Testing the Weak Form Market Efficiency: Evidence from the Casablanca Stock Exchange

Imane Guendouz

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Prof. Dr. Ali Hakan Ulusoy
Director

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

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

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

Prof. Dr. Cahit Adaoğlu
Supervisor

Examining Committee

1. Prof. Dr. Cahit Adaoğlu
2. Asst. Prof. Dr. Bezhan Rustamov
3. Asst. Prof. Dr. Nigar Taşpınar

ABSTRACT

In the three classifications of market efficiency, the weak form efficiency is the one that states past stock price movements cannot be used to forecast future prices and they follow a random walk. This study tests the weak form efficiency for the Casablanca Stock Exchange using parametric and non-parametric tests and studies the behavior of stock prices. Specifically, four parametric and non-parametric tests, namely the serial correlation test, the runs test, the unit root tests (i.e., the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) test), and the variance ratio test are used to test for the weak form market efficiency. The findings of all four empirical tests find that the Casablanca Stock Market is not weak form efficient and stocks prices follow a random walk. This finding implies that the technical analysis used for predicting the future stock prices is useless.

Keywords: the weak from efficiency, the random walk, the Casablanca Stock

ÖZ

Piyasa etkinliğinin üç sınıflandırmasının biri olan zayıf biçim etkinlik, geçmiş hisse senedi fiyat hareketlerinin gelecekteki fiyatları tahmin etmek için kullanılamayacağını ve hisse senedi fiyatlarının rastgele bir yürüyüşü izlediklerini öne sürmektedir. Bu çalışma, Kazablanka Borsası'nın zayıf biçim etkinliğini parametrik ve parametrik olmayan testler kullanarak test etmekte ve hisse senedi fiyatlarının davranışını incelemektedir. Spesifik olarak, dört parametrik ve parametrik olmayan testler, yani seri korelasyon testi, tekrarlar testi, birim kök testleri (Genişletilmiş Dickey-Fuller (ADF) testi ve Phillips Perron (PP) testi) ve varyans oranı testi, zayıf biçim piyasa verimliliğini test etmek için kullanılmıştır. Bu dört testin sonuçları Kazablanka Borsası'nın zayıf etkin olmadığını ve hisse senedi fiyatlarının rastgele bir seyir izlediğini göstermektedir. Sonuçlar gelecekteki hisse senedi fiyatlarını tahmin etmek için kullanılan teknik analizin kullanılmasını önermemektedir.

Anahtar Kelimeler: zayıf biçim etkinlik, rastgele yürüyüş, Kazablanka Borsası

DEDICATION

To my family

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AC	Autocorrelation
ADF	Augmented Dickey-Fuller
EMH	Efficiency Market Hypothesis
MASI	Moroccan All Shares Index
PP	Phillips Perron
SD	Standard Deviation
VR	Variance Ratio

Chapter 1

INTRODUCTION

1.1 Introduction

Due to its significant consequences, the hypothesis of an efficient market has been the focus of the greatest discussion in financial writing in recent decades. This concept was developed in the 1960s by a finance professor named Eugene Fama (1970) at University of Chicago. Fama (1970) is considered the foremost researcher in expressing the notion of efficiency and random walking. The idea of an efficiency market states that securities incorporate all publicly available information. Meanwhile, the theory of random walk indicates that prices cannot be predicted, and furthermore, follow a random pattern. Consequently, no investors can obtain abnormal returns, making it impossible to beat the market. Thus, the market could be considered as an efficient market (Al-Jafari, 2011).

Using three different forms of market efficiency, which are weak form, semi-strong form, and strong form, Fama (1970) introduced the efficient market concept, in which the weak form efficiency implies that all information from historical prices and trading data is already reflected in the current prices, and by using this type of information, future prices cannot be predicted. Accordingly, it will not be easy for investors to dominate the market. The semi-strong form shows that prices represent all public information about the prospects of companies available to the public, such as financial data, information about the industry, and past prices. This means that the weak and semi-strong forms are related to each other. That is if the market is efficient in a semi-strong form, it is also weak form efficient. The strong form states that the stock prices incorporate both public and private information (Aktan, Sahin & Kucukkaplan, 2018).

The efficient market hypothesis and the random walking theory have important implications for investment strategies because it is impossible to obtain abnormal returns unless a gap exists between market information and efficiency. This information is very useful for academics who research stock price behavior and standard risk-return performance. Investors should greatly consider whether the stock prices follow a random walk. Finally, the market system does not guarantee that resources are allocated efficiently in the market in the event of market inefficiency, which can have a significant effect on the economic market (Borges, 2010).

This research is different in several respects from other studies. Empirical studies that examined the efficiency of the Casablanca stock market are rare. Although, Morocco is considered one of the most important developing financial centers in Africa, and studying the behavior of its stock market would be a great benefit to investors.

In the past several decades, EMH has made a huge contribution to the financial sector. Among the three forms of market performance, the most frequently tested form is possibly the weak form. We can see that research on developing countries focuses primarily on the weak form and the semi-strong form test. It is very difficult to test a strong form of market performance, and there is hardly any evidence of its research in developing countries. Stock returns are said to be highly predictable in developed countries and stock markets are less efficient than those in developing countries (Al-Jafari, 2011).

1.2 Objective

The overall aim of the study is to test the weak from efficiency of Morocco stock market. Morocco has one major stock exchange located in Casablanca, namely, the Casablanca Stock Exchange. To test for the weak form efficiency, researchers typically use nonparametric and parametric tests hypothesis, namely the serial correlation, the runs, the variance ratio, and unit root tests.

The following null and alternative hypotheses are tested for the Casablanca Stock Exchange:

H0: The Casablanca Stock Exchange is efficient in the weak form.

H1: The Casablanca Stock Exchange is not efficient in the weak form.

1.3 Methodology

The weak form efficiency of the Casablanca Stock Exchange is tested in this research and we try to find evidence whether it would be possible to forecast the future securities prices from previous data of the Moroccan Most Active Shares Index (MADEX index). The data for the index was obtained from the Eikon DataStream. The Daily closing prices of the MADEX index in the period from February 1, 2002, to August 10, 2020, are collected having a total of 4,901 observations. These observations are used to explain the randomness in the data through different statistical techniques. The analysis included nonparametric and parametric methods. In particular, the runs test was used to examine the random behavior in the MADEX index, autocorrelation to verify the independence of the time series data by measuring the correlation between current and previous time series of MADEX, unit root test is employed to evaluate whether the variables are stationary or not and variance ratio test to examine a randomness assumption. All these statistical tests were performed by using Eviews and SPSS econometrics software.

