined the weak form of efficiency Indian stock market using the unit root test, runs test, and Kolmogorov–Smirnov test from January 2003 to

December 2012. The finding indicated that Indian stock was not weak-form efficient in the study period. Similarly, Kumar and Singh (2013) investigated the weak-form efficiency of the Indian stock market using the daily price observation from 1 January 2000 to 31 March 2013. They employed the Unit Root test, runs test, and Kolmogorov–Smirnov, showing that the Indian stock market is inefficient. Besides, studies were done by Pandey (2003), Thomas and Kumar (2009), Mishra, Misra, and Rastogi (2012), Jana and Meher (2012), Mehla and Goyal (2012), Arora (2013), and Dsouza and Mallikarjunappa (2015) presented evidence against the efficiency of Indian stock market.

Kenya's stock market is one of the samples selected in this study as a proxy for developing lower-middle-income countries. There are empirical studies conducted on whether the Kenyan stock market is efficient. Among them, Dickinson and Muragu (1994) examined the weak-form efficiency of the Nairobi Stock Exchange for the period from 1974 to 1978 using serial correlation and run tests. The finding shows that Nairobi Stock Exchange fulfilled the criteria of randomness. Anyumba (2010) also examined the Nairobi stock exchange's weak form efficiency and concluded it was efficient in the study period. Further, Bulla (2015) studied the weak-form efficiency of the Nairobi Stock Exchange using a serial correlation test and run test from 2000 to 2009. The finding indicated that Nairobi Stock Exchange fulfills the requirements of the random walk hypothesis.

Owido, Onyuma, and Owuor (2013) also investigated the Nairobi Stock Exchange using Auto-Regressive Conditional Heteroscedasticity (ARCH) models from 2006 to 2011. The result shows that Nairobi Stock Exchange is weak-form inefficient. Moreover, studies like Jeboisho (2014), Njuguna (2015), and Kamau (2018) examined the weak-form efficiency of the Nairobi stock exchange and found that the Nairobi stock exchange is weak-form inefficient.

Colombo Stock Exchange (CSE) is one of the sample stock markets selected from developing lower-income countries' stock markets. The followings are among the empirical studies conducted to examine the weak-form efficiency of the Sri Lanka stock market. Abeyratne and Power (1995) investigated the weak form efficiency of CSE using autocorrelation and run tests from April 1993 to July 1994. They conclude that CSE was not weak-form efficient. Samarakoon, Hasan, and Hasan (1999) also studied whether CSE is weak-form efficient or not using autocorrelation, Runs Test, Unit Root Test, and Kolmogorov-Smirnov Test for the period spanning from January 1985 to December 1995.

The study's findings indicated that CSE was not weak-form efficient within the study period. Further, Abeysekera (2001) examines CSE's weak form efficiency by employing autocorrelation, run tests, and unit root tests by collecting daily, weekly, and monthly price observations from January 1991 to November 1996. He concluded that CSE was not efficient in the weak form of efficiency. Moreover, studies such as Samarakoon (2004), Samaratunga (2009), Pathirawasam and Idirisinghe (2011), Fernando (2012), Dedunu (2017), and Fernando and Gunasekara (2018) also claimed that CSE is an inefficient stock market. On the contrary, Rehman, Masood, Arshed, and Shah (2012) presented evidence efficiency of CSE.

This section is devoted to reviewing empirical studies conducted to examine the weak-form efficiency of the Tunisian stock market. Among them, Saadi, Gandhi, and Dutta (2006) investigated the weak-form efficiency of the Tunisian stock exchange by making linear and nonlinear dependence analyses. The study's finding shows that the Tunisian stock market is not weak-form efficient. Furthermore, Guermezi and Boussaada (2016) studied banking sector stocks for the period July 2012 to June 2013 using GARCH (1, 1) and its extension EGARCH (1,1). The finding depicted that the Tunisian stock market banking sector is not weak-form efficient. Finally, Theiri and Ati (2020) also examined the efficiency of the Tunisian stock market using 52 stocks over the period 2014-2018. They applied the unit root test, Box–Pierce, and ARCH. The finding indicated that most sample stock indexes do not follow the random walk hypothesis.

Table 3

Selected Studies On the Weak Form Efficiency of DLMI Countries

Author(s)	Sample countries	Method	Sample period	Results
Appiah-Kusi and Menyah (2003)	Including Egypt and Kenya	EGARCH-M model	1990 to 1995	Efficient market
Jefferis and Smith (2005)	Including Egypt and Kenya	GARCH Models	1990 to 2001	Inefficient market
A. Worthington and Higgs (2006b)	Including Egypt, India, and Sri Lanka	Autocorrelation, Runs tests, unit root, and Variance ratio tests.	1997 to 2003	Inefficient market
Mlambo and Biekpe (2007)	Including Egypt, Kenya, and Tunisia	Serial correlation and Runs Test	1998:1 to 2002:12	Mixed Result
Smith (2008)	Including Egypt and Kenya	Variance ratio tests	2000:1 to 2006:9	Inefficient market
Alagidede and Panagiotidis (2009)	Including Egypt, Kenya, Tunisia	GARCH Models	1998 to 2006	Inefficient market
Enowbi et al. (2010)	Including Egypt and Tunisia	Autocorrelation, Unit root tests, and Variance ratio tests	2000:1 to 2009:3	Inefficient market

Nisar and Hanif (2012)	Including India and Sri Lanka	Runs test, serial correlation, unit root, and variance ratio test	1997 to 2011	Inefficient market
Gyamfi, Kyei, and Gill (2016)	Including Egypt, Kenya, and Tunisia	Non-parametric Generalized Spectral (GS) test	2000:8 to 2015:8	Inefficient market
Hamid et al. (2017)	Including India and Sri Lanka	Autocorrelation, Runs Test, Unit Root Test, and Variance Ratio Tests	2004:1 to 2009:12	Inefficient market
Kelikume, Olaniyi, and Iyohab (2020)	Including Egypt and Kenya	Wavelet Unit Root Test	2010:1 to 2018:5	Inefficient market
Dias and Santos (2020)	Including Egypt and Kenya	Variance ratio tests	2019:9 to 2020:9	Inefficient market

3.2. Literature Review on Semi-Strong Form of Stock Market Efficiency

This section is devoted to reviewing previous works of literature conducted to test the strong semis form of efficiency for sample developed and developing countries' stock markets.

3.2.1. Literature Review on Semi-Strong form Efficiency of Developed Countries

Using macroeconomic variables such as Money supply (M0, M3, M6), Real economic activity, price level, and the risk-free rate of return; Groenewold and Kang (1993) investigated the semi-strong form of efficiency of the Australian stock market for the period from 1982(8)-1988(6). They found that some macro variables have predictive power, and they conclude that in the 1980s, the semi-strong form efficiency of the Australian stock market did not emerge. Hatemi-J and Morgan (2009) also examined the semi-strong form efficiency of the Australian stock market using interest rates and the exchange rate variables from 1994 to 2006. The Granger non-causality tests result indicated that the interest rate and exchange rate may explain the change in stock price. Therefore, they conclude that the Australian stock market was not efficient in the semi-strong regarding interest and exchange rates.

Siddiqui (2003) examined the German stock market's semi-strong form efficiency by assessing the explanatory power of interest rate for feature stock market price. He collected the average three-month interest rate from January 1960 to May 2002 and employed a linear regression model. The result of the study depicted that interest rate has no explanatory power to explain feature stock return. Therefore, this indicated that the German stock market was semi-strong efficient in this study period. Further, Plíhal (2016) studied the semi-strong form efficiency of Germany's stock market using macroeconomic variables such as inflation, industrial production index, interest rate, money supply,

exchange rate, and trade balance for the period spanning from January 1999 to September 2015. He employed Johansen Co-Integration Test and Granger Causality. The finding indicated that none of these variables could explain the feature change in stock price. Accordingly, the German stock market is efficient in the semi-strong form of efficiency. Furthermore, Celebi and Hönig (2019) examined the impact of 24 factors on the German stock market using 27 years of data from 1991 to 2018. The finding indicated that macroeconomic variables significantly affected the German stock market during the crisis period.

Mukherjee and Naka (1995) studied the relation between the Japanese stock market and macro factors such as exchange rate, money supply, inflation, industrial production, long-term government bond rate, and call money rate using the Vector Error Correction Model (VECM). The finding shows that macro variables significantly affect the Japanese stock market. Therefore, this may violate the semi-strong form of the efficient market hypothesis. On the contrary, Hartmann and Pierdzioch (2007) examine the association between exchange rate and Japanese stock market return. They conclude that exchange rate movements can explain stock market return. Accordingly, considering the exchange rate, the Japanese stock market is efficient in the semi-strong form. Moreover, Megaravalli and Sampagnaro (2018) investigated the long-run and the short-run link between Japanese stock markets and macroeconomic variables such as exchange rates and inflation from January 2008 to November 2016. The cointegration and Granger causality test results only indicated a significant association between macroeconomic variables and the Japanese stock market in the long run.

Besides macroeconomic variables, a semi-strong form of efficiency can be tested using events like elections. Accordingly, Gwilym and Buckle (1994) examined the semi-strong form efficiency of the UK stock market using the 1992 UK election. They assessed the impact of opinion poll results on the stock market as the publicly available information. They conclude that the London stock market was semi-strong efficient as links between opinion polls and the stock market indexes are found. Likewise, Sir (2012) investigated the impact of the consumer price index, interest rates, exchange rates, money supply, and industrial productions on the UK stock market from February 1999 to January 2011. The finding shows that some macroeconomic variables can explain stock market variation in the UK. Thus, this indicated the inefficiency of the UK stock market in the semi-strong form.

Kraft and Kraft (1977) studied the causal relationship between the US stock market and macroeconomic variables such as money supply, the rate of change in the money supply, the corporate interest rate, and the riskless interest rate from 1955 to 1974. The causality test result indicated that none of these variables explained the future stock price change and suggested that the US stock market is semi-strong. Likewise, Hancock (1989) tests the semi-strong form of the US stock market using macroeconomic variables such as money stock, change in deficit, inflation, unemployment, GDP, government expense, and 3-month t-bill rate for the period from 1960 to 1985. The study's finding shows that the impact of these macroeconomic variables on the US stock market is insignificant and indicates that the US stock market is efficient in the semi-strong form of efficiency.

Contrary to the above studies, Laopodis (2009) examine the impact of fiscal policy actions on The US stock market from 1968 to 2005. The finding shows that past budget deficits negatively affect the stock market. So this indicates that the US stock market was semi-strong considering fiscal policy actions. Similarly, Bhuiyan and Chowdhury (2020) examine the association between the US stock market and macroeconomic variables such as industrial production, money supply, and long-term interest rate from 2000 to 2018. Again, the finding shows a significant relationship between the sample microeconomic variables and the US stock market during the study period.

3.2.2. Literature Review on Semi Strong fo Efficiency of DUMI Countries

De Carvalho et al. (2016) examined the semi-strong form efficiency of the Brazilian stock market through an event study by collecting intraday price and volume data from November 2012 to February 2014. The finding presents evidence regarding the efficiency of the Brazilian stock market in the semi-strong form as publicly available information fastly reflects on price. Furthermore, Similarly, Batista, Maia, and Romero (2018) investigated the efficiency of the Brazilian stock market in the semi-strong form using the event of the 2016 Brazilian presidential impeachment. Their finding shows that the Brazilian stock market is a well-informed market and efficient semi-strong form. Finally, contrary to the event study outcomes, studies such as Montes and Tiberto (2012), Linck and Frota Decourt (2016), Pandey and Sabamaithily (2018), de Araújo, Camozzato, and Yoon (2020), and Bernardelli and De Castro (2020) examines the semi-strong form efficiency of Brazilian stock market using publicly available macroeconomic

data and indicates that Brazilian stock market is inefficient in the semi-strong form of efficiency.

In examining the semi-strong form efficiency of the Chinese stock market, Ma (2000) deeply investigated the weak and semi-strong form efficiency of the Chinese stock market and concluded that the Chinese stock market is neither weak form nor semi-strong form efficient. Further, Kong and Taghavi (2006) examine the effect of annual earnings announcements on the Chinese stock market. Applying the M-EGARCH model, they test the possibility of beating the Chinese stock market using earning reports. The finding shows that there is room to get abnormal returns using earning announcement information. Therefore, they reject the semi-strong form of efficiency for the Chinese stock market. Finally, employing the APT, VECM, and Granger-Causality test, Ning, Wah, and Erdan (2019) examines the impact of macroeconomic variables such as interest rate, money supply, exchange rate, and inflation rate on the Chinese stock market for the period from September 1997 to December 2016. The finding indicated that macroeconomic variables have a significant effect on the Shanghai stock market. However, they have not affected the Hong Kong stock market. Therefore, the result shows a mixed result on the semi-strong efficiency of the Chinese stock market.

The Malaysian stock market is one of the sample stock markets used as a proxy for DUMI countries' stock markets. Considering the semi-strong form efficiency of the Malaysian stock market, Ibrahim (2000) examines the effect of macroeconomic variables such as exchange rate, money supply, and official reserves on the Malaysian stock market from January 1979 to June 1996. He applied the cointegration and causality test. The finding indicates that macroeconomics variables are influenced the movements of the Malaysian stock market. Therefore, the Malaysian stock market was inefficient in the semi-strong form. Similarly, studies such as Ibrahim (1999), Asmy, Rohilina, Hassama, and Fouad (2009), Thaker, Rohilina, Hassama, and Amin (2010), Yunus, Mahyideen, and Saidon (2014), Nasir, Hassan, Nasir, and Harun (2017), and Chauque and Rayappan (2018) investigated the macroeconomic variables on the Malaysian stock market. They concluded that macroeconomic variables significantly impact Malaysian stock market fluctuation. Consequently, these studies present evidence of the semi-strong inefficiencies of the Malaysian stock market.

Considering the semi-strong form efficiency of the South African stock market, Glass and Smit (1995) studied the impacts of anticipated and unanticipated monetary

growth on the Johannesburg stock exchange (JSE) from 1978 to 1992. The finding indicated that anticipated and unexpected monetary growth significantly explains the change in share prices. Consequently, the stock market of South Africa is inefficient in the semi-strong form of efficiency. Furthermore, Olivier (2018) and Ncanywa and Ralarala (2019) examined the semi-strong efficiency of JSE. They concluded that JSE is inefficient in the semi-strong form of efficiency due to the significant prediction power of examined variables.

On the contrary, Alam, Uddin, and Taufique (2011) reviewed the impact of the exchange rate on the JSE from 2000 to 2004. The finding indicated that exchange rate was not a significant factor to forecast stock price changes in JSE. Therefore, considering exchange rate, JSE is a semi strong efficient stock exchange.

The study conducted by Muradoglu and Metin (1996) and Balaban, Candemir, and Kunter (1996) are among the earliest studies on testing the semi-strong form of the Turkish stock market. They investigated the semi-strong form of the Turkish stock market by examining macroeconomic variables' impact on the Turkish stock exchange. Both studies show that the Turkish stock market was inefficient in the semi-strong form of efficiency during the 1990s. Yalaman and Celik (2008) examine the semi-strong form efficiency of Turkish money and capital market by employing Toda Yamamoto Causality Test. Their finding indicated that money markets in Turkey are in the semi-strong form of efficiency while the Turkish capital market is not efficient.

Gencer and Demiralay (2013) studied the impact of oil prices on 18 stock indexes from Borsa Istanbul using monthly observation from January 2002 to April 2013. They documented a mixed result regarding the effect of oil prices on Borsa Istanbul. Altinbaş, Kutay, and Akkaya (2015) investigated the impact of macroeconomic variables such as interest rate, inflation, exchange rate, oil prices, and industrial production index on the Turkish stock market. The finding reveals that macroeconomic factors significantly explain the change in the stock market. Finally, Kaderli, Doganer, and Baskaya (2017) examine the semi-strong form efficiency of Borsa Istanbul through event study analysis using the announcements of new business association as an event and conclude that the Turkish stock market was not efficient in the semi-strong form.

Additionally, Studies such as Alper and Esen (2017), Vardar, Kurt-Gumus, and Delice (2018), Demir (2019), İlhan and Akdeniz (2020), and Sivrikaya (2021) examined the impacts of macroeconomic variables on the Turkish stock market. The finding of these

studies reveals that at least one macroeconomic factors explain the fluctuation in the Turkish stock market. Therefore, the significant impact of macroeconomic variables indicated the inefficiencies of the Turkish stock market in the semi-strong form.

3.2.3. Literature Review on Semi-Strong form Efficiency of DLMI Countries

Omran and Pointon (2001) examined inflation's long and short-run impact on Egypt's stock market. The finding reveals that inflation is a significant determinant factor for Egypt's stock market for short and long-run time horizons. Similarly, Omran (2003) tests the impact of interest rate on Egypt's stock market and concludes that interest rate significantly affects the performance of Egypt's stock market. Besides, Messaouda (2021) investigated the semi-strong form efficiency of Egypt's stock market through the problem of asymmetric information. The study's finding indicates that the Egyptian stock market is not efficient in the semi-strong form due to the leakage of information before announcements to the public.

Studies such as Mandal and Rao (2010) and P. Gupta and Sardana (2018) examined the semi-strong form efficiency of the Indian stock market using publicly announced information such as earnings announcements and demonetization announcements, respectively. Both studies conclude that the Indian stock market is semi-strong form efficient concerning the examined information. On the contrary, Mallikarjunappa and Dsouza (2013) reviewed the semi-strong form of Indian stock market earnings announcements. The finding shows that the Indian stock market was inefficient regarding earnings announcements.

Pal and Mittal (2011) investigated the impact of macroeconomic variables such as interest rates, exchange rates, inflation, and gross domestic savings on the Indian stock market from January 1995 to December 2008. They applied the unit root test, co-integration, and error correction mechanism (ECM). The finding reveals that macroeconomic variables significantly impact the Indian stock market. Further, Naik and Padhi (2012), Agrawal and Sangeetha (2019), and Singh and Padmakumari (2020) examined the semi-strong form efficiency of the Indian stock market using macroeconomic variables. Their finding indicated that the Indian stock market is inefficient in the semi-strong form of efficiency. Contrary to this, Bhattacharya and Mukherjee (2003) and Baranidharan and Dhivya (2020) macroeconomic variables did not

significantly affect the Indian stock market. Therefore, they claimed that the Indian stock market is efficient in the semi-strong form of efficiency.

Considering to Kenya Stock exchange, Abonyo (2003) investigated the predictive power of macroeconomic variables such as inflation, money supply, GDP growth rate, T-bill interest rates, and exchange rate on the Kenya stock exchange. The finding shows that the examined macroeconomic factors have significant predictive power on the Kenya stock exchange. Further, Oriwo (2012) also examined the impact of macroeconomic variables such as interest rate, inflation rate, and T-bill on the Kenya stock exchange from March 2008 to March 2012. He concludes that macroeconomic variables significantly affect Kenya's stock market performance. Furthermore, Barasa (2014), Wasseja, Njoroge, and Mwenda (2015), Ndunda (2016), Karubari (2017), and Wanjiru, Omondi, and Ochieng (2020) examined the semi-strong form efficiency of Kenya stock exchange using macroeconomic variables. Their finding reveals that at least one macroeconomic variable significantly affected the Kenya stock exchange. Therefore, the Kenya stock exchange is inefficient in the semi-strong form of efficiency.

Gunasekarage, Pisedtasalasai, and Power (2004) studied the semi-strong form efficiency of the Sri Lanka stock market using macroeconomic variables such as money supply, consumer price index, and the treasury bill rate, and the exchange rate from January 1985 to December 2001. They conclude that macroeconomic variables were explained only a minority portion of stock market fluctuation. Similarly, Wickremasinghe (2011) examined the impact of six macroeconomic variables on the Sri Lanka stock exchange from January 1985 to December 2004. The test result shows a possibility of predicting stock market fluctuation using some macroeconomic variables. Furthermore, Pallegedara (2012), Nijam, Ismail, and Musthafa (2015), Sinnathamby and Rajapakse (2018), and Wijesooriya (2021) examined the prediction power of macroeconomics variables for the Sri Lanka stock exchange. They conclude that macroeconomic variables are significantly explaining Sri Lanka stock exchange fluctuations. Thus, the result indicated that the Sri Lanka stock exchange is not efficient in the semi-strong form of efficiency.

Hamma, Jarboui, and Ghorbel (2014) examined the association between oil prices and the Tunisia stock market from 2 April 2006 to 12 July 2012. The empirical finding indicated a unidirectional relationship between the oil market to the Tunisian stock market. Therefore, the oil market significantly affects the Tunisian stock market. Also,

El Ouni, Hamdaoui, and Lahdhiri (2014) studied the causality relationship between the Tunisia Stock market and Macroeconomic variables. The finding shows a causality relationship between macroeconomic variables to the Tunisia Stock market. According to the Tunisian stock market is inefficient in the semi-strong form of efficiency.

Further, Ben Yaala and Henchiri (2016) also examined the long and short-run impact of macroeconomic variables such as money supply, budget deficit, inflation, interest rate, rate, exchange rate, and mine production index on the Tunisian stock market for the period from January 2008 to December 2014. They applied correlation analysis, and Autoregressive distributed Lag (ARDL). The study results reveal that macroeconomic factors significantly affect the Tunisian stock market in the short and long run. Additionally, Boussaidi and Dridi (2020) investigated the momentum effect on the Tunis Stock Exchange from 1999 to 2016. The finding indicated that the significantly-adjusted momentum gains are statistically and economically significant. Thus, it violates the semi-strong form of the stock market efficiency hypothesis.

Table 4
Selected Studies on Semi-Strong Form Efficiency of Sample Countries

Author(s)	Sample countries	Variables	Method	Sample period	Results
Developed Countries					
Darrat (1987)	Germany and UK	Money Growth, inflation, interest rate, GNP, and budget deficit	Regression	1960 to 1982	Inefficient
Mookerjee (1987)	Japan, Germany, the UK, and the USA	money supply (M1) and (M2)	Granger Causality Test	1975:1 to 1985:3	The only US and UK efficient
Cheung and Ng (1998)	Germany, Japan, and the U.S.	Crude oil, M1, GNP, and total personal consumption	Johansen cointegration	1957:1–1992:2	Inefficient
Humpe and Macmillan (2009)	Japan and The US	Industrial production, consumer price index, money supply, and the long-term interest rate	cointegration analysis	1965 to 2005	Inefficient
M. Alam and Uddin (2009)	Australia, Germany, and Japan	interest rate	panel regressions	1998 to 2003	Inefficient
Masood, Tvaronavičienė, and Javaria (2019)	G7 countries	oil prices	Arbitrage pricing theory	2009:9 to 2016:8	Inefficient
Developing upper Middle Income					
Gay Jr (2008)	BRIC	Exchange rate and oil price	Box-Jenkins model	1999 to 2006	Efficient
M. Alam and Uddin (2009)	Malaysian and S.Africa	Interest rate	panel regressions	1998 to 2003	Inefficient
Lone, Darzi, and Islam (2021)	BRICS	Macroeconomic variables	ARDL bounds testing model and PMG/ARDL model	2011–2021	Inefficient except in South Africa
Developing Lower-middle Income					
Barakat, Elgazzar, and Hanafy (2016)	Egypt and Tunisia	CPI, exchange rate, money supply, and interest rate	Cointegration and Granger Causality Test	1998:1 to 1997:12	Inefficient
Moussa and Delhoumi (2021)	Egypt and Tunisia	interest rate and exchange rate	non-linear autoregressive distributed lag (NARDL)	1998:6 to 2018:6	Inefficient

3.3. Conclusion

This chapter reviews previous empirical studies which examined the weak and semi-strong forms of stock market efficiency of the sample countries' stock markets. Studies examining the weak form efficiency of developed and developing countries are reviewed in the first part of this chapter. Even though some researchers reported the inefficiency of stock markets in developed countries such as Australia, Germany, Japan, the UK, and the USA in the weak form of efficiency, most empirical studies have revealed that these countries' stock markets became efficient in a weak form of efficiency. However, considering the weak form efficiency of developing-upper-middle income countries such as Brazil, China, Malaysia, South Africa, and Turkey's stock markets, half of the studies examined claim the weak form efficiency of these markets. In contrast, the other half of the reviewed studies report the inefficiency of these markets. Most of the reviewed studies on developing-lower-income countries such as Egypt, India, Kenya, Sri Lanka, and Tunisia's stock markets conclude that these markets are inefficient in the weak form efficiency.

The second part of this section is devoted to reviewing the literature on testing semi-strong stock market efficiency for sample country stock markets. Previous empirical studies on the semi-strong form efficiency of stock markets in developed countries such as Australia, Germany, Japan, the UK, and the USA are not unanimous. Considering the semi-strong form efficiency of stock markets in emerging upper-middle-income countries such as Brazil, China, Malaysia, South Africa, and Turkey, it is difficult to say that they are categorically efficient in the semi-strong form. However, the efficiency of the stock market in these countries shows improvement in their efficiency from time to time. The semi-strong form efficiency of sample stock markets in Egypt, India, Kenya, Sri Lanka, and Tunisia is not identified categorically in the previous studies. Therefore, based on the studies reviewed, it is possible to conclude these stock markets' inefficiencies in semi-strong efficiency.

CHAPTER IV

RESEARCH METHODOLOGY

This chapter presents the details about sample countries, sample stock indexes, study period, and methods selected for analysis.

This study investigates the weak and semi-strong forms of stock market efficiency for 15 countries selected based on their economic level. According to the 2019 World Economic Situation and Prospects (WESP), countries in the world are classified into three broad categories: developed economies, economies in transition, and developing economies. WESP also produces another classification based on per capita gross national income (GNI). According to this report, countries have been grouped as high-income, upper-middle-income, lower-middle-income, and low-income (United Nations, 2019). Depending on the above classification and considering geographical location, five countries: Australia, Germany, Japan, the UK, and the USA are selected to represent developed or high-income countries. On behalf of developing countries, five countries, namely China, Malaysia, Brazil, South Africa, and Turkey from developing upper-middle-income (DUMI) and five countries such as Egypt, Kenya, India, Sri Lanka, and Tunisia from Developing lower-middle-income (DLMI) countries are selected.

After selecting countries to be included in the sample, the next step is determining the stock market index for each country. The criterion for selecting the index is identifying the indexes that highly represent each country's stock market. Thus, the selected countries and their sample indexes are presented below.

4.1. Testing the Weak form of Efficiency

The primary step for investigating sample stock indexes' efficiency in the weak form is to decide the study period and the types of observations that should collect. Therefore, each sample index's weekly closing price observation from January 8, 2000, to December 28, 2019, is collected from www.investing.com and <https://finance.yahoo.com>. The second procedure is deciding the stock return computation from the raw weakly price observation. There are two types of return computation methods in finance: simple liner returns and continuously compounded or log returns (Meucci, 2010). Studies such as Amihud and Mendelson (1991), Worthington

and Higgs (2005), Kim and Shamsuddin (2008), Nisar and Hanif (2012), Mobarek and Fiorante (2014), Ryaly et al. (2014), and Hamid et al. (2017) employed continuously compounded or log return method to calculate a time series return. Consequently, in this study, the sample stock's time series returns are calculated using the common logarithm method of continuously compounded or geometric returns. The weekly log returns are defined as follows:

$$R_{x,t} = \ln \left(\frac{p_{x,t}}{p_{x,t-1}} \right) * 100$$

Where $p_{x,t}$ Denotes the weekly closing price of the stock market index on day t.

Table 5
Sample countries and Selected Stock Indexes

No.	Country	Selected Index
1	Australia	ASX 200: Australian Securities Exchange(ASE) 200 Index
2	Germany	DAX 30: Deutscher Aktien Index(German stock index) 30
3	Japan	Nikkei 225 Index
4	UK	FTSE 100:The Financial Times Stock Exchange 100 Index
5	USA	S&P 500: Standard & Poor's 500 Index
6	Brazil	BOVESPA: Brazil Sao Paulo Stock Exchange Index
7	China	SZCI: SZSE Component Index
8	Malaysia	KLCI: Kuala Lumpur Composite Index
9	South Africa	SE Top 40: Johannesburg Stock Exchange (JSE) 40 Index
10	Turkey	BIST 100: Borsa Istanbul 100 Index
11	Egypt	EGX 30: Egyptian Exchange (EGX) 30 Index
12	India	Nifty 50: National Stock Exchange (NSE) Fifty Index
13	Kenya	NSE 20: Nairobi Securities Exchange (NSE) 20 Index
14	Sri Lanka	CSE All Share Price Index
15	Tunisia	TUNINDEX: Tunisia Stock Market Index

Researchers have applied several analyzing methods to investigate the weak form of the efficient market hypothesis. To select the best and most effective analyzing practices, the author reviewed previous studies' analysis methods. Consequently, the following techniques are chosen based on the review, and they will apply in this research to test the weak form efficiency of selected stock markets.

4.1.1. Autocorrelation

Autocorrelation is a conventional method to detect whether a time series follows a random walk. Campbell, Lo, and MacKinlay (1997) defined autocorrelation as “a correlation between two observations of the same series at different dates.” Further, Tsay (2014) also stated that assuming a time series x and the correlation between x_t and x_{t-k}

is known as “lag-k autocorrelation of x .” Statistically, the autocorrelation coefficient is defined as follows:

$$\rho_k = \frac{Cov(x_t, x_{t-k})}{\sqrt{Var(x_t), Var(x_{t-k})}} = \frac{Cov(x_t, x_{t-k})}{Var(x_t)} = \frac{\gamma_k}{\gamma_0}$$

Where ρ_k denotes the autocorrelation coefficient of series x at lag k , γ_k represents the autocovariance coefficients of series x at lag k . If ρ_k results are significantly non-zero, and the weak form of efficiency or random walk hypothesis will reject. In the autocorrelation test; $H_0: \rho_k = 0$ and $H_1: \rho_k \neq 0$ (Tsay, 2014). Different test statistics are applied to test autocorrelation. Among them, the Q test statistics, initially developed by Box and Pierce (1970) and then improved by Ljung and Box (1978), is an appropriate test of autocorrelation with multiple lag lengths (Islam & Erum, 2019). Ljung and Box (1978) proposed a Q test model to investigate autocorrelation jointly with various lags. Thus, the Q test statistics can be computed as follows:

$$Q_m = T(T+2) \sum_{k=1}^m \frac{\rho_k^2}{T-k}$$

Where T denotes the number of observations and m represents the number of autocorrelation. The decision criteria are “to reject H_0 if $X_\alpha^2 > Q_m$ and $X_\alpha^2 = 100(1-\alpha)$ th percentile of chi-squared distribution with m degrees of freedom”. If the p -value of Q_m is calculated, the decision criteria are to reject H_0 if $P \text{ value} < \alpha$, where α significance level (Tsay, 2014).

4.1.2. The Run Test

The run test is among the simple non-parametric tests applied to assess whether a time series follows a random walk or not. Wald and Wolfowitz (1940) developed the run test, sometimes called Wald–Wolfowitz runs test. From the stock price perspective, a run is just a series of stock’s price or return deviations with the same track. A stock price or return series may be either a positive (+) or negative (-) change (Pettway, 1984). The notion behind the run test is if the stock price or returns changes follow a random walk, “the actual number of runs should be close to the expected number of runs” (Borges, 2010). Let assume n^+ and n^- are the number of positive and negative stock price changes, respectively in n amount of sample observations. Where $n = n^+ + n^-$ and for extensive sample observations, the z statistic is calculated as follows:

$$Z = \frac{R - E(R)}{\sigma R}$$

Where R denotes the actual number of runs, $E(R)$ represents the expected number of runs, and σR indicates the standard deviation of runs.

$$E(R) = \frac{2n^+n^-}{n} + 1$$

$$\sigma R = \sqrt{\frac{2n^+n^-(2n^+n^- - n)}{n^2(n - 1)}}$$

If the computed z-value is > -1.96 and $< +1.96$, the value is significant, and the series follows a random walk. And if the inverse result appears, the value is insignificant, and the series is not following a random walk (Nisar & Hanif, 2012).

4.1.3. Unit Root Test

The random walk hypothesis is one of the prominent models researchers have applied to test the efficient market hypothesis in its weak form. Several studies on stock market efficiency, such as Chan et al. (1992), Choudhry (1994), Cooray (2003), Worthington and Higgs (2005), Samaratunga (2009), Mishra (2011), Ryaly et al. (2014), Malafeyev et al. (2017), and Ahmed and Hossain (2018) used unit root tests to examine whether a time series follow random walk or not.

The unit root test usually investigates whether a time series has a unit root (non-stationary) or has not had a unit root (stationary). When a time series follows a stochastic trend or unpredictable pattern, it can be said the series has a unit root. One of the essential characteristics of a unit root time series is the overtime changes of its mean and variance (Glynn, Perera, & Verma, 2007). There are two types of unit root processes: trend-stationary and difference-stationary (Hatanaka, 1996). As stated by Zivot and Wang (2006), difference-stationary and trend-stationary are appropriate for first-order integration $I(1)$ and zero-order integration $I(0)$ respectively. Non-stationary or unit root processes are also named $I(1)$ or first-order integration. Unit root test Postulates “the null hypothesis of a unit root (non-stationary), and an alternative hypothesis of a stationary (or trend stationery) time series” (Herranz, 2017).

