Identification of Price Exuberance in Latin American Equity Markets

Abstract

The identification of Latin American financial bubbles is of crucial interest to policy makers and financial investors both within and external to each Latin American country with a developed equity market. This work applies new recursive Augmented Dickey-Fuller methodologies to identify financial bubbles within the major equity markets of Latin America. We find that financial bubble periods in Latin America begin earlier and last longer than bubble periods in the United States during the 2008 financial crisis. In addition, price bubbles were identified prior to the establishment of the Integrated Latin American Market (MILA) in participating countries.

Keywords: GSADF, Latin America, MILA, price bubbles

1 Introduction

The identification of financial bubbles has become a critical endeavor for financial professionals given the string of recent financial bubbles including the Dot.com and real estate bubbles as well as the financial crisis in the United States. The identification of financial bubbles would provide policy makers and investors with a windows of opportunity to prevent losses to investments and damage to the greater economy.

Bubble detection is of global interest particularly to developing economies where economic contagion may be present. This work uses recently developed methodology by Phillips et al. (2011) (PWY) and Phillips et al. (2013) (PSY) to identify bubbles in various developed Latin American equity markets for specific time periods and in real time. We seek to identify which Latin American equity markets exhibited price bubbles during the recent financial crisis as well as the time periods in which each entered and exited the periods of price exuberance.

Latin America has been known for a particular tendency to display erratic growth rates, combined with political transitions and poor macroeconomic performance (Bittencourt, 2012). Furthermore, Latin America has a capital market that falls below growth expectations (De la Torre et al., 2007).

The domestic stock markets in developing countries are characterized by different results across nations. Some countries have experienced stock market growth, but in most cases, the growth was not significantly greater that in developed countries. Other countries have experienced a deterioration of their domestic capital markets. Furthermore, this difference becomes apparent when comparing the development of domestic capital market across the region. For example, Latin America is characterized by delisting and a lack of liquidity, capital markets in East Asia have developed relatively well. (Poitras, 2012).

However, according to the OECD, the global economy has shifted wealth towards emerging economies over the last decades. This has been reflected in the increasing contribution of emerging economies to the world GDP growth (OECD 2013). Developing markets have increased their share in global GPD from 40% in 2000 to 49% in 2010 and it is estimated that it will be 57% in 2030 (OECD, 2010).

More recently, De Gregorio (2013) shows that Latin American countries showed an

unprecedented resilience to the global financial crisis because of their macroeconomic conditions. Furthermore, Latin America has shown a steady growth in the sizes of its equity markets in the last two decades. Latin American market capitalization has increased from an average of 28% in the late 1990s to 52% during 2006-2010 (OECD). According to market capitalization reports by The World Bank for 2012 and the 2014 Fact Book of the Federacin Iberoamericana de Bolsas, Latin Americas market capitalization represents 24.1% of the U.S market and is equivalent to 99.8% of the United Kingdom and Germany markets combined.

The Integrated Latin American Market (MILA) was designed to capitalize on this resilience with the world's first virtual integration of multiple equity markets for Chile, Colombia and Peru. In addition to identifying price bubbles in Latin America during the financial crisis, this work seeks to identify if price bubbles occurred in and around the establishment of the MILA in order to describe the pricing characteristics surrounding market integrations.

MILA allows traders to have direct access to the other exchanges and removes a host country intermediary from the transaction. This new market, established in May 2011, was structured to maintain the independence of each country's equity market, but tear down the barriers of trade that disallow traders to easily facilitate the purchase of equities in the neighboring markets. This new virtual market enabled each country to encourage trading and increase diversification without giving up its own economic autonomy. This new infrastructure was interesting enough to encourage Mexico to join in August 2014 making the MILA the largest Latin American market.

The rest of the paper is structured as follows. Section 2 will discuss the data and provide descriptive statistics. Section 3 will describe the recursive random walk methodologies used to identify bubble periods. Section 4 will present the results of the work and provide some discussion. Section 5 will conclude the paper.

2 Data

The data used in this analysis was acquired from the Datastream Database. We acquired equity index data on the equity markets of Argentina, Brazil, Chile, Colombia, Mexico, Peru

and the United States. The dataset for from this work uses first of the month observations for the entire sample and totals 156 observations. The data originates on July 2000 and spans a 14 year period ending on June 2014.

Multiple major economic events are present in this time period including the real estate bubble, the financial crisis and the advent of the MILA. Table 1 displays the summary statistics for each of the country indexes.