1.4 Structure

In the first chapter, we introduce the objective of the study and discuss briefly the research method. In Chapter 2, we present the literature review on the efficient market theory of financial markets and its origins, and the different aspects of the emergence of the efficienct hypothesis theory. In Chapter 3, we briefly investigate the Casablanca Stock Exchange and empirically test for the weak form efficiency. Finally, Chapter 4 covers the main conclusions of this research.

Chapter 2

LITERATURE REVIEW

2.1 Efficient Market Hypothesis and Random Walk Theory

The random walk theory and the efficient market hypothesis suggest that the financial specialists cannot have abnormal returns because stock prices adjust immediately to new information. The efficient market hypothesis is based on the random walk theory, which agrees that price changes will be independent of past prices. However, these two terms do not represent the same concept. Specifically, an efficient market states that prices can increase or decrease in response to the relevant information, whereas the random walk means that prices take a random direction but can respond to irrelevant information.

Owing to the implications of the efficient market hypothesis and random walk, many studies have directed great attention to investigate this issue. The emergence of financial market efficiency hypothesis and random walk were discussed in early studies by Louis Bachelier, "The Theory of Speculation" in his research article (1900). Where he investigated the formula of the random movements of stock markets; randomity here means that securities follow a random walk, leading to the impossibility of predicting futures prices. He implied the theory of probability by prioritizing prices in his theory and contributed to developing modern finance theory (Preda, 2004). Similarly, Karl Pearson (1905) considered that the theory of random movement is the center of the market efficiency theory and that the information is unpredictable and the prices move randomly which is related to the financial market efficiency hypothesis (Lim, Lim Xiu Yun & Zhai, 2012).

Kendall (1953) included an empirical study in which he discovered that stock prices were not serially correlated, this suggests that a random process is followed by stock prices, explaining that the independence between the current price and its previous. Osborne (1959) then analyzed fluctuations in stock prices by applying statistical mechanisms in which it agreed that prices were formed at random. (Dimson and Mussavian, 1998).

More recent empirical studies have used alternative techniques and more complicated models in the price sequence in time series on the markets. Fama (1970) according to his first Ph.D. thesis entitled "Behavior of stock markets", published in the Journal Business, indicated the character of the prices and tried to develop the notion of efficiency market, besides, he composed the stock market to “sophisticated traders”, that shows two types of stock prices analysis and their relationships with efficiency markets, which are the fundamental analysis and the technical analysis (Fama, 1970).

Fundamentalists assume a fundamental value for each asset, however, traders will always take risks due to the change in the fundamental value, in the profit account for companies are not recognized, so the fundamental benefit differential cannot be calculated with certainty. Fundamentalists use both macro-economic and microeconomic methods to determine stock prices that could potentially underestimate or overestimate the fundamental value, this would assume a structural variation between the prices in the market and the real value of the market., while the technical analysis indicates that the stock prices study is based on the search for models that suggest a movement in crisis and determine the appropriate time to buy or sell.

As Fama (1970) stated, the market is efficient when the information will reflect price fluctuations, the notion of efficiency was first explored by Fama (1970) through the application of three levels of market efficiency, the weak-form, semi-strong and strong form. In which, the first level weak form suggests that prices reflect data (historical and trading data...) this shows that the predictability of future prices cannot be verified by technical analysis, so the investor cannot achieve a return above the normal level. The Semi-Strong assumes that the relevant information is publicly announced so that the investor cannot achieve a higher-than-normal performance. The strong form on the other hand, the security reflects all public and private information, indicating the impossibility for investors to generate abnormal profits. the weak-form efficiency market analyzed as part of the study is explicitly aimed at random walking measurements. Where random walk means that stock prices can be unpredictable (Kapusuzoglu, 2013).

On the other hand, Samuelson (1970) suggests another process, martingale. This was the first formal economic argument implicit in the case of the efficiency market. This stochastic process indicates the connection between spot prices and futures prices. Jensen (1978) found that the efficient market must take into account the different costs associated with the mechanism of estimation, such as information gathering, statistical methods, and the management of a market position, therefore the benefit would be zero, accordingly prices will reflect information if only the cost of the new information would not exceed the expected benefits. (Sewell, 2011).

2.2 The Three Forms of Market Efficiency

Because of the evolution of financial markets, researchers have continued to demonstrate that stock exchange prices adopt a purely random model, although Fama (1970) notes that all information available should reflect stock prices, implying that the price trends are random. Fama (1970) suggests that the hypothesis of the efficiency market is presented in three forms: weak-form EMH, semi-strong EMH, and strong EMH.

The weak form informs that all historical information is completely represented by stock prices, this level is the lowest level of efficiency represented by the market efficiency that if current prices reflect all previous price information, the reason why this form is classified as a degree of weakness is that historical prices are easy to obtain and free of charge. As a consequence, investors do not earn a profit.

Semi-strong efficiency is the second level of efficiency, it contains all historical data as well as all public information, which means that prices react instantly to any new information that is announced as soon as it is published. Information to be published, either by the press, annual reports, sales announcements, or profits. According to the semi-strong efficiency model, only unpublished private information may benefit from this level of market efficiency.

The third level of market efficiency, strong form, suggesting that all public, private or historical data is included at current prices., meaning that prices reflect all existing information, which is too difficult for investors to obtain a profit. In this form of information efficiency, all investors are equal in terms of information (Aktan, Sahin, & Kucukkaplan, 2018).

2.3 The Conditions Necessary for the Efficiency of Financial Markets

an efficient market referred to that future securities prices cannot be predictable because the prices represent the information available, as well any recent information disseminated instantly reflects securities prices. Therefore, in guaranteeing the market's efficiency, the information efficiency theory remains verifiable under three conditions, which constitute its main theoretical basis:

- Rationality of investors: The efficient market presupposes that all investors must behave rationally, and that, by acting rationally to make their decisions without running an additional risk, in other words, any anticipation of positive information should lead investors to purchase or retain the securities, on the other hand, if the information is negative it should lead investors to sell the securities, which implies rational anticipation of investors.
- The absence of transaction costs and taxes on stock markets: Transactions need to be carried out at a lower cost to encourage the investors to react instantaneously and rationally, as economic agents cannot exchange their securities easily if transaction costs are high, and they cannot react instantaneously.
- Investor Atomicity and Liquidity Atomics are one of the fundamental assumptions of pure and perfect competition, to this end, no investor must be dominating the market by itself and should not avoid the risk of market insolvency.

