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Contagion Evidency on Latin American Financial Markets: A Cross-bicorrelation Analysis

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Abstract

In this paper, we use a cross bicorrelations test to study the relationship between the main seven Latin American financial market's indexes. We find evidence of nonlinearity, for different window frames at a 97.5% level of confidence, over the period January 9, 1990 and November 23, 2012. Interestingly these evidence of nonlinearity was found in periods that coincide with periods of economic or political instability, such as the asian crisis on 1998, the financial crisis on 2008 and the Greek crisis on 2011. Furthermore, we find that in various cases the causality is bidirectional. We think this test could be used as a complementary tool to traditional tests used to study financial contagion. These findings are important cause they allow us to elaborate more on the existance of nonlinearity dependancy in markets caused by random events that could lead to contagion between countries on a same region.

Key words: Nonlinear dependence, Hinich Cross-bicorrelation test, financial contagion.

1. Introduction.

Research on financial contagion is vast and comes in various forms, but this is the first time that the cross-bicorrelations test has been applied to analyze such a theory, furthermore, it is the first time the test has been used to a group of Emerging Market's stock exchange indexes.

On contagion theory literature, it is stated that financial contagion can be produced in different ways: one theory says that small shocks, which initially affect only a few institutions or a particular region of the economy, spread by contagion to the rest of the financial sector and then infect the larger economy. Another theory focuses on the overlapping claims that different regions or sectors of the banking system have on one another. When one region suffers a bank crisis, the other regions suffer a loss because their claims on the troubled region fall in value. If this spillover effect is strong enough, it can cause a crisis in the adjacent regions. In extreme cases, the crisis will pass from region to region and will become a contagion (Grilli, Tedeschi and Gallegati, 2011; Allen and Gale, 2000).

There is also a line that researches contagion through information access, it bases on the assumption that information about one market has an impact on another market. The release of bad information about one bank provides information about other Banks, because of common portfolio holdings and common counterparty exposures. Even if it transpires that the second bank was not subject to a common shock, the information revealed about the second bank may induce to a run. Thus, even in the absence of a common shock, there is informational contagion (Cabrales and Gale, 2015).

When financial crises occur it is common to see vast literature on financial contagion to come out, the importance of financial crisis is that they raise the costs of intermediation and restrict credit, which in turn restrains the level of activity in the real sector and ultimately can lead to periods of low growth and recession. Most of the literature that searches for evidence of contagion during crises periods, has found evidence of linear contagion. Romero-Meza, et. al., (2015) applied a univariate bicorrelations test to the same data base we use, and in that paper they speculated that, since their findings on nonlinear dependence were found to be contemporaneous with international financial crises, the contagion caused by financial crises induces nonlinear dependencies. But they are restricted to prove in which directions this nonlinear dependency moves, or which is the "provoking" economy of the contagion.

Regarding literature on Latin American indicators, there's evidence of contagion among Brazilian, Chilean, Colombian and Mexican exchange rates. Contagion is less frequent during times of currency depreciation. (Coaiza-Maya, Gómez-González and Melo-Velandia, 2015).

For stock markets contagion, evidence shows that on Asian markets, using a conditional correlation model, international sovereign credit-rating agencies play a significant role in shaping the structure of dynamic correlations (Chiang, Jeon and Li, 2007).

And as for the influence of the American markets on Latin American markets, research has shown that international capital movements are all significantly affected by swings in interest rates in the United States. Increases in U.S. interest rates, other things equal, are associated with capital outflows from Latin America. Small and large countries appear to be equally vulnerable in this respect (Calvo, 1996).

It is important to remark, as we said before, that it is the first time that this test has been applied on this type of data, so the results will be useful to complement previous studies on this subject.

2. The Data.

We use daily data from Bloomberg over the period January 9, 1990 to November 23, 2012 for the main seven stock exchange indexes in Latin America. We use daily price series for IPSA Index (Chilean stock market), IBOV Index (Brazilian Sao Paulo stock exchange), MERVAL Index (Argentinian stock exchange), MEXBOL (Mexican stock exchange), IGBC Index (Colombian stock exchange), IGBVL Index (Peruvian stock exchange), and IBVC (Venezuelan stock exchange).

For MEXBOL Index, the data starts on January 20, 1994. For IGBC Index data begins on July 4, 2001. For IBVC Index data starts on January 3, 1994.