Different models are developed to test whether a time series is stationary or non-stationary. It is possible to categorize unit root tests into two groups: traditional unit root

tests that do not consider a structural break and unit root tests that consider structural breaks.

Traditional Unit Root Tests: Several studies applied these unit root tests that do not consider a structural break in the time series to examine whether a series follows a random walk. There are various types of unit root tests, where the most common are the Augmented Dickey-Fuller (ADF) tests (1979), the Phillips-Perron (PP) test (1988), and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test (1992). Accordingly, these three unit root tests are selected to investigate the random walk hypothesis.

Augmented Dickey-Fuller (ADF) test: Dickey-Fuller (1979) developed a model to test a unit root in time series. This model is known as τ (tau) test or Dickey-Fuller (DF) test. DF test assumes the error term (ε_t) is uncorrelated (Gujarati, 2004). Therefore, considering different possibilities, the DF test is predicted in the following three forms:

- I. X_t is a random walk (no drift): $\Delta X_t = \delta X_{t-1} + \varepsilon_t$
- II. X_t is a random walk (with drift): $\Delta X_t = \beta_1 + \delta X_{t-1} + \varepsilon_t$
- III. X_t is a random walk (with drift around a trend): $\Delta X_t = \beta_1 + \beta_{2t} + \delta X_{t-1} + \varepsilon_t$

Where ε_t is an error term, X_t is a dependent variable at time t , Δ is the first difference, and t is the time or trend variable. For the above three cases, “the null hypothesis is that $\delta = 0$; that is, there is a unit root—the time series is nonstationary. The alternative hypothesis is that δ is less than zero; that is, the time series is stationary” (Gujarati, 2004).

By assuming if error terms (ε_t) are correlated, and by including p lags of the independent variable in the model, Dickey and Fuller (1981) proposed an extended DF test called Augmented Dickey-Fuller (ADF) test (Brooks, 2019). ADF test is implemented by "augmenting" the abovementioned three DF equations by adding the lagged values of the dependent variable X_t as follows:

$$\Delta X_t = \beta_1 + \beta_{2t} + \delta X_{t-1} + \sum_{i=1}^m \alpha_i \Delta X_{t-i} + \varepsilon_t$$

Where ΔX_t is the first difference of a time series, $\Delta X_{t-1} = (X_{t-1} - X_{t-2})$ and $\Delta X_{t-2} = (\Delta X_{t-2} - \Delta X_{t-3})$, etc. $H_0: \delta = 0$ and $H_1: \delta < 0$, m is the maximum lag length of the dependent variable, which is decided by different information criteria like

Akaike criterion (AIC), Schwarz criterion (SIC), Hannan-Quinn criterion (HQC), etc. In this study, AIC was applied to determine the lag length.

Phillips-Perron (PP) test: Dickey and Fuller (1981) improved the DF test by adding the independent variable's lags into the model by controlling serial correlation and heteroskedasticity in the error term. Accordingly, selecting the lag length is one of the potential problems in the ADF test (Arltová & Fedorová, 2016). Thus, Phillips and Perron (1988) proposed a nonparametric statistical method that does not include the model's lag differences to overcome the error term's serial correlation and heteroskedasticity problem. The analyzing equation of PP is:

$$\Delta X_t = \beta D_t + \delta X_{t-1} + \varepsilon_t$$

Where: D_t is a vector of deterministic terms such as constant, trend, etc. ε_t is zero-order integration I (0) and “maybe heteroskedastic.” The PP test controls serial correlation and heteroskedasticity in the error term ε_t by adjusting the test statistics $t_\delta = 0$ and T_δ .

Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test: ADF and PP models are testing the null hypothesis of unit root (non-stationary) by assuming a time series X_t is integrated in the first order I (1). On the contrary, Kwiatkowski, Phillips, Schmidt, and Shin (1992) developed a model that assumed the null hypothesis of stationary around a deterministic trend I (0). This model is called Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test. They started by defining their regression model as follows: $X_t = \delta_t + r_t + \varepsilon_t$. Where ε_t a stationary is process and r_t is a random walk given by $r_t = r_{t-1} + u_t$, $u_t \sim iid(0, \sigma_u^2)$. The null hypothesis of stationarity is expressed as $H_0: \sigma_u^2 = 0$ or r_t is constant. KPSS test is based on LM test and it defined as:

$$LM = \frac{\sum_{t=1}^T S_t^2}{\hat{\sigma}_e^2}$$

Where e_t are the residuals from the regression of X_t on a constant and a time trend, $\hat{\sigma}_e^2$ is the residual variance from this regression (residual sum of squares divided by T) and S_t is the partial sum of e_t defined by $S_t = \sum_{i=1}^t e_i$, $t = 1, 2, 3, \dots, T$ (Maddala & Kim, 1998).

Unit Root Test With Structural Break: Traditional unit root tests are suspected of spurious results due to not considering the structural change in the time series. For the first time, Perron (1989) argued that if time series have a structural break, traditional unit root tests will be able to reject the null hypothesis of having a unit root. After Perron's

(1989) study, considering a structural change in the unit root test gained more momentum. Therefore, it is recommendable to check unit roots using structural break methods. So, Zivot–Andrews and Bai-Perron unit root tests, which evaluate single and multiple structural breaks, are applied in this study in addition to traditional unit root tests.

The Zivot–Andrews Unit Root Tests with One Structural Break: Considering structural breaks, Perron (1989) states that the 1929 great crash and the 1973 oil price shock are the two significant structural breaks between 1900 and 1986. Therefore, he claimed that one might find spurious results if the structural breaks are not considered in the unit root test model. Accordingly, Perron (1989) proposed a model that considers one exogenously structural break to overcome this problem. Following Perron’s recommendation, Zivot and Andrews (1992) developed a model to test unit root considering one endogenous structural break.

According to Zivot and Andrews (1992), in their one structural break model, the null hypothesis states that a series contains a unit root without any exogenous structural break. The alternative hypothesis also states that a series includes a trend-stationary with a structural break happening at an unspecified point in time. They demonstrated the alternative ideas depending on the ADF test statistics as in the Perron (1989) model to test the existence of unit root by the following three equations. Assume T_b is a potential break within a time series $\{y_t\}$ and then:

$$\text{Model (A): } y_t = \mu^A + \theta^A DU_t(\lambda) + \beta^A t + \alpha^A Y_{t-1} + \sum_{j=1}^k C_j^A \Delta Y_{t-j} + \varepsilon_t$$

$$\text{Model (B): } y_t = \mu^B + \beta^B t + \gamma^B DT_t(\lambda) + \alpha^B Y_{t-1} + \sum_{j=1}^k C_j^B \Delta Y_{t-j} + \varepsilon_t$$

$$\text{Model (C): } y_t = \mu^C + \theta^C DU_t(\lambda) + \beta^C t + \gamma^C DT_t(\lambda) + \alpha^C Y_{t-1} + \sum_{j=1}^k C_j^C \Delta Y_{t-j} + \varepsilon_t$$

Where DU_t is a dummy variable that denotes a break in the intercept and DT_t represents a break in the trend occurring at a time T_b . DU_t and DT_t define as follows. $DU_t(\lambda) = 1$ if $t > T_b$, 0 otherwise; $DT_t(\lambda) = t - T_b$ if $t > T_b$, 0 otherwise.

Model (A) allows a structural break in an intercept, Model (B) provides a structural break in a trend, and Model (C) allows for a structural break in both the intercept and trend. In this study, Model (C), which allows for a structural break in both the intercept and trend, is employed to investigate whether the selected time series follows a random walk.

The Bai-Perron Unit Root Tests with Multiple Structural Breaks: According to Lumsdaine and Papell (1997), Cooper (1998), and Chancharat and Valadkhani (2007), multiple structural breaks may exist in time series due to different reasons such as war, economic crisis, political events, policy changes, etc. Considering multiple structural breaks, Bai and Perron (1998) developed a unit root test that permits the analysis of the null hypothesis of i breaks versus the alternative hypothesis of $i + 1$ breaks. He proposed a multiple structural break unit root test based on the following multiple linear regression with T periods and m breaks.

$$Y_t = X_t' \beta + Z_t' \delta_j + u_t \quad (t = T_{j-1} + 1, \dots, T_j, j = 1, \dots, m + 1)$$

Where Y_t is the observed independent variable, X_t' and Z_t' are vectors of covariates with dimensions $p \times 1$ and $q \times 1$ respectively, β and δ_j ($j = 1, \dots, m + 1$) are the parallel vectors of coefficients, $T_1, \dots, T_m$ are represents the unknown breakpoints and u_t denotes the error term. Bai and Perron (1998) and (2003) developed the following three different test statistics to determine the number of breaks in the series.

1. A test of no break vs. a fixed number of breaks (supF type test)
2. Double Maximum Tests ($UD \max FT$ and $WD \max FT$)
3. A Test of L versus $L + 1$ Breaks ($SupF_T (L + 1|L)$)

From the abovementioned three types of Bai and Perron Multiple structural break tests, checking the availability of at least a structural break using the UD max or WD max tests is a preferable approach (Jouini & Boutahar, 2005). Therefore, in this study, we applied the UD max or WD max tests to examine the existence of multiple structural breaks for the sample stock indexes.

4.1.4. Variance Ratio Test

Lo and MacKinlay (1988) developed the variance ratio test, sometimes called the LOMAC variance ratio test. It is one of the widely applied tests to examine whether a series follows a random walk, i.e., efficient at the weak form or not. Lo and MacKinlay (1988) initially developed the variance ratio test depending on the “variance of

increments” attribute of the random walk hypothesis. This attribute states that if a series x_t following a random walk, “the variance of its increments is linear in the observation interval.” For instance, the variance of a four days difference should be four times the daily variance increments (Belaire-Franch & Contreras, 2004). Let x_t represents a time series variable containing $T + 1$ sample observations and the k^{th} difference variance ratio test value i.e., $VR(K)$, is defined as follows:

$$VR(k) = \frac{\sigma^2(k)}{\sigma^1(1)}$$

Where $\sigma^2(k)$ denotes the $1/k$ times the variance of $(x_t - x_{t-k})$ and $\sigma^1(1)$ represents the variance of $(x_t - x_{t-1})$. $H_0: VR(1) = 1$, meaning that if $VR(1) = 1$, the series follows a random walk. On the other hand, if $VR(1) < 1$ and $VR(1) > 1$ indicated that the series has a negative and positive autocorrelation, respectively (B. Zhang & Xindan, 2008). $\sigma^2(k)$ and $\sigma^1(1)$ computes as follows:

$$\sigma^2(k) = \frac{1}{m} \sum_{t=k}^T (x_t - x_{t-k} - k\mu)^2, m = k(T - K + 1)(T - k)/T$$

$$\mu = \frac{1}{T} \sum_{t=1}^T (x_t - x_{t-1}), \text{ and } \sigma^1(1) = \frac{1}{T-1} \sum_{t=1}^T (x_t - x_{t-1} - \mu)^2$$

LOMAC develop two individual variance ratio tests statistics such as $Z(K)$ test statistics which are robust under homoscedasticity and $Z^*(K)$ test statistics that are robust under heteroskedasticity. $Z(K)$ is robust under *iid* (independently and identically distributed) assumption while, $Z^*(K)$ is relaxed for *iid* assumption (Gradojević, Djaković, & Andjelić, 2010). $Z(K)$ and $Z^*(K)$ individual test statistics are computed as follows:

$$Z(K) = \frac{VR(K)-1}{\sqrt{\theta(K)}} \sim N(0,1) \quad \text{Where } \theta(k) = \frac{2(2k-1)(k-1)}{3kT}$$

$$Z^*(K) = \frac{VR(K)-1}{\theta^*(K)} \quad \text{Where } \theta^*(K) = \sum_{j=1}^{K-1} \left[\frac{2(K-j)}{K} \right]^2 \delta(j)$$

$$\delta(j) = \frac{\sum_{t=j+1}^T (x_t - x_{t-1} - \mu)^2 (x_{t-j} - x_{t-j-1} - \mu)^2}{[\sum_{t=1}^T (x_t - x_{t-1} - \mu)^2]^2}$$

4.2. Testing Semi Strong form of Efficiency

Examining the impact of publicly announced macroeconomic variables on the stock market is one of the methods used to test whether sample stock market series are efficient at the semi-strong form of efficiency or not. In this study, inflation (CPI),

money supply (M2/M3), exchange rates (ER), interest rates (IR), industrial production index (IPI), and crude oil price (OP) are selected as a proxy for macroeconomic variables.

Inflation: Inflation is one of the independent variables used in this study to assess the semi-strong form of stock market efficiency. Scott (1997) defines inflation as “a general increase in goods and services price level.” Several studies were conducted to investigate the effect of inflation on stock market fluctuation. For instance, earliest studies such as Bodie (1976), Jaffe and Mandelker (1976), Fama and Schwert (1977), and Schwert (1981) found a short-run negative relationship between inflation and stock return. On the contrary, studies such as Abdullah and Hayworth (1993) and Tripathi and Kumar (2015) found a long-run positive relationship. This study uses the Consumer Price Index (CPI) to proxy inflation.

Money supply: Money is an economy's aggregate quantity and worth. It is expected that changes in money supply directly impact portfolio variations and indirect impact on real economic activities. Due to this reason, the money supply is assumed to be the primary determinate of stock market return (Mookerjee, 1987). Several studies have investigated the nexus between money supply and stock market return. There are different types of the money stock measures, such as *M1* (Currency, demand deposits, and other checkable deposits), *M2* (*M1*+ savings and small deposits, overnight repos, money market funds), and *M3* (*M2*+ large time deposits and term repos). In this study, the broad money supply i.e., *M3* is used to measure the money supply.

Exchange rates: The correlation between exchange rate and the stock market return is explained by two opposite models. The first model claims that the exchange rate between two countries' currencies is affected by the changes in the stock price in the corresponding countries. On the contrary, the second model argues that the changes in the exchange rate between two countries' currencies affect the price of stocks in their respective countries (Fauziah, Moeljadi, & Ratnawati, 2015; Kanas, 2000). For this study, each country's currency with the US dollar exchange rate for sample countries except the USA, and the US dollar to yen exchange rate is used for the USA case.

Interest rates: The interest rate is one of the main determinates of stock price changes. An inverse causality is expected from the change in interest rate to the change in stock price. When an interest rate rises, the stock price will decrease as its present value is derived from the future dividends using the interest rate. On the other hand, when the

interest rate declines, the price of stock increases as low-interest rates encourage investment with a low cost of capital (Mok, 1993).

Industrial production index: Gross Domestic Product (GDP) measures the overall amount of goods and services made within the border of a sovereign country and is calculated quarterly and yearly. However, due to the unavailability of monthly data for GDP, most studies like Mukherjee and Naka (1995), Chen, Kim, and Kim (2005), Ratanapakorn and Sharma (2007), and Plíhal (2016) used Industrial Production Index (IPI) as a proxy of GDP. IPI is an economic indicator that measures the actual production yield of manufacturing, mining, and utilities relative to a specified base year. Therefore, a positive association between IPI and stock price is expected as an increase in actual economic activity positively impacts the productivity and profitability of industries and leads to a rise in stock price.

Crude Oil Price: Crude oil is one of the fundamental inputs for industrial production. The fluctuation of crude oil price has a profound impact on the economy in general; and on industries and corporations in specific through changing the inflation and household consumption level Kayalar, Küçüközmen, and Selcuk-Kestel (2017). Finally, its impact will reflect on the stock market. Despite no consent between researchers regarding the association between crude oil price and stock price, crude oil price change is one of the essential factors affecting stock price fluctuations. This study uses Cushing OK WTI Spot Price FOB Dollars per Barrel as the proxy crude oil price.

The sample stock indexes' monthly prices are collected from www.investing.com and <https://finance.yahoo.com>. Most macro variables are collected from the Federal Reserve Bank of St. Louis (FRED), and the remnants of data are gathered from each sample country's central banks and statistic agencies. The monthly observation was collected from January 2000 to December 2019. To test the semi-strong form efficient market hypothesis, if a significant negative or positive relation is found between the selected macro variables and stock return, the stock markets under study may not be efficient in semi-strong form. On the other hand, if no association is detected, the stock market is efficient at the semi-strong form of efficiency. For this purpose, cointegration analysis and causality tests are employed to investigate the impact of selected macro variables on sample stock markets.

4.2.1. Cointegration Analysis

Cointegration is an analysis technique for assessing the long-run relationship between two or more-time series variables. It tests the correlation between two or more time-series variables with a common stochastic trend. Assume that two-time series variables such as X_t and Y_t are integrated at the first order or I (1). Then X_t and Y_t are said to be cointegrated when a coefficient β i.e. $Y_t - \beta X_t$ is integrated at order zero or I (0). Where β denoted the cointegrated coefficient (Maddala & Kim, 1998). Further, Stock and Watson (2003) stated that “if X_t and Y_t are cointegrated, then they have the same, or common, stochastic trend. Computing the difference $Y_t - \beta X_t$ eliminates this common stochastic trend”. There are different types of tests applied to test cointegration. The communal tests used to detect cointegration are the Engle-Granger two-step method, Johansen test, and Phillips–Ouliaris cointegration tests. This study employs the Johansen cointegration test to investigate the cointegration between macroeconomic variables and the stock market.

Johansen Cointegration Test: The starting point of Johansen’s approach is vector autoregression (VAR) of order p given as follows:

$$Y_t = \mu + A_1 Y_{t-1} + \dots + A_p Y_{t-p} + \varepsilon_t$$

where Y_t is an $nx1$ vector of variables that are integrated in I(1) order and ε_t is an $nx1$ vector of innovations. This VAR can be re-written as

$$\Delta Y_t = \mu + \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-1} + \varepsilon_t$$

Where $\Pi = \sum_{i=1}^p A_i$ and $\Gamma_i = \sum_{j=i+1}^p A_j$

where the Γ_i ‘s and Π are matrixes of variables. The lag length in the VAR is i lags on each variable. If the coefficient matrix Π has reduced rank $r < n$, then there exist rxn matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is stationary. r is the number of cointegrating relationships, the elements of α are known as the adjustment parameters in the vector error correction model, and each column of β is a cointegrating vector. It can be shown that for a given r , the maximum likelihood estimator of β defines the combination of Y_{t-1} that yields the r largest canonical correlations of ΔY_t with Y_{t-1} after correcting for lagged differences and deterministic variables when present. Johansen suggests two distinctive probability ratio tests of the significance of these

established correlations and thereby the reduced rank of the Π matrix: λ_{max} = maximum eigenvalue and λ_{trace} = trace test.

$$\lambda_{trace} = -T \sum_{i=r+1}^n 1n(1 - \hat{\lambda}_i) \text{ and } \lambda_{max} = -T(1n(1 - \hat{\lambda}_i))$$

Where T is the sample size and $\hat{\lambda}_i$ is the i^{th} largest canonical correlation. The trace test tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of n cointegrating vectors. The maximum eigenvalue test, on the other hand, tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of $r + 1$ cointegrating vectors. The critical values of max and trace tests can be found in the study of Johansen and Juselius (1990) and in most econometrics packages.

4.2.2. Granger Causality Test

Granger (1969) proposed a method to detect causality between time series variables. The meaning x is a granger case of y means x is useful in forecasting Y_1 . Let us assume an information set of Ω_t that include $x_t \cdots x_{t-j}, y_t \cdots y_{t-i} \cdots$, we can say x_t is a *Granger cause* y_{t+h} when x_t is the optimal linear predictor y_{t+h} . Accordingly, x is Granger-causes y , if and only if $\sigma_1^2(y_t: y_{t-j}, x_{t-i}) < \sigma_2^2(y_t: y_{t-j})$, with j and $i = 1, 2, 3, \dots, n$ and σ^2 indicating the variance of the forecast error.

The Granger causality test can be performed through three types of situations. First, if only two variables are included in the model, the Simple Granger Causality Test is called. Second, it is called the multivariate Granger-causality test, When more than two variables are available in the model as one variable affects the result of others. Finally, the third type is a multivariate Granger-causality test in a VAR framework (Foresti, 2006). This paper employed a multivariate Granger-causality test to investigate the causality between macroeconomic variables and the stock market.

CHAPTER V

EMPIRICAL ANALYSIS AND RESULTS

This chapter presents the empirical analysis and results of the study. The first section exhibits the weak form of efficiency analysis results. Then, in the second part of this chapter, the outcomes of the semi-strong form of efficiency test are depicted.

As clearly stated in Chapter 4, this study encompasses a 20-year weekly study period from January 8, 2000, to December 28, 2019. To check whether stock markets are efficient and whether their efficiency changed over time, we classified the study period into three equal sub-periods and made an investigation for each period.

- I. The first sub-period covers from January 8, 2000, to August 26, 2006,
- II. The second sub-period embraces from September 1, 2006, to April 27, 2013, and
- III. The third sub-period covers from May 5, 2013, to December 28, 2019.

5.1. Testing The Weak Form Of Stock Market Efficiency

5.1.1. Descriptive Statistics

Before proceeding to the principal analysis of this study, the descriptive statistics of the data are computed to examine whether series are normally distributed. Normality is one of the characteristics of randomness. The series' normality characteristics can determine whether the series follows a random walk hypothesis. Accordingly, the following three consecutive tables describe the descriptive statics of all sample indexes for the entire sample period and three sub-periods.

Table 6 exhibits the descriptive statistics of developed countries' stock indexes for the entire sample period and sub-periods. It indicated that the mean of the log return for the whole sample period was positive. The maximum log returns of 14.9% were registered for the GDAXI index of Germany in the second sub-periods. In comparison, a minimum of -27.8% of log returns happened to the Nikkei 225 index of Japan in the second sub-period. The measure of variability indicated that the S&P ASX 200 index of Australia in

the first sub-period and GDAXI in the second sub-periods are the more stable and fluctuating stocks indexes with 1.53% and 3.56% standard deviation, respectively.

Table 6
Descriptive Statistics of Developed Countries' Stock Indexes

Indexes	Study Periods	Mean	Median	Max	Mini	Std. Dev.	Skew	Kurt	Jarque-Bera	Proba	Obs.
Australia (ASX200)	All period	0.076	0.254	9.114	-17.016	2.040	-0.940	9.172	1809.196	0.000	1043
	Sup period1	0.151	0.261	4.566	-5.260	1.533	-0.399	3.919	21.397	0.000	347
	Sub period 2	0.002	0.344	9.114	-17.016	2.704	-0.996	7.857	399.674	0.000	348
	Sub period 3	0.076	0.195	4.409	-5.934	1.682	-0.366	3.815	17.387	0.000	348
Germany (DAX 30)	All period	0.064	0.399	14.942	-24.347	3.125	-0.665	8.415	1351.375	0.000	1043
	Sup period1	-0.041	0.172	12.887	-13.919	3.353	-0.140	4.508	34.004	0.000	347
	Sub period 2	0.093	0.514	14.942	-24.347	3.563	-1.092	10.832	958.511	0.000	348
	Sub period 3	0.141	0.400	6.607	-8.685	2.326	-0.412	3.618	15.390	0.000	348
Japan (Nikkei225)	All period	0.025	0.237	11.450	-27.884	2.978	-1.094	10.988	2980.890	0.000	1043
	Sup period1	-0.035	0.245	9.469	-11.292	2.841	-0.291	3.390	7.083	0.029	347
	Sub period 2	-0.047	0.178	11.450	-27.884	3.372	-1.806	16.449	2811.647	0.000	348
	Sub period 3	0.157	0.258	8.807	-11.766	2.680	-0.514	4.552	50.283	0.000	348
UK (FTSE100)	All period	0.014	0.200	12.583	-23.632	2.360	-1.055	15.113	6570.406	0.000	1043
	Sup period1	-0.026	0.211	10.069	-8.866	2.172	-0.178	5.399	85.020	0.000	347
	Sub period 2	0.026	0.149	12.583	-23.632	2.987	-1.431	15.721	2465.217	0.000	348
	Sub period 3	0.042	0.215	6.909	-6.783	1.759	-0.322	4.265	29.242	0.000	348
USA (S&P 500)	All period	0.077	0.203	11.356	-20.084	2.402	-0.884	10.271	2433.436	0.000	1043
	Sup period1	-0.027	0.106	7.492	-12.330	2.380	-0.619	6.663	216.170	0.000	347
	Sub period 2	0.060	0.210	11.356	-20.084	2.951	-0.896	10.103	778.202	0.000	348
	Sub period 3	0.199	0.323	4.734	-7.312	1.715	-0.858	5.249	116.015	0.000	348

Skewness, kurtosis, and Jarque-Bera-test with p-value are among the main methods used to test the time series data's normality. According to Thadewald and Büning (2007), the theoretical value of skewness and kurtosis under normality are 0 and 3, respectively. However, for extensive sample size time series data, the value within ± 2 for skewness and within ± 7 for kurtosis may indicate substantial normality Kim (2013). Jarque-Bera test statistics is a function of skewness and kurtosis. The Jarque-Bera test null hypothesis states that the data may be normally distributed if the p-value is more than 5%. The inverse is true; if the p-value of the Jarque-Bera test is less than 5%, the series may not normally distribute.

The overall normality tests indicated that the listed indexes in Table 6 departed from normality. The skewness result in Table 6 showed that all indexes in full and all sub-periods are negatively skewed between -1.80 and -0.17. The negative skewness suggests that returns are highly flatted on the left. The kurtosis results also indicated that the kurtosis value is highly peaked and above 3.39. The p-value of the Jarque-Bera test is very small, and all are below 5%. However, when we checked the period change of

normality, there was a significant recovery to normality from the second to third sub-period.

The descriptive statistics of developing upper-middle-income countries are demonstrated in Table 7. The mean log return of indexes under this group is positive except for the KLCI index of Malaysia in the third sub-period. The BIST 100 index of Turkey recorded a maximum of 25.78 % and a minimum of -30.37% log return in the full and first-sub periods. The skewness is flatted chiefly on the left side, and their values are between -1.19 and 0.29. Jarque–Bera test results are very high, and their p-values are very small, indicating that the sample indexes in Table 7 are not normally distributed. The SA TOP 40 index of South Africa was normally distributed in the third sub-period with 0.089 skewness and 3.028 kurtoses. Jarque–Bera test was also very small, with a p-value of 0.763.

Table 7
Descriptive statistics of DUMI Countries' stock indexes

Indexes	Study Periods	Mean	Median	Max	Mini	Std. Dev.	Skew	Kurt	Jarque-Bera	Proba	Obs.
Brazil (BOVESPA)	All period	0.189	0.450	16.843	-22.326	3.709	-0.464	6.567	590.260	0.000	1043
	Sup period1	0.239	0.627	11.147	-19.994	4.186	-0.612	4.900	73.855	0.000	347
	Sub period 2	0.114	0.404	16.843	-22.326	3.884	-0.545	8.098	394.155	0.000	348
	Sub period 3	0.216	0.364	16.562	-8.537	2.955	0.223	5.135	69.006	0.000	348
China (SZCI)	All period	0.067	0.014	13.945	-15.860	3.292	-0.273	5.787	350.458	0.000	1043
	Sup period1	0.022	0.000	10.698	-8.148	2.811	0.296	4.595	41.854	0.000	347
	Sub period 2	0.086	0.000	13.945	-14.898	3.899	-0.025	4.511	33.148	0.000	348
	Sub period 3	0.093	0.313	9.109	-15.860	3.077	-1.198	8.055	453.778	0.000	348
Malaysia (KLCI)	All period	0.064	0.108	12.590	-11.448	1.867	-0.358	8.466	1320.892	0.000	1043
	Sup period1	0.046	-0.003	12.590	-11.448	2.200	0.057	8.251	398.894	0.000	347
	Sub period 2	0.163	0.356	6.653	-9.712	2.016	-0.989	6.449	229.134	0.000	348
	Sub period 3	-0.019	0.025	4.662	-5.236	1.245	-0.045	5.234	72.489	0.000	348
South Africa (SE Top 40)	All period	0.177	0.273	17.921	-11.101	2.750	-0.058	6.520	539.076	0.000	1043
	Sup period1	0.265	0.403	11.441	-11.101	2.925	-0.487	4.505	46.452	0.000	347
	Sub period 2	0.155	0.298	17.921	-11.006	3.154	0.222	7.522	299.333	0.000	348
	Sub period 3	0.111	0.191	7.114	-5.715	2.055	0.089	3.028	0.470	0.791	348
Turkey (BIST 100)	All period	0.190	0.499	25.783	-30.369	4.521	-0.274	8.484	1312.680	0.000	1037
	Sup period1	0.256	0.618	25.783	-30.369	6.003	-0.193	6.807	211.688	0.000	347
	Sub period 2	0.210	0.526	15.758	-19.273	3.993	-0.373	5.551	102.425	0.000	348
	Sub period 3	0.103	0.216	8.337	-14.371	3.049	-0.574	4.526	51.925	0.000	342

Table 8 depicts the descriptive statistics of developing lower-middle-income countries' stock indexes. The mean of log returns is positive except for the EGX30 index of Egypt in the second sub-period and the NSE20 index of India in the third sub-period. A maximum of 19.3% and a minimum -21.9% log return were registered for EGX30 under the third and second sub-periods. NSE20 was negatively skewed during the entire sample period, and the CSE ALL index of Sri Lanka was positively skewed during the

full and all sub-sample period. The Jarque–Bera test result is higher than 3.57, and the p-value of the Jarque–Bera test is almost near zero. Therefore, the overall descriptive statistics in Table 8 revealed that sample indexes in the third group also exit from normality.

Table 8
Descriptive Statistics of DLMI Countries' stock Indexes

Indexes	Study Periods	Mean	Median	Max	Mini	Std. Dev.	Skew	Kurt	Jarque-Bera	Proba	Obs.
Egypt (EGX 30)	All period	0.236	0.388	19.319	-21.958	4.091	-0.561	6.932	721.768	0.000	1036
	Sup period1	0.475	0.466	13.846	-17.410	4.306	-0.096	4.357	27.143	0.000	347
	Sub period 2	-0.086	0.377	15.523	-21.958	4.489	-1.188	7.555	382.658	0.000	348
	Sub period 3	0.323	0.345	19.319	-16.705	3.368	0.104	8.646	453.485	0.000	341
India (Nifty 50)	All period	0.194	0.379	14.357	-17.375	2.991	-0.556	6.468	576.581	0.000	1043
	Sup period1	0.158	0.412	14.357	-17.375	3.539	-0.383	5.906	130.942	0.000	348
	Sub period 2	0.218	0.576	10.994	-13.131	3.285	-0.735	5.049	92.006	0.000	347
	Sub period 3	0.207	0.277	6.280	-7.026	1.894	-0.198	3.571	6.996	0.030	348
Kenya (NSE 20)	All period	0.015	-0.011	14.810	-14.680	2.416	0.438	9.900	2102.624	0.000	1043
	Sup period1	0.191	-0.071	14.810	-6.365	2.338	1.431	10.123	851.913	0.000	347
	Sub period 2	0.020	0.123	14.594	-14.680	2.990	-0.034	7.963	357.254	0.000	348
	Sub period 3	-0.166	-0.078	9.341	-7.368	1.752	-0.023	6.579	185.770	0.000	348
Sri Lanka (CSE)	All period	0.230	0.037	17.953	-11.327	2.462	0.778	9.595	1995.684	0.000	1043
	Sup period1	0.398	0.142	17.953	-10.429	3.087	0.833	8.485	475.127	0.000	347
	Sub period 2	0.287	0.035	11.806	-11.327	2.661	0.280	5.242	77.393	0.000	348
	Sub period 3	0.005	-0.115	4.366	-4.619	1.241	0.122	4.249	23.504	0.000	348
Tunisia (TUNINDEX)	All period	0.168	0.130	8.347	-13.626	1.473	-0.654	16.884	8435.871	0.000	1041
	Sup period1	0.149	0.091	8.347	-7.285	1.455	0.995	10.753	926.308	0.000	347
	Sub period 2	0.232	0.275	7.912	-13.626	1.795	-1.778	17.826	3360.844	0.000	347
	Sub period 3	0.124	0.072	6.226	-3.640	1.086	0.464	6.579	197.647	0.000	347

The descriptive statistics presented in Table 6,7 and 8 shows that all sample indexes under the three categories were not normally distributed except in South Africa. Furthermore, the descriptive statistics of all sample indexes revealed that the second sub-period, which covers from September 2, 2006, to April 27, 2013, is significantly departed from normality compared to other sub-periods. The reason for this significant deportation from normality is that the second sub-period encompasses the 2008 financial crisis. To sum up, there is a substantial improvement in the data from non-normality to normality from the second to the third sub-period.

5.1.2. Autocorrelation Test Result

Autocorrelation is a traditional method that detects whether a time series follows a random walk. The autocorrelation coefficient (AC) and Ljung–Box Q-statistics with their P-value from 1 to 24-week lags are presented in the following tables.

