Latin American Business Review

ISSN: 1097-8526 (Print) 1528-6932 (Online) Journal homepage: https://www.tandfonline.com/loi/wlab20

The Unification of the Colombian Stock Market: A Step Towards Efficiency–Empirical Evidence

Cecilia Maya Ochoa & Gabriel Ignacio Torres Avendaño

To cite this article: Cecilia Maya Ochoa & Gabriel Ignacio Torres Avendaño (2005) The Unification of the Colombian Stock Market: A Step Towards Efficiency–Empirical Evidence, Latin American Business Review, 5:4, 69-98, DOI: 10.1300/J140v05n04_04

To link to this article: https://doi.org/10.1300/J140v05n04_04

Published online: 12 Oct 2008.

The Unification of the Colombian Stock Market: A Step Towards Efficiency– Empirical Evidence

Cecilia Maya Ochoa
Gabriel Ignacio Torres Avendaño

ABSTRACT. The empirical evidence presented in this study shows that there has certainly been a structural change in the Colombian stock market since the merger of the three regional Exchanges (*Bolsas*) into the Colombian Stock Exchange (*Bolsa de Valores de Colombia*). This change has been reflected in a greater level of efficiency in that market. Regarding individual assets, the findings coincide with Samuelson (1998) in the sense that the stock market is micro-efficient but macro-inefficient, which means that the efficient market hypothesis performs better for individual stocks than for the aggregated price indexes of the market.

RESUMEN. La evidencia empírica presentada en este estudio muestra que realmente operó un cambio estructural en el mercado accionario colombiano a partir de la fusión de las tres Bolsas regionales en la Bolsa

Cecilia Maya Ochoa is Professor and Researcher, Finance Department, Administration School, EAFIT University, Medellin, Colombia (E-mail: cmaya@eafit.edu.co).

Gabriel Ignacio Torres Avendaño is Industrial Engineer, Professor and Researcher, Finance Department, Administration School, EAFIT University, Medellin, Colombia (E-mail: gtorres@eafit.edu.co).

Latin American Business Review, Vol. 5(4) 2004
Available online at http://www.haworthpress.com/web/LABR

doi:10.1300/J140v05n04_04

de Valores de Colombia. Este cambio se ha reflejado en un mayor nivel de eficiencia de este mercado. En cuanto a los activos individuales, los hallazgos coinciden con Samuelson (1998) en el sentido de que el mercado bursátil es micro-eficiente pero macro-ineficiente, es decir, que la hipótesis de la eficiencia del mercado se cumple mejor para acciones individuales que para los índices de precios agregados del mercado.

RESUMO. A evidência empírica apresentada neste estudo mostra que, sem dúvida, tem ocorrido uma mudança estrutural no mercado de ações colombiano, a partir da fusão das três Bolsas de Valores regionais, dando origem à Bolsa de Valores de Colombia. Esta mudança refletiu o alto nível de eficiência deste mercado. Quanto aos ativos individuais, percebe-se a coincidência com Samuelson (1998), no sentido de que o mercado de ações é micro-eficiente, mas também é macro-ineficiente, ou seja, que a hipótese de um mercado eficiente atua melhor para as ações individuais do que para os índices de preços agregados do mercado.

KEYWORDS. Financial markets, efficient market hypothesis, random walk, Colombian stock exchange

INTRODUCTION

That returns on financial assets follow a random walk is a fundamental supposition for financial models, especially those for portfolio selection and valuation of assets. If this is the case, then it is not possible to predict future prices from such assets' historical behavior, which gives support to the weak version of market efficiency.

In 1970, Fama defined an efficient market as one in which prices always "fully" reflect all the available information. However, according to Roberts (1976), the set of available information can be classified into three sub-sets, which give rise to considering three levels of market efficiency:

Weak efficiency: the set of information includes historical prices.

Semi-strong efficiency: includes all the information publicly available to all participants in the market, e.g., announcements about earnings, payment of dividends, stock splits.

Strong efficiency: this level includes all the information known by any market participant, i.e., one that also understands private information.

More specifically, efficiency with respect to one set of information implies that it is not possible to obtain extraordinary gains in negotiating financial assets based on such information. That is the reason why market efficiency tests focus in that direction, seeking to verify if participants in the market manage to achieve extraordinary gains with the available information.

This study focuses on random walk tests aimed at verifying if it is possible to obtain extraordinary gains based on information about historical prices. Such would be the case if two elements were combined: first, that prices of financial assets may behave in a predictable manner and, second, that such information may be economically usable, considering the fact that in trading such assets, some transaction costs may be generated. Frequently, the empirical evidence shows that there is some predictability in prices, but that in taking into account transaction costs, the possible gain disappears.

On the other hand, a market efficiency test requires a definition of which returns are normal and which are extraordinary. Such definition comes from an equilibrium model. The problem that this creates is that if the test rejects efficiency, it will not be possible to know if such is due to having assumed an inadequate equilibrium model, or if the market really is inefficient. According to Fama (1970), this problem with the joint hypothesis implies that market efficiency as such can never be rejected. Furthermore, perfect efficiency is an idealization that is not economically feasible, but that serves as a useful benchmark for measuring the relative efficiency of a market (Campbell, Lo and MacKinley, 1997). The empirical findings discussed in this study will show how the Colombian stock market has been evolving toward a greater level of efficiency without yet being considered an efficient market.

Due to the difficulty of verifying the efficient market joint hypothesis, market efficiency tests, specifically, weak efficiency, are aimed at proving the hypothesis that prices of financial assets follow a random walk process. Extensive international empirical evidence on the subject, discussed in Maya and Torres (2004), concludes that random walks are not of this world. Regardless of whether the study has been conducted on a developed market or on an emerging market, the conclusion is the same. The random walk hypothesis is rejected for all markets, because there is evidence of the presence of an autocorrelation in the different series analyzed and, certainly, returns do not follow an independent, identical and definite distribution, much less a normal distribution. The difference between developed and emerging markets lies more in the magnitude of the serial dependency, which, by being small, does not allow the realizing of extraordinary gains in the former.

The reader may ask him/herself if it is not plain stubbornness to return to a subject to conduct another investigation concerning the existence of random walks–this time applied to the Colombian stock market–with an answer the same as Fama's (1991) with respect to the extensive empirical literature in connection with the efficiency of the markets. This author affirms that, in spite of the results having not been conclusive, such literature has improved the knowledge about the behavior of returns on assets, and that is why the research around the efficiency of the markets is counted among the most successful in empirical economics besides having the highest expectations of maintaining itself in such a position in the future. Therefore, the contribution of this research is aimed at a greater understanding of the time series and the transverse data of the returns on stocks in the Colombian stock market, without falling into despair at the fact that the Holy Grail, that is, the random walk, has remained elusive.

DESCRIPTION OF THE SERIES

The time series object of analysis in this study corresponds to the daily, weekly and monthly returns of the principal Colombian stock indexes; that is, the Medellín index (*Bolsa de Medellín–IBOMED*), the Bogatá index (*Bolsa de Bogotá–IBB*) and the Colombia Stock Exchange general index (*índice general de la Bolsa de Valores de Colombia–IGBC*). The first two indexes are merely of historic interest since these two Exchanges were merged[1] into one entity to form the Colombian Stock Exchange (*Bolsa de Valores de Colombia–BVC*), which began operations on July 3, 2001. For the IBB and IBOMED indexes, the selected data cover the timeframe June 29, 1991 through June 29, 2001. In the case of the IGBC, the data were selected covering the timeframe from its beginning through December 31, 2003. To compare the behavior of returns before and after the emergence of a unified stock market will permit us to conclude whether a structural change has been produced in such market in order to evolve toward a higher level of efficiency.