However, at the real level, most of the requirements for complete and perfect performance are difficult to achieve. As a result, assumptions about the theory of information efficiency remain benchmarks that are free of any robustness, the closer the market is to these points, the greater their efficiency increases.

2.4 The Sources and Nature of the Information

After the explanation of the information efficiency modules, we will determine the source and nature of the information in which investors decide to take a position, the information can generally be made in public by the company, in which case we are talking about the microenvironment which includes all the appropriate and precise information to the public, such as the annual statement of results, the opening of the company to a new market, or any information provided directly within the company.
Another source of information affecting investors is the macro-environment, in particular, any external public information is directly or indirectly related to the company, if there is a significant increase in the commercial market of the company, this information will influence the exchange rates of the company's shares even if it is external to the company.

Regardless of the nature or source of the information that is directly or indirectly relevant to the company, the efficiency market hypothesis allows the stock prices to represent the information, for this reason, the information has an effect on price variations, it depends on the quality of the information published. Therefore, the form of information in a financial market is an important indicator to recognize market sensitivity, including different types of information (past, public, or private), which will allow investors to focus on a type of information and benefit from it to make profits.

2.5 Empirical Results of the Weak Form Information Efficiency

The study looks for evidence of market efficiency in a weak assumption form in a less developed market such as the Casablanca Stock Exchange.

It is very handy to measure the efficiency of market at the weak level. due to the lack of adequate data, structural profile, and insufficient regulations. Some works have been made out in emerging markets to analyze the efficient market hypothesis (EMH) relative to the volume of papers published in the developed market. Indicating that developing markets are usually assumed to be less efficient than the developed market. (Mobarek & Keasey, 2000).

2.5.1 Developed Stock Markets

Lee (1992) noted that these 10 developed countries in Europe, and United Kingdom are weakly efficient in terms of their results, similar results of Choudhry (1994) that tested the efficiency of seven developed stock indices which are (U.K., Japan, France, Germany, U.S, and Italy) by applying unit roots tests, his results show that these markets are weakly efficient (Al-Jafari, 2013).

As Solink (1973) analyzed the shares through several tests on eight stock markets in France, Italy, the United Kingdom, Germany, Belgium, Netherland, Switzerland, Sweden, and the United States, where it concluded that the random march of European shares is more efficient than the stock exchange of the United States, besides, Ang and Pohlman (1978) considered that Japan, Singapore, and Australia are less efficient because of the weak type of data performance. As well the high price dependence is explained by powerful serial correlation. (Hamid, Suleman, Ali Shah & Imdad Akash, 2017).

2.5.2 Developing Stock Markets

According to Smith and Ryoo (2003), the five developing European securities markets which are Greece, hunger, Poland, Turkey, and Portugal rejected the assumption of random walk, by contract the Turkish stock market follows a random walk due to the implementation of the serial correlation (Al-Jafari, 2013).

Guidi, Gupta, and Maheshwari (2010) tested the developing securities markets for Eastern Europe by using several tests, they found that they rejected the hypothesis of efficient market. Hassan et al., (2006) applied several tests to investigate the efficiency and concluded that the securities markets of Slovakia, Greece, Turkey, Hungry, Poland, and Russia are following a random walk, while Abrosimova et al., (2005) conducted that Russian stock markets are supporting the weak-form efficient. (Al-Jafari, 2013).

Urrutia (1995) involved the variance ratio to check the validation of random walk of four Latin American stock exchanges, he found that they follow the weak-form efficient information. Besides, Bahrain, Kuwait, Saudi Arabia, and Oman were analyzed by Dahel and Laabas (1999), using random walking tests, where they led to Kuwait's stock market is more efficient than the other markets due to the strong capital market characteristic in Kuwait. (Hamid, Suleman, Ali Shah & Imdad Akash, 2017).

According to several studies that have tested the Turkish market for the efficiency of the weak form, based on Zychowicz et al. (1995), Antoniou et al. (1997) and Tas and Dursonglu (2005), they found the market is weakly inefficient due to the results which rejected the random walk, while according to Buguk and Brossen (2003), they found an efficient market in the weak form. Many studies have assessed the hypothesis of an efficient market for African equity markets. Based on several statistical tests, Batuo Enowbi, Guidi, and Mlambo (2009) found that among these countries Egypt, Morocco, South Africa, and Tunisia that only South African stocks follow a random walk, besides Smith, Jefferis, and Ryoo (2002) tested some African countries by applying multiple ratio tests in a result that the stock of South Africa accept the assumption of random walk, although Botswana, Egypt, Kenya, Mauritius, Morocco, Nigeria and Zimbabwe do not follow a random walk, the theory is that they are efficient in a weak form (Al-Jafari, 2013).

Jefferis and Smith (2005) employed time-varying GARCH models that Egypt, Morocco, and Nigeria are weakly efficient, while Magnusson and Wydick (2002) utilized autocorrelation test for some African markets, they found that they are not weak-form efficient (Afego, 2012). Also, Omran and Farrar (2006) confirmed that Jordan, Morocco, Egypt, Israel, and Turkey had rejected the Random walk hypothesis (Büyükşalvarcı & Abdioğlu, 2011).

Worthington and Higgs (2004) applied several tests that include different tests, serial correlation, run root tests, and unit tests, which these sixteen developed countries present efficiency in the weak form. In addition, Al-Loughani and Chappel (1997) numerous tests were applied in United Kingdom stocks market and as a result prices are not followed by Random Walk (Al-Jafari, 2013).

Chapter 3

THE CASABLANCA STOCK EXCHANGE AND EMPIRICAL ANALYSIS

3.1 The Casablanca Stock Exchange in Morocco: A Description

The stock exchange is the location where securities and financial products purchasers and traders meet. The function of the stock exchange is to arrange the meeting between these buyers and sellers to manage the exchanges between the issuing companies (sellers) of securities and the investors (buyers) to improve the relationship and manage financial transactions. The role of the financial market is to manage the relationship between companies and investors. Moreover, the financial market is a direct financing system for companies that need financing where investors invest their money to purchase securities or financial products.

3.1.1 History of the Casablanca Stock Exchange

Casablanca's securities market is a competitive marketplace where shares are exchanged. This exchange puts the various participants in the capital market together, helping businesses in need of funds to finance their operations and helping investors with surplus funds or assets to invest in securities.

