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The weak form efficiency of the stock market : The case of Moroccan Market

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ABSTRACT

This research work aims at studying the weak form of informational efficiency of the Moroccan stock market developed by Fama. We apply classical econometric tests to this end. Many studies have focused on the presence of non-linearity or long memory in the return series. In this paper, we propose to study these phenomena through the development of an ARFIMA process as suggested by Granger and Joyeux (1980) and Hosking (1981). We used the MASI composite index and our results provide solid proof that does not support the efficiency hypothesis of the Moroccan stock market and the ARFIMA process shows that the MASI series is characterized by a long memory structure.

Introduction

The analysis of stock market price variations is intimately linked to that of economic fluctuations; finance is only one facet of the economy. Expectations of the fundamentals of the economy represent a particular image of the theoretical expectations of prices. The financial market is often seen as a leading indicator of the economy as a whole. The study of economic fluctuations allows for a better explanation of stock price variations.

The issue of financial market efficiency has been a hot topic in the international financial arena for decades. Informational efficiency is the core of modern financial theory. Indeed, the Efficient Market Hypothesis (EMH) stipulates that the price observed on the market reflects all available information at all times. This definition was considered too general to allow for empirical verification. It is within this framework that Fama (1970) categorized the efficiency hypothesis by proposing three categories based on their informational set and then applied a slight modification in 1991 due to the abundance of work on the empirical study of the concept.

A market is said to be efficient in the weak form, the price of securities reflects all the information available and is based on the price history. So by definition the stock market series does not have a memory. It is therefore impossible for an investor to predict the future evolution of returns. Technical analysis is now unable to beat the market. In other words, the stock price follows a random walk process and the profitability series follows a white noise process.

In the semi-strong form of efficiency, the information set contains all publicly available information. The information set here includes the company's annual reports, as well as its sales and earnings, bonus share and dividend payouts, rumors and other industry or macroeconomic information. This information must be integrated into the share price at the very moment when this information becomes public, so that the realization of profits is not possible.

In an efficient market in the strong form, the total information available includes both the information that has become publicly available and any private information, which must be fully reflected in the price. This form of efficiency refers to insider trading as well as the study of the performance of professional investors who will be able to beat the market.

In a stock market it is clear that the autocorrelations of the series decrease in a rather slow way, a phenomenon that can be explained either by a non-stationarity or by a stationarity with long term dependence. It is this second aspect that will be the subject of our article.

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The purpose of this research work is to test the hypothesis of informational efficiency in its weak form of the Moroccan stock market, precisely by studying long memory processes.

The results of our research can be of interest to all financial market players and particularly investors (institutional and private). Also to company managers who are looking for a better understanding of the market and its efficiency before making any decisions.

Our main contribution in this paper is to enrich the existing literature by providing an answer on the presence of a long term structure in emerging markets and more particularly the Moroccan market.

The remainder of the paper is organized as follows. First, we present a brief review of the literature on long-memory detection, section 2 presents the methodology used, section 3 presents a description of the data and empirical analysis with the results concerning efficiency in its weak form in the Moroccan stock market and long-memory detection. The last section offers a conclusion.

1. Literature review

Informational efficiency is based on the concept of information and the issue of transparency and disclosure of this information. It translates into the ability of a market to process information in the most effective and efficient way possible. Informational efficiency is measured by the market's ability to integrate into the price all the information relating to the fundamental value of the asset.

Allen, Brealey, and Myers (2011) explain that a market is considered efficient if it is not possible to earn a return greater than that earned by the market. In other words, the value of the stock expresses the fair value of the firm. Eakins and Mishkin (2012) agreed with Fama's (1965) definition that a market is efficient if asset prices fully reflect all available information.

Bakir (2002) focuses on the Moroccan market and shows that stock prices tend to recover their intrinsic value and that the stock returns of the MASI index follow a normal distribution.

