Efficiency Analysis of the Moroccan Stock Market in Line with the Adaptive Market Hypothesis

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Abstract: The objective of the study is to examine the evolution of the efficiency of the Moroccan stock market and to verify if this evolution follows the trajectory of the adaptive market hypothesis. By using the Diebold-Mariano test applied to the returns of the MASI stock price, from 03/01/2002 to 24/01/2022. The empirical results show that the predominance of inefficiency in the Moroccan stock market along the period of study except for some years when the Moroccan stock market was efficient. This confirms that the adaptive market hypothesis is coherent with the Moroccan market.

Keywords: efficiency hypothesis, Diebold-Mariano test, Morocco, stock market. ARIMA model, Random walk.

JEL classifications: G1, G14, G15, F3, F37, C13.

1. INTRODUCTION

One of the fundamental concepts of neoclassical finance which has been extensively discussed and documented is that of market efficiency. This concept has its origins in the studies conducted by (Fama, 1970), (Samuelson, 1965) and (Roberts, 1967), who introduced the concepts of efficient markets and the Efficient Market Hypothesis (EMH) to the world. Markets are defined as efficient if prices reflect fully and always all the available information (Fama, 1970). This implies that all available information is immediately accessible to all participants and that prices instantly reflect this information. However, a distinction is made between the weak, semi-strong and strong forms of efficiency depending on the type of information which is reflected in the showed price of stocks.

The efficiency of markets hypothesis (EMH) presented by Eugene Fama (1970) allows to identify three forms of market efficiency, strong, semi-strong and weak form of efficiency. Investors use information to make investment decisions. In theory, financial markets reach this efficiency when it is impossible for investors to gain on the markets by using privileged information. This paper focuses on the weak form version, which claims that the stock prices fully reflect all the information contained in the historic market prices. More specifically, the literature identifies three types of efficient markets based on the type and profit implications of the information incorporated in the price of a stock at a given time.

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The market is efficient in terms of weak form if the current prices of the stocks completely and instantaneously reflect all the relevant information contained in the records of past transactions. therefore, successive stock returns are independent of each other. The semi-strong form of market efficiency predict that current prices adjust quickly to incorporate all publicly available information, including past prices, earnings, and other relevant items in the financial accounts published by firms or countries. Third, an efficient market in its strongest form will ensure that current prices fully incorporate all public and private information, including that exclusively held by corporate insiders. an efficient market, economic agents take positions according to the information they have and their own situation. This information is assumed to be common to all agents and to be free. The price observed on the market instantly reflects all the information available.

In Morocco, information is disseminated mainly through the official channel of the regulatory organ, the AMMC (Moroccan Capital Market Authority). Financial advisory services, in particular those provided by specialized newspapers, are little or not developed and still remain the responsibility of the brokers. These authorities can influence the profitability of firms by influencing the behavior of investors. This is a form of inefficiency in financial markets.

An important number of scientific articles have been published to investigate the informational efficiency of the Moroccan stock market, the study of (Bakir, 2002) by analyzing the daily data of 28 stocks listed on the Casablanca stock exchange over the period from January 1996 to December 2000 and relying on a set of tests (parametric and non-parametric), also rejects the hypothesis of efficiency in the

weak form of the Moroccan financial market. The study by (El Khattab & Moudine, 2014) is one of the main studies which attempt to analyze the informational efficiency of the Moroccan stock market. This study tests the weak form of the Moroccan market efficiency, using ARIMA (p, d, q) modelling, and then the tests of auto-covariances on daily data on the MASI index for a period from 2004 to 2012. The results reject the null hypothesis of Moroccan financial market efficiency in the weak form.

Chiny & Mir (2015) also studied the weak form of the efficiency of the Casablanca Stock Exchange (called BVC) using main empirical efficiency tests on daily data of four indices: MASI (Moroccan All Shares Index), the banking sector index (BNQ), the insurance sector index (ASSUR) and the real estate sector index (IMMO), over a period that spans 12 years (from 01/01/2002 to 31/12/2013). The results of this study formally reject the hypothesis of efficiency in the weak form of these indices.

