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# Nonlinear event detection in the Chilean stock market

Rafael Romero-Meza<sup>a,b,\*</sup>, Claudio A. Bonilla<sup>c</sup> and Melvin J. Hinich<sup>d</sup>

<sup>a</sup>*Escuela de Negocios de Valparaíso, Universidad Adolfo Ibáñez, Av. Diagonal Las Torres 2640, Peñalolen, Santiago, Chile*

<sup>b</sup>*Faculty of Economics and Business, Department of Management and Finance, University of Chile, Diagonal Paraguay 257, Santiago, Chile*

<sup>c</sup>*Facultad de Economía y Negocios, Universidad del Desarrollo, Av. La Plaza 700, Las Condes, Santiago, Chile*

<sup>d</sup>*Applied Research Laboratorios, The University of Texas at Austin, P. O. Box 8029, Austin Texas, USA*

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This study searches for economic and political events that may explain the episodic nonlinearities detected in the returns series of the Chilean stock market index. This methodology is a reverse form of event study. After applying the Hinich portmanteau bicorrelation test to detect episodes of nonlinear behaviour of the index, we investigate what might be the explanation of this behaviour. Our findings may help to explain the difficulty to forecast asset returns. We also shed some light into the major political and economic events that contribute to the numerous short bursts of nonlinear dependence in the Chilean stock market.

## I. Introduction

Since the pioneering work of Hinich and Patterson (1985), there has been growing evidence that stock market returns present sporadic nonlinear behaviour. We find studies of nonlinearity across developed and developing capital markets. There are examples of studies in developed capital markets 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), while examples for developing capital markets are Taiwan (Ammerman and Patterson, 2003); Turkey (Antonioni *et al.*, 1997); several Asian stock markets (Lim and Hinich, 2005a) and several Latin American stock markets (Bonilla *et al.*, 2006).

In spite of the existence of worldwide evidence of nonlinear behaviour of stock market returns, there is little knowledge about the factors behind

this behaviour. Hence, the aim of this study is to shed further light into this widely observed episodic feature of financial time series. In order to do that, we use a reverse form of event study in the same spirit of Brooks *et al.* (2000) and Lim and Hinich (2005b). This methodology has two steps. First, we apply the Hinich portmanteau bicorrelation test to detect episodes of nonlinear behaviour of the Chilean index. Second, we investigate what might be the major economic and political event that explains that behaviour. We expect that our findings will help to explain why it is so difficult to forecast asset returns.

The Chilean economy is a small and open economy. Working with a small economy facilitates the identification of important economic and political events. Another characteristic of the Chilean capital markets is its openness, which makes this market highly integrated to the international capital market. We observe that many of the Chilean blue chip companies have issued American Depository Receipt (ADR) in

\*Corresponding author. E-mail: rafael.romero@uai.cl

the US and that there are few restrictions to capital movement in this small country.

On statistical grounds, this study uses the windowed testing procedure to apply the Hinich portmanteau bivariate nonparametric test (Hinich, 1996; Hinich and Patterson, 2005) in the Chilean stock markets. This procedure divides the data in frames to test for nonlinearity. Examples of applications using similar methodologies are Brooks (1996), Brooks and Hinich (1998), Lim and Hinich (2005a) and Bonilla *et al.* (2006). Brooks (1996) finds evidence of nonlinearities in a 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 (2005a) apply the windowed testing procedure to fourteen Asian stock market indices and find several nonlinear episodes. Bonilla *et al.* (2006) encounters similar results for the seven most important Latin American stock market indices.

Nonlinear episodes detected in the Chilean stock return index would be the result of market adjustment to unexpected local and international shocks. When new information arrives to the market, it would generate a pattern of nonlinear price movements relative to previous movements since the traders are unsure of how to react, and hence they respond slowly. Moreover, we would expect that regulatory changes that affect the private pension funds (AFP) industry might cause nonlinear behaviour.

