Finance and Business Economics Review | Volume 5 /Number 1/ May/ 2021/ p313-329

The Efficiency of the Maghreb Financial Markets: Tests of the Weak Form.

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***Received**: 20/04/2021* ***Accepted**: 27/04/2021* ***Published**: 31/05/2021*

Abstract : The concept of efficient financial markets implies that the prices of financial assets correctly and fully reflect all available information. There are three forms of efficiency (weak, semi strong and strong). In this work, we present an empirical analysis of the weak form over a period of 10 years from 01/01/2010 to 12/31/2019 of the Maghreb financial markets (Moroccan, Tunisian and Algerian) through the monthly returns of their respective index (Masi, Tunindex and Dzairindex). For this, we used random walk tests (correlation tests, runs, stationarity and variance ratio). The advanced results are rather mixed because the stationarity tests (Dickey Fuller, Dickey Fuller Augmented and Phillips Perron) rejected this form for the three indices; correlation tests (Box-Pierce, Box - Ljung) have validated it for Masi and Tunindex; the runs test and the variance ratio test validated it for the three Maghrebian indices.

Keywords: Financial Market ; Maghreb ; Weak Form ; Efficiency.

1. Introduction:

The efficient financial market assumption is at the heart of financial theory. Indeed, all work concerning the Capital Asset Pricing Model (CAPM), the Arbitrage Pricing Theory (APT), the valuation of options or the basics of organizational finance are based in one way or another on this concept. In general, almost all of the models that explain the behavior and evolution of financial securities lead to an efficiency that researchers sometimes have difficulty demonstrating.
The term efficiency is an anglicism widely accepted in economic jargon. A market is efficient if the prices formed in it constitute reliable signals for resource allocation decisions. This definition allows us to discern three types of efficiency:
• Allocative efficiency which means that financial markets can contribute to the development of their economies, by channeling their funds towards the most productive jobs;
• Operational efficiency, in which intermediaries connect suppliers and applicants for relatively low costs;
• Information efficiency, which indicates that stock prices reflect at all times all the information available about any firm as well as how future events affect its performance. These are interdependent because the optimal allocation can only be done if the information is properly taken into account and the transactions are carried out at the best price.
On a practical level, this concept remains for the market authorities a representative of the equal treatment of investors and a guarantee of the lack of interest of insider transactions, because in the

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context of perfect efficiency, investors do not benefit from 'no informational advantage over others and the possession of private information does not return any monetary advantage to its holder. Therefore, under these conditions, the operations carried out within the market do not require acute surveillance, which facilitates the task of the authorities and allows them to ensure all stakeholders of the necessary or even essential equity for the proper functioning of the markets.

Institutionally speaking, efficiency remains the most obvious debate between theorists and practitioners of finance. The first place the variations in the series of returns on financial assets as exogenous variables and admit that portfolio management is based on minimizing the risk associated with these unforeseeable fluctuations. As for the latter, they seek to forecast prices and attempt to explain the evolution of the returns on financial assets. This quarrel between theorists and practitioners makes it possible to note an important financial stake, indeed, if this concept is accepted by the majority, a good part of the utility of portfolio management dissipates.

The efficient market hypothesis is very controversial and its interest continues to grow for financial economists. The latter means that investors do not have the opportunity to make abnormal profits compared to other investors on the same transactions and within the same financial market. So, to make bigger profits you have to invest in high risk assets. According to Roberts (1967) there are three types of efficiency: the weak form, the semi-strong form and the strong form. The tests on it are aimed at verifying whether the prices of financial assets contain all the information available in the financial markets. Historically, the empirical studies have practically evolved as follows: The first studies were based on tests of the weak form where all the information represented only series of historical prices or returns (past), their results had been advanced by in-depth tests out of the random walk literature. Attention was then turned to tests of the semi-strong form in which the speed of adjustment of prices to new information (announcements of stock splits, annual reports, new security issues, etc.) was a worry. Finally, the question was conclusively whether an operator could have monopoly access to any information relevant to price formation. While we support the idea that the efficient market model is good enough, remember that this is primarily a null hypothesis. And, like any null hypothesis, it can be verified as it may not.

All of the empirical work on market efficiency was referred to in the context of the "fair game". These models implied the impossibility of practicing various types of trading systems. A small part of the literature on the random walk has been interested in studying the profitability of these systems and in parallel a larger part concerned the tests of covariance of series of returns. These have followed up with rather mixed results. Indeed, Natalia Abrosimova, GishanDissanaike, Dirk Linowski (2002) tested it on the Russian market using daily, weekly and monthly time series from September 01, 1995 to May 01, 2001 with self-testing. analysis and ratio of variance, The results confirm the existence of a random walk. CumhurBuguk, Wade Brorsen, (2003) tested the random walk hypothesis for three Istanbul Stock Exchange indices with weekly close prices and concluded that most of the tests claimed that all three series followed a random walk. In the same year Abraham Abraham, Fazal J. Seyyed, Sulaiman A. Alsakran tested it by tackling parametric and non-parametric tests on the three emerging golf markets and the latter had insignificant results due to the low frequency of exchanges. ; Khan Masood Ahmad, Shahid Ashraf and Shahid Ahmed (2006) Attempted to find evidence of the existence of this weak form using daily data from the stock indexes of the National Stock Exchange of India, Nifty, and the Bombay Stock Exchange,