Established in 1929, the Casablanca Stock Exchange was called the "Office de Compensation des Valeurs Mobilières". The main significance of this office in the mid-20th century was to develop and control the functioning and organization of the financial sector. The Office is governed by laws, including those of 1948, which gave it the status of a legal entity and became the Casablanca Stock Exchange in 1957. In 1967, the stock exchange was established as a public entity. The history of the foundation of the Casablanca exchange is as follows: (The Casablanca Stock Exchange: History, 2012).

1929: It is the date of the creation of securities offsetting office on the initiative of Moroccan banks exercising their activities in Morocco.

1948: The Securities Compensation Office became the stock listed office after adjusting the role of the Compensation Office to better respond to the customer's needs.

1967: At this date, the Casablanca Stock Exchange was put under the jurisdiction of the Ministry of Finance with a Board of Directors and controlled by a Director-General appointed by the King, and from that date, the Casablanca Stock Exchange complied with the status of a public entity as it was regulated by the Ministry.

1993: It is on that date that the Casablanca stock exchange was founded, is an anonymous company regulated by the law of 1 September 1993 (Dahir 1-93-211).

1995: For the development of the Casablanca stock exchange system, this period was marked by the creation of the “Association Professionnelle des Sociétés de la Bourse” (APSB), as well as the creation of securities investment organizations (OPCVM)

2001: Establishment of the current Casablanca stock exchange and introduction of the MASI and MADEX indexes.

3.1.1 Operation of the Casablanca Stock Exchange

The stock market is a controlled and a regulated market where financial services occur. The Casablanca stock exchange is composed of the primary market and the secondary market. To make a position of securities in the financial market, furthermore, the stock exchange should sell these securities to the primary market. Consequently, these instruments can be traded by investors in the secondary market.

The primary market is the market where the first selling of financial assets occurs. Once these assets are sold to investors in the primary market, they can be negotiated on the secondary market. The secondary market is recognized as the market where all securities issued in the primary market can be traded among investors.

The Casablanca Stock Exchange is composed of active participants that manage the operations in the financial market. These participants ensure the functioning of the stock exchange system. These participants are public and private organizations which are:

Brokerage Firms: They are intermediaries whose main purpose is the performance of stock market securities transactions. These firms facilitate the trading between the selling and the buying side. They also provide services for the companies to be listed through IPOs with the necessary consulting. (Brokerage firms, 2018).

Asset Management Companies: Firms that allow companies and administrations to optimize the management of their fixed assets and to justify them concerning parties (shareholders, banks, tax authorities, auditors, insurance, etc.). Their activities are generally to negotiate the purchase orders to give consultation on portfolios for investors and wealth management companies.

L Autorite Marocaine du Marche des Capitaux (AMMC): It is a public authority associated with legal personality playing the role of monitoring and supervising exchange operations and information by keeping the rules on transparency of Casablanca Stock market operations. The missions of this company are related to the supervision of operations and maintaining market security.

Maroc Clear: It was created under law°35-69 of July 1997 and it has the following main missions; keeping securities' accounts and ensuring the circulation of securities. (THE CASABLANCA STOCK EXCHANGE: History, 2012).

L Association Professionnelle des Societies de Bourse (APSB): It is an organization that brings together all companies listed in the Casablanca Stock Exchange which are responsible for representing these companies to other players in the financial market and public authorities. *(APSB*, 2019, December 9).

3.1.2 The Casablanca Stock Market Indexes

Indices are used as a reference measure to analyze the efficiency of the stock market. It helps investors to monitor their investment portfolio and have a global perspective on the stock market's development and success. The Casablanca Stock Exchange includes mainly two benchmarks indexes to allow investors an index of the performance of the Casablanca Stock Exchange market.

Moroccan All Shares Index (MASI): It is an indicator of cross-sectional capitalization; it covers all financial instruments which are listed on the Casablanca

Stock Exchange. This index is issued to present the financial performance of all securities listed in the Casablanca Stock Market.

Moroccan Most Active Shares Index (MADEX): It is a benchmark index introduced in 2002. It is a compact index that measures the daily movement of free-float market capitalization due to the price movements of the most active stocks. It groups the most active stocks.

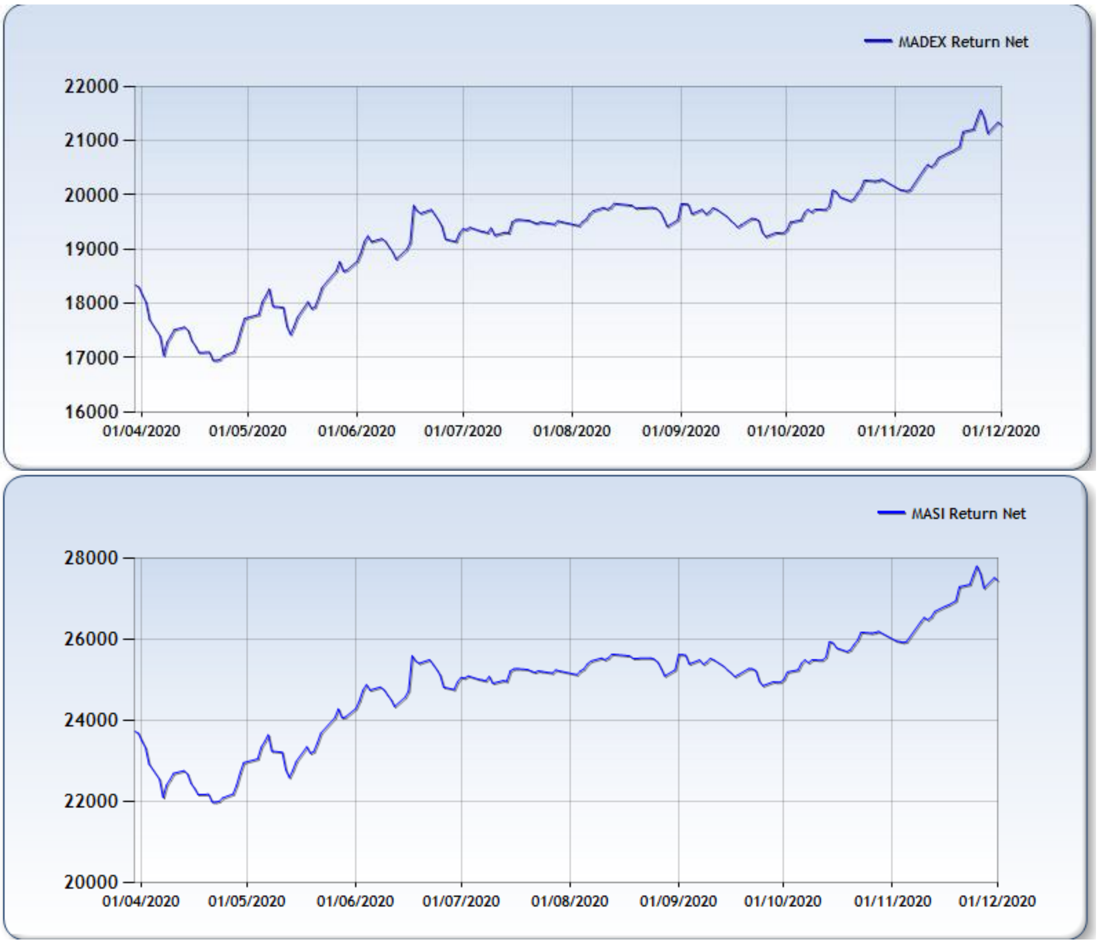

Figure 1: Recent performance of MASI and MADEX indexes

According to Figure 1, both MASI and MADEX move in the same direction and there is a high correlation between these two indexes having the same trends during this period.

