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RESEARCH ARTICLE

EFFICIENCY OF THE MOROCCAN STOCK MARKET: IDENTIFICATION OF RATIONAL BUBBLE THROUGH A NON-PARAMETRIC APPROACH

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ABSTRACT

The information efficiency of the financial markets is the foundation of modern finance. However, each bubble that forms and takes the time to develop before bursting, thus generating a financial crisis, comes to challenge the hypotheses that constitute this theory. The purpose of this work is to test the main index of the Moroccan stock market, Moroccan All Shares Index (MASI), in order to verify the efficiency hypothesis by examining whether bubbles can be detected. While the unit root tests highlighted mitigated conclusions about the random market model, cointegration tests rejected the hypothesis of a long-term relationship between prices and dividends. The results of the Generalized Sup Augmented Dickey-fuller (GSADF) test applied to the MASI enabled the detection of a bubble. Also, the dating strategy delimits it over a period going from the end of 2006 to the beginning of 2008. Thus, the hypothesis of informational efficiency in the case of Moroccan stock market cannot be accepted.

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INTRODUCTION

In 1990, L. Bachelier introduced the notion of fundamental value and established that the market, at a given moment, does not believe in the rise or the fall (risk neutrality) because there are as many buyers as there are sellers for a quoted price. He assumed that the mechanism of the financial markets is conditioned by the theory of the zero-sum fair game where the price variations follow a process without memory and accordingly, the best forecast of the price of tomorrow becomes the price of today. Starting from Euler's equation, Bachelier proposed the random model to explain the price dynamics:

$$\mathrm{P_t} = \omega(\mathrm{P_{t+1}} + \mathrm{D_{t+1}}) \quad (1)$$

where $\omega = \frac{1}{1+y}$ with y is the discount rate, $\mathrm{P_t}$ is the price of the asset and $\mathrm{D_{t+1}}$ the cash-flow. The model implies two hypotheses, the white noise of the perceived cash flow and the constancy of the discount rate:

$$\mathrm{d_{t+1}} = d_t + \varepsilon_{t+1} \quad (2)$$

where the ε_t are iid with a nonzero mean $\mathrm{E}(\varepsilon_t) = g$, that is $\varepsilon_t = g + \eta_t$ where the η_t areiid and $\mathrm{E}(\eta_t) = 0$. From these two restrictions, we can derive the random walk model as follows:

$$p_t = p_0 + gt + \sigma W_t \quad (3)$$

where W_t is a standard Brownian process, with $W_0 = 0$, $E(W_1) = 0$ and $E(W_1^2) = 1$. Since a price probability distribution is assumed to be stationary, price history becomes the best source of information for estimating future returns.

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Bachelier model had been extended by P. Samuelson (1965) and the relationship between price and information is highlighted through E. Fama's (1970) theory of informational efficiency of financial markets in its three forms (weak, semi-strong and strong). According to him, investors form rational expectations (maximizing their marginal utility) and the prices of assets, at any given moment, incorporate all the economic and financial information (public and private). There are no speculative bubbles, any gap between the price and its fundamental value can only be a white noise with expectation of achievement equal to zero, since the interference of ignorant or uninformed operators is systematically countered by the force of informed arbitrageurs. The formula (1) may be generalized by using the property of the iterated expectation:

$$P_t = \sum_{i=1}^{n} \frac{E_t(D_{t+i})}{(1+y)^i} + \frac{E_t(P_{t+n})}{(1+y)^n} \quad (4)$$

Since an asset is supposed to be held perpetually, the time horizon will tend to infinity and therefore, the conditional expectation will converge to zero, $\lim_{n\to\infty} \frac{E_t(P_{t+n})}{(1+y)^n} = 0$ (transversality condition). The Euler equation becomes:

$$P_t = P_t^f = \sum_{i=1}^{\infty} \omega^i E_t(D_{t+i}) \quad (5)$$

with P_t^f the fundamental value of the asset. This formula implies that the expected return is simply equal to the discount rate assumed constant. However, history shows that bubbles appear, persist over time before exploding, causing financial crises with direct consequences for the real economy, which challenges the theory of efficiency. Fisher (1932), Keynes, (1936) and Kindleberger (1978) raised the point that the dynamics of bubbles have their origin in the dynamic of the real economy and would, therefore, be rational. Thanks to the work of Blanchard and al. (1982), the mathematical framework was set up to describe this rational dynamics:

$$P_t = P_t^f + B_t = \sum_{i=1}^{\infty} \omega^i E_t(D_{t+i}) + B_t \quad (6)$$