Sensex, for the period 1999-2004. The random walk hypothesis for both indices was rejected. The inefficiency is explained by increasing and high volatility in the stock markets. Nonparametric tests also indicate that the distribution of the underlying variables is not normal and that the deviation from normality was significant in the later years of study. Both indices show a negative autocorrelation at the 2nd order shift indicating overreaction one day after the information arrived, followed by a correction the next day.
Collins G. Ntim, Kwaku K. Opong, Jo Danbolt, Frank SenyoDewotor, (2011) compared the underlying efficiency of a set of 24 continent-wide stock price indices and eight indices individual African national stock prices using descriptive statistics of monthly returns estimated by parametric and non-parametric techniques (to test the behavior of returns in stock markets). The results showed that regardless of the test used, the returns of the 24
African indices examined are less disseminated than the eight national indices examined. The authors also report evidence showing that continent-wide stock price indices have lower form informational efficiency better than their domestic counterparts.
Walid Mensi, AviralKumarTiwari, KhamisHamedAl-Yahyaeeb (2018), examined the efficiency of five European GIPSI stock markets, relative to global and regional markets in the United States. Using the MF-DFA approach, the latter showed evidence of long-term and long-term memory for all markets and concluded that the Greek market is inefficient regardless of time horizons, Portuguese markets are inefficient at short term, long term Irish markets and global and regional stock markets are less efficient than short term GIPSI (excluding Greece) markets.
The weak form of financial market efficiency consists in stating that the current price of a financial asset is completely independent of all the information concerning this asset, published in the past. Most of the tests of this form has focused on the major US and European financial markets versus emerging or developing country markets because their markets are generally believed to be inefficient. In order to confirm or refute this thought, we will proceed in our research to test the hypothesis of efficiency of the Maghreb stock market indices (Moroccan, Tunisian, Algerian) by applying the weak form of the EMH to them.

The purpose of this research is to test the hypothesis of the efficiency of financial markets in the weakest sense; tests performed are all from the random walk of the MASI, TUNINDEX and DZAIRINDEX. To do this the study will be divided into three parts, in the first we present the general theoretical framework of the market efficiency hypothesis, in the second part we present the tests of the efficiency of the weak form as well as their results and will end with a conclusion.

2.The efficiency hypothesis of financial markets:

A financial market is said to be efficient if and only if the prices of its financial securities fully and correctly reflect all the relevant information. Formally, we say that the market is efficient with regard to a set of information ϕ if the prices of the securities are not affected in any way by the disclosure of this information to the participants. Moreover, efficiency in relation to a set of information ϕ implies the impossibility of realizing economic profits by trading on the basis of this information. This can be expressed as follows, if ϕ is the set of information concerning asset j at time t, any abnormal return obtained at time t + 1 can be written $\boldsymbol{\varepsilon_{j,t+1}}$ **with** $\boldsymbol{\varepsilon_{j,t+1} = (E(R_{j,t+1})/\emptyset_t)}$

. This equation shows that the excess returns is the difference between the actual returns and the expected returns taking risks into account.
According to Fama (1970), there are three types of efficient markets: The weak form of the Efficient Market Hypothesis (EMH) asserts that prices fully reflect the information contained in the historical price sequence. Thus, investors cannot design an investment strategy aimed at generating abnormal profits based on an analysis of past price structures. It is this form of efficiency that is associated with the term “random walk hypothesis”.

The semi-strong form of EMH claims that current stock prices reflect not only historical price information, but also all publicly available information about a company's securities. If the markets are efficient in this sense, then an analysis of balance sheets, income statements, announcements of changes in dividends or stock splits or any other public information about the company will in no way lead to realization of abnormal economic profits. The strong form of EMH asserts that the asset price of any company listed in the financial markets includes all information (public and secret) known to the players. Therefore, even the holders of inside information cannot take advantage of it to achieve superior investment results. There is a perfect revelation of all the private information in the market prices.
The efficient market hypothesis is inseparable from Bachelier's (1900) random walk theory. The latter signals the presence of successive and independent variations in the series of returns or prices. In other words, the changes in returns or prices do not follow any trend and no future prediction can be made based on today's price i.e. P_{t+1} -Pt is completely independent of Pt -Pt-1. Unlike theoretical tests of future prices or returns which are based on real past prices or returns, this theory rejects any dependence between past and future prices and embodies a market where any new information is instantly integrated into prices. While sometimes news information is expected, most of the time it is not and comes at random. The essence of the notion that the prices of financial assets follow a random walk comes down to the unpredictable nature of news. Some days the news is good, others not. We cannot therefore make any precise prediction. When the information for any security is good, participants adjust their estimates of its future returns upwards or reduce the discount rate they attach to those returns. Either way, stock prices are going up. Conversely, when the news is less good, stock prices fall.
Random changes in financial assets were seen as an intriguing result that occupied an important place in the 1960s and to make sense of them a general model called efficient market hypothesis (EMH) was born. The latter enjoyed unprecedented popularity during the 1960s and 1970s thanks to the solidity of its theoretical foundations. These foundations began with the work of Samuelson (1965) who considered an information efficient market as a market where all information was quickly seen by speculators and immediately incorporated into market prices (share prices). In the same year, Fama (1965a) also defined for the first time an efficient market on the basis of an empirical study of stock prices, he observed that the financial markets followed a random walk. Another paper by Fama (1965b) detailed the random walk model of stock prices to show that technical and fundamental analysis could in no way produce risk-adjusted excess returns. Fama and Blume (1966) examined the returns with the Alexander (1961) filter method on the daily closing prices of thirty individual Dow Jones Industrial Average (DJIA) stocks between 1956 and 1962 and

concluded that only three stocks on thirty generated annual average returns from long positions higher than those of the

"buy and hold" strategy. In practice, the negativity of excess profits can come from excessively high costs (brokerage fees, operating costs of filtering methods, inactivity of invested funds, and clearing house fees). to confirm their convictions on the existence of information efficiency in financial markets.