3.2 Data and Methodology

This section aims to empirically test the hypothesis of weak form efficiency in the Casablanca Stock Market. In other terms, do the stock prices in the Casablanca Stock Market follow a random walk?

Fama (1970) states that if the changes of prices are independent and the stock prices should meet the identical distribution. That means the market follows the assumption of randomness. The randomness formula uses the algorithm price $x_t = lnp_t$ where the ρ_t the price at time t that should be constantly compared to the previous price x_{t-1}. Considering that the historical pattern should not be used to forecast future price changes. The formula represented as follows (Grochevaia & Hang, 2016):

$$x_t = x_{t-1} + \mu + \varepsilon \quad (1)$$

where μ is the estimated change in price and ε is the statistically independent error term. Then the market follows a random walk that assumes that the market is weak form efficient.

The following null and alternative hypotheses are tested:

> H0: The Casablanca stock market's MADEX index follows a random walk (i.e., it is t weak form efficient).
>
> H1: The Casablanca stock market's MADEX index does not follows a random walk (i.e., it is not weak form efficient).

This study comprises the period from 02/01/2002 to 08/10/2020 daily closing prices of MADEX index (Moroccan Most Active Shares Index) obtained from Datastream Eikon. Four methodologies, namely the serial correlation test of returns, the runs test, the unit root tests (i.e. the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) test), and the variance ratio test, are used to test for the weak form efficiency.

3.2.1 Serial Correlation

To check the connection between the index returns at lags, the serial correlation test is used, and is used to check the independence of the times series data. According to the random walk, there must be no correlation at lags. Ljung and Box (1979) (Q) test checks the random walk of the stock returns by testing whether the covariance among the stock returns is zero. This test detects the random movement of stock market prices, also no serial correlation must be significantly different from zero (Abbas, 2014). The formula is as follows:

$$Q = n(n+2)\sum_{k=1}^{m}\frac{\hat{\rho}_k^2}{n-k} \sim \chi^2 m \qquad (2)$$

n : number of observations

$p(k)$: sample autocorrelation at lag k

k: maximum number of lags considered.

The chi-square distribution table value with m degrees of freedom and significance amount is under the null hypothesis. The null hypothesis states that where series are independent and distributed identically. It means no correlation and the alternative hypothesis states that there is a correlation implying that the market is not efficient in the weak form.

3.2.2 Runs Test

The runs test is another test to verify the randomness assumption. It is a non-parametric test and does not assume that the returns are normally distributed. It relies on the successive signs of variations in observatory variables (+/-) of returns. This test measures the degree of dependence and the distribution of returns on assets through historical series of stock returns. Based on the results, if the series of studies performed is equal to the number of tests predicted, it means the data is random. (Borges, 2011).

The test is defined as a statistical analysis of the difference between the predicted number of runs in a pure random μ_r (i.e., the expected standard deviation) and the number of runs observed.

$$\mu = \frac{(2N_+ . N_-)}{N} + 1 \tag{3}$$

And

$$\sigma^2 = \frac{2N_+ . N_- (2N_+ . N_- - N)}{N^2 (N-1)} \tag{4}$$

where:

N+: Total number of + signs

N-: Total number of – signs

Then, the test calculates the probability that the number of runs (R) observed falls in the interval:

$\mu r - a\sigma r \leq R \leq \mu r + a\sigma r$ where a is 1.96 for 5% of confidence level. To simplify the test, the Z statistic is used:

$$Z = (R - \mu r)/\sigma r \tag{5}$$

If P(z) > 5% (p-value), then the null hypothesis that indicates the randomness of returns sequence would not be rejected.

3.2.3 Unit Root Tests

The unit root tests are used to determine the stationary of stock prices, and hence, the randomness of the time-series data. The random walk requires a unit root to be included in the time series (i.e., nonstationary). Consequently, to decide if stock prices adopt a random walk, unit root tests can be used. It is also explained as a result of weak market efficiency (Dickey and Fuller, 1981).

In this analysis, the Augmented Dickey-Fuller (ADF) (1979, 1981) and Phillips-Perron (PP) (1988) unit root testing are used to determine whether the time series includes unit root (Abrosimova, Dissanaike & Linowski, 2002). The Augmented Dickey-Fuller (1979) contains a high-order regressive mechanism to eliminate the issue of autocorrelation by incorporating a lagged variation of the dependent variable y. where the ADF uses the following models as follows:

No constant, no trend: $\Delta yt = \gamma yt - 1 + vt$ (6)

Constant, no trend: $\Delta yt = \alpha + \gamma yt - 1 + vt$ (7)

Constant and trend: $\Delta yt = \alpha + \gamma yt - 1 + \lambda t + vt$ (8)

Model 1 does not have a constant pattern; Model 2 has a constant but no pattern, and Model 3 has both a constant and a pattern. Each of these models has different requirements. The residuals are assumed to be independent. (Aktan, Sahin, & Kucukkaplan, 2018).

Phillips & Perron (1988) examine the stationary of the series by taking account of the feature's statistics such as the variance and the autocorrelation. Compared to the test of ADF for detecting the presence of unit root, the difference is the way that it manages the serial correlation. The Phillips-Perron made a non-parametric modification to t-statistic, and by taking into account serial correlations without incorporating the lagged differential terms, Phillips-Perron used the regression with no constant and no trend (Phillips & Perron, 1988).

$$yi = \alpha + \rho yi - 1 + vt \quad (9)$$

In the study, root unit tests for both Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) are used at the level form and the first difference. In both analyses, the null hypothesis shows that the series is not stationary and has the unit root, whereas the alternative hypothesis suggests that the series is stationary and does not have the unit root.

