Nonlinear Behavior of Emerging Market Bonds Spreads: The Asian Case

Abstract

We introduce a new procedure that attempt to identify nonlinear event windows. The Hinich Bicorrelation test is complemented with two statistical techniques, scarcely used in the empirical economics and finance literature, to identify nonlinear periods free of the impact of outliers for four important Asian bond´s spread series. The two complementary techniques are trimming and ´hard clipping´ that jointly used would control for the presence of outliers in the data. We find that outliers are an important element to consider in the identification of the stochastic nature of financial time series. After reducing the impact of outliers, we are able to identify in a better way the underlying nonlinear structure of the spreads series. Results suggest that nonlinear serial dependencies are episodic in nature. All the spread returns series, except for Thailand, increase the number of windows with nonlinear dependence when the percentage of trimming for outliers increases, suggesting that the latter may affect the identification of nonlinear dependence. The findings support the idea that, even in these well informed and sophisticated markets, the weak-form of the efficient market hypothesis cannot be supported, and further investigation is required to better understand the nature of financial and economic time series.

JEL Classification: C12, G19

Key words: Nonlinear behavior; Hinich portmanteau bicorrelation test; emerging market bonds spreads; Asia; efficient market hypothesis; trimming; hard clipping.

1 Introduction

In the last two and a half decades, the field of financial econometric has witnessed the growth of a number of papers reporting evidence of nonlinear behavior in the time series of stock and exchange rates of returns. This line of research started with the seminal contribution of Hinich and Patterson (1985) that applied the bispectrum test to study nonlinearities in the New York Stock Exchange. Studies of nonlinearities in developed capital markets were done by Scheinkman and LeBaron (1989), and Hsieh (1991) for the US; Abhyankar et al (1995) and Opong et al (1999) for the UK; Kosfeld and Robé (2001) for Germany among others. Studies for developing capital markets are the works of Ammerman and Patterson (2003) for Taiwan; Antoniou et al (1997) for Turkey; Panagiotidis (2005) for Greece, Lim and Hinich (2005) for the Asian markets; Bonilla et al. (2006) for several Latin American stock markets and Romero-Meza et al. (2007) for the Chilean stock market as examples.

The recent survey paper of Lim and Brooks (2011) reviews the weak-form market efficiency literature examining return predictability from past price changes focused on the stock markets, and it finds more than 300 papers in the last five years that apply a number of different methods.

The study of nonlinearities is closely linked with the concept of market efficiency. If a financial market (stock or currency market) satisfies the weak-form of the efficient market hypothesis (EMH), then future prices cannot be predicted with past prices, and the rate of return must follow a random walk. In consequence, we should not expect to have any kind of serial dependencies in the data, because that would be an indicator of potential return predictability.

Still there remain unanswered questions regarding the extent to which the presence of extreme values affects the standard identification of nonlinearity of economic and financial series. In this paper we apply the trimming and ´hard clipping´ jointly with the Hinich bicorrelation test to study the identification on nonlinear patterns without the impact of outliers.

Moreover, in spite of the worldwide evidence of nonlinear behavior of the stock and currency markets, there are few applications that study the potential of nonlinearities in the spreads of the emerging market bonds (EMB). Thus we select four important Asian markets to apply these new procedure.

EMB have been studied in the economic literature. The approached commonly used searches for aspects like macroeconomics determinants of the spreads (Edwards, 1984; Eichengreen and Mody, 2000; Jaque and Rojas, 2003), the effect of monetary policy and volatility on the spreads (Edwards and Susmel, 2003; Arora and Cerisola, 2001) and other related topics with a macro approach. However, one of the problems with this literature is the lack of focus on the financial microstructure of these markets, the potential of nonlinear behavior of the spreads, and its effects on market efficiency (Panagiotidis, 2005).

We designed a new procedure that attempt to find the largest number of windows that exhibit nonlinear dependence in the rate of return series of some of the most active Asian emerging market bonds spreads such as China, Malaysia, Philippines and Thailand. This new procedure consist in running the Hinich bicorrelation test for each data series the same number of times as the window length, in our case at most 35 times, controlling for the presence of outliers, using the trimming and ´hard clipping´. As far as we know, this is the first time that these set of procedures are applied to financial time series.

The structure of the remainder of the papers is as follows. Section 2 provides a brief review of the literature related to our paper. Section 3 briefly describes the Hinich portmanteau bicorrelation test, and also the trimming and the hard clipping techniques. Section 4 presents the data to be used in this study. Section 5 presents the empirical results obtained. Final conclusions are given in section 6

2 Related Literature

Even though there are some applications that uses the same base methodology, namely the Hinich bicorrelation test, such as Brooks (1996), Brooks and Hinich (1998), Lim and Hinich (2005), Bonilla et al (2006), Romero-Meza et al. (2007), Bonilla et al. (2008), Aranda and Jaramillo (2010), Bonilla et al. (2011a y 2011b), Coronado et al. (2012) and Espinosa et al. (2013). Our approach is novel because we introduce two statistical techniques trimming and ´hard clipping´ that we think could become important tools for empirical finance and economics studies.