In Figure 1 we can see the price evolution for each stock market, we see that while most of the markets show a tendency towards relatively normal fluctuations, the IBVC Index "escaped" its tendency starting 2011, we believe this so called "escape" may have been driven by mainly two factors, firstly by the sky rocketing price of oil, given Venezuela's vast resources on oil and its profound income dependency on it and for the later, but not least important, the out of control inflation that has been taking place in Venezuela for the last decade (27.2% in 2010, 27.6% in 2011, and 20.10% in 2012).

We calculate the rate of return as —— where is the closing price of the index on day . We use daily data because it is more consistent on results than low-frequency data. Low-frequency data could not be able to take into account many economic and political events that could emerge from one day to the next.

We use window frames of 50 days, given that the length of the time series could include some structural breaks, thus with the 50 days window any stationarity assumption is not stringent, to look for more information regarding this issue, go to Brooks and Hinich (1999) or Brooks and Hinich (2006).

Due that we take into account more than 20 years of financial market's history, it is important to notice that we are looking into periods with both very high and very low volatility levels.

3. The Brooks and Hinich Cross Bicorrelations Test.

The cross-bicorrelations test allows us to detect any presence of nonlinear dependence between two time series. The econometrics is as follows. The data is a sample of size N, with two stationary time series $\{x(t_k)\}$ and $\{y(t_k)\}$. These series have been standardized in a way that they show a sample mean of zero and a variance of one, which can be achieved by subtracting the sample's mean and dividing by the sample's standard deviation. As we are working with the first logged differences and small sub-samples of the total series, to suppose stationarity is more than reasonable.

The test's null hypothesis states that the two series are pure independent white noise processes, against an alternative hypothesis that states that any of the cross-covariances, $C_{xy}(r) = E[x(t_k)y(t_k)]$, or any of the cross-bicovariances, $C_{xxy}(r,s) = E[x(t_k) x(t_k+r) y(t_k+s)]$, are different from zero. As a consequence of the invariance of $E[x(t_1) x(t_2) y(t_3)]$ against changes of (t_1,t_2), the assumption of stationarity implies that the expected value is a two lags function and that $C_{xxy}(-r,s) = C_{xxy}(r,s)$. If the ultimate lag used is $L < N$, then the main domain for the bicovariances is the rectangle formed by $\{1 \le r \le L, -L \le s \le L\}$.

Under the null hypothesis, $C_{xy}(r) = 0$ y $C_{xxy}(r,s) = 0$ for every r,s except when $r = s = 0$. If there is any lagged dependence of second or third order between the two series, then, $C_{xy}(r) \neq 0$ and $C_{xxy}(r,s) \neq 0$ for at least one value of r, or a pair of values of r and s, respectively. The following statistics account for the cross-correlation xy of r, and the cross-bicorrelation xxy of r,s; respectively:

$$C_{xy}(r) = (N-r)^{-1} \sum_{t=1}^{N-r} x(t_k)\, y(t_k+r), \qquad r \neq 0$$

$$C_{xxy}(r,s) = (N-m)^{-1} \sum_{t=1}^{N-m} x(t_k)\, x(t_k+r)\, y(t_k+s), \qquad \text{where } m = \max(r,s)$$

The cross-bicorrelation can be interpreted as a correlation between the actual value of one of the series and the value of the previous cross-correlations between the two series. As a first step of the test, there is a "cleaning" stage at which any sign of linear correlation and any linear cross-correlation is removed; this way, any sign of dependence left between the series should be nonlinear. Let $L = N^c$, where $0 < c < 0.5$.

The test statistics of cross-correlations and cross-bicorrelations different from zero are:

$$H_{xy}(N) = \sum_{r=1}^{L} (N - r) C_{xy}^{2}(r)$$

and

$$H_{xxy}(r,s) = \sum_{s=-L}^{L} {}' \sum_{r=1}^{L} (N - m) C_{xxy}^{2}(r,s), \qquad (s \neq -1,1,0)$$

The statistic is jointly composed by the cross-correlation and the cross-bicorrelation, where the number of proved correlations is L and the number of cross-bicorrelations is proved by According to Hinich (1996), and are asymptotically with *L* and degrees of freedom, respectively.

4. Results.

In Table 1 we report the number of significant windows where the evidence for nonlinear dependence is found. It is important to remark that linear dependence in the data is removed completely, for its minor presence could take to spurious rejections of the null hypothesis. For this analysis, any presence of linear autoregressive dependence is removed by fitting a VAR(4) to the series. Out of 21 pairs of series we found 41 window frames in which bivariate nonlinear dependence is present.