Theoretical and empirical advances have appeared since the early centuries The concept of an efficient market was anticipated a long time ago with the work of the Italian mathematician Girolamo Cardano (1564).

Bachelier (1900) is recognized as the founder of mathematical finance is that of the characterization of the variation of the rent in a scientific way. He sought to establish a mathematical formula that could express the law of probability of variations in stock prices at any time t.

If we owe the mathematical frmulation of the random walk to Bachelier, Samuelson (1965) and Fama (1965) have developed the theorical framework of the random walk.

Narayan and Prasad (2007) identify three unit root tests that they apply to 17 different markets to finally conclude the presence of unit root in all countries. Murthy et al (2011) by applying unit root tests over a period of thirty-nine years for the indices of the Dow Jones, NASDAX and S&P 500 have proven the efficiency of the American market

Long memory in financial time series is characterized by a self-creation function that decreases at a hyperbolic rate as the lag increases, while in a short memory process it decreases exponentially. Similarly, by an infinite spectrum with zero frequency. In other words, a long memory process is a partially integrated process, its degree of integration is greater than zero and less than one.

From an economic point of view, the presence of a long memory in the financial series implies a continuous deviation between the price and its fundamental value. This implies that the lag time for prices to adjust to information is relatively large. In other words, today's information is not immediately reflected in the price. This long delay does not coexist with the theory of efficient markets.

Mandelbrot (1971) concludes that the existence of a long memory leads to less perfect arbitrage and that prices are predictable. More recent studies use another approach to detect the presence of a long-run dependence structure in the financial literature. This is the fractionally integrated moving average autoregressive model (ARFIMA), where d is the fractional differentiation parameter. An ARFIMA process is characterized by a long memory if the parameter d is different from zero, so the sign of d defines the nature of the process. Statistically speaking, a parameter d belonging to the interval (0 , 0.5) means that the sum of autocorrelation diverges towards infinity, the ARFIMA process presents a persistent behavior. However, if the parameter d belongs to the interval (-0.5 ; 0) the sum of autocorrelations converges to zero and the long memory is said to be anti-persistent.

In research using the ARFIMA process by the semi-parametric Geweke and Porter-Hudak (GPH) test, Berg and Lyhagen (1996) present evidence for the existence of long memory in the monthly and daily series in the Swedish market. Kapur (2004) finds that the Indian stock market exhibits long memory by applying ARFIMA-GARCH estimators. Thupayagale (2010) examining 11 series of African stock returns including Morocco and finds the presence of long memory. Lopez-Haerrera et (2012) using an ARFIMA process provide evidence of a long-run structure in Mexican stock returns. Tan et al(2010) examine the

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Kuala Lumpur stock market and find the presence of long memory.

Moreover, Lardic and Mignon (1997) extend their analysis using both the ARFIMA process and the R/S statistic to highlight the presence of a long memory in the series of daily returns of the TOPIX, SBF250, TSE300 and BCI indices to finally support the results of Lo (1991).

Falloul (2020), Faiteh and Najab (2020) investigate the Moroccan stock market and reject the hypothesis of the weak form efficiency .

We propose here to verify the following hypotheses:

H1: The Moroccan stock market is not efficient in its weak form.

H2: There are significant autocorrelations of the stock market series of the Masi index.

2. Methodology

The purpose of this section is to present the tests and methods used to test the weak form of informational efficiency of the Moroccan stock market.

2.1. The autocorrelation test

Testing the random walk consists in examining the independence of the returns of the securities. We will then say that the returns are uncorrelated with their lags if we assume that prices follow a random walk. The idea is to test the null hypothesis in equation :

$R_t = \mu + \sum_{k=1}^{q} \rho_k R_{t-k}\, \varepsilon_t \;\; ; \; \varepsilon_t \rightarrow IID(0, \sigma^2)$

$H0: \rho_k = 0 \;\; ; k = 1,2,3, \ldots\ldots, q$

$H1: \rho_k \neq 0$

With $R_t$the returns of the index at time t ; μ is a constant and $\rho_k$the coefficient measuring the serial correlation between $R_t \; and \; R_{t-1}$for all k > 0 , ε_t expresses the error term; q represents the number of lags.

