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FINANCIAL MARKETS EFFICIENCY: MADEX IS NOT A RANDOM WALK

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Abstract: This paper aims to test the hypothesis of informational efficiency of the Moroccan financial market, first reviewing the theoretical underpinnings of this hypothesis, as well as various research works conducted in this direction in different financial markets including the Moroccan market subject of our study.
To this end, we have applied different tests on the series of logarithmic returns of the MADEX index, including the autocorrelation test, the Ljung box test in addition to a non-parametric test (Runs test) to analyze the series of daily logarithmic returns of the index over a period of 10 years covering from 01/01/2010 to 01/01/2020
Our results indicate that the Moroccan market is inefficient in the weak sense through the rejection of the presence of a random walk process argued by the presence of significant autocorrelation at the first lag and by a number of sequences significantly different from the normal value of the daily return of the main index of the Casablanca stock exchange MADEX.

Keywords: informational efficiency, financial markets, random walk.
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1. Introduction

In equilibrium, prices in stock markets must integrate in their formation all available information and should quickly adjust to new ones so that no investor can generate abnormal returns by using them, in this case the markets are qualified as efficient in the informational sense and are therefore worthy of the confidence of the investors.

Financial theory has provided several answers to this logic through a battery of quantitative tools developed over time for this purpose, making it "the most scientific of all social sciences". (Ross, 2005).

The topic of informational efficiency of markets is widely discussed in the modern financial literature; Not only is it the basis of multiple academic publications each year, but it is also commonly used in the field of market finance when integrated into the framework of asset pricing models, portfolio management, the work on opportunity cost (CAPM) and arbitrage pricing theory (APT).

Researchers believe that the efficiency criterion is fundamental for the proper functioning of markets, as it gives them credibility and helps attract investors to the markets (Dani et al., 2016) as it describes the transparency of markets, their capacity to integrate faithfully in their prices all the information likely to help in the decision making process, what would allow an optimal allocation of the available resources.

Several publications have attempted to test the truth or falsity of this hypothesis in different developed and emerging financial markets, however, and to this day, this hypothesis is not the object of unanimous conclusions and the opinions of theorists in this sense are often controversial (Lardic Mignon, 2004) it also has been the subject of several criticisms since its initial formulation (French, 1980) (Gibbons & Hess, 1981) ; it is noticed that works in this sense on the Moroccan market are very rare and controversial ; hence the importance of taking stock of this theory.

The purpose of this paper is therefore to overcome this lack and to test the hypothesis of informational efficiency in the weak sense of the Moroccan stock market through a battery of tests developed for this purpose including tests of normality, tests of autocorrelation, and the test of variance ratio; We aim therefore by this research to confirm or deny the hypothesis on the Moroccan financial market and this in order to measure his ability to ensure the well investment of savings to productive employment and therefore contribute to the economic development of the country.

1. Efficiency of financial markets literature review

Definition:

From the point of view of financial theory, efficiency is a concept that can take on several dimensions. In general, three types of financial market efficiency can be distinguished: allocative efficiency, operational efficiency, also called functional efficiency, and informational efficiency. (Bauer, 2004).

These different forms of financial market efficiency are linked by a hierarchical relationship, as informational efficiency is subordinated to operational and allocative efficiency (Bauer, 2004; Harrab, 2017).

Allocative efficiency: This concept describes the ability of financial markets to allocate available financial resources to the most productive uses; in such a context, investors finance projects with the highest net present value and no project deemed profitable is discarded for lack of capital (Bauer, 2004).

A market is allocatively efficient if it allows its participants to maximize their utility given the resources available to them (Tobin et al., 1985)It should be noted that allocative efficiency is closely linked to informational efficiency, as the proper allocation of financial resources presupposes transparency of information and the proper integration of the latter into the valuation process of listed assets.

Operational efficiency: This efficiency concerns the main function of the market and its bodies, which consists of the link between capital providers and capital seekers. It depends on the good management and organization of the market; the market will be qualified as efficient in the operational or functional sense when its financial intermediaries fully play their role of link between capital providers and capital seekers, such a situation makes it possible to measure the cost of transferring funds from savers to borrowers, and the market is efficient in the operational sense if it makes it possible to play its role of linkage at the lowest possible cost (Bauer, 2004)

Informational efficiency: refers to the issue of information symmetry and transparency; in an informationally efficient market, the price fully and instantaneously reflects all available relevant information (Fama, 1995)In an informationally efficient market, the price fully and instantaneously reflects all the relevant information available, this definition, which is considered too general to be verified empirically, led the same theorist to propose three types of efficiency (Fama, 1970), thus Fama distinguishes :

- *Efficiency in the weak sense:* which assumes that the price incorporates all historical information, technical analysis is then of no use in this case, as all past information likely to help predict the future is already incorporated in the price.

