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# **Financial Exuberance in Latin America: An Empirical Study for the Equity Market**

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## Abstract

The subject of the present study is the potential existence of speculative bubbles in the Latin American equities markets as it has been shown to exist prior to market crashes in several other stock indexes of developed markets. The time series of the MSCI Emerging Markets Latin America and its several sub indices is analysed for the time period from January 1995 to February 2018 using the supremum Augmented Dickey Fuller test as well as recursive regression methodologies proposed by Phillips, Wu and Yu (2011) and Phillips, Shi and Yu (2013).

Keywords: Generalized sup ADF test; Sup ADF test; Periodically collapsing bubbles

## I Introduction

Financial exuberance refers to the sentiment that the current market might be overvalued and at risk of a subsequent crash. Statistically, exuberance in market data manifests itself through explosiveness in prices. Speculative bubbles describe periods in which financial exuberance results in a very rapid escalation of asset prices with a subsequent rapid price decrease.<sup>1</sup> The general idea of the existence of bubbles has been discussed for the past several decades in financial literature. It is based on the idea that market participants respond to external factors which are not or not yet incorporated in market fundamentals, thus driving the price away from its true value, i.e. from the present value of its future cash flows. If enough market participants have this psychological response to whatever market event that might be perceived as important for the magnitude of future cash flows, the price changes in a way of a 'self-fulfilling prophecy'.

While the possible existence of financial bubbles is a greatly discussed topic in financial literature, there is no academic consensus on the fact of their existence<sup>2</sup>, duration or the methodology used in the attempts to detect them, whether ex-post or ex-ante. The present study uses the approach suggested by Phillips, Wu and Yu

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<sup>1</sup> Some authors, including Phillips, Wu, and Yu (2011) use a set of specific criteria for the period of explosiveness to qualify it as a bubble as opposed to a period of exuberance. In the following, both terms will be used interchangeably.

<sup>2</sup> Here, the existence of bubbles refers to a bubble being a deviation from what can be explained by a rational investor model, that is a sharp increase in prices that is not justified by market fundamentals or other unobservable but known to be existing factors.

(2011), and which was later adjusted by Phillips, Shi and Yu (2013). These methods use right-sided unit root tests recursively, allowing not only to detect periodically collapsing bubbles but also to date stamp their origination and their collapse.

The academic stance on the origination of sharp increases followed by rapid decreases in prices commonly referred to as 'bubbles' is inconclusive. Among other possible explanations, periods of exuberance may originate from herd behaviour among investors or mispricing relative to market fundamentals, which, in turn, might have behavioural reasons. Changes in the discount rate might also be the reason for financial exuberance, if market fundamentals are highly sensitive to such changes. However, Phillips, Shi and Yu (2013) argue that irrespective of the reason for the formation of exuberance, its existence manifests itself in explosiveness in prices and can therefore be tested statistically.

From the point of view of an investor, formation of speculative bubbles is relevant since it usually precedes a period of price decreases and indicates that an asset might be irrationally overvalued. When bubbles burst, the result might be a large quantity selling of assets resulting in losses for the investors that still hold the asset. In highly integrated markets, a bubble burst within one asset class might result in contagion across several asset classes and in extreme cases ultimately result in a recession, as most recently observed during the 2008 bubble burst of the U.S. American housing market and the subsequent financial crisis. REFERENCES!!!!!!

The Latin American equities market is the focus of the present study, motivated by the different characteristics that an emerging market has compared with a developed market and the effects that these characteristics can have on the formation of speculative bubbles. The Latin American market is approximated here by the MSCI Emerging Markets Latin America index, which reflects the majority of equity market capitalization in Latin American countries classified as 'emerging'.

This paper is structured as follows. A summary of some of the relevant published studies on the topic of financial exuberance is presented in section II. Section III provides a brief overview of the recent developments in the Latin American equity market. The groundwork of the empirical part of this study are recursive testing techniques first developed by Phillips, Wu and Yu (2011) and later extended

by Phillips, Shi and Yu (2013). Their approach as well as the general econometric methodology of testing for explosiveness are discussed in section IV. The main findings of this paper are presented in section V. The focus of the analysis lies on drawing a parallel between the detected exuberance in the MSCI EM Latin America Index for the period from 1995 to 2018 and the economic, political and other notable events that coincided with these phases of exuberance. Section VI concludes and gives suggestions for possible extensions of the present study.

## II Related Literature

The following overview of literature focuses on publications most relevant for the topic of the present study.

Shiller (1981) discusses the validity of the 'efficient markets model' in the context of price volatility. Underlying is the argument that stock price indexes are often too volatile, meaning that the frequent movements are too big to be attributed to new information that can be incorporated into movements in dividends. Using volatility comparisons between stock price series for the U.S. American market and its ex-post rational prices he shows that empirical data violate the assumption of the 'efficient markets model' that stock price movements can be explained by new information about future dividends. Blanchard and Watson (1982) provide a theoretical discussion of possible underlying processes that bubbles can follow and of the effects that bubbles can have on the market fundamentals. The authors argue that the existence of speculative bubbles is not in contradiction to the assumption of rational behaviour of the financial markets' participants. Building on the study by Shiller (1981), Blanchard and Watson conclude that while the violation of the variance bounds are not in accordance with rational expectations models, these violations might result from rational bubbles but also from irrationality. West(1988) also points out that excess volatility of stock prices does not necessarily have to stem from a formation of bubbles, since excess volatility has been found in bonds with a finite maturity, which cannot be attributed to bubbles.

West (1987) proposes an approach for bubble testing based on the specification test of Hausman (1978). The main idea is to compare two sets of parameters that

describe the impact of dividends on equity prices, with the one set of parameters being obtained from an actual regression and the other one being constructed. The second set is obtained from solving an equation that describes the dividends as an ARIMA process and the arbitrage equation that yields the discount rate. The null hypothesis of no bubbles is rejected if the two sets of parameters are not equal apart from sampling error. The innovation of this tests also stems from the fact that it explicitly considers a bubble components, as described by Blanchard and Watson (1982) as part of the alternative hypothesis as opposed to the previous methodology of variance comparisons. In an empirical application to U.S. stock market data the null hypothesis of no bubbles is rejected.