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. Other example of testing for nonlinearity in mature markets is the work of Lekkos, Milas and Panagiotidis (2005), which analyses the ability of common risk factors to predict the dynamics of the US and UK interest rate swap spreads. Lim and Hinich (2005) 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. Romero-Meza et al (2007) explores for economic and political events that may explain specific nonlinear windows for the Chilean stock market. Bonilla et al. (2008) studies the behavior of several Latin American bond markets spreads. Bonilla et al (2011) investigates the presence of nonlinear dependences in the Mexican stock market. However, none of these researchs have investigated the possible impact in the analysis of having outliers.

The emerging market bond spreads are markets well informed with sophisticated traders in charge of allocating resources in the international capital market. They must be informed about the macroeconomics characteristics of every country where funds are allocated, such as their financial stability, the exchange rate policies, public sector deficit, and major political changes arising. In consequence, the market information and management suggest an adequate EMH. Yet emerging market economies present recurrent episodes of economic and political instabilities that are difficult to foresee. This provides the opportunity to investigate episodic nonlinear behavior expected by the agents´ reactions involved in the decision market.

One of the few papers that have studied the behavior of EMB is Bonilla et al. (2008) that study the behavior of Latin American EMB and it is the closest to our paper in methodology and scope. However, we depart from that work in applying a novel methodology. We apply recursively the bicorrelation test to examine all possible windows of a certain length. We select the application of two statistical techniques, trimming and hard clipping, barely used in the financial and economic empirical literature. The trimming is used to control for the presence of outliers in the data and a binary transformation known as hard clipping to further validate the presence of nonlinear dependence. A recent application of the trimming technique is found in Wild et al. (2010) to study nonlinear serial dependence for spot electricity price in Australia. The binary data transformation, called “hard clipping” in the signal processing literature, has been used in Bonilla et al. (2007) and Romero-Meza et al (2011) to check for the adequacy of GARCH specification for Latin American exchange rate and stock returns, respectively. In this paper, we apply simultaneously both statistical techniques to detect the nonlinear dependence for the Asian EBM.

We find that outliers are important elements to consider in the identification of the stochastic nature of financial times series. We observe systematic nonlinear structure in the spreads series. Our results suggest that nonlinear serial dependencies are episodic in nature. All the spread returns series (with the exception of Thailand) increase the number of windows with nonlinear dependence when we increase the percentage of trimming for outliers. Thus the outliers can affect the identification of the nonlinear dependence. Our findings support the idea that, even in this well informed and sophisticated market, the weak-form of the efficient market hypothesis cannot be supported, and further investigation is required to better understand the nature of financial series of the Asian EMB spreads.

Section 3 briefly describes the Hinich portmanteau bicorrelation test, and also the trimming and the hard clipping techniques. Section 4 presents the data to be used in this study. Section 5 presents the empirical results obtained. Final conclusions are given in section 6

3 The Hinich Portmanteau Bicorrelation Test

We now proceed to describe the windowed test procedure used in this paper and the Hinich portmanteau bicorrelation test statistic (denoted as H statistic). Let the sequence $\{z(t)\}$ denotes the standardized sampled data process, where the time unit t is an integer. The standardization is $z(t_k) = \frac{y(t_k) - m_y}{s_y}$, which is done ´frame-by-frame´, where m_y is the sample mean and s_y^2 is the sample variance of the sample frame. The Hinich test uses non-overlapped data window, thus if n is the window length, then the $k-th$ window is $\{z(t_k), z(t_k+1), \ldots, z(t_k+n-1)\}$. The next non-overlapped window is

$\{z(t_{k+1}), z(t_{k+1}+1), \ldots, z(t_{k+1}+n-1)\}$, where $t_{k+1} = t_k + n$. The null hypothesis for each window is that $z(t)$ are realizations of a stationary pure white noise process that has zero bicorrelation. The alternative hypothesis is that the process generated within the window is random with some non-zero bicorrelations $C_{zzz}(r,s) = E[z(t)z(t+r)z(t+s)]$ in the set $0 < r < s < L$, where L is the number of lags that define the window. For a mathematical derivation of this statistics and its small sample properties the interested reader is referred to Hinich (1996). We thus state without derivation the test statistics denoted *H*. The Hinich portmanteau *H* statistics and its corresponding distribution are:[1]

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

where $G(r,s) = (n-s)^{1/2} C_{zzz}(r,s)$ and

$$C_{zzz}(r,s) = (n-s)^{-1} \sum_{t=1}^{n-s} z(t)z(t+r)z(t+s) \quad \text{for } 0 \le r \le s$$

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

[1] For a mathematical derivation of this statistics and its small sample properties see Hinich and Patterson (2005) and Hinich (1996)

significant if the H statistic rejects the null of pure noise at the specified threshold level.