- *Efficiency in the semi-strong sense*: the price incorporates all public information, which includes both data from the issuing companies such as annual reports, profit announcements, bonus share distributions, and information published by the press. This type of efficiency renders fundamental analysis useless, as simply public information, which could help to assess asset prices from a fundamental finance perspective under the rational expectations hypothesis, would be unusable.
- *Efficiency in the strong sense:* the information incorporated in the price includes all information concerning prices, including both historical, public and private information, i.e. that to which the firm's insiders have access, so there is no interest in insider trading in this case.

The table below summarizes the different forms of informational efficiency in financial markets according to (Fama, 1970).

	Weak sens	***Semi-strong sens***	***Strong sens***
Information's reflected	Historical information	Public information	Private information
Example	Historical returns , historical dividends …	Annual reports	Information detained by firm's insider's
Usable information's to make profits	Actual and future information	Private information	-

Table 1. Forms of informational efficiency in financial markets

Source: R. Rahaoui (2007)

Indeed, the different types of efficiency mentioned above are not independent. It is natural that a market is all the more efficient as the cost of the transactions that take place on it is low; in this case, prices will be good regulators of operators' decisions.

In terms of defining the concept, Samuelson A. Paul, (1965) introduced the considerable effort, in the sense that he provides, a market is said to be efficient if the price is equal to its fundamental value at any time; hence, the price observed on the market is equal to its fair value, defined as the discounted sum of the future dividends rationally anticipated by the agents using the latter's opportunity cost (Orléan, 2004).

Jensen, (1978) proposes another definition of efficiency: "a market is efficient conditional on a set of information Ωt if it is impossible to make economic profits by speculating on the basis of the set of information Ωt", thus a market is said to be efficient if profitable forecasting through information is impossible for market participants (FAMA & FRENCH, 1992).

Beaver, (2014) defines an efficient market as one where prices act as if everyone knows the information system perfectly.

According to (Malkiel, 2003) a market is said to be efficient if it fully and correctly reflects all the information that can be used to determine the prices of securities, the market is formally said to be efficient with respect to certain sets of information if the prices of securities were not affected by revealing this information to all participants;

Moreover, efficiency with respect to a set of information implies that it is impossible to make economic profits by trading on the basis of this information.

1.1 Empirical tests of the efficient financial market's hypothesis

- ***Efficiency tests in developed markets:***

Long before the emergence of the concept of efficiency, the movement of stock prices has aroused the interest of the scientific community, starting with (Bachelier, 1900) who was interested in describing the movement of stock prices, which he considered "abnormal", he and (Cowles, 1933) confirmed that the profitability series on the American market evolved in a random and unpredictable way.

(Kendall & Hill, 1953) working on twenty-two weekly series, showed that prices in the American market followed a random process.

The first empirical tests on the efficiency of markets were conducted on developed markets, and were generally concluded in favor of the weak efficiency of these markets, taking into account the weak autocorrelation of their returns, and their weak transaction costs, other works in this direction were made, one can quote as reference those carried out by (Working, 1934); (Kendall, 1943), (Kendall, 1953);(Cootner, 1964)(Fama, 1965) which dealt with the equity markets in Australia, Europe and the United States, and which showed that prices in these markets followed a random walk.

All the above studies support the idea that successive changes in asset prices in developped markets are random and do not depend on historical variations.

(Malkiel, 2003), (Jensen, 1978), (French & Roll, 1986) In the past few years, research has confirmed the efficiency of stock, bond, options and commodity markets in developed countries such as the United States, Europe and Australia.

Over the years, several research studies have confirmed the hypothesis of the efficiency of financial markets, making it a paradigm of modern finance.

It should be noted that despite the large amount of research confirming this hypothesis, it is not always the subject of unanimous conclusions, and it has been criticized by a new current in the scientific community, the behaviorists such as (Grossman and Stiglitz, 1980), (Case & Shiller, 1989), (Lo & MacKinlay, 2014) believe that the efficient market hypothesis has no solid foundation, (Vuillemey, 2013) In fact, the efficiency hypothesis has been criticized epistemologically as a research program rather than a hypothesis in itself for several reasons, including the problems of the joint hypothesis and the diversity of valuation models and the very 'general' definition of the notion of 'relevant information' as well as the subjectivity of its judgment.