Verifying that the autocorrelation of the first q orders is zero can be done by computing the Box and Pierre(1970) statistic, also called the portmanteau test, which assumes that the errors are independent and identically distributed according to the normal distribution.

The proposed statistic is the following:

$$BP(q) = N \sum_{k=1}^{q} \rho^{\,2} \;\; (k)$$

Ljung and Box (1978) improved Box and Pierre's test to account for small sample sizes where a sudden movement over a $\rho_k$can have a significant effect on the statistic. The modified test then becomes:

$$LB(q) = N(N+2) \sum_{k=1}^{m} \frac{\rho_k^2}{N-k}$$

Under the null hypothesis of no serial correlation. The Ljung-Box statistic follows a Chi-square distribution with m degrees of freedom. In practice, if LB(q)<$\mathcal{X}^2$ (m) (LB(k) ~ $\mathcal{X}^2$ (k − m), we accept the random walk hypothesis. In the same way, the rejection of the null hypothesis implies a non-validity of the random walk model insofar as the returns do not follow a white noise.

2.2. Test on the variance ratio

The variance ratio test was developed by Lo and MacKinlay (1988) and has advantages in its application to financial markets and is used to test the stationarity of the time series as a necessary condition for testing the random walk. The interest proclaimed by researchers for the RV test is expressed in 1) its strength in sensitivity to fluctuations in correlated prices; 2) its robustness to the effect of heteroscedasticity.

The variance ratio test is based on the idea that in an uncorrelated setting, the variance of returns over q units of time $r_t - r_{t-q}$ is proportional to that of one unit so the proportionality factor is given by q (positive integer describing the difference interval) i.e., $Var\, r_t - r_{t-q} = q\; Var\, r_t - r_{t-q}$. In other words, the variance of returns is defined as a linear function of the time interval required for its determination. By dividing the variance whose interval is long by that whose interval is short, we obtain the variable VR by the ratio is :

$$VR(q) = \frac{\frac{1}{q} Var(r_t - r_{t-q})}{Var(r_t - r_{t-1})} = \frac{\sigma^2(q)}{\sigma^2(1)}$$

Under the null hypothesis H0 of no correlation, VR is equal to unity, i.e. the series follows a random walk. If necessary, the variance ratio will take a value strictly less (greater) than 1 if there are negative (positive) correlations respectively. The parameters σ(q) and σ(1) are unknown, we use a history of size nq for the estimates; ($n\epsilon\mathbb{N}; nq$:is the number of observations for $r_0, r_1, \ldots, r_{nq}$).

Their values are defined by :

$$\hat{\mu} = \frac{1}{nq} \sum_{k=1}^{nq} (r_k - r_{k-1}) = \frac{1}{nq}(r_{nq} - r_0)$$

$$\hat{\sigma}^2(1) = \frac{1}{nq-1} \sum_{k=1}^{nq} (r_k - r_{k-1} - \hat{\mu}) \quad ^2$$

$$\hat{\sigma}^2(q) = \frac{1}{h} \sum_{k=1}^{nq} (r_k - r_{k-1} - q\hat{\mu}) \quad ^2, h$$

$$= q(nq + 1 - q)(1 - \frac{q}{nq})$$

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By the statistical test we check if VR(q) is significantly different from one unit at the 5% threshold. It is then necessary to test the following hypotheses:
H0: VR(q) = 1, It follows a random walk: The market is efficient at in its weak form ;
H1: VR(q) ≠ 1, The market is not efficient.
Lo and MacKinlay propose a statistical test Z that approximately follows a centered reduced normal distribution.