3.2.4 Variance Ratio Test

A significant and more advanced test is developed by Lo and MacKinlay (1988, 1989). They suggest that the variance ratio can be used to analyze the behavior of the stock index. This test is obtained by the method of random walk, which means that the variance in the sampling interval of the random walk increment should be linear, assuming the stock index follows a random trend that future stock prices are not influenced by current or past stock returns. Consequently, the variance of returns over period difference (q) daily intervals should equal the variance of the daily stock returns time of one period difference (1). That indicates the hypothesis of random walking can be measured by comparing the variance $p_t - p_{t-q}$ to q times the variance of $p_t - p_{t-1}$ (Grochevaia & Hang, 2016).

$$VR(q) = \frac{VAR(q)}{VAR(1)} \tag{10}$$

where $VAR(q)$is the variance of $p_t - p_{t-q}$

VAR (1) are q times the variance of $p_t - p_{t-1}$

These variances are calculated respectively as:

$$VAR(1) = \frac{1}{nq-1} \sum_{t=1}^{nq} (p_t - p_{t-1} - \mu)^2 \tag{11}$$

$$VAR(q) = \frac{1}{m} \sum_{t=q}^{nq} (p_t - p_{t-q} - q\mu)^2 \tag{12}$$

Where $m = q(nq - q + 1)(1 - \frac{q}{nq})$ and $\mu = \frac{1}{nq(p_{n_q} - p_{0})}$

p = period

On one hand, the test statistic, Z is formed under the assumption of homoscedasticity by comparing the variance ratio of the sample with the asymptotic variance of the variance ratio, which gives a standard normal asymptotic test for the proportion of variance. On the other hand, the Z* statistic, consistent with heteroscedasticity and the ability to use overlapping data, leads to more accurate and robust testing. (Liu & He, 1991).

The test statistic can be defined under the homoscedasticity assumption:

$$Z(q) = \frac{VAR(q)-1}{\phi(q)} \tag{13}$$

where the asymptotic variance is $\phi(q) = \frac{2(2q-1)(q-1)}{3q(nq)}$, nq is the number of observations. The test statistic under the heteroscedasticity assumption is defined as:

$$Z^{*}(q) = \frac{VR(q)-1}{\phi_i(q)^{\frac{1}{2}}} \tag{14}$$

where the asymptotic variance is $\phi_i(q) = \sum_{t=1}^{q-1} \left[\frac{2(q-j)}{q}\right]^2 \delta(j)$,

where the heteroscedasticity- consistent estimator is:

$$\delta(j) = \frac{\sum_{t=j+1}^{nq} (x_t - x_{t-1} - \mu)^2 (x_{t-j} - x_{t-j-1} - \mu)^2}{\left[\sum_{t=1}^{nq} (x_t - x_{t-1} - \mu)^2\right]^2} \tag{15}$$

The significance of variance is one that incorporates the significance of autocorrelation under the assumption of heteroscedasticity. If the value is below one, that means a negative serial correlation, while if it exceeds one, it shows a positive serial correlation. Where the variance ratio is greater or less than one, the random walk hypothesis is rejected (Grochevaia & Hang, 2016).

3.3 Results and Analyses

3.3.1 Data

Figure 1 shows the daily closing MADEX index which is the index composed of the most active shares in the Casablanca Stock Exchange. It includes 4,961 observations from the 1st of February 2002 to the 8th of October 2020. Daily prices are calculated as the price of the stock market index at t.

The series has been divided into three periods, visually determined by various patterns in the MADEX index. That period 1 (from 01-02-2002 to 03-12-2008) shows a significant growth that achieving the peak on 03-12-2008, after that day it starts to decline slightly, and then rises gradually in Period 2 (from 03-12-2008 to 26-01-2011). In Period 3 (from 26-01-2011 to 08-10-2020), the index fluctuates around a stable trend. According to the graph, the index series has significant fluctuations indicating that the index is not stationary.

It is obvious from the graph that the data of MADEX exhibit strong volatility. The stock market faced a large increase until 2008, and then, the index had a downward trend which can be explained by the start of the global financial crisis. In 2010, the crisis in Europe showed that the financial markets have significantly reduced the margin of action of politicians in the euro area. At that time, the European Union stated that it would be offering Greece financial support in order to avoid her bankruptcy (Elliott, 2017b, December 1).

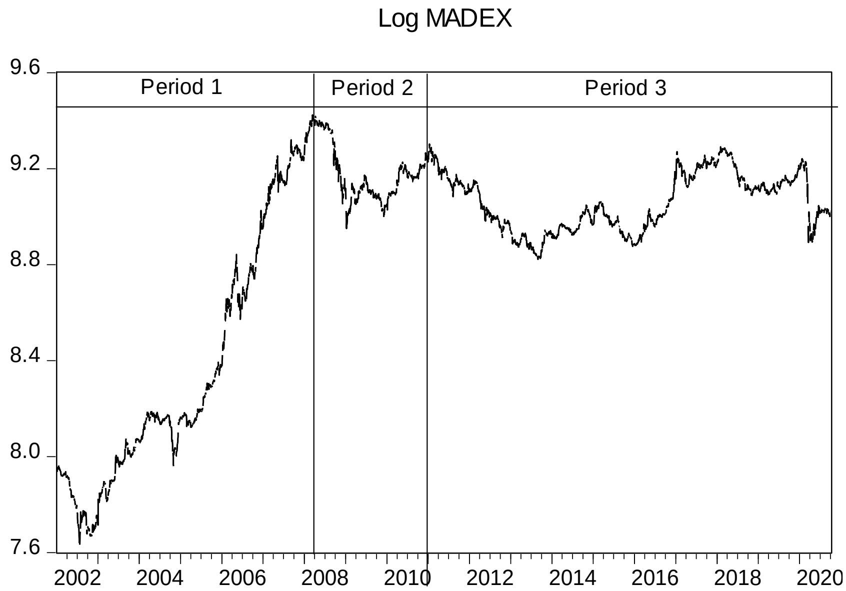

Figure 2: Casablanca stock market MADEX index – closing prices

Table 1: Descriptive statistics for the MADEX stock index

	Daily	Daily (Period 1)	Daily (Period 2)	Daily (Period 3)	Weekly	Monthly
Start **End**	01-02-2002 08-10-2020	01-02-2002 03-12-2008	03-12-2008 26-01-2011	26-01-2011 08-10-2020	01-02-2002 08-10-2020	01-02-2002 08-10-2020
Observation	4897	1806	561	2532	980	226
mean	7590.603	5609.138	9235.224	8641.278	7591.029	7592.498
Median	8222.940	3610.540	9100.430	8418.820	8238.732	8235.930
Maximum	1237.043	1374.43	10965.43	10833.02	12284.68	12110.96
Minimum	2063.560	2063.560	7716.030	6782.180	2094.044	2182.795
SD	2633.394	3303.345	624.5842	1022.523	2632.798	2631.951
Skewness	-0.732956	0.770693	0.132315	0.227551	-0.735460	-0.74259
Kurtosis	2.402611	2.023313	2.6407757	1.883161	2.404969	2.413424
Jarque-Bera	511.2816**	250.5666**	12.13673**	153.4442**	102.8048**	24.01102**
Prob.	0.000000	0.000000	0.002315	0.000000	0.000000	0.000006