In addition to studying the stock indexes, the behavior of the series of returns on a selection of individual assets is analyzed, specifically, a group of fifteen stocks in the period after the emergence of the BVC. The criterion for the selection derives from their high tradability since medium and low tradability stocks are often not traded because they generate a distorted time series due to the high number of void returns. The classification of the Colombian stocks, based on their tradability, comes from the monthly report, which is generated by the Superintendency of Colombian Securities (*Superintendencia de Valores de Colombia* at www.supervalores.gov.co). Appendix I shows the stocks that have been classified as being of high tradability, and the number of times they have been traded. Based on this information, the following group of fifteen common stocks was chosen: Almacenes Éxito S.A.,[2] Banco de Bogotá S.A., Bancolombia S.A., Bavaria S.A., Cementos Argos S.A., Cementos del Caribe S.A., Cementos Paz del Rio S.A., Compañía Colombiana de Inversiones S.A., Compañia Colombiana de Tabaco S.A.,[3] Corporación Financiera Nacional y Suramericana S.A., Grupo Aval–Acciones y Valores S.A., Interbolsa S.A.–Comisionista de Bolsa, Inversiones Nacional de Chocolates S.A., Suramericana de Inversiones S.A., and Valores Bavaria S.A.[4]

Once the stock indexes and individual assets series are selected, returns are calculated as the difference among the logarithms of the prices for the two consecutive periods, which generates a series of continually compounded returns. For the daily returns, only the business day average prices are taken into account for the Exchange without interpolations or adjustments for weekends or holidays. As discussed in Séiler and Rom (1997), based on French (1980), although this seems to violate the basic principle of working with time series, which consists in the data having to be selected with equal intervals, and the requirement being that one must select in accordance with the underlying process of the series. Here, the process is the trading of a stock, thus taking only data from days on which trading occurs is appropriate.

For calculating the weekly returns, the methodology of Campbell, Lo, and MacKinley (1997) is followed, estimating them based on the difference of the logarithm of the price from Tuesday to Tuesday. If on a Tuesday, there is no price, e.g., because it is a holiday, the Wednesday price is used, and if there is no price on Wednesday, Monday's price is resorted to. This methodology is a little different than that suggested by Lo and MacKinley (1988), who utilize Wednesday as the base day, and which has been more widely used in other studies of this nature. However, the former was chosen for being the most recently proposed by those authors. In any case, both adequately serve the purpose that was pursued when using series with a periodicity superior to the daily one, which is to avoid the biases produced by the lack of trading on certain business days.

METHODOLOGY

The following methodology for this study is geared to identifying a pattern of behavior for the time series of returns of the stock indexes and of the selected stocks. In the case where no discernable pattern is found, it is possible to conclude that such returns effectively follow a random walk process. However, as Campbell, Lo and Mackinley (1997) explain, it is possible to identify three distinct random walk versions according to their level of demand, and which may be identified as RW1, RW2 and RW3, explained below.

The first random walk version (RW1) requires that increments in prices follow an independent and identical distribution. The dynamic of asset prices P_t is given by:

$$P_t = \mu + P_{t-1} + \varepsilon_t \qquad (1)$$
$$\varepsilon_t \sim IID(0, \sigma^2)$$

where μ is the value expected in the increment of the price, and σ is the standard deviation. Since the increments are independent, the random walk is also a fair game like the Martingale strategy, for instance, but is more demanding than the Martingale, because independence implies not only that the increments are non-correlated, but also that their non-linear functions are not correlated either.

Frequently, it is assumed that the increments follow a normal distribution, but if the series of prices were utilized, such would imply that we could have negative prices. Thus, one assumes that it is the natural logarithm of the prices represented by P_t, the one that follows a random walk with increments that follow a normal distribution, that is:

$$p_t = \mu + p_{t-1} + \varepsilon_t \qquad (2)$$
$$\varepsilon_t \sim IIDN(0, \sigma^2)$$

which gives way to the lognormal model of Bachelier (1900).

The second random walk version, RW2, only requires that the increments be independent without requiring that they follow an identical distribution. Therefore, this version takes into account the presence of heteroscedasticity in the increments, a common characteristic of financial time series. Finally, the third version, RW3, only requires that the increments not be correlated, which means $Cov[\varepsilon_t, \varepsilon_{t-k}] = 0$, although it admits that dependency could exist between them, e.g., $Cov[\varepsilon_t^2, \varepsilon_{t-k}^2] \neq 0$ for $k \neq 0$.

With the aim of verifying the first random walk version in the Colombian stock market, three goodness of fit tests are applied, which are the Chi-Square, the Kolmogorov-Smirnov and the Anderson-Darling, for determining if the series of selected returns follows a normal distribution as required by RW1. The null hypothesis for the three tests is that the variable follows a set distribution. The second two tests mentioned are very sensitive to the magnitude of the size of sample N. As N is incremented, the test-values are incremented and the null hypothesis is more often rejected. The result obtained in these tests can be considered as a good indication of the goodness of fit. The result of the Chi-Square test depends on the degrees of freedom and these, in turn, on the number of intervals of class (N) selected, which translates into a weakness of the test.

As for the type of tests utilized for verifying RW2, that is, that the increments be independent among themselves without requiring that they be identically distributed, these tests are characterized by not resorting to any tools of statistical inference. However, they are tests frequently used by financiers in their daily practice. The most common are the Alexander Filters technique and technical analysis. These tests will not be employed herein, because they themselves deserve an independent study, which is not part of the objectives of the present one.

Finally, investigations with respect to the random walk theory are generally aimed at verifying version RW3, which only requires that financial returns not be correlated among themselves. For this, we resort to the methodology of Box-Jenkins, also known as the ARIMA model, the Q-statistic and the variance ratio test.

With respect to the models for predicting time series such as regressions and exponential softening, the criticism is that these assume that the series are statistically independent from one period to the next. When dealing with financial returns, such is usually not the case, as the abundant literature has shown concerning technical analysis and technical rules. Thus, the Box-Jenkins methodology is the most appropriate and most commonly used for verifying the existence of random walks since it considers the possibility of statistical dependence in the data from one period to the next.

To apply it, the first step to follow is that of verifying the stationarity of the series of returns; that is, that there are no unit roots in the series. The direct observation of the series or the study of the correlelogram are empirical instruments for detecting the presence of unit roots, although they are imprecise methods. That is why appropriate contrasts have been developed for knowing whether the series has or does not have unit roots, such as the contrasts of Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF), which permit detecting the existence of unit roots if the generating process of the data is an auto-regressive order process *p, AR (p)*. However, as Enders points out (1995, p. 257), such contrasts propose the inclusion of the intercept and/or the deterministic tendency in the auxiliary equation, which could lead to an erroneous interpretation of the results, because since it reduces the degrees of freedom, it increases the size of the critical region and also reduces the power of the contrast. That is why Dolado, Jenkinson and Sosvilla-Rivero (1990) suggest a procedure for verifying the existence of unit roots when the generating process of the data is unknown.