Despite the large body of works mentioned above on the efficiency of the stock market, no consensus has been reached among the financial community, suggesting that the process by which stock prices are generated is not well known, it is a flexible process that sometimes fits with the arguments of the efficient financial market hypothesis and sometimes with the contributions of behavioral finance. It is in this context that (LO, 2004) proposed an alternative financial theory named the adaptive markets hypothesis (AMH), based on dynamic efficiency rather than static efficiency.

The objective of this paper is to evaluate and track the evolution over time of the efficiency of the Moroccan financial market using an approach based on the Diebold-Mariano test applied to the daily returns of the MASI index, over the period from January 3, 2002 to January 24, 2022. The article is organized as follows: the second section presents a literature review on the adaptive market hypothesis and Moroccan stock market efficiency. The third section presents the materials and methods, the fourth section gives the empirical results. This investigation will be closed by a conclusion recapitulating the main results from the theoretical literature review and the empirical study.

2. THEORETICAL AND EMPIRICAL LITERATURE REVIEW

To date, few researchers have attempted to examine exactly how market efficiency may change over time. Information about how market efficiency changes would be important for investors, who need to know whether their chances of accurately predicting prices will increase, remain the same, or decrease. One of the reasons why the studies of weak-form market efficiency are replicated so extensively is that the factors that affect market efficiency are constantly changing (Lim & Brooks, 2011).

The objective of these studies was limited to testing whether markets were efficient. A new perspective on the adaptive nature of the market was offered by Lo (2004, 2005) using the Adaptive Market Hypothesis (AMH). According to this hypothesis, market efficiency is related to environmental factors such as the number of participants in the market, the size of the profit opportunities available and the adaptive capacity of market operators.

Although the AMH is not officially defined, its implications have been studied to indicate the existence of the adaptive nature of markets efficiency. The first implication of the AMH is that the relationship between risk and reward is unlikely to be stable over time. The second implication is that arbitrage opportunities exist from time to time. The third implication suggests that changing economic conditions alter investment strategies. The AMH theory doesn't substitute to the EMH, but it helps to understand the empirical variation of the EMH; time-varying efficiency can be better understood in the framework of the adaptative stock market.

In the literature, the studies that have tried to measure market efficiency in the weak form have been based on a multitude of tests that have made it possible to conclude about the existence or not of informational efficiency, these tests are autocorrelation test, runs test, variance test … (Hiremath & Kumari, 2014) study the Indian stock market to examine whether the AMH is used to better describe its behaviors. The results of linear tests including autocorrelation, runs, and multiple variance ratio test, the results show that there is cyclical exchange between the efficient market and the inefficient market. (Shi, Jiang, & Zhou, 2017) implement some innovative tests like the wild bootstrap automatic variance ratio test and the generalized spectral to study the Chinese stock market efficiency. They find that there is an interplay between random walk behavior and predictability of stock returns. They suggest that the strongest predictability appears when the market is in turbulence, for which they conclude that the behavior of the Chinese stock market is consistent with the AMH (adaptative market hypothesis).

Smith, (2012) tested the AMH theory on 15 stock markets of European emerging countries with those of more developed countries, including Greece, Portugal and England. The variance ratio test is run on time series from February 2000 to December 2009. The results show that market efficiency changes over time to some extent, which is in line with the AMH theory.

A study carried out by (Phan Tran Trung & Pham Quang, 2019) in the Vietnamese context aimed to test the adaptive market hypothesis in the two main Vietnamese stock exchanges, namely Ho Chi Minh City Stock Exchange (HSX) and Hanoi Stock Exchange (HNX) through measuring the relation between past and current prices. The study used some different test like the automatic portmanteau test ("AP"), automatic variance ratio test ("AVR") and the time-varying autoregressive (TV-AR) approach, the generalized spectral test ("GS"). The empirical results support the adaptive market hypothesis in the Vietnamese stock market. Furthermore, the results suggest that the evolution of the HSX was an important factor in the adaptive market hypothesis.