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

Table 1 shows the descriptive statistics for MADEX stock index. The mean, median, minimum, and maximum index level statistics in the 3 periods have different numbers, where the highest is in the second period. While the standard deviation (SD) in the second period is the lowest number relative to the two other periods. The skewness is negative in the daily, weekly, and monthly data while the sub-periods are positive. The series has a positive kurtosis but with a decrease in the third period. The probability of Jarque-Bera is statistically significant at a 5% confidence level indicating a departure from normal distribution.

Returns are measured as the logarithmic difference in a sequence of two consecutive values. Returns are measured as follow:

$$R_t = \ln(\frac{P_t}{P_{t-1}}) \qquad (16)$$

where P_t: stock index closing prices at moment

P_{t-1}: stock index closing prices at moment P_{t-1}

Table 2: Descriptive statistics for the MADEX stock returns

	Daily	Daily (Period 1)	Daily (Period 2)	Daily (Period 3)	Weekly	Monthly
Start **End**	01-02-2002 08-10-2020	01-02-2002 03-12-2008	03-12-2008 26-01-2011	26-01-2011 08-10-2020	01-02-2002 08-10-2020	01-02-2002 08-10-2020
Observation	4897	1806	561	2532	980	226
mean	0.0259	0.0625	0.0360	-0.0104	0.1095	0.4735
Median	0.0000	0.0295	0.0096	0.0000	0.0966	0.2569
Maximum	10.713	10.712	2.9116	-9.4733	7.2004	15.920
Minimum	-7.0892	-5.0935	-4.9176	-9.4733	-11.389	-16.565
SD	0.2019	0.9694	0.8099	0.6987	1.7851	4.1589
Skewness	0.3949	0.4862	-0.5590	-1.2732	-0.5233	-0.158
Kurtosis	6.6515	14.801	7.9072	26.422	8.3972	5.0674
Jarque-Bera	30518.4**	10545.3**	591.05**	58539.2**	1232.94**	41.008**
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

This table shows that MADEX returns the index is negatively skewed, meaning that high negative returns continue to outperform positive returns. Kurtosis is greater than three, which means that the unconditional distribution of return has significantly deviated from normality. The Jarque-Bera test means that all series are not normally distributed for the daily period, for the full daily period, sub-periods, weekly, and monthly using a 5% significance level.

3.3.2 Serial Correlation Test

Table 3 summarizes the results of the sample serial correlation and Ljung-Box statistics for the MADEX return series. The logarithm of return is calculated as below

$$DLOG(MADEX) = 100 * DLOG(MADEX) \quad (17)$$

The samples autocorrelation coefficient is indicated by AC at a lag, and Q signifies the Ljung-Box stats, which indicates the absence or presence of one to ten order autocorrelations.

At 5% of the confidence level for all periods, the serial correlation is statistically significant, meaning that the null hypothesis of no serial correlation is rejected. This proves that the current return is linked to previous returns. In other terms, today's positive return seems to follow a positive return on the next day. These positive autocorrelations of the return of MADEX indicate that the returns will be predictable in the short horizon. As can be seen in the table, over different lags, it exhibits a negative or positive correlation, that indicates the rejection of the null hypothesis of the efficiency in the weak form. Consequently, the returns for all periods exhibit an indication of predictability.

Table 3: Serial correlation test for returns of MADEX stock index.

	Daily		**(Period 1)**		**(Period 2)**		**(Period 3)**	
	AC	**Q Ljung-box**	**AC**	**Q Ljung-box**	**AC**	**Q Ljung-box**	**AC**	**Q Ljung-box**
1	0.165	106.28**	0.281	142.73**	0.264	39.243**	0.157	62.31**
2	-0.02	108.25**	0.008	142.83**	0.081	42.970**	0.075	76.65**
3	-0.01	109.46**	-0.01	143.17**	0.009	43.017**	-0.012	77.05**
4	0.032	113.68**	0.024	144.20**	-0.05	44.813**	-0.073	90.67**
5	0.007	114.16**	-0.02	145.04**	-0.03	45.375**	0.0003	90.70**
6	0.011	116.53**	-0.01	146.46**	0.003	45.318**	-0.000	90.70**
7	-0.02	116.83**	-0.02	146.46**	0.042	46.366**	0.039	94.58**
8	-0.02	117.10**	0.047	150.50**	0.025	46.710**	-0.014	95.05**
9	-0.00	117.22**	0.015	150.93**	-0.03	47.408**	0.038	98.80**
10	0.015	118.09**	0.028	152.335**	-0.03	48.255**	0.019	99.71**

. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

3.3.3 Unit Root Tests

The t-statistic values of unit root tests for ADF and PP for MADEX Index are represented in the table below. The three versions of estimations of ADF and PP tests are used namely without constant and time pattern, with constant but no time pattern, and without constant but with a time pattern. They are measured at a level and the first difference and are determined by the Akaike Info Criterion with 10 lags maximum.

According to the findings in the table below, at level, the t-statistics for ADF and PP for the full period and as well for the sub-periods are statistically insignificant meaning the validity of the root unit and the series data include the root unit. The results imply that series at the level are nonstationary. The table reports that the series is found to be nonstationary at a level showing evidence to reject the assumption of random walk, meaning the lack of weak from efficiency in the Casablanca Stock Market.

After taking the first difference of the index returns, ADF and PP tests become statistically significant implying that the time series is stationary I (1). This finding is consistent with the corresponding Moroccan Stock Exchange results by Batuo Enowbi, Guidi, and Mlambo (2009) showing the non-validity of weak level of efficiency (Al-Jafari, 2011).

Table 4: ADF and PP unit root tests for MADEX index.