Once the stationarity of the returns utilizing the methodology of Dolado et al. is verified, the next step is identifying their generating process, comparing the autocorrelation coefficients and partial autocorrelation of the data with the theoretic distributions. In the process of selecting the possible models, the Akaike Info Criterion (AIC) and Schwarz Bayesian Criterion (SBC) are utilized to select which is the most appropriate model. As Enders (1995, p. 88) affirms, the SBC behaves better for wider samples, because, although both criteria tend to select models of an order superior to or equal to the true one as the size of the sample approaches infinity, the SBC is asymptomatically consistent, while the AIC tends to select an over-parameterized model.

Once the most appropriate ARIMA model is calculated, its residuals are analyzed utilizing the LM (Lagrange Multiplier) test for verifying the existence of ARCH errors; that is, residuals presenting conditional heteroscedasticity. In case evidence of such is found, the next step is estimating different GARCH models and determining which best describes the behavior of the conditional variance. To do so, GARCH (1,1), GARCH-M (with standard deviation) and EGARCH are estimated as they are considered the most appropriate for describing financial return series.

The most basic and common model employed is the GARCH (1,1), which adequately represents series, and which, like those of financial returns, present clusters of volatility, that is, after high variations in the return, periods of high volatility follow. The other GARCH model that can be adequate for describing the behavior of financial time series is the GARCH-M, which is characterized by representing the conditional average as dependent of the conditional variance. This manner of modeling the series allows incorporating the basic income-risk relation that determines the valuation of financial assets, because it recognizes that, for a greater level of risk, the risk-adverse investor will demand a greater risk reward. In this study, the version that models the average as dependent of the standard deviation instead of the conditional variance is utilized in understanding that financial risk is better described by the volatility of the average asset by its standard deviation. Additionally, for analyzing the significance of the estimated coefficients, the matrix of covariances consistent with heteroscedasticity is employed.

Finally, in some cases the financial returns follow a process that is better described by the EGARCH or exponential GARCH model, especially when dealing with financial index returns. In this model, the formula for the conditional variance is as follows:

$$\log(\sigma_t^2) = \omega + \beta \log(\sigma_{t-1}^2) + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \quad (3)$$

Nelson (1991) proposes this way of modeling the conditional variance as an alternative to the GARCH (*p, q*) for modeling the behavior of financial return series. Unlike this model, the EGARCH recognizes that the impact occasioned by "good" or "bad" news can be asymmetric in the sense that the variation in the volatility of the series would be greater as a result of the latter kind of news. Therefore, the signal and not only the size of the impact would determine volatility. According to (3), the impact would be asymmetric if $\gamma \neq 0$. Clearly, if the generating process of the returns being represented requires resorting to the ARIMA or GARCH models, such returns present an autocorrelation, and thus do not follow a random walk process.

Another test frequently employed for detecting the presence of autocorrelations in series is the Box-Pierce (1970) Q statistic:

$$Q_m = T \sum_{k=1}^{m} \rho^2(k) \quad (4)$$

ρ is the autocorrelation coefficient;

T is the size of the sample;

m is the number of residues considered in calculating the statistic;

k is the order of autocorrelation.

However, this statistic is not adequate for small samples, for which one resorts to the version for finite samples suggested by Ljung-Box (1979):

$$Q_m' = T(T+2)\sum_{k=1}^{m}\frac{\rho^2(k)}{T-k} \qquad (5)$$
$$Ho: Q_m' \sim \chi^2_m$$

When summing up the autocorrelations of the square, the Q-statistic detects the existence of autocorrelations in both directions and for all residues. Thus, it has power against a wide range of alternative hypotheses besides the random walk. The difficulty for its use lies in the adequate selection of the number *m* of autocorrelations because, if a low number is chosen, it could be that the presence of higher-degree autocorrelations is not detected; on the other hand, if a very high number is chosen, the test loses power due to the higher degree of autocorrelations, which, however, are not significant.

In this study, we analyze the Ljung-Box Q-statistic for five and ten daily periods corresponding to one and two weeks, respectively, as well as for four weekly periods corresponding to one month, and for six and twelve monthly periods. The null hypothesis is that there are no significant autocorrelations in the series until the number *m* of selected residues.

In this search for empirical evidence of random walks, the last test to apply is that of ratio of variances. If RW1 is fulfilled, the variance in the increments is linear in the interval of observation, e.g., the variance of the weekly return must be equal to five times the variance of the daily return (Campbell, Lo and MacKinlay, 1997). The null hypothesis is that the ratio of the variance of the *q*-period returns concerning the variance of the return of one period multiplied by *q* is equal to one:

$$VR(q) = \frac{Var[r_t(q)]}{q * Var[r_t]} = 1 + 2\sum_{k=1}^{q-1}\left(1 - \frac{k}{q}\right)\rho(k) = 1 \qquad (6)$$
$$r_t(k) = r_t + r_{t-1} + \ \ldots \ + r_{t-k+1}$$

where $\rho(k)$ is the kth coefficient of the autocorrelation of r_t. Therefore, the coefficient of the variances is a linear combination of the first $(q-1)$ autocorrelations with weights that keep on diminishing linearly. According to RW1, $\rho(k) = 0$ for k > 1, therefore, the ratio is equal to one.

However, if there is a positive autocorrelation, the coefficient will be greater than one and if it is negative, the coefficient will be less than one.

To test the null hypothesis of RW1, the following statistic is calculated:

$$\psi(q) = \frac{[VR(q)-1]}{\sqrt{\phi(q)}} \sim N(0,1)$$
$$\phi(q) = \frac{[2(2q-1)(q-1)]}{3q(nq)} \quad (7)$$

However, it is possible that RW1 may be rejected due to the heteroscedasticity in the returns; thus, it is necessary to resort to a test that is robust with respect to changes in the variance, and which is based on statistic ψ^*:

$$\psi^*(q) = \frac{VR(q)-1}{\sqrt{\hat{\theta}/nq}} \sim N(0,1) \quad (8)$$

where

$$\hat{\theta}(q) = 4\sum_{k=1}^{q-1}\left(1-\frac{k}{q}\right)^2 \hat{\delta}_k \quad (9)$$

and

$$\hat{\delta}_k = \frac{nq\sum_{j=k+1}^{nq}(p_j - p_{j-1} - \mu)^2(p_{j-k} - p_{j-k-1} - \mu)^2}{\left[\sum_{j=1}^{nq}(p_j - p_{j-1} - \mu)^2\right]^2} \quad (10)$$

Such a test would prove RW3. While the returns are not correlated, even in the presence of heteroscedasticity, the coefficient variance must approach one as the number of observations increases, because the variance of the sum of the non-correlated increments must be equal to the sum of the variances.

This study calculates both statistics, $\psi(q)$ and $\psi^*(q)$ for $q = 2$ in the daily returns and $q = 4$ in the weekly returns, for a 95% confidence level.

In case the null hypothesis is rejected, that is, that the variance of a period of two days is different from two times the variance of one day, or that the variance of one month is different from four times the variance of one week, we can conclude that the returns of the corresponding series do not follow a random walk process. The results obtained through the application of all the tests described in this section are presented below.

EMPIRICAL EVIDENCE

In the first place, the normalcy tests applied to the series intend to verify the possibility of fulfilling the strictest version of the random walk, which has been identified as RW1; that is, that the returns on the Colombian stock indexes and on selected assets follow an identical, independent and normal distribution. Thus, the Chi-Square, Kolmogorov-Smirnov and Anderson-Darling tests are resorted to.