In Table 2 we report the dates in which this nonlinear dependence evidence is found. What we think is the most interesting finding is that in 11 cases, the nonlinear dependence is found to have a bidirectional causality, and more interesting is that this frames take place, mostly in periods of time in which there's a high international financial volatility, such as for the 1998 Asian crises and the latest 2008 crisis and its minor replica in 2011, due to shocks on commodity prices, specially oil related ones, and the political instability in Middle East.

We found evidence of bidirectional nonlinear dependence for the year 1998, for the pairs of series IPSA-MEXBOL, IBOV-MERVAL, MERVAL-MEXBOL, MEXBOL-IGBVL. Since the biggest financial event in 1998 was the Asian crisis, we believe it is right to assess this nonlinearity dependency evidence as a result of the impact of the crisis on Latin American stock markets. When the 1998 crisis took place, previous financial climate in Latin America was at a peak, that's why when the climate was modified by the spreading crisis, most international investors saw the need to cash out their profits in Latin American markets, to compensate for the loss on other financial markets. Those financial movements affected mostly the biggest dependent countries, on international financing, at that time in Latin America, such as Chile, Argentina, Mexico and Venezuela; all of these countries made important fiscal, commercial and monetary adjustments to try to overcome the effects of the crisis.

Given that we found evidence of bivariate nonlinear dependence during the Asian crisis period, this might lead us to think that it would be likely to find the same kind of evidence for other periods of international financial instability. It is interesting to take notice on the fact that for the financial crisis of 2008, we could only find one case of bidirectional nonlinear dependency during, IPSA-MERVAL, we find it is possible to give positive credit to measures taken in previous years to the crisis, such as the notorious reduction in external public debt, which offered governments a bigger action margin to stabilize private markets in countries that still had a big volume of external debt. Moreover, as it is elaborated in Jara, Moreno and Tovar (2009), since the 2008 crisis was originated at the financial sector of developed economies and not in Latin America or any other region with emerging markets, and given the strong situation on markets that were living the commodity prices, this type of crisis was different from previous ones. It is explained that when the crisis is originated in emerging markets, then international investors will tend to cash out and look for shelter on developed economies, which are safer. But since in 2008 it was the main economies that were hit, then these investors cashed out from the developed markets and took cover on markets that were not extremely hit, such as Latin American markets, which were having a really good run due to the price boom of commodities like copper, coffee beans and oil.

We find evidence of bidirectional nonlinear dependency also for the year 2011, for the pairs of series IPSA-MEXBOL, IBOV-MERVAL, MERVAL-IGBC, and MEXBOL-IGBVL. These four pairs show nonlinear dependence in a period of time established between middle June and middle August., this evidence can be paired to the sharp increase in Greek CDS, after the former Greek Prime Minister Georgios Papandreou rejected the European bailout plan. Again this evidence matches the argument presented by Jara, Moreno and Tovar (2009), that since Greece and other countries that were going through a rough patch, could be considered as developing countries, then international investors looked for safer markets, in the US and Europe. In Table 3 we can see a summary making the linkages between the period of financial instability and the evidence of bivariate nonlinear dependency found.

We also found 30 other window frames in which the causality of the nonlinear dependence is unidirectional. The time frames also match those of international volatility.

We can see that the direction of the nonlinear dependence for these unidirectional findings is not uniform:

- The IPSA Index leads the IGBC Index one time, the MERVAL Index two times.
- The IBOV Index leads the MEXBOL Index once; and it is led by the IBVC Index one time, the IGBC Index one time, and the MEXBOL Index two times.
- The IGBVL Index is at the beginning led by the IBVC Index in 97', but then the causality inverts in 2011.
- The MERVAL Index is led by the IGBC Index in 04', and then in 06' it is the MERVAL Index that leads the IGBC Index. Then in 2008 the MERVAL Index is led by the MEXBOL Index.
- The MEXBOL Index is led once in 2006 by the IGBC Index; but both in 1999 and 2008 it leads the IGBVL nonlinearity dependence.