• ***Efficiency tests in the Moroccan market:***

Less numerous than those conducted in developed markets, some research has been interested in testing the informational efficiency hypothesis in the Moroccan market;

(Omran & Farrar, 2006) They examined the markets of Egypt, Jordan, Morocco, Turkey and Israel using the main stock market indices. They used weekly data from January 1996 to April 2000, the results rejected the random walk hypothesis for all markets, except for the stock market index of Israel (TA100), which seems to follow a random walk.

(Mlambo, Chipo and Biekpe, 2010) studied weak efficiency in ten African markets (Kenya, Egypt, Zimbabwe, Morocco, Tunisia, Mauritius, Namibia, Ghana, Botswana and Cote d'Ivoire) over a time horizon of 6 years and found weak inefficiency in all markets except Namibia, Kenya and Zimbabwe.

(Kupukile & Mlambo, 2011) (Kupukile & Mlambo, 2011) studied the efficiency of four African markets (South Africa, Egypt, Morocco and Tunisia). Again, efficiency in the weak sense was rejected in the markets studied, with the exception of the South African market.

(Bakir, 2002) who also showed that the profitability of the MASI was predictable and deviated from the normal distribution, using a range of tests for normality and autocorrelation.

(Chiny Faycal, 2015) analyzed the weak form of the efficiency of the Moroccan stock market, through the tests of autocorrelation, the variance ratio test and the non-parametric test of runs. It concluded the formal rejection of the hypothesis of efficiency on the Moroccan stock market, the same conclusion was confirmed by the work of (Moudine, Chourouk and El Khattab, 2016) .

(Maa, 2020) demonstrated the predictability of the Masi index of the Moroccan market, through ARIMA modelling, and consequently rejected the hypothesis of efficiency of the Moroccan financial market, confirming the above-mentioned conclusions.

More recent work on the Moroccan is conducted by (Inayat & Najab, 2020) The authors explain that this is due to organisational imperfections and the high cost of transactions in the market, which is aggravated by the tax burden, (Falloul, 2020) The paper rejects the hypothesis of efficiency of the Moroccan market, through the modelling of the Masi index by an ARIMA process showing that it presents a long memory, its work was refined by tests of autocorrelation, unit root test of Dickey Fuller and the test of Philips perron.

In the light of the above literature, we can formulate the present hypotheses of our research:

$\boldsymbol{H_0}$: The Moroccan market is efficient in a weak sense.

Against the alternative hypothesis:

$\boldsymbol{H_1}$: The Moroccan market is not efficient in the weak sense.

2. Research methodology:

We will try to test the hypothesis of efficiency in the weak sense of the Moroccan financial market through the test of the random walk of the MADEX index; the daily data are collected from the website www.investing.com and cover a period of 10 years, from 2010 to 2020; the choice of a long enough period will allow us to give more robustness to our tests and results
Before starting to develop the efficiency tests, we felt it necessary to first define what logarithmic return is, which is defined as follows:

$$R_t = \ln(p_t) - \ln(p_{t-1})$$

With :

p_t : the price at time t

p_{t-1}: the price at time t-1

Normality tests:

1.2 The coefficients of flatness and symmetry (skewness and kurtosis)

$$\mu_k = \frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^k$$

The centered moment of order k, the Skewness coefficient which measures the skewness of the statistical distribution is expressed as:

$$\beta_1^{1/2} = \frac{\mu_3}{{\mu_2}^{3/2}}$$

And the Kurtosis coefficient, which measures the kurtosis of the distribution, is expressed as:

$$\beta_2 = \frac{\mu_4}{{\mu_2}^2}$$

If the number of observations is greater than 30 (n >30) (Régis Bourbonnais, n.d; 2018) which is the case for our study:

$$\beta_1^{\frac{1}{2}} \sim N\left(0; \sqrt{\frac{6}{n}}\right) \; et \; \beta_2 \sim N\left(3; \sqrt{\frac{24}{n}}\right)$$

$$v_1 = \frac{\left|\beta_1^{\frac{1}{2}} - 0\right|}{\sqrt{\frac{6}{n}}} \; et \; v_2 = \frac{\left|\beta_2 - 3\right|}{\sqrt{\frac{24}{n}}}$$

Which will be compared to 1.96 (normal distribution value, at the 5% threshold) to test the following hypotheses:

H_0: $v_1 = 0$ (the distribution is symmetrical) $v_2 = 0$ (the flattening of the series is normal)

H_1: $v_1 \neq 0$ (the distribution is not symmetrical) and $tv_2 \neq 0$ (the flattening of the series is not normal)

H_0 Is accepted if $v_1 < 1{,}96$ et $v_2 < 1{,}96$ If not, it is rejected.