In the goodness of fit test conclusions, preference is given to the results obtained with the K-S test because it is more efficient than the Chi-Square, and because A-D is only a modification of K-S, as was stated previously in the methodology section. Additionally, the K-S test is widely used in this kind of study. The null hypothesis to consider in this case is that the yields on stocks in Colombia follow a normal distribution (μ, σ).[5]

The result of applying the tests described is that for the series of daily yields, both for the indexes and the selected assets, the null hypothesis is rejected in all cases, and only for the stock of Banco de Bogotá the Logistic distribution hypothesis for a $\alpha = 5\%$ is accepted. Such distribution, by being very close to normal, allows assuming normality by making an error of little significance (Johnson and Kotz, 1999b, p. 5). For the other stocks, the behavior of the yields does not fit any of the twenty-six distributions considered for this study.

For the series of weekly yields, the null hypothesis is equally rejected for normalcy. As for the logistic distribution hypothesis, such is accepted for Banco de Bogotá ($\alpha = 5\%$), Bancolombia ($\alpha = 5\%$), Cementos Caribe ($\alpha = 15\%$), Coltabaco ($\alpha = 10\%$), Almacenes Éxito ($\alpha = 15\%$), Bavaria ($\alpha = 2.5\%$), Cementos Argos ($\alpha = 15\%$), Cementos Paz del Rio ($\alpha = 1\%$), Colinversiones ($\alpha = 5\%$), Corfinsura ($\alpha = 15\%$), Nacional de Chocolates ($\alpha = 65\%$), Suramericana ($\alpha = 15\%$) and Valbavaria ($\alpha = 2.5\%$). For the weekly series of IBOMED and IBB, the hypothesis is rejected because these follow a logistic distribution inasmuch as for the weekly series of

IGBC, it is accepted for an $\alpha = 10\%$. It is equally accepted that the distribution is logistic for the weekly series of IBB and IBOMED with an α of 2.5% and 1%, respectively.[6]

The explanation that the daily series do not follow a distribution of the twenty-six analyzed stocks can be found in the high number of null returns, which generates an excessive leptocurtosis in the series. On the other hand, the weekly series, exempt from this problem, mostly follow the same logistic distribution with the exception of the historic indexes. As was stated earlier, this logistic distribution can approach a normal distribution, which would accept the RW1 random walk hypothesis in the weekly returns of the individual assets and for the IGBC, although the latter only with a 90% confidence level.

Since several of the selected series do not comply with the random walk hypothesis in its most demanding version, next it will be verified whether or not they fit this type of process, but in its least strict version, RW3; that is, that the series do not present autocorrelation. It is this RW3 version that has greater empirical evidence in the literature concerning the topic. For this aim, the three types of tests described previously based on the Box-Jenkins methodology or ARIMA model, the Q-statistic and the coefficient of variances were applied.

Prior to utilizing the Box-Jenkins methodology, it is necessary to verify the stationarity of the series; that is, that they do not present unit roots. In the practical development of the study, the methodology of Dolado et al. (1990) is applied with this aim, beginning by considering the case of a series with tendency and intercept. Without the need to consider other cases, in the results obtained the null hypothesis of the existence of unit roots is rejected for all the series of returns with daily, weekly and monthly periodicity, utilizing the critical values defined by MacKinnon for the different sample sizes and with 10%, 5% and 1% significance levels, as shown in Appendix II. These results should not be surprising because these series of returns are calculated as logarithmic price differences; therefore, if it is possible that the price series be integrated from order one, when differentiating it for calculating the returns, the resulting series will not present unit roots.

After the stationarity of the series is verified, then the analysis of the correlelogram of the return series follows in order to examine the presence of autocorrelation and, if such is the case, to identify the ARIMA model, which best describes its behavior. In the case of the indexes, an autocorrelation is identified for both the daily, and weekly returns, as well as the monthly returns. The same does not happen with the series of the selected stocks, which show autocorrelation in the daily series, but for the weekly series only five out of the 15 stocks present autocorrelation. As explained before, the intention to calculate weekly returns is only to obtain a series exempt from the problems that bring out the non-trading of certain assets on certain days. In the empirical evidence that is presented in this study, the different behavior of the series with daily and weekly periodicity is well-known, the reason why Campbell, Lo and Mackinley (1997), among others, decided to undertake similar studies taking only weekly returns into consideration.

As for the ARIMA model identified in each case, there is an important difference between the behavior of the historical indexes of the Bogotá and Medellín Stock Exchange versus the present index of the BVC. In the case of daily returns, the IBB shows autocorrelation to the second order, while IBOMED requires the inclusion of the conditional standard deviation in the equation that models the average, which is arrived at by resorting to the ARCH in Mean (ARCH-M) model. The daily IGBC, in turn, presents an autocorrelation of the first order only, which indicates a structural change in the Colombian stock market beginning with the merger of the three regional stock exchanges into one national exchange As was expected, this merger generated a more liquid stock market, with a greater number of trades, which resulted in a greater efficiency reflected in the series' behavior. The additional evidence that is analyzed later in this study is equally conducive to this conclusion. As for the daily returns of the selected individual assets, the great majority follow a first order autoregressive process AR(1), except Almacenes Éxito and Interbolsa, which do not present any autocorrelation. Table 1 shows the estimates of the ARIMA model for the daily returns.

As for the weekly returns, the historical indexes present first and third order autocorrelation, while the IGBC presents significant coefficients for the AR(5) and MA(5) components. Of the selected stocks, ten do not present autocorrelation of any order, which coincides with Samuelson's (1998) conclusion in the sense that individual assets usually fit their behavior to that described by the random walk hypothesis. As for those stocks whose returns present autocorrelation, they follow very different processes, as is shown in Table 2.

Monthly returns are only analyzed for the IBB and the IBOMED, since the IGBC is a more recent index; thus, it is not possible to reach a conclusion from such a short time series. Both historical indexes follow a first order autoregressive process AR (1) (see Table 3).

However, although the previous processes are the ones that most adequately describe the series' behavior, when applying the LM test to

TABLE 1. Estimate of Daily Returns

SERIES	ARIMA Model			
	Variable	**Coefficient**	***Est. Error***	**t-statistic**
IBB	C	0.0002	0.0004	0.4639
	AR(1)	0.3324	0.0323	103.063
	AR(2)	0.1075	0.0272	39.585
IBOMED	SQR (GARCH)	0.1206	0.0586	20.573
	C	–0.0007	0.0004	–19.586
	AR(1)	0.4721	0.0260	181.611
IGBC	C	0.0013	0.0005	23.973
	AR(1)	0.3177	0.0411	77.261
ALM. EXITO	………	………	………	…….
BANCO DE BOGOTÁ	C	0.0011	0.0004	27.775
	AR(1)	0.3707	0.0844	43.941
	AR(2)	–0.1553	0.0721	–21.529
BANCOLOMBIA	C	0.0020	0.0007	26.246
	AR(1)	0.1175	0.0417	28.158
BAVARIA	C	–0.0001	0.0006	–0.2289
	AR(1)	0.2450	0.0418	58.636
CEM. ARGOS	C	0.0014	0.0005	26.103
	AR(1)	0.2820	0.0451	62.492
CEM. CARIBE	C	0.0011	0.0006	20.885
	AR(1)	0.2274	0.0378	60.102
CEM. PAZ DEL RIO	C	0.0014	0.0009	15.677
	AR(1)	0.1755	0.0482	36.433
COLINVERSIONES	C	0.0027	0.0010	28.138
	AR(1)	0.2845	0.0470	60.568
COLT. ADJ.	C	0.0014	0.0008	17.002
	AR(1)	0.1957	0.0460	42.541
CORFINSURA	C	0.0011	0.0009	12.145
	AR(1)	0.1365	0.0551	24.781
GRUPO AVAL	C	0.0000	0.0003	0.0992
	AR(1)	–0.1068	0.0845	–12.630
INTERBOLSA	……	……	……	……
NAL DE CHOCS.	C	0.0015	0.0006	26.232
	AR(1)	0.1604	0.0400	40.125