The final EMH paper was published by Fama (1970) who defined the efficient market as a market that fully reflects all available information. The author presented the three different forms of information efficiency as well as the results of tests of the weak, semi-strong and strong form of the financial markets efficiency hypothesis, Fama concluded that almost all the evidence earlier indicated that the financial market was efficient in the weak sense. Although he found some price dependencies, these had no impact on asset prices. Fama also looked at the problem of the joint hypothesis. Essentially, he argued that it would be impossible to properly test the EMH system, as no academic consensus was found on the true pricing model of the underlying assets. Whenever an efficiency test rejected it, there was always a possibility that it was simply due to the pricing model of the underlying asset. Besides Fama (1970), other researchers have attempted to formulate a clear definition of what is meant by an efficient market. Jensen (1978, p. 96) wrote that "a market is efficient for a set of information $\emptyset_t$ if it is impossible to make economic profits by trading on the information base established in $\emptyset_t$ ". Malkiel (1992) stated that a stock market is efficient whenever stock prices remain unchanged, despite the disclosure of information to each of the market participants. Even though Jensen and Malkiel's definitions have a lot of academic merit, we adopt Fama's definition. In particular, this research focuses on the low efficiency form of financial markets, ie all available information contains only historical information on prices (Fama, 1970).

2.1.Tests of the weak form of the efficiency of financial markets (random walk models):

A financial market is the place where any investor buys and sells equity or debt securities issued by government, businesses and local communities. This role ensures the liquidity of financial securities held by investors. This fluidity allows issuers (state, companies and local communities) to find funds to finance their growth by appealing to the public. As a result, the financial market is seen as the source of funding for economies. In order to test its efficiency,
we relied on the tests of the low efficiency form of financial markets. The tests of the weak form are numerous and consist in the majority of cases in detecting the dependence which may exist in the time series of price changes. Indeed, The Efficient Markets Hypothesis supports the idea that asset returns should be independent of each other over time. The first studies in this direction were made by Working (1934). A few years later, Kendall (1953) argues that one cannot predict future time series prices from their past changes. Cootner (1964), Fama (1970) provide an overview of theoretical development and empirical evidence on the predictability of financial markets. It should be noted that these tests are the result of extensive tests in the random walk literature.

The random walk model can be stated as follows:

$$P_t = P_{t-1} + \varepsilon_t \qquad (1)$$

Where ε_test white noise, Pt is the return on the asset at time t, P_{t-1} is the return on the asset at time t-1. If the returns follow a random walk, this implies the presence of informational efficiency under the available set of information $\emptyset_t$.

However, the reverse relationship is not always true and the presence of a random walk does not necessarily mean efficient financial markets.

Campbell, Lo, MacKinlay (1997) present a more extended version of the random walk, they summarize its properties as well as those of martingales and expose them in three hypotheses. They have placed orthogonality as a major condition for random walks:

$$\text{Cov}\ [f(R_t),g(R_{t+k})]=0 \qquad (2)$$

Where f (R_t),g (R_{t+k}) are two arbitrary functions, , R_t, R_{t+k} are the asset returns at time t and t + k (k ≠ 0). If equation (2) holds for all the functions of f (R_t),g (R_{t+k}), this will mean that the returns are independent of each other and that they present a random walk with increments distributed identically (RW1) and a random walk with independence but distributed in a non-identical way (RW2). Even though RW2 contains RW1 as a special case, it allows more general pricing processes (for example, unconditional heteroskedasticity in increments). If f (R_t),g (R_{t+k}), are arbitrary linear functions, then (2) implies that the returns are not correlated with each other and present a random walk with dependent but uncorrelated increments (RW3, i.e. the martingale model). This classification allows the RW2 and RW3 hypotheses to be tested under less restrictive conditions than those imposed on the traditional RW1 model.
The first tests of the random walk hypothesis were based on the sequence and inversion tests based on the comparison of the frequencies of the sequences (Cowles, Jones 1937); Another popular approach is to test the serial correlation of price changes (Fama 1965; Moore 1962). Other recent tests including tests of ratio of variance and tests for unit roots, the first have been proposed by Lo, MacKinlay (1988). They are based on the fact that the variance of the random walk increments should be a linear function of time. The most important property of this test is that it allows testing not only the RW1 hypothesis, but also RW2 and RW3.

2.1.1.Database:

The Maghreb stock exchanges (Casablanca, Tunis and Algiers) are regulated markets where equity (shares) and debt securities (bonds) are listed either continuously or at fixing.