5. Concluding Remarks

The evidence of nonlinear dependence found is various and vast. It is found in almost all cases when the economy was facing international financial instability, mostly in the years 1998 (Asian crisis), 2008 (US financial crisis) and 2011 (Greek crisis peak). Even though there's vast evidence found that can be used to affirm the existence of financial contagion in the region during high volatility times, the evidence is not conclusive enough to point the finger towards one or two economies that could be the bigger "provokers" of this financial contagion, spreading its "disease" across the region. It is found that nonlinear dependence in most of the cases is unidirectional, but there's still a wide range of window frames in which the causality is bidirectional (11 out of 41 window frames found). Plus, it has also been found that even though in one crisis it might be Country A that leads Country B, then in a future crisis, the causality might be inverted. So we think that it is the nature and origin of the nonlinear event that will dictate the direction of the causality, and so on the contagion.

It is of high importance to remark that this is the first time that this cross-bicorrelations test is used to analyze this type of relationships between stock markets in Latin America and to this long period of time.

We think that for future research, given the evidence found, it could be of much interest to look into the impact of commodities such as copper, oil, coffee and soybeans, on Latin American financial markets.

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FIGURE 1

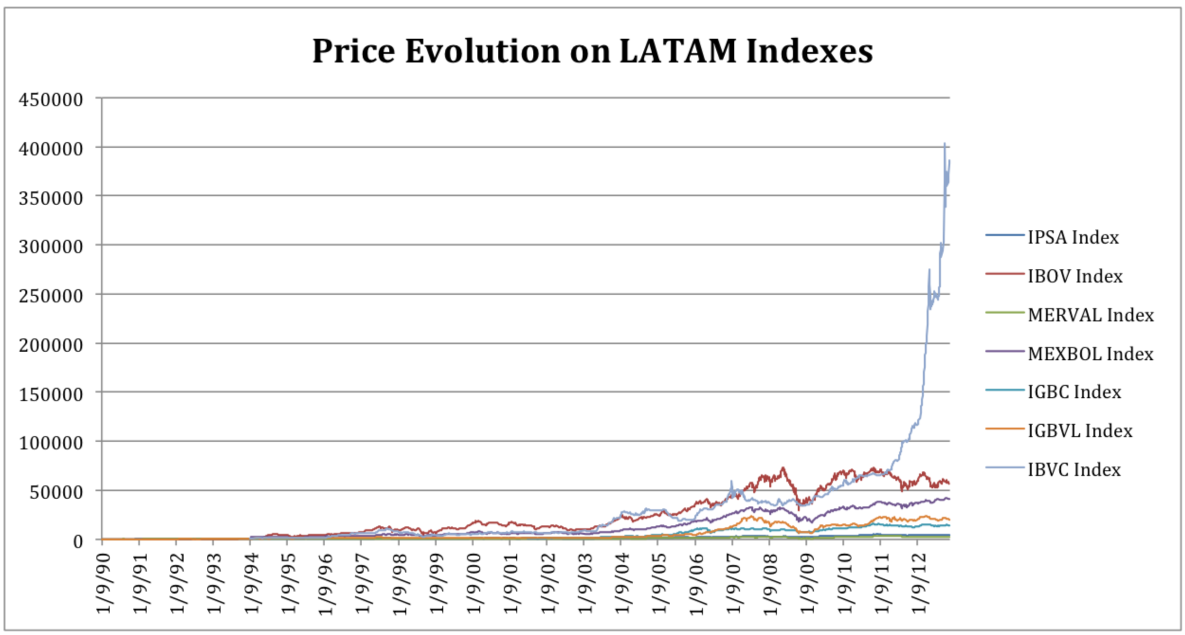

TABLE 1: NUMBER OF SIGNIFICANT FRAMES

	IPSA	IBOV	IBVC	IGBC	IGBVL	MERVAL	MEXBOL
IPSA	-	: 2 (2.0%) : 0 (0.0%)	: 0 (0.0%) : 0 (0.0%)	: 0 (0.0%) : 1 (1.9%)	: 0 (0.0%) : 0 (0.0%)	: 1 (0.9%) : 3 (2.7%)	: 2 (2.2%) : 2 (2.2%)
IBOV	-	-	: 1 (1.1%) : 0 (0.0%)	: 1 (1.9%) : 0 (0.0%)	: 0 (0.0%) : 0 (0.0%)	: 2 (2.0%) : 2 (2.0%)	: 2 (2.2%) : 1 (1.1%)
IBVC	-	-	-	-	-	-	-
IGBC	-	-	: 0 (0.0%) : 0 (0.0%)	-	: 0 (0.0%) : 0 (0.0%)	-	-
IGBVL	-	-	: 1 (1.1%) : 1 (1.1%)	-	-	-	-
MERVAL	-	-	: 0 (0.0%) : 0 (0.0%)	: 2 (3.8%) : 2 (3.8%)	: 2 (2.7%) : 1 (1.4%)	-	: 3 (3.3%) : 2 (2.2%):
MEXBOL	-	-	: 0 (0.0%) : 0 (0.0%)	: 1 (1.9%) : 0 (0.0%)	: 2 (2.2%) : 4 (4.4%)	-	-