Jack Berra's test

Jack Berra's test synthesizes the previous results; indeed, if $\beta_1{}^{\frac{1}{2}}$ and β_2 obey a normal distribution, then the statistic:

$$S = \frac{n}{6}\beta_1 + \frac{n}{24}(\beta_2 - 3)^2$$

$s \sim \chi^2$ With two degrees of freedom.

The assumptions of the test are as follows:

H_0: The distribution is normal.

H_1: The distribution is not normal.

If $s > \chi^2{}_{1-\alpha}$ we reject the hypothesis of normality H_0 at the significance level α.

This test is also valid when the variance of the residuals of the model is not the same for all the observations, we speak then of heteroscedasticity which is the opposite of the case of homoscedasticity and which is observable at the level of the graph of the distributions by tails of probabilities thicker (leptokurdian distribution) than those of the normal distribution.

1.3 The autocorrelation test

The underlying idea is to see if it is possible to make a prediction with certainty about the future of prices based on past prices (Ţiţan, 2015)In order to test the weak form of financial market efficiency, the majority of empirical studies have used autocorrelation tests (Lardic Mignon, 2004) This method was first suggested by (Fama, 1965) to validate or refute the hypothesis of market efficiency in its weak form, according to (Elango & Hussein, 2008) it is one of the most reliable econometric methods of testing autocorrelations for weak market efficiency.

Markets are deemed to be efficient in the weak sense if the time series of the returns on the various assets listed on them have low autocorrelation and if the transaction costs are low enough to allow the basic conditions of the EMH to be met (Kendall & Hill, 1953)(Cootner, 1964) .

The aim is to examine the randomness of the series of returns, according to which the prices of the indices must be statistically independent and not auto-correlated. We recall that the same test was used by (FAMA & FRENCH, 1992; Lo & MacKinlay, 2014) on the American market to prove its informational efficiency in the weak sense.

From a formal point of view, the first-order autocorrelation test is expressed as:

$$P_t = \mu + \rho P_{t-1} + \varepsilon_t$$

Where:

μ: Represents the expected price change independently of the previous day's price.

ρ: The serial correlation between the price at time t and that at time t-1.

ε_t A white Gaussian noise.

1.4 The autocorrelation function

The autocorrelation function measures the serial correlation between variable k at time t and the same lagged variable at time t-k, where k is the lag, and is expressed as:

$$\rho_k = \frac{cov(y_t, y_{t-k})}{\sigma_{y_t} . \sigma_{y_{t-k}}}$$

$$\rho_k = \frac{\sum_{t=1}^{t=n-k}(y_t - \bar{y})(y_{t-k} - \bar{y})}{\sqrt{\sum_{t=1}^{t=n-k}(y_t - \bar{y})^2} . \sqrt{\sum_{t=1}^{t=n-k}(y_{t-k} - \bar{y})^2}}$$

If the number of observations is large, the sampling autocorrelation formula can be used (Régis Bourbonnais, n.d.2003) If the number of observations is large, the sampling autocorrelation formula can be used, which is more convenient, note:

$$\rho_k = \frac{\sum_{t}^{n-k}(y_t - \bar{y})(y_{t+=1} - \bar{y})}{\sum_{t=1}^{n}(y_t - y)^2} \quad k$$

With:

N: the number of observations.

$\bar{y}$: The mean of the prices

As the serial autocorrelation coefficient measures the degrees of dependence of a variable on its time lagged historical value, a ρ_k In the case of a zero autocorrelation coefficient, this means that the price change is not auto correlated, or in the opposite case that the price changes are correlated. The zero autocorrelation coefficient is a sign of validity of the efficiency hypothesis in the weak sense because it shows that past profitability does not influence future prices, or in other words that historical information is already incorporated in the price. (Fama, 1970).
Insignificant autocorrelations for all lags would indicate that markets are efficient, and that they can follow a random walk ; autocorrelation at some lag significantly different from zero will lead us to reject the hypothesis of market efficiency in the weak sense.
To test whether the serial autocorrelation is significantly different from zero at a 5% significance level, we therefore pose the following null and alternative hypotheses:

$$H_0: \rho_k = 0$$

$$H_1: \rho_k \neq 0$$

We can use the hypothesis test of the autocorrelation coefficient based on the comparison of an empirical Student's t with a theoretical t. Indeed, (Quenouille, 1949) showed that if the number of observations is greater than 30 (n>30), the correlation coefficients follow a normal distribution with zero expectation and standard deviation $\sigma = \frac{1}{\sqrt{n}}$,

$$\rho_k \sim N^{(0;\frac{1}{\sqrt{n}})}.$$

The confidence interval is then:

$$\rho_k = 0 \pm t^{\frac{\alpha}{2}}\left(\frac{1}{\sqrt{n}}\right)$$

If ρ_k is outside the confidence interval, it is therefore considered significantly different from zero at the α.