Table 9
Autocorrelation Results for Developed Countries the Entire Period

Lag	Australia (ASX 200)			Germany (DAX 30)			Japan (Nikkei 225)			UK (FTSE 100)			USA (S&P 500)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	-0.07	4.4**	0.04	-0.04	1.6	0.21	-0.01	0.2	0.67	-0.07	5.1**	0.02	-0.07	5.4**	0.02
2	0.02	4.7	0.10	0.05	4.0	0.14	0.05	2.5	0.29	0.03	5.8	0.05	0.05	8.2**	0.02
3	-0.04	6.6	0.09	-0.10	13.5*	0.00	-0.05	5.0	0.17	-0.12	20.3*	0.00	-0.08	14.0*	0.00
4	-0.04	8.3	0.08	0.03	14.7*	0.01	0.00	5.0	0.28	-0.05	22.6*	0.00	-0.03	15.1*	0.01
5	0.04	10.3	0.07	0.00	14.7*	0.01	0.00	5.0	0.41	0.04	24.5*	0.00	0.02	15.6*	0.01
6	0.04	11.9	0.06	0.06	18.6*	0.01	0.02	5.3	0.51	0.03	25.7*	0.00	0.05	18.4*	0.01
7	-0.03	12.7	0.08	-0.05	20.8*	0.00	0.00	5.3	0.63	-0.09	34.5*	0.00	-0.06	22.7*	0.00
8	0.01	12.8	0.12	0.00	20.8*	0.01	0.02	5.6	0.69	0.05	37.0*	0.00	0.02	23.2*	0.00
9	0.04	14.5	0.11	-0.03	22.0*	0.01	0.00	5.7	0.77	-0.04	38.8*	0.00	-0.06	26.4*	0.00
10	-0.01	14.7	0.14	-0.01	22.2**	0.01	0.01	5.8	0.83	-0.03	39.6*	0.00	0.01	26.5*	0.00
11	-0.02	15.0	0.18	0.02	22.5**	0.02	-0.01	5.9	0.88	0.00	39.6*	0.00	0.05	29.1*	0.00
12	-0.04	16.6	0.17	-0.04	24.3**	0.02	0.02	6.1	0.91	-0.06	43.8*	0.00	-0.02	29.7*	0.00
13	0.07	21.6	0.06	0.07	30.0*	0.01	0.04	8.0	0.84	0.12	59.3*	0.00	0.01	29.8*	0.01
14	0.04	23.0	0.06	0.01	30.1*	0.01	0.00	8.0	0.89	0.00	59.3*	0.00	0.01	29.8*	0.01
15	0.02	23.3	0.08	0.02	30.4*	0.01	0.00	8.0	0.92	0.04	60.6*	0.00	0.06	34.1*	0.00
16	0.00	23.3	0.11	0.02	30.7**	0.02	0.00	8.0	0.95	0.05	62.9*	0.00	0.03	35.3*	0.00
17	0.02	23.7	0.13	-0.02	31.0**	0.02	0.02	8.3	0.96	-0.05	65.2*	0.00	0.01	35.3*	0.01
18	-0.02	23.9	0.16	0.00	31.0**	0.03	-0.01	8.5	0.97	-0.01	65.2*	0.00	-0.04	36.8*	0.01
19	-0.02	24.5	0.18	0.00	31.0**	0.04	0.02	8.8	0.98	0.02	65.5*	0.00	0.00	36.8*	0.01
20	0.04	25.9	0.17	0.03	32.2**	0.04	0.05	11.3	0.94	0.02	65.9*	0.00	0.03	37.8*	0.01
21	0.05	28.6	0.12	0.03	33.1	0.05	0.04	12.9	0.91	0.06	69.6*	0.00	0.06	42.2*	0.00
22	0.03	29.3	0.14	0.08	39.4*	0.01	0.02	13.5	0.92	0.03	70.6*	0.00	0.03	42.9*	0.01
23	0.00	29.3	0.17	-0.01	39.4**	0.02	-0.04	15.2	0.89	0.00	70.6*	0.00	0.02	43.1*	0.01
24	-0.07	34.5	0.08	-0.03	40.3**	0.02	-0.07	20.9	0.64	-0.03	71.9*	0.00	-0.03	44.0*	0.01

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

Table 10
Autocorrelation Results for Developed Countries in the first sub-period

Lag	Australia (ASX 200)			Germany (DAX 30)			Japan (Nikkei 225)			UK (FTSE 100)			USA (S&P 500)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	-0.04	0.52	0.47	-0.04	1.58	0.21	-0.01	0.07	0.79	0.03	0.21	0.64	-0.08	2.12	0.15
2	-0.03	0.77	0.68	0.05	3.97	0.14	-0.01	0.08	0.96	-0.07	1.89	0.39	0.03	2.43	0.30
3	0.06	2.14	0.54	-0.10	13.52*	0.00	0.00	0.08	0.99	-0.11	5.92	0.12	-0.04	2.91	0.41
4	-0.09	4.84	0.30	0.03	14.68*	0.01	0.03	0.42	0.98	-0.07	7.51	0.11	-0.08	4.90	0.30
5	0.03	5.13	0.40	0.00	14.70*	0.01	0.04	1.02	0.96	0.04	8.15	0.15	-0.02	4.98	0.42
6	-0.02	5.33	0.50	0.06	18.62*	0.01	0.00	1.02	0.99	0.05	8.88	0.18	0.05	5.93	0.43
7	-0.11	9.28	0.23	-0.05	20.76*	0.00	0.02	1.12	0.99	-0.03	9.14	0.24	-0.07	7.87	0.34
8	0.03	9.60	0.29	0.00	20.76*	0.01	0.01	1.18	1.00	-0.01	9.20	0.33	-0.07	9.83	0.28
9	-0.01	9.67	0.38	-0.03	22.01*	0.01	-0.04	1.85	0.99	-0.03	9.56	0.39	-0.04	10.51	0.31
10	0.01	9.74	0.46	-0.01	22.23*	0.01	0.06	3.09	0.98	0.05	10.28	0.42	0.06	11.99	0.29
11	0.06	10.90	0.45	0.02	22.54**	0.02	0.06	4.27	0.96	0.01	10.29	0.51	0.15	20.34**	0.04
12	-0.05	11.89	0.46	-0.04	24.33**	0.02	0.02	4.35	0.98	0.09	13.01	0.37	0.03	20.61	0.06
13	0.06	12.97	0.45	0.07	30.04*	0.01	0.04	4.84	0.98	0.09	15.94	0.25	-0.02	20.79	0.08
14	-0.05	13.83	0.46	0.01	30.08*	0.01	0.01	4.88	0.99	-0.07	17.69	0.22	-0.06	22.23	0.07
15	-0.01	13.85	0.54	0.02	30.44*	0.01	-0.05	5.87	0.98	-0.05	18.51	0.24	0.01	22.30	0.10
16	-0.05	14.71	0.55	0.02	30.67**	0.02	0.03	6.17	0.99	0.02	18.71	0.28	0.01	22.36	0.13
17	0.09	17.82	0.40	-0.02	30.95**	0.02	-0.03	6.41	0.99	-0.01	18.78	0.34	0.02	22.46	0.17
18	-0.02	18.01	0.46	0.00	30.97**	0.03	-0.01	6.44	0.99	0.01	18.81	0.40	-0.08	24.68	0.13
19	-0.08	20.60	0.36	0.00	30.97**	0.04	-0.07	8.42	0.98	-0.07	20.54	0.36	-0.10	27.99	0.08
20	0.03	21.02	0.40	0.03	32.17**	0.04	0.06	9.73	0.97	-0.05	21.49	0.37	-0.05	28.74	0.09
21	0.02	21.12	0.45	0.03	33.06	0.05	0.05	10.52	0.97	0.08	23.92	0.30	0.10	32.55	0.05
22	0.09	24.21	0.34	0.08	39.39*	0.01	0.07	12.38	0.95	0.15	31.76	0.08	0.10	36.00**	0.03
23	0.01	24.23	0.39	-0.01	39.44**	0.02	-0.05	13.43	0.94	-0.01	31.78	0.11	0.05	36.87**	0.03
24	-0.05	25.14	0.40	-0.03	40.33**	0.02	-0.09	16.39	0.87	-0.05	32.77	0.11	0.00	36.87	0.05

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

Table 11

Autocorrelation Results for Developed Countries in the second sup-period

Lag	Australia (ASX 200)			Germany (DAX 30)			Japan (Nikkei 225)			UK (FTSE 100)			USA (S&P 500)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	-0.06	1.14	0.29	-0.12	4.66**	0.03	-0.02	0.16	0.69	-0.14	6.66*	0.01	-0.06	1.43	0.23
2	0.01	1.19	0.55	0.15	12.70*	0.00	0.14	7.03**	0.03	0.11	11.14*	0.00	0.08	3.76	0.15
3	-0.04	1.85	0.60	-0.10	16.44*	0.00	-0.07	8.66**	0.03	-0.12	16.10*	0.00	-0.10	6.94	0.07
4	-0.03	2.24	0.69	-0.03	16.71*	0.00	0.01	8.70	0.07	-0.07	17.81*	0.00	-0.03	7.31	0.12
5	0.08	4.25	0.51	0.04	17.20*	0.00	-0.01	8.72	0.12	0.08	20.01*	0.00	0.08	9.58	0.09
6	0.09	6.88	0.33	0.08	19.21*	0.00	0.05	9.46	0.15	0.07	21.56*	0.00	0.07	11.24	0.08
7	-0.03	7.14	0.41	-0.11	23.23*	0.00	0.01	9.50	0.22	-0.13	27.64*	0.00	-0.06	12.31	0.09
8	0.03	7.37	0.50	0.06	24.43*	0.00	0.03	9.73	0.28	0.11	32.29*	0.00	0.07	14.05	0.08
9	0.03	7.78	0.56	-0.08	26.83*	0.00	0.02	9.84	0.36	-0.11	36.45*	0.00	-0.09	16.99	0.05
10	-0.05	8.69	0.56	-0.08	28.97*	0.00	-0.04	10.42	0.41	-0.08	38.96*	0.00	-0.03	17.27	0.07
11	-0.04	9.40	0.59	-0.02	29.15*	0.00	-0.06	11.58	0.40	-0.01	39.00*	0.00	-0.01	17.28	0.10
12	-0.02	9.62	0.65	-0.09	31.89*	0.00	0.01	11.60	0.48	-0.18	50.19*	0.00	-0.07	19.20	0.08
13	0.09	12.79	0.46	0.12	36.91*	0.00	0.10	15.03	0.31	0.17	60.19*	0.00	0.04	19.67	0.10
14	0.10	16.17	0.30	0.10	40.69*	0.00	0.04	15.50	0.35	0.06	61.32*	0.00	0.08	21.87	0.08
15	0.04	16.72	0.34	0.05	41.47*	0.00	0.04	16.05	0.38	0.09	64.59*	0.00	0.12	26.87**	0.03
16	0.02	16.84	0.40	0.02	41.67*	0.00	-0.03	16.46	0.42	0.05	65.57*	0.00	0.06	28.12**	0.03
17	0.02	16.94	0.46	-0.05	42.44*	0.00	0.06	17.63	0.41	-0.05	66.60*	0.00	0.01	28.17**	0.04
18	-0.01	16.96	0.53	0.01	42.51*	0.00	-0.03	17.87	0.46	0.01	66.61*	0.00	-0.02	28.27	0.06
19	0.01	17.03	0.59	0.06	43.62v	0.00	0.05	18.74	0.47	0.07	68.50*	0.00	0.06	29.72	0.06
20	0.05	18.08	0.58	0.07	45.64*	0.00	0.05	19.70	0.48	0.05	69.42*	0.00	0.08	32.01**	0.04
21	0.06	19.26	0.57	-0.02	45.78*	0.00	0.01	19.77	0.54	0.07	71.18*	0.00	0.04	32.58	0.05
22	0.03	19.53	0.61	-0.01	45.82*	0.00	0.00	19.77	0.60	-0.02	71.35*	0.00	-0.01	32.64	0.07
23	-0.03	19.78	0.66	0.01	45.84*	0.00	-0.06	21.00	0.58	0.00	71.35*	0.00	-0.02	32.74	0.09
24	-0.07	21.37	0.62	-0.02	46.03*	0.00	-0.12	26.69	0.32	-0.04	71.98*	0.00	-0.07	34.72	0.07

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

Table 12

Autocorrelation Results for Developed Countries in the third sup-period

Lag	Australia (ASX 200)			Germany (DAX 30)			Japan (Nikkei 225)			UK (FTSE 100)			USA (S&P 500)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	-0.11	4.36**	0.04	0.0	0.3	0.6	0.00	0.00	0.98	-0.02	0.13	0.72	-0.10	3.26	0.07
2	0.06	5.59	0.06	-0.1	2.2	0.3	-0.05	0.97	0.62	-0.08	2.39**	0.30	-0.01	3.33	0.19
3	-0.12	10.87*	0.01	-0.1	3.1	0.4	-0.09	3.61	0.31	-0.13	8.09**	0.04	-0.09	6.25	0.10
4	-0.02	10.97**	0.03	0.1	7.4	0.1	-0.06	4.74	0.32	0.05	8.88	0.06	0.04	6.91	0.14
5	-0.02	11.13	0.05	0.0	8.2	0.1	-0.05	5.56	0.35	-0.06	9.95	0.08	-0.09	9.81	0.08
6	-0.02	11.28	0.08	0.0	8.2	0.2	-0.01	5.62	0.47	-0.07	11.55	0.07	0.00	9.81	0.13
7	0.02	11.48	0.12	-0.1	9.3	0.2	-0.01	5.64	0.58	-0.07	13.25	0.07	-0.08	12.11	0.10
8	-0.04	12.01	0.15	-0.1	11.4	0.2	0.02	5.81	0.67	-0.04	13.77	0.09	0.04	12.67	0.12
9	0.06	13.37	0.15	0.1	13.6	0.1	-0.01	5.87	0.75	0.11	18.16**	0.03	0.01	12.69	0.18
10	0.05	14.15	0.17	0.0	13.7	0.2	0.00	5.87	0.83	0.01	18.23	0.05	-0.03	12.98	0.23
11	-0.01	14.20	0.22	0.0	13.7	0.3	-0.02	6.01	0.87	0.00	18.23	0.08	0.01	12.99	0.29
12	-0.06	15.32	0.23	0.0	14.3	0.3	0.04	6.55	0.89	0.04	18.71	0.10	0.02	13.11	0.36
13	0.00	15.32	0.29	0.0	14.3	0.4	-0.02	6.71	0.92	0.05	19.43	0.11	-0.05	13.91	0.38
14	-0.05	16.08	0.31	-0.1	15.4	0.4	-0.06	8.18	0.88	-0.08	21.81	0.08	-0.06	15.18	0.37
15	-0.02	16.27	0.36	0.0	15.4	0.4	-0.02	8.34	0.91	0.00	21.81	0.11	0.00	15.18	0.44
16	0.00	16.27	0.43	0.0	15.6	0.5	0.00	8.34	0.94	0.06	23.00	0.11	-0.02	15.34	0.50
17	-0.04	16.76	0.47	0.0	15.8	0.5	-0.02	8.42	0.96	-0.07	24.57	0.11	-0.04	15.82	0.54
18	-0.02	16.88	0.53	0.0	15.9	0.6	-0.01	8.44	0.97	-0.06	25.81	0.10	-0.02	15.91	0.60
19	-0.05	17.97	0.53	0.0	16.0	0.7	0.05	9.29	0.97	-0.04	26.51	0.12	-0.01	15.98	0.66
20	-0.01	17.99	0.59	0.0	16.9	0.7	0.03	9.68	0.97	0.05	27.33	0.13	0.05	16.82	0.66
21	0.06	19.31	0.57	0.0	17.6	0.7	0.07	11.43	0.95	0.02	27.50	0.16	0.06	18.03	0.65
22	-0.02	19.52	0.61	0.1	19.9	0.6	0.01	11.49	0.97	0.05	28.27	0.17	0.01	18.07	0.70
23	0.06	20.84	0.59	-0.1	21.0	0.6	0.02	11.58	0.98	0.00	28.27	0.21	0.04	18.64	0.72
24	-0.10	24.69	0.42	0.0	21.5	0.6	0.00	11.58	0.98	0.00	28.28	0.25	0.01	18.71	0.77

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

The autocorrelation test results for developed countries' stock indexes for the whole period, the first sub-period, the second sub-period, and the third sub-period are presented in Tables 9,10,11, and 12. The autocorrelation result for the entire study period

indicated that only the Japan stock index does not have a significant autocorrelation. On the other hand, Australia, Germany, UK, and USA indexes have at least one significant autocorrelations within 24 lags. These indicated that only the Japanese stock markets seem following a random walk during the entire period.

When we check the efficiency improvement from one sub-period to the following sub-period, all developed indexes have no significant autocorrelations except for Germany and the USA in the first sub-period. The second sub-period result shows significant autocorrelations for Germany, Japan, the UK, and the USA. German, Japan, and the USA indexes have no significant autocorrelations in the third sub-period. The p-value of these countries' indexes is more than 5%. Hence, this indicated that German, Japan, and the USA stock indexes were following Random walk in the last sub-period cover from May 5, 2013, to December 31, 2019. Consequently, the result implies an improvement from inefficiency to efficiency from the previous to the following sub-period.

Table 13

Autocorrelation Results for DUMI Countries in the Entire Period

Lag	Brazil (BOVESPA)			China (SZCI)			Malaysia (KLCI)			South Africa (SE Top 40)			Turkey (BIST 100)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	-0.09	7.6*	0.01	0.06	4.3**	0.04	0.08	6.2*	0.01	-0.07	5.3**	0.02	-0.03	1.2	0.27
2	0.07	13.3*	0.00	0.05	6.9**	0.03	0.04	8.1**	0.02	-0.01	5.4	0.07	0.08	8.5*	0.01
3	0.00	13.3*	0.00	0.05	9.8**	0.02	-0.01	8.1**	0.04	-0.06	9.0**	0.03	0.01	8.6**	0.04
4	0.03	14.2*	0.01	0.03	10.4**	0.03	0.02	8.7	0.07	0.01	9.1	0.06	-0.03	9.8**	0.04
5	0.00	14.2*	0.01	0.00	10.4	0.06	0.05	11.2	0.05	0.00	9.1	0.11	-0.02	10.2	0.07
6	0.06	18.3*	0.01	0.03	11.3	0.08	0.03	12.0	0.06	0.04	10.8	0.10	-0.09	17.9*	0.01
7	-0.07	23.0*	0.00	-0.01	11.4	0.12	0.02	12.5	0.09	-0.02	11.3	0.13	-0.02	18.3*	0.01
8	-0.01	23.0*	0.00	0.08	18.4**	0.02	-0.01	12.5	0.13	-0.04	12.7	0.12	-0.05	20.5*	0.01
9	-0.02	23.3*	0.01	0.07	23.9*	0.00	-0.04	14.5	0.10	0.05	15.4	0.08	0.00	20.6**	0.02
10	-0.06	27.1*	0.00	0.00	23.9*	0.01	0.01	14.7	0.14	0.00	15.4	0.12	-0.03	21.6**	0.02
11	0.01	27.2*	0.00	0.06	27.8*	0.00	-0.02	15.3	0.17	0.01	15.5	0.16	0.03	22.6**	0.02
12	-0.01	27.4*	0.01	0.02	28.4*	0.01	0.00	15.3	0.22	-0.06	19.4	0.08	0.03	23.6**	0.02
13	0.02	27.7*	0.01	-0.01	28.6*	0.01	0.02	16.0	0.25	0.08	25.4**	0.02	0.01	23.7**	0.03
14	0.03	28.9*	0.01	-0.04	30.7*	0.01	0.05	19.0	0.17	0.04	27.3**	0.02	0.06	27.1**	0.02
15	0.00	28.9**	0.02	0.02	31.1*	0.01	0.04	20.7	0.15	0.01	27.3**	0.03	-0.01	27.1**	0.03
16	-0.02	29.4**	0.02	0.04	32.4*	0.01	0.04	22.2	0.14	0.02	27.5**	0.04	0.02	27.5**	0.04
17	0.03	30.6**	0.02	0.11	44.9*	0.00	0.00	22.2	0.18	-0.06	30.7**	0.02	-0.01	27.6	0.05
18	-0.03	31.3**	0.03	0.05	47.0*	0.00	0.02	22.5	0.21	0.01	30.8**	0.03	-0.02	28.2	0.06
19	-0.01	31.5**	0.04	0.09	55.2*	0.00	-0.01	22.7	0.25	-0.02	31.4**	0.04	-0.02	28.5	0.07
20	0.05	34.2**	0.03	0.08	62.6*	0.00	-0.01	22.8	0.30	0.02	32.0**	0.04	-0.04	30.2	0.07
21	-0.01	34.3*	0.03	0.08	69.5*	0.00	-0.01	22.9	0.35	-0.02	32.4	0.05	-0.02	30.7	0.08
22	0.04	36.2**	0.03	-0.03	70.1*	0.00	0.06	27.0	0.21	0.00	32.4	0.07	-0.03	31.4	0.09
23	-0.04	37.6**	0.03	-0.01	70.2*	0.00	0.07	31.6	0.11	0.00	32.4	0.09	0.04	33.4	0.07
24	-0.01	37.9**	0.04	-0.04	71.5*	0.00	0.03	32.4	0.12	-0.02	32.7	0.11	0.06	36.6	0.05

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

Table 14

Autocorrelation Results for DUMI Countries in the First sub-period

Lag	Brazil (BOVESPA)			China (SZCI)			Malaysia (KLCI)			South Africa (SE Top 40)			Turkey (BIST 100)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	-0.11	3.84	0.05	0.02	0.08	0.78	0.11	3.82	0.05	-0.02	0.08	0.78	-0.04	0.45	0.50
2	0.06	4.90	0.09	0.00	0.08	0.96	0.05	4.74	0.09	-0.04	0.58	0.75	0.09	3.12	0.21
3	0.05	5.80	0.12	0.07	1.91	0.59	-0.02	4.90	0.18	-0.04	1.01	0.80	0.02	3.32	0.35
4	0.04	6.34	0.18	-0.07	3.59	0.47	0.00	4.90	0.30	-0.02	1.15	0.89	-0.06	4.68	0.32
5	-0.02	6.55	0.26	0.07	5.12	0.40	0.11	8.79	0.12	0.11	5.31	0.38	-0.03	5.02	0.41
6	0.02	6.66	0.35	0.07	7.03	0.32	0.01	8.86	0.18	-0.05	6.16	0.41	-0.16	13.64*	0.03
7	-0.04	7.18	0.41	-0.07	8.79	0.27	-0.01	8.89	0.26	0.04	6.62	0.47	-0.03	13.87	0.05
8	-0.03	7.40	0.49	0.08	11.32	0.18	-0.01	8.95	0.35	0.00	6.62	0.58	-0.08	15.92*	0.04
9	0.01	7.41	0.60	0.04	11.79	0.23	-0.09	12.08	0.21	0.04	7.17	0.62	0.01	15.95	0.07
10	-0.12	12.81	0.24	-0.05	12.52	0.25	-0.01	12.12	0.28	0.00	7.17	0.71	0.00	15.95	0.10
11	0.08	15.03	0.18	0.06	13.65	0.25	-0.06	13.29	0.28	0.03	7.48	0.76	0.03	16.20	0.13
12	-0.03	15.35	0.22	-0.09	16.32	0.18	-0.03	13.63	0.33	-0.08	9.88	0.63	0.07	17.82	0.12
13	0.02	15.47	0.28	-0.03	16.56	0.22	0.03	13.91	0.38	0.07	11.47	0.57	-0.02	17.91	0.16
14	0.02	15.61	0.34	-0.02	16.64	0.28	0.02	14.10	0.44	0.01	11.50	0.65	0.10	21.81	0.08
15	-0.02	15.69	0.40	-0.02	16.79	0.33	0.02	14.30	0.50	-0.04	11.99	0.68	-0.03	22.07	0.11
16	-0.08	17.88	0.33	0.03	17.03	0.38	0.02	14.40	0.57	-0.05	12.96	0.68	0.06	23.31	0.11
17	0.07	19.85	0.28	0.07	19.02	0.33	-0.04	14.90	0.60	-0.05	14.00	0.67	-0.08	25.37	0.09
18	-0.01	19.86	0.34	-0.02	19.17	0.38	0.02	14.99	0.66	0.07	15.91	0.60	-0.02	25.52	0.11
19	-0.07	21.60	0.31	0.08	21.36	0.32	-0.02	15.10	0.72	0.01	15.96	0.66	-0.04	26.17	0.13
20	0.09	24.37	0.23	-0.04	21.94	0.34	-0.01	15.11	0.77	-0.05	16.78	0.67	-0.09	29.12	0.09
21	-0.01	24.42	0.27	0.04	22.39	0.38	0.00	15.11	0.82	-0.03	17.20	0.70	-0.06	30.45	0.08
22	0.08	26.97	0.21	-0.01	22.40	0.44	0.00	15.11	0.86	0.03	17.44	0.74	-0.09	33.57	0.05
23	-0.06	28.34	0.20	-0.02	22.56	0.49	0.10	18.69	0.72	0.01	17.49	0.78	0.03	33.92	0.07
24	-0.01	28.39	0.24	0.03	22.83	0.53	-0.01	18.72	0.77	-0.02	17.64	0.82	0.10	37.59*	0.04

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

Table 15

Autocorrelation Results for DUMI Countries in the Second sub-period

Lag	Brazil (BOVESPA)			China (SZCI)			Malaysia (KLCI)			South Africa (SE Top 40)			Turkey (BIST 100)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	-0.09	2.87	0.09	0.06	1.24	0.27	0.08	2.00	0.16	-0.14	7.07*	0.01	-0.01	0.03	0.87
2	0.11	7.37**	0.03	0.07	2.98	0.23	0.08	4.23	0.12	0.04	7.66**	0.02	0.11	4.41	0.11
3	-0.07	9.01**	0.03	0.11	6.84	0.08	0.00	4.23	0.24	-0.07	9.16**	0.03	-0.01	4.45	0.22
4	0.04	9.49	0.05	0.05	7.57	0.11	0.03	4.55	0.34	0.06	10.34**	0.04	0.03	4.66	0.32
5	0.01	9.50	0.09	0.00	7.57	0.18	0.00	4.56	0.47	-0.06	11.57**	0.04	-0.06	5.87	0.32
6	0.12	14.62**	0.02	0.01	7.62	0.27	0.07	6.46	0.37	0.11	16.06*	0.01	0.03	6.12	0.41
7	-0.09	17.57*	0.01	0.03	7.90	0.34	0.07	8.05	0.33	-0.07	17.73*	0.01	-0.03	6.41	0.49
8	0.09	20.69*	0.01	0.13	14.13	0.08	0.01	8.06	0.43	-0.05	18.73**	0.02	0.01	6.48	0.59
9	-0.03	21.03*	0.01	0.08	16.45	0.06	0.04	8.54	0.48	0.05	19.78**	0.02	0.02	6.65	0.67
10	-0.02	21.17**	0.02	0.05	17.52	0.06	0.03	8.80	0.55	0.01	19.80**	0.03	-0.11	10.80	0.37
11	-0.04	21.83**	0.03	0.14	24.40*	0.01	-0.01	8.84	0.64	-0.02	19.99	0.05	0.05	11.73	0.38
12	-0.05	22.71**	0.03	0.10	27.66*	0.01	0.02	8.98	0.70	-0.09	23.20**	0.03	-0.07	13.50	0.33
13	0.02	22.87**	0.04	0.03	27.90*	0.01	0.07	10.67	0.64	0.12	28.30*	0.01	0.11	17.92	0.16
14	0.09	25.73**	0.03	-0.03	28.30*	0.01	0.10	14.65	0.40	0.09	31.21*	0.01	0.07	19.92	0.13
15	0.02	25.90**	0.04	0.01	28.31*	0.02	0.08	17.14	0.31	0.02	31.31*	0.01	0.10	23.47	0.08
16	0.06	27.35**	0.04	0.05	29.39**	0.02	0.06	18.31	0.31	0.08	33.76*	0.01	-0.05	24.22	0.09
17	-0.03	27.61	0.05	0.16	38.32*	0.00	0.06	19.80	0.28	-0.10	37.09*	0.00	0.11	28.30*	0.04
18	-0.04	28.11	0.06	0.12	43.53*	0.00	0.04	20.28	0.32	0.01	37.13*	0.01	-0.05	29.06	0.05
19	0.01	28.18	0.08	0.09	46.71*	0.00	-0.01	20.33	0.38	-0.01	37.18*	0.01	0.03	29.43	0.06
20	0.10	31.83	0.05	0.15	54.97*	0.00	-0.01	20.40	0.43	0.10	41.17*	0.00	0.07	31.05	0.06
21	-0.01	31.89	0.06	0.09	57.94*	0.00	-0.06	21.67	0.42	-0.04	41.83*	0.00	0.03	31.33	0.07
22	-0.01	31.91	0.08	-0.03	58.33*	0.00	0.11	26.02	0.25	-0.03	42.24*	0.01	0.07	33.28	0.06
23	-0.03	32.35	0.09	-0.01	58.38*	0.00	0.03	26.42	0.28	-0.01	42.31*	0.01	0.03	33.57	0.07
24	-0.03	32.58	0.11	-0.06	59.67*	0.00	0.10	29.96	0.19	-0.02	42.51*	0.01	0.00	33.57	0.09

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respective

Table 16

Autocorrelation Results for DUMI Countries in the third sub-period

Lag	Brazil (BOVESPA)			China (SZCI)			Malaysia (KLCI)			South Africa (SE Top 40)			Turkey (BIST 100)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	-0.03	0.40	0.53	0.11	4.32*	0.04	-0.01	0.02	0.89	-0.02	0.10	0.75	-0.07	1.74	0.19
2	0.04	1.01	0.61	0.06	5.51	0.06	-0.09	3.01	0.22	-0.08	2.47	0.29	-0.01	1.79	0.41
3	0.03	1.34	0.72	-0.05	6.36	0.10	0.02	3.09	0.38	-0.09	5.41	0.14	-0.04	2.33	0.51
4	-0.01	1.39	0.85	0.07	8.07	0.09	0.07	4.67	0.32	-0.06	6.78	0.15	-0.04	2.82	0.59
5	0.05	2.16	0.83	-0.04	8.56	0.13	-0.03	4.98	0.42	-0.07	8.45	0.13	0.10	6.34	0.27
6	0.05	3.18	0.79	0.03	8.79	0.19	-0.08	7.52	0.28	0.07	10.18	0.12	0.00	6.35	0.39
7	-0.07	5.01	0.66	-0.02	8.89	0.26	-0.02	7.63	0.37	-0.03	10.56	0.16	0.02	6.47	0.49
8	-0.16	13.93	0.08	0.00	8.89	0.35	-0.01	7.68	0.47	-0.08	12.56	0.13	-0.04	7.15	0.52
9	-0.04	14.61	0.10	0.09	11.54	0.24	-0.12	13.14	0.16	0.05	13.35	0.15	-0.06	8.44	0.49
10	-0.02	14.69	0.14	-0.07	13.45	0.20	0.03	13.39	0.20	-0.01	13.42	0.20	0.00	8.45	0.59
11	-0.05	15.42	0.16	-0.06	14.82	0.19	0.03	13.68	0.25	0.05	14.24	0.22	-0.03	8.68	0.65
12	0.09	18.22	0.11	-0.01	14.90	0.25	0.02	13.88	0.31	0.07	16.00	0.19	0.07	10.19	0.60
13	-0.02	18.39	0.14	-0.06	16.19	0.24	-0.13	19.80	0.10	-0.04	16.54	0.22	-0.08	12.36	0.50
14	-0.06	19.60	0.14	-0.09	18.85	0.17	-0.01	19.81	0.14	-0.02	16.70	0.27	-0.14	18.95	0.17
15	-0.02	19.73	0.18	0.06	20.24	0.16	-0.02	19.89	0.18	0.08	19.00	0.21	-0.04	19.51	0.19
16	-0.06	21.12	0.17	0.01	20.31	0.21	0.03	20.19	0.21	-0.02	19.18	0.26	-0.03	19.78	0.23
17	0.06	22.54	0.17	0.05	21.07	0.22	-0.03	20.44	0.25	0.00	19.18	0.32	0.07	21.59	0.20
18	-0.05	23.50	0.17	-0.04	21.51	0.25	-0.04	21.12	0.27	-0.12	24.17	0.15	-0.01	21.65	0.25
19	0.02	23.63	0.21	0.10	24.87	0.17	-0.01	21.15	0.33	-0.09	27.39	0.10	-0.02	21.76	0.30
20	-0.09	26.72	0.14	0.08	27.16	0.13	-0.04	21.85	0.35	-0.03	27.69	0.12	-0.05	22.53	0.31
21	0.01	26.77	0.18	0.11	31.81	0.06	0.07	23.62	0.31	0.06	28.91	0.12	0.06	23.91	0.30
22	0.07	28.58	0.16	-0.04	32.26	0.07	0.11	28.39	0.16	0.02	29.08	0.14	0.07	25.46	0.28
23	-0.01	28.60	0.19	0.02	32.44	0.09	0.02	28.58	0.20	-0.01	29.09	0.18	0.07	27.20	0.25
24	0.01	28.67	0.23	-0.03	32.83	0.11	-0.03	28.93	0.22	0.02	29.22	0.21	0.02	27.29	0.29

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

Tables 13 to 16 show the autocorrelation test results of upper-middle-income countries' stock indexes for the entire period and three sub-periods. The results of the whole period in Table 13 indicated that Brazil, China, Malaysia, South Africa, and Turkey indexes have significant autocorrelations within 24 lags. Thus, the results suggest that all indexes are not following random walks during the entire period.