Where B_t is a bubble. Determining expectation at time *t*:

$$E_t P_{t+1} = E_t[\omega E_{t+1} D_{t+2} + \omega^2 E_{t+1} D_{t+3} + \cdots + B_{t+1}] \quad (7)$$

using the property of iterative expectations:

$$E_t P_{t+1} = [\omega E_t D_{t+2} + \omega^2 E_t D_{t+3} + \cdots + E_t B_{t+1}] \quad (8)$$

If the right term of formula (8) is replaced by the fundamental value P_t^f in (6):

$$\omega(E_t D_{t+1} + E_t P_{t+1}) = \omega E_t D_{t+1} + [\omega^2 E_t D_{t+2} + \omega^3 E_t D_{t+3} + \cdots + \omega E_t B_{t+1}] \quad (9)$$

thus:

$$\omega(E_t D_{t+1} + E_t P_{t+1}) = P_t^f + \omega E_t B_{t+1} = P_t \quad (10)$$

The formulas (6) and (11) cannot be both solutions of the evaluation equation. They can be equivalent only if the bubble follows a martingale process:

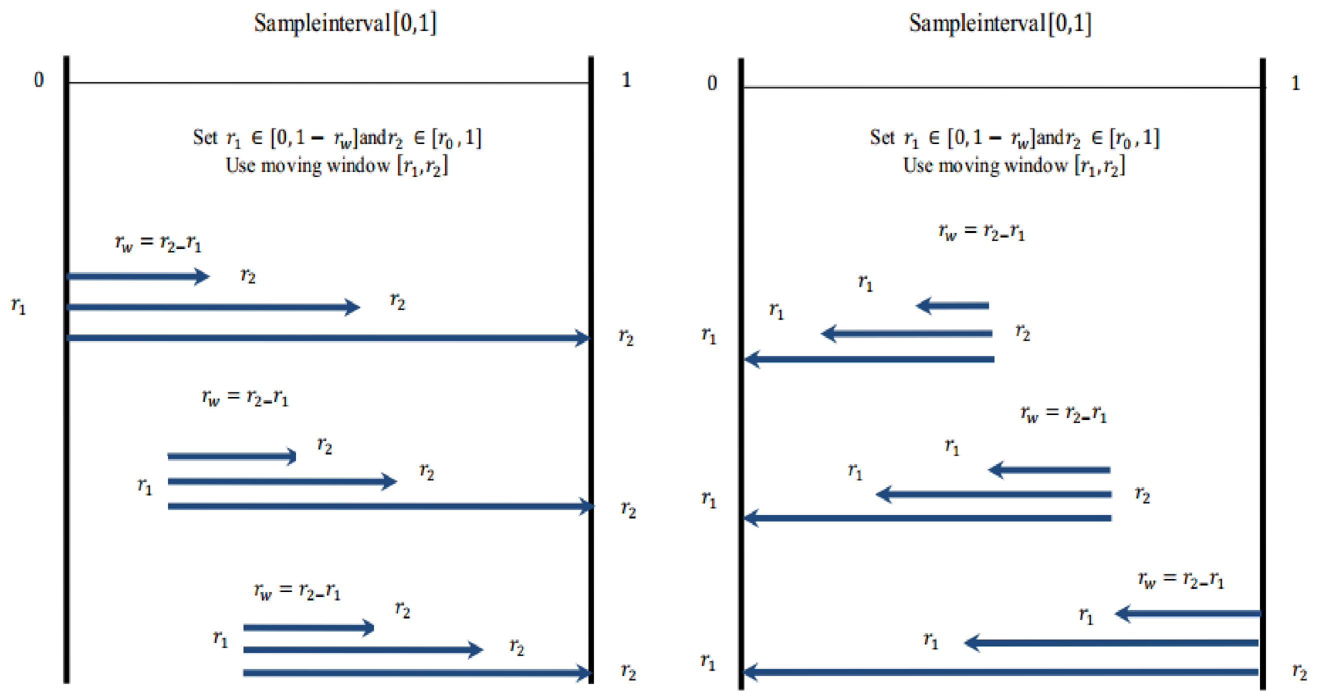
$$E_t B_{t+1} = \frac{B_t}{\omega} = (1+y) B_t \quad (11)$$