Regarding the market of electronic money as the bitcoin market where the units of electronic money are exchanged on a computer network that has some unique properties characterized by the absence of a central point of control (there are no "banks"). The study of the efficiency of this innovative form of financial markets is very interesting since these markets are in development at the international level espe-

cially with the support of Elon Mask who encourages the integration of electronic payment systems. In this framework, a study made by (Khuntia & Pattanayak, 2018) examine the AMH in the context of bitcoin in the period of 2010 to 2017, using a time-varying approach. Their findings are coherent with Lo (2004) underlying that bitcoin market goes through different levels. As for results in others markets, the authors confirm that periods of inefficiency coincide with major political or economic events.

For the case of the Moroccan financial market, the review of works that have attempted to examine informational efficiency have not agreed on its existence or otherwise. Several methods and statistical approaches have been used, some, have confirmed the existence of informational efficiency and others have refuted it. Lekhal & El Oubani, (2020) worked on aspects of the adaptive market hypothesis (AMH) in the Moroccan financial market over the period from January 1992 to September 2019 using different approaches like rolling window. the results of the study are consistent with the AMH framework, which proves to be a better explanation of emerging market behavior than the efficient market hypothesis (EMH). The target will be to show the periods of efficiency and inefficiency of the Casablanca stock market.

The objective of the study was to examine the evolution over time of the efficiency of the Moroccan stock market and to verify if this evolution follows the description of the adaptive market hypothesis. The Diebold-Mariano test is applied to the returns of the MASI stock index, over the period from 03/01/2002 to 08/02/2022. We will carry out an out-of-sample comparison between the random walk and the ARIMA in order to be able to pronounce on the sub-periods where the Moroccan financial market was or was not in the form of the weak market efficiency. The next section presents the process and methodology of study.

3. DATA AND METHODOLOGY

The time series used in this study represent the daily data of the MASI index from 03/01/2002 to 24/01/2022. we will proceed with the definition of the MASI data used to describe our studied time series.

The table below gives the descriptives statistics of the principal time series, since the jarque- bera probability value is lower than 5% as shown in the table 1, we can conclude that the data don't follow a normal distribution. Moreover, the time series is spread to the left because the skewnes coefficient is less than 0. The table shows that the time series is less flat than the normal distribution and it is a leptokurtic series. The number of observations referring to the daily price of MASI index is 4999.

Table 1. Descriptive Statistics.

-	**Price**
Mean	9518.803
Median	10280.98
Maximum	14925.99
Minimum	2953.300
Std. Dev.	3125.944
Skewness	-0.804516
Kurtosis	2.512820
Jarque-Bera	588.7000
Probability	0.000000
Sum	47584495
Sum Sq. Dev.	4.88E+10
Observations	4999

*Descriptive statistics of the time series.

In order to get an idea of the distribution of the series under study, a histogram visualization will be provided in the graph below:

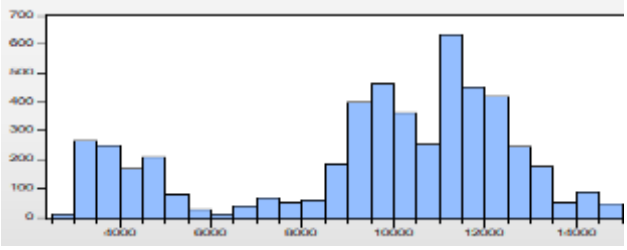
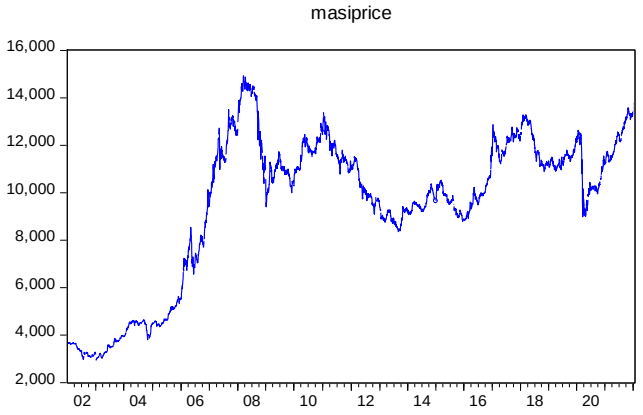


Fig. (1). Graphic representation of the time series.