[Table 1]

3 Methodology

This work uses the Supremum Augmented Dickey-Fuller (SADF) and General Supremum Augmented Dickey-Fuller (GSADF) tests to identify if price exuberance exists within a financial asset or in this case index. The crux of GSADF methodology is its ability to identify breaks in the random walk and assign those breaks to time periods in order to visualize when the breaks begin and determine how long they last. In addition, the GSADF can identify multiple periods of price exuberance within the historical pricing of a financial asset. In addition, the recursive nature of the GSADF methodology allows for this identification to occur in real time. The beginning and end periods of these breaks are of substantial interest to policy makers and finance professionals. They allow financial professionals to identify and act when a financial asset enters a period of price exuberance.

Both of these econometric methods use the Augmented Dickey-Fuller (ADF) test,

$$\Delta P_t = \alpha_{r_1,r_2} + \beta_{r_1,r_2} P_{t-i} + \sum_{i=1}^{k} y^i_{r_1,r_2} \Delta P_{t-1} + \varepsilon_t, \tag{1}$$

where y_t denotes a time series process, $\varepsilon \overset{iid}{\sim} N(0, \sigma^2_{r_1,r_2})$, and r_1 and r_2 denote fractions of the total sample size that specify the starting and ending points of each subsample period and the test statistic is calculated by

$$ADF^{r_2}_{r_1} = \frac{\hat{\beta}_{r_1,r_2}}{s.e.(\hat{\beta}_{r_1,r_2})}. \tag{2}$$

The limit distribution for ADF_0^1 is

$$\frac{\int_0^1 W dW}{\int_0^1 W^2}. \tag{3}$$

The challenge of creating windows where structural breaks could be measured in terms of time/date windows was tackled by PWY when they proposed a forward recursive ADF test to identify the origination and end of explosive time periods. This test was evaluated by Homm and Breitung (2012) who described that the PWY procedure performed appropriately in comparison with other models and was effective in identifying the windows of the NASDAQ's dot.com bubble.

Both of these methods are structured in a two-step process. First, Before identifying the windows which may be identified as bubble periods, we must first identify if there is a period of price exuberance in the series by using the ADF t-statistic. Once we know that there is exuberance in the series we can try to identify the windows in which this period exists.

PWY's statistic is constructed by making the process recursive over the entire sample with a defined minimum window size. The t-stat is then selected by taking the SADF from all of the independent, and forwardly recursive, ADF tests. The SADF statistic is then defined as

$$SADF(r_0) = sup_{r_2 \in [r_0,1]} ADF_0^{r_2}. \tag{4}$$

the limit distribution of the SADF statistic is given by

$$sup_{r2 \in [r_0,1]} \frac{\int_0^1 W dW}{\int_0^1 W^2} \tag{5}$$

PWY suggest that there is explosive behavior in the series when the SADF statistic is greater than the right tailed critical values from its limit distribution.

Following PWY, PSY introduce the GSADF process which is a second recursive process to compliment the forward recursive process in PWY. The important difference between the two methodologies is that PSY is designed to identify multiple bubbles within a series.

PSY takes the *sup* ADF from each shift in end endperiod, as in PWY, but then constructs a series of t-statistics by shifting the beginning point of each period and running

the first loop each time. From this series of *sup* ADF statistics, PSY takes the greatest value and assigns that as the GSADF statistic. PSY sugest that we can identify explosive behavior when the GSADF test statistic is greater than its right tail critical values. The GSADF statistic is the maximum of $SADF_{r_2}$ and is defined by

$$GSADF_{\tau}^{r_{w0}} = sup_{r_2 \in [r_{w_0}, \tau]} \{ sup_{r_2 \in [r_0, 1]} (ADF_{r_1, r_2}) \} \tag{6}$$

where r_{w0} is the size of the initial window, r_1 and r_2 are the beginning and ending points of each sample in the recursive process and τ is the final observation. The limit distribution of the GSADF statistic is

$$sup_{r_2 \in [r_o, 1], r_1 \in [0, r_2 - r_0]} \{ \frac{\frac{1}{2} r_w [W(r_2)^2 - W(r_1)^2 - r_w] - \int_0^1 W(r) dr [W(r_2) - W(r_1)]}{r_w^{\frac{1}{2}} [r_w \int_{r_w}^{r_2} W(r)^2 dr - [\int_{r_w}^{r_2} W(r)^2 dr]^2]^2} \} \tag{7}$$

The null hypothesis is that there are no explosive periods within the series such that the presence of any SADF or GSADF greater than its own right-tail critical values, respectively, confirms that there is at least one period where the series exhibits price exuberance.