Box-Pierce and Ljung-Box

Recall that this function is calculated for each lag k, since it would be difficult or even impossible to calculate the ρ_k for any lag k, we propose to perform the Junk box test which allows to test all the autocorrelations up to a certain lag by a single statistic noted Q_{LB}.

The Box-Pierce test allows us to identify temporal processes without memories (i.e., a set of random variables that are independent of each other), to do this, we must check whether the $coeficients\ de\ correlations\ entre\ (y_t, y_{t-k})$are zero or that $\rho_k = 0\ \forall t\ et\ \forall k$.

A white noise process involves:

$$\rho_1 = \rho_2 = \cdots = \rho_h = 0$$

To test this, either the assumptions:

$H_0 : \rho_1 = \rho_2 = \cdots = \rho_m = 0$

$H_1 : \exists\ \rho_i \neq 0$ with $1 < i < m$

The box-Pierce statistic is expressed as :

$$Q = n \sum_{k=1}^{k=h} \widehat{\rho_k}^2$$

h = number of delays,

ρ_k = Empirical autocorrelation of order k

n = the number of observations.

The Q statistic is used to judge whether or not there is significant autocorrelation up to k lags, it is asymptotically distributed as a χ^2 (chi-square) with h degrees of freedom.

The hypothesis is therefore accepted at the threshold α if Q < χ^2 tabulated at the threshold $1 - \alpha$ and h degrees of freedom and rejected otherwise.

It is also possible to use another statistic Q' which is derived from the first one (Q) , but which has better asymptotic properties called the Ljung-box Q developed in 1978 and noted :

$$Q^{'} = n(n+2)\sum_{k=1}^{h}\frac{\widehat{\rho_k}^2}{n-k}$$

It is also distributed according to a χ^2 with h degrees of freedom.

The decision rules are identical to the previous ones, it is then a matter of accepting H_0 at the threshold α if Q < χ^2 tabulated at the threshold $1-\alpha$ and h degrees of freedom and reject it otherwise, these tests are called (catch-all) or the (portmanteau) test.

The runs test (Bradley 1968):

The runs test also called sequence test or Geary test is a non-parametric test to check if a series is random or not, this test is able to check the independence in the price movement (Elhami & Hefnaoui, 2018) It is a stronger test than its predecessors because it is not dependent on the normality of the series.

By definition, a run is a series of elements with the same sign preceded and followed by an opposite sign, so it is a sequence of price changes with the same sign:

H_0:the prices follow a random walk and are therefore independent.

H_1:the series is not random.

$$E(R) = \frac{2N_1N_2}{N} + 1$$

$$V(R) = \frac{2N_1N_2(2N_1N_2 - N)}{N^2(N-1)}$$

Where:

N = total number of observations

N1 = number of '+' values

N2 = number of '-' values

R = number of runs

Next, we define the Z-statistic to test the significance of the difference between the observed number of runs in the series and the expected number calculated as follows:

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

If $|Z|$>1.96 (normal distribution value for 5% risk) H0 is rejected (Sharma & Kennedy, 1977).

3. Results and discussion:

As mentioned above, in order to carry out our statistical tests, we have a database containing the historical evolution of the closing price of the main index of the Casablanca Stock Exchange, which is the floating MADEX index, collected from the website: www.investing.com. We aim in this paper to test the hypothesis of informational efficiency of the financial market in its weak form.

The data have a daily frequency and cover the period from 01/01/2010 to 01/01/2020, i.e. 10 years of data, the closing prices allowed us to constitute the daily logarithmic return series as follows

$$R_T = \ln\left(\frac{P_t}{P_{t-1}}\right)$$

1.4.1 Descriptive statistics and normality tests

Date: 11/06/21 Time: 10:47
Sample: 1 2490

	MADEX
Mean	3.04E-05
Median	2.37E-05
Maximum	0.014571
Minimum	-0.013332
Std. Dev.	0.002689
Skewness	0.265913
Kurtosis	5.924635
Jarque-Bera	916.7693
Probability	0.000000
Sum	0.075671
Sum Sq. Dev.	0.018001
Observations	2490

Table 1: developed by us via EVIEWS

Table 1 presents the results of the descriptive statistical analysis of the logarithmic returns of the daily index of the MADEX index, we first notice that the daily returns of the index have a positive average, the maximum logarithmic return being 0.0145 and the minimum was -0.01332 with a low standard deviation of 0.0026.

The skewness and kurtosis coefficients differ from those of a normal distribution, which are respectively 0 and 3. Indeed, the kurtosis coefficient for our series is positive and high, which shows that the statistical distribution of MADEX returns is leptokurtic, i.e. the empirical distribution has thicker kurtosis than the normal distribution.