The graph shows a disparity between the values of the MASI index and therefore the time series is not stationary and has a unit root a priori. In order to use it, it would be necessary to proceed with the stationarity tests to avoid the problems of spurious regression. for our case the study of stationarity does not represent a major interest because it will be split into sub samples of annual sub series. Before doing that, the time series understudy will be represented in the graph to explore its trend. Thus, the masi price time series and by this non formal test presented graphic visualization. It has a trend and a priori it is nots stationary in level, may be in, first difference.



The MASI is divided by year into 20 subsamples to test whether the Autoregressive Integrated Moving Average (ARIMA) model outperforms the random walk model in each subsample by using the Diebold-Mariano (DM) test. Table (1) shows the descriptive statistics of the MASI in each subsample period. Most of the sub-periods in the subsamples are negatively asymmetric, which is consistent with

Table 2. Descriptive Statistics of Subsamples.

Start Date	End Date	Obs	Mean	StandardDev	Skewness	Kurtosis
03/01/2002	03/01/2003	251	3355.584	225.6616	0.2101978	1.529717
06/01/2003	06/01/2004	247	3489.57	313.3394	-0.0431307	1.660485
07/01/2004	07/01/2005	257	4386.078	223.7147	-0.9817929	2.537633
10/01/2005	10/01/2006	253	4882.419	407.4206	0.4932253	1.962119
13/01/2006	12/01/2007	250	7760.65	931.125	0.6942634	2.889727
15/01/2007	15/01/2008	251	11956.95	913.8894	-0.3007392	2.207373
16/01/2008	16/01/2009	248	13388.57	1438.913	-1.104035	2.995071
19/01/2009	19/01/2010	248	10809.06	404.4828	-0.1784874	2.510036
20/01/2010	20/01/2011	257	11880.79	567.3814	0.028997	2.634389
21/01/2011	20/01/2012	254	11699.74	595.3937	0.640098	2.464379
23/01/2012	23/01/2013	252	10095.78	10095.78	0.7042313	2.556217
28/01/2013	28/01/2014	247	8934.112	283.6811	-0.2494216	1.951415
29/01/2014	29/01/2015	250	9634.95	340.8448	0.4894428	2.113733
30/01/2015	29/01/2016	246	9557.751	510.9515	0.2554356	1.910456
01/02/2016	01/02/2017	253	10138.68	908.2868	1.340072	4.328959
02/02/2017	02/02/2018	251	12157.22	435.0077	-0.1810633	2.636837
05/02/2018	05/02/2019	248	11943.01	802.2868	0.415562	1.51824
06/02/2019	06/02/2020	248	11521.59	410.1464	0.910779	3.223126
07/02/2020	05/02/2021	248	10480.99	844.6278	0.5030174	2.62486
08/02/2021	08/02/2022	251	12577.41	764.2987	-0.082984	1.781518

*This table show the descriptives statistics of the MASI index in each sub sample.

the results of Skewness, which assesses the extent to which the distribution of a variable is symmetric. In contrast, the descriptive statistics show a kurtosis that is non-flat (sharp), which is confirmed by the kurtosis that is greater than +1.

The table above shows that most of the daily returns of the sub sample are negatively skewed, which is coherent and consistent with the literature.

In each subsample, the out-of-sample performance of the random walk model is compared to that of the ARIMA model using the Diebold-Mariano test. The random walk model can be calculated by the following equation:

$$P_t = \alpha_0 + \beta_1 P_{t-1} + \varepsilon_t \dots (1)$$

Where, P_t represents the forecasted value of the MASI price on day 1, P_{t-1} represents the observation at the time t-1, while ε_t is the error term. The random walk model is used because the best prediction of tomorrow's price is the price of today. Weak form tests are the most common since they have been widely associated with random walk tests. The underlying idea is to determine whether future values can be predicted from past data.

In contrast, the Autoregressive Integrated Moving Average (ARIMA) model is given as follows:

$$MASI = \alpha_1 MASI_{t-1} + \alpha_2 MASI_{t-2} + \cdots + \alpha_p MASI_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} \quad (2)$$

Where MASI stands for the forecasted value of daily MASI index at time *t*, $MASI_{t-1}$ represents the observation at time *t-1*, p refers to the number of lags and *q* represents the number of moving average terms while ε_t is the error term.