$$Z = \frac{VR(q) - 1}{\sqrt{\phi(q)}} \sim N(0,1)$$

With : $\phi(q) = \frac{2(2q-1)(q-1)}{3q(nq)}$

An implication of rejecting the null hypothesis may be caused by heteroscedasticity in the variances. To account for this effect, Lo and MacKinlay modified the statistic to obtain

$$Z^* = \frac{VR(q) - 1}{\sqrt{\phi(q)^*}} \sim N(0,1)$$

With :

$$\phi(q)^* = \sum_{j=1}^{q-1} \left[\frac{2(q-j)}{q}\right]^2 \delta(j)$$

When :

$$\delta(j) = \frac{\sum_{k=j+1}^{nq} (r_k - r_{k-1} - \mu)^2 (r_{k-j} - r_{k-j-1} - \mu)^2}{\sum_{k=1}^{nq} (r_k - r_{k-1} - \mu)^2}$$

We pose:
δ(j) Is the heteroskedasticity consistency estimator;
ϕ(q) Represents the asymptotic variance at the ratio of the variance under the assumption of homoscedasticity;
ϕ(q)* Represents the asymptotic variance at the ratio of variance under the heteroskedasticity assumption.

We reject the random walk hypothesis if the Z and Z* statistics are significant and the series will be said to be self-correlated.

2.3. Runs Test

Nonparametric tests are considered less simple in their application compared to parametric tests. We are interested in two of the most popular tests, the run test and the Wright(2000) variance ratio.
Assuming that asset returns follow a random walk means that there are as many positive returns as negative ones, hence the interest of the run test also called the sign change test. It is a test that is widely used in the empirical literature on the issue of efficiency, Christine Stachowiak (2004) and was first introduced by Mood (1940). It is considered to be a non-parametric test in that it does not impose any specification on the probability of distribution of the financial series. In other words, it does not require an assumption about the residuals (ε_t). Rather, the test relies on the sign of price changes rather than the magnitude of prices, so it focuses on the direction of changes in the series under study.

A "run" represents a sequence of successive price changes of the same sign, preceded and followed by price changes of different signs. For stock prices, three different types of price changes can be expressed, which means that there are three different cycles (positive, negative or zero). Under the assumption that the returns of the financial series are independent and that the positive, negative and zero proportions of the sample are unbiased estimators of the population proportions.
Wallis and Roberts (1956) calculate the mathematical expectation of the total number of runs as follows:

$$m = \frac{\left[N(N+1) - \sum_{i=1}^{3} n_i^2\right]}{N}$$

With:
N : is the total number of price changes ;
n_i: is the number of price changes of each sign (i=1,2,3) ;
m: is the total expected number of runs of all signs.
The standard deviation of m is given by the following formula:

$$\sigma_m = \left[\frac{\sum_{i=1}^{3} n_i^2 \left(\sum_{i=1}^{3} n_i^2 + N(N+1)\right) - 2N \sum_{i=1}^{3} n_i^3 - N^3}{N^2(N-1)}\right]^{\frac{1}{2}}$$

Under the null hypothesis of a random walk, the frequency of occurrence of "+" and "-" must be identical.

The statistic for the runs test is based on the statistic Z→ N(0,1)

$$Z = \frac{(R \pm 0{,}5) - m}{\sigma_m} \sim N(0,1)$$

With:
R: The total number of runs observed ;
0.5: Represents the correction coefficient for the continuity fit. It is positive if R ≤ m and is negative if R ≥ m.

2.4. Unit Root Tests

It is imperative to check if financial series follow a stationary process before writing any model. Indeed, saying that a series is stationary implies that it has a structure that does not evolve and remains constant over time. In other words, it is a series with a constant and finite mean and variance over time and whose mean value returns to the constant after a shock.
The Dickey-Fuller Augmented test is a parametric test that consists of detecting the existence of a trend and determining the best way to stationaryize a series.
The application of the ADF test is based on two types of processes:

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- TS process (Trend Stationary) which indicates a non-stationarity of deterministic type;
- DS process (Differency Stationary) which represents random non-stationary processes.