- The Casablanca Stock Exchange has three indices: MASI (global index made up of all stocks of the equities type), MADEX (Compact index made up of stocks quoted continuously) and the sector index (compact index made up of stocks belonging to the

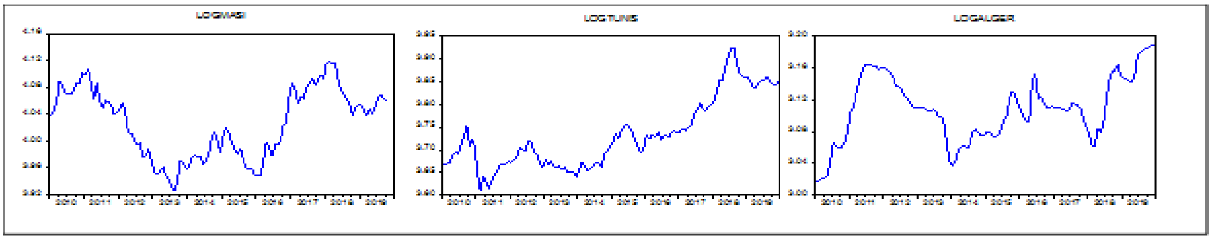
same sector of activity). Each transaction issued (purchase or sale of a financial security) is delivered simultaneously against payment in cash.

• The Tunis stock exchange also has three indices: TUNINDEX (global index made up of all listed shares), SECTORAL INDICES (measure the evolution of a given sector) and TUNINDEX20 (represents the performance of the 20 largest companies in Tunis).

• The Algiers stock exchange only includes the DZAIRINDEX (global index made up of all listed shares).

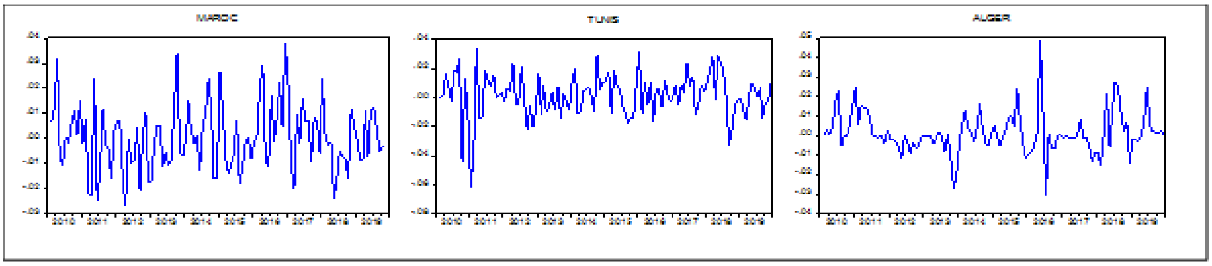
The choice of the Maghreb (Algeria, Morocco, Tunisia) comes down to the common history that binds them, the homogeneity they present in terms of religion, language and ethical unity. This is also due to the similar economic context after their independence which prompted them to choose a structural adjustment plan. The objective of this choice (Maghreb countries) is to determine the existing gaps and identify their reasons, to identify the strengths and weaknesses of each Maghreb financial market. The collection, processing and preparation of data for the empirical tests were carried out by the Casablanca Stock Exchange Company "SBVC", the TUNIS Stock Exchange Company and the Stock Exchange Management Company. "SGBV" furniture. However, our samples are composed of monthly data of the global indices of the three Maghreb stock exchanges (Masi, Tunindex and Dzairindex) over a 10-year period from 01/01/2010 until 12/31/2019. Payment dates and dividend amounts for each security as well as information regarding capital increases have been taken into account in the price quotes. The figs below give us a graphical representation of the logarithm series of prices as well as logarithms of returns.

<u>Fig N° (01):</u> Graphical representation of the series of logarithms of index prices.



Source: Eviews 8.

<u>Fig N° (02)</u>: Graphical representation of the series of price returns.



Source: Eviews 8.

2.2. Methodology:

In order to verify the existence of a possible efficiency in its weak sense, we will use the correlation test of the return series (parametric test), the runs test (nonparametric test), the stationarity test of the return series and the variance ratio test for Masi, Tunindex and Dzairindex indices over the cited period. To do this, we must first calculate the daily returns at the close of the Maghreb indices by taking the ratio between two consecutive daily prices as follows: $R_t = \ln (P_t / P_{t-1}.)$

Where R_t: the return at time t, ln: the logarithm, P_t: the price of the asset at time t and P_{t-1} : the price of the asset at time t-1.

Before starting our tests, we will statistically present the price performance series of the three indices in the table below:

Table N° (01): Statistical analysis of the return series.

Indice	Moyenne (Monthly)	SD (Monthly)	Skewnes	Kurtosis	Jarque-Bera
MASI	0.000184	0.013271	0.409396	2.994558	3.268436
TUNINDEX	0.001539	0.015135	-0.791026	5.283050	38.25456
DZAIRINDEX	0.001438	0.010559	0.892537	6.676398	82.81603

Source: Eviews 8.

2.2.1. Correlation tests of the return series:

Parametric correlation tests show the existence or absence of relationships within series of returns over time; The series correlation measures the degree of dependence between the consecutive returns of the series (whether hourly, daily, monthly or otherwise), in other words, these tests allow us to know if the returns on day t are correlated with the returns for day t-1, t-2 or tn. A zero serial correlation would therefore imply that the price changes in consecutive periods are not correlated with each other (full price independence) and can therefore be seen as a rejection of the hypothesis that investors can find out more about the future variations in returns from previous ones. A positive and statistically significant series correlation is evidence of market dynamics and suggests that the prices of future returns are more likely to be positive, a negative and statistically significant series correlation indicates a price reversal consistent with a market or positive stocks are more likely to follow negative returns and vice versa. From an investment strategy perspective, series correlations can be used to generate excess returns. A positive series correlation results in a strategy of buying after periods of positive returns and selling after periods of negative returns. A negative series correlation would suggest a strategy of buying after periods with negative returns and selling after periods with positive returns. Since these strategies generate transaction costs, the correlations must be large enough to allow investors to generate profits to cover these costs.