	Daily at level			**Daily at first difference**		
	None	**Intercept**	**Intercept and trend**	**None**	**Intercept**	**Intercept and trend**
ADF	0.3693	-1.8083	-1.2419	-34.579**	-34.594**	-34.622**
PP	0.3760	-1.7963	-1.2359	-54.814**	-54.815**	-54.811**

	Daily at level (Period 1)			**Daily at first difference (Period 1)**		
	None	**Intercept**	**Intercept and trend**	**None**	**Intercept**	**Intercept and trend**
ADF	1.4110	-0.36605	-1.44875	-11.704**	-11.827**	-11.822**
PP	1.3544	-0.3803	-1.49525	-30.462**	-30.403**	-30.390**

	Daily at level (Period 2)			**Daily at first difference (Period 2)**		
	None	**Intercept**	**Intercept and trend**	**None**	**Intercept**	**Intercept and trend**
ADF	0.9473	-1.11948	-2.40781	-18.367**	-18.395**	-18.395**
PP	1.1055	-0.6469	-2.2457	-18.367**	-18.357**	-18.350**

	Daily at level (Period 3)			**Daily at first difference (Period 3)**		
	None	**Intercept**	**Intercept and trend**	**None**	**Intercept**	**Intercept and trend**
ADF	-0.76359	-2.35654	-2.6876	-11.137**	-11.146**	-11.159**
PP	-0.98990	-2.35979	-2.7488	-43.130**	-43.111**	-43.112**

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

3.3.4 Runs Test

Changes in log returns that are calculated by +1 and 0 are added to measure changes in signs (runs test). The table below presents the outputs of MADEX index runs tests for the daily duration and the three sub-periods. According to the findings, the Z statistic is significant at 5%. Furthermore, a statistically significant negative value can be seen from the negative Z statistic, it indicates that the number of runs recorded for the full duration and the three sub-periods is less than the expected number of runs.

Based on that, it can be summarized that the distribution of returns changes does not follow a random walk, implying that Casablanca stock market is not efficient in weak -form.

Table 5: Runs tests for Daily returns MADEX stock index.

	Daily	**(Period 1)**	**(Period 2)**	**(Period 3)**
Total cases	4896	1805	560	2531
Cases< mean	2258	796	249	1213
Cases>=mean	2638	1009	311	1318
Number of runs	2153	721	242	1192
Z-statistic	-8.089**	-8.115**	-3.046**	-2.881**
P-value	0.0000	0.0000	0.0004	0.0002

Note: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

3.3.5 Variance Ratio Tests

Table 5 demonstrates the findings of the variance ratio analyses for the overall daily period and the three sub-periods. This analysis is tested below the range length of 2, 4, 8, and 16 as used in similar studies.

According to the findings, the statistics of Z(q) for the whole periods as well the three subs-period are statistically significant and the null hypothesis at 1% and 5% level of confidence for all five intervals is rejected. While the statistics of Z*(q) for the full duration and the three sub-periods are statistically significant at 1% and 5% of level of confidence except for the daily and two periods in interval 16. The null hypothesis of a random process is failed to be accepted except in two instances, the daily, first, and the second period in interval 16. This finding suggests that heteroscedasticity can be the fundamental factor affecting the rejection of the null hypothesis of a random homoscedasticity walk, which in turn makes it impossible to determine individual contributions on the serial correlation in returns (Grochevaia, & Hang, 2016).

The study also reports that the variance ratio is more than one, indicating certain positive autocorrelation that the variances increase in proportion to time. With these empirical findings, we can assume that this market could be not efficient in the weak form.

Table 6: Variance ratio tests results for MADEX index price

		2	4	8	16	Chow-Denning
Daily	VR(q) Z(q) Z*(q)	1.2093 13.101** 7.6557**	0.8886 -3.724** -2.219**	1.1110 2.3499** 1.5399	1.1102 1.5676 0.2787	7.6555**
Daily (Period1)	VR(q) Z(q) Z*(q)	1.2959 12.572** 5.0646**	1.3915 8.8916** 3.6667**	1.3352 4.8152** 2.1137*	1.3080 2.9735** 1.4241	5.0648**
Daily (Period2)	VR(q) Z(q) Z*(q)	1.2485 5.8811** 3.0806**	1.4585 5.7997** 3.2864**	1.5152 4.1221** 2.6462*	1.4825 2.5940** 1.8457	3.2864**
Daily (Period3)	VR(q) Z(q) Z*(q)	1.1562 7.8630** 3.0782**	1.2791 7.8291** 2.7003**	1.3004 5.1092** 1.7374*	1.4284 4.8972** 1.8131*	3.0782**

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels

Chapter 4

CONCLUSION

The notion of weak efficiency of the Casablanca stock market was investigated in this research study through the analysis of the MADEX index between 2002 and 2020. Due to the significant changes in this time series, data were divided into three subperiods and analyzed individually. This study used statistical techniques, parametric and nonparametric tests, which are the serial correlation, unit root, runs tests, and variance ratio test, in order to test for the weak form efficiency. The empirical findings of this study suggest the rejection of the assumption of random walk meaning the Casablanca stock market index does not follow a random walk at the weak form level. This implies that historical stock market patterns can be used to estimate future movements. Hence, we can conclude that the Moroccan stock market is not efficient in the weak form.

Our empirical results confirm earlier findings of the Casablanca stock market, implying that the stock market is not weak form efficient. For instance, according to Worthington and Higgs (2006), the Moroccan stock exchange is not weak form efficient. Generally, the study's empirical findings are compatible with the results of developing nations, due to particular features such as the lack of adequate data in a convenient form, structural profile, inadequacy regulation, low liquidity, high volatility, low level of commercial activity, and weak infrastructure. Abnormal returns are easier to obtain and the stock markets are less efficient compared to developed countries (Aktan, Sahin & Kucukkaplan, 2018).

It seems very important that financial market authorities and actors strengthen their ability to meet the requirements of an efficient market, i.e., to improve the information systems applied to make information accessible to all at a lower cost, to activate the transaction market by growing the number of listed companies, to increase the culture of stock exchange investment, to integrate the principles of the stock market, to ensure the dissemination and transparency.

As a result of the efforts and progress made, Morocco has experimented with new IT systems to improve the ability to create an efficient market allowing for the availability of information and being sufficient and more relevant. Companies, therefore, need to adopt a more detailed policy to communicate and clarify the company's financial situation to investors and the financial market authorities. Indeed, the Moroccan stock market is an example of the financial markets of emerging countries that has taken steps towards achieving an efficient stock market, since the efficient market strengthens the country's financial system against possible financial risks.

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