Once we identify that a series has a bubble somewhere within its selected observations, we use a backward *sup* ADF (BSADF) series to identify the windows where this price exuberance exists. The BSADF process is constructed by moving r_1 backward instead of r_2 forward and provides consistent estimates of the origination and termination points of each bubble (Phillips et al., 2013). The BSADF statistic is defined as

$$BSADF_{r_2}(r_0) = sup_{r_1 \in [0, r_2 - r_0]} BADF_{r_1}^{r_2}. \tag{8}$$

The dates of the beginning and closing periods of price exuberance are identified as the first and last dates within each window where the BSADF statistic is greater than the right tail critical values of its own distribution. Windows with too short a time period may not be reflective of true periods of price exuberance and a minimum window length, h, must be defined to differentiate between price fluctuations and actual bubbles. Furthermore, it is crucial to note the actual limit distributions of each test because they are not standard and must be calculated via Monte Carlo simulations (Pavlidis et al., 2014).

4 Results

In the first phase of the GSADF test, we test for the presence of bubble periods within each sample by constructing the SADF and GSADF statistic for each. We also construct the critical values for each of these statistics using Monte Carlo simulations with n = 4000 iterations.

[Table 2]

Table 2 displays the SADF and GSADF statistics for each series as well as the critical values for each methodology. Brazil, Chile, Colombia, Mexico and Peru each display SADF and GSADF statistic values that are greater than the 95% critical value for each methodology. this is indicative that each series contains at least one period of price exhuberance. The United States' shows a lower than 95% critical value statistic for the SADF but does display a greater than 95% critical value for the GSADF statistic. Only Argentina does not show through this test that its series has potential price bubbles.

However, one potential criticism of the first test procedure is that the inability to reject the lack of explosive periods is not a confirmation that there are no explosive periods(Liao-Etienne et al., 2012). Therefore, we keep Argentina within the samples tested and continue to the identification of bubble periods using the BSADF statistic.

Figures 1-7 display the time series price values for the country specific index of each country in our study as well as the BSADF statistics and their 95% critical values. Figure 7 displays the same variables for the S&P 500 for the United States.

[Figure 1]

[Figure 2]

[Figure 3]

[Figure 4]

[Figure 5]

[Figure 6]

[Figure 7]

Figure 8 displays the time periods when each index is in a GSADF defined bubble period. The overlap for the 2007-2008 financial crisis is evident for all countries but interestingly, the equity bubbles were visible for Latin American countries before they were present in the United States.

In addition, the United States appears to break out of the 2007 bubble before Latin American countries. The second bubble period in the United States, in early 2009, can be described as a left tail bubble and visible in Figure 7 as the down dip of the equity market following the bubble collapse in 2008. It notably occurs well after Latin American bubbles have ended and should not be confused for price exuberance.

[Figure 8]

Some Latin American countries appear to have a follow up bubble period beginning in late 2009 and with heterogeneous consistency and some appear to continue until late 2011. Brazil's second bubble appears early and dissipates quickly and Argentina's is over by the spring of 2009. Only Mexico, appears to stay away from periods of over valuation as defined by breaks in its index's random walk following 2008.

Chile, Colombia and Peru's second bubbles may be more related to the establishment of the MILA in May 2011 and not related to the financial crisis of 2008. Chile's bubble begins in January 2010 and is prolonged through the MILA initialization until September 2011. Colombia's second bubble is identified from December 2010 until April 2011. Peru's second bubble begins in September 2010 and ends in May 2011. The price bubbles for Chile, Colombia and Peru are present in all three countries for the five months leading up to the establishment of the MILA in May 2011.

Of the three, Chile extends its bubble period after the MILA begins for an additional four months until September 2011. The price pattern following the end of the identified bubble period is accompanied by a sharp decline in prices that can described as a bubble burst. This result suggests that investors believed that prices of stocks in each index would increase with the development of the MILA. This perception may have created a period of overvaluation that began with the announcement of the future formation of the MILA and ended with its operational initiation.

Not addressed in this work but of potential interest, is the identification of a bubble period in the United States that continues until the end of the working data in July 2014. This may be an example of the power of the GSADF in identifying price bubbles in real time, and may be a potential future topic for additional research.