It is therefore entirely possible that there is a series correlation between returns, with no possibility of generating excess returns for most investors. Those who think that financial markets are efficient expect insignificant correlations for all of these combinations. The results indicate insignificant correlations in stock returns over time, but recently some studies considered stock portfolios of different market values (size) indicated that the autocorrelation is stronger for small equity portfolios.

In order to perform this test, we calculated the correlation coefficient for the following orders (k = 1.3, 6, 9, 12, 15, 18, 20) of the three indices (Masi, Tunindex and Dzairindex). Recall that the autocorrelation coefficient of a series Y and of order k is equal to:

$$\rho_k = \sum_{t=k+1}^{T}(Y_t - \overline{Y})\ (Y_{t-k} - \overline{Y}) \Big/ \sum_{t=1}^{T}(Y_t - \overline{Y})^2$$

The significance test of the results is carried out under the following assumptions:

H_0 : $\rho_k = 0$ ($\rho_1=\rho_2=\ldots\ldots=\rho_m= 0$(returns are not correlated))

H_1 : $\rho_k \neq 0$ (i={1, ……., m}(returns are correlated)).

Assuming that the null hypothesis H_0 which assumes the absence of correlation relations between the different returns is true, the statistic $S=\sqrt{T}\widehat{\rho(k)}$ follows a normal distribution N(0,1). The latter is rejected at the 5% threshold, if its absolute value is greater than 1.96. Other complementary tests such as The Box-Pierce and Box-Ljung tests which are used to test the same null hypothesis of the correlation test, these tests examine the significance of subsequent correlation coefficients.

In the case of the Box-Pierce test, the statistic is:

$$Q_m = T\sum_{k=1}^{m}\hat{\rho}(k)^2$$

In the Box - Ljung test, the statistic is as follows:

$$\grave{Q}_m = T(T+2)\sum_{k=1}^{m}\frac{\hat{\rho}(k)^2}{T-k}$$

$\hat{\rho}(k)$: is the autocorrelation coefficient of order k, for k = 1.3, 6, 9, 12, 15, 18, 20; T: is the length of the time series; m: ln (T) (maximum delay).

The Q_{B-P} and Q_{B-L} statistics contain many autocorrelation coefficients and follow a distribution of X_m^2, (chi-square with m degrees of freedom, Mills 1999). When the value of the empirical statistic Q exceeds the value of the theoretical distribution of X_m^2, H_0 can be rejected at the predefined significance level.

2.2.2. Test of the runs:

The non-parametric test of homogeneous cycles (runs test) makes it possible to measure the degree of dependence that exists between historical series of prices or returns, and this independently of their distribution. It is interested only in the series of signs (+ / -) of the variations (positive / negative) of the prices or of the returns of the assets. Indeed, each change of price is designated either by a plus (+) if it is is a price increase, or by a minus (-) if it is a price decrease. The result is a set of pros and cons, as follows: ++++ —— ++ - ++. A run occurs when two consecutive changes are the same (two or more consecutive positive or negative changes constitute a run). A positive runs is a sequence of positive price movements preceded by zero or negative movement and vice versa for a negative runs. The statistical test is based on the appreciation of the difference between the number of runs expected in a random context and the number of runs observed for the selected sample. A positive correlation between the prices of an asset results in the existence of long runs (long series of positive signs or negative signs) and a negative correlation results in the existence of short runs, ie repeated changes of signs. If the changes are independent neither of the two cases should be observed.

If the signs of a series of prices or returns are randomly distributed, the total number of runs follows a normal distribution from which we can easily calculate the expectation μ and the standard deviation.

$$E(\widehat{H}) = 1 + \frac{2 * n_1 * n_2}{n_1 + n_2} \qquad ; \qquad VAR(\widehat{H}) = \frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)}$$

Where: n_i: the number of returns for each sign; N: the number of observations;
The significance test of the results is carried out under the following assumptions:
H_0 : R_t^* Is white noise against H_1 : R_t^* is not white noise.
The null hypothesis holds with the Z statistic, which is asymptotically normally distributed (N(0.1)) for large samples, it is written as follows:

$$Z = \frac{X - \mu}{\sigma}$$

where: X: the number of runs observed

If | Z |> 1.96, we reject the null hypothesis of white noise at a significance level of 5%, according to Taylor (1996), if Z <0, there is a trend in the data, and if on the contrary Z > 0 implies a return to the average of returns over the long term.

2.2.3. Stationarity test:

To show that a market is efficient in the weak sense (presence of a random walk), the condition of non-stationarity of the return series is necessary, its verification is done either by a TS process (Trend Stationary) or by a DS process (Differency Stationary)). If the return

series follow a TS process it will mean that they follow a linear trend and are therefore predictable, compromising the efficiency assumption in its weak sense. At the same time, if series of returns follow a DS process, a more in-depth analysis will have to be done because the condition of non-stationarity is at this moment insufficient to prove the existence of a possible random walk (Campbell, Lo, MacKinlay (1997 To perform our tests, we use the Augmented Dickey-Fuller (ADF) and Phillips Perron tests to analyze the presence of unit root (non-stationarity) within the return series.