The autocorrelations result in the first sub-period is presented in Table 14, and it shows that all upper middle-income sample indexes were following random walks except Turkey. There are three significant autocorrelations for Turkey out of 24 lags. Brazil, China, South Africa, and Turkey have substantial autocorrelations in the second sub-period. However, there were no significant autocorrelations for Malaysia during the second sub-period. Turkey's index's efficiency improved from the first to second sub-period and has only one considerable autocorrelation in lag 17. Remarkably, all upper-middle-income countries' stock indexes became efficient with no significant autocorrelations in the third sub-period. There was no improvement for all upper middle-income indexes except Turkey from the first sub-period to the second sub-period. However, from second to third, all indexes improved, and also followed random walk during the third sub-period.

Table 17
Autocorrelation Results for DLMI Countries in the Entire Period

Lag	Egypt (EGX 30)			India (Nifty 50)			Kenya (NSE 20)			Sri Lanka (CSE)			Tunisia (TUNINDEX)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	0.08	7.0*	0.01	0.05	2.6	0.11	0.14	20.0*	0.00	0.18	32.6*	0.00	0.03	1.2	0.27
2	0.01	7.1**	0.03	0.09	11.0*	0.00	0.07	24.6*	0.00	0.08	38.6*	0.00	0.11	13.9*	0.00
3	0.05	9.7**	0.02	-0.01	11.1*	0.01	0.04	26.4*	0.00	0.11	51.5*	0.00	0.06	17.4*	0.00
4	0.03	10.4**	0.03	0.02	11.4*	0.02	0.01	26.4*	0.00	0.07	56.5*	0.00	0.06	21.4*	0.00
5	0.05	12.8**	0.03	-0.04	13.1*	0.02	0.02	26.9*	0.00	0.05	59.1*	0.00	-0.01	21.5*	0.00
6	-0.01	12.8**	0.05	0.02	13.5**	0.04	0.08	33.9*	0.00	0.02	59.5*	0.00	-0.03	22.2*	0.00
7	-0.03	14.0**	0.05	-0.07	18.6*	0.01	0.07	39.1*	0.00	-0.03	60.4*	0.00	0.06	26.4*	0.00
8	0.08	20.9*	0.01	0.03	19.5*	0.01	0.02	39.6*	0.00	0.02	60.9*	0.00	0.02	26.7*	0.00
9	0.05	23.8*	0.01	0.04	21.3*	0.01	0.02	40.9*	0.00	-0.02	61.6*	0.00	0.02	27.0*	0.00
10	0.01	23.8*	0.01	-0.04	22.7*	0.01	0.01	40.1*	0.00	-0.02	62.0*	0.00	0.03	28.0*	0.00
11	0.02	24.3*	0.01	-0.04	24.4*	0.01	0.02	40.6*	0.00	0.02	62.5*	0.00	0.08	35.2*	0.00
12	0.03	25.3*	0.01	0.00	24.4**	0.02	0.08	46.7*	0.00	0.00	62.5*	0.00	-0.05	37.5*	0.00
13	0.04	26.8*	0.01	0.07	30.2*	0.00	0.07	51.9*	0.00	0.01	62.7*	0.00	0.04	39.2*	0.00
14	0.07	31.7*	0.00	0.05	32.6*	0.00	0.01	52.1*	0.00	0.05	65.6*	0.00	0.05	41.6*	0.00
15	0.05	34.5*	0.00	0.03	33.5*	0.00	0.07	56.9*	0.00	0.02	66.1*	0.00	0.07	46.4*	0.00
16	0.03	35.6*	0.00	0.03	34.5*	0.01	0.04	58.5*	0.00	0.07	70.9*	0.00	0.01	46.5*	0.00
17	0.05	38.1*	0.00	0.03	35.4*	0.01	0.04	60.3*	0.00	0.05	73.5*	0.00	-0.03	47.6*	0.00
18	0.02	38.5*	0.00	-0.04	36.9*	0.01	0.03	61.3*	0.00	0.11	86.6*	0.00	0.01	47.7*	0.00
19	0.01	38.6*	0.01	-0.02	37.2*	0.01	0.04	63.4*	0.00	0.02	87.0*	0.00	-0.02	48.0*	0.00
20	0.05	41.2*	0.00	0.00	37.2*	0.01	0.02	63.9*	0.00	-0.03	88.1*	0.00	-0.02	48.3*	0.00
21	0.00	41.2*	0.01	-0.02	37.7*	0.01	0.02	64.6*	0.00	0.07	92.8*	0.00	0.04	50.2*	0.00
22	0.05	43.6*	0.00	0.06	41.5*	0.01	0.05	66.8*	0.00	0.02	93.1*	0.00	0.02	50.5*	0.00
23	0.04	45.1*	0.00	-0.01	41.8*	0.01	-0.01	66.9*	0.00	0.02	93.4*	0.00	0.01	50.6*	0.00
24	-0.03	46.1*	0.00	-0.04	43.1*	0.01	0.01	66.9*	0.00	0.03	94.1*	0.00	-0.04	52.4*	0.00

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

Table 18
Autocorrelation Results for DLMI Countries in the First Sub Period

Lag	Egypt (EGX 30)			India (Nifty 50)			Kenya (NSE 20)			Sri Lanka (CSE)			Tunisia (TUNINDEX)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	0.08	2.20	0.14	0.09	3.10	0.08	0.24	20.01*	0.00	0.12	5.22**	0.02	-0.07	1.80	0.18
2	0.00	2.21	0.33	0.04	3.60	0.17	0.12	24.79*	0.00	0.00	5.22	0.07	0.13	7.63**	0.02
3	0.07	3.96	0.27	0.04	4.18	0.24	0.09	27.52*	0.00	0.07	7.11	0.07	0.06	8.75**	0.03
4	0.04	4.44	0.35	-0.03	4.45	0.35	0.10	30.96*	0.00	0.04	7.58	0.11	-0.04	9.28	0.06
5	0.04	5.01	0.42	0.01	4.48	0.48	0.06	32.06*	0.00	0.00	7.59	0.18	0.02	9.36	0.10
6	-0.06	6.07	0.42	-0.05	5.32	0.50	0.07	34.00*	0.00	-0.01	7.60	0.27	0.02	9.47	0.15
7	-0.01	6.13	0.53	-0.11	9.49	0.22	0.01	34.01*	0.00	-0.01	7.66	0.36	-0.03	9.86	0.20
8	0.10	9.42	0.31	0.07	11.02	0.20	0.01	34.03*	0.00	-0.01	7.67	0.47	0.04	10.44	0.24
9	0.08	11.69	0.23	0.09	14.11	0.12	0.06	35.38*	0.00	-0.13	13.64	0.14	-0.01	10.49	0.31
10	0.06	12.90	0.23	-0.01	14.14	0.17	0.02	35.51*	0.00	-0.03	14.02	0.17	0.02	10.61	0.39
11	0.04	13.37	0.27	-0.06	15.33	0.17	0.03	35.90*	0.00	0.02	14.21	0.22	0.01	10.62	0.48
12	0.00	13.37	0.34	0.06	16.48	0.17	0.04	36.51*	0.00	-0.05	14.96	0.24	-0.04	11.13	0.52
13	0.09	16.50	0.22	0.08	18.58	0.14	0.07	38.27*	0.00	-0.06	16.38	0.23	0.03	11.55	0.57
14	0.08	19.02	0.16	0.06	19.83	0.14	-0.01	38.28*	0.00	0.03	16.68	0.27	0.02	11.62	0.64
15	0.05	19.74	0.18	-0.06	21.02	0.14	0.16	47.23*	0.00	0.00	16.68	0.34	0.04	12.19	0.67
16	0.09	22.68	0.12	-0.01	21.06	0.18	0.07	49.18*	0.00	-0.02	16.85	0.40	0.04	12.89	0.68
17	0.07	24.58	0.11	0.01	21.10	0.22	0.20	64.50*	0.00	0.02	17.03	0.45	-0.08	15.07	0.59
18	0.04	25.24	0.12	-0.02	21.24	0.27	0.09	67.20*	0.00	0.12	22.69	0.20	0.03	15.47	0.63
19	-0.02	25.35	0.15	-0.05	22.31	0.27	0.04	67.72*	0.00	-0.03	23.12	0.23	0.01	15.48	0.69
20	0.08	27.60	0.12	-0.05	23.24	0.28	0.13	74.03*	0.00	-0.14	30.33	0.07	0.04	16.02	0.72
21	0.01	27.62	0.15	-0.01	23.27	0.33	0.07	75.67*	0.00	-0.01	30.38	0.09	0.12	21.37	0.44
22	0.05	28.65	0.16	0.11	28.03	0.18	0.05	76.46*	0.00	0.02	30.57	0.11	-0.05	22.20	0.45
23	0.06	29.92	0.15	-0.03	28.46	0.20	-0.02	76.55*	0.00	0.06	31.69	0.11	0.01	22.23	0.51
24	-0.06	31.30	0.15	-0.07	30.47	0.17	0.00	76.55*	0.00	0.04	32.18	0.12	-0.06	23.70	0.48

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

Table 19

Autocorrelation Results for DLMI Countries in the second Sub Period

Lag	Egypt (EGX 30)			India (Nifty 50)			Kenya (NSE 20)			Sri Lanka (CSE)			Tunisia (TUNINDEX)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	0.07	1.55	0.21	0.02	0.19	0.67	0.05	0.71	0.40	0.22	16.35*	0.00	0.06	1.05	0.31
2	0.06	2.71	0.26	0.17	9.76*	0.01	0.04	1.32	0.52	0.15	24.26*	0.00	0.09	3.70	0.16
3	0.07	4.30	0.23	-0.03	10.18**	0.02	0.03	1.70	0.64	0.18	35.76*	0.00	0.02	3.83	0.28
4	0.03	4.54	0.34	0.05	11.15**	0.03	-0.07	3.41	0.49	0.11	40.38*	0.00	0.12	9.18	0.06
5	0.06	5.77	0.33	-0.07	12.86**	0.03	-0.02	3.48	0.63	0.11	44.57*	0.00	-0.05	10.21	0.07
6	0.04	6.46	0.37	0.07	14.73**	0.02	0.09	6.32	0.39	0.07	46.43*	0.00	-0.08	12.62	0.05
7	-0.06	7.85	0.35	-0.06	15.97**	0.03	0.11	11.00	0.14	-0.04	47.12*	0.00	0.11	17.22**	0.02
8	0.07	9.68	0.29	0.05	16.72**	0.03	0.02	11.19	0.19	0.06	48.42*	0.00	-0.02	17.36**	0.03
9	0.04	10.30	0.33	0.01	16.76	0.05	-0.03	11.53	0.24	0.09	51.16*	0.00	0.03	17.58**	0.04
10	-0.04	10.96	0.36	-0.09	19.98**	0.03	0.02	11.65	0.31	-0.02	51.25*	0.00	0.01	17.62	0.06
11	-0.03	11.34	0.42	-0.07	21.59**	0.03	0.01	11.67	0.39	0.02	51.40*	0.00	0.17	27.84*	0.00
12	0.00	11.35	0.50	-0.06	23.01**	0.03	0.11	15.72	0.20	0.05	52.14*	0.00	-0.06	29.07*	0.00
13	0.02	11.56	0.56	0.09	25.94**	0.02	0.07	17.47	0.18	0.10	55.72*	0.00	0.05	30.03*	0.01
14	0.14	18.31	0.19	0.05	26.72**	0.02	0.01	17.49	0.23	0.06	57.18*	0.00	0.06	31.37*	0.01
15	0.06	19.75	0.18	0.14	33.36*	0.00	0.02	17.58	0.29	0.05	58.04*	0.00	0.14	38.59*	0.00
16	0.01	19.79	0.23	0.09	36.17*	0.00	0.03	17.89	0.33	0.20	72.02*	0.00	0.01	38.64*	0.00
17	0.04	20.25	0.26	0.05	37.16*	0.00	-0.05	18.68	0.35	0.08	74.23*	0.00	-0.01	38.69*	0.00
18	-0.01	20.27	0.32	-0.04	37.68*	0.00	0.01	18.75	0.41	0.11	78.42*	0.00	0.02	38.82*	0.00
19	0.04	20.81	0.35	0.01	37.70*	0.01	0.03	19.14	0.45	0.08	80.92*	0.00	-0.03	39.10*	0.00
20	0.00	20.81	0.41	0.06	38.91*	0.01	-0.06	20.38	0.43	0.12	86.01*	0.00	-0.05	40.14*	0.01
21	-0.01	20.84	0.47	-0.04	39.42*	0.01	0.01	20.41	0.50	0.20	101.11*	0.00	0.02	40.28*	0.01
22	0.03	21.24	0.51	0.02	39.56*	0.01	0.05	21.16	0.51	0.02	101.30*	0.00	0.04	40.99*	0.01
23	0.01	21.28	0.56	-0.01	39.62**	0.02	-0.01	21.17	0.57	-0.05	102.12*	0.00	-0.02	41.17*	0.01
24	-0.04	21.99	0.58	-0.02	39.74**	0.02	0.02	21.26	0.62	0.01	102.16*	0.00	-0.04	41.84*	0.01

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

Table 20

Autocorrelation Results for DLMI Countries in the Third Sub Period

Lag	Egypt (EGX 30)			India (Nifty 50)			Kenya (NSE 20)			Sri Lanka (CSE)			Tunisia (TUNINDEX)		
	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob	AC	Q-Stat	Prob
1	0.10	3.74	0.05	0.0	0.0	0.9	0.21	15.73*	0.00	0.28	27.15*	0.00	0.14	7.19*	0.01
2	-0.08	5.75	0.06	0.0	0.2	0.9	0.03	15.95*	0.00	0.12	32.48*	0.00	0.14	14.51*	0.00
3	0.00	5.75	0.12	-0.1	1.9	0.6	-0.04	16.40*	0.00	-0.03	32.71*	0.00	0.15	22.90*	0.00
4	0.02	5.87	0.21	0.0	2.1	0.7	0.05	17.39*	0.00	0.00	32.71*	0.00	0.04	23.48*	0.00
5	0.03	6.08	0.30	-0.1	3.9	0.6	0.03	17.62*	0.00	0.00	32.71*	0.00	0.07	25.20*	0.00
6	-0.02	6.19	0.40	0.0	4.2	0.7	0.04	18.13*	0.01	-0.11	37.10*	0.00	0.04	25.69*	0.00
7	-0.05	6.92	0.44	0.0	4.2	0.8	0.02	18.29*	0.01	-0.10	40.72*	0.00	0.08	28.18*	0.00
8	0.06	7.99	0.44	-0.2	12.3	0.1	0.01	18.32**	0.02	-0.04	41.15*	0.00	0.08	30.50*	0.00
9	0.03	8.33	0.50	0.0	12.5	0.2	0.05	19.38**	0.02	0.06	42.31*	0.00	0.05	31.21*	0.00
10	-0.01	8.39	0.59	0.1	13.8	0.2	-0.06	20.86**	0.02	-0.02	42.44*	0.00	0.10	34.60*	0.00
11	0.08	10.40	0.50	0.1	16.1	0.1	0.03	21.18**	0.03	-0.03	42.81*	0.00	-0.03	34.97*	0.00
12	0.07	11.98	0.45	0.0	16.6	0.2	0.03	21.59**	0.04	0.04	43.48*	0.00	-0.03	35.40*	0.00
13	-0.01	12.04	0.52	0.0	16.6	0.2	0.04	22.13	0.05	0.07	45.32*	0.00	0.02	35.48*	0.00
14	-0.07	13.70	0.47	0.0	17.3	0.2	0.04	22.80	0.06	0.10	49.12*	0.00	0.04	36.04*	0.00
15	0.02	13.88	0.53	-0.1	18.8	0.2	0.04	23.42	0.08	-0.01	49.16*	0.00	-0.08	38.29*	0.00
16	-0.02	13.98	0.60	0.0	19.4	0.2	0.00	23.42	0.10	-0.03	49.59*	0.00	-0.03	38.70*	0.00
17	0.01	14.00	0.67	0.0	19.4	0.3	-0.04	23.89	0.12	0.01	49.65*	0.00	0.00	38.70*	0.00
18	0.07	15.60	0.62	-0.1	21.3	0.3	-0.07	25.70	0.11	-0.03	49.94*	0.00	-0.05	39.52*	0.00
19	-0.01	15.61	0.68	0.0	21.3	0.3	0.02	25.82	0.14	-0.06	51.12*	0.00	-0.01	39.53*	0.00
20	0.08	18.12	0.58	-0.1	22.7	0.3	0.03	26.19	0.16	-0.09	53.92*	0.00	-0.05	40.44*	0.00
21	0.00	18.12	0.64	0.0	22.7	0.4	0.00	26.20	0.20	-0.07	55.78*	0.00	-0.08	42.71*	0.00
22	0.05	18.96	0.65	0.0	22.8	0.4	0.05	26.99	0.21	-0.02	55.96*	0.00	-0.01	42.75*	0.01
23	0.05	20.01	0.64	0.0	23.3	0.4	-0.01	27.07	0.25	0.03	56.21*	0.00	0.02	42.88*	0.01
24	0.02	20.11	0.69	0.0	24.2	0.4	-0.01	27.09	0.30	0.04	56.95*	0.00	-0.05	43.73*	0.01

Note: AC: Autocorrelation, Q-Stat: Ljung-Box Test Statistics, * and **significant at 1%, 5%, respectively

The autocorrelations result for lower-middle-income countries' indexes are presented in Tables 17,18,19, and 20 for the entire period, first, second and third sub-

periods, respectively. All samples had a significant autocorrelation during the study period, meaning that lower-middle-income countries' stock indexes were not following a random walk. The first sub-period shown in Table 17 indicated that all DLMI countries except Kenya observed the random walk with no significant autocorrelation. Sri Lanka and Tunisia have only one and two significant autocorrelations, respectively.

Egypt followed random walk during each sub-period, while Sri Lanka and Tunisia did not follow random walk in the entire, second and third sub-period. Only Egypt and Kenya followed the random walk with no significant autocorrelations in the second sub-period. On the other hand, India, Sri Lanka, and Tunisia have significant autocorrelations in the second sub-period. Only Egypt and India followed the random walk in the last sub-period depicted in Table 20. During this period, Kenya, Sri Lanka, and Tunisia have significant autocorrelations for all lags. India and Sri Lanka showed a backward improvement from the first sub-period and Kenya from the second to third sub-period. To sum up, the overall results of the autocorrelation test are summarized in the following table.

Table 21
Summary of Autocorrelation Test Results

Index	Full Period	1st Sub-Period	2nd Sub-Period	3rd Sub-Period
Australia	Inefficient	Efficient	Efficient	Inefficient
Germany	Inefficient	Inefficient	Inefficient	Efficient
Japan	Efficient	Efficient	Inefficient	Efficient
UK	Inefficient	Efficient	Inefficient	Inefficient
USA	Inefficient	Inefficient	Inefficient	Efficient
Brazil	Inefficient	Efficient	Inefficient	Efficient
China	Inefficient	Efficient	Inefficient	Efficient
Malaysia	Inefficient	Efficient	Efficient	Efficient
South Africa	Inefficient	Efficient	Inefficient	Efficient
Turkey	Inefficient	Inefficient	Inefficient	Efficient
Egypt	Inefficient	Efficient	Efficient	Efficient
India	Inefficient	Efficient	Inefficient	Efficient
Kenya	Inefficient	Inefficient	Efficient	Inefficient
Sri Lanka	Inefficient	Efficient	Inefficient	Inefficient
Tunisia	Inefficient	Efficient	Inefficient	Inefficient

5.1.3. The Run Test Analysis

The run test analysis is one of the conventional methods used to investigate whether a series follows a random walk. This approach is one of the non-parametric tests that do not assume the distribution parameters of a series. The details of the model are

described in the methodology chapter. In addition, the run test results for all samples and study periods are depicted below.

Table 22

Runs Test Results for the entire Period

Index	Total Cases	Mean	Case < Mean	Case >= Mean	Actual Runs	Z	P
Australia (ASX 200)	1,043	0.0761	478	565	516	-0.1792	0.8578
Germany (DAX 30)	1,043	0.0642	475	568	530	0.7274	0.4670
Japan (Nikkei 225)	1,043	0.0252	488	555	498	-1.3904	0.1644
UK (FTSE 100)	1,043	0.0142	477	566	532	0.8299	0.4066
USA (S&P 500)	1,043	0.0771	487	556	538	1.1066	0.2685
Brazil (BOVESPA)	1,043	0.1895	482	561	519	-0.0317	0.9747
China (SZCI)	1,043	0.0670	526	517	498	-1.5157	0.1296
Malaysia (KLCI)	1,043	0.0636	511	532	500	-1.3815	0.1671
South Africa (SE Top 40)	1,043	0.1773	500	543	513	-0.5346	0.5929
Turkey (BIST 100)	1,037	0.1901	490	547	530	0.7521	0.4520
Egypt (EGX 30)	1,036	0.2365	491	545	472	-2.8421	0.0045
India (Nifty 50)	1,043	0.1942	490	553	478	-2.6489	0.0081
Kenya (NSE 20)	1,043	0.0151	531	512	426	-5.9702	0.0000
Sri Lanka (CSE)	1,043	0.2297	571	472	401	-7.3026	0.0000
Tunisia (TUNINDEX)	1,041	0.1684	539	502	484	-2.2878	0.0222

Note: If the Z value is between ± 1.96 and $P > 5\%$, accept the randomness of the series at a 5% significant level

Table 22 exhibits the run test results for all sample indexes in the sample period. During the entire period, the Z statistics of developed and developing upper-middle-income countries are within the boundary of ± 1.96 . In addition, their corresponding p-value for all developed and developing upper-middle-income countries is more than 5%. These results indicated that the sample indexes in developed and developing upper-middle-income countries follow a random walk. On the other hand, sample indexes from developing lower-middle-income countries are not following a random walk with z statistics more than ± 1.96 and their respective p-value less than 5%.

The Runs test results for all samples in the 1st sub-period are depicted in Table 23. During the 1st sub-period, the Z-statistics outcomes of developed and developing upper-middle-income countries are within the boundary of ± 1.96 . In addition, their corresponding p-value for all developed and developing upper-middle-income countries is more than 5%. Accordingly, the developed and developing-upper middle-income countries' indexes were followed random walk during the 1st sub-period. However, sample indexes from developing lower-middle-income countries did not follow random

walk except in Tunisia. The z statistics of Tunisia in the 1st sub-Period is -0.309, which lies between ± 1.96 , and its p-value was 0.757.

Table 23
Runs Test Results for the First Sub-Period

Index	Total Cases	Mean	Case < Mean	Case >= Mean	Actual Runs	Z	P
Australia (ASX 200)	347	0.1500	168	179	169	-0.5730	0.5670
Germany (DAX 30)	347	-0.0413	166	181	177	0.3040	0.7610
Japan (Nikkei 225)	347	-0.0346	160	186	173	-0.0490	0.9610
UK (FTSE 100)	347	-0.0257	156	191	181	0.8980	0.3690
USA (S&P 500)	347	-0.0273	166	181	175	0.0890	0.9290
Brazil (BOVESPA)	347	0.2386	156	191	177	0.4630	0.6430
China (SZCI)	347	0.0220	184	163	162	-1.2800	0.2004
Malaysia (KLCI)	347	0.0375	209	138	161	-0.7000	0.4840
South Africa (SE Top 40)	347	0.2653	166	181	167	-0.7730	0.4400
Turkey (BIST 100)	347	0.2559	164	183	177	0.3260	0.7450
Egypt (EGX 30)	347	0.4748	174	173	153	-2.3120	0.0210
India (Nifty 50)	347	0.2178	160	187	151	-2.4290	0.0150
Kenya (NSE 20)	347	0.1913	194	153	122	-5.4610	0.0000
Sri Lanka (CSE)	347	0.3983	189	158	148	-2.7220	0.0065
Tunisia (TUNINDEX)	347	0.1488	184	163	171	-0.3090	0.7570

Note: If the Z value is between ± 1.96 and $P > 5\%$, accept the randomness of the series at a 5% significant level

Table 24
Runs Test Results for the Second Sub-Period

Index	Total Cases	Mean	Case < Mean	Case >= Mean	Actual Runs	Z	P
Australia (ASX 200)	348	0.0018	156	192	165	-0.8830	0.3770
Germany (DAX 30)	348	0.0930	159	189	182	0.8970	0.3700
Japan (Nikkei 225)	348	-0.0471	162	186	155	-2.0680	0.0390
UK (FTSE 100)	348	0.0264	160	188	176	0.2300	0.8180
USA (S&P 500)	348	0.0598	161	187	348	1.2930	0.1960
Brazil (BOVESPA)	348	0.1139	161	187	178	0.4290	0.6680
China (SZCI)	348	0.0857	178	170	161	-1.4940	0.1350
Malaysia (KLCI)	348	0.1782	190	158	165	-0.9240	0.3560
South Africa (SE Top 40)	348	0.1554	163	185	170	-0.4640	0.6430
Turkey (BIST 100)	348	0.2103	160	188	173	-0.0940	0.9250
Egypt (EGX 30)	348	-0.0857	153	195	161	-1.2490	0.2120
India (Nifty 50)	348	0.1575	160	188	161	-1.3910	0.1640
Kenya (NSE 20)	348	0.0204	165	183	149	-2.7490	0.0059
Sri Lanka (CSE)	348	0.2868	185	163	141	-3.5900	0.0003
Tunisia (TUNINDEX)	347	0.3450	171	176	166	-0.9100	0.3630

Note: If the Z value is between ± 1.96 and $P > 5\%$, accept the randomness of the series at a 5% significant level

Table 24 depicts sample indexes' run test results during the 2nd sub-period. Developed countries' indexes followed random walk during this period except for Japan. The Z statistics for Japan in the 2nd sub-period is -2.068, and its p-value is 0.039. All

sample indexes from developing upper-middle-income countries followed a random walk. From developing lower-middle-income countries, Egypt, India, and Tunisia followed the random walk. On the contrary, Kenya and Sri Lanka were not followed random walks during the 2nd sub-period.

Table 25
Runs Test Results for the Third Sub-Period

Index	Total Cases	Mean	Case<Mean	Case>=Mean	Actual Runs	Z	P
Australia (ASX 200)	348	0.0760	161	187	184	1.0770	0.2820
Germany (DAX 30)	348	0.1406	154	194	178	0.5770	0.5640
Japan (Nikkei 225)	348	0.1571	167	181	166	-0.9380	0.3480
UK (FTSE 100)	348	0.0418	159	189	176	0.2480	0.8040
USA (S&P 500)	348	0.1985	162	186	186	1.2760	0.2020
Brazil (BOVESPA)	348	0.2161	163	185	166	-0.8950	0.3710
China (SZCI)	348	0.0932	162	186	173	-0.1260	0.8990
Malaysia (KLCI)	348	-0.0186	170	178	184	0.9770	0.3290
South Africa (SE Top 40)	348	0.1115	169	179	173	-0.1990	0.8420
Turkey (BIST 100)	342	0.1027	165	177	175	0.3480	0.7280
Egypt (EGX 30)	341	0.3227	170	171	158	-1.4641	0.1430
India (Nifty 50)	348	0.2073	170	178	168	-0.7420	0.4580
Kenya (NSE 20)	348	-0.1658	160	188	141	-3.5526	0.0004
Sri Lanka (CSE)	348	0.0047	186	162	140	-3.6865	0.0002
Tunisia (TUNINDEX)	347	0.1244	182	165	347	-2.2720	0.0230

Note: If the Z value is between ± 1.96 and $P > 5\%$, accept the randomness of the series at a 5% significant level

The run test results for all sample indexes during the 3rd sub-period are rendered in Table 25. Therefore, Table 25 shows that sample indexes from developed and developing upper-middle-income countries have Z statistics, which lie between ± 1.96 and a p-value of more than 5%. Thus, the finding implies that they were following a random walk. On the other hand, Egypt and India followed a random walk from developing lower-middle-income countries. Kenya, Sri Lanka, and Tunisia indexes were not following Random walk in the 3rd sub-period.

Table 26
Summary of the Run Test Results

Index	Full Period	1 st Sub-Period	2 nd Sub-Period	3 rd Sub-Period
Australia (ASX 200)	Efficient	Efficient	Efficient	Efficient
Germany (DAX 30)	Efficient	Efficient	Efficient	Efficient
Japan (Nikkei 225)	Efficient	Efficient	Inefficient	Efficient
UK (FTSE 100)	Efficient	Efficient	Efficient	Efficient
USA (S&P 500)	Efficient	Efficient	Efficient	Efficient
Brazil (BOVESPA)	Efficient	Efficient	Efficient	Efficient
China (SZCI)	Efficient	Efficient	Efficient	Efficient
Malaysia (KLCI)	Efficient	Efficient	Efficient	Efficient
South Africa (SE Top 40)	Efficient	Efficient	Efficient	Efficient
Turkey (BIST 100)	Efficient	Efficient	Efficient	Efficient
Egypt (EGX 30)	Inefficient	Inefficient	Efficient	Efficient
India (Nifty 50)	Inefficient	Inefficient	Efficient	Efficient
Kenya (NSE 20)	Inefficient	Inefficient	Inefficient	Inefficient
Sri Lanka (CSE)	Inefficient	Inefficient	Inefficient	Inefficient
Tunisia (TUNINDEX)	Inefficient	Efficient	Efficient	Inefficient

The run test result generally indicated that developed countries' indexes followed a random walk during the whole sample period and all sub-study periods except for Japan in the 2nd sub-period. All sample indexes from developed upper-middle-income countries followed the random walk in the entire study period and all sub-periods. Conversely, sample indexes from developing lower-middle-income countries were not following random walk during the whole study period. In the sub-study periods, the result was mixed. In the first sub-period, all developing lower-middle-income countries' indexes were not following a random walk except Tunisia. Only Kenya and Sri Lanka were in the 2nd sub-periods, and in the 3rd sub-periods, Kenya, Sri Lanka, and Tunisia were not following a random walk.

5.1.4. Unit Root Test Analysis

Unit root test is among the conventional methods to test whether a time series follows a random walk. There are two types of unit root tests: traditional unit root tests that do not consider structural breaks and unit root tests that take into account structural breaks. In this section, the results of standard conventional unit root tests such as Augmented Dickey-Fuller (ADF) tests, the Phillips-Perron (PP) test, and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test are presented in the following tables with the entire period and three sub-periods.

The stationarity of the sample indexes was checked at the level and first differences. At the level, the unit root test is performed using the raw data without transforming it into any form. However, if the series is transferred into changes or log

differences, the unit root test can be at the difference. In this study, unit root tests were checked for both cases. The unit root test equation was done by including only the intercept.

Table 27
Unit Root test for the entire Period

Index	ADF		PP		KPSS	
	Level	Difference	Level	Difference	Level	Difference
Australia (ASX 200)	-1.261	-34.430***	-1.218	-34.471***	2.602***	0.058
Germany (DAX 30)	-0.294	-33.579***	-0.227	-33.578***	3.208***	0.183
Japan (Nikkei 225)	-0.843	-32.702***	-0.844	-32.702***	1.627***	0.284
UK (FTSE 100)	-1.735	-21.013***	-1.384	-34.804***	2.245***	0.134
USA (S&P 500)	1.446	-34.693***	1.545	-34.693***	3.005***	0.352*
Brazil (BOVESPA)	0.454	-35.190***	0.413	-35.058***	3.139***	0.079
China (SZCI)	-2.052	-30.317***	-2.196	-30.730***	1.377***	0.054
Malaysia (KLCI)	-1.057	-30.520***	-1.097	-30.624***	3.710***	0.093
South Africa (SE Top 40)	-0.497	-34.648***	-0.302	-34.721***	3.977***	0.076
Turkey (BIST 100)	-0.419	-21.191***	-0.386	-33.611***	3.870***	0.054
Egypt (EGX 30)	-0.701	-29.604***	-0.729	-29.785***	2.918***	0.157
India (Nifty 50)	0.663	-20.341***	0.663	-30.774***	3.862***	0.079
Kenya (NSE 20)	-1.329	-28.041***	-1.498	-28.676***	1.292***	0.209
Sri Lanka (CSE)	-1.065	-26.983***	-1.074	-27.746***	3.661***	0.298
Tunisia (TUNINDEX)	-0.207	-20.062***	-0.168	-31.913***	3.872***	0.162

Notes: Test equations for all cases contain an intercept. The critical value for the ADF and PP tests for both level and difference are: -3.44(1%); -2.86(5%) and -2.56(10%) while for the KPSS test are: 0.74(1%), 0.46(5%) and 0.35(10%).

For ADF and PP, test hypotheses are H0: unit root (nonstationary), H1: no unit root (stationary). The KPSS test hypotheses are H0: no unit root (stationary), H1: unit root (nonstationary)

*, **, *** denote significant at 10%, 5% and 1%, respectively.