The construction of the ADF test is based on an ordinary least squares OLS estimation of three models.

Model 1 : $Y_t = \phi Y_{t-1} + \varepsilon_t$Autoregressive model of order 1

Model 2 : $Y_t = \phi Y_{t-1} + c + \varepsilon_t$ Autoregressive model of order 1 with constant

Model 3 : $Y_t = \phi Y_{t-1} + \beta t + c + \varepsilon_t$ Autoregressive model of order 1 with trend

2.5.BDS test

Brock, Dechert and Scheinkman (1987) introduced a statistic to test the white noise hypothesis against the hypotheses of deterministic chaos and stochastic nonlinearity. It is the most widely used test for independence of time series. The independence test is based on the correlation integral with T(T-1) in the denominator for reasons of asymptotic convergence. The BDS statistic developed for a series X_t (t=1 to T) of a priori random observations will allow to test a null hypothesis that the series is independently and identically distributed i.e. that the series is linear against an unspecified hypothesis. The rejection of the null hypothesis means that the series is non-linear.

On the basis of the time series X_t (t=1 to T) of length T translating the state of a system governed by an equation of motion of unknown law. The first step in the development of the test is to form m-dimensional sub-samples or vectors, also called m-histories, whose components correspond to consecutive values of the observed series:

The m-histories allow the reconstruction of the attractor of the system under study which expresses its behavior over the long term. m is the embedding dimension, which translates the dimension of the space of steps in which the attractor is reconstructed. The terminology used here comes from the Chao theory.

The BDS statistic is given by :

$$W_{m,T}(\mathcal{E}) = \frac{\sqrt{T}(C_m(\mathcal{E}) - (C_1(\mathcal{E}))^m}{Б_{m,T}(\mathcal{E})}$$

$C_m(\mathcal{E})$: The correlation integral.

In order to test the H0 hypothesis we need to compare the BDS statistic to N(0.1) at 5%(1.96).

$W_{m,T}(\mathcal{E})$: follows a reduced center normal distribution.

2.6. Presentation of ARFIMA models

Stationary processes are said to have long memory when autocorrelations are persistent and decay more slowly than the rate associated with ARMA models. Modeling long-run dependence is difficult for standard ARMA specifications because it requires high order, non-parasitic ARMA representations that are usually accompanied by undesirable short-run dynamics (Sowell, 1992).

A popular approach to modeling long memory processes is to employ the notion of fractional integration (Granger and Joyeux, 1980; Hosking, 1981). A fractionally integrated series is a long memory series that is not integrated of order I(1).

Following Granger and Joyeux (1981) and Hosking (1981), one can define a fractional difference operator in discrete time that depends on the parameter "d":

$$\nabla^d = (1-L)^d = 1 - dl - \frac{d(1-d)}{2!} - \frac{d(1-d)(2-d)}{3!}L^3 - \dots = \sum_{k=0}^{\infty} \frac{\tau(k-d)}{\tau(-d)\tau(k+1)} L^k$$

for : $-1/_2 < d < 1/_2$ $et\ \tau\ is\ gamma\ fonction$

More generally, if the fractional differentiation of order "d" gives an ARMA (p,q), we say that the process is ARFIMA(p,d,q). In polynomial form, it is written :

$$\emptyset(L)(1-L)^d X_t = \Theta(L)\varepsilon_t$$

If the fractional difference parameter applied to a process produces a random walk, then the process is an ARFIMA (0, d, 0). According to Hosking:

- if d= 1/2: The process is non-stationary but invertible;
- If 0<d<1/2 : The process has a long memory but it is stationary and invertible
- If -1/2<d<0: The process has a short memory, with all negative autocorrelations and partial autocorrelations, and that it is stationary and invertible.
- If d=0 : The process is white noise.