5 Conclusion

This work utilizes newly developed ADF recursive methodology to identify random walk breaks in equity indexes and identify period specific eras of price exuberance. We apply this methodology specifically to Latin American equity markets and identify that the major periods of price exuberance coincide with each other and with the financial crisis bubbles in the United States. Latin American equity markets appear to be begin earlier and stay in price exuberance for a longer period of time than the United States market. This characteristic may serve as an indicator for other international markets, particularly the United States. In Latin America, the bubble periods start earlier and last longer.

The impact of this work is the identification of periods when Latin American equity indexes were in pricing bubble periods. This work also helps to visualize when each country entered and exited those bubble periods. Furthermore, the double recursive nature of the methodology allows for the identification of multiple bubble periods. This work visualizes the coinciding price bubbles in Latin American countries preceding the financial crisis in the United States.

In addition, this work identifies a second bubble period for Chile, Colombia and Peru that leads up to the establishment of the virtual market integration for the three countries. The prices of equities within this period are identified through the GSADF methodology as

being in price exuberance. This result requires additional research on the price valuation of Chilean, Colombian and Peruvian stocks prior to and immediately following the establishment of the MILA. The visualization of these pricing bubbles can serve as a warning to investors for future market integrations of multiple equity markets to assess the pricing movements of domestic equities prior to international integration. An additional interpretation may be that the establishment of the MILA created an increased valuation for equity prices for these three countries.

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Table 1: Descriptive Statistics

Descriptive Statistics

	N	Mean	Std Dev	Min	Max
Argentina	156	519.416	207.538	84.790	949.980
Brazil	156	21365.660	12786.000	2378.881	44065.340
Chile	156	25.455	13.274	6.320	49.660
Colombia	156	3931.009	2828.768	319.530	9019.960
Mexico	156	2021.065	973.020	539.260	3624.460
Peru	156	4.362	2.737	0.350	8.650
USA	156	1243.641	244.125	700.820	1924.970

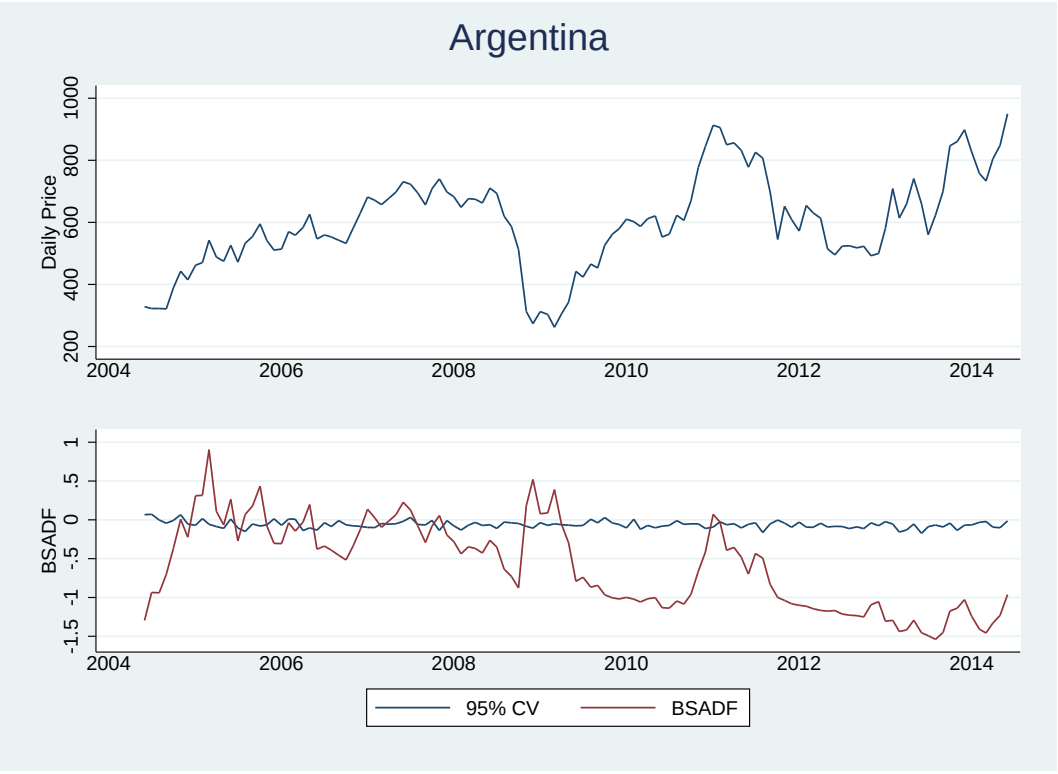
Note: This table describes the Descriptive Statistics for the equity markets in each country. the total observations for each is 156.