Diba and Grossman (1987, 1988a) argue that the existence of a bubble in data would imply that the bubble process started at time zero, that is, on the first day of the trading of the asset. This would in turn imply that this asset has been overvalued relative to the market fundamentals from the beginning. Diba and Grossman (1988b) do not find empirical evidence for the existence of rational bubbles in stock prices, stating as an implication that if fluctuations of market prices are not in accordance with fundamentals, then the fundamentals must be misspecified. Diba and Grossman (1988b) argue that the existence of a bubble in the time series implies nonstationarity of the means, which they test empirically using two strategies. The first one is based on the argument that explosiveness in stock prices must result either from a bubble or from explosiveness in the dividend series, which leads to a test which compares whether stock prices are more explosive than dividends. If not, then there is no bubble present. Further, the authors argue that a simulated time series that incorporates bubbles should exhibit higher order nonstationarity than a time series without bubbles. Diba and Grossman (1988b) find that price time series are not more explosive than dividends, concluding that there is no evidence for bubbles in stock prices. The claim is further supported by the finding that first-differences of simulated time series with integrated bubbles exhibit nonstationarity, implying that their tests are able to detect bubbles when such exist.

Evans (1991) critically examines the findings of Diba and Grossman (1987, 1988b) by showing that standard unit root testing procedures may incorrectly lead to a non-rejection of the null hypothesis of stationarity even in the presence of bubbles. By

simulating a time series from a nonlinear model with periodically collapsing bubbles he suggested that the resulting bubbles were usually non-detectable by standard unit root or cointegration tests since these time series only appeared to be stationary. Gurkaynak (2005) provides a summary of the methodologies discussed above.

More recently, Phillips, Wu, and Yu (2011) empirically tested U.S. stock market data using right-sided unit root tests and supremum tests by defining exuberance in financial data as explosiveness in an autoregressive process (AR). Building on the argument by Evans (1991) that standard unit-root testing procedures might not be able to detect periodically collapsing bubbles, Phillips et al.(2011) also apply their supremum test recursively, starting with a small window of observations that is extended in each regression. Using this approach, they are able to identify multiple bubbles in the price series which were not identified using a standard right-sided unit root test for the whole sample. Further, the recursive testing method allows to date stamp the origination and collapse of a bubble period, which Phillips et al.(2011) demonstrate for a few well documented historical bubbles. Homm and Breitung (2012) compare different recursive testing procedures that have been developed recently and find that the test developed by Phillips, Wu, and Yu (2011) is the most powerful recursive test for detecting multiple bubbles, hence this methodology is chosen for the empirical analyses in this study.

Phillips, Shi and Yu (2013) develop a generalized version of the supremum ADF test originally proposed by Phillips, Wu and Yu (2011). In an empirical application of the test to the S&P 500 stock market data for the period from 1871 to 2010 they show that the new approach is able to detect more of the well-known periods of financial exuberance than the original supremum ADF test. The generalized supremum ADF test is an extension of the original test proposed by PWY, meaning that it also uses the recursive right-side ADF tests. However, the window width used for the testing is flexible, meaning that the starting point of the observation and ending point both change in a prespecified range of windows. In simulations, Phillips et. al (2013) show that the generalized version of the supremum ADF test (further: GSADF test) outperforms the simple supremum ADF test in detecting exuberance when multiple explosive patterns are present in the data. The better

performance encompasses both the more precise date stamping as well as the bubble detection ability of the test.

### **III Latin American Equity Market in 1995-2018**

The term 'Emerging Markets' is used to refer to countries and regions whose economies are developing at a faster pace than those of developed countries, as measured by GDP growth, but which are not yet fully advanced. From an investment perspective, emerging markets offer attractive return opportunities due to the general growth prospects and due to the higher risk, which is generally associated with investment in such markets. Potentially high currency volatility, an unstable political and regulatory environment and an underdeveloped infrastructure are a few of the common additional risk factors that investors are faced with when turning to emerging markets. The higher risk, paired with the general higher expected growth of the market economy drive the high returns associated with an investment in emerging markets, thus making them attractive to many investors.

Starting in the second half of the 1980s the Latin American economies experienced a wave of deregulation, following a decade of financial crises (the Latin American Debt crisis). Due to the deregulation, these markets experienced large capital inflows, which could have several effects on developing economies. Firstly, due to an increased international integration the countries' economies are more susceptible to external shocks, thus also becoming subject to higher asset volatility. Phenomena such as momentum investing, contagion effects and herd behaviour of investors might give rise to the development of asset bubbles (World Bank, 1997). Higher systemic risk that results from a higher integration must be rewarded by a higher return, which in turn drives asset prices higher. There appears to be a negative relationship between the level of development of a market and the excess volatility present in it (World Bank, 1997). Additionally, market participants might suffer from a lack of accessible information regarding their investments, due to several factors such as difference in regulatory rules and oversight, infrastructural problems, and others. The lack of information might increase the already higher volatility present in these

markets. Further, the financial liberalization and market deregulation has attracted large capital inflows to emerging markets over the past decades, with some authors arguing that this might contribute to the origination of asset bubbles (World Bank, 1997; Kim and Yang, 2009). All these factors give rise to the assumption that emerging markets, that have undergone a wave of liberalization in the recent past, might be highly susceptible to the emergence of financial exuberance in times of high market volatility. In the present study, the emerging market of Latin America is approximated using the MSCI institute definitions.

Economically, Latin America experienced a period of unusual growth between 2003 and 2013, which is attributable to a number of factors. Apart from the high capital flows into the region, the demand for commodities increased substantially, mainly from Asia. The high demand drove up both the commodities prices as well as trading volumes, thus stimulating regional economies that are heavily reliant on commodities exports. During the recent financial crisis commodity prices plummeted, but by 2011 recovered to almost pre-crisis levels<sup>3</sup>. However, in 2014 commodity prices fell sharply again and have not recovered since. This can be attributed to the weakened world economy in the aftermath of the financial crisis as well as to the slowdown of China's economy in particular.

