

# Contribution of the Cointegration Theory to the Study of the Volatility of Financial Markets: Case of the Casablanca Stock Exchange

**Nabil Sifouh**

FSJES Souissi, Mohammed V University, Rabat

**Khadija Oubal**

Research professor, FSJES Souissi, Mohammed V University, Rabat

**Sara Bayoud**

FSJES Souissi, Mohammed V University, Rabat

## Abstract

The purpose of this paper is to highlight the long-term relationship between stock prices and dividends for a sample of companies listed on the Casablanca Stock Exchange between 2002 and 2016 using the cointegration theory especially its developments in panel data. Our results show that prices are more volatile than dividends, which rejects the possibility of their anticipation by the dividend discount model under the assumption of efficient markets.

**Keywords:** cointegration, prices, dividends, panel data, volatility

## 1. Introduction

The notion of volatility is a reality characterizing the world of financial markets. However, since the beginning of the 1980s, real price movements far exceeded those of firm fundamentals, particularly dividends. This phenomenon has been demonstrated for the first time by Shiller (1981) and LeRoy and Porter (1981) when there have been sharp price deviations from rationally anticipated prices by the future dividend discount model under assumption of informational efficiency of financial markets (Efficient Market Hypothesis EMH). The first test of excessive volatility by Shiller (1981) is based on rather restrictive assumptions, which explains the limits of the first tests of excessive volatility. The first criticisms are econometric and concern in particular the non-stationarity of dividends and prices. The first tests are based on analysis of variance; this has certain limits insofar as the variance is not constant and does not reflect that of the population (Arbulu and Fontaine, 1998). Another fundamental criticism is that the anticipated prices are determined by discounting future dividends to infinity, and knowing the series of future dividends with certainty seems impossible,

this increases the probability of the error in estimating ex post rational price (Flavin, 1983). Given the limits of the first tests of volatility, the development of statistical tools based on the concept of cointegration will allow a considerable methodological advance to test the volatility of stock prices and in particular the deviations of the latter from the fundamentals.

Cointegration tests seek a long-term relationship between two or more variables, knowing that deviations are sometimes occasional seasonal or cyclical events (Lilti, 1994). The development of methods based on cointegration tests allowed, initially, the response to the criticisms of traditional volatility tests. And secondly, the identification of sustainable gaps between prices and fundamentals that correspond to what it is commonly called "speculative bubbles". In the context of tests related to the study of long-term relationships between time series, cointegration tests have developed considerably since the 1990s, when the cross-section dimension was added to the series studied. Indeed, since the work of Levin and Lin (1992), a particular interest is brought to the study of non-stationary panel data. According to Hurlin and Mignon (2006), cointegration and unit root tests in panel data are more powerful than their counterparts in time series without cross-section dimension.

The purpose of this paper is to test the volatility of the Moroccan stock market through the use of cointegration techniques in panel data in order to analyze the long-term relationship between stock prices and dividends. This work allows us to study the price-dividend relationship in order to check whether the dividend discount model is valid to anticipate future prices. Moreover, the analysis of this relationship will have an implication in terms of efficiency of the Moroccan market, because an efficient market must fully reflect the information available, which means that prices must not fluctuate more than the fundamentals to be predicted by the discounted dividend model.

## **2. Literature Review**

The Efficient Markets Hypothesis EMH developed following the work of Samuelson (1965) and Fama (1965, 1970, 1991) states that no one is able to make profits that are abnormally higher than the market average, since the whole of available information is fully integrated into the prices of listed assets. This hypothesis is in perfect harmony with that of the rationality of investors (Muth, 1961), which supposes that investors are able to correctly anticipate future fluctuations in asset prices. Given these assumptions, the empirical literature shows that real prices fluctuate more than dividends thus highlighting a financial anomaly that is called excessive volatility; this anomaly was studied in the early 1980s as one of the phenomena that go against the efficiency hypothesis and the fundamentalist rationality described by modern finance.

The first tests of excessive volatility consist in comparing the standard deviations of real prices and ex post rational prices obtained by the discounting of future dividends.