Overview of TS and DS processes:

-The TS (Trend Stationary) process represents a deterministic non-stationarity which is written: $x_t = f_t + \varepsilon_t$ where f_t maybe a linear or nonlinear function of time; ε_t : a stationary process.

The most common TS process is the linear TS process which is written as follows:

$$x_t = a_0 + a_1 t + \varepsilon_t \ ;$$

If ε_t is white noise, the characteristics of this process are:

$$E[x_t] = a_0 + a_1 t \ ; \ V[x_t] = \sigma^2 \ ; \mathrm{Cov}(x_t, x_t') = 0 \ (t \neq t');$$

The presence of a unitary root of this process (non stationarity) returns to its expectation which is a function of time.

-the DS (DifferencyStationary) process represents a non-stationarity of random type that can be stationary by a difference filter: $(1-D)^d$=β+ε_t where ε_t: white noise; β: constant; D: the shift operator; d: the order of the offset filter. The constant β introduced into the DS process makes it possible to determine two processes:

- DS process without drift (β = 0) which is written: $x_t = x_{t-1} + \varepsilon_t$, whose characteristics are: $E[x_t] = x_0 + \beta t$; $V[x_t] = t\sigma_\varepsilon{}^2$; Cov(x_t, x_t')=$\sigma_\varepsilon{}^2 * \min(t, t')$ if$t \neq t'$; this process is not stationary in variance because it depends on time.
- DS process with drift (β ≠ 0) which is written: $x_t = x_{t-1} + \beta + \varepsilon_t$, whose characteristics are: $E[x_t] = x_0 + \beta t$; $V[x_t] = t\sigma_\varepsilon{}^2$; Cov(x_t, x_t')=$\sigma_\varepsilon{}^2 * \min(t, t')$ if $t \neq t'$; this process is not stationary in variance and expectation because they depend on time.

Unit root tests:

Dickey-Fuller and Augmented Dickey-Fuller (ADF) test:

Dickey-Fuller tests highlight the stationarity of time series by the presence of a stochastic or deterministic trend. There are three models that serve as a constructive basis for these tests. If the null hypothesis H_0 : ϕ_1=1 is accepted in the following three models, then the process is non-stationary.

- y_t=$\alpha_1 y_{t-1}$+ε_t AR (1)
- y_t= α_0+ $\alpha_1 y_{t-1}$+ε_t AR with constant
- y_t=bt + $\alpha_1 y_{t-1}$ + c+ε_t AR with trend

If H_0 is accepted, the non-stationarity of the return series is verified whatever the model.

The Augmented Dickey-Fuller (ADF) tests are the same as the Dickey-Fuller tests with the only difference that the former assume that the error ε_test a white noise and the latter not and take into account the presence of correlation in the errors.

Phillips and Perron test:

This test was built on a nonparametric correction of the Dickey Fuller test to take into account heteroskedastic errors. The latter takes place in four stages.

- Estimate the basic models of the Dickey-Fuller test using the ordinary least squares method.
- Estimate the short-term variance $\widehat{\sigma^2}$=${}^1/_n \sum_{i=1}^{n} e_t^2$.

Estimate the long-term variances_t^2 (correcting factor) from the covariances of the residuals of the models estimated previously: s_t^2=${}^1/_n \sum_{i=1}^{n} e_t^2$ + $2 \sum_{i=1}^{l}(1 - {}^i/_{l+1})$ ${}^1/_n \sum_{l=i+1}^{n} e_l e_{l-i}$

To estimate this variance, it is necessary to estimate a number of lags l from the number of observations n ; l=4$(n/100)^{2/9}$.

- Calculate the statistic of PP : $t^*_{\widehat{\phi_l}} = \sqrt{k} * \frac{(\widehat{\phi_1 - 1})}{\sigma_{\widehat{\phi_l}}} + \frac{n(k-1)\sigma_{\phi_l}}{\sqrt{k}}$ with k= $\widehat{\sigma^2} / s_t^2$.

2.2.4. Variance ratio test:

We consider a random walk with a drift process: : $P_t = P_{t-1} + \mu + \varepsilon_t$

Where μ is an arbitrary drift parameter; P_t is the logarithm of the returns at time t; P_{t-1} is the logarithm of the returns at time t-1; ε_t is the error term (white noise).

The random walk hypothesis brings together two implications: Absence of correlation within the residuals and presence of a unit root. Variance ratio tests focus on uncorrelated residuals and are preferable to unit root tests for two reasons: the latter aim to establish whether a series is stationary or trending stationary (Campbell et al., 1997) and are known to have a very low power and cannot detect certain deviations from the random walk (Hakkio, 1986). This contrasts with the ratio of variance test which has good size and power properties.

The Lo and MacKinlay ratio of variance test makes use of the fact that the variance of the increments of a random walk is linear across the sampling interval. Therefore, if the natural logarithm of the stock's return follows a random walk, then the return variance should be proportional to the return horizon.