Before using the ARIMA model, the time series must be stationary, the augmented Dikey fuller (ADF) test is used. In this regard, if random walk model outperforms the ARIMA forecasting model, we can conclude that the market behavior is consistent with weak efficiency, i.e., a random walk. Diebold-Mariano (DM) is used to compare the forecasting performance of the random walk model and the ARIMA model.

Assuming that we have two forecasts, P_t^{f1} and P_t^{f2} for an ex-post price P_t. The forecast errors of the two models can be written as follows:

$$\varepsilon_t^{f1} = P_t - P_t^{f1} \ldots(3)$$

$$\varepsilon_t^{f2} = P_t - P_t^{f2} \ldots (4)$$

The accuracy of a forecast can be measured using a loss function. Let q_t be the loss differential which is given by the following formula:

$$q_t = (P_t - P_t^{f1})^2 - (P_t - P_t^{f2})^2 \ldots (5)$$

$$q_t = (\varepsilon_t^{f1})^2 - (\varepsilon_t^{f2})^2 \ldots (6)$$

Based on this formula, we are able to assess whether the current stock price is a better indicator for the forecast. In statistical terms, this means that we can formulate the null hypothesis and the alternative hypothesis in terms of the difference in expected losses.

$$H_0 = E(q_t) \geq 0 \ldots (7) \quad \text{vs} \quad H_1 = E(q_t) < 0 \ldots (8)$$

The Diebold-Mariano (DM) test was conceived to compare forecasts; it has been and remains very efficient for the comparison of forecasts. The DM test was not designed to compare models. However, much of the subsequent literature uses DM-type tests to compare models, in pseudo-out-of-sample situations. In this case, there are more basic but persuasive full-sample model comparison procedures; they have been widely used and should continue to be used. The idea that pseudo-out-of-sample analysis is somehow the "only", or the "best", or even necessarily a "good" way to avoid in-sample overfitting in model comparisons is largely wrong. On the other hand, pseudo-out-of-sample analysis is still useful for some tasks, notably to provide information about comparative predictive performance during particular historical episodes.

The essential part of the DM approach is to take forecast errors as primitives, intentionally, and make assumptions directly about those forecast errors. More specifically, the DM approach is based on assumptions made directly about the loss differential associated with forecast errors. The loss associated with the forecast error e_t and it is denoted by$L(e_t)$. The time i-quadratic function loss will be $L(e_t) = e_t^2$, the loss differential between forecast 1 and 2 is: $d_{12t} = L(e_{1t}) - L(e_{2l})$, DM requires that the loss differential be stationary in covariance. This condition is sufficient but may not be fully necessary.DM assumes the following conditions:

$$\text{Assumption DM}: \begin{cases} E(q_{12t}) = \mu, \forall t \\ \text{cov}\left(dq_{12t}, q_{12(t-\tau)}\right) = \gamma(\tau), \forall t \\ 0 < \text{var}(q_{12t}) = \sigma^2 < \infty. \end{cases}$$

The key hypothesis of equal predictive accuracy which means equal expected loss corresponds to $E(q_{12t}) = 0$

Under the assumption below, we can conclude that:

The test statistics of Diebold and Mariano (1995) can be calculated by the following equation:

$$DM = \sqrt{T}\frac{\bar{q}}{\sigma_q} \sim N(0,1) \ldots (8)$$

Where q represents the mean of q_t, σ_q represents an estimate of the standard deviation of q, and T represents the sample size. Therefore, if the test is less than 5%, we reject the null hypothesis of no significant difference between the forecasts.

3.1. Empirical Results

Table (2) shows the results of the Diebold and Mariano (1995) test for all 20 sub-periods in our sample for the MASI. A p-value less than 5% implies that the test rejects the null hypothesis of equal accuracy of both forecasts.

When studying the presence or absence of weak efficiency form, a positive statistic indicates that the ARIMA model performs better out-of-sample than the random walk model, while a negative statistic indicates that the random walk model outperforms the ARIMA model, and thus we can conclude the existence of a form of weak efficiency. The link between random walk and the weak form efficiency is due to the fact that Price variations (returns) are unpredictable since all known and anticipated outcomes are already reflected in the current price. This was initially interpreted in terms of the absence of autocorrelation of returns over time. In this case, it is impossible to predict future returns from past returns. Econometrically, it implies that prices follow a random walk and that returns respond to a white noise process. The price observed in the market then fluctuates randomly around the fundamental value.