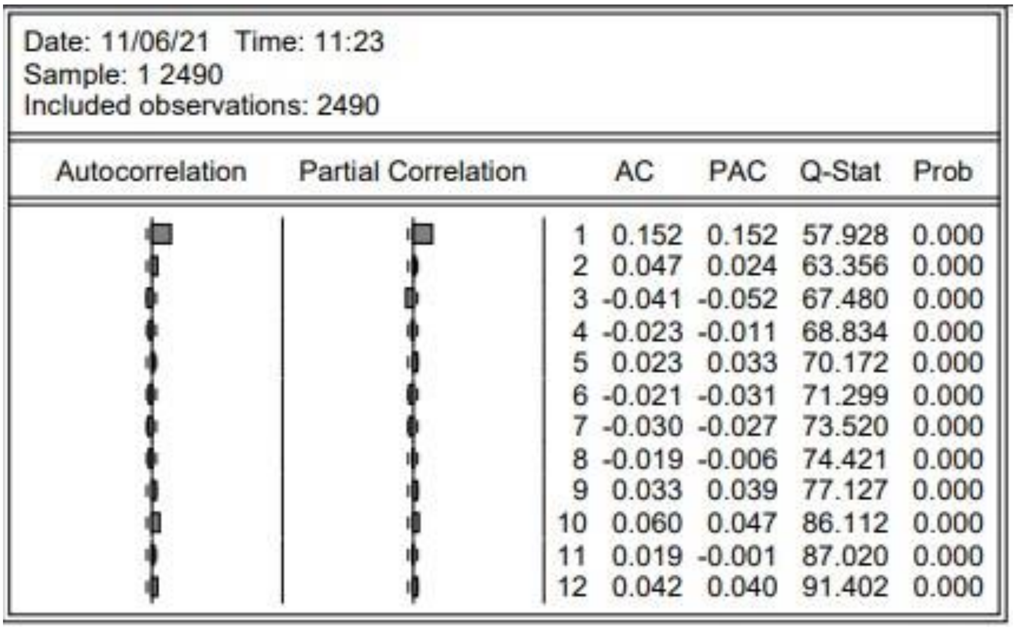
The positive skewness coefficient shows that the distribution contains more above than below average returns.

Contrary to what financial theory assumes about the normality of returns, the Berra normality test rejects the null hypothesis that the logarithmic return is normally distributed.

1.5 Autocorrelation tests

In order to analyze the weak market efficiency, we propose to analyze the serial autocorrelations of the index profitability series up to the 10th time lag (1-10th order).

If the market is efficient in the weak sense, we should obtain autocorrelation coefficients that are zero or significantly close to zero. The treatment of the series on EVIEWS through the LJung-box test gives the following results:



Date: 11/06/21 Time: 11:23
Sample: 1 2490
Included observations: 2490

	AC	PAC	Q-Stat	Prob
1	0.152	0.152	57.928	0.000
2	0.047	0.024	63.356	0.000
3	-0.041	-0.052	67.480	0.000
4	-0.023	-0.011	68.834	0.000
5	0.023	0.033	70.172	0.000
6	-0.021	-0.031	71.299	0.000
7	-0.030	-0.027	73.520	0.000
8	-0.019	-0.006	74.421	0.000
9	0.033	0.039	77.127	0.000
10	0.060	0.047	86.112	0.000
11	0.019	-0.001	87.020	0.000
12	0.042	0.040	91.402	0.000

Figure 2 Correlogram of the MADEX index (EVIEWS)

This finding is not validated on the Moroccan market since the first-order auto-correlation, as shown in Table 2, is higher than 15% for MADEX, and the first autocorrelation coefficient with the first lag is significantly high, while the other autocorrelation coefficients become low beyond the second order.

This positive first-order autocorrelation indicates that there is a significantly positive relationship between today's return and yesterday's return, which is incompatible with the weak efficiency hypothesis that assumes that returns should be uncorrelated.

In order to avoid relying only on the correlogram and the autocorrelation coefficients to reject the hypothesis, we use the Ljung-box test which allows us to take into consideration different lags. The test confirms the previous findings, it rejects the nullity hypothesis of the different correlation coefficients and thus systematically rejects the hypothesis of a random walk of the daily index return.

The profitability series do not form a white noise process and we can therefore reject the hypothesis of low efficiency at the 5% significance level (P value <5%).

This being said, we can conclude that the hypothesis of weak efficiency will be rejected on the Moroccan market given the presence of significant serial autocorrelations in the daily returns of the MADEX index.