TABLE 1 (continued)

SERIES	ARIMA Model			
	Variable	Coefficient	*Est. Error*	t-statistic
SURAMERICANA	C	0.0023	0.0008	29.633
	AR(1)	0.1989	0.0526	37.827
VLRS.BAVARIA	C	–0.0039	0.0014	–27.245
	AR(1)	0.1152	0.0538	21.430

TABLE 2. Estimate of Weekly Returns

SERIES	ARIMA Model			
	Variable	Coefficient	*Est. Error*	t-statistic
IBB	C	0.0020	0.0018	11.576
	AR(1)	0.1712	0.0524	32.682
	AR(3)	0.0907	0.0382	23.723
IBOMED	C	0.0026	0.0020	12.734
	AR(1)	0.1689	0.0517	32.636
	AR(3)	0.0863	0.0466	18.523
IGBC	C	0.0091	0.0006	148.570
	AR(5)	0.6122	0.0779	78.629
	MA(5)	–0.9507	0.0003	–33,729.370
ALM. EXITO	…	….	…	…
BANCO DE BOGOTÁ	C	0.0038	0.0022	16.748
	AR(4)	0.2245	0.0611	36.730
BANCOLOMBIA	C	0.0109	0.0040	27.451
	AR(4)	–0.7826	0.0564	–138.663
	MA(4)	0.9426	0.0197	479.178
BAVARIA	…	….	…	…
CEM. ARGOS	…	….	…	…
CEM. CARIBE	…	….	…	…
CEM. PAZ DEL RIO	…	….	…	…
COLINVERSIONES	…	….	…	…
COLT. ADJ.	C	0.0061	0.0027	22.623
	AR(1)	–0.2279	0.1052	–21.659
CORFINSURA	C	0.0098	0.0079	12.424
	AR(2)	0.1964	0.0868	22.622
	AR(3)	0.2162	0.0869	24.894

SERIES	ARIMA Model			
	Variable	Coefficient	*Est. Error*	t-statistic
GRUPO AVAL	C	0.0021	0.0008	25.985
	MA(1)	–0.4146	0.0821	–50.524
INTERBOLSA	…	…	…	…
NAL DE CHOCS.	…	…	…	…
SURAMERICANA	…	…	…	…
VLRS.BAVARIA	…	…	…	…

TABLE 3. Estimate of Monthly Returns

SERIES	ARIMA Model			
	Variable	Coefficient	*Est. Error*	t-statistic
IBB	C	0.0131	0.0091	14.460
	AR(1)	0.2154	0.0875	24.607
IBOMED	C	0.0090	0.0099	0.9161
	AR(1)	0.2574	0.0852	30.211

the residuals, which are obtained in the different estimates, it is proven that, for the indexes with daily, weekly and monthly periodicity, and for the stocks with daily periodicity, the errors are of the ARCH type. Then the most appropriate GARCH process is estimated for modeling the conditional variance (see Appendix III).

The daily series returns on the IBOMED and IBB indexes show a very unusual behavior compared to those of the other series. The process which best describes them is an exponential GARCH or EGARCH in accordance with (3):

$$\log(\sigma_t^2) = \omega + \beta \log(\sigma_{t-1}^2) + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \qquad (11)$$

where γ represents the asymmetry of the impact of the positive or negative news on the volatility of the series, γ is not significant for either index. Regarding the daily returns of the IGBC and the stocks, they follow a GARCH (1,1) process, as the Table 4 shows.

In the case of weekly returns, only the historical indexes require being modeled (see Table 5), resorting to a GARCH (1,1) like the monthly

TABLE 4. Estimate of Daily Returns–Moderation of Variance

Series	**Variable**	**Coefficient**	***Est. Error***	**z-statistic**
IBB*	C	–14.516	0.3590	–40.436
	|RES|/SQR [GARCH](1)	0.3986	0.0542	73.590
	RES/SQR [GARCH](1)	0.0024	0.0500	0.0479
	EGARCH(1)	0.8708	0.0386	225.772
IBOMED*	C	–15.269	0.2199	–69.438
	|RES|/SQR [GARCH](1)	0.5587	0.0541	103.340
	RES/SQR [GARCH](1)	–0.0469	0.0424	–11.055
	EGARCH(1)	0.8784	0.0219	401.265
IGBC	C	0.0000	0.0000	21.520
	ARCH(1)	0.0608	0.0071	85.723
	GARCH(1)	0.9407	0.0040	2,344.116
ALM. EXITO	………	………	………	………
BANCO DE BOGOTÁ	C	0.0000	0.0000	28.552
	ARCH(1)	0.4233	0.1484	28.519
	GARCH(1)	0.5783	0.0865	66.849
BANCOLOMBIA	C	0.0000	0.0000	10.801
	ARCH(1)	0.0385	0.0091	42.377
	GARCH(1)	0.9347	0.0168	556.234
BAVARIA	C	0.0000	0.0000	0.6783
	ARCH(1)	0.0776	0.0080	97.117
	GARCH(1)	0.9167	0.0034	2,678.839
CEM. ARGOS	C	0.0000	0.0000	30.681
	ARCH(1)	0.2581	0.0567	45.537
	GARCH(1)	0.6336	0.0630	100.567
CEM. CARIBE	C	0.0000	0.0000	19.384
	ARCH(1)	0.1182	0.0461	25.661
	GARCH(1)	0.7728	0.0760	101.658
CEM. PAZ DEL RIO	C	0.0000	0.0000	17.271
	ARCH(1)	0.1031	0.0468	22.009
	GARCH(1)	0.7955	0.0859	92.589

Series	Variable	Coefficient	*Est. Error*	z-statistic
COLINVERSIONES	C	0.0000	0.0000	18.951
	ARCH(1)	0.1841	0.0707	26.054
	GARCH(1)	0.8072	0.0556	145.143
COLT. ADJ.	C	0.0000	0.0000	19.955
	ARCH(1)	0.1081	0.0330	32.743
	GARCH(1)	0.8316	0.0478	173.823
CORFINSURA	C	0.0000	0.0000	13.942
	ARCH(1)	0.0913	0.0299	30.500
	GARCH(1)	0.8857	0.0344	257.123
GRUPO AVAL	…	…	…	…
INTERBOLSA	…….	……	……	……
NAL DE CHOCS.	….	….	…..	….
SURAMERICANA	C	0.0000	0.0000	20.972
	ARCH(1)	0.1094	0.0395	27.675
	GARCH(1)	0.8571	0.0444	193.136
VLRS.BAVARIA	C	0.0001	0.0000	18.917
	ARCH(1)	0.1127	0.0402	28.004
	GARCH(1)	0.8558	0.0456	187.877

*Series estimated through EGARCH process.

returns on those indexes (see Table 6). Neither the IGBC nor the selected stocks exhibit any ARCH effect, according to the LM test. Except for the weekly returns, the sum of the estimated value of the α and β coefficients of the GARCH (1,1) models approaches one, which means that the persistence of the volatility shocks is expected to be high.