Table 28
Unit Root Test for the First Sub-Period

Index	ADF		PP		KPSS	
	Level	Difference	Level	Difference	Level	Difference
Australia (ASX 200)	0.653	-19.357***	0.713	-19.362***	1.538***	0.364*
Germany (DAX 30)	-1.411	-17.885***	-1.419	-17.874***	0.861***	0.393*
Japan (Nikkei 225)	-1.648	-18.862***	-1.669	-18.860***	0.540	0.608**
UK (FTSE 100)	-1.611	-18.116***	-1.504	-18.274***	0.721	0.556**
USA (S&P 500)	-1.898	-20.060***	-1.752	-20.309***	0.558	0.381*
Brazil (BOVESPA)	0.382	-20.689***	0.424	-20.577***	1.621***	0.288
China (SZCI)	-1.374	-18.451***	-1.467	-18.482***	1.495***	0.146
Malaysia (KLCI)	-1.001	-17.551***	-1.224	-17.552***	1.012***	0.150
South Africa (SE Top 40)	1.520	-18.859***	1.914	-18.874***	1.537***	0.313
Turkey (BIST 100)	0.071	-19.480***	0.012	-19.451***	1.676***	0.196
Egypt (EGX 30)	0.468	-17.122***	0.419	-17.209***	1.595***	1.143***
India (Nifty 50)	1.329	-16.873***	1.244	-16.884***	1.574***	0.558**
Kenya (NSE 20)	0.959	-14.535***	0.971	-14.954***	1.685***	0.626**
Sri Lanka (CSE)	0.179	-16.385***	0.159	-16.430***	2.113***	0.179
Tunisia (TUNINDEX)	1.809	-20.904***	1.739	-20.677***	0.988***	0.549**

The critical value for the ADF and PP tests for both level and difference are: -3.45(1%); -2.87(5%) and -2.57(10%) while for the KPSS test are: 0.74(1%), 0.46(5%) and 0.35(10%).

*, **, *** denote significant at 10%, 5% and 1%, respectively.

Table 29
Unit Root Test for Second Sub-Period

Index	ADF		PP		KPSS	
	Level	Difference	Level	Difference	Level	Difference
Australia (ASX 200)	-1.456	-19.662***	-1.456	-19.671***	0.912***	0.130
Germany (DAX 30)	-1.616	-11.935***	-1.651	-20.741***	0.324	0.098
Japan (Nikkei 225)	-1.493	-11.493***	-1.541	-18.976***	1.382***	0.344
UK (FTSE 100)	-1.827	-21.337***	-1.827	-21.250***	0.344	0.127
USA (S&P 500)	-1.013	-19.790***	-0.989	-19.773***	0.427	0.195
Brazil (BOVESPA)	-2.553	-20.339***	-2.583	-20.276***	0.573	0.149
China (SZCI)	-1.556	-17.505***	-1.825	-17.706***	0.624	0.324
Malaysia (KLCI)	-1.120	-17.214***	-1.180	-17.286***	1.394***	0.116
South Africa (SE Top 40)	-1.267	-21.446***	-1.147	-21.460***	1.199***	0.077
Turkey (BIST 100)	-0.696	-18.745***	-0.709	-18.745***	1.455***	0.102
Egypt (EGX 30)	-1.263	-17.393***	-1.562	-17.589***	0.933***	0.080
India (Nifty 50)	-1.821	-10.959***	-1.950	-18.150***	0.964***	0.065
Kenya (NSE 20)	-1.420	-17.757***	-1.443	-17.777***	0.865***	0.176
Sri Lanka (CSE)	-0.665	-14.917***	-0.783	-15.879***	1.652***	0.157
Tunisia (TUNINDEX)	-1.701	-17.557***	-1.670	-17.691***	1.962***	0.389*

The critical value for the ADF and PP tests for both level and difference are: -3.45(1%); -2.87(5%) and -2.57(10%) while for the KPSS test are: 0.74(1%), 0.46(5%) and 0.35(10%).

*, **, *** denote significant at 10%, 5% and 1%, respectively.

Table 30
Unit Root Test for the Third Sub-Period

Index	ADF		PP		KPSS	
	Level	Difference	Level	Difference	Level	Difference
Australia (ASX 200)	-1.362	-20.758***	-1.100	-21.025***	1.643***	0.055
Germany (DAX 30)	-1.804	-19.163***	-1.779	-19.224***	1.702***	0.057
Japan (Nikkei 225)	-1.397	-18.694***	-1.242	-19.254***	1.822***	0.057
UK (FTSE 100)	-2.245	-18.933***	-1.883	-19.766***	1.302***	0.049
USA (S&P 500)	-0.276	-20.464***	0.222	-21.419***	2.180***	0.054
Brazil (BOVESPA)	1.020	-19.212***	1.086	-19.205***	1.921***	0.234
China (SZCI)	-1.962	-16.617***	-1.962	-16.617***	0.504	0.103
Malaysia (KLCI)	-2.026	-19.045***	-1.999	-19.045***	0.703	0.091
South Africa (SE Top 40)	-2.856	-18.903***	-2.608	-20.477***	1.615***	0.177
Turkey (BIST 100)	-1.374	-20.037***	-1.258	-20.079***	1.554***	0.069
Egypt (EGX 30)	-1.323	-16.560***	-1.344	-16.565***	1.803***	0.229
India (Nifty 50)	-0.601	-18.433***	-0.577	-18.521***	2.083***	0.057
Kenya (NSE 20)	-0.575	-14.935***	-0.399	-14.928***	1.985***	0.093
Sri Lanka (CSE)	-1.868	-14.175***	-1.792	-14.172***	0.679	0.105
Tunisia (TUNINDEX)	-0.902	-10.607***	-0.991	-16.950***	1.960***	0.077

The critical value for the ADF and PP tests for both level and difference are: -3.45(1%); -2.87(5%) and -2.57(10%) while for the KPSS test are: 0.74(1%), 0.46(5%) and 0.35(10%).

*, **, *** denote significant at 10%, 5% and 1%, respectively.

The unit root test results (ADF, PP, and KPSS) for the entire period and three sub-periods are reported in Tables 26,27,28 and 29. The test is conducted using the raw data

at level (closing price) and log difference (log return). The KPSS unit root test hypothesis is given with the inverses of ADF and PP unit root tests. The ADF and PP test null hypothesis states that the examined stock market index series has a unit root (non-stationary). In contrast, the alternative hypothesis says that series has not a unit root (stationary).

The ADF and PP unit root test result indicates that t-statistics values fail to reject the null hypothesis at the 10% significance level for all sample indexes in the entire and all sub-periods. Therefore, all sample indexes in developed and developing countries followed a random walk at the level form. This result implies that at the level, the null hypothesis is accepted. Likewise, The KPSS unit root test result shows that all sample indexes' t-statistics decline the null hypothesis at a 10 % significant level in the entire sample period, meaning that all samples are non-stationary in the level form. Non-stationarity is the primary condition of the random walk hypothesis. However, in the first sub-period, Japan, the UK, and the USA; in the second sub-period, Germany, the UK, the USA, Brazil, and China; and in the third sub-period, China, Malaysia, and Sri Lanka were stationary at the 10% significant level. Thus, according to the KPSS unit root test result, stock indexes in these countries were not efficient at the level in the specified sub-periods.

The ADF and PP unit root test results at the weekly difference for the complete and sub-periods show that all stock index series test statistics reject the null hypothesis of unit root (non-stationary) at a 1% significance level. The rejection of non-stationary indicates that all stock index series in developed and developing sample countries are not following a random walk.

The KPSS test result of the weekly difference series in the entire period supports the results of ADF and PP. However, the USA stock market seems efficient at a 1% significant level in the whole sub-period. Further, in the first sub-period, from developed countries, Australia, German, and the USA seem random at a 1% significant level, while Japan and UK seem random at a 5% significant level. Furthermore, Among DLMI countries, Egypt a 1%, India, Kenya, and Tunisia a 5% significantly efficient according to the KPSS test. In general, the finding of the three-unit root test methods such as ADF, PP, and KPSS indicated that the sample stock market indexes were not efficient.

The unit root test is one method applied to investigate the weak form of stock market efficiency. However, the unit root test result may seem spurious if a structural break is available in the time series. Consequently, we investigated the randomness of

sample series using methods that consider the availability of a structural break. Therefore, this study applies the zivot-Andrews Unit Root Test, which considers one structural break, and the Bai-Perron Multiple Structural Break Test.

Zivot and Andrews' null hypothesis states that a series contains a unit root without any exogenous structural break. The alternative hypothesis claims that a sequence has a trend-stationary with a structural break happening at an unspecified time. The Zivot and Andrews test result is presented in the following table.

Table 31

Zivot and Andrews unit root test Results with one structural break

	Full Period			Period I			Period II			Period III		
	BP	K	t_a	BP	K	t_a	BP	K	t_a	BP	K	t_a
Australia	10/13/2007	0	-34.66**	3/8/2003	0	-19.86**	11/22/2008	0	-20.54**	12/22/2018	2	-12.33**
Germany	3/15/2003	2	-20.62**	3/15/2003	2	-12.89**	3/7/2009	1	-12.63**	4/11/2015	3	-9.31**
Japan	4/8/2006	2	-19.37**	4/26/2003	0	-19.37**	10/25/2008	1	-12.23**	5/30/2015	0	-18.76**
UK	3/8/2003	3	-19.16**	3/8/2003	3	-12.00**	11/22/2008	4	-9.54**	2/13/2016	2	-13.20**
USA	3/7/2009	3	-18.05**	10/5/2002	0	-20.57**	3/7/2009	2	-12.62**	2/13/2016	0	-20.62**
Brazil	5/18/2008	1	-22.41**	9/29/2002	0	-21.19**	10/26/2008	1	-13.41**	1/24/2016	0	-19.61**
China	10/13/2007	2	-17.23**	1/19/2002	0	-19.08**	11/1/2008	2	-10.92**	6/13/2015	0	-17.66**
Malaysia	3/20/2004	1	-21.78**	5/19/2001	4	-8.59**	10/25/2008	0	-18.60**	8/22/2015	1	-14.86**
S. Africa	4/27/2003	2	-20.72**	4/21/2002	0	-19.25**	11/23/2008	0	-22.32**	12/23/2018	4	-10.59**
Turkey	2/26/2006	1	-21.40**	9/23/2001	0	-19.73**	11/23/2008	1	-12.58**	12/28/2018	0	-20.26**
Egypt	2/5/2006	0	-30.36**	3/13/2005	0	-18.29**	2/8/2009	0	-18.21**	2/14/2016	1	-14.61**
India	1/6/2008	0	-20.66**	1/11/2004	0	-17.34**	10/26/2008	1	-11.74**	6/8/2014	0	-18.66**
Kenya	2/1/2004	1	-20.71**	9/15/2002	0	-15.78**	3/8/2009	0	-18.82**	1/29/2017	0	-15.32**
Sri Lanka	10/26/2003	2	-15.73**	8/19/2001	0	-16.80**	12/28/2008	2	-9.14**	10/5/2014	0	-14.58**
Tunisia	10/3/2010	3	-14.34**	3/23/2003	3	-9.68**	10/3/2010	4	-8.21**	9/2/2018	2	-9.03**

The critical values for Zivot and Andrews test are -5.57, -5.08, and -4.82 at 1 %, 5 %, and 10% significance levels, respectively. * denotes statistical significance at a 5% level. ** denotes statistical significance at a 10% level.

The Zivot–Andrews unit root test is used in this study to examine one endogenous Structural break for the sample stock indexes with their first difference. Table 31 indicates that 2003 and 2006 are the repeated break dates during the entire period. The first sub-period 2003 and 2004, the second sub-period 2008, and the third sub-period 2015 and 2016 are the repeated brak dated for sample indexes. When we come to the test statistic, test statistics for all samples and all study periods, the test statistics are significant at a 5% significant level. This result indicates that we can reject the null hypothesis at a 5% significant level. Therefore, the finding of the Zivot–Andrews unit root test by controlling one endogenous structural break is not shown any improvement from the ADF test.

5.1.5. Bai-Perron Multiple Structural Break Test Results

The unit root test methods include ADF, PP, and KPSS analysis are among the familiar techniques that have been applied to the randomness of a time series. However, unit root tests' results may be spurious if structural changes are available in the time series due to economic, political, and other factors. For this reason, we examined the randomness of sample stock indexes using the Zivot–Andrews unit root test that can contain only one structural break. According to the Zivot–Andrews unit root test result, there is no change in the randomness of the sample time series considering the validity of one structural break. Consequently, we decide to check the existence of multiple structural changes for the sample stock indexes for the full and all sub-periods. This test can give an insight on the explanation of traditional unit root test results.

The recommended approach to test the existence of multiple structural breaks using Bai and Perron's method starts with the UDMax and WDMMax tests. The null hypothesis of the UDMax and WDMMax tests states that there is no structural break in the series. In contrast, the alternative hypothesis argues for the existence of an unknown number of changes in the sample.

The UDMax and WDMMax test results of developed countries' stock indexes are depicted in Table 32. Considering $SupF_t(k)$ test statistics for the significance level of 5%; $SupF_t(1)$, $SupF_t(2)$, $SupF_t(3)$, $SupF_t(4)$, and $SupF_t(5)$ statistics were found to be insignificant for all developed countries' indexes except for Germany and Japan in the first sub-period. All the $SupF_t(k)$ coefficients are lower than their corresponding Bai-Perron critical values except for Germany and Japan in the first sub-period. The result shows no significant structural break for all developed stock indexes during the entire study period. According to Sequential F-statistic, UDMax and WDMMax determined breaks; there is no significant break for the whole period of study.

Table 32 shows only one significant structural change for Germany and Japan is identified in the first sub-period. However, Germany and Japan had no considerable break during the second and third sub-periods. Besides, Australia, the UK, and the USA had no significant structural break during the three sub-study periods.

Table 32
Bai-Perron Multiple Breakpoint Test for Developed Countries

		<i>Sup</i> <i>FT(1)</i>	<i>Sup</i> <i>FT(2)</i>	<i>Sup</i> <i>FT(3)</i>	<i>Sup</i> <i>FT(4)</i>	<i>Sup</i> <i>FT(5)</i>	<i>UDMax</i>	<i>WDMax</i>	Number of breaks selected		
BP critical values		8.58	7.22	5.96	4.99	3.91	8.88	9.91	Seq.	UDMax	WDMax
Australia	All period	2.776	2.037	4.004	3.317	2.576	4.004	5.765	0	0	0
	Sup period1	5.748	6.562	5.158	3.881	2.938	6.562	7.798	0	0	0
	Sub period 2	3.415	4.144	4.096	3.775	2.686	4.144	6.492	0	0	0
	Sub period 3	1.984	2.510	2.043	2.166	1.109	2.510	3.724	0	0	0
Germany	All period	6.344	6.269	4.567	4.251	3.046	6.344	7.450	0	0	0
	Sup period1	9.52*	6.162	4.234	3.515	2.805	9.52*	9.526	1	1	0
	Sub period 2	2.902	2.611	2.721	2.620	1.733	2.902	4.504	0	0	0
	Sub period 3	2.071	1.625	2.098	2.623	1.912	2.623	4.511	0	0	0
Japan	All period	5.794	5.706	4.640	4.668	3.785	5.794	8.306	0	0	0
	Sup period1	9.32*	5.496	4.672	3.713	3.181	9.32*	9.329	1	1	0
	Sub period 2	5.084	3.099	3.317	3.446	2.610	5.084	5.926	0	0	0
	Sub period 3	1.049	2.706	2.522	2.395	2.213	2.706	4.855	0	0	0
UK	All period	4.398	5.371	3.920	3.433	2.885	5.371	6.382	0	0	0
	Sup period1	7.999	4.781	3.390	2.551	2.150	7.999	7.999	0	0	0
	Sub period 2	4.287	4.431	3.966	3.235	2.470	4.431	5.709	0	0	0
	Sub period 3	1.339	2.070	1.636	1.655	1.107	2.070	2.845	0	0	0
USA	All period	7.983	4.186	3.847	3.007	2.523	7.983	7.983	0	0	0
	Sup period1	5.340	3.227	2.579	2.076	2.046	5.340	5.340	0	0	0
	Sub period 2	6.435	3.928	3.902	3.338	2.382	6.435	6.435	0	0	0
	Sub period 3	2.969	1.860	1.889	1.804	1.450	2.969	3.181	0	0	0

Model specification: Trimming 0.15, Max. Breaks 5, Sig. level 0.05

Statistics and statistics are used to determine whether there is a structural break in the test series. The original hypothesis H_0 is that there is no break in the time series

* Significance at the 5% level.

The UDMax and WDMax test results of developing upper-middle-income countries' stock indexes are shown in table 33. Taking into consideration $SupF_t(k)$ test statistics for the significance level of 5%; $SupF_t(1)$, $SupF_t(2)$, $SupF_t(3)$, $SupF_t(4)$, and $SupF_t(5)$ statistics were insignificant for all developed countries' indexes except for China in the second and third sub-periods and Malaysia in the second sup-period. All the $SupF_t(k)$ coefficients are lower than their paralleling Bai-Perron critical values except for China in the second and third sub-periods and Malaysia in the second sub-period. The result shows no significant structural break for all developing upper-middle-income stock indexes during the entire study period. According to Sequential F-statistic, UDMax and WDMax determined breaks; there is no significant break for the whole period of study. Considering the three sub-study periods, Brazil, South Africa, and Turkey had no significant structural break in the three sub-periods.

Table 33
Bai-Perron Multiple Breakpoint Test for DUMI Countries

		<i>Sup</i> <i>FT</i> (1)	<i>Sup</i> <i>FT</i> (2)	<i>Sup</i> <i>FT</i> (3)	<i>Sup</i> <i>FT</i> (4)	<i>Sup</i> <i>FT</i> (5)	<i>UDMax</i>	<i>WDMax</i>	Number of breaks selected		
BP critical values		8,58	7,22	5,96	4,99	3,91	8,88	9,91	Seq.	<i>UDMax</i> x	<i>WDMax</i>
Brazil	All period	2.070	4.359	4.804	4.263	3.403	4.804	7.467	0	0	0
	Sup period1	5.751	5.304	3.888	3.228	2.345	5.751	6.303	0	0	0
	Sub period 2	3.716	3.044	4.366	3.492	2.655	4.366	6.286	0	0	0
	Sub period 3	6.153	3.674	2.807	2.634	1.266	6.153	6.153	0	0	0
China	All period	4.649	6.279	5.049	5.18*	3.124	6.279	8.908	0	0	0
	Sup period1	5.384	5.789	4.787	5.06*	3.899	5.789	8.712	0	0	0
	Sub period 2	21.94*	20.39*	15.86*	12.01*	9.62*	21.94*	24.24*	5	1	2
	Sub period 3	8.72*	9.08*	6.24*	5.13*	4.62*	9.08*	10.79*	5	2	2
Malaysia	All period	1.501	4.211	3.423	3.112	2.638	4.211	5.789	0	0	0
	Sup period1	3.244	2.807	3.965	3.816	3.159	3.965	6.933	0	0	0
	Sub period 2	3.939	7.168	7.22*	5.90*	4.49*	7.221	10.39*	0	0	3
	Sub period 3	2.256	2.148	2.652	2.603	1.811	2.652	4.475	0	0	0
S.Africa	All period	1.663	4.651	3.106	3.012	2.225	4.651	5.527	0	0	0
	Sup period1	5.531	7.704*	5.501	4.223	3.459	7.704	9.155	0	0	0
	Sub period 2	1.882	2.845	2.182	1.814	1.435	2.845	3.381	0	0	0
	Sub period 3	2.798	1.344	1.589	1.755	1.459	2.798	3.201	0	0	0
Turkey	All period	2.461	3.579	3.232	2.947	2.497	3.579	5.479	0	0	0
	Sup period1	2.456	1.329	1.613	1.405	1.216	2.456	2.669	0	0	0
	Sub period 2	4.317	4.662	4.551	4.515	3.577	4.662	7.849	0	0	0
	Sub period 3	0.933	3.861	3.423	2.715	2.225	3.861	4.928	0	0	0

Model specification: Trimming 0.15, Max. Breaks 5, Sig. level 0.05

Statistics and statistics are used to determine whether there is a structural break in the test series. The original hypothesis H_0 is that there is no break in the time series

* Significance at the 5% level.

The Bai-Perron multiple structural break test results for developing lower-middle-income countries in Table 34 indicate that the $SupF_t(k)$ test statistics for the significance level of 5%; $SupF_t(1)$, $SupF_t(2)$, $SupF_t(3)$, $SupF_t(4)$, and $SupF_t(5)$ statistics were insignificant for the Indian stock index only. However, the $SupF_t(k)$ test statistics for the significance level of 5% were significant for Egypt, Kenya, Sri Lanka, and Tunisia in the whole study period. According to *UDMax* and *WDMax* determined breaks, Kenya has two structural breaks. There is no agreement between the Sequential F-statistic, *UDMax*, and *WDMax* regarding the determined breaks for Kenya, Sri Lanka, and Tunisia.

Table 34

Bai-Perron Multiple Breakpoint Test for DLMI Countries

BP critical values		Sup FT(1)	Sup FT(2)	Sup FT(3)	Sup FT(4)	Sup FT(5)	UDMax	WDMMax	Number of breaks selected		
		8,58	7,22	5,96	4,99	3,91	8,88	9,91	Seq.	UDMax	WDMMax
Egypt	All period	7.503	16.08*	11.48*	8.79*	7.41*	16.08*	19.11*	0	2	2
	Sup period1	18.16*	13.99*	9.53*	6.68*	5.77*	18.16*	18.16*	5	1	1
	Sub period 2	7.585	5.364	5.618	5.09*	3.635	7.585	8.763	0	0	0
	Sub period 3	5.780	4.547	5.104	4.697	3.181	5.780	8.076	0	0	0
India	All period	4.958	6.853	4.785	4.100	2.841	6.853	8.144	0	0	0
	Sup period1	7.237	6.730	4.606	3.990	3.648	7.237	8.006	0	0	0
	Sub period 2	4.375	4.583	4.582	4.339	3.179	4.583	7.461	0	0	0
	Sub period 3	1.647	2.908	2.713	2.183	1.360	2.908	3.906	0	0	0
Kenya	All period	6.268	10.91*	7.42*	9.11*	6.14*	10.91*	15.66*	0	2	4
	Sup period1	35.14*	18.40*	13.15*	10.54*	9.51*	35.14*	35.14*	5	1	1
	Sub period 2	4.565	5.038	5.936	8.02*	4.75*	8.029	13.806	0	0	4
	Sub period 3	5.025	6.636	7.46*	5.23*	3.457	7.460	10.739	0	0	3
Sri Lanka	All period	12.39*	7.25*	7.64*	6.69*	4.89*	12.39*	12.39*	5	1	1
	Sup period1	14.16*	8.59*	5.794	4.677	4.21*	14.16*	14.16*	2	1	1
	Sub period 2	10.42*	16.73*	11.90*	9.55*	8.326*	16.73*	19.88*	5	2	2
	Sub period 3	4.374	4.262	3.628	3.901	2.120	4.374	6.708	0	0	0
Tunisia	All period	5.359	11.45*	7.92*	5.96*	4.76*	11.45*	13.60*	0	2	2
	Sup period1	6.843	11.33*	9.22*	7.18*	5.74*	11.33*	13.47*	0	2	2
	Sub period 2	9.57*	9.18*	7.44*	5.64*	4.95*	9.57*	10.91*	5	1	2
	Sub period 3	12.24*	13.07*	9.70*	8.18*	6.07*	13.07*	15.54*	5	2	2

Model specification: Trimming 0.15, Max. Breaks 5, Sig. level 0.05

Statistics and statistics are used to determine whether there is a structural break in the test series. The original hypothesis H_0 is that there is no break in the time series

* Significance at the 5% level.

In summary, we conducted the Bai-Perron multiple structural break test to support the traditional unit root test result. However, the general results of the Bai-Perron multiple structural break tests indicated no significant structural break for sample indexes, especially in developed and developing upper-middle-income countries. Therefore, the inefficiencies of developed and developing upper-middle-income countries' stock markets are not explained by a structural break during the study period.

5.1.6. Lo-MacKinlay Variance Ratio Test Results

Lo-MacKinlay Variance Ratio is the last method applied to test this study's weak form stock market efficiency. The variance ratio test examines the randomness of stock index series under the null hypothesis that stock index returns follow a random walk against the alternative of the stock index returns not following a random walk. This test is a more robust test than the traditional autocorrelation and unit root tests in detecting the randomness of stock market returns. The Variance ratio test results presented in Table 34,35, and 36 includes the K-Week return lags, the variance ratio test Var. (K), the variance ratio test statistics is assuming homoscedasticity $Z(K)$, variance ratio test

statistics under heteroscedasticity $Z^*(K)$, their corresponding p-values, and the Chow-Denning joint tests.

The Lo-MacKinlay variance ratio is examined for 2, 4, 8, 16, and 32 weeks lag. If the examined stock indexes follow a random walk, their variance ratios are estimated to be one for the specified lags. However, if the analyzed variance ratios are significantly different from one, the series is not following a random walk. According to the $Z(K)$ and $Z^*(K)$ test statistics, if the $Z(K)$ and $Z^*(K)$ test statistics is greater than the 5% (± 2.49) critical value, the series is not following the random walk. If the p-values of the $Z(K)$ and $Z^*(K)$ test statistics are more significant than 5%, we can accept the null hypothesis of following a random walk. Lastly, considering the Chow-Denning joint test, if the z-statistics lie between ± 1.96 , the series follows a random walk.

Table 35
Lo-MacKinlay Variance Ratio test Results for Developed Countries

	All period				Sup period1				Sub period 2				Sub period 3			
	K	Var.(K)	Z(K)	P	Z*(K)	P	Var.(K)	Z(K)	P	Z*(K)	P	Var.(K)	Z(K)	P	Z*(K)	P
Australia	2	0.46	-17.38	0	-9.06	0	0.49	-9.42	0	-7.43	0	0.47	-9.94	0	-5.58	0
	4	0.24	-13.04	0	-7.44	0	0.26	-7.35	0	-6.23	0	0.24	-7.54	0	-4.64	0
	8	0.12	-9.65	0	-6.03	0	0.11	-5.57	0	-4.89	0	0.11	-5.58	0	-3.79	0
	16	0.06	-6.91	0	-4.45	0	0.06	-3.98	0	-3.57	0	0.06	-3.99	0	-2.80	0
	Joint test		17.38	0	9.06	0		9.42	0	7.43	0		9.94	0	5.58	0
German	2	0.46	-17.49	0	-8.26	0	0.53	-8.75	0	-5.69	0	0.38	-11.6	0	-4.97	0
	4	0.23	-13.25	0	-6.65	0	0.24	-7.53	0	-5.39	0	0.23	-7.68	0	-3.48	0
	8	0.12	-9.60	0	-5.16	0	0.13	-5.45	0	-4.17	0	0.10	-5.64	0	-2.75	0
	16	0.06	-6.90	0	-3.99	0	0.06	-3.96	0	-3.11	0	0.05	-4.00	0	-2.13	0
	Joint test		17.49	0	8.26	0		8.75	0	5.69	0		11.57	0	4.97	0
Japan	2	0.47	-17.10	0	-8.03	0	0.50	-9.38	0	-7.58	0	0.42	-10.8	0	-4.19	0
	4	0.25	-13.01	0	-6.44	0	0.24	-7.58	0	-6.45	0	0.24	-7.56	0	-3.09	0
	8	0.12	-9.59	0	-5.32	0	0.12	-5.53	0	-4.88	0	0.12	-5.55	0	-2.57	0
	16	0.06	-6.88	0	-4.30	0	0.06	-3.98	0	-3.63	0	0.06	-3.97	0	-2.12	0
	Joint test		17.10	0	8.03	0		9.38	0	7.58	0		10.81	0	4.19	0
UK	2	0.45	-17.63	0	-7.10	0	0.54	-8.47	0	-6.09	0	0.39	-11.4	0	-4.71	0
	4	0.24	-13.05	0	-5.74	0	0.27	-7.25	0	-5.50	0	0.23	-7.62	0	-3.45	0
	8	0.11	-9.71	0	-4.60	0	0.13	-5.49	0	-4.37	0	0.10	-5.69	0	-2.78	0
	16	0.05	-6.93	0	-3.47	0	0.06	-3.98	0	-3.33	0	0.05	-4.01	0	-2.07	0
	Joint test		17.63	0	7.10	0		8.47	0	6.09	0		11.37	0	4.71	0
USA	2	0.44	-18.00	0	-8.88	0	0.45	-10.23	0	-5.43	0	0.43	-10.6	0	-5.50	0
	4	0.24	-13.12	0	-6.97	0	0.25	-7.50	0	-4.57	0	0.24	-7.55	0	-4.12	0
	8	0.11	-9.68	0	-5.51	0	0.12	-5.53	0	-3.87	0	0.11	-5.61	0	-3.23	0
	16	0.05	-6.93	0	-4.26	0	0.05	-4.01	0	-3.08	0	0.06	-4.00	0	-2.47	0
	Joint test		18.00	0	8.88	0		10.23	0	5.43	0		10.59	0	5.50	0

The variance ratios for K-Week returns, $Var.(K)$, are reported in the first row. $Z(k)$, variance ratio test statistics assuming homoscedasticity, and $Z^*(K)$, variance ratio test statistics under heteroscedasticity. The critical values for the $Z(k)$ and $Z^*(K)$ tests are 2.4909 (5%).*Null hypothesis rejection is significant at the 5% level.

Table 36

Lo-MacKinlay Variance Ratio test Results for DUMI Countries

	K	All period						Sup period1					Sub period 2					Sub period 3				
		Var. (K)	Z(K)	P	Z*(K)	P	Var. (K)	Z(K)	P	Z*(K)	P	Var. (K)	Z(K)	P	Z*(K)	P	Var. (K)	Z(K)	P	Z*(K)	P	
Brazil	2	0.43	-18.52	0	-10.73	0	0.43	-10.68	0	-7.97	0	0.41	-11.05	0	-5.33	0	0.46	-9.99	0	-6.98	0	
	4	0.22	-13.41	0	-8.22	0	0.22	-7.80	0	-6.29	0	0.22	-7.77	0	-3.89	0	0.24	-7.54	0	-5.75	0	
	8	0.12	-9.65	0	-6.18	0	0.11	-5.57	0	-4.74	0	0.10	-5.65	0	-2.94	0	0.14	-5.43	0	-4.47	0	
	16	0.06	-6.91	0	-4.72	0	0.06	-3.98	0	-3.54	0	0.05	-4.01	0	-2.25	0	0.06	-3.97	0	-3.45	0	
Joint test			18.52	0	10.73	0		10.68	0	7.97	0		11.05	0	5.33	0		9.99	0	6.98	0	
China	2	0.51	-15.90	0	-10.47	0	0.51	-9.18	0	0.51	0	0.49	-9.44	0	-6.28	0	0.53	-8.76	0	-6.20	0	
	4	0.26	-12.77	0	-8.82	0	0.27	-7.26	0	0.27	0	0.25	-7.44	0	-5.36	0	0.26	-7.35	0	-4.91	0	
	8	0.12	-9.58	0	-6.98	0	0.11	-5.59	0	0.11	0	0.11	-5.58	0	-4.39	0	0.14	-5.42	0	-3.49	0	
	16	0.06	-6.87	0	-5.22	0	0.06	-3.98	0	0.06	0	0.06	-3.97	0	-3.28	0	0.07	-3.94	0	-2.59	0	
Joint test			15.90	0	10.47	0		9.18	0	9.18	0		9.44	0	6.28	0		8.76	0	6.20	0	
Malay.	2	0.52	-15.55	0	-9.28	0	0.53	-8.74	0	-5.84	0	0.50	-9.36	0	-5.49	0	0.54	-8.51	0	-6.05	0	
	4	0.26	-12.70	0	-8.20	0	0.28	-7.16	0	-5.11	0	0.26	-7.35	0	-4.75	0	0.23	-7.67	0	-5.60	0	
	8	0.14	-9.44	0	-6.77	0	0.14	-5.41	0	-4.23	0	0.13	-5.46	0	-4.00	0	0.12	-5.51	0	-4.15	0	
	16	0.06	-6.86	0	-5.32	0	0.07	-3.94	0	-3.26	0	0.06	-3.97	0	-3.23	0	0.06	-3.98	0	-3.16	0	
Joint test			15.55	0	9.28	0		8.74	0	5.84	0		9.36	0	5.49	0		8.51	0	6.05	0	
S.Afri.	2	0.47	-17.04	0	-7.04	0	0.51	-9.10	0	-7.06	0	0.42	-10.81	0	-3.87	0	0.53	-8.75	0	-6.88	0	
	4	0.23	-13.28	0	-6.12	0	0.25	-7.48	0	-6.26	0	0.21	-7.91	0	-3.18	0	0.26	-7.38	0	-6.22	0	
	8	0.12	-9.60	0	-4.93	0	0.12	-5.53	0	-5.01	0	0.11	-5.58	0	-2.51	0	0.13	-5.48	0	-4.92	0	
	16	0.06	-6.92	0	-3.92	0	0.06	-3.97	0	-3.74	0	0.05	-4.02	0	-2.02	0	0.06	-3.98	0	-3.77	0	
Joint test			17.04	0	7.04	0		9.10	0	7.06	0		10.81	0	3.87	0		8.75	0	6.88	0	
Turkey	2	0.44	-17.99	0	-8.97	0	0.44	-10.46	0	-5.96	0	0.44	-10.51	0	-5.68	0	0.47	-9.78	0	-9.78	0	
	4	0.25	-12.92	0	-7.29	0	0.25	-7.41	0	-4.80	0	0.24	-7.58	0	-4.56	0	0.24	-7.50	0	-7.50	0	
	8	0.13	-9.51	0	-6.15	0	0.13	-5.48	0	-4.10	0	0.12	-5.54	0	-3.62	0	0.12	-5.49	0	-5.49	0	
	16	0.06	-6.89	0	-4.80	0	0.05	-3.99	0	-3.20	0	0.06	-3.97	0	-2.87	0	0.06	-3.96	0	-3.96	0	
Joint test			17.99	0	8.97	0		10.46	0	5.96	0		10.51	0	5.68	0		9.78	0	9.78	0	

The variance ratios for K-Week returns, $Var. (K)$, are reported in the first row. $Z(k)$, variance ratio test statistics assuming homoscedasticity, and $Z^*(K)$, variance ratio test statistics under heteroscedasticity. The critical values for the $Z(k)$ and $Z^*(K)$ tests are 2.4909 (5%).*Null hypothesis rejection is significant at the 5% level.

