

Time Series Properties of Four Latin American Equity Markets: Argentina, Brazil, Chile and Mexico

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Extracto

Este trabajo investiga la hipótesis de *random walk* para cuatro mercados de capitales latinoamericanos: Argentina, Brasil, Chile y México. Se emplean dos versiones del test de razón de varianza: suponiendo homosedasticidad y razón de varianza robusta a heterosedasticidad. Los datos corresponden a precios mensuales de índices nacionales expresados en dólares para el período diciembre 1975 a marzo 1991.

La razón de varianza acepta la *random walk* para Argentina, Brasil y México, pero la rechaza para Chile. Estos resultados sugieren que los inversores extranjeros no pueden ganar retornos extraordinarios invirtiendo en estos mercados. Sin embargo, las bajas correlaciones entre los índices indican que invirtiendo en estos países se puede reducir el riesgo de las carteras de inversión.

Abstract

Variance ratio tests indicate that the equity markets of Argentina, Brazil and Mexico follow random walks, but not those of Chile. The low correlations among the four markets suggest that investments in these countries can contribute to reduce portfolio risk.

The research on the random walk hypothesis has been heavily concentrated on the large equity markets of the United States, Canada, Japan and Europe (Summers 1986; Fama and French 1986a, 1986b; Lo and MacKinlay 1988, and Poterba and Summers 1988). Even though some studies have been conducted for stock markets of developing countries (Errunza 1983 and Errunza and Losq 1985), little research has been done in Latin American capital markets (Errunza and Losq 1987).

This paper employs the variance-ratio test to investigate the random walk hypothesis for the following four Latin American equity markets: Argentina, Brazil, Chile and Mexico. Two versions of the variance-ratio tests are implemented: first, the variance-ratio under the maintained hypothesis of homoscedasticity and, second, the heteroscedasticity-robust variance-ratio.

The empirical results reported in the paper indicate that the random walk hypothesis is rejected for Chile but it is generally confirmed for Argentina, Brazil and Mexico. Therefore, American investors might not be able to develop investment strategies that can generate abnormal returns in these three countries. However, the low correlation among these markets suggests that American investors can reduce the risk of their portfolios by diversifying in international stocks of these countries.

1. Methodology

This paper utilizes the variance-ratio method of Lo and MacKinlay (1988, 1989). The intuition behind the variance-ratio test is the following: if the natural logarithm of a time series denoted Y_t is a pure random walk of the form

$$Y_t = \mu + Y_{t-1} + \epsilon_t \quad (1)$$

then, the variance of its q -differences grows proportionally with the difference q . That is, the variance of the increments in a random walk is linear in the sampling interval. Therefore, if a time series follows a random walk process, the variance of its q -differences should be q times the variance of its first differences. If we have $nq + 1$ stock price observations, $P_0, P_1, P_2, \dots, P_{nq}$ at equally spaced intervals (q is any integer greater than one), then the ratio of $1/q$

times the variance of $Y_t - Y_{t-q}$ to the variance of $Y_t - Y_{t-1}$ would be equal to one, where Y is the natural logarithm of the price P .

Let us define

$$VR(q) = \frac{\sigma^2(q)}{\sigma^2(1)}, \quad (2)$$

where $\sigma^2(q)$ is $1/q$ the variance of the q -differences and $\sigma^2(1)$ is the variance of the first differences.