This is the variance bounds test conducted for the first time by Shiller (1981) for a sample of US stocks between 1871 and 1979. Shiller shows that the standard deviation of the market index is 50.2 against 8.96 for the ex-post rational price index. For the French market, Arbulu and Fontaine (1998) reach the same conclusion and show that the French stock market is excessively volatile. Cuthberston and Hyde (2002) demonstrate through an excessive volatility test that the German and French markets are not efficient. The common point between these studies concerns the methodological approach adopted for the volatility test. In other words, these studies were based on the variance bounds test according to the study by Shiller (1981), and as we mentioned in the introduction, some criticisms are likely to contradict the validity of the tests. These criticisms mainly concern the rather reductive assumptions to apply the discounted dividend model. Since the end of the 1980s, these limits have been the starting point for other methodological approaches, including those based on the cointegration theory developed following the work of Granger and Engel (1987).

Cointegration is a fundamental concept introduced to understand the long-term evolution of two or more time series. Granger and Engel (1987) consider two non-stationary cointegrated variables when their linear combination is stationary. It is therefore understandable that the study of cointegration between two variables first requires the study of stationarity. If two variables are not stationary in level and stationary in first difference, they are said integrated of order 1 I (1), then, the cointegration test consists in testing the stationarity of the residual resulting from their linear combination.

The cointegration study provided a considerable theoretical framework for testing the efficiency of financial markets and in particular the relationship between dividends and prices. Campbell and Shiller (1987) studied the volatility of the US market using cointegration theory. Following the early work of these authors, cointegration studies will significantly improve efficiency and volatility tests (Lilti; 1994). Priso (1997) rejects the EMH of the New York financial market by first using the two-step cointegration test, in the first step, Priso analyzed the stationarity of the variables studied by the unit root test of Dickey Fuller DF (1979) and augmented Dickey Fuller ADF (1981) and Phillips Perron's PP test (1988). The second step in his empirical approach consisted in testing the stationarity of the residuals of the combination between the variables studied. To complete its approach and confirm the results obtained, the cointegration test of Johansen (1988) was applied, the test results all converge towards the presence of traces of inefficiency of the New York Stock Exchange. In other studies, Beneburg (2006) applied the Johansen cointegration test as a complementary approach to Shiller's (1981) variance bounds test to arrive at the same conclusions regarding the excessive volatility of a composite index of 15 markets between 1970 and 2005.

It appears that the cointegration study approach between price series and dividends provides answers regarding the long-term relationship between these variables. The rejection of such a relationship is explained on the one hand by the volatility of real prices compared to fundamentals, and on the other hand by the rejection of informational efficiency.

### 3. Methodology

In this research, we analyze empirically the volatility of the Moroccan stock market by exploiting the recent developments of the econometric tools of cointegration in panel data.

#### 3.1 Unit root test in panel data

The first unit root tests in panel data were introduced by Levin and Lin in 1992, and then developed in 1993 and 2002 by Levin, Lin and Chu (LLC). Another test makes it possible to test the presence of unit root by considering under the alternative hypothesis (stationarity) the heterogeneous character of the autoregressive root, this is the test developed by Im, Pesaran and Shin IPS (2003). In addition to the LLC and IPS tests, other researchers were interested in the cointegration study in non-stationary panel data, in this context, Maddala and Wu (1999) propose a strategy based on a Fisher nonparametric test (1932). A fourth test that we have adopted is the test of Hadri (2000) developed a test that differs from other tests by its null hypothesis (stationarity) The tests of LLC, IPS, Madala and Wu MW or the Hadri test allow us to study the order of integration of two or more series in order to be able to highlight (or not) a long-term relationship between two or more variables.

#### 3.2 Pedroni cointegration test (1999)

The Pedroni test is one of the most powerful and well-documented tests in the empirical literature. Pedroni developed his cointegration test by considering seven statistics: three for the between dimension and four for the within dimension. As for the Engel and Granger test (1987), Pedroni tests the stationarity of residues in this regression:

$$\varepsilon_{i,t} = \theta \varepsilon_{i,t-1} + \mu_{i,t}$$

The null hypothesis of no cointegration is tested against the alternative hypothesis of cointegration, the alternative hypothesis H1 is different according to the nature of the test considered, test with between dimension or test with within dimension:

$$H_1: \theta_i = \theta < 1: \text{ for within dimension}$$

$$H_1: \theta_i < 1: \text{ for between dimension}$$

#### 3.3 Sample and data

The sample of this study is made up of 30 companies listed on the Casablanca Stock Exchange between 2002 and 2016. We have selected the most active price's and dividend's companies. The data concern the closing prices of December 31 of each year, and the dividends distributed during each period (the year) since 2002.