Table 2: GSADF Test and Statistics

Countries	SADF	GSADF
Argentina	0.198	0.905
Brazil	3.447	3.447
Chile	2.608	2.608
Colombia	11.334	11.334
Mexico	3.398	3.398
Peru	6.647	6.670
USA (S&P 500)	0.521	2.038
Critical Values		
90%	0.934	1.540
95%	1.243	1.882
99%	1.907	2.359

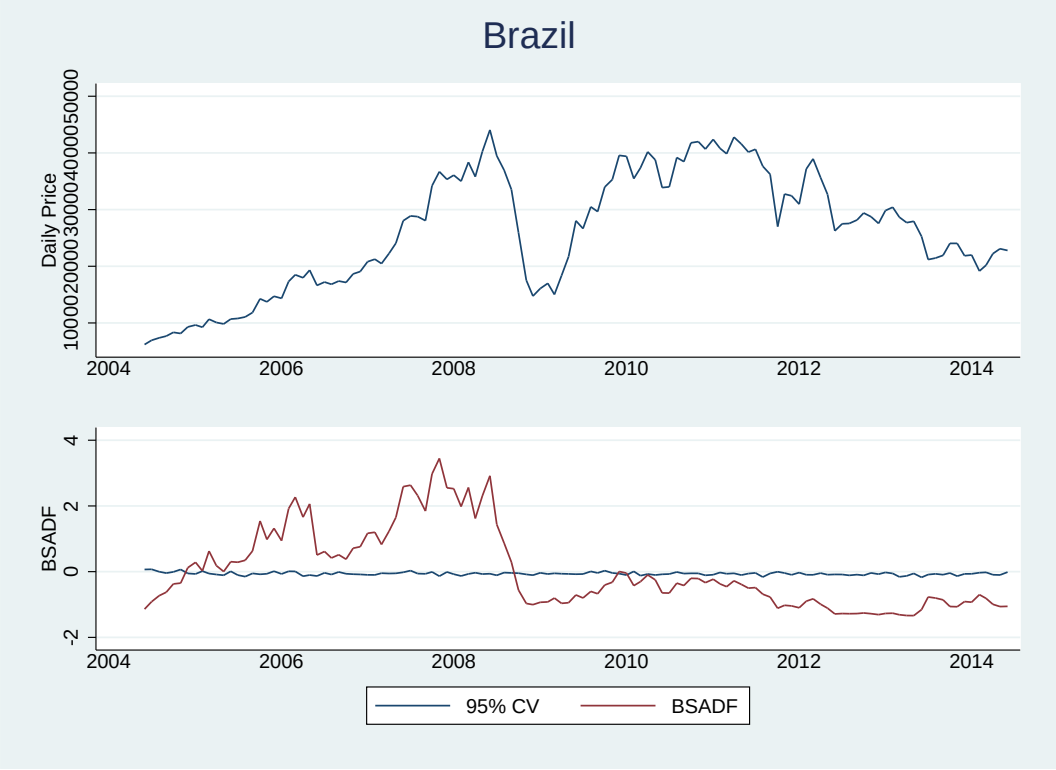
Note: This table displays the SADF and GSADF test statistics for all Latin American countries selected as well as the S&P500 index. The critical values for the test sample are also displayed and based on 156 observations and an initial window of 36 months.

Figure 1



Note: This figure details the monthly prices of the equity market in Argentina and parallels the GSADF test statistics for the same period superimposed on the GSADF 95% critival values. We identify price bubbles, in either tail, in the original price series when the test statistic is greater than the 95% critical values.