The basic idea is to calculate the key statistic called the DM statistic in the fourth Column in the table 2 above, positive values will indicate that the random walk outperforms the ARIMA model out-of-sample and therefore the market is considered to be efficient in its weak form, if the value of the DM test is negative, ARIMA outperforms the random market model out-of-sample and we can conclude that the Casablanca market is not in the weak efficiency form.

From our results, we can note that most of the Diebold and Mariano (1995) test statistics are positive and all are significant at the 1% significance level. This suggests that the ARIMA model outperforms the random walk model, which implies that the Moroccan stock market is not in a weak form of efficiency. However, the Diebold and Mariano (1995) test statistic comes out negative for some sub-periods 5, 6, 7, 13 and 14. This implies the existence of a weak efficiency of the Moroccan stock market for these sub-periods.

In conclusion, the results suggest that the Moroccan stock market shows a predominance of the absence of a weak form of efficiency. This is confirmed by the overpowering predictions of the ARIMA model over the random walk model. The Table **3** below shows that all of the statical values of Diebold Mariano test are significant at the level of significance of 1%.

Table 3. Diebold-Mariano test.

Periods	Start date	End date	DM test	P value	Efficiency
1	03/01/2002	03/01/2003	8.94	0.000	Inefficient
2	06/01/2003	06/01/2004	4.60	0.001	Inefficient
3	07/01/2004	07/01/2005	2.53	0.000	Inefficient
4	10/01/2005	10/01/2006	1.43	0.000	Inefficient
5	13/01/2006	12/01/2007	-2.67	0.001	Weakly Efficient
6	15/01/2007	15/01/2008	-8.96	0.001	Weakly Efficient
7	16/01/2008	16/01/2009	-1.46	0.001	Weakly Efficient
8	19/01/2009	19/01/2010	1.59	0.000	Inefficient
9	20/01/2010	20/01/2011	1.55	0.001	Inefficient
10	21/01/2011	20/01/2012	1.68	0.001	Inefficient
11	23/01/2012	23/01/2013	1.26	0.000	Inefficient
12	28/01/2013	28/01/2014	8.68	0.001	Inefficient
13	29/01/2014	29/01/2015	-9.22	0.000	Weakly Efficient
14	30/01/2015	29/01/2016	-9.34	0.001	Weakly Efficient
15	01/02/2016	01/02/2017	1.00	0.001	Inefficient
16	02/02/2017	02/02/2018	1.41	0.000	Inefficient
17	05/02/2018	05/02/2019	1.62	0.001	Inefficient
18	06/02/2019	06/02/2020	1.55	0.000	Inefficient
19	07/02/2020	05/02/2021	1.34	0.001	Inefficient
20	08/02/2021	08/02/2022	1.60	0.001	Inefficient

*This table provides the statistical value of Diebold mariano test (1995)

5. CONCLUSION

The theory of market efficiency, because of the unpredictability of returns, has been very often associated with the random walk model. It is however very important to note that the relationship between random walk and efficiency is not an equivalence. Indeed, while the random walk hypothesis is based on efficiency theory, the efficient market hypothesis does not imply that prices follow a random walk. Therefore, if prices do not follow a random walk, this does not lead to market inefficiency.

The efficiency of financial markets is a controversial topic in behavioral finance. The market efficiency hypothesis, developed by Fama, proposes three forms of financial market efficiency, namely strong, semi-strong and weak forms of efficiency. In this context, this paper studied the weak form of efficiency of the Moroccan stock market.

Two models were used to gest predicted values named forecasts, these forecasts were compared using the Diebold-Mariano test: the random walk and the ARIMA model. The results suggest that the Moroccan stock market, approximated by the MASI index, is not always in a weak form of efficiency since the ARIMA model outperforms the random walk model in some years. the ultimate result is that the Moroccan financial market is in an efficient state consistent with the adaptive efficiency hypothesis of financial markets.

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