The following formulas for calculating $\sigma^2(q)$ and $\sigma^2(1)$ are taken from Lo and MacKinlay 1988:

$$\sigma^2(q) = \frac{1}{m} \sum_{t=q}^{nq} (Y_t - Y_{t-q} - q\hat{\mu})^2, \quad (3)$$

where

$$m = q(nq - q + 1) \left[1 - \frac{q}{nq} \right]$$

and

$$\sigma^2(1) = \frac{1}{(nq - 1)} \sum_{t=1}^{nq} (Y_t - Y_{t-1} - \hat{\mu})^2, \quad (4)$$

where

$$\hat{\mu} = \frac{1}{nq} (Y_{nq} - Y_0)$$

Lo and MacKinlay 1988 derive two asymptotic standard normal test-statistics for their variance-ratio. The first is developed under the maintained hypothesis of homoscedasticity, which implies the error terms in the random walk process are i.i.d. and constant volatility over time. The asymptotic variance of the variance-ratio under homoscedasticity $\phi(q)$ is

$$\phi(q) = \frac{2(2q-1)(q-1)}{3q(nq)} \quad (5)$$

and the standard normal test-statistic under homoscedasticity $Z(q)$ is

$$z(q) = \frac{VR(q) - 1}{[\phi(q)]^{1/2}} \sim N(0,1). \quad (6)$$

The second test-statistic is robust to heteroscedasticity. This statistic is important because it is now a widely held belief among financial economists that stock volatility changes over time (Merton 1980, French, Schwert and Stambaugh 1987). The heteroscedasticity-consistent asymptotic variance of the variance-ratio $\phi^*(q)$ is given by

$$\phi^*(q) = \sum_{j=1}^{q-1} \left[\frac{2(q-j)}{q} \right]^2 \hat{\sigma}(j), \quad (7)$$

where

$$\hat{\sigma}(j) = \frac{\sum_{t=j+1}^{nq} (Y_t - Y_{t-1} - \hat{\mu})^2 (Y_{t-j} - Y_{t-j-1} - \hat{\mu})^2}{\left[\sum_{t=1}^{nq} (Y_t - Y_{t-1} - \hat{\mu})^2 \right]^2}. \quad (8)$$

Finally, the heteroscedasticity-consistent standard normal test-statistic $Z^*(q)$ corresponds to

$$z^*(q) = \frac{VR(q) - 1}{[\phi^*(q)]^{1/2}} \sim N(0,1). \quad (9)$$

2. Data

The data used in this paper are monthly national index prices, in U.S. dollars, for four Latin American national market indexes: Argentina, Brazil, Chile, and Mexico. The data sample, obtained from IFC, corresponds to the December 1975 to March 1991 time period. The IFC indices are capitalization-weighted indices of listed stocks selected on the basis of liquidity, market capitalization, and industry classification. The combined market value of the indices are approximately sixty percent of the total market capitalization at the end of each year. Even though liquidity and size are important criteria for inclusion in the indices, the IFC may include in the indices small companies whose stocks are not actively traded in order to give a balanced view of the capitalization of the market.

3. Analysis of the Empirical Results

The relevant returns for an American investing in foreign securities are returns adjusted by the exchange rates between the U.S. dollar and the domestic currencies. In order to investigate the time series properties of Latin American stocks from the viewpoint of an American investor, variance-ratio tests are applied to the national equity market indices of Argentina, Brazil, Chile and Mexico. The base observation interval is one month. Variance-ratio estimates, $VR(q)$, asymptotic variances of the variance-ratio, $\phi(q)$ and $\phi^*(q)$, and variance-ratio statistics, $Z(q)$ and $Z^*(q)$ are computed for the following intervals, $q = 2, 4, 8, 16, 24$ and 30 . That is, by using one month as the base interval, $VR(q)$, $\phi(q)$, $\phi^*(q)$, $Z(q)$ and $Z^*(q)$ are calculated for each q by comparing the variance of the one-month base interval with that of two-month, four-month, eight-month, sixteen-month, twenty-four-month, and thirty-month observation intervals.

The value estimates of $VR(q)$ and $Z(q)$ under the maintained hypothesis of homoscedasticity are presented in panel A of table 1. It can be seen that the random walk hypothesis is confirmed for Argentina, Brazil, and also for Mexico for investment horizons longer than four months. However, the random walk is rejected for Chile. Rejection of the random walk may be due either to heteroscedasticity or to serial correlation. In order to discriminate between these two possibilities, an heteroscedasticity-robust variance-ratio test is implemented.