**Table 1:** Lists of companies selected for the empirical test.

Companies listed	Activity area	Market capitalization
Agma lahrou-tazi	Insurance	540000000
Aluminium du Maroc	Construction and Building Materials	573123420
Oulmes	Drinks	2811600000
Auto hall	Distributions	5663286320
Attijariwafa Bank	Banks	87516707180
Axa crédit	Finance company	186000000
Bahma	Immovable	166726400
BMCE Bank	Banks	36718209594
BMCI	Banks	7967571600
Centrale Danone	Food industry/production	9420000000
CDM	Banks	5549419140
Ciment du Maroc	Construction and Building Materials	19993865540
Cosumar	Food industry/production	15842344393
CTM	transport	790755810
Eqdome	Finance company	1753762500
Afrika gaz	Oil and gas	9281250000
Lesieur cristal	Construction and Building Materials	4006568950
La fargeholcimmar	Construction and Building Materials	60218286800
Maghrebail	Finance company	1273447440
Maroc leasing	chemistry	1082939520
Managem	Mine	1093586606
Auto nejma	Distributions	2290064832
Nexans Maroc	Electrical and electrical equipment	359299728
Basseries du Maroc	Drinks	6649684550
Sonasid	Construction and Building Materials	1427205000
Unimer	Food industry/production	2031670640
Maghreb oxygne	chemistry	87750000
Smi	Mine	5264288000
Wafa assurance	Insurance	1720950000
Tasliif	Finance company	543039525

**Source:** authors, Casablanca Stock Exchange website (July 2017)

In this study, this is a 15-year period which makes the number of observations insufficient to test a cointegration relationship between dividends and prices. For this, we will exploit the econometric developments concerning unit root and cointegration tests in panel data. This will allow the number of observations to be increased by adding the cross-section dimension to the time dimension. In this case we have 450 observations ( $N \times T = 30 \times 15$ ). To test a possible long-term relationship between prices and dividends, the empirical approach is to check the order of integration of the price and dividend series. For this, four stationarity tests will be considered, the LLC, IPS and MW tests with null hypothesis, the presence of unit root and the Hadri test whose null hypothesis is stationarity. If we succeed in showing that the two series have the same order of integration, the approach will be completed by a cointegration test on panel data. In this research we opt for the Pedroni test. We apply these different tests on the series in price and dividend panel data in level and logarithm in order to draw the main conclusions concerning the volatility of the Moroccan market for the period considered. Otherwise, if we can detect sustainable differences between prices and dividends, we can conclude that the market value of firms listed on the Casablanca stock exchange deviates durably from the fundamental values in contrary to what is predicted by the Efficient Markets hypothesis.

#### 4. Results and Discussion

In this section, we will first present a graphical analysis of the evolution of prices and dividends, and then we will present the results of unit root tests and cointegration in panel data.

##### 4.1 Descriptive analysis

Before presenting the results of the unit root and cointegration tests between the price series and the dividend series in panel data, an initial analysis consists in making a graphic description of the evolution of two indices, a price index and a dividend index. Each index is a market capitalization weighted average as follows:

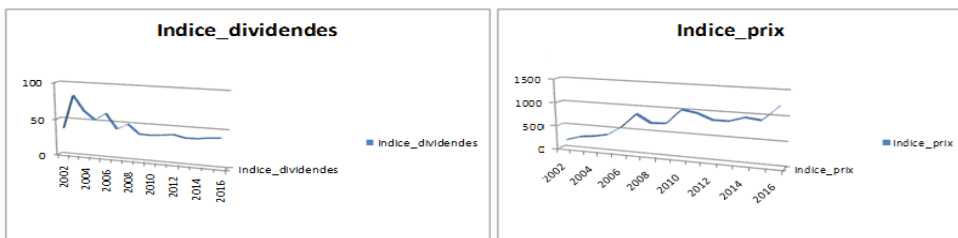
$$D_t = \sum_{i=1}^{30} w_{it} D_{it}$$

Where,  $D_t$  is the dividend index of the year  $t$ ,  $D_{it}$  is the dividend of the stock  $i$  distributed during the year  $t$ , and  $w_{it}$  is the weight of the stock  $i$  in the portfolio consisting of 30 companies.

$$P_t = \sum_{i=1}^{30} w_{it} P_{it}$$

Where,  $P_t$  is the price index in year  $t$ ,  $P_{it}$  is the closing price of December 31st of year  $t$  of stock  $i$ .

