Episodic Nonlinearity in Latin American Stock Market Indices

Claudio A. Bonilla (Corresponding author)
Facultad de Economía y Negocios
Universidad del Desarrollo
Av. Las Condes 12438, Lo Barnechea, Chile
Phone: (56 2) 299 9232
Fax: (56 2) 299 9219
cbonilla@udd.cl

Melvin J. Hinich
Applied Research Laboratories
The University of Texas at Austin
P. O. Box 8029, Austin Texas, USA
Phone: (512) 835 3200
Fax: (512) 835 3259
hinich@mail.la.utexas.edu

Rafael Romero-Meza
Facultad de Ciencias Económicas y Administrativas
Departamento de Administración
Universidad de Chile
Diagonal Paraguay 257, Santiago, Chile
Phone: (56 2) 678 3709
Fax: (56 2) 222 0639
rromero@negocios.uchile.cl

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Abstract

This letter applies the Hinich portmanteau bicorrelation test jointly with the windowed testing procedure to detect nonlinear behavior in the rate of returns series for seven Latin American stock market indices. Our results suggest that the nonlinear serial dependencies are episodic in nature. All the stock returns series are characterized by few brief periods of highly significant nonlinearity, followed by long time periods in which the returns follow a pure noise process. Our findings help explain why there are difficulties in forecasting asset returns.

JEL Classification: C12, G19

Key words: Latin American stock indices, episodic nonlinearity, Hinich portmanteau bicorrelation test

I. Introduction

Twenty years ago, Hinich and Patterson (1985) were among the first in reporting evidence of nonlinearity in daily stocks returns for the NYSE. Since then, the study of nonlinear behavior in the stock market has become a growing field in the financial econometric literature. We find studies of nonlinearity across different countries. Developed capital market like the US (Hinich and Patterson, 1985; Scheinkman and LeBaron, 1989; Hsieh, 1991); the UK (Abhyankar *et al,* 1995; Opong *et al,* 1999) and Germany (Kosfeld and Robé, 2001) among others have been studied. We also find studies of nonlinearity in developing capital markets like Taiwan (Ammerman and Patterson, 2003); Turkey (Antoniou *et al,* 1997); and several Asian stock markets (Lim and Hinich, 2005).

This paper uses the windowed testing procedure to apply the Hinich portmanteau bicorrelation non-parametric test (Hinich and Patterson, 1995 and Hinich, 1996) in several Latin American stock markets. This procedure divides the data in frames to test for nonlinearity. When frames are linear is possible to do short run forecasting depending on the nature of the serial correlation. However if the frame is nonlinear the method for forecasting is still an open mathematical problem.

Examples of applications using similar methodologies are Brooks (1996), Brooks and Hinich (1998) and Lim and Hinich (2005). Brooks (1996) finds evidence of nonlinearities in set of ten daily sterling exchange rates covering the entire post Bretton-Woods era. Brooks and Hinich (1998) examine the episodic nature of ten European exchange rates and conclude that the nonlinear structure that is present in the data invalidate the GARCH specification usually assumed in the

study of exchange rates. Lim and Hinich (2005) apply the windowed testing procedure to fourteen Asian stock market indices, and they also find nonlinear behavior of episodic nature.

Nonlinear behavior of exchange rates and stock markets has also been studied using parametric approaches. Here we find the works of Erlat (2004), Caporale and Spagnolo (2004), Mills and Jordanov (2003), Liew *et. al.* (2003), and McMillan and Speight (2001). However, in spite of the growing interest of this line of research in most part of the financial world, the possibility for nonlinear behavior in Latin American markets have rarely been studied.[1]

It is of interest to study the Latin American financial markets since they are among the most unstable financial markets in the world. In these countries, political and social events usually affect the volatility of the rate of returns of the financial assets, as well as internal and external economic shocks. Therefore, we expect to see in these markets several episodes where the rates of returns present nonlinear behavior.