3. Data

Our sample consists of the daily closing price index of the Moroccan stock market. We collect data for the MASI index from bloomberg.com over the period 1993-2021. We accumulate 6969 observations. The MASI index is determined from all the stocks listed on the Casablanca stock exchange. It is an index which is calculated on the basis of the floating capitalization and having for base 1000 at 31/12/1991.

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We define P_t as the MASI price index at time t. The return noted R_t is calculated by the following formula:

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

4. Empirical results

In this section, we present the main empirical results developed with the help of the Eviews software.

4.1. Study of the market behavior

Table 1- Descriptive statistics on the series of returns

Mean	Max	Min	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
0.000325	0.053054	-0.092317	0.006942	-0.569607	16.24563	51314.81

- ✓ The kurtosis coefficient is very high and is well above 3 which is the value of the kurtosis coefficient of the normal distribution. This excess in the value of the coefficient indicates a high probability of occurrence of extreme events.
- ✓ The distribution of returns is leptokurtic, i.e. with fat tails/ heavytails/ tailevents
- ✓ The skewness coefficient is different from 0, which is the value of the skewness coefficient for a normal distribution, and is negative. The distribution is skewed to the left, so we say that the distribution of returns is asymmetric. This phenomenon of asymmetry in the probability distribution of returns is an indicator of non-linearity. The magnitude of negative losses is much higher than that of gains, due to the bursting of bubbles and financial crises.
- ✓ From the Jarque-Bera statistic, we reject the null hypothesis H0 of normality of the Masi returns.

4.2. Run test

Table 2 - Run test

T	R1	R2
6969	2965	0.0000

R1: Represents the number of runs; R2: p-value

The non-parametric test, the runs test, verifies the null hypothesis of random walk of the yield series. The table above gives us the number of runs and the p-value which is less than 0.05. We do not reject the null hypothesis of independence of the returns. This implies that the historical data do not predict future returns, which argues in favor of the weak form of the informational efficiency hypothesis.

However, although the runs test is easy in its application, it suffers from low power which leaves us undecided as to the acceptance of these conclusions. Hence the need to compare its results with those of the variance ratio test for example.

4.3. Variance ratio test

The variance ratio test was applied for various values of the truncation parameter. We varied our parameter from 2 to 4096. Our justification for the choice of various values of the truncation parameter aims at not neglecting a potential presence of long memory in our yield series and which in the same way could hide with the choice of a small value of the parameter.

Table 3 - Variance Ratio Test

Joint Tests	Value	df	Probability
Max |z| (at period 2)*	11.34221	6967	0.0000

Individual Tests

Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.634111	0.032259	-11.34221	0.0000
4	0.344777	0.058485	-11.20319	0.0000
8	0.170363	0.088078	-9.419310	0.0000
16	0.084853	0.117865	-7.764359	0.0000
32	0.044118	0.147792	-6.467749	0.0000
64	0.021600	0.181598	-5.387724	0.0000
128	0.010901	0.227086	-4.355610	0.0000
256	0.005381	0.289040	-3.441106	0.0006
512	0.002884	0.377124	-2.644003	0.0082
1024	0.001657	0.500188	-1.995936	0.0459
2048	0.001065	0.666462	-1.498863	0.1339
4096	0.000706	0.882216	-1.132709	0.2573

The table above shows that the MASI return series is characterized by a strong dependence. The variance ratio being between 0.0007 and 0.63, less than unity which refers to a negative correlation. The random walk hypothesis is rejected under the two hypotheses of homoscedasticity and heteroscedasticity, from the value of the truncation parameter of 1024. Indeed, the probabilities associated with the z-statistic remain insignificant for the truncation parameter 1024 and 4096 with respective probabilities of 0.1339 and 0.2573 which are higher than a threshold of 10% and which weaken in some way the significance of the variance ratio.