Table 37

Lo-MacKinlay Variance Ratio test Results for DLMI Countries

	All period						Sup period1					Sub period 2					Sub period 3				
	K	Var. (K)	Z(K)	P	Z* (K)	P	Var. (K)	Z(K)	P	Z* (K)	P	Var. (K)	Z(K)	P	Z* (K)	P	Var. (K)	Z(K)	P	Z* (K)	P
Egypt	2	0.54	-14.81	0	-8.82	0	0.54	-8.56	0	-6.41	0	0.50	-9.29	0	-4.93	0	0.59	-7.57	0	-5.09	0
	4	0.26	-12.65	0	-8.05	0	0.26	-7.36	0	-5.95	0	0.26	-7.39	0	-4.13	0	0.27	-7.22	0	-5.49	0
	8	0.12	-9.52	0	-6.49	0	0.12	-5.54	0	-4.65	0	0.12	-5.52	0	-3.34	0	0.13	-5.44	0	-4.59	0
	16	0.06	-6.83	0	-5.00	0	0.06	-3.99	0	-3.44	0	0.07	-3.96	0	-2.64	0	0.07	-3.91	0	-3.45	0
	Joint test			14.81	0	8.82	0		8.56	0	6.41	0		9.29	0	4.93	0		0	0	5.49
India	2	0.48	-16.81	0	-9.71	0	0.53	-8.72	0	-5.33	0	0.43	-10.67	0	-6.72	0	0.52	-9.02	0	-6.66	0
	4	0.26	-12.79	0	-7.92	0	0.28	-7.13	0	-4.80	0	0.24	-7.55	0	-5.01	0	0.24	-7.52	0	-5.81	0
	8	0.13	-9.53	0	-6.44	0	0.13	-5.50	0	-4.26	0	0.12	-5.53	0	-3.90	0	0.14	-5.40	0	-4.41	0
	16	0.06	-6.87	0	-4.98	0	0.06	-3.95	0	-3.47	0	0.06	-3.99	0	-2.94	0	0.06	-3.96	0	-3.43	0
	Joint test			16.81	0	9.71	0		8.72	0	5.33	0		10.67	0	6.72	0		0	0	6.66
Kenya	2	0.54	-14.79	0	-5.97	0	0.58	-7.81	0	-3.77	0	0.50	-9.33	0	-4.08	0	0.62	-7.15	0	-4.54	0
	4	0.29	-12.30	0	-5.64	0	0.30	-7.00	0	-3.78	0	0.28	-7.19	0	-3.58	0	0.30	-6.98	0	-4.97	0
	8	0.14	-9.37	0	-5.01	0	0.16	-5.27	0	-3.36	0	0.13	-5.50	0	-3.19	0	0.15	-5.32	0	-4.37	0
	16	0.07	-6.83	0	-4.24	0	0.07	-3.91	0	-2.81	0	0.06	-3.97	0	-2.70	0	0.07	-3.92	0	-3.57	0
	Joint test			14.79	0	5.97	0		7.81	0	3.78	0		9.33	0	4.08	0		0	0	4.97
Sri.lank	2	0.56	-14.16	0	-6.40	0	0.57	-7.99	0	-4.03	0	0.54	-8.57	0	-4.90	0	0.61	-7.35	0	-5.85	0
	4	0.28	-12.38	0	-6.16	0	0.27	-7.22	0	-4.04	0	0.28	-7.16	0	-4.43	0	0.34	-6.53	0	-5.47	0
	8	0.15	-9.30	0	-5.20	0	0.14	-5.39	0	-3.41	0	0.15	-5.36	0	-3.67	0	0.18	-5.19	0	-4.59	0
	16	0.07	-6.82	0	-4.09	0	0.07	-3.92	0	-2.62	0	0.06	-3.97	0	-3.05	0	0.09	-3.87	0	-3.58	0
	Joint test			14.16	0	6.40	0		7.99	0	4.04	0		8.57	0	4.90	0		0	0	5.85
Tunisia	2	0.46	-17.42	0	-6.37	0	0.40	-11.13	0	-4.33	0	0.48	-9.64	0	-3.70	0	0.50	-9.36	0	-5.52	0
	4	0.24	-13.07	0	-5.55	0	0.24	-7.56	0	-3.43	0	0.23	-7.65	0	-3.42	0	0.28	-7.17	0	-4.47	0
	8	0.13	-9.52	0	-4.69	0	0.11	-5.60	0	-3.20	0	0.13	-5.45	0	-2.73	0	0.13	-5.45	0	-3.71	0
	16	0.06	-6.86	0	-3.88	0	0.05	-4.00	0	-2.90	0	0.06	-3.95	0	-2.20	0	0.07	-3.91	0	-2.93	0
	Joint test			17.42	0	6.37	0		11.13	0	4.33	0		9.64	0	3.70	0		9.36	0	5.52

The variance ratios for K-Week returns, $Var. (K)$, are reported in the first row. $Z(k)$, variance ratio test statistics assuming homoscedasticity, and $Z^*(K)$, variance ratio test statistics under heteroscedasticity. The critical values for the $Z(k)$ and $Z^*(K)$ tests are 2.4909 (5%).*Null hypothesis rejection is significant at the 5% level.

The variance ratio test results for developed, developing upper middle income, and developing lower-middle-income countries' stock markets with the full and three sub-periods are presented in Tables 35,36, and 37. The variance ratios for all samples are significantly less than one. Further, the $Z(K)$ and $Z^*(K)$ test statistics for all samples during the entire and sub-periods are more than the 5% significant value. Furthermore, the Chow-Denning joint test z-statistics are beyond the ± 1.96 boundaries. Therefore, these findings indicated that the sample indexes from 15 countries did not follow a random walk. Thus, the sample indexes from developed, developing upper-middle-income, and developing lower-middle-income countries are not efficient in the weak form of efficiency.

The summary of methods applied to test the weak form of efficiency, such as autocorrelation, run test, unit root test, and variance ratio test for the whole study period, is depicted in the following table.

Table 38
Summary of the weak form of stock market efficiency tests

Index	Autocorrelation	Runs Test	Unit root test	Variance Ratio Test
Australia (ASX 200)	Inefficient	Efficient	Inefficient	Inefficient
Germany (DAX 30)	Inefficient	Efficient	Inefficient	Inefficient
Japan (Nikkei 225)	Efficient	Efficient	Inefficient	Inefficient
UK (FTSE 100)	Inefficient	Efficient	Inefficient	Inefficient
USA (S&P 500)	Inefficient	Efficient	Inefficient	Inefficient
Brazil (BOVESPA)	Inefficient	Efficient	Inefficient	Inefficient
China (SZCI)	Inefficient	Efficient	Inefficient	Inefficient
Malaysia (KLCI)	Inefficient	Efficient	Inefficient	Inefficient
South Africa (SE Top 40)	Inefficient	Efficient	Inefficient	Inefficient
Turkey (BIST 100)	Inefficient	Efficient	Inefficient	Inefficient
Egypt (EGX 30)	Inefficient	Inefficient	Inefficient	Inefficient
India (Nifty 50)	Inefficient	Inefficient	Inefficient	Inefficient
Kenya (NSE 20)	Inefficient	Inefficient	Inefficient	Inefficient
Sri Lanka (CSE)	Inefficient	Inefficient	Inefficient	Inefficient
Tunisia (TUNINDEX)	Inefficient	Inefficient	Inefficient	Inefficient

5.2. Testing The Semi-Strong Form of Stock Market Efficiency

In the first part of this chapter, the test for a weak form of stock mark efficiency is illustrated. Then, this section is devoted to presenting the semis-strong form test of efficiency. This study examines the semi-strong state of stock market efficiency for selected sample indexes using macroeconomic variables. Looking at the impact of publicly announced macroeconomic variables on stock return is one of the methods to

test whether sample stock return series are efficient at the semi-strong form of efficiency or not. For example, suppose the dependent variable of the stock return is significantly affected by selected macro variables, either negatively or positively. In that case, that specific stock market is not efficient at the semi-strong form of efficacy.

The impact of macroeconomic factors such as inflation (CPI), money supply (M2/M3), exchange rates (ER), interest rates (IR), industrial production index (IPI), and crude oil price (OP) on sample stock indexes are examined using cointegration and Granger causality analysis. However, the monthly observations of IPI and CPI for the study period were unavailable for Australia, Malaysia, Kenya, Sri Lanka, and Tunisia. Further, IR is also not available for Malaysia, Egypt, Kenya, and Sri Lanka. Likewise, M3 is not available for Egypt, Tunisia, and Sri Lanka. However, M2 was used for Sri Lanka in place of M3.

Each dependent and independent variable's monthly observations are collected from January 2000 to December 2019. Exclusively, due to the unavailability of data from most macroeconomic variables before 2010 for Egypt, the study period covers from January 2010 to December 2019.

Checking the integrity order of variables is an essential procedure for cointegration analysis. For example, a time series may integrate at order zero $I(0)$, Order one $I(1)$, or a combination of $I(0)$ and $I(1)$. If the time series is integrated at $I(0)$, meaning that the series is stationary at in level, performing cointegration is unnecessary because the short-run shock will adjust in the long-run equilibrium. On the other hand, if the time series is integrated at the first difference or $I(1)$, the series is stationary in the first difference. In this case, the cointegration test is the appropriate method to investigate the long-run relationship between dependent and independent variables. The literature indicates two prominent cointegration tests for series integrated at $I(1)$: the Johansen Cointegration test and the Engle-Granger Cointegration Test. In this study, only the Johansen Cointegration test is applied. The advantage of the Johansen Cointegration Test over the Engle-Granger Cointegration test is that Engle-Granger Cointegration identifies only one cointegration relation. At the same time, the Johansen Cointegration test can detect more than one cointegration equation. In addition to the Johansen Cointegration Test, the Granger causality test was applied in this study. On the other hand, if the variables in the model have a combination of $I(0)$ and $I(1)$, it is necessary to perform a

cointegration analysis to assess the long-run relationship among variables. In this case, the bounds test or Autoregressive Distributed Lag (ARDL) is the suitable method.

5.2.1. Cointegration Test

The first step in cointegration analysis is checking whether the variables are integrated into the first order I(1) or I (0). Next, unit root tests such as ADF and PP are applied to identify the order of integration.

Table 39
Unit Root Test for Developed Countries

Country	Variable	ADF		PP		KPSS	
		Level I(0)	Difference I(1)	Level I(0)	Difference I(1)	Level I(0)	Difference I(1)
Australia	LogP	-1.2294	-14.1745***	-1.4259	-14.3078***	1.4188***	0.0508
	LogER	-9.930***	-12.3576***	-6.036***	-19.3784***	0.2160***	0.0618
	LogOP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogIR	0.2429	-8.6371***	0.3307	-9.0288***	1.7189***	0.2169
	LogM3	-2.7596*	-7.4840***	-2.5912*	-14.0848***	1.9244***	0.803***
Germany	LogP	-0.5698	-14.4666***	-0.6806	-14.4654***	1.4519***	0.1862
	LogER	-7.618***	-10.9849***	-6.5354*	-17.4539***	0.2953***	0.0201
	LogOP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogIR	-1.1469	-5.8723***	-0.7341	-5.8723***	1.6764***	0.0671
	LogM3	0.8145	-4.2795***	0.8190	-15.7124***	1.9352***	0.1997
	LogCPI	-0.9135	-3.3650***	-1.0210	-20.7202***	1.9457***	0.1283
	LogIPI	-1.8488	-6.3880***	-1.9424	-17.6383***	1.6866***	0.0789
Japan	LogP	-1.0574	-13.6782***	-1.3492	-13.7379***	0.7610**	0.2931
	LogER	-1.5647	-14.8310***	-1.6917	-14.8512***	0.4208*	0.0957
	LogOP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogIR	-1.3820	-12.3767***	-1.3659	-12.4160***	0.5939**	0.1087
	LogM3	2.9038**	-4.5493***	3.8756***	-10.2002***	1.8324***	1.2068***
	LogCPI	-0.7380	-12.6280***	-0.3567	-12.4119***	0.9053***	0.4092*
	LogIPI	-2.8088**	-13.6773***	-2.9754	-13.7483***	0.2583	0.0341
UK	LogP	-1.3297	-15.6008***	-1.4824	-15.6248***	1.1297***	0.1358
	LogER	-14.05***	-14.1956***	-6.413***	-16.2477***	0.0223	0.0115
	LogOP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogIR	-1.4864	-5.3320***	-1.2942	-7.1168***	1.6061***	0.1068
	LogM3	-3.660***	-13.6554***	-3.1656**	-13.9843***	1.8127***	0.9188
	LogCPI	-0.8330	-2.6205***	-0.3067	-16.3746***	1.9514***	0.1468
	LogIPI	-1.8365	-19.1949***	-1.8223	-19.2879***	1.2152***	0.0834
USA	LogP	0.4035	-14.2367***	0.1715	-14.3073***	1.5309***	0.3225
	LogER	-1.9737	-11.3214***	-1.6954	-11.3214***	0.5748**	0.1797
	LogOP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogIR	-1.5934	-9.5967***	-1.5532	-9.6219***	0.7398**	0.2821
	LogM3	-1.0148	-12.5760***	-0.8814	-12.7722***	1.9520***	0.0978
	LogCPI	-10.85***	-10.9234***	-8.683***	-52.1316***	0.2902	0.1713
	LogIPI	-1.9768	-4.0690***	-1.3144	-13.9298***	1.1281***	0.0603

Notes: Test equations for all cases contain. The critical value for the ADF and PP tests for both level and difference are: -3.445(1%); -2.873(5%) and -2.573(10%) while for the KPSS test are: 0.739(1%), 0.463(5%) and 0.347(10%). For ADF and PP, test hypotheses are H0: unit root (nonstationary), H1: no unit root (stationary). The KPSS test hypotheses are H0: no unit root (stationary), H1: unit root (nonstationary)
*, **, *** denote significant at 10%, 5% and 1%, respectively.

Table 39 indicates that most of the variables for each country are integrated at I (1), and at least one variable is integrated at I (0). Therefore, the bound test or Autoregressive Distributed Lag (ARDL) is the appropriate method for developed countries.

Table 40
Unit Root Test for DUMI Income Countries

Country	Variable	ADF		PP		KPSS	
		Level I(0)	Difference I(1)	Level I(0)	Difference I(1)	Level I(0)	Difference I(1)
Brazil	LogP	-0.6248	-13.712***	-0.7100	-13.6873***	1.5119***	0.0847
	LogER	-10.512***	-10.558***	-6.339***	-19.3116***	0.1910	0.0152
	LogOP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogIR	-0.5508	-18.6436***	-0.6927	-18.6436***	1.4821***	0.1098
	LogM3	-3.6878***	-13.9527***	-3.4131**	-14.1909***	1.9440***	1.0625***
	LogCPI	-1.5904	-7.0424***	-1.8411	-7.0944***	1.9214***	0.3036**
	LogIPI	-2.3021	-18.0632***	-2.2363	-18.0203***	0.8039***	0.3094**
China	LogP	-6.6032***	-16.1048***	-6.784***	-18.0906***	0.1337	0.0098
	LogER	-11.020***	-11.7231***	-4.964***	-12.2407***	0.2066	0.0148
	LogOP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogM3	-1.3487	-2.5723***	-1.5778	-19.0545***	1.9325***	0.2716*
	LogCPI	0.0757	-2.6503***	0.4592	-11.9967***	1.9417***	0.1360
	LogIPI	-1.5627	-4.4548***	-1.5627	-4.4548***	1.2942***	0.0882
Malaysia	LogP	-0.8935	-13.7303***	-1.0141	-13.7965***	1.7178***	0.0977
	LogER	-13.060***	-11.7775***	-6.100***	-15.3669***	0.0288	0.0152
	LogOP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogM3	-2.4015	-18.0750***	-2.3245	-18.0644***	0.4742***	0.0655
South Africa	LogP	-6.7393***	-9.8859***	-5.7333	-16.0453***	0.3982***	0.0231
	LogER	-9.442***	-12.2377***	-6.0845	-18.6354***	0.1719	0.0142
	LogOP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogIR	-1.7211	-9.1746***	-1.8445	-9.4371***	0.9870***	0.0915
	LogM3	-4.2609***	-6.1769***	-3.803***	-15.2067***	1.8701***	1.0825***
	LogCPI	-0.6834	-10.0516***	-0.4458	-10.4852***	1.9474***	0.0722
Turkey	LogP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogER	-0.8203	-13.3734***	-0.8868	-13.3734***	1.7075***	0.1561
	LogOP	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	LogIR	-1.4536	-14.8783***	-1.4541	-14.8882***	1.6772***	0.1596
	LogM3	-3.8191***	-12.5969***	-3.401***	-12.7458***	1.9211***	0.7410***
	LogCPI	-2.620*	-2.8457*	-4.215***	-7.5425***	1.9643***	0.7184***
	LogIPI	-0.5827	-18.1007***	-0.7212	-18.0679***	1.8743***	0.0481

Notes: Test equations for all cases contain. The critical value for the ADF and PP tests for both level and difference are: -3.445(1%); -2.873(5%) and -2.573(10%) while for the KPSS test are: 0.739(1%), 0.463(5%) and 0.347(10%). *, **, *** denote significant at 10%, 5% and 1%, respectively.

The unit root test results in Table 40 show that most of the variables in the sample countries are integrated into I (1). However, at least one variable is incorporated at I (0)

in each country's model. Consequently, the bounds test or Autoregressive Distributed Lag (ARDL) method is the most appropriate for developing upper-middle-income countries.

The unit root test result for developing lower-middle-income countries is presented in Table 41. The result indicated that all variables in each model for all countries are integrated into I (1). Therefore, if all variables are integrated at I (1), the Johansen Cointegration Test is the appropriate model to investigate the long-run relationship between dependent and independent variables.

Table 41
Unit Root Test for DLMI Countries

Country	Variable	ADF		PP		KPSS	
		Level I(0)	Difference I(1)	Level I(0)	Difference I(1)	Level I(0)	Difference I(1)
EGYPT	<i>LogP</i>	-0.7604	-11.2126***	-0.6797	-11.2243***	1.0630***	0.1287
	<i>LogER</i>	-0.7313	-11.2001***	-0.7313	-11.1999***	1.1443***	0.0874
	<i>LogOP</i>	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	<i>LogCPI</i>	0.3003	-7.5554***	0.6594	-7.4710***	1.2735***	0.2565
	<i>LogIPI</i>	-0.3424	-4.8310***	-4.690***	-29.2432***	0.8224***	0.5000**
INDIA	<i>LogP</i>	-0.4439	-14.7533***	-0.5027	-14.7863***	1.7925***	0.0689
	<i>LogER</i>	-0.2815	-13.9223***	-0.3481	-13.9090***	1.5418***	0.1332
	<i>LogOP</i>	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	<i>LogIR</i>	-1.8631	-14.9103***	-1.7536	-14.9764***	0.3793*	0.1539
	<i>LogM3</i>	-1.8258	-1.9842***	-3.108***	-15.2710***	1.9463***	1.1487***
	<i>LogCPI</i>	0.1179	-2.6673*	0.7076	-12.2690***	1.9498***	0.3127
	<i>LogIPI</i>	-0.8866	-25.9981***	-0.6876	-26.1416***	1.8782***	0.1198
KENYA	<i>LogP</i>	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	<i>LogER</i>	-0.9085	-11.3403***	-1.0906	-12.0536***	1.5576***	0.0640
	<i>LogOP</i>	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	<i>LogCPI</i>	-0.9884	-9.8687***	-0.9258	-9.3014***	1.9500***	0.1065
SRILANKA	<i>LogP</i>	-1.6846	-13.5504***	-1.5997	-13.7442***	1.7002***	0.2343
	<i>LogER</i>	-0.861	-13.9008***	-0.8847	-14.0466***	1.9976***	0.1005
	<i>LogOP</i>	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	<i>LogM2</i>	-0.4055	-6.6907***	-0.3678	-14.2112***	1.9464***	0.1310
TUNISIA	<i>LogP</i>	-0.4041	-13.6299***	-0.4812	-13.7430***	1.8239***	0.1313
	<i>LogER</i>	0.8261	-14.4258***	0.6556	-14.4814***	1.4895***	0.3508
	<i>LogOP</i>	-1.9858	-12.4658***	-1.9301	-12.4195***	0.9825***	0.1429
	<i>LogIR</i>	-1.1206	-7.7586***	-0.9254	-12.9780***	0.3600*	0.3478*

Notes: Test equations for all cases contain. The critical value for the ADF and PP tests for both level and difference are: -3.445(1%); -2.873(5%) and -2.573(10%) while for the KPSS test are: 0.739(1%), 0.463(5%) and 0.347(10%). *, **, *** denote significant at 10%, 5% and 1%, respectively.

Optimal Lag Selection: In economics, the model's dependent variable may sometimes respond to the independent variable with a lapse of time. This lapse of time is called *Lag*. Too many lags may lead to a loss of degrees of freedom. It also may cause

multicollinearity, serial correlation in the error term, and misspecification error. There is no hard and fast rule regarding how many lags should be used in the model. It is common to use 1 or 2 lags for yearly data, 1 to 8 lags for quarterly data, and 6, 12, and 24 lags for monthly data. However, it is possible to decide the lag length using statistical criteria like Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan-Quinn information criterion (HQ). In this study, AIC and SC criterion result is presented by applying 12 lags as a maximum lag. From the AIC and SC criteria, we used AIC for the final decision on the lag length. The following three tables present the lag length criterion result for each sample country's model.

Table 42

Optimal Lag length criterion for Sample developed countries

	Australia		Germany		Japan		UK		USA	
Lag	AIC	SC	AIC	SC	AIC	SC	AIC	SC	AIC	SC
0	-7.8	-7.8	-21.68	-21.59	-23.15	-23.05	-21.05	-20.95	-15.85	-15.74
1	-26.22	-25.76*	-39.94	-39.30	-46.46	-45.61*	-44.21	-43.36*	-40.24	-39.35*
2	-26.50*	-25.68	-40.48*	-39.31*	-46.53*	-44.96	-44.47	-42.90	-40.60*	-38.95
3	-26.45	-25.25	-40.46	-38.75	-46.33	-44.01	-44.38	-42.06	-40.52	-38.09
4	-26.38	-24.80	-40.37	-38.11	-46.26	-43.20	-44.50*	-41.45	-40.37	-37.17
5	-26.25	-24.30	-40.34	-37.55	-46.15	-42.36	-44.41	-40.62	-40.34	-36.36
6	-26.15	-23.82	-40.37	-37.03	-45.98	-41.46	-44.31	-39.78	-40.12	-35.37
7	-26.15	-23.44	-40.48	-36.60	-45.84	-40.58	-44.39	-39.13	-40.07	-34.55
8	-26.26	-23.18	-40.37	-35.94	-45.70	-39.69	-44.17	-38.17	-40.00	-33.71
9	-26.26	-22.81	-40.48	-35.51	-45.56	-38.82	-44.20	-37.46	-39.92	-32.85
10	-26.25	-22.41	-40.47	-34.97	-45.43	-37.96	-44.05	-36.58	-39.87	-32.03
11	-26.18	-21.97	-40.39	-34.34	-45.47	-37.26	-44.04	-35.83	-39.63	-31.01
12	-26.18	-21.59	-40.41	-33.82	-45.39	-36.44	-44.33	-35.38	-39.58	-30.19

The lag length criterion result in Table 42 indicated that the optimal lag based on the AIC criterion for Australia, Germany, Japan, and the USA is lag 2. In contrast, the appropriate lag for the UK is lag 4.

Table 43

Optimal Lag length criterion for Sample DUMI countries

Lag	Brazil		Chania		Malaysia		South Africa		Turkey	
	AIC	SC	AIC	SC	AIC	SC	AIC	SC	AIC	SC
0	-16.58	-16.48	-18.70	-18.55	-6.27	-6.21	-8.66	-8.57	-13.42	-13.33
1	-39.42	-38.57*	-31.33	-30.27*	-15.83	-15.53*	-30.76	-30.12	-34.19	-33.55*
2	-39.98*	-38.41	-31.37	-29.42	-15.88	-15.33	-31.31	-30.13*	-34.35*	-33.19
3	-39.88	-37.56	-31.28	-28.43	-15.84	-15.06	-31.39	-29.67	-34.34	-32.62
4	-39.71	-36.66	-31.20	-27.45	-15.87	-14.84	-31.31	-29.06	-34.27	-32.01
5	-39.75	-35.96	-31.75	-27.10	-15.81	-14.55	-31.22	-28.42	-34.21	-31.41
6	-39.70	-35.17	-32.01	-26.46	-15.81	-14.31	-31.31	-27.97	-34.08	-30.74
7	-39.66	-34.39	-32.82	-26.37	-15.83	-14.09	-31.44	-27.56	-34.01	-30.13
8	-39.78	-33.78	-32.76	-25.42	-15.96*	-13.98	-31.68	-27.25	-33.96	-29.54
9	-39.66	-32.93	-32.78	-24.54	-15.93	-13.70	-31.80	-26.84	-33.89	-28.93
10	-39.57	-32.10	-32.84	-23.70	-15.95	-13.49	-31.89	-26.39	-33.92	-28.42
11	-39.58	-31.37	-33.16	-23.11	-15.93	-13.22	-32.2*	-26.18	-33.84	-27.80
12	-39.58	-30.63	-34.2*	-23.29	-15.93	-12.98	-32.19	-25.60	-33.73	-27.14

Table 43 depicts the optimal lag length of the sample developing upper-middle-income countries' model. Accordingly, the AIC criterion indicated that lag 2 is the appropriate lag for Brazil and Turkey; lag 12 for China; lag 8 for Malaysia; and lag 11 for South Africa.

Table 44

Optimal Lag length criterion for Sample DLMI countries

Lag	Egypt		India		Kenya		Sri Lanka		Tunisia	
	AIC	SC	AIC	SC	AIC	SC	AIC	SC	AIC	SC
0	-12.53	-12.41	-21.65	-21.54	-7.60	-7.54	-6.87	-6.81	-6.43	-6.37
1	-24.67	-23.92*	-43.34	-42.50*	-23.03	-22.73	-24.19*	-23.89*	-21.64	-21.34*
2	-24.73*	-23.36	-43.54*	-41.96	-23.27*	-22.73*	-24.18	-23.64	-21.72*	-21.18
3	-24.52	-22.54	-43.37	-41.05	-23.26	-22.47	-24.11	-23.33	-21.68	-20.90
4	-24.59	-21.98	-43.27	-40.22	-23.22	-22.20	-24.05	-23.03	-21.62	-20.60
5	-24.41	-21.18	-43.25	-39.46	-23.21	-21.94	-24.00	-22.74	-21.53	-20.27
6	-24.44	-20.59	-43.13	-38.60	-23.10	-21.60	-23.93	-22.43	-21.46	-19.96
7	-24.40	-19.93	-43.07	-37.81	-23.05	-21.30	-23.96	-22.21	-21.42	-19.68
8	-24.44	-19.35	-43.07	-37.07	-22.98	-20.99	-23.88	-21.89	-21.43	-19.45
9	-24.63	-18.92	-42.88	-36.14	-22.92	-20.69	-23.84	-21.62	-21.44	-19.22
10	-24.55	-18.22	-42.80	-35.33	-22.86	-20.39	-23.83	-21.36	-21.39	-18.93
11	-24.64	-17.69	-42.76	-34.55	-22.80	-20.09	-23.76	-21.06	-21.32	-18.61
12	-24.66	-17.09	-42.79	-33.84	-22.73	-19.78	-23.74	-20.80	-21.31	-18.36

Table 44 shows the optimal lag length for developing lower-middle-income countries. According to this result, lag 2 is the optimal lag length for Egypt, India, Kenya, and Tunisia. However, lag one is the appropriate lag for Sri Lanka.

5.2.2. Autoregressive Distributed Lag

The unit root test for sample developed and developing upper-middle-income countries indicated that the models for each country are a mix of I (0) and I (1) variables.

Therefore, if there is a mix of I (0) and I (1) variables in the model, the Autoregressive Distributed Lag (ARDL) model is appropriate to test cointegration. Accordingly, The ARDL result for developed and developing upper-middle-income countries are presented in the following tables.

Two asymptotic critical bounds are utilized in the ARDL method. If the obtained F and T-statistic value exceed the critical upper bound, the null hypothesis, which claims no long-run relationship between the variables, would be rejected. Suppose the F and T-statistic value is below the critical lower bound, the null hypothesis cannot be rejected, and the result is that there is no long-run relationship between the variables. No comments can be made if the F-statistic value is between two critical bounds.

Table 45
ARDL Bound Test Result for Developed Countries

Country	Model	F-Bounds Test				T-Bounds Test			
		F-stat.	Signif.	I(0)	I(1)	T-stat.	Signif.	I(0)	I(1)
Australia	<i>F(Logp/Loger, Logop, Logir, Logm3)</i> (1, 0, 1, 1, 0)	1.8740	5%	2.86	4.01	-1.6889	5%	-2.86	-3.99
			1%	3.74	5.06		1%	-3.43	-4.60
German	<i>F(Logp/Loger, Logo p, Logir, Logm3, Logcpi, Logipi)</i> (1, 0, 0, 1, 0, 0, 0)	2.6070	5%	2.45	3.61	-2.3064	5%	-2.86	-4.38
			1%	3.15	4.43		1%	-3.43	-4.99
Japan	<i>F(Logp/Loger, Logo p, Logir, Logm3, Logcpi, Logipi)</i> (1, 1, 1, 0, 0, 0, 1)	3.3137	5%	2.45	3.61	-2.5918	5%	-2.86	-4.38
			1%	3.15	4.43		1%	-3.43	-4.99
UK	<i>F(Logp/Loger, Logo p, Logir, Logm3, Logcpi, Logipi) /</i> (1, 0, 0, 4, 0, 4, 0)	3.1403	5%	2.45	3.61	-3.4795	5%	-2.86	-4.38
			1%	3.15	4.43		1%	-3.43	-4.99
USA	<i>F(Logp/Loger, Logo p, Logir, Logm3, Logcpi, Logipi)/</i> (1, 2, 2, 1, 0, 0, 0)	3.0092	5%	2.45	3.61	-1.5860	5%	-2.86	-4.38
			1%	3.15	4.43		1%	-3.43	-4.99

Table 45 shows that Australia's F-test and T-test results are below the 5% critical lower bound, indicating that we cannot reject the null hypothesis, which claims no long-run relationship. Accordingly, in the case of Australia, there is no long-run relationship between the stock index price and macroeconomic variables. The German, Japan, and USA results indicated that at least F-test or T-test results are below the 5% lower bound critical values. Therefore, there is no long-run relationship between the stock index price and macroeconomic variables for Germany, Japan, and The USA. In the case of the UK,

only F-test result is below the 1% significant level critical value. Hence, considering the F-test 1% significant value, there is no long-run relationship between the UK's stock market index and macroeconomic variables. We can perform the LS short-run model for sample developed countries depending on these results.

5.2.3. Short Run VAR Test for Developed Countries

After conducting the bound test, the result indicates either long-run cointegration or no long-run cointegration. In the case of no long-run cointegration, the short-run VAR first difference model can estimate using the LS method. To examine the short-run association through the LS method, first, the lag length of the model should be determined. Then, the short-run LS test for developed countries was performed after deciding the lag length. Accordingly, the VAR lag order selection criteria indicated that lag one is the significant lag length for Australia.

$$D(LOGP) = C(1) + C(2) * D(LOGP(-1)) + C(3) * D(LOGER(-1)) + C(4) * D(LOGOP(-1)) + C(5) * D(LOGIR(-1)) + C(6) * D(LOGM3(-1))$$

Table 46

Sort run First difference VAR Test Result for Australia

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0022	0.0015	1.5035	0.1341
D(LOGP(-1))	0.0553	0.0664	0.8333	0.4055
D(LOGER(-1))	-0.0351	0.0165	-2.1277	0.0344
D(LOGOP(-1))	0.0264	0.0268	0.9874	0.3245
D(LOGIR(-1))	0.0186	0.0538	0.3449	0.7304
D(LOGM3(-1))	-0.3065	0.3601	-0.8511	0.3956
<i>R-squared</i>	<i>0.0337</i>	<i>F-statistic</i>		<i>1.6174</i>
<i>Adjusted R-squared</i>	<i>0.0129</i>	<i>Prob(F-statistic)</i>		<i>0.156216</i>
<i>S.E. of regression</i>	<i>0.015536</i>	<i>Durbin-Watson stat</i>		<i>1.9891</i>

The short-run first difference VAR test result for Australia in Table 46 shows that only oil price $D(LOGER(-1))$ is a significant factor that affects the Australian stock market at a 5% significant level in the short run. Furthermore, according to the R-squared value of the model, the independent variables explain only 3% of the systematic fluctuations of the Austrian stock market during the study period. Hence, the finding indicates that the Australian stock market is not significantly affected by macroeconomic variables in the long-run and short-run time horizon during the study period. Furthermore,

the Breusch-Godfrey Serial Correlation LM Test and CUSUM Test indicates the model was not affected by serial correlation and was also stable.