This is the first time that nonlinearity will be studied in a systematic way in the most important Latin American emerging markets (Mexico, Brazil, Argentina, Chile, Colombia, Venezuela and Peru). Our paper constitutes the first attempt to study nonlinearity in these markets using a widely accepted technique in the financial econometric literature, the Hinich portmanteau bicorrelation test.

II. The Hinich Portmanteau Bicorrelation Test

[1] There are few exceptions that, using different methodologies, have analyzed stocks returns for one particular Latin American market (see Arango *et al* (2004) and Valdes (2002))

In this section we briefly describe the windowed test procedure and the Hinich portmanteau bicorrelation test statistic (denoted as H statistic). Let the sequence $\{y(t)\}$ denote the sampled data process, where the time unit t is an integer. The test procedure employs non-overlapped data window, thus if n is the window length, then the k-th window is $\{y(t_k), y(t_k+1),....., y(t_k+n-1)\}$. The next non-overlapped window is $\{y(t_{k+1}), y(t_{k+1}+1),..... y(t_{k+1}+n-1)\}$, where $t_{k+1} = t_k+n$. The null hypothesis for each window is that $y\{t\}$ are realizations of a stationary pure noise process that has zero bicorrelation. The alternative hypothesis is that the process generated within the window is random with some non-zero bicorrelations $C_{yyy}(r, s) = E[y(t)y(t+r)y(t+s)]$ in the set $0 < r < s < L$, where L is the number of lags that define the window.

The Hinich portmanteau H statistics and its corresponding distribution are:[2]

$$H = \sum_{s=2}^{L}\sum_{r=1}^{s-1} G^2(r,s) \quad \sim \chi^2_{(L-1)(L/2)} \qquad (1)$$

where $G(r,s) = (n-s)^{\frac{1}{2}} C_{ZZZ}(r,s)$, and $C_{ZZZ}(r,s) = (n-s)^{-1}\sum_{t=1}^{n-s} Z(t)Z(t+r)Z(t+s)$ for $0 \leq r \leq s$.

The $Z(t)$ are the standardized observations, obtained by subtracting the sample mean of the window and dividing by its standard deviation. The number of lags L is specified as $L= n^b$ with $0 < b < 0.5$, where b is a parameter under the choice of the analyst. Based on results from Monte Carlo simulations (see Hinich and Patterson, 1995), the recommended use of b is b=0.4 in order to maximize the power of the test while ensuring a valid approximation to the asymptotic theory. In

[2] For a mathematical derivation of this statistics and its small sample properties see Hinich and Patterson (1995) and Hinich (1996)

this test procedure, a window is significant if the *H* statistic rejects the null of pure noise at the specified threshold level.

III. The Data

The analysis presented here is based on daily data obtained from ECONOMATICA for seven Latin American stock market indices: BOVESPA (Brazil), MERVAL (Argentina), IPC (Mexico), IGPA (Chile), IGBC (Colombia), IGBVL (Peru) and IBC (Venezuela). The sample periods for the indices are: BOVESPA from April 1993 to October 2004, MERVAL from October 1996 to October 2004, IPC from November 1991 to October 2004, IGPA from January 1990 to September 2002, IGBC from January 1991 to October 2004, IGBVL from January 1986 to October 2004, and IBC from November 1990 to October 2004. The data is transformed in the following way: $r_t = \ln(p_t / p_{t-1})$, where p_t is the closing price of the market stock index in day t. This can be interpreted as a continuously compounded daily return (see Brock et al, 1991).

III. Empirical Results

Before checking for nonlinearity we remove linear dependencies by fitting an AR(p) fit to the return series. This way we make sure that the rejection of the null hypothesis of pure noise at the specified threshold level is due only to significant nonlinearity.

To apply the test, the data has been divided into a set of non-overlapped window of 25 observations in length. The window length should be sufficiently long to validity apply the test and yet short enough to capture nonlinear episodes within a window (Brooks and Hinich, 1998). The

portmanteau bicorrelation test is then applied to the residuals of the fitted AR(p) model. Table 1 presents the results for the bicorrelation test using the windowed test procedure for all returns series.