The overall picture of the variance ratio test allows us to conclude that the MASI performance series does not follow a random walk and therefore the series has a memory. The hypothesis of informational efficiency of the Moroccan market is not retained, the market is not efficient.

4.4. The contribution of the BDS test

According to the test previously used, the results seem a bit divergent because of their linear character do not allow to detect the structure of non-linear dependence. It seems necessary to use a more robust test to detect this non-linearity because our series is an asymmetric distribution indicative of non-

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linearity. The BDS test seems more appropriate for our situation.

The BDS test tests the null hypothesis that the series is independently and identically distributed against the unspecified alternative hypothesis. We varied the extension dimension (m) from 2 to 15.

The results in the table below suggest the rejection of the hypothesis of independence of returns, which is contrary to the hypothesis of informational efficiency. The Moroccan stock market is inefficient in the weak sense.

Table 4 - BDS Test

Dimension	BDS Statistic	Std. Error	z-Statistic
2	0.039730	0.001244	31.94457
3	0.072635	0.001975	36.76811
4	0.093310	0.002352	39.67514
5	0.104639	0.002451	42.69099
6	0.108310	0.002364	45.82026
7	0.106380	0.002166	49.10690
8	0.101390	0.001915	52.94722
9	0.094522	0.001648	57.36255
10	0.087152	0.001389	62.75662
11	0.079764	0.001151	69.28933
12	0.072687	0.000941	77.20766
13	0.066016	0.000761	86.70719
14	0.059838	0.000610	98.10354
15	0.054199	0.000485	111.8117

4.5. Stationarity test: Unit root test

The implementation of tools allowing the detection of chaos and short or long memory requires that our series is stationary. A first step of the analysis requires us to test this stationarity by using statistical tests of unit root.

The unit root tests are based on the assumption that the process is not deterministic and that it hard to predict. In fact, it is imperative to verify the stationarity of stock returns.

There are different unit root tests such as: Augmented Dikey Fuller test (ADF), Phillips Perron test (PP) and Kwiatkowski, Philips, Schmidt and Shin (KPSS).

The ADF test is widely used in recent research. Its particularity is that in its regression it includes a lagged dependent variable. We present in the following the results of Augmented Dikey Fuller (ADF)test.

Table 5 - Augmented Dikey Fuller test for the logarithmic series

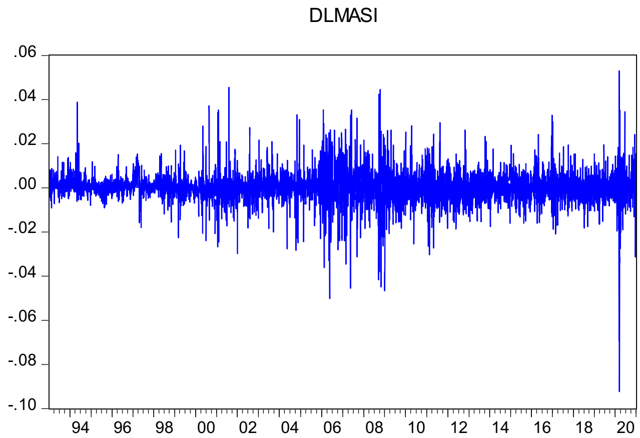
Variable	Coefficient	Std error	T-statistic	Prob
ADF			-1.794815	0.7075
Lmasi (ro)	-0,000442	0,000246	-1,794815	0,0727
C	0,003991	0,001912	2,086604	0,037
Trend (b)	2,99E-08	8,05E-0,8	0,371578	0,7102
ADF	-2.979178			0.0369
Lmasi (ro)	-0.000362	0.000122	-2.979178	0.0029
C	0.003400	0.001065	3.192434	0.0014

The DF test statistic is compared with the critical values 1.95 for model 1, -2.86 for model 2 and 3.41 for model 3 at 5% threshold

On the basis of the results obtained, we can conclude that the time series of the Masi index highlights the presence of a unit root in the structure of our series. Indeed, the presence of a unit root (stochastic trend) is a source of non-stationarity. If we have a non-significant trend and a significant constant we can confirm that our series is of the DS type with drift.