Considering the rational bubble is anticipated and increases at the rate y, the investors are ready to pay for the bubble at the expense of the fundamental value in such manner that price can grow continuously since (1+y)>1.B_t is deterministic and strictly positive, it can deflate but never burst. The purpose of this article is to test the efficiency of the Moroccan stock market and track down bubbles, if they exist, by studying the stochastic properties of price dynamics.

MATERIALS AND METHODS

Diba and Grossman (1988a, 1988b) adopted the approach based on the investigation of the stationarity properties of prices and dividends to detect the presence of bubbles, which generally introduce an explosive element in the price series, not necessarily present in dividends. Indeed, the rational bubble is the difference between P_t and P_t^f and thus, if it exists, it will be impossible to stationarize the price series by differentiation. On the other hand, the absence of bubbles implies that prices and dividends must be cointegrated, as stated by Campbell and Shiller (1987). Moreover, Engle et Granger (1987) considered that if two variables follow a random walk ($I(1)$) and are cointegrated, so there is a linear combination of these variables which is stationary ($I(0)$).In their work, Diba and Grossman (1988a, 1988b) opted for unit root tests to check first the stationarity of the price and dividend series and then, by using cointegration tests, verify if there is a long-term relationship between these variables. For its part, Evans (1991) highlighted that the unit root and cointegration tests can be biased in front of periodically collapsing rational bubbles, in contrast to Blanchard bubble which is growing continuously.

To eliminate this risk, a new generation of more robust unit root tests can be used. Phillips and al. (2009), based on repeated execution of the regression of the Augmented Dickey-Fuller test on small samples from the series of observations, which has been broken down into small windows sequentially, established a new test strategy, Sup ADF (SADF). The test is performed recursively while extending the window previously used each time. The regression sample begins with a first fraction r_1 and ends with r_2, such that $r_2 = r_1 + r_w$, where r_w is the fragment of the sample containing the observations used in the regression. The size of the window r_w extends from r_0 to 1, where r_0 is the smallest window of the selected sample so as to optimize the estimation, and 1 is the largest window of the sample that includes all observations. The start point$r_1$of the sample sequence being set to 0, therefore the end point of each sample r_2 must be equal to r_w. Phillips and al. (2012, 2015) introduced the GSADF test, a generalization of the SADF procedure, which makes it possible to identify explosive behaviors in sequences larger than those deployed by SADF and to date them. Indeed, besides the extension of the window $r_w$and the variation of the end point of the regression r_2 from r_0 to 1, the GSADF test also allows mobility of the starting point r_1 in a range from 0 to $1 - r_w$. The regression then begins with the first observation when $r_1 = 0$, and when $r_1 = 1 - r_w$, so the sample regressed covers the last observation. The dating strategy involves comparing the statistic GSADF recursive (BGSADF) with the critical values of GSADF, which allows defining the beginning and the end of the explosive behaviors.



Source: Phillips and al. (2012, 2015)

Figure 1. GSADF test

In this work, the unit root tests that will be used are Augmented Dickey-Fuller (ADF), Phillips and Perron (PP) and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS), and for cointegration, Engel and Granger and Johansen tests. To detect the presence of bubbles, GSADF test will be conducted and if bubbles exist, their dating will be done thanks to the BGSADF. The investigations will extend over a period ranging from 1/01/1995 to 12/30/2012, taking into account 940 weekly observations. By using the Eviews 10 software, tests are carried out on log MASI (LM), logdividend (LD), Δ log Masi $(\Delta(LM))$ and Δ log dividende $(\Delta(LD))$ series, under the efficiency assumptions:

H_1: Investors are rational
H_2: Investors are risk neutral
H_3: The discount rate is constant
H_4: All information is available

RESULTS

At the 5% confidence level, the ADF test for Masi and dividend logarithms, illustrated in table 1, displays statistics that are below the critical value -3.41 with respective probabilities of 0,9488 and 0,5853. The null hypothesis of the existence of a unit root is therefore accepted; the two processes are then, non-stationary in level. On the other hand, in primary differences, the series are stationary, with a zero probability of realization of H0. Thus, given that the orders for integrating the prices of the shares and their dividends are identical and of order 1 $((LM) \sim I(1), (LD) \sim I(1))$ and their primary differences are of order $0(\Delta(LM) \sim I(0), (\Delta(LD) \sim I(0))$, the results of the ADF test favor the acceptance of the random walk model in accordance with the fundamental theory where $P_t = P_t^f$. The results of the PP test agree with those of ADF, their statistics being higher than the critical value -3.41. Their probabilities are greater than the confidence threshold of 5% which validates the existence of a unit root in the two series. Their primary differences, on the other hand, are stationary.

Table 1. Unit root tests: ADF, PP and KPSS

Series	ADF*		PP*		KPSS**	
	t-statistic	Probability	$t_{\hat{\emptyset}}^{*}$-statistic	Probability	LM-statistic	Critical-values
LM	-0,9472	0,9488	-1,0533	0,9346	0,3192	0.1460
LD	-2,0268	0,5853	-2,7548	0,2147	0,3017	0.1460
$\Delta(\mathbf{LM})$	-7,7958	0,0000	-26,7175	0,0000	0,1705	0.1460
$\Delta(\mathbf{LD})$	-9,0260	0,0000	-28,18703	0,0000	0,0328	0.1460

MacKinnon (1996) one-sided p-values. Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1) Source: Eviews 10

Table 2. Cointegration test: Engel and Granger test

Series	z-statistic	Probability
LM	-6,0215	0,6495
LD	-8,3569	0,4699

Proba MacKinnon (1996) p-values Source: Eviews 10

Table 3. Cointegration test: Johansen test

Hypothesis	Maximum eigenvalue	Trace-statistic	Critical value at 5%	Probability
None	0,0119	13,29	15,4947	0,1045
At most	0,0022	2,0730	3,8414	0,1499

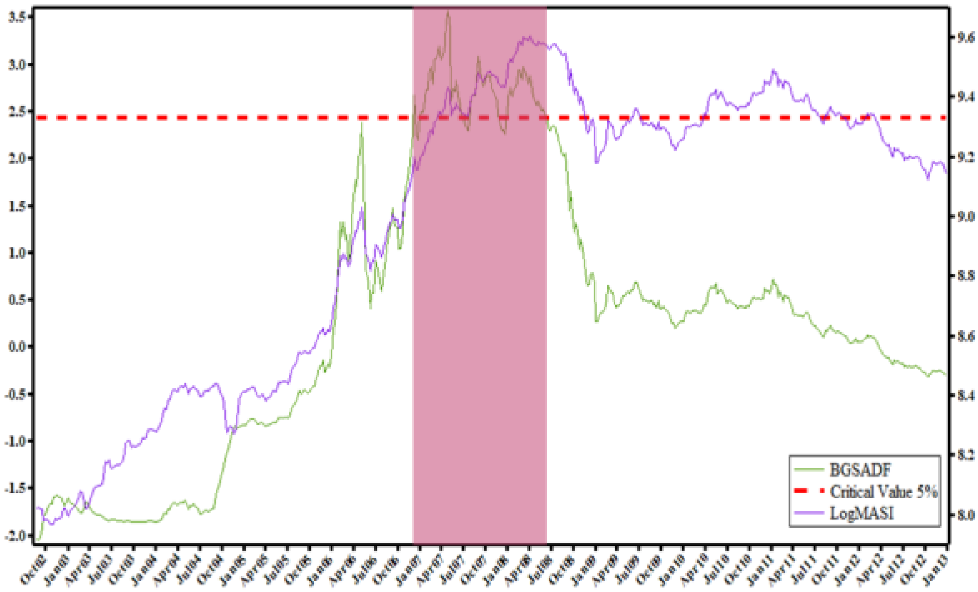
Proba MacKinnon (1996) p-values; Source: Eviews 10

The random walk hypothesis is accepted since the two variables, Masi and dividends, are integrated in the first order. However, the results of the KPSS test lead to different conclusions from the previous ones. While the dividends follow a random walk, the Masi index does not seem to do so.