Within the MSCI institute classification, the Emerging Markets within Latin America is constituted by five countries: Brazil (58.49%), Mexico (24.34%), Chile (9.94%), Colombia (3.78%) and Peru (3.45%)<sup>4</sup>. Argentina, although a major Latin American economy is not included in the index, since it is not classified as an emerging market. The MSCI Emerging Markets (EM) Latin America Index comprises 109 constituents and it is constructed such that it reflects 85% of the free float-adjusted market capitalization for each country. The biggest sectors that constitute the MSCI EM Latin America Index are Financials (31.11 %), Materials (17.24 %), Consumer Staples (15.81 %), and Energy (9.91 %). The index has a total market capitalization of USD 674, 133.72 millions, with a median market capitalization of its constituents of USD 3,704.30 millions. Figure 1 plots the evolution of the overall index and its

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<sup>3</sup> <https://www.indexmundi.com/commodities/>

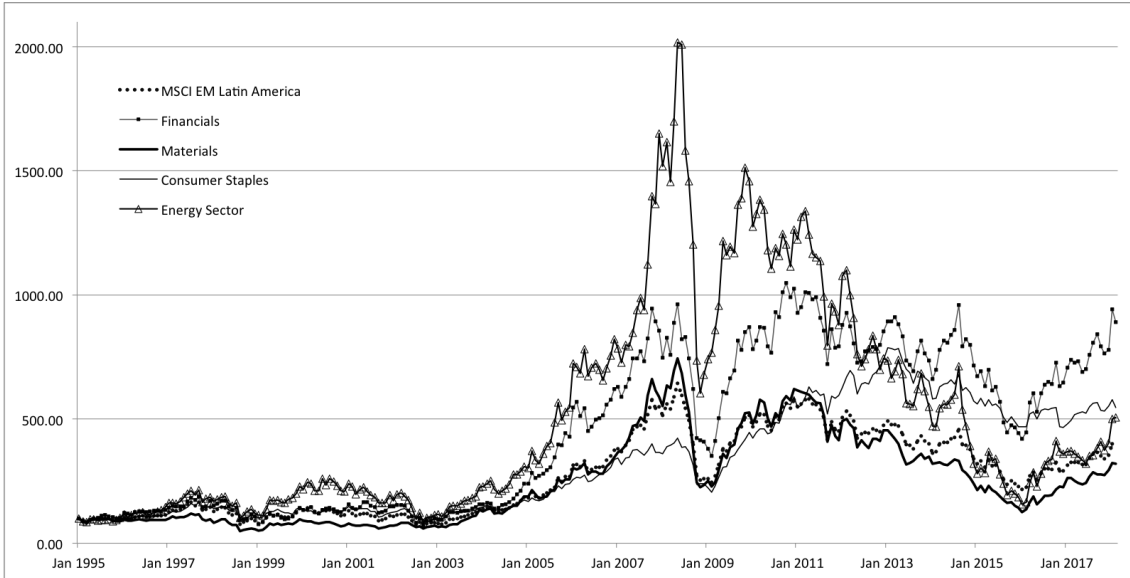
<sup>4</sup> <https://www.msci.com/documents/10199/5b537e9c-ab98-49e4-88b5-bf0aed926b9b>.

All information in this paragraph is based on the fact sheet from this web-link, which is provided on the website of the MSCI institute.



**Figure 1: Comparative evolution of the indexes over the period of 1995-2018**

Monthly time series of the normalized MSCI Emerging Market Latin America Index and its four biggest components for the time period from January 1995 to February 2018. All indexes were normalized to 100 at the starting point.



four biggest constituents.

Figure 1 clearly reflects the market turbulence associated with the financial crisis that started in 2008. One aspect of the empirical analysis in the present study will be to date stamp the exuberance in the data for this time period. What is, however, not obvious from this figure is whether there has been a bubble in the Latin American equity markets that is commonly known as the 'Dotcom'-bubble. This will also be analysed in the following.

## IV Econometric Methodology

The standard procedure to test a simple AR(1) process for a unit root is the Dickey-Fuller test (DF test). Consider an AR(1) process with a drift

$$y_t = \mu + \delta y_{t-1} + \epsilon_t \quad (1)$$

where  $\mu$  is the drift in the process and  $\epsilon_t$  follows an independent and normal distribution. The standard DF test determines whether the process described in Equation

(1) follows a unit root case ( $\delta = 1$ ) or whether it is stationary ( $|\delta| < 1$ ). However, under the null hypothesis ( $H_0 : \delta = 1$ )  $y_t$  is non-stationary and the normal central limit theorem does not apply for non-stationary time series, which means that stationarity cannot be tested directly by using the normal distribution. Instead, the approach used in the Dickey-Fuller test is to subtract  $y_{t-1}$  from Equation (1) resulting in

$$y_t - y_{t-1} = \mu + (\delta - 1)y_{t-1} + \epsilon_t \quad (2)$$

Setting  $\rho = \delta - 1$  we get

$$\Delta y_t = \mu + \rho y_{t-1} + \epsilon_t \quad (3)$$

Equation (3) allows us to rewrite the null hypothesis as  $H_0 : \rho = 0$ . While the left-hand side of the equation is stationary, the variable  $y_{t-1}$  remains non-stationary and we cannot test  $\rho$  by comparing the t-statistic with an ordinary student-t distribution. The t-statistic must be compared with the Dickey-Fuller distribution. The null-hypothesis of a non-stationary time series is rejected if the t-statistic is larger than the relevant DF critical value in absolute terms.

The present study explores the possibility of a third pattern of behaviour of a particular time series - the explosive case. The null hypothesis is  $H_0 : \beta = 0$  and the explosive alternative hypothesis is right-tailed and expressed as  $H_1 : \beta > 0$ . The main pitfall of the Dickey-Fuller test is that it is inconsistent if  $\epsilon_t$  is not white noise. In such a case, an Augmented-Dickey-Fuller test should be applied, which is an extension of a Dickey-Fuller test for autoregressive processes of order two or higher. For instance, for an AR(2) process the regression equation is

$$\Delta y_t = \mu + \rho y_{t-1} + \phi \Delta y_{t-1} + \epsilon_t \quad (4)$$

for which the null and the alternative hypotheses remain the same as for Equation (3). The test can be generalized from an AR(2) to an AR(J) process by including more lagged differences of  $y_t$ , that is

$$\Delta y_t = \mu + \rho y_{t-1} + \sum_{j=1}^J \phi_j \Delta y_{t-j} + \epsilon_t. \quad (5)$$

The optimal lag length can be determined by looking at the t-statistic of the last included lag and by determining if there is serial correlation in the error term, or through some information criteria (e.g. AIC, BIC).

In the empirical part of this study, the methodology proposed by Phillips, Wu and Yu (2011) is applied to test for a unit root against the alternative of explosiveness in the data. For each time series (the standardized Latin America Index and the standardized sector indices) a regression is performed.