Graphically (figure 1), we note that the price index has had an upward trend since 2004 to reach a first peak in 2007, then a second peak in 2010. These observations are in line with the first descriptive analyzes of the El bakkouchi (2014) study. Indeed, the Moroccan market experienced an initial phase of euphoria from 2003 until 2007, since 2007, the Moroccan market has recorded a significant decline in its overall performance in 2008 and 2009, before posting good results in 2010. El bakkouchi points out that it was a mini-market crash in the Moroccan market triggered in 2007 until 2010, a period that coincided with the Subprime crisis in the US market.



**Figure 1 :** Evolution of price and dividend indices (indice\_prix/indice\_dividendes) between 2002 and 2016

**Source:** Authors, excel.

As for the dividend index, it reached its peak in 2003, and then there is a downward trend after that date. From 2009, the index is relatively stable, unlike the price index which seems more volatile with an uptrend in recent years.

According to this first descriptive analysis, we note that the two indices do not evolve in the same direction, to confirm this result we will complete our analysis by the cointegration study in panel data between prices and dividends in order to study the nature of the long-term relationship between the two series.

#### 4.2 Unit root and cointegration tests in panel data: price-dividend relationship.

As a first step, the procedure consists in determining the order of integration of the retained series, in order to verify if the series of the prices and dividends are integrated of the same order or not. Table 2 shows the statistics obtained from the various stationarity tests applied to the price, log price, dividend and log dividend series.

**Table 2:** Stationarity tests in panel data (series in level)

Variables	Model	LLC	IPS	MW	Hadri
Price	Without trend	-2,54 (0,005)	-0,36 (0,36)	57,60 (0,56)	10,66 (0,00)
	With trend	-3,40 (0,0003)	0,12 (0,55)	55,45 (0,64)	7,58 (0,00)
Log price	Without trend	2,30 (0,98)	-2,02 (0,02)	17,20 (1,00)	10,03 (0,00)
	With trend	-4,80 (0,000)	-0,47 (0,32)	62,43 (0,38)	10,26 (0,00)
Dividend	Without trend	1,01 (0,84)	-2,65 (0,04)	64,24 (0,33)	10,88 (0,00)
	With trend	-5,62 (0,000)	-3,03 (0,0012)	100,34 (0,0008)	16,73 (0,00)
Log dividend	Without trend	1,71 (0,95)	-3,50 (0,0002)	39,20 (0,98)	9,60 (0,00)
	With trend	-6,60 (0,0000)	-3,12 (0,0009)	93,99 (0,0033)	7,17 (0,00)

*The number of delays is chosen according to Schwarz criteria<sup>1</sup>*

**Source:** authors, evIEWS 9

We reject the null hypothesis when p-value (number in parenthesis) is less than 5% (significance level) knowing that the Hadri test stands out by its null hypothesis of stationarity compared to the other tests. Overall, the conclusion that can be drawn

<sup>1</sup>These are the information criteria that minimize functions called: Akaike function or Schwarz function: See, for example, Bourbonnais.R (2015), "Econométrie", Dunod, 9th edition.

from these tests is that the four series are not stationary (in level), although this result is more significant for the price series than for the dividend series.

We continue our approach by testing the stationarity in panel data for series in first difference, (table 3).