In order to stationary our Masi time series, we proceed by the first difference filter. This can be visualized from the following graph:

Graph 1 - Logarithmic series of Masi transformed into first difference



Testing informational efficiency by ARFIMA regression

We study the efficiency of the Moroccan stock market through the size of the fractional differentiation parameter "d" in the estimated equation.

The table below gives the results of the estimation of the ARFIMA (p,d,q) model for the Masi series.

Table - Estimation of the ARFIMA(p,d,q) model

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Variables	Coeff	Erreur standard	t- stat	Probabilité
C	0.000342	0.000275	1.245514	0.2130
D	0.139935	0.033779	4.142655	0.0000
AR(1)	0.888134	0.036010	24.66346	0.0000
AR(2)	-0.150509	0.009727	-15.47397	0.0000
MA(1)	-0.745975	0.054449	-13.86581	0.0000

$$y = 0.000342 + 0.888134y_{t-1} - 0.150509y_{t-2} - 0.745975\varepsilon_{t-1} + 0.139935$$

The ARFIMA model (2, 0.139935 , 1) was chosen on the basis of the Akaike and Schwartz information criteria. Except for the constant, all the parameters are significant according to the student test. The fractional integration parameter d equals 0.139935 and is between 0 and ½ , the process has a long memory and is stationary.
The result of our parameter value leads us to guess that the estimated ARFIMA model is close to an ARMA model where the detected long memory may be small.

Conclusion

The objective of this article was to test the hypothesis of informational efficiency in its weak form of the Moroccan stock market and check the presence of long memory process.
In the end, we present strong evidence for the presence of long memory in the Masi index. This implies that the weak efficiency hypothesis of the Moroccan stock market, according to which the asset price reflects the information contained in the price history at all times, is not verified. It appears that the future returns of the Masi are predictable and that the price history contains relevant information that could have a positive effect on the quality of the future returns of the Masi. Our initial hypothesis is rejected.
A first implication, is that it is able to improve the accuracy of forecasting Masi index returns. Note that in the presence of long memory, the persistence of shocks to asset returns on day d, can influence returns 6 months later. On the other hand, the existence of a short-term memory generally disappears in about ten days.
A second implication concerns the phenomenon of mean reversion in prices, which was initiated by Summers (1986). Indeed, the existence of the mean reversion phenomenon implies a slow return of prices to their fundamental value. It is interesting to note that the gap between the two values can be very long-lasting; however, prices will always eventually return to their fundamental value. We can then say that the longer the period considered for the slide of prices towards their fundamental value, the more the series exhibits a long term memory and vice versa. As already underlined then to think the persistence of the shock and a durable deviation which gives more fields and a great possibility to establish a remunerative strategy on the Moroccan stock market. Speculators can finally take advantage of this opportunity and speculate on this price difference.
In summary, the presence of long memory in a series of Masi returns has as an essential consequence the existence of a gap between the price and its fundamental value, which testifies to a duration in the adjustment of prices to information, something that confirms our second hypothesis.The results provided by developed market show little memory in their processes. Indeed, a divergence in the way information is prcessed could explain these results (Yartey and Adjasi 2007).

The search for a long-run dependence structure in the daily return series of the Masi seems particularly interesting in the sense that it is directly linked to the theory of stock market efficiency. The empirical results provided in this article can be developed to test the efficiency of the market. On the one hand, it seems appropriate to analyze the size and liquidity of the market. On the other hand, it would be interesting to divide the sample in several periods of crisis and calm situation, in period of publication of results, in period of specific events such as regulations or changes of regime.
Also, it would be interesting to perform backtesting studies of technical analysis.

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