The optimal lag length  $J$  is chosen according to Campbell and Perron (1991). To this end, the regression from Equation (5) is performed repeatedly, starting with  $J = 12$  and subsequently decreasing the number of lags until the last included lag is significant at a 5% significance level and the residuals do not display autocorrelation. For the full time series of each index a right-sided ADF test is performed and the critical values are obtained by Monte-Carlo simulation.

Hereafter, in order to date stamp the beginning and the ending of exuberance, forward recursive regressions are applied, as originally proposed by Phillips, Wu, and Yu (2011). The methodology hereby is to start with a subsample of the data and to perform the regression in (5) repeatedly, while increasing the subsample by one observation with each repetition. This allows the construction of the supremum ADF test statistics. For this approach, the starting point of all subsamples is held constant. The initial fraction of the sample that is used is denoted by a positive integer which corresponds to the fraction  $r_0$  of the total number of observations. This means that the first regression involves  $\tau_0 = [nr_0]$  observations,  $n$  being the total number of observations. Denoting the origination date of explosive behaviour in the data by  $r_e$  and the collapse date by  $r_f$ , the estimates of these dates are

$$\hat{r}_e = \inf_{s \geq r_0} \{s : ADF_s > cv_\beta^{adf}(s)\}, \hat{r}_f = \inf_{s \geq \hat{r}_e} \{s : ADF_s < cv_\beta^{adf}(s)\}, \quad (6)$$

with  $cv_\beta^{adf}(s)$  being the right-side critical value of the supremum ADF for a significance level of  $\beta$ . As suggested by Phillips et. al (2011), the critical values are computed as follows:

$$cv_\beta^{adf}(s) = \frac{\ln[\ln(ns)]}{100}. \quad (7)$$

While the recursive test developed by Phillips, Wu, and Yu (2011) is very effective in detecting explosiveness if the sample data contain a single bubble episode, its discriminatory power is low if there are bubble episodes with multiple breaks. A generalized version of the forward recursive supremum ADF testing (SADF) is proposed by Phillips, Shi, and Yu (2013) proposed a generalized version of the forward recursive supremum ADF test (GSADF test), which is a recursive testing methodology that uses flexible window widths for the recursive regressions. While the starting point of the recursion is fixed in SADF tests, the GSADF test allows both the starting and the ending point of the recursion to change for a specified feasible range of observations. The authors of the test show in simulations that the GSADF test performs better than the SADF test when multiple bubbles occur in the data, in particular offering a more consistent dating mechanism.

For the varying window lengths of the GSADF test the end point of each regression is denoted by  $r_2$  and as for the SADF test it varies from  $r_0$ , which is the shortest window length, to 1, which is full sample length. The starting point of each regression is denoted by  $r_1$  and the range in which it is allowed to change is from 0 to  $r_2 - r_0$ . Then, the GSADF test statistic is the largest ADF statistic for all tested window lengths and determined as shown in Equation (8):

$$GSADF(r_0) = \sup ADF_{r_1}^{r_2} \quad (8)$$

with  $r_2 \in [r_0, 1]$  and  $r_1 \in [0, r_2 - r_0]$ . In a similar way as for the SADF test, the origination date of explosive behaviour in the data is denoted by  $r_e$  and the collapse date by  $r_f$ , with the estimates of these dates given by the following equation:

$$\hat{r}_e = \inf_{r_2 \geq [r_0, 1]} \{r_2 : ADF_{r_2} > cv_{\beta}^{adf}(r_2)\}, \hat{r}_f = \inf_{r_2 \geq [\hat{r}_e, 1]} \{r_2 : ADF_{r_2} < cv_{\beta}^{adf}(r_2)\}, \quad (9)$$

with  $cv_{\beta}^{adf}(r_2)$  being the right-side critical value of the supremum ADF for a significance level of  $\beta$ . The critical values used for the recursive regressions are computed according to Equation (7).

## V Empirical Analysis

### A Data

The data were obtained from Bloomberg and consist of monthly prices of the MSCI Emerging Markets (EM) Latin America Index as well as monthly index prices that are included in the Latin America Index for the period of time from January 1995 to February 2018. The sectors analysed in this study are: Energy, Financials, Consumer Staples, Consumer Discretionary, Utilities, Materials, Industrials, Health Care, Telecommunications and Information Technology. January 1995 was selected as the starting point of the analysis for completeness reasons, since it was the first month for which index prices for all sectors of the Latin American Index were available on the database. All indices are normalized to a starting level of 100. For each index the time series consists of 278 monthly observations.

### B Results and Interpretation

Prior to applying the recursive regression procedure by Phillips et al. (2011), the full sample of the time series of the MSCI Latin America index is tested for explosiveness with a standard right-sided ADF test. Table I presents the t-statistics from right-sided ADF tests for the general Latin America index as well as for the analyzed sectors using the full sample from January 1995 to February 2018. Right-sided critical values for significance levels of 1%, 5%, and 10% were computed by Monte-Carlo simulations and are also provided in the table. In accordance with the argument of Diba and Grossman (1987, 1988b) the null hypothesis cannot be rejected with these tests, implying that the behaviour of the data is not consistent with the existence of financial exuberance. However, as suggested by Evans (1991), the standard ADF testing procedure may not be able to detect explosiveness in the data, if bubbles periodically collapse during the tested time period. When applying the  $sup_{r \in [r_0, 1]} ADF_r$  test to the entire sample of data, explosiveness is detected even at a significance level of 5%, as reported in Table I.

**Table I: Right-sided ADF test for full sample**

The table shows test statistics and the corresponding critical values for a right-sided Augmented Dickey-Fuller test with the null hypothesis of a unit root test against an alternative of an explosive root. Test results are based on a full sample of 278 observations and for the supremum ADF  $r_0 = 0.10$  is used. Critical values are obtained using Monte-Carlo simulations.