Figure 2

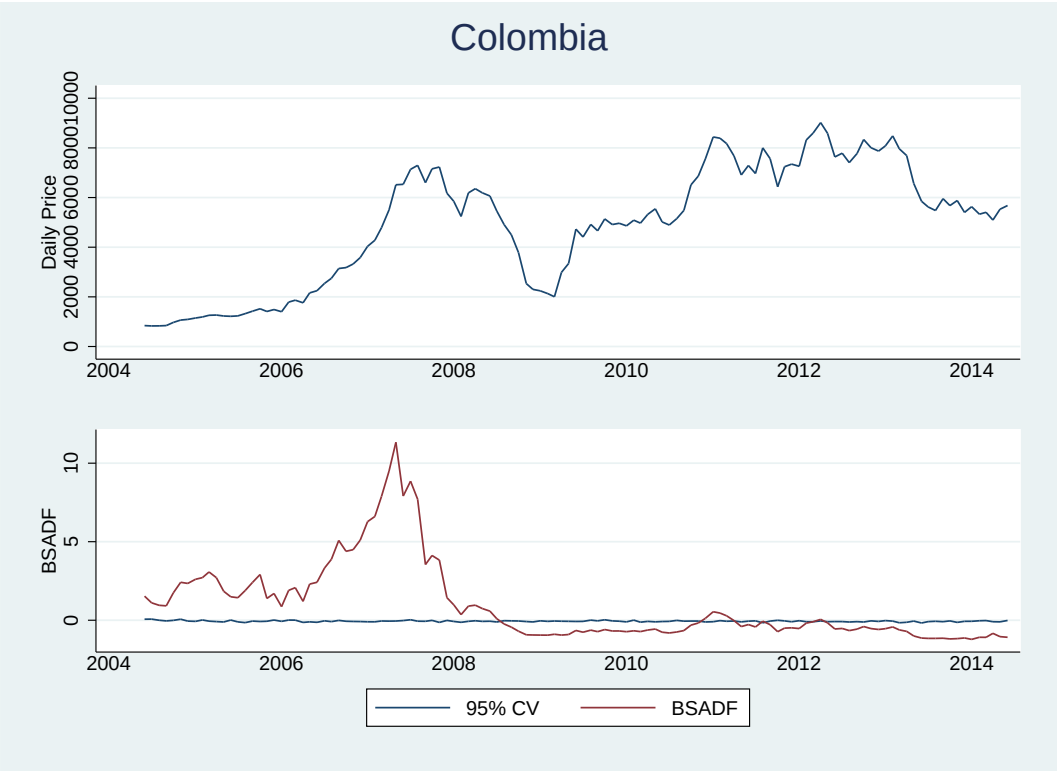


Note: This figure details the monthly prices of the equity market in Brazil and parallels the GSADF test statistics for the same period superimposed on the GSADF 95% critival values. We identify price bubbles, in either tail, in the original price series when the test statistic is greater than the 95% critical values.

Figure 3

Note: This figure details the monthly prices of the equity market in Chile and parallels the GSADF test statistics for the same period superimposed on the GSADF 95% critival values. We identify price bubbles, in either tail, in the original price series when the test statistic is greater than the 95% critical values.