**Table 3:** Stationarity tests in panel data (series in first difference)

Variables	Model	LLC	IPS	MW	Hadri
Prix	Without trend	-6,80 (0,00)	-6,38 (0,00)	148,64 (0,00)	2,33 (0,00)
	With trend	-6,37 (0,00)	-3,78 (0,00)	109,21 (0,00)	11,48 (0,00)
Log prix	Without trend	-6,12 (0,00)	-5,20 (0,00)	126,52(0,00)	4,79 (0,00)
	With trend	-6,36 (0,00)	-3,55 (0,00)	106,08 (0,00)	11,01 (0,00)
Dividendes	Without trend	-11,61 (0,00)	-8,29 (0,00)	181,16 (0,00)	8,71 (0,00)
	With trend	-11,12 (0,00)	-5,45 (0,00)	135,66 (0,00)	46,44 (0,00)
Log dividendes	Without trend	-10,49 (0,00)	-7,06 (0,00)	160,30 (0,00)	0,62 (0,27)
	With trend	-9,94 (0,00)	-4,16 (0,00)	116,52 (0,00)	9,71 (0,00)

**Source:** authors, eviews 9

According to this table, the three tests, LLC, IPS and MW converge towards the same result indicating the stationarity of all the series in first difference.

Summing up these results, we find that the four series, price, log price, dividends and log dividends are integrated of order 1 I (1). This first result makes it possible to wonder about a possible long-term relationship, for this we complete our approach by the cointegration study by the application of the Pedroni test.

Using the Pedroni (1999) method, Tables 4 and 5 provide the values of the seven tests statistics that evaluate the long-run relationship between price series (log prices) and dividends (log dividends).

**Table 4:** Pedroni cointegration test (1999): price/dividend ( $H_0$ : no cointegration; risk:  $\alpha=5\%$ )

Statistics	Values	p-value	Cointegration
<i>v-Statistic Panel</i>	-1.422944	0.9226	No
<i>Rho-Statistic Panel</i>	1.143677	0.8736	No
<i>PP-Statistic Panel</i>	-2.364318	0.0090	Yes



<i>ADF-Statistic Panel</i>	-6.399684	0.0000	Yes
<i>Rho-Statistic Group</i>	3.448838	0.9997	No
<i>PP-Statistic Group</i>	-1.709394	0.0537	No
<i>ADF-Statistic Group</i>	-4.342433	0.0000	Yes

**Source:** authors, eviews 9

**Table 5:** Pedroni cointegration test (1999): log price/log dividend ( $H_0$ : no cointegration;  $\alpha=5\%$ )

Statistics	Values	p-value	Cointegration
<i>v-Statistic Panel</i>	-1.311906	0.9052	No
<i>Rho-Statistic Panel</i>	1.871921	0.9694	No
<i>PP-Statistic Panel</i>	-1.373236	0.0848	No
<i>ADF-Statistic Panel</i>	-3.835045	0.0001	Yes
<i>Rho-Statistic Group</i>	3.114804	0.9991	No
<i>PP-Statistic Group</i>	-3.341858	0.0004	Yes
<i>ADF-Statistic Group</i>	-5.369337	0.0000	Yes

**Source :** authors, eviews 9

Overall, we can conclude that there is no long-run equilibrium relationship between prices and dividends. In other words, the prices observed deviate from the dividends contrary to what is predicted by modern financial theory. According to this result, the Moroccan market seems very volatile for at least the last fifteen years and the EMH is therefore hard to accept.

## 5. Conclusion

The purpose of this research was to study the volatility of the Moroccan financial market through the examination of the long-term relationship between prices and dividends. Using cointegration theory and in particular its panel data applications, our results show that the Moroccan market is volatile so that the dividend discount model does not seem to be valid for predicting price fluctuations. Admittedly, our conclusions will have implications in terms of informational efficiency and in terms of rationality of investors; however the emergence in recent decades of theories competing with classical financial theory is likely to stimulate our reflection on the very notion of rationality. Otherwise, how can we explain such deviations from a theory by using other approaches such as behavioral finance for example?

## References

- [1] Arbulu, P and Fontaine, P. (1998). Volatilité excessive d'un marché des actions : cas des Etats- Unis et de la France. *Journal de la société statistique de Paris*, tome 139, no 2, 7-34.
- [2] Berneburg, M. (2006). Excess Volatility in European Equity Style Indices - New Evidence. *Halle Institute for Economic Research*, 16, 1-27.