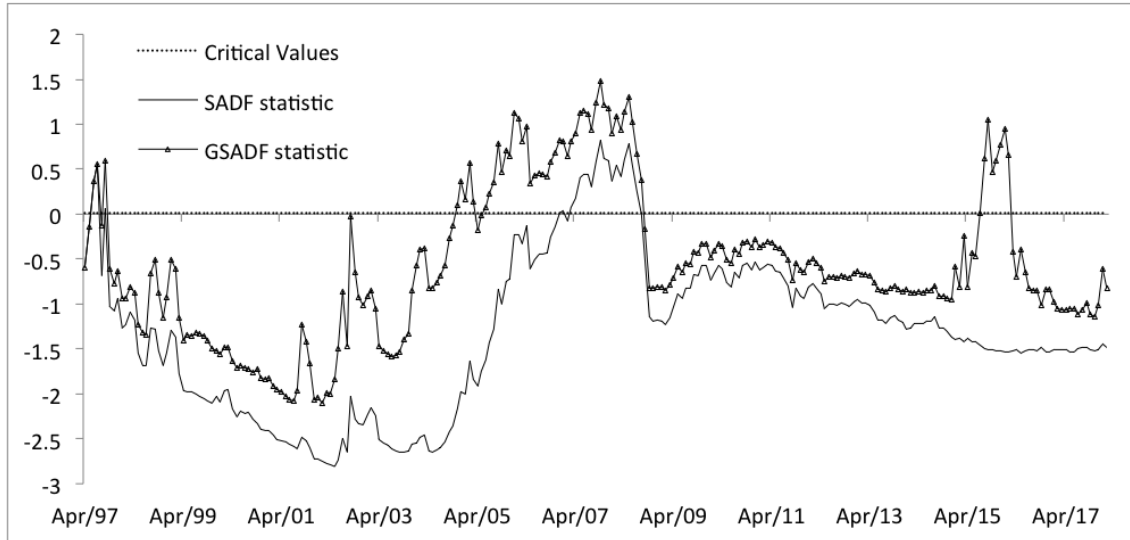
	$ADF_1$	$sup_{r \in [r_0, 1]} ADF_r$
MSCI Latin America Indices:		
EM Latin America	-1.25	2.71
Energy Sector	-1.62	5.60
Financial Sector	-1.10	1.55
Materials Sector	-1.03	4.75
Consumer Staples Sector	-0.95	1.80
Telecommunications Sector	-1.90	1.95
Industrials Sector	-1.52	1.51
Utilities Sector	-1.58	1.42
Consumer Discretionary Sector	-1.59	2.24
Critical Values for the Explosive Alternative		
1%	0.51	2.11
5%	-0.16	1.46
10%	-0.53	1.19

In the next step, the forward recursive regressions as suggested by Phillips, Wu, and Yu (2011) are computed for the general Latin America index as well as for the sector indexes. Figure 2 plots the results of the tests proposed by Phillips et al. (2011, 2013) for the MSCI Latin America index. The critical values for the forward recursive regression are computed as described by Equation (7). With an initial sample of 28 observations ( $r_0 = 0.1$ ),  $[ns]$  ranges between 28 and 278, and the critical values  $cv_{\beta}^{adf}(s)$  thus range from 0.01204 to 0.01728.

The plot of the t-statistics starts in April 1997, since the first window of observations for the supremum ADF statistic is 28 observations. As expected, using flexible windows (GSADF test) more periods of exuberance can be detected in the data. This effect is most notable in the time leading up to the latest financial crisis as well as for some period of exuberance in 2015/2016. While the SADF test picks up on exuberance starting in December 2006 until July 2008, the GSADF test consistently rejects the null hypothesis for the period from June 2005 until August 2008, which was the month in which the Lehman Brothers filed for bankruptcy.

### Figure 2: Recursive ADF and double recursive ADF plot of the MSCI Latin America Index

This figure plots the time series of the ADF t-statistics for the logarithmic price index of MSCI EM Latin America Index for the period from April 1997 until February 2018. The time series are based on a supremum ADF test (SADF) and on the generalized supremum ADF test (GSADF). The critical values are obtained by applying Equation (7) to the number of observations.



The first time period attributable to the run up to the subprime crisis detected by the GSADF test is as early as from November 2004 until March 2005. While it is nearly impossible to attribute certain periods of explosiveness in prices to precise political or economic events, it is plausible to assume that here the GSADF test results reflect the time period of sharply increasing commodity prices. Latin American economy is greatly dependent on commodity exports and with rising prices and rising exports due to higher demand, especially from Asia, the performance of the index was rising until the recent financial crisis. While keeping in mind that these data reflect investor sentiment in the Latin American equities markets, the three year long exuberance in prices can also be the result of contagion across markets, since exuberance has been shown to have been present in other markets, such as the U.S. market, in the time leading up to the financial crisis. Here, contagion of exuberant investor sentiment seems a possible explanation, since foreign investors have better access to the Latin American equities market due to its increasing openness and integration, which has been previously discussed. As can be observed for the period in the 1990s, both the SADF and GSADF statistic reflect exuberance in the data with a collapse of a bubble in September 1997. All subsequent Figures display

a similar pattern, with the precise dates of bubble formation varying for different indexes. This period of exuberance may be attributed to the financial crisis of the late 1990s, which spread across Asia, Latin America and Russia. Since there is no subsequent bubble formation for the period that is known in the U.S. American market data as the 'Dot-com' bubble, it can be assumed that no exuberance has formed during that short time period, since the Latin American market had just undergone a collapse of a stock market bubble. Thus, while the 'Dot-com' bubble formed approximately in the period from 1997 until 2001, whatever exuberance there was present in the Latin American stock market has collapsed as a result of the Asian and Latin American crisis of 1997/1998. This assumption is supported by the fact that the Latin American market does not have a strong information technology sector. Within the MSCI EM Latin America index the information technology sector has a weight of 1%.

Most recently, explosiveness in this data series is shown for the period from July 2015 until February 2016 when examining the GSADF statistic. Possible explanations for this are presented below in the interpretation of the sector specific ADF recursive tests. The underlying idea is the general reliance of the Latin American economy on commodity prices and trade. As will be discussed below, commodity prices have declined sharply over the past 5 years, slowing down the economy of several Latin American countries. Brazil-based constituents of the MSCI EM Latin America index account for 59% of the index composition, which leads to the assumption that general investor sentiment in Brazil can greatly affect the development of the index. In the aftermath of a period of low commodity prices, political turbulence due to the Petrobras scandal and the impeachment of President Dilma Rousseff in August 2016 and low private sector investment, the Brazilian economy has entered into a deep recession.

The greatest visible difference between the results of both tests that can be seen in Figure 2 is the explosiveness that is detected around the year 2016. The GSADF test exceeds the critical values for 8 months from June 2015 until January 2016. In this period, the SADF test does not show any sign of exuberance.



### Figure 3: Recursive sup ADF statistic and generalized sup ADF statistic of the energy sector

This figure plots the time series of the ADF t-statistics for the logarithmic price index of MSCI Latin America Energy Sector Index for the period from April 1997 until February 2018. The time series are based on a supremum ADF test (SADF) and on the generalized supremum ADF test (GSADF). The critical values are obtained by applying Equation (7) to the number of observations.