Figure 4

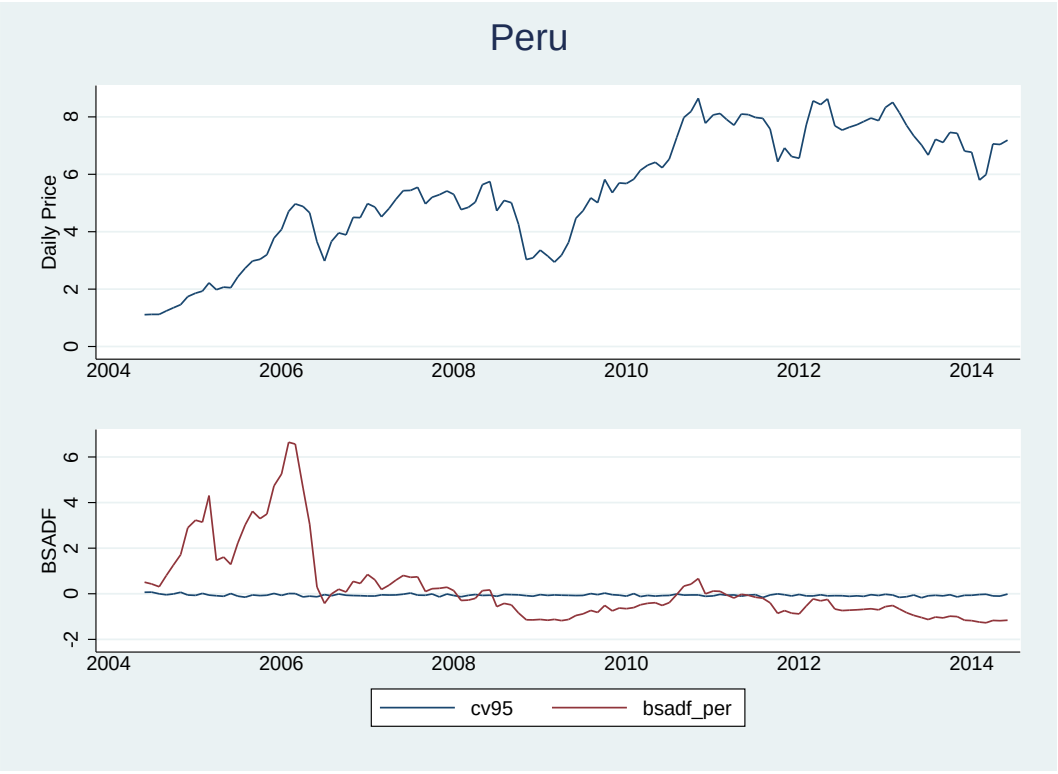


Note: This figure details the monthly prices of the equity market in Colombia and parallels the GSADF test statistics for the same period superimposed on the GSADF 95% critival values. We identify price bubbles, in either tail, in the original price series when the test statistic is greater than the 95% critical values.

Figure 5

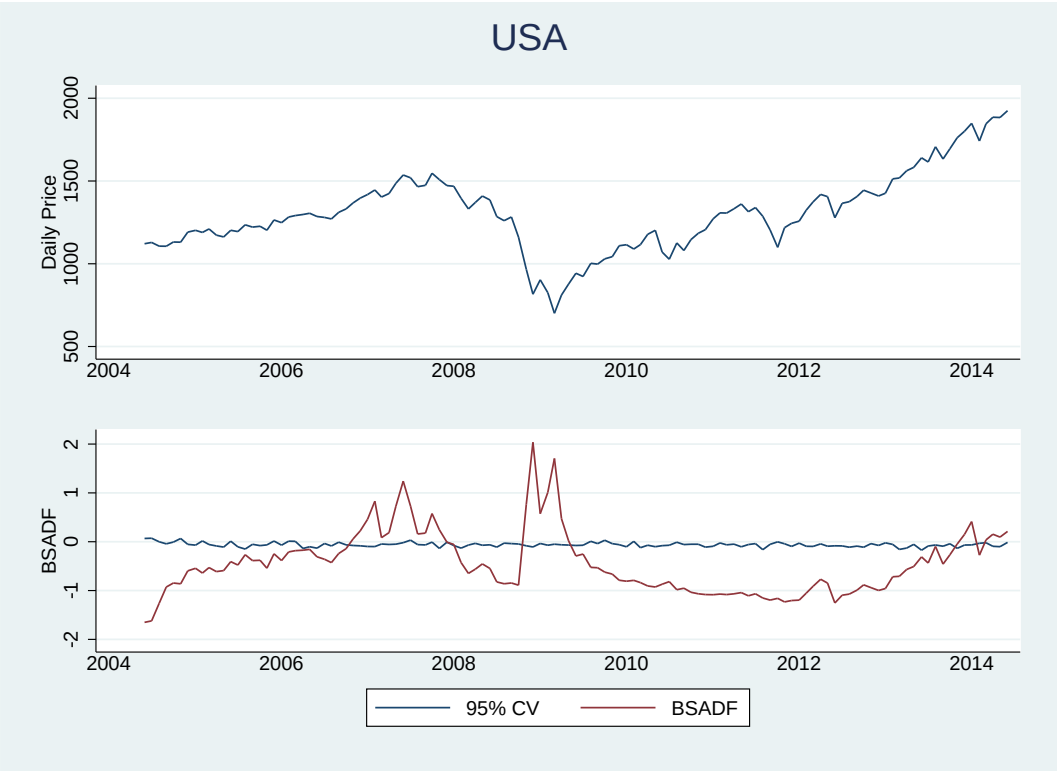
Note: This figure details the monthly prices of the equity market in Mexico and parallels the GSADF test statistics for the same period superimposed on the GSADF 95% critival values. We identify price bubbles, in either tail, in the original price series when the test statistic is greater than the 95% critical values.