The results obtained when applying the autocorrelation test based on the Ljung-Box Q-statistic corroborates with the findings of the previous tests (see Table 7). With a 95% confidence level, the great majority of daily series both for the indexes and the stocks show autocorrelation to *m* equal to five and ten days. From that group, Almacenes Éxito, Bancolombia and Interbolsa are excluded, which according to the tests, have demonstrated following a random walk process.

Likewise, the monthly series of the indexes present autocorrelation for a number of residues of six and twelve months.[7] On the other hand, for the weekly series with *m* equal to two and four weeks, the null hypothesis of no autocorrelation cannot be rejected, again with exception of the historical index series and the Corfinsura and Grupo Aval stocks,

TABLE 5. Estimate of Weekly Returns–Moderation of Variance

Series	Variable	Coefficient	*Est. Error*	z-statistic
IBB	C	0.0007	0.0002	35.562
	ARCH(1)	0.3161	0.0983	32.154
	GARCH(1)	0.2236	0.1442	15.511
IBOMED	C	0.0003	0.0002	12.453
	ARCH(1)	0.1054	0.0543	19.407
	GARCH(1)	0.7170	0.1566	45.793
IGBC	.....	.....	....	....
ALM. EXITO	.....	.....	....	....
BANCO DE BOGOTÁ	C	0.0000	0.0000	–0.5374
	ARCH(1)	–0.0026	0.0441	–0.0579
	GARCH(1)	0.9898	0.0605	163.615
BANCOLOMBIA	.....	.....	....	....
BAVARIA	.....	.....	....	....
CEM. ARGOS	.....	.....	....	....
CEM. CARIBE	.....	.....	....	....
CEM. PAZ DEL RIO	.....	.....	....	....
COLINVERSIONES	.....	.....	....	....
COLT. ADJ.	.....	.....	....	....
CORFINSURA	.....	.....	....	....
GRUPO AVAL	.....	.....	....	....
INTERBOLSA	.....	.....	....	....
NAL DE CHOCS.	.....	.....	....	....
SURAMERICANA	.....	.....	....	....
VLRS.BAVARIA	.....	.....	....	....

TABLE 6. Estimate of Monthly Returns–Moderation of Variance

Series	Variable	Coefficient	*Est. Error*	z-statistic
IBB	C	0.0010	0.0007	14.882
	ARCH(1)	0.1539	0.0942	16.337
	GARCH(1)	0.6881	0.1330	51.745
IBOMED	C	0.0010	0.0006	16.893
	ARCH(1)	0.1611	0.0984	16.372
	GARCH(1)	0.7043	0.1204	58.490

TABLE 7. Ljung-Box Q Statistics–Daily Returns

Variables	Q-5	Prob.	Q-10	Prob.
IBB	428.770	0.000	469.510	0.000
IBOMED	612.960	0.000	664.780	0.000
IGBC	65.793	0.000	69.402	0.000
EXITO	11.091	0.050	12.551	0.250
BOGOTA	39.868	0.000	48.738	0.000
BCOLOMBIA	8.223	0.144	12.488	0.254
BAVARIA	60.400	0.000	66.617	0.000
ARGOS	40.514	0.000	47.876	0.000
CARIBE	46.534	0.000	55.347	0.000
CEPAZRIO	57.617	0.000	58.830	0.000
COLINVERS	25.850	0.000	32.661	0.000
COLTADJ	32.828	0.000	46.011	0.000
CORFINSURA	24.613	0.000	51.315	0.000
GRUPOAVAL	17.453	0.004	23.138	0.010
INTERBOLSA	0.041	1.000	0.065	1.000
CHOCOLATES	19.402	0.002	24.891	0.006
SURAMINV	17.960	0.003	25.670	0.004
VALBAVARIA	27.154	0.000	33.776	0.000

as well as of IGBC,[8] Banco de Bogotá and Almacenes Éxito for a number of four-week residues (see Tables 8 and 9).

The final test carried out in this study is the variance ratio. According to the random walk hypothesis, if there is no autocorrelation in the series, the variance of the return for the two periods must be equal to twice the variance of the return for one period;[9] thus, the ratio for such variances must be equal to one. In this analysis, this test is applied to the ratio between the variance of the return for two days and twice the return for one day, as well as to the ratio between the variance of the return for four weeks with respect to four times the return for one week. The estimates ψ and ψ^* follow a standard normal distribution, by which the null hypothesis that the variance ratio is equal to one will be rejected for the values of ψ and ψ^* outside the range $[-1.96, 1.96]$ for a 95% confidence level.

With respect to the daily series, the null hypothesis for all the daily series is rejected, both for the indexes and for the individual assets, the

TABLE 8. Ljung-Box Q Statistics–Weekly Returns

Variables	Q-2	Prob.	Q-4	Prob.
IBB	25.832	0.000	18.654	0.000
IBOMED	31.025	0.000	43.982	0.000
IGBC	1.367	0.505	8.319	0.081
EXITO	5.143	0.076	10.890	0.028
BOGOTA	0.394	0.821	12.679	0.013
BCOLOMBIA	0.711	0.701	3.834	0.429
BAVARIA	1.829	0.401	6.159	0.188
ARGOS	2.314	0.315	4.819	0.306
CARIBE	0.779	0.677	0.839	0.933
CEPAZRIO	0.354	0.838	2.305	0.680
COLINVERS	5.013	0.082	7.955	0.093
COLTADJ	5.587	0.061	6.032	0.197
CORFINSURA	7.095	0.029	15.969	0.003
GRUPOAVAL	17.010	0.000	18.868	0.001
INTERBOLSA	0.056	0.972	0.099	0.999
CHOCOLATES	0.133	0.936	1.580	0.812
SURAMINV	3.172	0.205	6.320	0.176
VALBAVARIA	2.948	0.229	3.510	0.476

TABLE 9. Ljung-Box Q Statistics–Monthly Returns

Variables	Q-6	Prob.	Q-12	Prob.
IBB	15.999	0.014	18.542	0.100
IBOMED	19.765	0.003	23.888	0.021

only exception being Interbolsa. However, when the version of the test that is robust to the heteroscedasticity ψ^* is applied, seven of the fifteen selected stocks show behavior in accordance with hypothesis RW3 (see Table 9). A similar result is obtained applying the test in its two versions for the weekly returns. Again, seven of the fifteen stocks follow a random walk, different from the behavior of all the indexes,[10] as can be observed in Tables 10 and 11.