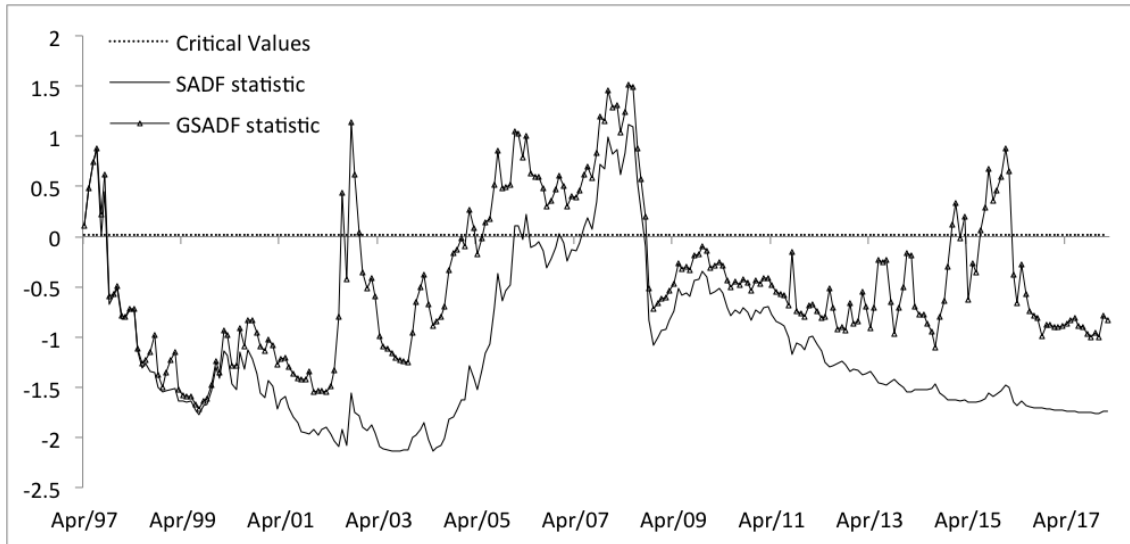


Figure 3 plots the time series of the forward recursive tests for the energy sector. The most recent period exuberance revealed by the values of GSADF t-statistics spans over the year 2015 and until February 2016. There are several possible explanations for this. The beginning of this exuberance coincides with a short period of increasing oil prices<sup>5</sup>, which followed a sharp decline of oil prices throughout the second half of 2014. This increase in oil prices lasted until late 2015, after which the price dropped drastically to 60% of the level at which the increase started in early 2015. This might have been one of the reasons behind the bubble collapse in February 2016 illustrated in Figure 3. This period of the collapse of the bubble also coincides with the debt rating downgrade of Petrobras<sup>6</sup>, which occurred in February 2016 following the biggest corruption scandal in the history of Brazil. Petrobras (Petróleo Brasileiro S.A.), a Brazilian energy company, accounts for 7% of the general index (MSCI EM Latin America) and is a major driving force of the MSCI energy sector index. While it is difficult to assume a causality relationship between a specific event and the formation and collapse of a bubble, it is plausible

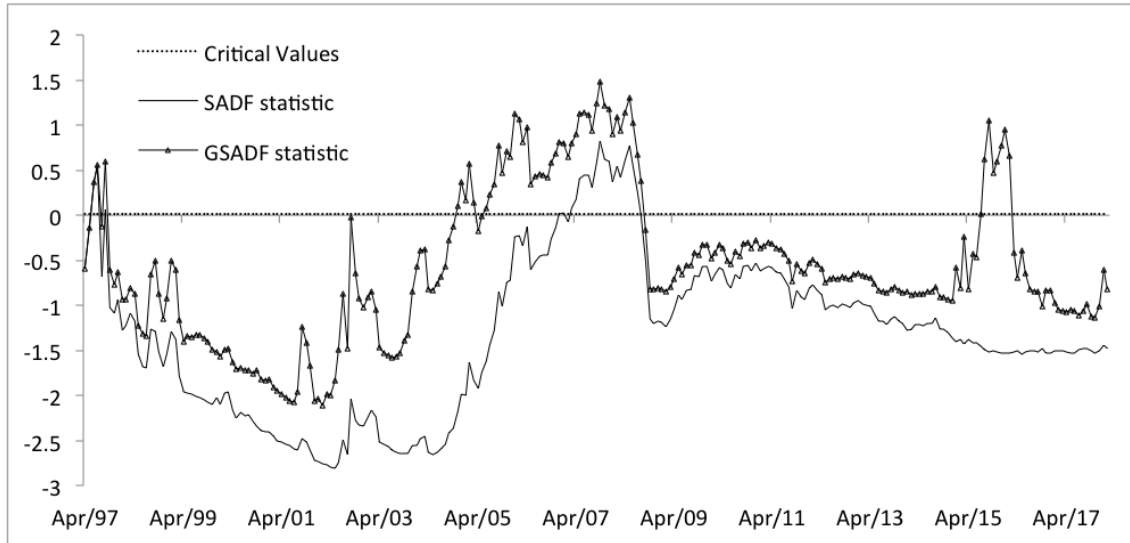
<sup>5</sup> [www.reuters.com](http://www.reuters.com)

<sup>6</sup> The majority of the instruments were downgraded by Moody's from B3 to Ba3, which is a non-investment grade rating.

that the rating downgrade and the corruption scandal at Petrobras as well as the political turbulence might have weakened the investor confidence in other Brazilian companies.

**Figure 4: Recursive sup ADF statistic and generalized sup ADF statistic of the financial sector**

This figure plots the time series of the ADF t-statistics for the logarithmic price index of MSCI Latin America Financial Sector Index for the period from April 1997 until February 2018. The time series are based on a supremum ADF test (SADF) and on the generalized supremum ADF test (GSADF). The critical values are obtained by applying Equation (7) to the number of observations.