In this paper we apply recursively the test *H* jointly with the windowed procedure for all windows of length n in order to detect all time frames where there are nonlinear dependences. We call this procedure 'moving windows' where starting with the first observation we move one observation forward until reaching the $n-th$ observation. We apply the test *H* to each window of the first configuration given by $\{z(t_1),\ldots,z(t_n)\}$, $\{z(t_{n+1}),\ldots,z(t_{2n})\}$, ...until comprise the whole data sample. Next we move the frame by one observation forward, and we apply the test *H* to each window of the second configuration given by $\{z(t_2),\ldots,z(t_{n+1})\}$, $\{z(t_{n+2}),\ldots,z(t_{2n+1})\}$, ...until comprise the whole data sample. We do this until we analyze the n possible configurations, in our case we use a lenht *n* iqual to 35 observations. Thus, we apply at most 35 times the Hinich bicorrelation test. When the last window is shorter than n the test is not applied to that specific window.

Given that the test *H* is based on average, the impact of an outlier is important. A shock could cause the test to detect dependence. As we are looking for windows where there are truly nonlinear dependences, we apply the trimming to outliers. This method involves cutting a $k\%$ of the larger y smaller observations of a given sample. To do this, we order the data and find the $(k/100)$ quantile $x_{k/100}$ and the $(1-k/100)$ quantile $x_{1-k/100}$ of the order statistics. Next we set all sample values less than the $(k/100)$ quantile to $x_{k/100}$ and set all sample values greater than $(1-k/100)$ quantile to $x_{1-k/100}$. The remaining $(100-k)\%$ data values are not transformed in any way.

To trim the data does not ensure that extreme cut values still continue affecting the test *H*, thus we also apply a binary data transformation, called 'hard clipping' in the signal processing literature. This is achieved by transforming the returns into a set of binary data denoted $\{x(t)\}$ where $x(t) = 1$ if $z(t) \geq 0$ and $x(t) = -1$ if $z(t) < 0$. If data generating process underlying $z(t)$ has innovations symmetrically distributed with zero mean, then the hard clipping converts it into a Bernoulli process (Bonilla et al (2007) and Romero-Meza et al (2011)) which has moments that are well-behaved with respect to the asymptotic theory (Hinich, 1996). When we apply the test *H* to the transformed data, we are sure that any significant window is not due to the presence of outliers because the data are now 1 and -1.

Therefore a window that is significant with the standardized data, with and without trimming, jointly with the hard clipped data, it must be a window where exist nonlinear dependence that is not the result of a shock or outlier.

We think that this new procedure could be very important for empirical finance and economics when a researcher is dealing with financial series that exhibit large movement in short periods of time.

4 The Data

The analysis presented here is based on daily data for four of the most important Asian economies. The data was obtained from JP Morgan Securities. In particular, we use the Emerging Market Bond Index Global (EMBIG) China, Philippines, Malaysia and Thailand. The sample periods for the indices are from January 1998 to August 2009 for all countries except for Thailand that goes from January 1998 to March 2006. Given that each index is expressed in basis point and it is not possible to reject unit roots in all series, we take first difference in the following way: $y(t) = (I_t - I_{t-1})/10{,}000$, where I_t is the closing level spread index in day t. Thus, the differenced series $y(t)$ is expressed in percentage.

Table 1 shows the descriptive statistics of our sample data.

Insert table 1 here

5 Empirical Results

Before checking for potential nonlinear behavior of the series, we remove any linear dependencies by fitting an AR(p) to the differenced spreads rate of return series. Thus 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 35 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 Hinich portmanteau bicorrelation test is then applied to the residuals of the fitted AR(p) model.

Table 2 presents the results for the test using recursively the windowed test procedure jointly with the data trimming and the hard clipping for all spreads series.

Insert table 2 here

Each column of table 2 identifies the dates of windows where we find nonlinear dependence simultaneously in the trimmed and hard clipped data.

We see that all spread series exhibit nonlinear dependence, and the number of windows increase with the percentage of trimming. This is an interesting result because it shows that, even in this important international market in which very sophisticated traders operate, the weak form efficient market hypothesis is not supported by the data. This result support previous finding of nonlinearities encountered in stock market indices for emerging markets economies in Asia and Latin America. However, to our knowledge, this is the first time that nonlinearity is reported for the four most important Asian emerging market bonds spreads considering explicitly the impact of outliers.