Figure 6



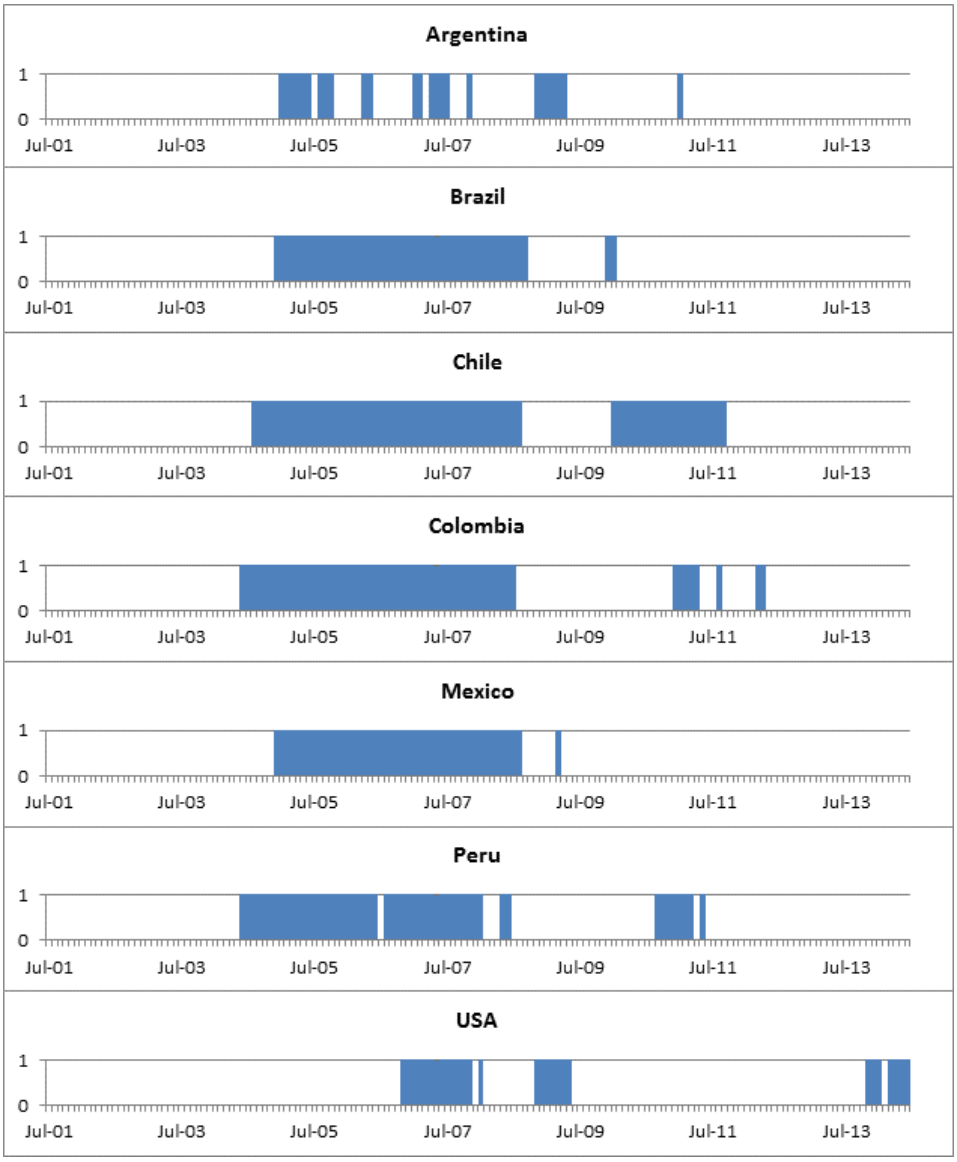
Note: This figure details the monthly prices of the equity market in Peru and parallels the GSADF test statistics for the same period superimposed on the GSADF 95% critival values. We identify price bubbles, in either tail, in the original price series when the test statistic is greater than the 95% critical values.

Figure 7



Note: This figure details the monthly prices of the equity market in the United States and parallels the GSADF test statistics for the same period superimposed on the GSADF 95% critival values. We identify price bubbles, in either tail, in the original price series when the test statistic is greater than the 95% critical values.

Figure 8



Note: This figure comparatively displays the time periods when bubbles are identified for each country over the same time periods. The figures first describe a time period that parallels the build up to the financial crisis in the United States, but notably, for Latin American Countries begins earlier and last longer. The second bubble periods for Chile, Colombia and Peru visibly describe the time periods leading up to the establishment of the MILA.