According to the VAR lag order selection criteria, lag two is the appropriate model for Germany's model. The model equation is specified as follows. The short-run first difference VAR test for the German stock index is presented in Table 47.

$$D(LOGP) = C(1) + C(2) * D(LOGP(-1)) + C(3) * D(LOGER(-1)) + C(4) * D(LOGOP(-1)) + C(5) * D(LOGIR(-1)) + C(6) * D(LOGM3(-1)) + C(7) * D(LOGCPI(-1)) + C(8) * D(LOGIPI(-1))$$

Table 47

Sort run First difference VAR Test Result for Germany

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0013	0.0024	0.5681	0.5707
D(LOGP(-1))	0.0938	0.0752	1.2473	0.2139
D(LOGER(-1))	-0.0485	0.0437	-1.1097	0.2686
D(LOGOP(-1))	0.0368	0.0560	0.6582	0.5112
D(LOGIR(-1))	-0.0070	0.0286	-0.2436	0.8078
D(LOGM3(-1))	-0.1366	0.5014	-0.2724	0.7857
D(LOGCPI(-1))	-0.5113	1.4979	-0.3413	0.7333
D(LOGIPI(-1))	-0.3622	0.2935	-1.2343	0.2187
<i>R-squared</i>	<i>0.0244</i>	<i>F-statistic</i>		<i>0.6254</i>
<i>Adjusted R-squared</i>	<i>-0.0146</i>	<i>Prob(F-statistic)</i>		<i>0.7345</i>
<i>S.E. of regression</i>	<i>0.0278</i>	<i>Durbin-Watson stat</i>		<i>1.97261</i>

The finding in Table 47 shows that no macroeconomic factor significantly affects the German stock market in the short run. Furthermore, the diagnostic test results indicated that the model presented in Table 47 is not affected by serial correlation. However, it is unstable as CUSUM statistics fall beyond the 5% critical value.

The short-run first difference VAR model test for Japan is depicted in Table 48. The VAR lag order selection criteria recommend lag one for the Japan model. The lag one model equation is presented as follows.

$$D(LOGP) = C(1) + C(2) * D(LOGP(-1)) + C(3) * D(LOGER(-1)) + C(4) * D(LOGOP(-1)) + C(5) * D(LOGIR(-1)) + C(6) * D(LOGM3(-1)) + C(7) * D(LOGCPI(-1)) + C(8) * D(LOGIPI(-1))$$

Table 48

Sort run First difference VAR Test Result for Japan

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0016	0.0025	0.6328	0.5275
D(LOGP(-1))	0.0768	0.0743	1.0340	0.3022
D(LOGER(-1))	0.1499	0.1508	0.9943	0.3211
D(LOGOP(-1))	0.0466	0.0416	1.1199	0.2639
D(LOGIR(-1))	-0.0190	0.0157	-1.2071	0.2286
D(LOGM3(-1))	-2.1696	2.9422	-0.7374	0.4616
D(LOGCPI(-1))	-0.5891	1.2636	-0.4662	0.6415
D(LOGIPI(-1))	0.0360	0.1759	0.2046	0.8380
<i>R-squared</i>	0.0287	<i>F-statistic</i>		0.9697
<i>Adjusted R-squared</i>	-0.0009	<i>Prob(F-statistic)</i>		0.4541
<i>S.E. of regression</i>	0.0243	<i>Durbin-Watson stat</i>		2.0004

Table 48 shows that no significant macroeconomic factors affected Germany's stock market variation during the study period. The R-squared of the model also indicated that macroeconomic variables could explain 3% of the stock market variation. Similar to The German model, the Japanese model is also unaffected by serial correlation. Yet, it is unstable as CUSUM statistics fall beyond the 5% critical value.

The short-run first difference VAR test result for the UK with lag one is depicted in Table 49. The lag one model is shown mathematically as follows.

$$\begin{aligned}
 D(LOGP) = & C(1) + C(2) * D(LOGP(-1)) + C(3) * D(LOGER(-1)) + C(4) * D(LOGOP(-1)) + C(5) \\
 & * D(LOGIR(-1)) + C(6) * D(LOGM3(-1)) + C(7) * D(LOGCPI(-1)) + C(8) \\
 & * D(LOGIPI(-1))
 \end{aligned}$$

Table 49

Sort run First difference VAR Test Result for UK

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0011	0.0014	0.7407	0.4597
D(LOGP(-1))	-0.0279	0.0671	-0.4159	0.6779
D(LOGER(-1))	-0.0022	0.0262	-0.0831	0.9339
D(LOGOP(-1))	0.0167	0.0289	0.5787	0.5634
D(LOGIR(-1))	0.0009	0.0376	0.0235	0.9813
D(LOGM3(-1))	0.0346	0.2556	0.1353	0.8925
D(LOGCPI(-1))	-0.9920	0.9032	-1.0984	0.2732
D(LOGIPI(-1))	0.4926	0.2799	1.7600	0.0797
<i>R-squared</i>	0.0207	<i>F-statistic</i>		0.6936
<i>Adjusted R-squared</i>	-0.0091	<i>Prob(F-statistic)</i>		0.6775
<i>S.E. of regression</i>	0.0168	<i>Durbin-Watson stat</i>		1.9962

The result indicated that only non of macroeconomic factors significantly affect the UK stock market. However, according to the R-squared value, the power of

macroeconomic factors to explain the stock market variation is poor. The diagnosis tests for the UK model indicate no serial correlation and are stable as CUSUM statistics fall inside the 5% critical value.

The short-run impact of macroeconomic variables on the US stock market is examined using the first difference VAR model. The lag length criteria show that lag one is the appropriate lag for the US mode. The lag one model is shown mathematically as follows.

$$D(LOGP) = C(1) + C(2) * D(LOGP(-1)) + C(3) * D(LOGER(-1)) + C(4) * D(LOGOP(-1)) + C(5) * D(LOGIR(-1)) + C(6) * D(LOGM3(-1)) + C(7) * D(LOGCPI(-1)) + C(8) * D(LOGCPI(-1))$$

Table 50
Sort run First difference VAR Test Result for the USA

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.00611	0.00291	2.10028	0.0377
D(LOGP(-1))	-0.122	0.08991	-1.3572	0.1771
D(LOGER(-1))	0.03805	0.17835	0.21333	0.8314
D(LOGOP(-1))	-0.0448	0.06029	-0.7424	0.4592
D(LOGIR(-1))	-0.083	0.0348	-2.386	0.0185
D(LOGM3(-1))	-1.0688	1.13286	-0.9434	0.3473
D(LOGCPI(-1))	0.00151	0.0061	0.24824	0.8044
D(LOGCPI_1(-1))	0.0043	0.03544	0.12138	0.9036
<i>R-squared</i>	0.05578	<i>F-statistic</i>		1.07177
<i>Adjusted R-squared</i>	0.00374	<i>Prob(F-statistic)</i>		0.38541
<i>S.E. of regression</i>	0.01722	<i>Durbin-Watson stat</i>		2.04422

Table 50 shows that only $D(LOGIR(-1))$ is a significant macroeconomic factor that may affect the US stock market performance during the study period. According to the R-squared of the model, the macroeconomic variables could explain 5% of the US stock market fluctuation. Therefore, in the long and short-run, macroeconomic factors were not significantly affected the performance of the US stock market.

To sum up, the short-run association between macroeconomic variables and developed countries' stock indexes is examined through the first difference VAR method. The finding reveals that there was no significant macroeconomic factor for Germany, Japan, and the UK. On the contrary, Australia and The USA model have at least one significant factor. However, according to each country's model's R-squared, the explanatory power of macroeconomic variables is meager. Therefore, macroeconomic variables are not cointegrated with the sample developed countries' stock markets in the

short and long run. Hence, this may indicate the efficiency of developed countries' stock markets in the semi-strong form of efficiency.

Table 51
ARDL Bound Test Result for DUMI Countries

Country	Model	F-Bounds Test		T-Bounds Test					
		F-stat.	Signif.	I(0)	I(1)	T-stat.	Signif.	I(0)	I(1)
Brazil	<i>F (Logp/Loger, Logop, Logir, Logm3, Logcpi, Logipi)</i>		5%	2.45	3.61		5%	-2.86	-4.38
	<i>(1, 1, 1, 1, 2, 0, 0)</i>	3.7652	1%	3.15	4.43	-3.3418	1%	-3.43	-4.99
China	<i>F (Logp/ Loger, Logop, Logm3, Logcpi, Logipi)</i>		5%	2.62	3.79		5%	-2.86	-4.19
	<i>(2, 2, 0, 0, 0, 0)</i>	14.651	1%	3.41	4.68	-8.0895	1%	-3.43	-4.79
Malaysia	<i>F (Logp/ Loger, Logop, Logm3)</i>		5%	3.23	4.35		5%	-2.86	-3.78
	<i>(6,0,7,0)</i>	1.3670	1%	4.29	5.61	-1.5354	1%	-3.43	-4.37
S.A	<i>F (Logp/Loger, Logop, Logir, Logm3, Logcpi)</i>		5%	2.62	3.79		5%	-2.86	-4.19
	<i>(11,11,1,8,0,11)</i>	19.464	1%	3.41	4.68	4.99917	1%	-3.43	-4.79
Turkey	<i>F (Logp/Loger, Logop, Logir, Logm3, Logcpi, Logipi)</i>		5%	2.45	3.61		5%	-2.86	-4.38
	<i>(2, 2, 0, 1, 2, 1, 0)</i>	2.2721	1%	3.15	4.43	-2.0555	1%	-3.43	-4.99

The result in Table 51 depicted that the F-test and T-test results for China and South Africa are above the upper bond significant value. Therefore, the null hypothesis, which indicated no long-run relationship, is rejected for China and South Africa. On the other hand, the result for Brazil, Malaysian, and Turkey revealed that we could accept the null hypothesis of no cointegration. Accordingly, we can perform ECM for China and South Africa, while for Brazil, Malaysian, and Turkey, we can perform Short-run first difference VAR.

5.2.4. Short Run VAR Test for DUMI Countries

Using VAR Lag Order Selection Criteria, lag 1 is the significant lag length for Brazil. Then the short run first difference VAR test is done for Brail, and the result is depicted in Table 50. The Brazil model was extracted statistically as follows.

$$\begin{aligned}
 D(LOGP) = & C(1) + C(2) * D(LOGP(-1)) + C(3) * D(LOGER(-1)) + C(4) * D(LOGOP(-1)) + C(5) \\
 & * D(LOGIR(-1)) + C(6) * D(LOGM3(-1)) + C(7) * D(LOGCPI(-1)) + C(8) \\
 & * D(LOGIPI(-1))
 \end{aligned}$$

Table 52
Sort run First difference VAR Test Result for Brazil

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.00228	0.00442	0.514748	0.6072
D(LOGP(-1))	0.12307	0.06925	1.777077	0.0769
D(LOGER(-1))	-0.0325	0.02173	-1.493298	0.1367
D(LOGOP(-1))	-0.009	0.05191	-0.174229	0.8618
D(LOGIR(-1))	0.05143	0.05478	0.938961	0.3487
D(LOGM3(-1))	0.36985	0.57251	0.646024	0.5189
D(LOGCPI(-1))	-0.4507	1.21453	-0.37111	0.7109
D(LOGIPI(-1))	0.35181	0.23549	1.493965	0.1366
<i>R-squared</i>	0.04035	<i>F-statistic</i>		1.3816
<i>Adjusted R-squared</i>	0.01115	<i>Prob(F-statistic)</i>		0.21392
<i>S.E. of regression</i>	0.03009	<i>Durbin-Watson stat</i>		1.9765

Table 52 revealed no significant macroeconomic factors affecting Brazil's stock market variability. Therefore, the result shows no considerable short-run and long-run relationship between macroeconomic factors and the stock market in Brazil. The diagnosis tests for the Brazil model suggest no serial correlation and are steady as CUSUM statistics fall inside the 5% critical value.

The short-run first difference VAR model for the Malaysian stock market is also examined using one lag length. The result of the short-run cointegration between macroeconomic variables and the stock market for Malaysia is presented in table 53.

$$D(LOGP) = C(1) + C(2) * D(LOGP(-1)) + C(3) * D(LOGER(-1)) + C(4) * D(LOGOP(-1)) + C(5) * D(LOGM3(-1))$$

Table 53
Sort run First difference VAR Test Result for Malaysia

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0008	0.0011	0.7588	0.4487
D(LOGP(-1))	0.1269	0.0658	1.9302	0.0548
D(LOGER(-1))	-0.0292	0.0363	-0.8026	0.4230
D(LOGOP(-1))	-0.0337	0.0291	-1.1590	0.2476
D(LOGM3(-1))	0.0172	0.0169	1.0189	0.3093
<i>R-squared</i>	0.0247	<i>F-statistic</i>		1.4771
<i>Adjusted R-squared</i>	0.0080	<i>Prob(F-statistic)</i>		0.2099
<i>S.E. of regression</i>	0.0172	<i>Durbin-Watson stat</i>		2.0058

The finding shows that only there is no significant factor that affects the Malaysian stock market. Further, the R-squared of the model indicated that macroeconomic variables

only explain the Malaysian stock market fluctuation of about 2%. Therefore, macroeconomic variables do not affect the Malaysian stock market. The diagnosis tests for the Brazil model suggest no serial correlation and are steady as CUSUM statistics fall inside the 5% critical value.

The Short-run first difference VAR model test result with two lags for the Turkish stock market is exhibited in Table 54.

Table 54
Sort run First difference VAR Test Result for Turkey

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0014	0.0050	0.2704	0.7871
D(LOGP(-1))	-0.1780	0.0757	-2.3497	0.0197
D(LOGP(-2))	0.0536	0.0781	0.6863	0.4932
D(LOGER(-1))	-0.2557	0.1802	-1.4190	0.1573
D(LOGER(-2))	0.2402	0.1861	1.2905	0.1982
D(LOGOP(-1))	-0.1034	0.0776	-1.3336	0.1837
D(LOGOP(-2))	0.0754	0.0752	1.0032	0.3169
D(LOGIR(-1))	-0.0358	0.0986	-0.3626	0.7173
D(LOGIR(-2))	-0.0116	0.0979	-0.1182	0.9060
D(LOGM3(-1))	0.3054	0.4240	0.7202	0.4722
D(LOGM3(-2))	0.1443	0.4274	0.3377	0.7359
D(LOGCPI(-1))	-0.3055	0.6953	-0.4394	0.6608
D(LOGCPI(-2))	-0.0077	0.6198	-0.0124	0.9901
D(LOGIPI(-1))	-0.0114	0.2841	-0.0402	0.9680
D(LOGIPI(-2))	0.5070	0.2829	1.7917	0.0745
<i>R-squared</i>	<i>0.0737</i>	<i>F-statistic</i>		<i>1.2623</i>
<i>Adjusted R-squared</i>	<i>0.0153</i>	<i>Prob(F-statistic)</i>		<i>0.2326</i>
<i>S.E. of regression</i>	<i>0.0427</i>	<i>Durbin-Watson stat</i>		<i>1.9546</i>

$$\begin{aligned}
 D(LOGP) = & C(1) + C(2) * D(LOGP(-1)) + C(3) * D(LOGP(-2)) + C(4) * D(LOGER(-1)) + C(5) \\
 & * D(LOGER(-2)) + C(6) * D(LOGOP(-1)) + C(7) * D(LOGOP(-2)) + C(8) \\
 & * D(LOGIR(-1)) + C(9) * D(LOGIR(-2)) + C(10) * D(LOGM3(-1)) + C(11) \\
 & * D(LOGM3(-2)) + C(12) * D(LOGCPI(-1)) + C(13) * D(LOGCPI(-2)) + C(14) \\
 & * D(LOGIPI(-1)) + C(15) * D(LOGIPI(-2))
 \end{aligned}$$

Table 54 shows no short-run significant macroeconomic determinant factors for the Turkish stock market. According to The R-squared value, macroeconomic variables can explain 7% of the Turkish stock market variation in the short run. The short-term difference VAR model for Turkey is not affected by serial correlation. Yet, it is unstable as CUSUM statistics fall beyond the 5% critical value.

5.2.5. Error Correction Model For China and South Africa

As explained previously in this section, if the variables are a mix of I(0) and I(1) order of integration, the ARDL is the appropriate model to estimate the cointegration between dependent and independent variables. After performing the ARDL Bound test, if the calculated f-statistics are more significant than the upper bound critical value, the null hypothesis of no cointegration is rejected. It indicates that there is cointegration. Therefore, if there is a long-run cointegration between variables, it is necessary to estimate Error Correction Model (ECM). Based on the ARDL Bound test result in Table 49, the f-statistics of China and South Africa are above the upper bound test. Consequently, it is necessary to estimate ECM for China and South Africa. The ECM test result for China and South Africa are depicted in the following tables.

The mathematical representation of China's ECM model is as follows.

$$D(LOGP) = C(1) + C(2) * D(LOGP(-1)) + C(3) * D(LOGER) + C(4) * D(LOGER(-1)) + C(5) * D(LOGOP) + C(6) * D(LOGOP(-1)) + C(7) * D(LOGM3) + C(8) * D(LOGM3(-1)) + C(9) * D(LOGCPI) + C(10) * D(LOGCPI(-1)) + C(11) * D(LOGIPI) + C(12) * D(LOGIPI(-1)) + C(13) * ECM(-1)$$

Table 55
Long Run ECM Test for CHINA

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0003	0.0168	0.0165	0.9868
D(LOGP(-1))	0.2825	0.2464	1.1466	0.2528
D(LOGER)	-2.2578	0.5693	-3.9657	0.0001
D(LOGER(-1))	0.1108	0.6240	0.1776	0.8592
D(LOGOP)	0.3389	0.3144	1.0781	0.2822
D(LOGOP(-1))	-0.1549	0.3342	-0.4636	0.6434
D(LOGM3)	0.5250	1.3426	0.3910	0.6962
D(LOGM3(-1))	-0.7739	1.5045	-0.5144	0.6075
D(LOGCPI)	-1.0453	5.5882	-0.1871	0.8518
D(LOGCPI(-1))	1.7633	5.4106	0.3259	0.7448
D(LOGIPI)	-1.3537	1.3182	-1.0269	0.3056
D(LOGIPI(-1))	-1.1229	1.3076	-0.8588	0.3914
ECM(-1)	-0.5991	0.2604	-2.3003	0.0223
<i>R-squared</i>	<i>0.1244</i>	<i>F-statistic</i>		<i>2.6512</i>
<i>Adjusted R-squared</i>	<i>0.0775</i>	<i>Prob(F-statistic)</i>		<i>0.0024</i>
<i>S.E. of regression</i>	<i>0.1811</i>	<i>Durbin-Watson stat</i>		<i>2.0275</i>

Table 55 shows the ECM results for china. The finding indicates that the exchange rate at the level is a significant factor affecting the Chinese stock market. The ECM coefficient is also substantial, showing that almost 60% of the deviation from the long-

term equilibrium is gradually corrected within a week. The diagnosis tests for the Chinese model suggest no serial correlation and stability.

Table 56
Long Run ECM Test for South Africa

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0170	0.0240	0.7057	0.4811
D(LOGP(-1))	0.6799	0.4959	1.3710	0.1718
D(LOGER)	-0.5276	0.1662	-3.1753	0.0017
D(LOGER(-1))	0.2217	0.2346	0.9454	0.3455
D(LOGOP)	0.4805	0.3198	1.5024	0.1344
D(LOGOP(-1))	-0.1754	0.3739	-0.4691	0.6394
D(LOGIR)	-0.8551	1.0623	-0.8050	0.4217
D(LOGIR(-1))	1.2584	1.1611	1.0838	0.2796
D(LOGM3)	3.4759	2.7060	1.2845	0.2003
D(LOGM3(-1))	-4.8470	3.2279	-1.5016	0.1346
D(LOGCPI)	-4.4290	7.4689	-0.5930	0.5538
D(LOGCPI(-1))	-1.2289	7.4641	-0.1646	0.8694
ECM(-1)	-0.5653	0.4984	-1.1342	0.2579
<i>R-squared</i>	0.0732	<i>F-statistic</i>		1.4739
<i>Adjusted R-squared</i>	0.0235	<i>Prob(F-statistic)</i>		0.1352
<i>S.E. of regression</i>	0.1832	<i>Durbin-Watson stat</i>		2.0072

The statistical equation for South Africa's model can define as follows.

$$\begin{aligned}
 D(\text{LOGP}) = & C(1) + C(2) * D(\text{LOGP}(-1)) + C(3) * D(\text{LOGER}) + C(4) * D(\text{LOGER}(-1)) + C(5) \\
 & * D(\text{LOGOP}) + C(6) * D(\text{LOGOP}(-1)) + C(7) * D(\text{LOGIR}) + C(8) * D(\text{LOGIR}(-1)) \\
 & + C(9) * D(\text{LOGM3}) + C(10) * D(\text{LOGM3}(-1)) + C(11) * D(\text{LOGCPI}) + C(12) \\
 & * D(\text{LOGCPI}(-1)) + C(13) * \text{ECM}(-1)
 \end{aligned}$$

The ECM long-term autocorrelation test for South Africa is depicted in table 56. The result shows that only the exchange rate is a significant factor in the short-term part. The ECM coefficient is not statistically significant. The diagnosis tests indicate that the model is stable and not affected by serial correlation.

In summary, the ARDL bound test result for developing upper-middle-income indicated that Brazil, Malaysia, and Turkey's stock markets are not cointegrated in the short term. Hence, the first difference VAR test is employed for these countries. The short-run VAR test results show that no significant macroeconomic variable is available for Brazil, Malaysia, and Turkey. Therefore, these findings may strengthen no cointegration in the long run for these countries. On the contrary, The China and South African stock markets are cointegrated in the long run. Consequently, the long-run ECM

model is applied to China and South Africa. Hence the Chinese and South African stock markets seem inefficient in the semi-strong form of efficiency.

5.3. Johansen Cointegration Test

The Johansen Cointegration test is employed for developing lower-middle-income countries as they are integrated at I (1). There are two basic statistical tests in the Johansen Cointegration test: Trace and Max statistics. The decision criteria are to accept the null hypothesis if the value of Trace and Max statistics >5% critical value; otherwise, fail to reject the H0.

Table 57
Unrestricted Cointegration Rank Test Test Results

	Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**	Eigenvalue	Max- Eigen Statistic	0.05 Critical Value	Prob.**
Egypt	None	0.2037	64.1502	69.8189	0.1303	0.2037	26.1918	33.8769	0.3092
	At most 1	0.1591	37.9584	47.8561	0.3038	0.1591	19.9335	27.5843	0.3458
	At most 2	0.0883	18.0250	29.7971	0.5642	0.0883	10.6289	21.1316	0.6842
	At most 3	0.0609	7.3960	15.4947	0.5320	0.0609	7.2254	14.2646	0.4628
	At most 4	0.0015	0.1706	3.8415	0.6796	0.0015	0.1706	3.8415	0.6796
India	None *	0.1964	157.4548	125.6154	0.0001	0.1964	51.3799	46.2314	0.0129
	At most 1 *	0.1368	106.0749	95.7537	0.0081	0.1368	34.5644	40.0776	0.1834
	At most 2 *	0.1094	71.5105	69.8189	0.0364	0.1094	27.2383	33.8769	0.2508
	At most 3	0.0947	44.2723	47.8561	0.1044	0.0947	23.3713	27.5843	0.1582
	At most 4	0.0486	20.9010	29.7971	0.3639	0.0486	11.7015	21.1316	0.5773
	At most 5	0.0344	9.1995	15.4947	0.3473	0.0344	8.2306	14.2646	0.3557
	At most 6	0.0041	0.9689	3.8415	0.3250	0.0041	0.9689	3.8415	0.3250
Kenya	None	0.0478	29.7491	47.8561	0.7317	0.0478	11.5194	27.5843	0.9503
	At most 1	0.0440	18.2297	29.7971	0.5491	0.0440	10.5841	21.1316	0.6886
	At most 2	0.0251	7.6456	15.4947	0.5040	0.0251	5.9817	14.2646	0.6156
	At most 3	0.0071	1.6639	3.8415	0.1971	0.0071	1.6639	3.8415	0.1971
Sr Lanka	None *	0.0864	51.7314	47.8561	0.0207	0.0864	21.2414	27.5843	0.2619
	At most 1 *	0.0822	30.4900	29.7971	0.0416	0.0822	20.1588	21.1316	0.0679
	At most 2	0.0368	10.3311	15.4947	0.2561	0.0368	8.8226	14.2646	0.3012
	At most 3	0.0064	1.5085	3.8415	0.2194	0.0064	1.5085	3.8415	0.2194
Tunisia	None	0.0639	30.5941	47.8561	0.6882	0.0639	15.5189	27.5843	0.7062
	At most 1	0.0373	15.0751	29.7971	0.7752	0.0373	8.9229	21.1316	0.8386
	At most 2	0.0152	6.1523	15.4947	0.6775	0.0152	3.5984	14.2646	0.8991
	At most 3	0.0108	2.5539	3.8415	0.1100	0.0108	2.5539	3.8415	0.1100
Trace test indicates no cointegration at the 0.05 level					Max-eigenvalue test indicates no cointegration at the				
* denotes rejection of the hypothesis at the 0.05 level					0.05 level, * denotes rejection of the hypothesis at the				
**MacKinnon-Haug-Michelis (1999) p-values					0.05 level, and **MacKinnon-Haug-Michelis (1999)				
					p-values				

The Johansen cointegration test results in Table 57 indicate that the null hypothesis of at most two, three, and four cointegration equations are accepted at a 5% significant level for all developing lower-middle-income countries. Consequently, the finding claims at least one cointegration equation among variables is accepted for all

samples. In general, the Johansen Cointegration Trace and Maximum Eigen statistic value show a cointegration among variables for all sample countries from developing lower-middle-income countries. Accordingly, the finding reveals that stock markets in developing lower-middle-income countries are not efficient at the semi-strong form of efficiency.

5.3.1. Error Correction Model For DLMIC Countries

The Johansen cointegration test results for developing lower-middle-income countries such as Egypt, India, Kenya, Sri Lanka, and Tunisia indicated a cointegration between stock market return and macroeconomic variables. After identifying the availability of cointegration, the next step is estimating Error Correction Model (ECM) for small samples. This section delivers the ECM test results of developing lower-middle-income countries.

The ECM test result for Egypt is presented in Table 60 below. The model is statistically represented as follows.

$$D(LOGP) = C(1) + C(2) * D(LOGER) + C(3) * D(LOGOP) + C(4) * D(LOGCPI) + C(5) * D(LOGIPI) + C(6) * ECM(-1)$$

Table 58

Error Correction Model test For Egypt

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.00518	0.004282	1.20966	0.2289
D(LOGER)	0.10121	0.117392	0.86218	0.3904
D(LOGOP)	0.08115	0.099138	0.81857	0.4148
D(LOGCPI)	-0.6958	0.712396	-0.9767	0.3308
D(LOGIPI)	-0.071	0.140102	-0.507	0.6131
ECM(-1)	-0.113	0.044268	-2.552	0.012
<i>R-squared</i>	<i>0.07148</i>	<i>F-statistic</i>		<i>1.739693</i>
<i>Adjusted R-squared</i>	<i>0.03039</i>	<i>Prob(F-statistic)</i>		<i>0.131223</i>
<i>S.E. of regression</i>	<i>0.0351</i>	<i>Durbin-Watson stat</i>		<i>1.993881</i>

The finding in Table 58 shows that no significant macroeconomic factor affected the variation of Egypt's stock market in the short-run part of the ECM test. The ECM coefficient is significant, and it indicates about 11% of the deviation from the long-term equilibrium is gradually corrected within a week. The Breusch-Godfrey Serial

Correlation LM Test and CUSUM Test indicates the model was not affected by serial correlation and was also stable.

The ECM test result for India is demonstrated in Table 59. The model is symbolized mathematically as follows.

$$D(LOGP) = C(1) + C(2) * D(LOGER) + C(3) * D(LOGOP) + C(4) * D(LOGIR) + C(5) * D(LOGM3) + C(6) * D(LOGCPI) + C(7) * D(LOGIPI) + C(8) * ECM(-1)$$

Table 59
Error Correction Model test For India

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0054	0.0026	2.0886	0.0378
D(LOGER)	-1.6192	0.1789	-9.0487	0.0000
D(LOGOP)	0.0487	0.0413	1.1775	0.2402
D(LOGIR)	-0.0034	0.0942	-0.0360	0.9713
D(LOGM3)	-0.1918	0.3602	-0.5324	0.5950
D(LOGCPI)	0.0851	0.4882	0.1743	0.8618
D(LOGIPI)	0.2049	0.1559	1.3144	0.1900
ECM(-1)	-0.0533	0.0235	-2.2663	0.0244
<i>R-squared</i>	0.2886	<i>F-statistic</i>		13.3859
<i>Adjusted R-squared</i>	0.2670	<i>Prob(F-statistic)</i>		0.0000
<i>S.E. of regression</i>	0.0244	<i>Durbin-Watson stat</i>		1.9988

The short-run part of the ECM test for India indicates there is a significant association between the Indian stock market price and the change in the exchange rate. Therefore there was a short-run cointegration exists in the case of India. The log-run part of the ECM model represented by $ECM(-1)$ is also significant. The ECM coefficient reveals that 5% of the long-run disequilibrium may gradually correct within a week. The diagnosis tests for this model indicate the model was stable and had no serial correlation.

From the selected six macroeconomic factors in this study, only exchange rate, oil price, and inflation rates data were obtained for the study period for Kenya. The ECM test for Kenya is exhibited in Table 58 below, and the model is specified as follows.

$$D(LOGP) = C(1) + C(2) * D(LOGER) + C(3) * D(LOGOP) + C(4) * D(LOGCPI) + C(5) * ECM(-1)$$

Table 60

Error Correction Model test For Kenya

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0012	0.0018	0.6449	0.5196
D(LOGER)	-0.7720	0.1817	-4.2497	0.0000
D(LOGOP)	-0.0022	0.0397	-0.0567	0.9548
D(LOGCPI)	-0.1531	0.3546	-0.4317	0.6664
ECM(-1)	-0.0328	0.0158	-2.0790	0.0387
<i>R-squared</i>	0.087103	<i>F-statistic</i>		5.581709
<i>Adjusted R-squared</i>	0.071498	<i>Prob(F-statistic)</i>		0.000262
<i>S.E. of regression</i>	0.023774	<i>Durbin-Watson stat</i>		1.725085

The results in Table 60 reveal that there was a significant cointegration between Kenya's stock market and exchange rate in the short-run. The long-run component of the ECM coefficient is also significant. The Breusch-Godfrey Serial Correlation LM Test and CUSUM Test indicates the model was affected by serial correlation and was also unstable.

Due to the unavailability of sufficient data during the study period, only exchange rate, oil price, and money supply are included in the Sri Lanka Model. The ECM for Sri Lanka is statistically expressed as follows.

$$D(LOGP) = C(1) + C(2) * D(LOGER) + C(3) * D(LOGOP) + C(4) * D(LOGM2) + C(5) * ECM(-1)$$

Table 61

Error Correction Model test For Sri Lanka

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0024	0.0033	0.7026	0.4830
D(LOGER)	-0.7726	0.2974	-2.5983	0.0100
D(LOGOP)	0.0732	0.0459	1.5953	0.1120
D(LOGM2)	0.6056	0.5534	1.0942	0.2750
ECM(-1)	-0.0032	0.0179	-0.1762	0.8603
<i>R-squared</i>	0.0441	<i>F-statistic</i>		2.6964
<i>Adjusted R-squared</i>	0.0277	<i>Prob(F-statistic)</i>		0.0316
<i>S.E. of regression</i>	0.0273	<i>Durbin-Watson stat</i>		1.8050

The finding in Table 61 reveals exchange rate is a significant cointegration with the Sri Lanka stock market. The long-run coefficient of ECM is not significant. The improvement power from log run disequilibrium to very low. The diagnosis test results for this model revealed that the modes were not affected by serial correlation and were stable.