After identifying some windows of nonlinearity, we search for economic and political events that might explain this behaviour. There are some interesting results in related papers. Ammermann and Patterson (2003) find that the episodic dependence in the Taiwan stock return index would be directly attributable to changes in the price limits implemented during the year 1987 and 1988. Brooks *et al.* (2000) find that the nonlinear dependency structures in ten daily Sterling exchange rates are highly localized in time, and that they would be attributed to widespread upsets in the currency markets and changes in US accounting procedures that affected US firms with business abroad. Finally, Lim and Hinich (2005b) identify a number of key events that explain seven nonlinear episodes in the Malaysian stock return index, such as the Baring debacle, local political and economic changes and international political and financial relevant news.

<sup>1</sup>For a mathematical derivation of this statistics and its small sample properties see Hinich and Patterson (2005) and Hinich (1996).

## II. The Hinich Portmanteau Bivariate Test

In this section we briefly describe the windowed test procedure and the Hinich portmanteau bivariate 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 nonoverlapped data window, thus if  $n$  is the window length, then the  $k$ th window is  $\{y(t_k), y(t_k + 1), \dots, y(t_k + n - 1)\}$ . The next nonoverlapped window is  $\{y(t_{k+1}), y(t_{k+1} + 1), \dots, y(t_{k+1} + n - 1)\}$ , 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 bivariate correlation. The alternative hypothesis is that the process generated within the window is random with some nonzero bivariate correlations  $C_{yyy}(r, s) = E[y(t)y(t+r)y(t+s)]$  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<sup>1</sup>:

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

where  $G(r, s) = (n-s)^{1/2} C_{ZZZ}(r, s)$ , 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, 2005), 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 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 for the Índice General de Precios de Acciones (IGPA), the Chilean stock market index. The data was obtained from ECONOMATICA. The sample period for the index is January 1990 to September 2002. The data were 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 standard transformation may be interpreted as a continuously compounded daily return (see Brock *et al.*, 1991).

Information about the major economic and political events that may trigger episodic nonlinearities was obtained from different sources: First, we used monthly reports obtained from the Chilean Security Commission. Then, we study the Official Newspaper (a newspaper that publishes any legal change and important information for the Chilean business community). Finally, we search international newspapers, available in the national public library, to get information about international events.

#### IV. Empirical Results

Before checking for episodes of nonlinearity, we removed linear dependencies by fitting an AR(p) to the return series. Then, we may apply the Hinich bicorrelation test to the residuals of the AR(p) model. We do that to demonstrate that the nonstationarity is a consequence on nonlinearity, which is episodically present in the data, rather than a form of linear dependence.

In order to apply the test, we divided the data into a set of nonoverlapped window of 25 days. The window length should be sufficiently long to validly apply the test and yet short enough for the data generating process to have remained roughly constant (Brooks and Hinich, 1998). The portmanteau bicorrelation test is then applied to the residuals of the fitted AR(0) model. Table 1 presents the results for the bicorrelation test using the windowed test procedure for the IGPA returns series. We see in the third column that the Chilean index has fifteen windows where significant nonlinearity is present, rejecting the random walk hypothesis of the rate of returns for the specific threshold level.<sup>2</sup>

Interestingly, the percentage of significant windows (11.81%) of the Chilean index is much larger than the respective proportion found in other European, Latin American or Asian indices, as has been reported in previous studies (see Brooks and Hinich, 1998; Lim and Hinich, 2005a; Bonilla *et al.*, 2006). This peculiarity of the Chilean market requires further research, and this study attempts to give some preliminary answers.

It has been proposed that the regulation of the highly important Chilean AFP industry may play a role in the episodic nonlinearities that we found. Our findings give support to this hypothesis since for several windows of nonlinearities there were events associated with changes in the AFP regulations.