1.6 Runs Test

To confirm the above results, we also proposed to use a non-parametric test which is the runs test to test the following hypotheses:

H_0 : MADEX is a random walk

H_1 : MADEX is not a random walk

	MADEX LOGARITHMIC RETURNS
Test value	0
Total number of observations	2490
Number of suites	1192
Z	-2,159
Sig. Asymptotic (bilateral)	0,031

Table 3: MADEX sequence test developed by ourselves via SPSS.

We can see from Table 3 that the number of sequences greater than /inferior to zero is 1192, the calculated statistic is greater than 1.96 (normal law value for 5% risk). $|Z|$ We can thus once again reject the null hypothesis which assumes that MADEX is a random walk and therefore conclude that the Moroccan market is not efficient in the weak sense.

Conclusion:

The paper seeks to empirically verify the hypothesis of informational efficiency in the weak sense of the Moroccan stock market, through the empirical analysis of the daily time series of the logarithmic returns of the main index of the Casablanca Stock Exchange, the MADEX.

To do so, we started with a literature review, presented the different theoretical approaches to the hypothesis, and then used a battery of parametric and non-parametric tests to empirically verify the hypothesis in question in the Moroccan market.

We've applied normality tests, the Berra jack test, autocorrelation tests and the Ljung box test as well as the non-parametric runs test, all of which were concluded in favor of the informational inefficiency of the Casablanca stock market.

The results found are therefore consistent with the work of (Mouallim & Chraibi, 2020) (Bera et al., 2019; Chiny Faycal, 2015) who found the Moroccan market to be inefficient, as well as the work of Bakir, 2002; Elhami & Hefnaoui, 2018 who assume that markets in emerging countries are generally inefficient.

As a conclusion, we can say that the prices of stocks on the Moroccan markets do not follow the random walk model as assumed by the theory of informational efficiency, and therefore allow us to reject the hypothesis of low informational efficiency on this market.

We can formulate several hypotheses on the reasons likely to explain this inefficiency, in particular the youth of the Moroccan stock market, the inefficiency of the control bodies, the asymmetry of information, and the importance of transaction costs weighed down by the tax burden that burdens the potential earnings of market operators as underlined by (Moudine, Chourouk and El Khattab, 2016).

The informational inefficiency of the market may be one of the causes of its lack of attractiveness and a brake on its development, as Morocco relies on the development of its economy through a modern and developed financial market the competent authorities should act to address this dilemma.

Bibliography

1. BACHELIER, L. (1900). Theory of speculation Annales. *Annales Scientifiques de l'É.N.S. 3e Série, Tome 17*, *17*, 21-86. ○ Bakir, K. (2002). *The efficiency of financial markets in emerging countries: the example of the Casablanca Stock Exchange*. *10*(2), 1-21.
2. Beaver, W. H. (2014). Market Efficiency. *Encyclopedia of World Poverty*, *56*(1), 23-37. https://doi.org/10.4135/9781412939607.n436
3. Bera, J., Smirnov, K., & Kpss, T. (2019). *TESTING HYPOTHESES OF THE INFORMATION EFFICIENCY OF THE MOROCCAN STOCK MARKET:*