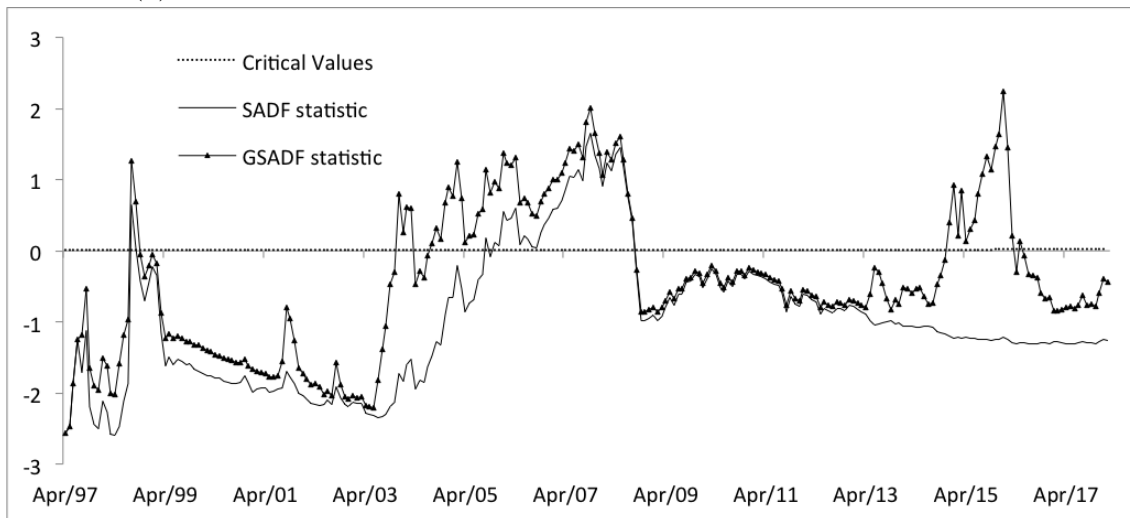
The recursive ADF test results for the financial sector, depicted in Figure 4 shows a roughly similar pattern to the indexes discussed above. While the possible explanations for rapid developments in the indexes mentioned above also hold for all following indices, there might be an additional driver behind the bubble period in the MSCI financials index, which according to the GSADF statistic lasted from September 2015 until February 2016. Here again, Brazil might play a major role, since the Brazilian banks Itaú Unibanco and Banco Bradesco account for 7.01% and 4.94% of the total index composition<sup>7</sup>, respectively. Further, the Brazilian holding company Itaúsa, which is, among others, active in the financial industry and is classified as part of the 'Financials Sector' within the MSCI EM Latin America index, accounts for another 2.34% of the overall index and is one of the ten greatest

<sup>7</sup> The index weights refer to the weight within the general index, the MSCI EM Latin America index. Index weights within the sector indexes are not publicly available.

index constituents by weight. Nevertheless, despite the downgrade of Brazilian government bonds to a junk-level in September 2015, the financials sector displays a period of explosiveness.

**Figure 5: Recursive sup ADF statistic and generalized sup ADF statistic of the materials sector**

This figure plots the time series of the ADF t-statistics for the logarithmic price index of MSCI Latin America Materials Sector Index for the period from April 1997 until February 2018. The time series are based on a supremum ADF test (SADF) and on the generalized supremum ADF test (GSADF). The critical values are obtained by applying Equation (7) to the number of observations.



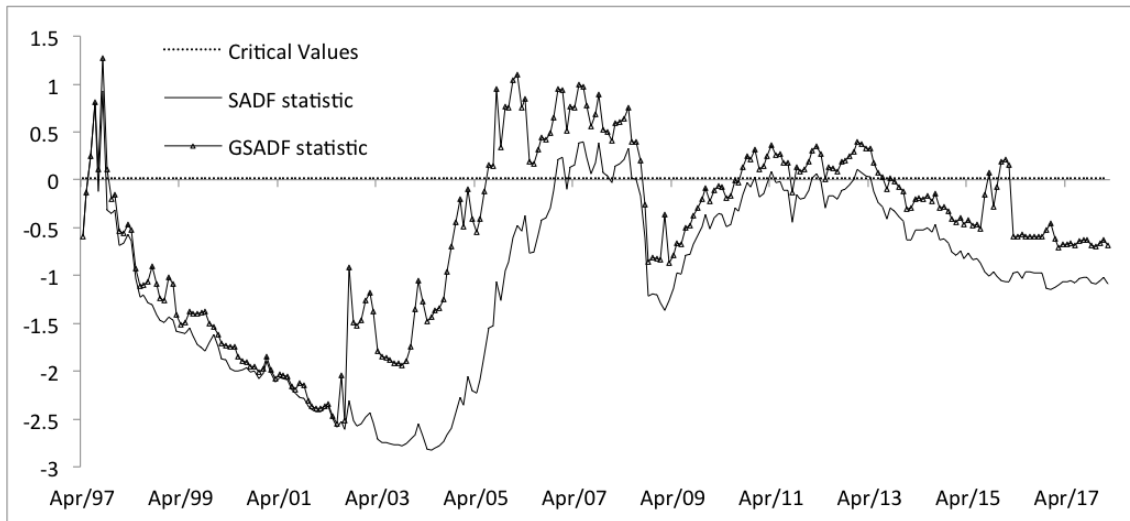
Figures 5 and 6 display of the recursive ADF test results for the materials sector and the consumer staples sector, respectively. The materials sector displays periods of explosiveness that are similar to the other discussed indexes. This sector is known to be highly sensitive to changes in supply and demand and the test results displayed in Figure 5 are in accordance with this feature. The period of bubble formation leading up to 2007/2008, which is visibly present in all indexes, is more prolonged in the materials sector. Here, the GSADF statistic first exceeds the critical values in October 2003, which is 11 months before the general Latin America index.

As can be observed in Figure 6, the GSADF statistic shows explosiveness in consumer staples data in the period from September 2010 until September 2013, unlike for the data of the indexes discussed above during the same period. Consumer staples is a sector which is characterized by low elasticity of demand. One possible explanation might have been a higher investor confidence in the consumer staples

sector relative to possible investments in equities belonging to other sectors, since it is generally characterized by low volatility and steady growth. In times of a generally negative economic outlook in the region due to the previously discussed factors, such as the low commodity prices and economic stagnation or recession, higher amount of investments into the consumer staples sector would have driven the prices upwards, resulting in the period of exuberance that is depicted in Figure 6.

**Figure 6: Recursive sup ADF statistic and generalized sup ADF statistic of the consumer staples sector**

This figure plots the time series of the ADF t-statistics for the logarithmic price index of MSCI Latin America Consumer Staples Sector Index for the period from April 1997 until February 2018. The time series are based on a supremum ADF test (SADF) and on the generalized supremum ADF test (GSADF). The critical values are obtained by applying Equation (7) to the number of observations.