Table 4.GSADF test

LogMASI	3,5675
Critical values	
90%	3,0172
95%	2,4299
99%	2,2569

The test was carried out on a sample of 938 observations with an interval $r_0 = 0{,}1$.Critical values are obtained by Monte Carlo simulation over 1000 replications
Source: Eviews 10



Source: Eviews 10

Figure 2. Dating of the bubbledetected

The LM statistics of the price logarithm and of its primary differences, being above the critical point, infer from their non-stationarity. In this sense, since $\Delta(LM)$ are not $I(0)$, the dynamic of prices cannot be a random process according to the results of KPSS test. As shown in table 2, the critical probabilities of the Engel and Ganger test are greater than 47%. Therefore, the null hypothesis that the series are not co integrated cannot be rejected.

The results of this test reveal that their residual vector is not stationary and therefore a long-term relationship between the Masi and the dividends seems to be impossible. The results of Johansen's test, displayed in table 3, supports the conclusion of the Engel and Ganger test. The hypothesis of cointegration between the series is rejected at the 5% threshold. Both tests conclude that there are no long-term relationships between the series. Since the Masi prices and dividends are not cointegrated, the Moroccan market efficiency hypothesis is not supported. The application of the GSADF test on the Masi series shows an explosive behavior in the movement of the MASI. Indeed, the GSADF statistics, as shown in table 4, being higher than the critical values at the thresholds of 1%, 5% and 10%, the hypothesis of the presence of a bubble component, which is involved in the formation of prices, cannot be rejected. Using the dating strategy of Phillips *et al.*, the times of the start and end of the exuberance have been defined by comparing the BGSADF statistic with the critical value at 5%. As illustrated in figure 2, the bubble appeared at the end of the last quarter of 2006 and persisted for more than six quarters before exploding at the end of the second quarter of 2008.

DISCUSSION, LIMITS AND CONCLUSION

While the ADF and PP unit root tests stipulate that the dynamics of the MASI follow a random walk, the KPSS test, for its part, shows that this series is not integrated into first order. For their part, cointegration tests demonstrate that there is no long-term equilibrium relationship between the MASI and its dividend and therefore, the hypothesis of the efficiency of the Moroccan stock market can be discussed. These results support the work of YE Khattab and C. Moudine (2014) and F. Chiny and A. MIR (2015) on the informationalefficiency of this same market and who noted the existence of pockets of inefficiency in the formation of the MASI index. The observations of Khattab and Mourdine of the trend of the MASI over the period 2006 - 2007 and of its Price Earning Ratio highlighted an overvaluation of the Moroccan market with a sustained growth of 278%, which stopped from the second quarter of 2008. Thanks to the GSADF test strategy, we can confirm that, in this same period, from the end of 2006, a bubble has formed in the Moroccan stock market and has continued to develop for more than a year before deflating and triggering a general market decline. This dating also coincides with that of the subprime crisis started in the USA, which had serious repercussions on the economy of several countries. At this stage, this work can confirm the existence of a bubble but does not explain how it formed or burst. On another side, the assumption that the financial markets are governed by efficiency in the sense of Fama cannot explain the appearance of this bubble. In fact, prices follow a random walk but not always, gaps may be formed between the fundamental value and the market price, which the arbitrageurs cannot eliminate. Regarding the bubble detected in the Moroccan market, its origin could be linked to several endogenous or exogenous factors and this is the reason why new areas of research on the price movement can be opened. This can be done through a study of the Moroccan stock market based on parametric tests or by looking at new theories of the financial markets, in particular behavioral finance.

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