Note: Numbers in parentheses are percentages of significant frames.
*97.5% level of confidence.

TABLE 2: DATES OF SIGNIFICANT FRAMES

Window size 50

IPSA – IBOV	February 8, 1995 – May 2, 1995 December 19, 2011 – March 2, 2012	
IPSA – IBVC		
IPSA – IGBC		May 2, 2006 – July 18, 2006
IPSA – IGBVL		
IPSA – MERVAL	May 13, 2009 – July 29, 2009	April 26, 1999 – July 12, 1999 May 8, 2000 – July 20, 2000 May 13, 2009 – July 29, 2009
IPSA – MEXBOL	July 17, 1998 – October 1, 1998 June 16, 2011 – August 29, 2011	July 17, 1998 – October 1, 1998 June 16, 2011 – August 29, 2011
IBOV – IBVC	November 8, 2010 – January 24, 2011	
IBOV – IGBC	July 6, 2011 – September 19, 2011	
IBOV – IGBVL		
IBOV – MERVAL	August 29, 1997 – November 7, 1997 June 17, 2011 – August 31, 2011	August 29, 1997 – November 7, 1997 June 17, 2011 – August 31, 2011
IBOV - MEXBOL	September 26, 1997 – December 8, 1997 February 11, 2010 – April 30, 2010	December 22, 1998 – March 12, 1999
IGBC – IBVC		
IGBC – IGBVL		
IGBVL – IBVC	August 25, 1997 – November 3, 1997	April 7, 2011 – June 22, 2011

MERVAL – IBVC		
MERVAL – IGBC	April 19, 2004 – July 2, 2004 June 2, 2011 – August 19, 2011	December 27, 2006 – March 12, 2007 June 2, 2011 – August 19, 2011
MERVAL – IGBVL	September 4, 1997 – November 14, 1997 November 26, 1998 – February 11, 1999	November 26, 1998 – February 11, 1999
MERVAL – MEXBOL	September 18, 1997 – November 27, 1997 December 11, 1998 – February 25, 1999 January 4, 2008 – March 18, 2008	September 18, 1997 – November 27, 1997 December 11, 1998 – February 25, 1999
MEXBOL – IBVC		
MEXBOL – IGBC	June 29, 2006 – September 13, 2006	
MEXBOL – IGBVL	September 25, 1997 – December 9, 1997 June 13, 2011 – August 25, 2011	September 25, 1997 – December 9, 1997 December 22, 1998 . March 9, 1999 December 18, 2007 – March 4, 2008 June 13, 2011 – August 25, 2011

Note: = cross-bicorrelation, = cross-bicorrelation, = bicorrelation, = bicorrelation.

TABLE 3: WINDOWS FOUND DURING INSTABILITY EVENTS

Asian Crisis (late 1997, 1998 and mid 1999)	IPSA-MEXBOL IBOV-MERVAL IBOV-MEXBOL IGBVL-IBVC MERVAL-IGBVL (2) MERVAL-MEXBOL (2) MEXBOL-IGBVL	IPSA-MERVAL IPSA-MEXBOL IBOV-MERVAL MERVAL-IGBVL MERVAL-MEXBOL (2) MEXBOL-IGBVL (2)
Financial Crisis (2008-2009)	IPSA-MERVAL MERVAL-MEXBOL	IPSA-MERVAL
Greek Crisis (late 2010 – 2011)	IPSA-MEXBOL IBOV-IBVC IBOV-IGBC IBOV-MERVAL MERVAL-IGBC MEXBOL-IGBVL	IPSA-MEXBOL IBOV-MERVAL IGBVL-IBVC MERVAL-IGBC MEXBOL-IGBVL

*Note: Numbers in parentheses account for the number of times the bivariate nonlinear dependency was found for the same instability event.