The variance ratio test statistics for an investment horizon over period q are defined as follows: VR(q) = [$\widehat{var}$(lnP_t /ln P_{t-q})/q]/ [$\widehat{var}$(lnP_t /ln P_{t-1})]

Where P_t is the logarithm of the returns at time t; P_{t-1} is the logarithm of the returns at time t-1; P_{t-q} is the logarithm of the returns at time t-q; $\widehat{var}$(.) is an unbiased estimator of the variance. The expected value of VR (q) is equal to one for any investment horizon q under the assumption of a random walk; ($\widehat{var}$(lnP_t /ln P_{t-q}) et $\widehat{var}$(lnP_t /ln P_{t-1}) are given by the following functions:

$\widehat{var}$(lnP_t /ln P_{t-q})= $1/_m \sum_{t=q}^{nq}(lnP_t - lnP_{t-q} - q\hat{\mu})^2$

$\widehat{var}(lnP_t /ln P_{t-1})$= $1/_{nq-1} \sum_{t=1}^{nq}(lnP_t - lnP_{t-1} - \hat{\mu})^2$

Since financial time series are volatile over time and deviate from normality, we therefore use the statistics of standard tests robust to the heterosedasticity of Lo and MacKinlay:

$$z^*(q) = [VR(q) - 1]/[\widehat{\theta\ (q)}]^{1/2}$$

where : $\widehat{\theta\ (q)}$= $\sum_{j=1}^{q-1}\left[\frac{2(q-j)}{P}\right]^2 \hat{\delta}(j)$; $\hat{\delta}(j)$=[$\sum_{t=j+1}^{nq}(lnP_t - lnP_{t-1} - \hat{\mu})^2$ (ln P_{t-j} $-\mathrm{lnP_{t-j-1}} - \hat{\mu})^2$]/[$\sum_{t=1}^{nq}(\mathrm{lnP_t} - \mathrm{lnP_{t-1}} - \hat{\mu})^2$]

The Monte-Carlo simulations of Lo and MacKinlay (1989) showed that the asymptotic distribution of $z^*(q)$works well in finite samples, and the variance ratio test is more reliable than the stationarity, runs and correlation tests.

3. Results:

The results of the Correlations, Box-Pierce and Box-Ljung tests for the three indices are presented in table N ° (02):

Table N° (02): Autocorrelation test of monthly returns of Masi, Tunindex and Dzairindex indices.

IDC	K	01	03	06	09	12	15	18	20
MASI	$X^2_{0.05}$	3,841	7,815	12,592	16,919	21,026	24,996	28,869	31,41
	AC	0,148	0,02	0,098	0,106	-0,01	0,122	0,026	-0,159
	S	0,148	0,0346	0,24	0,318	-0,0346	0,4725	0,1103	-0,711
	Q_{B-P}	2,5627	5,3843	9,2944	10,9029	12,6716	15,0127	17,769	23,5016
	Q_{B-L}	2,629	5,6204	9,9643	12,0134	14,3612	17,5148	21,3587	28,8319
TUNINDEX	$X^2_{0.05}$	3,841	7,815	12,592	16,919	21,026	24,996	28,869	31,41
	AC	0,123	0,128	-0,06	-0,087	0,032	-0,085	-0,077	-0,077
	S	0,123	0,2217	-0,1469	-0,261	0,1108	-0,3292	-0,3266	-0,3443
	Q_{B-P}	1,8003	3,7558	9,9336	13,1965	14,5584	18,4885	19,2978	20,5536
	Q_{B-L}	1,8461	3,9177	10,6369	14,5161	16,4633	21,5107	23,1192	25,1211
DZAIRINDEX	$X^2_{0.05}$	3,841	7,815	12,592	16,919	21,026	24,996	28,869	31,41
	AC	0,415	0,068	-0,053	0,028	0,031	0,025	-0,123	-0,105
	S	0,415	0,1177	-0,1298	0,084	0,1073	0,0968	-0,5218	-0,4695
	Q_{B-P}	20,4947	21,4453	23,5966	23,7625	26,135	27,4652	29,784	32,334
	Q_{B-L}	21,0158	22,3697	25,2671	26,1387	29,5545	31,9547	35,6818	39,5194

S represents the statistic of the classical correlation test; T-tabulated are taken from the table of Sudent's law at a significance level of 5% ; Q_m represents the statistic of the Box-Pearce test; Q'_m represents the statistic of the Ljung-Box test; Qtabulee are taken from the chi-square law table at a significance level of 5%. **Source: Eviews8.**

The results of the runs test for the three indices are presented in table N ° (03):

Table N° (03): Results of the test runs for the Tunindex, Masi and Dzairindex.

Indices	Number of runs observed (x)	Number of runs expected	Standard deviation of runs	Z-statistic	P(Z)
Tunindex	56	59,5546	5,3441	-0,6651	0,2529
Masi	54	59,3931	5,3750	-0,6312	0,26392
Dzairindex	38	60,2941	5,4122	-0,7934	0,2137

The tabulated value of the t-statistic at the 5% significance level is 1.96 ; **Source: Excel 2013.**

The results of the non-stationarity tests of the yield series of the three North African indices (Masi, Tunindex and Dzairindex) are presented in the table below:

Table N° (04): Results of the stationarity test for the Tunindex, Masi and Dzairindex.

	Test of Dickey Fuller		Test of Augmented Dickey Fuller		Test of Phillips et Perron	
Indices	**T-statistics**	**P-values**	**T-statistics**	**P-values**	**T-statistics**	**P-values**
Masi	-8.5195	0.0000	-9.2481	0.0000	-9.1590	0.0000
Tunindex	-9.5103	0.0000	-9.4549	0.0000	-9.5090	0.0000
Dzairindex	-6.9071	0.0000	-6.8611	0.0000	-6.8149	0.0000

The tabulated value of the Dickey Fuller, Augmented Dickey Fuller and Phillips and Perron test at the 5% level is (-1.9436); **Source: Eviews8.**

The results of the variance ratio test of the series of returns of the three Maghreb indices (Masi, Tunindex and Dzairindex) are presented in the table below:

Table N° (05): Results of the variance ratio test for the Tunindex, Masi and Dzairindex.