- [3] Bourbonnais, R. (2015). *Econométrie. Dunod*, 9ème édition.
- [4] Campbell, J.Y and Shiller, R.J. (1987). Cointegration and Tests of Present Value Models. *Journal of political Economy* 95, 1062-1088.
- [5] Cuthbertson, K & Hyde, S. (2002). Excess volatility and efficiency in French and German stock markets. *Economic Modelling*, 19, 399-418.
- [6] Dickey, D.A and Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica*, 49, 1057-1072.
- [7] Dickey, D.A. and Fuller, W.A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, 74, 417-31.
- [8] El bakkouchi, M. (2014). Analyse du risque de marché boursier marocain en période de crise des subprimes : Cas de l'indice MASI. Thèse de doctorat, Ecole Doctorale Economie et Gestion Laboratoire d'accueil : LAMETA, Faculté d'économie, université Montpellier I.
- [9] Engle, R and Granger, C. (1987). Cointegration and error correction: representation, estimation, and testing. *Econometrica*, mars 1987, vol 55, 251-276.
- [10] Fama, E. (1991). Efficient capital market II. *Journal of Finance*, 46, 5 1575 – 1617.
- [11] Fama, E. (1965). The Behavior of Stock Market Prices. *The Journal of Business*, 38, 34-105.
- [12] Fama, E. (1970). Efficient Capital Markets: a Review of Theory and Empirical Work. *Journal of Finance*, vol. 25, no1.383-417.
- [13] Fisher, R.A. (1932). *Statistical Methods for Research Workers*. Oliver & Boyd, Edinburgh.
- [14] Flavin Marjorie, A. (1983). Excess Volatility in the financial Markets: A Reassessment of the Empirical Evidence. *Journal of political economy*, 91, 929-956.
- [15] Hadri, K. (2000). Testing for Unit Roots in Heterogeneous Panel Data. *Econometrics Journal*, 3, 148-161.
- [16] Hurlin, C et Mignon, V. (2006). Une synthèse des tests de racine unitaire sur données de panel. *Economie et prévision, mine- direction de la prévision*, 169, 253-294.
- [17] Im, K.S, Pesaran, M.H et Shin, Y. (2003). Testing for unit roots in heterogeneous panels., *journal of econometrics*, 115, 1, 53-74.
- [18] Johansen, S. (1988). Statistical analysis of cointegration factors. *Journal of Economic Dynamics and Control*, n° 12, 1988, 231-254.
- [19] LeRoy, S. and Porter, R. (1981). The Present Values Relation: test Based on Implied variances bounds. *Econometrica*, 555-574.
- [20] Levin, A and Lin, C.F. (1992). Unit root tests in panel data: asymptotic and finite sample properties. Discussion paper, *department of economics, university of california at san diego*, 92-93.

- [21] Levin, A, Lin, C. (1993). Unit root test in panel data: new results, *university of california at san diego*. discussion paper 93-56.
- [22] Levin, A, Lin, C.F. et Chu, C.S.J. (2002). Unit root test in panel data: asymptotic and finite sample properties. *Journal of econometrics*, 108, 1-24
- [23] Lilti, J.J. (1994). Les apports de la cointégration aux tests d'efficience. *Journal de la société statistique de Paris*, tome 135, no 4, 47-63.
- [24] Maddala,G. et Wu,S. (1999). A Comparative Study of Unit Root Tests and a New Simple Test. *Oxford Bulletin of Economics and Statistics*, 61, 631-652.
- [25] Pedroni,P. (1999). Critical values for cointegration tests in heterogeneous Panels with Multiple Regressors. *Oxford bulletin of economics and statistics*, 83, 21-56.
- [26] Philips,P et Perron,P. (1988). Time Series Regression with Unit Root. *Biometrika*, June 1988,75, 335-346.
- [27] Priso, A.M. (1997). Efficience du marché boursier new-yorkais : une analyse à partir de la théorie de cointégration. *Journal de la société statistique de paris*, tome 139, no 1, 21-52.
- [28] Samuelson, P.A. (1965). Proof that Properly Anticipated Prices Fluctuate Randomly. *Industrial Management Review*, p. 6, 2, 41-49.
- [29] Shiller, R.J. (1981). Do Stock Prices Move too much to be justified by Subsequent Changes in Dividends? *The American Economic Review*, VOL. 71, NO. 3, 421-436.