The results of the various applied tests coincide with the following aspects: the weekly and monthly series behave more accordingly with a

TABLE 10. Variance Ratio Test–Daily Series q = 2

Series	Test Statistics		
	VR(q)	Ψ(q)	Ψ*(q)
IBB	13.500	173.389	65.415
IBOMED	14.374	216.679	54.333
IGBC	12.943	72.615	22.505
EXITO	10.828	20.428	17.523
BOGOTA	36.018	642.063	204.725
BCOLOMBIA	10.946	23.356	18.563
BAVARIA	12.944	72.663	12.554
ARGOS	12.272	56.073	34.076
CARIBE	12.359	58.208	36.109
CEPAZRIO	12.506	61.834	25.794
COLINVERS	12.144	49.597	24.932
COLTADJ	11.828	45.119	14.269
CORFINSURA	11.656	40.866	17.899
GRUPOAVAL	0.8965	–25.534	–12.306
INTERBOLSA	0.9992	–0.0187	–17.803
CHOCOLATES	11.614	39.832	27.719
SURAMINV	11.693	41.784	27.205
VALBAVARIA	12.028	50.041	20.933

random walk than the daily series, such being attributed to null returns originated from a lack of trading of individual assets on certain days. While the daily series do not follow a determined distribution, the other series follow a logistic one. On the other hand, the daily series present conditional heteroscedasticity to the difference of the weekly series.

As for the individual assets, the majority of the weekly returns behave in accordance with the random walk hypothesis including the most demanding version, RW1. Unlike the indexes, although the IGBC shows an evolution with regards to the historical indexes as, according to the K-S test, the logistic distribution hypothesis is accepted, the product residuals from the ARIMA model estimate do not present errors of the ARCH type, and, finally, according to the Q-statistic, for a number of four-week residues, the no autocorrelation hypothesis is not rejected.

TABLE 11. Variance Ratio Test–Weekly Series q = 4

Series	Test Statistics		
	VR(q)	ψ(q)	ψ*(q)
IBB	14.890	59.657	48.745
IBOMED	15.169	63.065	46.281
IGBC	21.559	69.905	62.685
EXITO	0.7865	–12.909	–0.9195
BOGOTA	18.023	48.518	29.989
BCOLOMBIA	14.371	26.436	27.240
BAVARIA	10.500	0.3023	0.2004
ARGOS	18.826	53.375	43.224
CARIBE	16.353	38.421	27.442
CEPAZRIO	16.082	36.781	33.493
COLINVERS	15.433	30.732	23.128
COLTADJ	0.0008	–60.423	–48.988
CORFINSURA	20.605	64.131	54.659
GRUPOAVAL	0.7266	–16.532	–0.9309
INTERBOLSA	12.136	12.919	13.214
CHOCOLATES	18.399	50.792	51.266
SURAMINV	22.265	74.172	71.887
VALBAVARIA	12.483	15.014	12.260

CONCLUSION

In conclusion, the analysis of the empirical evidence presented in this study shows that there has really been a structural change in the Colombian stock market since July 2001 with the merger of the three regional stock exchanges of Medellín, Bogotá and Occidente into the Colombian stock exchange. Such change has been reflected in a greater level of efficiency in this market, although a sufficient level has not yet been reached which would allow classifying this market as an efficient one, not even in the weak version of efficiency.

As for the behavior analysis of the returns of the individual assets, the findings coincide with the studies of Samuelson (1998) since the stock market is micro-efficient, but macro-inefficient, i.e., that the market efficiency hypothesis works better for individual stocks than for the aggregated price indexes of the market. Upon considering the weekly returns to avoid the problems described for the series of daily periodicity, the tests applied reject the presence of autocorrelation for most of the selected stocks, and they also abide by the requisites of the most demanding version of random walk, RW1. Such series do not present heteroscedasticity, and for them the hypothesis that they follow a certain distribution is accepted–in this case, the logistic.

On the other hand, no evidence has been found that the returns of the present Colombian stock market, measured by the profitability of its IGBC index, follow a random walk process. Nevertheless, in relation to the behavior of the historical indexes, the order of autocorrelation is observed to be less, since the possibility of obtaining extraordinary profit, based on the analysis of the historical price information is reduced. Thus, one can assert that there has been an evolution toward a greater level of efficiency for the stock market in Colombia, although to classify it as efficient, it would be necessary to take into account transaction costs which allow the conclusion concerning the possibility of obtaining extraordinary results, but which exceeds the aim of this study, whose objective has been to verify the random walk hypothesis.

The present study arrives at a conclusion similar to the one reached in studies on the subject carried out in developed markets, where the random walk hypothesis has been equally rejected, as the extensive international empirical evidence on the subject has demonstrated. The difference in those results compared with those obtained in emerging countries stem from the magnitude of the serial dependence, which makes its economic use difficult and permits those countries to more approach the efficient markets concept, at least in its weak version.

As a market acquires greater liquidity, the number of investors and issuers increase, the access to information is easier, and the market evolves toward a greater efficiency, which seems to be happening with the Colombian stock market, although it will be a long time before it can be compared to a developed market or, better yet, to be considered an efficient market.

NOTES

1. For the formation of the Colombian Stock Exchange, the Western Exchange (La Bolsa de Occidente) was also merged, which, nevertheless, has not been included in this study due to its low participation in the Colombian stock market.

2. Almacenes Éxito S.A. presents a merger by takeover with Cadenalco in November of 2001. 4.7 Cadenalco shares were traded for one Éxito share. The Éxito series is adjusted according to the terms of the merger.

3. The company, Coltabaco, split on October of 2001. Each share of that company was divided in two, one under the name Colinversiones, and the other keeping the name Coltabaco. The series ColtAdj reflects this adjustment.

4. Other stocks qualifying as being of high tradability such as Textiles Fabricato-Tejicondor and Compañía Colombiana de Tejidos COLTEJER were excluded from the portfolio because they are in a process of financial restructuring having been protected by law 550 of 1999. Carulla-Vivero is excluded because it appears as high tradability only once. ISA was a preferred stock during part of the period studied and thus was not included on the list.

5. For processing the data, we utilized the BESTFIT software, which allows carrying out the goodness of fit test concerning twenty-six distributions.

6. It should be noted that, according to the methodology employed, the goodness of fit test is accepted if the estimated alpha is inferior to what corresponds according to the confidence level required.

7. In the IBB case, the null hypothesis of no autocorrelation is rejected to a 90% confidence level.

8. With a 90% confidence level.

9. The variance of the sum is equal to the sum of the variances if the correlation is zero.

10. It is important to note that for the variance ratio test, at least 256 data are necessary for obtaining a reasonable power in comparison to alternative tests (Chow and Denning, 1993) cited in Pant and Bishnoi (2002); and in the case of the weekly returns, with exception of the historical indexes, only 128 data can be counted on.

REFERENCES

Box, G., & Jenkins, G. (1976). *Time Series Analysis: Forecasting and Control*. Revised Edition. Holden Day.

Campbell, J. Y., Lo, A. W. & MacKinley, A. C. (1997). *The Econometrics of Financial Markets*. New Jersey: Princeton University Press.

Delfiner, M. (2002). "Comportamiento de los Precios de las Acciones en el Mercado Bursátil Argentino: Un Estudio Comparativo," *CEMA Working Papers*, No 215. Universidad del CEMA Buenos Aires: Argentina.

Dolado, J., Jenkinson, T. & Sosvilla-Rivero, S. (1990) "Cointegration and Unit Roots," *Journal of Economic Surveys,* 4, pp. 249-273.

Enders, W. (1995). *Applied Econometric Times Series*. New York: J. Wiley & Sons.

Fama, E. (1965). "The Behavior of the Stock Market Prices," *Journal of Business*, pp. 34-104.

Fama, E. (1970). "Efficient Capital Markets: A Review of Theory and Empirical Work," *The Journal of Finance*, Vol. 25, No. 2, pp. 353-417.