4. *APPLICATION TO MADEX SECURITIES By Khalid ABOUAHMED Gestion & Socié*. *January 2013*, 1-14.
5. Case, K. E., & Shiller, R. J. (1989). The efficiency of the market for single-family homes. *American Economic Review*, *79*(1), 125-137.
6. Chiny Faycal, M. A. (2015). Testing the Efficiency of the Moroccan Financial Market. *Global Journal of Management And Business*, *15*(2). ○ Cootner, P. H. (1964). Cootner-1964.Pdf. In *Industrial Management Review* (pp. 231252). ○ Cowles, A. (1933). Can Stock Market Forecasters Forecast? *Econometrica*, *1*(3), 309. https://doi.org/10.2307/1907042
7. Dani, S. A. I. T., Dani, S. A. I. T., & Radi, B. (2016). The financial market efficiency controversy and the emergence of the behavioral paradigm. *Moroccan Journal of Business Studies*, *1*(1), 149-176. ○ Elango, R., & Hussein, M. (2008). An empirical analysis on the weak-form efficiency of the GCC markets applying selected statistical tests. *International Review of Business*
8. *Research* .... http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1026569 ○ Elhami, M., & Hefnaoui, A. (2018). Market Efficiency in MENA Emerging and Frontier
9. Markets. *Finance and Finance International*, *10*, 1-18. https://doi.org/10.12816/0045344 ○ Falloul, E. M. (2020). Test of Weak Efficiency on Casablanca Stock Market, Chaotic
10. Dynamic and Long Memory. *Global Journal of Management and Business Research*,
11. *20*(3), 27-41. https://doi.org/10.34257/gjmbrbvol20is3pg27 ○ Fama, E. F. (1965). Random Walks in Stock Market Prices. *Financial Analysts Journal*,
12. *51*(1), 75-80. https://doi.org/10.2469/faj.v51.n1.1861 ○ Fama, E. F. (1970). Session Topic: Stock Market Price Behavior Session Chairman:
13. Burton G. Malkiel Efficient Capital Markets: A Review Of Theory And Empirical Work. *The Journal of Finance*, *25*(2), 383-417. ○ Fama, E. F. (1995). Random Walks in Stock Market Prices. *Financial Analysts Journal*,
14. *51*(1), 75-80. https://doi.org/10.2469/faj.v51.n1.1861 ○ FAMA, E. F., & FRENCH, K. R. (1992). The Cross-Section of Expected Stock Returns. *The Journal of Finance*, *47*(2), 427-465. https://doi.org/10.1111/j.1540-
15. 6261.1992.tb04398.x ○ French, K. R. (1980). Reruans and the Weekend EffectE. *Journal of Financial Economics*, *8*, 55-69. ○ French, K. R., & Roll, R. (1986). Stock return variances. *Journal of Financial Economics*,
16. *17*(1), 5-26. https://doi.org/10.1016/0304-405x(86)90004-8 ○ Gibbons, M. R., & Hess, P. (1981). Day of the Week Effects and Asset Returns. *The Journal of Business*, *54*(4), 579. https://doi.org/10.1086/296147 ○ Harrab, S. (2017). *Can we still talk about the financial markets efficiency? Can we still talk about the financial markets efficiency ?* 382-401. ○ Inayat, & Najab, A. (2020). *Organizational structure and informational efficiency: the case of the Moroccan stock market*. *4*, 316-331. ○ Kupukile, M. B. E. and F. G. and, & Mlambo. (2011). [WIP] Mp r a. *Economic Policy*, *2116*, 0-33.
17. Lardic Mignon, S. (2004). *The informational efficiency of markets*. ○ Lo, A. W., & MacKinlay, A. C. (2014). 2. Stock Market Prices Do Not Follow Random
18. Walks: Evidence from a Simple Specification Test. *A Non-Random Walk Down Wall*
19. *Street*, *1*(1), 17-46. https://doi.org/10.1515/9781400829095.17 ○ Maa, F. (2020). *Business Intelligence and Financial Market Efficiency: 1*(2), 72-85.
20. Malkiel, B. G. (2003). *Critics*. *17*(1), 59-82. ○ Mlambo, Chipo and Biekpe, N. (2010). *Munich Personal RePEc Archive The efficient market hypothesis: Evidence from ten African stock markets The efficient market hypothesis: Evidence from ten African stock markets*. *25968*.
21. Mouallim, I., & Chraibi, A. (2020). Testing the informational efficiency of the Moroccan stock market. *Revue Internationale Des Sciences de l'Organisation*, *N°8*(1), 111. https://doi.org/10.3917/riso.008.0111
22. Moudine, Chourouk and El Khattab, Y. (2016). *Munich Personal RePEc Archive Testing the informational efficiency of the moroccan stock market*. *70169*.

23. Omran, M., & Farrar, S. V. (2006). Tests of weak form efficiency in the Middle East emerging markets. *Studies in Economics and Finance*, *23*(1), 13-26. https://doi.org/10.1108/10867370610661927
24. Orléan, A. (2004). Efficiency, behavioural finance and convention: a theoretical synthesis.
25. *Les Crises Financieres: Conseil d'analyse Economique*, 241-270.
26. Régis Bourbonnais, M. T. (n.d.). *Time series analysis*.
27. Ross, S. A. (2005). Neoclassical Finance (Princeton Lectures in Finance). In *Journal of Chemical Information and Modeling* (Vol. 53, Issue 9). ○ Samuelson A. Paul. (1965). Rational Theory of Warrant Pricing , Industrial Management Review, 6:2 (1965:Spring) p.13. *Management*, *2*. ○ Ţiţan, A. G. (2015). The Efficient Market Hypothesis: Review of Specialized Literature and Empirical Research. *Procedia Economics and Finance*, *32*(15), 442-449.
28. https://doi.org/10.1016/s2212-5671(15)01416-1
29. Tobin, J., Studies, F. I.-B. of J. monetary and economic, & 1985, U. (1985). Deregulation in Perspective". In *Imes.Boj.or.Jp.*
30. Vuillemey, G. (2013). *On the epistemological status of the efficient market hypothesis*.