The heteroscedasticity-consistent variance-ratios are reported in panel B of table 1. Again, the null of random walk is fully confirmed for Argentina and Brazil, and also for Mexico for periods longer than four months. The random walk is again rejected for Chile. The rejection of the random walk for Chile agrees with Gregoire 1985, who has also found, using data for the 1973-1984 time period, that Chilean stock returns do not follow a random walk process. The results of panel B suggest that rejections of the random walk are due to autocorrelation of monthly stock prices.

Table 1

*Variance-Ratio Estimates for Four Latin American Emerging
Stock Markets
Monthly Returns — U.S. Dollar — Sample Period:
December 1975 - March 1991*

Variance-ratio tests of the random walk hypothesis for monthly stock index prices for the following emerging stock markets: Argentina, Brazil, Chile, and Mexico. One month is taken as a base observation interval. The variance-ratios are reported in the main rows and the test statistics are in parentheses. An asterisk * indicates that the variance-ratio is statistically different from one at the 5% significance level (rejection of the random walk).

EMERGING MARKET	NUMBER OF BASE OBSERVATIONS AGGREGATED TO FORM VARIANCE-RATIO					
	2	4	8	16	24	30
PANEL A: VARIANCE-RATIOS UNDER HYPOTHESIS OF HOMOSCEDASTICITY						
Argentina	1.012 (0.156)	1.026 (0.185)	0.862 (-.619)	0.742 (-.757)	0.628 (-.857)	0.545 (-.914)
Brazil	0.997 (-.042)	0.935 (-.463)	0.879 (-.539)	0.907 (-.273)	0.676 (-.745)	0.538 (-.927)
Chile	1.155* (2.081)	1.500* (3.574)	1.657* (2.937)	2.392* (4.086)	2.650* (3.798)	2.820* (3.652)
Mexico	1.257* (3.461)	1.267* (2.908)	1.344 (1.540)	1.575 (1.688)	1.604 (1.389)	1.601 (1.205)
PANEL B: HETEROSCEDASTICITY-ROBUST VARIANCE-RATIOS						
Argentina	1.012 (0.111)	1.026 (0.133)	0.862 (-.451)	0.742 (-.569)	0.628 (-.665)	0.545 (-.727)
Brazil	0.997 (-.036)	0.935 (-.397)	0.879 (-.467)	0.907 (-.242)	0.676 (-.678)	0.538 (-.860)
Chile	1.155* (1.028)	1.500* (3.501)	1.657* (2.919)	2.392* (4.225)	2.650* (4.107)	2.820* (4.094)
Mexico	1.257* (2.733)	1.267* (1.961)	1.344 (0.784)	1.575 (0.881)	1.604 (0.745)	1.601 (0.660)

Chile and Mexico exhibit variance-ratios larger than unity. Variance-ratios larger than one indicate positive return autocorrelation. These results agree with Lo and MacKinlay 1988 and Poterba and Summers 1988, who find positive autocorrelation for the NYSE and AMEX and other European equity indices. Plausible explanations are the presence of small companies in the ICF indices, thin trading, noise trading, and local government interventions.

The evidence that the random walk hypothesis cannot generally be rejected for Argentina, Brazil, and Mexico, suggests that American investors might not be able to develop trading strategies that would allow them to earn excess returns. Foreign investors could profit from investments in Chile and in Mexico (for investment horizons shorter than four months). However, this conclusion must be taken with caution, because the results presented in this paper have been obtained using returns before adjusting for transaction costs. As it has been reported in many tests of market efficiency (i.e. Fama 1970), once returns are adjusted by brokers' commissions, abnormal returns would probably vanish.

Nevertheless, American investors can still benefit by diversifying internationally in these Latin American markets. In effect, the low and statistically insignificant correlation coefficients of monthly returns in U.S. dollars shown in Table 2 suggest that the risk of an American investor's portfolio can be reduced by investing in Latin American stocks.