Our results suggest that, at least in theory, there exist the possibility of obtaining abnormal returns in this market when a nonlinear episode occurs. Unfortunately, the episodic nature of the results makes difficult to predict when that is going to happen.

The results suggest that outliers are an important factor to consider when analyzing an economic and financial data series. For several markets we find that the larger the trimming the larger the number of windows that present nonlinear dependence. Thus further investigation is required to better understand the nature of financial and economic time series that present shock or outliers.

The dates presented in Table 2 are potentially useful for future investigation into the events that lead to this nonlinear behavior in each case.

6 Conclusions

In this paper we use the Hinich portmanteau bicorrelation test to study episodic nonlinear events of four of the most important Asian emerging market bonds spreads. We introduced three methodological improvements. We applied the test *H* recursively in order to detect all nonlinear windows where there is evidence of nonlinear dependence. Furthermore, we apply two statistical techniques scarcely used in the financial and economic empirical literature, which could become valuable tools to data analysis in the field. The trimming is used to control for the presence of outliers in the data and a binary transformation (hard clipping) to further validate the presence of nonlinear dependence.

The results are consistent with findings in the financial econometrics literature that reject the random walk hypothesis of the financial markets. In this paper we confirm the universally accepted phenomenon of nonlinear behavior in financial data, to the case of the Asian emerging market bond´s spreads, when the effects of outliers have been considered.

Our results reveal that the nonlinear serial dependencies are episodic in nature, that is, all the spreads 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.

All the spread returns series (with the exception of Thailand) increase the number of windows with nonlinear dependence when we increase the percentage of trimming, indicating that outliers can affect the identification of the nonlinear dependence.

It called our attention the fact that, even in the international bond market for emerging economies, where well informed and sophisticated traders come together, the efficient market hypothesis does not hold properly. The rejection of the efficient market hypothesis for the four most important Asian bonds spreads series opens the possibility of predictability. However, the episodic nature of the nonlinearities makes difficult to know when the serial dependencies will appear and when they will vanish.

Finally, Table 2 provides the dates when these dependencies occurred, which is potentially useful for future investigation into the events that lead to this nonlinear behavior.

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Table 1

Summary Statistics

	China	Malaysia	Philippines	Thailand
Mean	-3.45e-07	-1.21e-06	-3.31e-06	-1.93e-05
Median	0.000000	0.000000	0.000000	0.000000
Maximum	0.005900	0.014200	0.014100	0.019000
Minimum	-0.010200	-0.013700	-0.016700	-0.014700
Std. Dev.	0.000592	0.000839	0.001261	0.001231
Skewness	-0.880423	2.702737	0.029137	1.982793
Kurtosis	54.31415	111.2687	36.13833	65.31018
J - Bera	318545.9	1418485.	132647.6	334927.6
# Observ.	2900	2897	2899	2062

Table 2

Windowed-Test Results for Asian Spreads

Dates of joint nonlinear dependence with and without trimming

Country	0% Trimmed	10% Trimmed	20% Trimmed	30% Trimmed
China	20/11/2001 -11/01/2002	20/11/2001-11/01/2002	15/11/2001-11/01/2002	07/06/2000-23/08/2000
		01/08/2002-30/09/2002	08/08/2002-01/10/2002	15/11/2001-08/01/2002
			24/12/2003-17/02/2004	11/08/2005-30/09/2005
				14/06/2007-02/08/2007
				25/10/2007-13/12/2007
Malaysia	19/05/1998 -13/07/1998	24/06/1999-13/08/1999	29/01/1998-23/03/1998	28/01/1998-27/03/1998
	15/09/1999 -03/11/1999	13/10/2004-14/12/2004	22/06/1999-18/08/1999	16/06/1999-16/08/1999
	08/08/2008 -26/09/2008		13/10/2004-03/12/2004	08/12/2000-30/01/2001
			24/05/2006-13/07/2006	13/10/2004-20/12/2004
Philippines	06/05/1999 -01/07/1999	07/07/1998-24/08/1998	07/07/1998-24/08/1998	07/07/1998-24/08/1998
	09/08/2001 -05/10/2001	07/05/1999-29/06/1999	06/05/1999-28/06/1999	06/05/1999-24/06/1999
	07/07/2003 -26/08/2003	29/12/2000-20/02/2001	06/02/2002-27/03/2002	22/03/2000-10/05/2000
	13/03/2008	06/02/2002-	10/09/2004-	06/02/2002-

	-06/05/2008	27/03/2002	29/10/2004	27/03/2002
		13/03/2008-06/05/2008	13/03/2008-15/05/2008	10/09/2004-29/10/2004
				03/11/2005-27/12/2005
				15/02/2007-11/04/2007
				14/03/2008-07/05/2008
Thailand	16/10/2000 -04/12/2000	02/11/2000-26/01/2001	17/11/2000-25/01/2001	19/09/2001-07/11/2001