However, there are also important international events that may affect the behaviour of the Chilean stock market (see the last column of Table 1). For example, given the dependence of the Chilean economy to commodity prices, we find that the shocks in oil and copper markets may help to explain some episodes of nonlinearity (40% of the Chilean exportations come only from copper). Moreover, the Chilean stock market index seems to be highly affected by international crisis, such as the Gulf War, the Baring debacle, the War of Kosovo and the attack to the Twin Towers. This high sensitivity to international events may be due to the high integration of the Chilean capital market to the rest of the world (Parisi, 1996).

#### V. Conclusions

Using the Hinich portmanteau bicorrelation test, we investigate the economic and political events that may provoke the episodic nonlinearities detected on the return series of the Chilean stock market index. We use a reverse form of event study in the same spirit of Brooks *et al.* (2000) and Lim and Hinich (2005b).

We found that the percentage of significant nonlinear windows (11.81%) of the Chilean index is larger than what has been found in previous studies that apply the same methodology to European, Latin American and Asian countries. This study attempts to give some preliminary answer to this peculiarity of the Chilean market. We found that for several windows of nonlinearity there were events associated with changes in the AFP regulations.

Moreover, there are also important international events that affect the behaviour of the Chilean stock market, among them are the evolution of commodities prices and international crisis.

The study of the Chilean stock market is interesting not only because the small size of this market facilitate the identification of important economic and political events, but also because this market is

<sup>2</sup>In this study the threshold level was set at 0.01. The level of significance is the bootstrapped thresholds that correspond to 0.01.

Table 1. Windowed-test results for IGPA returns series

Fitted AR(p)	Total no. of windows	Significant H windows	Dates of significant H windows	Key events
AR(0)	127	15 (11.81%)	4/19–5/25/90 8/8–9/13/90 8/14–9/21/92 10/26–11/30/93 8/10–9/14/94 2/8–3/14/95 4/20–5/25/95 7/8–8/11/97 3/23–4/27/99 9/27–10/26/99 10/27–12/1/99 2/16–3/22/01 8/20–9/26/01 9/27–11/2/01 12/10–1/16/02	<p>The Central Bank initiated the operation of new foreign exchange norms on 4/19/90. The Central Bank modified the policy about foreign direct investment on 5/16/1190.</p> <p>Kuwait is attacked by Iraq. Increase in the price of oil, gold and US dollar on 8/3/90. Oil price is over US\$30 per barrel on 8/24/90.</p> <p>The Central Bank increases the interest rate and the deposit reserve on 8/19/92. The Central Bank eliminates restrictions on capital returns and authorizes AFPs to invest at most 3% abroad on 8/21/92.</p> <p>The copper price had the largest decrease in six years on 10/27/93. The Finance Ministry and the Central Bank reduce requirement of foreign exchange operations on 9/9/94. American legislators are unable to apply fast track to the US-Chile Free Trade Agreement on 9/14/94.</p> <p>Baring debacle: Asian markets push down the world financial market on 27/2/95.</p> <p>AFPs can operate foreign investments under new norms on 5/11/95. South East financial crisis affects Latin American financial markets on 7/16/97.</p> <p>OTAN starts attack to Yugoslavia due to Kosovo conflict on 3/25/99. Commodities registered its lowest price in 159 years on 4/19/99. There are concerns in the market for 'bubble' in the US stock market on 9/28/99.</p> <p>Oil price increased to historical record in 9 years. Iraq announces stop in export of oil on 11/23/99.</p> <p>US attack Iraq on 2/16/01.</p> <p>The American Twin Towers are attacked on 9/11/01.</p> <p>Afghanistan is attacked on 10/9/01. New Capital Market Law is announced on 10/26/01.</p> <p>Federal Reserve reduces the interest rate to the lowest level in 40 years on 12/12/01. Argentinean President De la Rúa resigns on 12/21/01.</p>

highly integrated with the international capital market.

Our findings help explain why there are difficulties in forecasting asset returns. We also shed some light on the major political and economic events that contribute to the short burst of nonlinear dependence in the Chilean stock market. Future research should definitely take a close look at the individual stocks that cause these nonlinear episodes.

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