<<Insert Table 1 here>>

The third row shows the number of windows where the null hypothesis of pure noise is rejected by the *H* statistic with percentage in parenthesis[3]. As we can see, every Latin American Index has at least one window where significant nonlinearity is present, rejecting the random walk hypothesis of the rate of returns for all the Latin American Markets.

The results reveal that the nonlinear serial dependencies are not persistent across time for all the indices. Instead, all the stock returns series seem to be characterized by few brief episodes of highly significant non-linearity surrounded by long periods of pure noise.

It is interesting to observe that the Chilean market index (IGPA) presents 15 significant windows that amount for the 11.81% of total windows, and that this percentage of significant windows is much larger than any other of the Latin American market studied, and also larger than the percentage reported in other emerging markets studies that used the Hinich portmanteau bicorrelation test (see Lim and Hinich, 2005). This peculiarity of the Chilean market has to be studied in more detail in future research. It may be the case that the high relative importance of the

[3] In this study the threshold level was set at 0.01. The level of significance is the bootstrapped thresholds that correspond to 0.01.

Chilean private pension funds (AFP) and the relative performance regulation that govern such small stock market is playing a role in the episodic nonlinearities encountered here.

The last row of Table 1 provides the dates when these dependencies occurred, which is potentially useful for future investigation into the events that lead to this non-linear behaviour in each of the markets.

IV. Conclusions

This letter uses the Hinich portmanteau bicorrelation test to study episodic nonlinear events in seven Latin American stock market indices. The results are consistent with findings in previous research that applied the same methodology to the Asian stock markets and exchange rates. They reveal that the nonlinear serial dependencies are episodic in nature, that is, all the stock returns series are characterized by few brief periods of highly significant nonlinearity, followed by long time periods in which the returns follow pure noise process.

The rejection of the efficient market hypothesis for the seven Latin American markets opens the possibility of return predictability. However, the episodic nature of the nonlinearities makes difficult to know when the serial dependencies will appear and when they will vanish.

Finally, it called our attention the high number of significant windows for the Chilean index. It would be of interest to study whether the special characteristics of the Chilean market, dominated by the AFPs under a relative performance regulation, have responsibility in the high frequency of the nonlinear events.

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Table 1
Windowed-Test Results for Latin American Stock Market Indices

	BVSP	**MERVAL**	**IPC**	**IGPA**	**IGBC**	**IGBVL**	**IBC**
Fitted AR(p)	AR(1)	AR(2)	AR(0)	AR(0)	AR(1)	AR(1)	AR(1)
Total Nº of windows	113	79	128	127	125	180	69
Windows with significant H-statistics	5 (4.35%)	2 (2.53%)	1 (0.78%)	15 (11.81%)	1 (0.8%)	4 (2.22%)	3 (4.35%)
Dates of significant windows	9/17/93 10/22/93 6/20/97 7/25/97 6/29/00 8/12/00 7/3/01 8/8/01 2/20/04 3/29/04	6/24/97 7/29/97 9/4/97 10/8/97	5/28/92 7/2/92	4/19/90 5/25/90 8/8/90 9/13/90 8/14/92 9/21/92 10/26/93 11/30/93 8/10/94 9/14/94 2/8/95 3/14/95 4/20/95 5/25/95 7/8/97 8/11/97 3/23/99 4/27/99 9/27/99 10/26/99 10/27/99 12/1/99 2/16/01 3/22/01 8/20/01 9/26/01 9/27/01 11/2/01 12/10/01 1/16/02	3/8/93 4/16/93	11/13/87 12/21/87 4/6/95 5/17/95 11/4/97 12/10/97 6/14/00 7/20/00	1/13/98 3/20/98 3/21/01 6/22/01 10/21/03 12/18/03

Nota: BVSP (Brasil), MERVAL (Argentina), IPC (Mexico), IGPA (Chile), IGBC (Colombia), IGBVL (Peru), IBC (Venezuela)