Greene, W.H. (1997). *Econometric Analysis*. 3rd Ed. New Jersey: Prentice Hall. 1075 p.

Johnson, N. & Kotz, S. (1999a). *Distributions in Statistics*, Vol. I. New York: J. Wiley and Sons. 300 p.

Johnson, N. & Kotz, S. (1999b). *Distributions in Statistics*, Vol. II. New York: J. Wiley and Sons. 306 p.

Lo, A. W. & MacKinlay, A. C. (1988). "Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test," *Review of Financial Studies*, Vol. 1 No. 1, pp. 41-66.

Maddala, G. S. (1992). *Introduction to Econometrics*. 2nd Ed. New Jersey: Prentice Hall. 631 p.

Maya, C. & Torres, G. (2004). "Las Caminatas Aleatorias No Son de Este Mundo," *Working Paper*. Escuela de Administración, Universidad EAFIT.

Nelson, D. (1991). "Conditional Heteroskedasticity in Asset Returns: A New Approach," *Econometrica*. Vol. 59, No. 2, pp. 347-370.

Pant, B. & Bishnoi, T. R. (2002). "Testing Random Walk Hypothesis for Indian Stock Market Indices," *Nirma Institute of Management*, Ahmedabad.

Samuelson, Paul A. (1965). "Proof that Properly Anticipated Prices Fluctuate Randomly," *Industrial Management Review*, No. 6, Spring, pp. 41-49.

Samuelson, Paul A. (1973). "Proof that Properly Discounted Present Values of Assets Vibrate Randomly," *The Bell Journal of Economics and Management Science*, Vol. 4, No. 2, pp. 369-374.

Samuelson, P. A. (1998). "Summing Up on Business Cycles: Opening Address," in J. C. Fuhrer & S. Schuh (Editors), *Beyond What Causes Business Cycles*. Boston: Federal Reserve Bank of Boston.

Seiler, Michael & Rom, Walter (1997). "A Historical Analysis of Market Efficiency: Do Historical Returns Follow a Random Walk?" *Journal of Financial and Strategic Decisions*, Vol. 10, No. 2, pp. 49-57.

Stephens, M. A. (1974). "EDF Statistics for Goodness of Fit and Some Comparisons," *Journal of the American Statistical Association*, Vol. 69, pp. 730-737.

Stephens, M. A. (1976). "Asymptotic Results for Goodness-of-Fit Statistics with Unknown Parameters," *Annals of Statistics*, Vol. 4, pp. 357-369.

Stephens, M. A. (1977). "Goodness of Fit for the Extreme Value Distribution," *Biometrika*, Vol. 64, pp. 583-588.

Stephens, M. A. (1977). "Goodness of Fit with Special Reference to Tests for Exponentiality," Technical Report, No. 262. Department of Statistics. Stanford, CA: Stanford University.

SUPERINTENDÊNCIA de Valores de Colombia (2004). Disponible em: *http://www.supervalores.gov.co*. Acceso em: 30 Noviembre, 2003.

APPENDIX I

IBA Stock Tradability Index
High Tradability Stocks
July of 2001-October of 2003

	Stock	Symbol	No. Months
1	Almacenes Éxito S.A.	AO EXITO	28
2	Banco de Bogotá S.A.	AO BOGOTA	28
3	Bancolombia S.A.	AO BCOLOMBIA	28
4	Bavaria S.A.	AO BAVARIA	28
5	Cementos Argos S.A.	AO ARGOS	28
6	Cementos del Caribe	AO CARIBE	28
7	Cementos Paz del Rio	AO CEPAZRIO	23
8	Compañía Colombiana	AO COLINVERS	25
9	Compañía Colombiana	AO COLTABACO	28
10	Corporación Financiera	AO CORFINSURA	19
11	Grupo Aval Acciones y	AO GRUPOAVAL	28
12	Interbolsa S.A.	AO INTERBOLSA	8
13	Inversiones Nacional	AO CHOCOLATES	28
14	Suramericana de	AO SURAMINV	28
15	Valores Bavaria S.A.	AO VALBAVARIA	28

APPENDIX II

Unit Root Test

TABLE 1. Results of the Unit Root Test (Methodology of Dolado et al.)

Variables	Test Statistic		
	Daily	Weekly	Monthly
IBB	–261.284	–77.950	–80.917
IBOMED	–311.842	–79.539	–79.252
IGBC	–182.830	–46.325	–51.746
ALM. EXITO	–227.581	–134.761	–35.463
BANCO DE BOGOTÁ	–188.136	–44.288	–58.425
BANCOLOMBIA	–224.674	–46.812	–46.084
BAVARIA	–182.439	–49.992	–32.642
CEM. ARGOS	–196.170	–43.744	–40.430
CEM. CARIBE	–139.985	–53.035	–40.869
CEM. PAZ DEL RIO	–121.240	–52.535	–42.733
COLINVERSIONES	–186.879	–43.335	–43.509
COLT. ADJ.*	–125.612	–51.324	–32.737
CORFINSURA	–209.289	–36.124	–39.998
GRUPO AVAL	–131.327	–53.462	–28.516
INTERBOLSA	–247.833	–53.627	–151.210
NAL DE CHOCS.	–120.424	–40.746	–32.640
SURAMERICANA	–208.727	–42.123	–45.910
VLRS.BAVARIA	–202.932	–59.094	–32.402

*COLTABACO adjusted for the split of the stock in October 2001.

TABLE 2. Mackinnon Critical Values

Variables	1%	5%	10%
Daily Indexes	–34.672	–34.143	–31.289
Daily Assets	–39.777	–34.143	–31.319
Weekly Indexes	–34.453	–28.674	–25.699
Weekly Assets	–40.325	–34.455	–31.474
Monthly Indexes	–40.373	–34.478	–31.488
Monthly Assets	–36.959	–2.975	–26.265

APPENDIX III

LM Test

TABLE 1. LM Test Results

Variables	Test Statistics (obs*R^2)					
	Daily	Prob.	Weekly	Prob.	Monthly	Prob.
IBB	598.471	0.0000	72.789	0.0070	244.825	0.0000
IBOMED	2,136.889	0.0000	128.850	0.0003	40.748	0.0435
IGBC	365.146	0.0000	…	…	…	…
ALM. EXITO	…	…	…	…	…	…
BANCO DE BOGOTÁ	382.227	0.0000	96.682	0.0019	…	…
BANCOLOMBIA* **	117.695	0.0082	0.0652	0.7985	…	…
BAVARIA	763.303	0.0000	20.965	0.1476	…	…
CEM. ARGOS	118.819	0.0006	…	…	…	…
CEM. CARIBE* **	193.626	0.0002	…	…	…	…
CEM. PAZ DEL RIO* **	280.743	0.0000	…	…	…	…
COLINVERSIONES **	85.569	0.0034	…	…	…	…
COLT. ADJ.	114.525	0.0007	28.316	0.0924	…	…
CORFINSURA	282.212	0.0017	0.0428	0.8360	…	…
GRUPO AVAL	0.3808	0.5372	0.0167	0.8972	…	…
INTERBOLSA	…	…	…	…	…	…
NAL DE CHOCS.	17.821	0.1819	…	…	…	…
SURAMERICANA	82.932	0.0040	…	…	…	…
VLRS.BAVARIA	89.851	0.0027	…	…	…	…

***Test with three residues for daily series.
**Test with two residues for daily series.