		K			
		2	**4**	**8**	**16**
Masi	**V(R)**	1.1663	1.0954	1.3159	1.7414
	Z-statistics	1.6683	0.5272	1.1523	1.8769
	Pb	0.0952	0.5980	0.2492	0.0605
Tunindex	**V(R)**	1.1400	1.3181	1.3443	1.0209
	Z-statistics	1.0141	1.2830	0.9064	0.0415
	Pb	0.3105	0.1995	0.3647	0.9668
Dzairindex	**V(R)**	1.4393	1.8055	1.9246	2.2723
	Z-statistics	4.2109	3.7821	2.8927	2.9321
	Pb	0.0000	0.0002	0.0038	0.0034

The tabulated value of F is 3.92 at a significance level of 5%; **Source: Eviews8.**

3.1.Discussion:

If the Maghreb markets are efficient in the weak sense, the correlation coefficients of the three indices (Masi, Tunindex and Dzairindex) must not be significantly different from 0, the value of S must be less than 1.96 and the Box-Ljung statistics (Q_{B-J}) and Box-Pierce ($\boldsymbol{Q_{B-P}}$) must all be less than their respective $X^2_{0.05k}$. Table N°(02) presents mixed results concerning the correlation coefficient, we notice that the correlation coefficients of the orders k of the indices Masi (k = 1, 15, 20), Tunindex (k = 1, 3) and Dzairindex (k = 1, 18, 20) are not significantly different from 0, on the other hand, we notice that the statistic S is lower than 1.96 for the three indices and at the level of all the orders k, which pushes us to accept the null hypothesis that of independence of profitability. We can therefore conclude from these results that the Maghreb financial markets are efficient in the weak sense. At the same time, Box-Ljung (Q_{B-J}) and Box-Pierce ($\boldsymbol{Q_{B-P}}$) statistics are all lower than their $X^2_{0.05k}$ for Masi and Tunidex. What pushes us accepted the null hypothesis which means absence of correlation and the values of the correlation coefficients confirm it (all close to 0) .We can conclude that the

monthly returns are not very dependent on the returns of the previous months, except for what is the month before which remains an important benchmark for the investor. And concerning the

Dzairindex, the results show that the statistics of Box-Ljung (Q_{B-J}) and Box-Pierce ($\boldsymbol{Q_{B-P}}$) are all greater than their $X^2_{0.05k}$which allows us to reject the hypothesis zero, that of independence of returns and affirming the existence of correlation and dependence between the different returns, we can therefore predict future returns from past returns for the Algiers stock market index. These results show that the Moroccan and Tunisian financial markets are efficient in the weak sense unlike the Algerian market which is not.

Regarding the test of runs (Table N ° (03)), we notice that the value of Z is negative for the three indices because the number of theoretical runs is always greater than the number of calculated runs, we also notice that the absolute value of all the values of Z (of the Masi, Tunindex and Dzairindex indices) are below the critical value at the significance level of 5% (1.96). This result corresponds to the existence of positive dependence in the profitability series. We therefore accept the null hypothesis of white noise (that is, the returns are independent of each other). We then conclude that the Maghreb financial markets represented by the indices (Masi, Tunindex and the Dzairindex) are efficient in the weak sense.

Table N° (04) presents the results of the three stationarity tests of Dickey Fuller, Augmented Dickey Fuller and Phillips-Perron. These show that the calculated values of t-statistics of the three North African indices are all lower than the tabulated values (-1.9436), at the same time the probabilities are all zero (less than 0.05). We therefore decline any presence of a unit root and conclude that the series of yields are stationary. These results allow us to reject the low efficiency form of the Maghreb financial markets.

Table N° (05) presenting the results of the Lo and MacKinlay test (1988, 1989) for the three Maghrebian indices, points out that the probabilities are not all zero and differ from one delay to another. On the other hand, we notice for the three Maghreb indices that the calculated values of the Z-statistic are all lower than the tabulated value at the 5% threshold except for the first delay of the Algiers stock exchange (q = 2), we therefore conclude that the series of returns of Masi, Tunindex and Dzairindex follow a random walk and give the privilege to their respective exchanges to be efficient in the weak direction.

4. Conclusion:

The weak form efficiency of financial markets asserts that it is impossible to make a profit by speculating on a financial security based on past information about that security. There are several tests aimed at corroborating or refuting this hypothesis, for our part, we opted for correlation tests, runs tests, stationarity tests and variance ratio tests. In this article, we tested the low efficiency form of the Maghreb markets (Moroccan, Tunisian and Algerian) through their respective stock market indices (Masi, Tunindex and Dzairindex) using monthly returns data. It was concluded according to the correlation tests, runs and variance ratio that the Masi and Tunindex indices present a random walk and are therefore efficient according to the weak form of the hypothesis, unlike the non-stationarity tests which deplore any presence of unit root and this for the three Maghrebian indices. The Masi and Tunindex indices are efficient according to the correlation, runs and variance ratio tests and are ineffective according to the stationarity tests and the Dzairindex index is efficient according to the runs test and the variance ratio test and is inefficient according to the correlation test and stationarity test.

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