Lastly, the Tunisia model includes the dependent variables such as exchange rate, oil price, and interest rate. The ECM model for Tunisia is denoted in the following equation.

$$D(LOGP) = C(1) + C(2) * D(LOGER) + C(3) * D(LOGOP) + C(4) * D(LOGIR) + C(5) * ECM(-1)$$

Table 62

Error Correction Model test For Tunisia

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003002	0.00101	2.97762	0.0032
D(LOGER)	0.042074	0.10489	0.40112	0.6887
D(LOGOP)	-0.001025	0.02575	-0.0398	0.9683
D(LOGIR)	-0.051374	0.08449	-0.608	0.5438
ECM(-1)	-0.016948	0.01244	-1.3623	0.1744
<i>R-squared</i>	<i>0.009273</i>	<i>F-statistic</i>		<i>0.54756</i>
<i>Adjusted R-squared</i>	<i>-0.007662</i>	<i>Prob(F-statistic)</i>		<i>0.70098</i>
<i>S.E. of regression</i>	<i>0.015366</i>	<i>Durbin-Watson stat</i>		<i>1.73453</i>

The finding in Table 62 shows non of the short-run and long-run components of the ECM were significant. This indicates no short-run cointegration between the stock market and macroeconomic factors for Tunisia. The model was not stable but not influenced by serial correlation.

To sum up, the ECM test for developing-lower-middle-income countries reveals that there was a significant cointegration for Kenya, India, and Sri Lanka. However, no short-run cointegration between the stock market and macroeconomic variables for Egypt and Tunisia. Considering the long-run component, the coefficient of ECM was significant for Egypt, Kenya, and India, while not significant for Sri Lanka and Tunisia.

5.4. Granger Causality Test

The previous parts of this study investigated the cointegration between stock market price and macroeconomic variables using ARDL and Johansen cointegration tests. These tests show only the association between variables. Nevertheless, they did not show the causality effects between variables. For this reason, the Granger causality test is applied to examine the causality direction among the variables. The Granger causality test examines whether the lagged past value of one variable can predict the feature values of another variable. Accordingly, if the past observations of macroeconomic variables

significantly granger cause the prospect price of the stock market, the market is inefficient in the semi-strong form of efficiency. However, if the past observations of macroeconomic variables can not granger the cause for the stock market variation, the market is efficient in the semi-strong form of efficiency.

Stationarity is one of the basic assumptions for Granger causality analysis. Therefore, the stationarity of the variables is examined in the first section. All variables used to test the semi-strong form of stock market efficiency are stationary at first difference. Therefore the granger causality test is applied using the first difference of all variables. Choosing the proper lag length of the model is also among the necessary steps in applying the Granger causality test. In this study, the lag length is determined based on the result of at least two lag selection criteria. The Granger causality test results for developed and developing countries are presented in the following tables.

Table 63
Pairwise Granger Causality Tests for Developed Countries

Country	Australia		Germany		Japan		UK		USA	
Lags:	1		2		2		2		2	
Null Hypothesis:	F-Sta.	Prob.	F-Stat.	Prob.	F-Stat.	Prob.	F-Stat.	Prob.	F-Stat.	Prob.
D(LOGER) does not Granger Cause D(LOGP)	2.834	0.061	1.036	0.310	0.585	0.558	0.032	0.858	0.084	0.919
D(LOGP) does not Granger Cause D(LOGER)	1.009	0.366	2.346	0.127	0.538	0.585	0.003	0.958	0.896	0.410
D(LOGOP) does not Granger Cause D(LOGP)	0.429	0.652	0.506	0.478	0.534	0.587	0.204	0.652	2.136	0.121
D(LOGP) does not Granger Cause D(LOGOP)	7.321	0.001*	14.093	0.000*	3.482	0.032*	17.733	0.000*	7.342	0.001*
D(LOGIR) does not Granger Cause D(LOGP)	1.166	0.313	0.191	0.663	1.149	0.319	0.047	0.828	0.563	0.571
D(LOGP) does not Granger Cause D(LOGIR)	1.931	0.147	0.177	0.674	0.170	0.844	0.038	0.846	6.124	0.003*
D(LOGM3) does not Granger Cause D(LOGP)	0.636	0.531	0.057	0.812	2.209	0.112	0.021	0.885	3.191	0.043*
D(LOGP) does not Granger Cause D(LOGM3)	0.453	0.636	0.047	0.829	4.412	0.013*	1.860	0.174	7.890	0.001*
D(LOGCPI) does not Granger Cause D(LOGP)			0.078	0.780	0.113	0.893	1.072	0.302	0.227	0.797
D(LOGP) does not Granger Cause D(LOGCPI)			0.872	0.351	1.727	0.180	1.462	0.228	1.411	0.246
D(LOGIPI) does not Granger Cause D(LOGP)			0.167	0.683	0.605	0.547	3.471	0.064	8.840	0.000*
D(LOGP) does not Granger Cause D(LOGIPI)			13.548	0.000*	2.348	0.098	0.726	0.395	8.303	0.000*

*Indicates a significant causal relationship at a 5% significance level.

Table 63 depicts the Granger causality between sample stock market indexes and selected macroeconomic determinants for Australia, Germany, Japan, the UK, and the USA. The null hypothesis of Granger causality states that *X does not Granger cause Y*

decision criteria accept the null hypothesis when the p-value is more than 5%-indicating no causality and reject the null hypothesis when the p-value is less than 5%-indication there is causality between variables. A bi-direction Granger causality is performed between the first difference of stock index price $D(LOGP)$ and other macroeconomic variables. The result indicates that there is a significant causality from the stock market to oil price changes. For the cause of the USA, there is bidirectional causality between stock index price and macroeconomic variables such as Money supply and Industrial production index. Thus, there is no significant uni-direction causality from macroeconomic variables to the stock market index for developed countries.

Table 64
Pairwise Granger Causality Tests for DUMI countries

Country	Brazil		China		Malaysia		South Africa		Turkey	
Lags:	1		2		1		8		1	
Null Hypothesis:	F-Stat.	Prob.	F-Stat.	Prob.	F-Stat.	Prob.	F-Stat.	Prob.	F-Stat.	Prob.
D(LOGER) does not Granger Cause D(LOGP)	2.295	0.131	3.669	0.027*	0.442	0.507	13.041	0.000*	1.295	0.256
D(LOGP) does not Granger Cause D(LOGER)	0.097	0.755	27.479	0.000*	1.140	0.287	53.813	0.000*	0.509	0.477
D(LOGOP) does not Granger Cause D(LOGP)	0.173	0.678	0.289	0.749	1.091	0.297	0.526	0.837	0.829	0.363
D(LOGP) does not Granger Cause D(LOGOP)	14.537	0.000*	1.993	0.139	8.187	0.005*	0.648	0.736	17.271	0.000*
D(LOGIR) does not Granger Cause D(LOGP)	1.160	0.283					2.863	0.005*	0.103	0.748
D(LOGP) does not Granger Cause D(LOGIR)	7.295	0.007*					2.148	0.033*	1.406	0.237
D(LOGM3) does not Granger Cause D(LOGP)	0.667	0.415	1.420	0.244	0.741	0.390	0.880	0.534	0.079	0.779
D(LOGP) does not Granger Cause D(LOGM3)	1.509	0.221	0.372	0.690	0.804	0.371	0.916	0.504	4.022	0.046*
D(LOGCPI) does not Granger Cause D(LOGP)	0.030	0.863	0.061	0.941			1.083	0.376	0.001	0.981
D(LOGP) does not Granger Cause D(LOGCPI)	1.128	0.289	0.162	0.851			0.820	0.586	0.828	0.364
D(LOGIPI) does not Granger Cause D(LOGP)	3.141	0.078	0.372	0.690			0.637	0.743	0.523	0.470
D(LOGP) does not Granger Cause D(LOGIPI)	3.524	0.062	0.157	0.855			0.665	0.720	5.115	0.025*

*Indicates a significant causal relationship at a 5% significance level.

Table 64 presents the Granger causality result for developing upper-middle-income countries. The result shows that no significant macroeconomic factors affect the stock market fluctuation for all developing upper-middle-income countries. On the contrary, stock market variables might be a granger cause for variation in macroeconomic variables. Further, the finding indicates a bidirectional causality between the stock market and exchange rate for China and South Africa. Furthermore, there is a bidirectional effect between the stock market and interest rate in South Africa

The Granger causality test result for developing lower-middle-income countries are presented in Table 63. The finding shows no significant granger cause from macroeconomic variables in the sample of developing lower-middle-income countries' stock markets. However, There is a granger causality from stock price to exchange rate in Egypt, from stock price to oil price for India and Kenya, From stock price to inflation for Egypt, and from Stock price to Industrial production index for India.

Table 65

Pairwise Granger Causality Tests for DLMI countries

Country	Egypt		India		Kenya		Sri Lanka		Tunisia	
Lags:	1		2		1		1		1	
Null Hypothesis:	F-Sta.	Prob.	F-Stat.	Prob.	F-Stat.	Prob.	F-Stat.	Prob.	F-Stat.	Prob.
D(LOGER) does not Granger Cause D(LOGP)	0.210	0.648	2.154	0.144	1.004	0.368	0.027	0.869	0.405	0.525
D(LOGP) does not Granger Cause D(LOGER)	23.673	0.000*	0.039	0.844	1.171	0.312	2.102	0.148	0.184	0.668
D(LOGOP) does not Granger Cause D(LOGP)	1.228	0.270	0.049	0.824	1.172	0.312	0.945	0.332	0.015	0.902
D(LOGP) does not Granger Cause D(LOGOP)	0.031	0.861	16.074	0.000*	3.077	0.048*	2.265	0.134	1.044	0.308
D(LOGIR) does not Granger Cause D(LOGP)			0.155	0.694					0.009	0.926
D(LOGP) does not Granger Cause D(LOGIR)			2.967	0.086					1.632	0.203
D(LOGM3) does not Granger Cause D(LOGP)			0.040	0.841			0.530	0.468		
D(LOGP) does not Granger Cause D(LOGM3)			0.499	0.481			0.028	0.868		
D(LOGCPI) does not Granger Cause D(LOGP)	0.398	0.530	0.234	0.629	0.061	0.941				
D(LOGP) does not Granger Cause D(LOGCPI)	5.312	0.023*	0.117	0.732	0.049	0.952				
D(LOGIPI) does not Granger Cause D(LOGP)	0.063	0.803	0.488	0.485						
D(LOGP) does not Granger Cause D(LOGIPI)	0.473	0.493	8.154	0.005*						

*Indicates significant causal relationship at 5% significance level.

To sum up, In this chapter, the weak and semi-strong forms of stock market efficiency for sample developed countries are investigated for the period from 2000 to 2019. To examine the weak form of efficiency of sample indexes, autocorrelation, run test, unit root tests, and variance ratio tests were employed. However, cointegration and Granger causality tests are applied to examine sample countries' semi-strong forms of efficiency using macroeconomic variables.

CHAPTER VI

DISCUSSION

6.1. Introduction

The general objective of this study is to examine the efficient market hypothesis for 15 countries' stock markets in three different economic statuses: developed, developing-upper-middle income, and developing-lower-middle-income countries. In particular, this study aimed to answer four specific objectives. The first objective is to examine the weak form efficiency of sample countries' stock markets. The second objective is to assess the dynamics of weak-form efficiency over time. Investigating the semi-strong form efficiency is the third objective. The fourth and last objective is to analyze whether there is a similarity in the stock market's efficiency depending on the sample countries' economic status. This chapter is devoted to discussing the findings in line with the previous related literature. The discussion is framed into four sections based on the specific purposes of this study.

6.2. Testing the Weak Form Efficiency of Stock market

The autocorrelation test result suggests that only Japan followed a random walk during the entire study period from DUMI countries. Contrary to the existing evidence, the Australia, Germany, UK, and USA indexes have significant autocorrelations within 24 lags. Except for Australia and UK, there was no considerable autocorrelation for all developed countries' stock markets during the last sub-period, covering from May 5, 2012, to December 31, 2019. Therefore, in line with the third sub-study period, developed countries' stock markets follow a random walk. The autocorrelation result for developed upper-middle-income countries like Brazil, China, Malaysia, South Africa, and Turkey has a significant autocorrelation in the entire study period. But, in the third sub-study period, all developed upper-middle-income countries seem to follow a random walk with no considerable autocorrelation. When we come to the developing lower-middle-income countries, they have a significant autocorrelation in the entire study period. In the third study period, no significant autocorrelations were identified for Egypt and Kenya.

The inferences from run test analysis indicated that the sample stock markets in developed and developing upper-middle-income countries followed a random walk

during the entire sub-study periods. On the contrary, stock markets in developing lower-middle-income countries were not following a random walk during the whole study period. Only Egypt and India follow a random walk in the third study period.

The result of the unit root tests showed that all developed and developing countries' stock markets followed a random walk in the entire and sub-periods at the level. However, when the unit root test is examined for the first difference/ log return, all developed and developing stock markets become stationary-meaning not following a random walk during the entire period and sub-periods. Considering the impact of structural breaks on the randomness of time series, the Zivot–Andrews unit root test, which evaluates one structural break, is applied. Conversely, the finding shows that there was no improvement in the result. Furthermore, the availability of multiple structural breaks is examined through Bai-Perron multiple structural break test. The finding indicates no multiple structural breaks for developed and developing upper-middle-income countries. Finally, the Lo-MacKinlay variance ratio test examines the weak form efficiency of sample stock markets. The variance ratios for all samples are significantly less than one. Further, the $Z(K)$ and $Z^*(K)$ test statistics for all samples during the entire and sub-periods are more than the 5% significant value. Furthermore, the Chow-Denning joint test z-statistics are beyond the ± 1.96 boundaries. Therefore, these findings indicated that the sample indexes from 15 countries did not follow a random walk.

The weak form efficiency test of this study suggests two contrary results. First, the autocorrelation and run tests demonstrate the weak form of efficiency of developed and developing upper-middle-income countries. At the same time, these result indicates the weak form inefficiencies of developing lower-middle-income countries. The weak-form efficiency test results' of developed countries' stock market consensus with the finding of studies such as Nisar and Hanif (2012), Singh et al. (2015), and Erdem and Ulucak (2016), which claims the weak form efficiency of developed countries' stock markets. The weak form efficiency of Brazil, China, Malaysia, South Africa, and Turkey is also supported by studies such as Mobarek and Fiorante (2014) and Singh et al. (2015). On the other hand, unit root and variance ratio tests indicate that all developed and developing countries' stock markets are weak-form inefficient. Studies such as Mishra (2011), Hamid et al. (2017), and Tiwari et al. (2019) also present a result of the weak form inefficiency of developed countries' stock markets. On the weak-form inefficiency of developed upper-middle-income countries, Mishra (2011), Hamid et al. (2017), De

Carvalho et al. (2016), and Malafeyev et al. (2017) do not exhibit a weak form efficiency for developing-upper-middle-income countries. The weak form efficiency of developing-lowe-income countries such as Egypt, Kenya, India, Sri Lanka, and Tunisia are confirmed by several studies like Smith (2008), Alagidede and Panagiotidis (2009), Enowbi et al. (2010), Nisar and Hanif (2012), Hamid et al. (2017), Kelikume et al. (2020), and Dias and Santos (2020).

6.3. Investigating The Dynamics of Weak Form Of Efficiency Over Time

The stock market efficiency changes over time can be expected due to different reasons like globalization, financial market liberalization, etc. Therefore, the 20 years weekly observations are divided into three equal sub-periods to examine the dynamics of weak-form efficiency over time. The first sub-period is between January 8, 2000, and August 26, 2006. The second sub-period covers from September 1, 2006, to April 27, 2013, and the sub-study period starts on May 5, 2013, and ends on December 28, 2019.

The autocorrelation results of the three sub-periods indicated no significant changes from the first sub-period to the second sub-period. However, there was almost no considerable autocorrelation between developed and developing upper-middle-income countries' 24 lags from the second to the third-sub period. On the contrary, no significant periodic changes were recorded for developing-lower-middle-income countries' stock markets except for India and Kenya. The Kenyan stock market went from random in the second subperiod to nonrandom in the third subperiod. According to the run test result, developed and developing-upper-middle income countries followed a random walk throughout the three sub-periods. However, among developing –lowe-middle income countries, Kenya and India show healing from the first to the second and third sup periods. Contrary to this, The Tunisia stock market followed a random walk in the first and second-sub period, and then it became nonrandom in the third sub-period. Unexpectedly, according to the unit root and Variance ratio test results, efficiency was not improved within the three sub-periods.

Even though we can not detect a significant periodic change in the unit root and variance ratio tests, the changes in efficiency over time or becoming more efficient compared to the previous periods are confirmed by empirical studies like Yang, Kwak, Kaizoji, and Kim (2008), Mobarek and Fiorante (2014), and Singh et al. (2015). This

study's autocorrelation and Run test results exhibit the improvement of weak-form efficiency from the second sub-period to the third sub-period.

6.4. Testing the Semi-strong Form of Efficiency

Among the methods applied to investigate the semi-strong form of efficiency is examining the impacts of macroeconomic variables on stock market variation. For this purpose, cointegration and Granger causality tests are employed to analyze the association between macroeconomic variables and stock markets.

According to the cointegration and granger causality test results, Australia, Germany, Japan, the UK, and the USA's stock markets seem efficient in the semi-strong form of efficiency. Further, the granger causality test shows that the stock market returns are the leading indicators for macroeconomic fluctuations. These findings constitute Plíhal (2016), who concludes that no leading macroeconomic factors explain the stock return changes in the German stock market. Further, Plíhal (2016) states that stock market return was a leading indicator for macroeconomic variations. However, contrary to the finding of this study, researchers like Humpe and Macmillan (2009), Sir (2012), and Masood et al. (2019) present evidence on the existence of cointegration and granger causality from macroeconomic variables to developed countries' stock markets.

The cointegration test result for developed upper-middle-income countries shows no long-term cointegration between stock market returns and macroeconomic variables for Brazil, Malaysia, and Turkey. However, China and South Africa have a significant cointegration. On the other hand, the causality test results show no significant macroeconomic factor affecting stock returns in Brazil, China, Malaysia, South Africa, and Turkey. Consequently, as per the Granger causality test, developed upper-middle-income countries seem efficient in the semi-strong form of efficiency. This conclusion is supported by studies like Gay Jr (2008) for Brazil and China, Alam et al. (2011), and Lone et al. (2021) for South Africa. However, studies such as Alam and Uddin (2009), Pandey and Sabamaithily (2018), de Araújo et al. (2020), Bernardelli and De Castro (2020), Yunus et al. (2014), Nasir et al. (2017), Chauque and Rayappan (2018), Vardar et al. (2018), Demir (2019), İlhan and Akdeniz (2020), and Sivrikaya (2021) presented shreds of evidence on the semi-strong form inefficiency of developed upper-middle-income countries.

The Johansen Cointegration test result indicated that all samples of lower-middle income countries have a significant cointegration between the stock market and macroeconomic factors except Sri Lanka. The Granger causality test result for developing lower-middle-income countries reveals no significant mono-directional causality from macroeconomic variables to the Stock market return. However, there is some Granger causality from the stock market to the macroeconomic variable. The semi-strong form efficiency of developed lower-middle-income countries is supported by studies such as Bhattacharya and Mukherjee (2003) and Baranidharan and Dhivya (2020) for the case of India only. On the contrary, the vast majority of studies on the semi-strong form efficacy of developing lower-income countries like Barakat et al. (2016) and Barakat et al. (2016) claim the inefficiency in the semi-strong form of efficiency.

6.5. The Similarity of Stock Market Efficiency for Countries in the Same Economic Status

Investigating the stock market efficiency situation for countries of the same economic status is among the specific objectives of this study. There is no unique methodology applied for this objective. The author of this study tries to draw inferences from the three economic groups such as developed, developing-upper-middle income, and developing lower-middle-income countries' weak and semistrong form of efficiency test results.

The findings reveal that developed, developing-upper, and lower-middle-income countries' weak and semi-strong forms of efficiency test results are almost similar for countries in each group. These inferences may confirm most empirical studies' stock market efficiency test results. The familiar empirical studies indicate that the stock markets of developed countries are efficient in weak and semi-strong forms and that the stock markets of emerging economies are efficient in weak form and are approaching semi-strong efficiency.

CHAPTER VII

CONCLUSION AND RECOMMENDATIONS

7.1. Introduction

This chapter presents the study's conclusion by summarising the key research findings based on research objectives and discussing the recommendation and contributions of the study. The research limitation and suggestions for further studies are also reviewed in this chapter.

7.2. Conclusion

This study aimed to investigate the weak and semi-strong forms of stock market efficiency for Fifteen developed (Australia, German, Japan, The UK, and The USA), developing-upper-middle-Income (Brazil, China, Malaysia, South Africa, and Turkey), and developing-lower-middle income countries (Egypt, India, Kenya, Sri Lanka, and Tunisia).

The first objective of the study is to test the weak form of stock market efficiency for sample countries' indexes using weakly observations of each index. The result indicates that there is no consistent result among the methods applied. Based on the autocorrelation and Run test results, developed and developing lower-middle-income countries' stock markets seem efficient in the weak form of efficiency. However, these methods indicated that developed lower-middle-income countries' stock markets were inefficient. On the contrary, the unit root and variance ratio test results reveal that all sample countries' stock markets were not efficient in the semi-strong form of efficiency.

To examine the changes in efficiency over time, the weak form of efficiency for three sub-period (Sub-period I: 1/ 8 2000 - 8/ 26/2006, Sub-period II: 9/1/ 2006 – 4/27/2013, and Sub-period III:9/ 5/2013 – 12/ 28/2019) also studied by each method. The autocorrelation and run test results show a significant change from inefficiencies to efficiency from the second to the third sub-period.

Investigating the semi-strong form of stock market efficiency of sample stock indexes is the third objective of the study. There is an inconsistency among the applied methods to test semi-strong forms of efficiency. The cointegration test results indicated no long-run cointegration among stock returns and macroeconomic variables in

developed and developing –upper-middle-income countries. However, this test result shows a congregation between macroeconomic variables developing-lower-middle-income countries' stock market returns. On the other hand, the Granger causality test result reveals no significant Granger causality from macroeconomic variables to stock return. Conversely, the stock market returns became a leading indicator for some macroeconomic factors. Depending on the Granger causality test outcomes, all simple stock markets seem efficient in the semi-strong form of efficiency.

The author tries to grasp inferences from the efficiency test results from sample countries at three economic levels to answer whether stock markets in countries with the same economic status have similar efficiency characteristics. The findings' inferences indicated that the stock market efficiency characteristics in the same economic level countries seem identical.

Finally, it should be given attention to the conclusion of the weak and semi-strong forms of efficiency test results. Because the weak form efficiency may differ depending on the sample study period (daily, weekly, monthly), sample index, and applied method. Further, the semi-strong efficiency result may also vary due to the sample study period, sample index, applied methodology, and used determinant macroeconomic factors.

7.3. Recommendations

Technical and fundamental analysts are trying to get abnormal profit when the markets are inefficient. And as efficiencies vary from time to time, stock market analysts, investors, and financial instrument regulatory bodies, which play a vital role in policymaking in developed and developing upper-middle-income countries, should take necessary measures to improve and keep the informational efficiency of the stock markets.

Stock markets in the developing-lower-income countries are not still preserving the weak form of efficiency. Therefore, policymakers and other responsible government bodies in these countries should provide precise prudential regulation of financial institutions and markets to attain the informational efficiency of the stock market.

7.4. Limitations of The Study

It is usual in academic study to confront limitations. There are limitations in the weak and semistrong form of efficiency tests of this study. In the case of the weak form of efficiency test, only weekly observations of sample indexes were used and examined using only four methods such as autocorrelation, run, unit root, and variance ratio tests. Even though inflation, Money supply, exchange rates, interest rates, Industrial Production Index, and crude Oil Price were selected to examine the semi-strong form of efficiency, the author could not find the data for some variables in some countries. For instance, Industrial production and inflation rate could not be available for the selected study period. Further, the interest rate for China, interest rate, CPI, and IPI for Malaysia, Money supply and interest rate for Egypt, Money supply, interest rate, and IPI for Kenya, interest rate, CPI, and IPI for Sri Lanka, and money supply, CPI and IPI for Tunisia were not available for the specified study period. Moreover, the semi-strong efficiency form was examined only through cointegration and granger causality test methods.

7.5. Further Research Suggestion

Generally, the finding of the methods applied in this study yielded inconsistent results. Hence, it is challenging to categorically conclude the weak and semi-strong forms of sample countries' stock market efficiencies. The appropriate explanation of the contradicting results may be the selected study period, data frequency, and the methodology employed. Therefore, researchers should conduct further studies on the weak-form efficiency of developing and developed stock markets using daily, weekly, and monthly frequency data through various advanced statistical methods.

For the semi-strong form of efficiency tests, as a result of varies depending on the number of macroeconomic factors included in the model, further research should be done using the variable more macroeconomic factors besides cointegration and causality test methods. In this study, the stock market return becomes a leading factor for macroeconomic variable factors. For that reason, The author also recommends future research on whether macroeconomic factors are a leading indicator for stock market variation or stock market returns are the leading indicators for macroeconomic variables changes.

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APPENDICES

Annex 1 Country classifications by WESP: Developed Countries

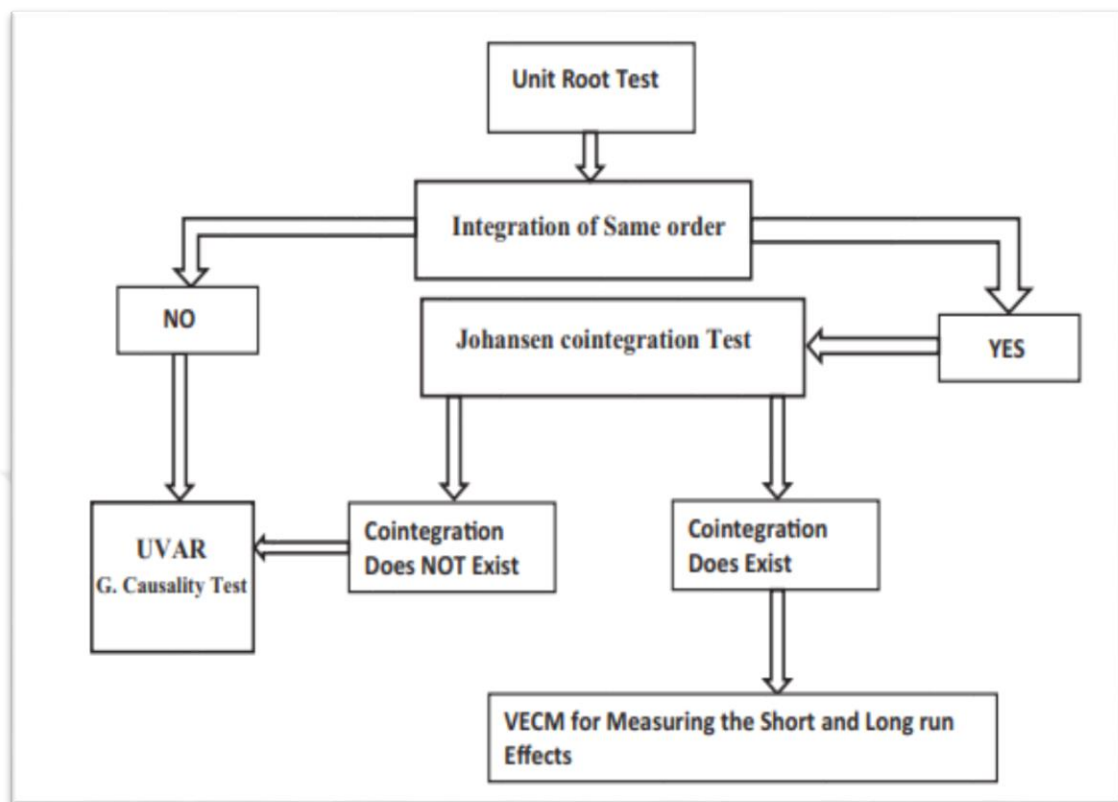
North America	Europe		Major developed economies (G7)
	European Union	Other Europe	
Canada United States	EU-15 Austria ^a Belgium ^a Denmark Finland ^a France ^a Germany ^a Greece ^a Ireland ^a Italy ^a Luxembourg ^a Netherlands ^a Portugal ^a Spain ^a Sweden United Kingdom ^b	Iceland Norway Switzerland	Canada Japan France Germany Italy United Kingdom United States
Developed Asia and Pacific	EU-13^c Bulgaria Croatia Cyprus ^a Czech Republic Estonia ^a Hungary Latvia ^a Lithuania ^a Malta ^a Poland Romania Slovakia ^a Slovenia ^a		
Australia Japan New Zealand			

Annex 2 Country Classifications by WESP: Developing Countries

Africa		Asia	Latin America and the Caribbean
North Africa	Southern Africa	East Asia ^b	Caribbean
Algeria	Angola	Brunei Darussalam	Bahamas
Egypt	Botswana	Cambodia	Barbados
Libya	Eswatini	China	Belize
Mauritania	Lesotho	Democratic People's Republic of Korea ^c	Guyana
Morocco	Malawi	Fiji	Jamaica
Sudan	Mauritius	Hong Kong SAR ^d	Suriname
Tunisia	Mozambique	Indonesia	Trinidad and Tobago
Central Africa	Namibia	Kiribati	Mexico and Central America
Cameroon	South Africa	Lao People's Democratic Republic	Costa Rica
Central African Republic	Zambia	Malaysia	Cuba
Chad	Zimbabwe	Mongolia	Dominican Republic
East Africa	West Africa	Myanmar	El Salvador
Burundi	Benin	Papua New Guinea	Guatemala
Comoros	Burkina Faso	Philippines	Haiti
Democratic Republic of the Congo	Calbo Verde	Republic of Korea	Honduras
Djibouti	Côte d'Ivoire	Samoa	Mexico
Eritrea	Gambia (Islamic Republic of the)	Singapore	Nicaragua
Ethiopia	Ghana	Solomon Islands	Panama
Kenya	Guinea	Taiwan Province of China	South America
Madagascar	Guinea-Bissau	Thailand	Argentina
Rwanda	Liberia	Timor-Leste	Bolivia (Plurinational State of)
Somalia	Mali	Vanuatu	Brazil
South Sudan ^e	Niger	Viet Nam	Chile
Uganda	Nigeria	South Asia	Colombia
United Republic of Tanzania	Senegal	Afghanistan	Ecuador
	Sierra Leone	Bangladesh	Paraguay
	Togo	Bhutan	Peru
		India	Uruguay
		Iran (Islamic Republic of)	Venezuela (Bolivarian Republic of)
		Maldives	
		Nepal	
		Pakistan	
		Sri Lanka	
		Western Asia	
		Bahrain	
		Iraq	
		Israel	
		Jordan	
		Kuwait	
		Lebanon	
		Oman	
		Qatar	
		Saudi Arabia	
		State of Palestine ^c	
		Syrian Arab Republic	
		Turkey	
		United Arab Emirates	
		Yemen	

Annex 3 Country Classifications by WESP: Measured by Per Capita GNI

High-income		Upper-middle-income		Lower-middle-income	
Argentina ^c	Latvia	Albania	Kazakhstan	Angola	Lesotho
Australia	Lithuania	Algeria	Lebanon	Bangladesh	Mauritania
Austria	Luxembourg	Armenia ^c	Libya	Bhutan	Mongolia
Bahamas	Malta	Azerbaijan	Malaysia	Bolivia (Plurinational State of)	Morocco
Bahrain	Netherlands	Belarus	Maldives	Cabo Verde	Myanmar
Barbados	New Zealand	Belize	Mauritius	Cambodia	Nicaragua
Belgium	Norway	Bosnia and Herzegovina	Mexico	Cameroon	Nigeria
Brunei Darussalam	Oman	Botswana	Montenegro	Congo	Pakistan
Canada	Panama ^c	Brazil	Namibia	Côte d'Ivoire	Papua New Guinea
Chile	Poland	Bulgaria	Paraguay	Djibouti	Philippines
Croatia ^c	Portugal	China	Peru	Egypt	Republic of Moldova
Cyprus	Qatar	Colombia	Romania	El Salvador	São Tomé and Príncipe
Czech Republic	Republic of Korea	Costa Rica	Russian Federation	Eswatini	Solomon Islands
Denmark	Saudi Arabia	Cuba	Samoa	Georgia	Sri Lanka
Estonia	Singapore	Dominican Republic	Serbia	Ghana	State of Palestine
Finland	Slovak Republic	Ecuador	South Africa	Honduras	Sudan
France	Slovenia	Equatorial Guinea	Suriname	India	Timor-Leste
Germany	Spain	Fiji	Thailand	Indonesia	Tunisia
Greece	Sweden	Gabon	The former Yugoslav Republic of	Kenya	Ukraine
Hong Kong SAR ^d	Switzerland	Guatemala ^c	Macedonia	Kiribati	Uzbekistan
Hungary	Taiwan Province of China	Guyana	Turkey	Kyrgyzstan	Vanuatu
Iceland	Trinidad and Tobago	Iran (Islamic Republic of)	Turkmenistan	Lao People's Democratic Republic	Viet Nam
Ireland	United Arab Emirates	Iraq	Venezuela (Bolivarian Republic of)		Zambia
Israel	United Kingdom	Jamaica			
Italy	United States	Jordan ^c			
Japan	Uruguay				
Kuwait					

Annex 4 Johansen Cointegration Test Procedure

Adopted from Jalil, and Rao (2019)