Table 2

*Correlation Coefficients of Latin American
Emerging Stock Markets Monthly Returns
U.S. Dollar — Sample Period: December 1975 - March 1991*

	ARGENTINA	BRAZIL	CHILE	MEXICO
Argentina	1.000* (0.000)			
Brazil	-0.061 (0.409)	1.000* (0.000)		
Chile	0.114 (0.124)	0.003 (0.973)	1.000* (0.000)	
Mexico	0.114 (0.126)	-0.054 (0.465)	0.147 (0.150)	1.000* (0.000)

Notes. - Probabilities are in parentheses.
- An asterisk (*) indicates the null of no correlation is rejected at the 5% of significance level.

4. Summary and Conclusions

The paper tests the random walk hypothesis for four Latin American equity indices: Argentina, Brazil, Chile and Mexico. The data correspond to monthly prices in U.S. dollars covering the December 1975 to March 1991 time period.

Variance-ratio estimates obtained under both the maintained hypothesis of homoscedasticity and the heteroscedasticity-robust test indicate that the stock markets of Argentina, Brazil, and Mexico follow a random walk process. The random walk is rejected for Chile. These results suggest that American investors might not be able to earn excess returns by investing in the Argentinean, Brazilian, and Mexican markets, but they might succeed in Chile and also in Mexico (for investment horizons shorter than four months). In addition, the low correlations among these four Latin American national index prices suggest that American investors can reduce the risk of their portfolios by diversifying internationally in the stocks of these countries.

References

- ERRUNZA, V. (1983). "Emerging Markets — a New Opportunity for Improving Global Portfolio Performance", *Financial Analysts Journal*, pp. 51-58.
- ERRUNZA, V. and E. LOSQ (1985). "The Behavior of Stock Prices on LDC Markets", *Journal of Banking and Finance*, pp. 561-575.
- (1987). "How Risky are Emerging Markets? Myths and Perceptions versus Theory and Evidence," *Journal of Portfolio Management*, pp. 62-66.
- FAMA, E. (1970). "Efficient Capital Markets: a Review of Theory and Empirical Work", *Journal of Finance* 25, pp. 383-417.
- FAMA, E. and K. FRENCH (1986a). *Permanent and Temporary Components of Stock Prices* (Working Paper 178). Chicago: University of Chicago, Center for Research in Security Prices.

- (1986b). *Common Factors in the Serial Correlation of Stock Returns* (Working Paper 200). Chicago: University of Chicago, Center for Research in Security Prices.
- FRENCH, K., G.W.SCHWERT and R.F.STAMBAUGH (1987). "Expected Stock Returns and Volatility", *Journal of Financial Economics* 19, pp. 3-30.
- GREGOIRE, J. (1985). "El ajuste de los precios accionarios a la información: resultados empíricos", *Paradigmas en Administración* (Santiago de Chile) 7, pp. 121-131.
- LO, A. and C.MACKINLAY (1988). "Stock Market Prices Do not Follow Random Walks: Evidence from a Simple Specification Test", *Review of Financial Studies* 1, pp. 41-66.
- (1989). "The Size and Power of the Variance-Ratio Test in Finite Samples: a Monte Carlo Investigation", *Journal of Econometrics* 40, pp. 203-238.
- MERTON, R.C. (1980). "On Estimating the Expected Return on the Market: an Exploratory Investigation", *Journal of Financial Economics* 8, pp. 323-361.
- POTERBA, J.M. and L.H.SUMMERS (1988). "Mean-Reversion in Stock Prices: Evidence and Implications", *Journal of Financial Economics* 22, pp. 27-59.
- SUMMERS, L.H. (1986). "Does the Stock Market Rationally Reflect Fundamental Values?", *Journal of Finance* 41, pp. 591-601.