Results of the recursive sup ADF tests and generalized supremum ADF tests can be found in Appendix A for sectors 'Telecommunication Services', 'Industrials', 'Utilities', and 'Consumer Discretionary'. Overall, all subsectors of the MSCI EM Latin America index display a similar period of exuberance and the results of the recursive ADF tests for the four sectors included in Appendix A are included for comparison purposes. These four sectors have lower weights in the general index (Telecommunication Services 6.38%, Industrials 6.04%, Utilities 5.27%, Consumer Discretionary 4.90%) and are therefore assumed to not be the main drivers for bubble formation in the overall index.

## VI Conclusion

The present study provides an insight in the periods of exuberance in the Latin American equity market in the period from 1995 until early 2018. The empirical analysis is conducted using the supremum ADF forward recursive regressions test by Phillips, Wu and Yu (2011) and the generalized supremum ADF recursive regressions test by Phillips, Shi and Yu (2013) on monthly index prices for the MSCI Emerging Markets Latin America index as well its sector subindices. The methodology of these tests is aimed at locating periods of exuberant behaviour in the data, as characterized statistically by having an explosive root. The tests are have the power to find exuberance in periods when multiple bubbles might be present and when these bubbles collapse periodically. The recursive tests further allow to date stamp the beginning and end of bubble formation, thus leaving room for the interpretation of the results in an economic and political context.

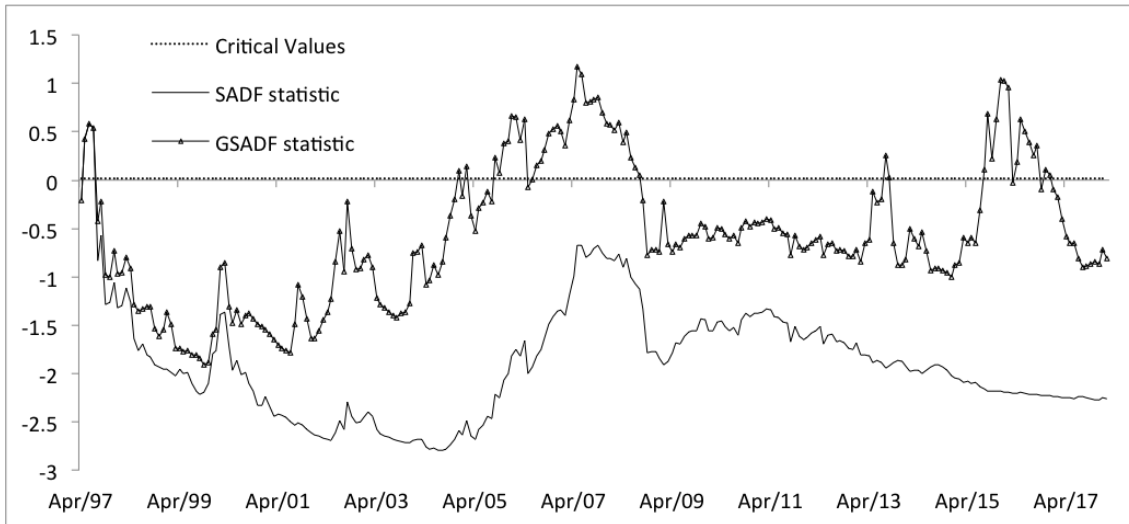
For the Latin American equity market, several time periods of bubble formation are detected. Present in all analysed indices, is a bubble collapse in 1997/1998, which coincides with the Asian and Latin American crisis of 1997-1998. Further, a long period of explosiveness between 2003/2004 until 2008 is found in all indexes, which may be attributed to the economic period of high commodity prices. This period ends with the onset of the worldwide financial crisis and in the majority of the index data the bubble collapses in September 2008, the month of the default of Lehman Brothers. Most recently there seems to be evidence of exuberance across all sectors from 2015 until early 2016. A short period of rising oil prices coincides with this finding, which might be an explanation for the exuberance.

The approach of the present study merely allows to identify periods of explosiveness and locate the months of their beginning and ending. A causal relationship between certain economic or political events and the formation of a bubble can never be established with certainty and any links that can be provided between events that have affected the Latin American economy and the bubbles detected through data analysis are interpretations based on publicly accessible information. In this context, an extension to the present paper could be the empirical analysis of the Latin American equity market by country as well as a more detailed analysis of the identified periods of exuberance.

## VII Appendix A

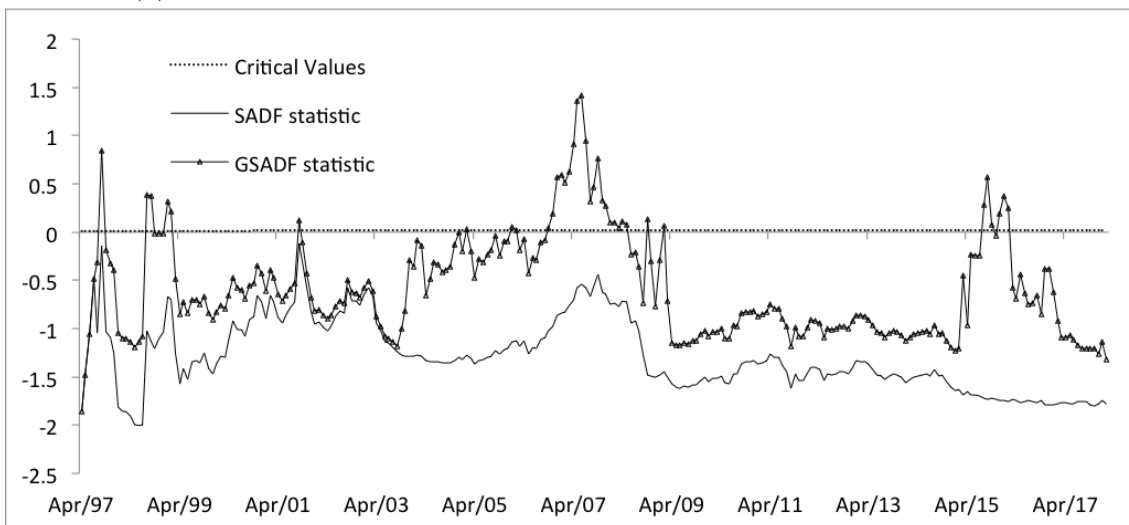
**Figure 7: Recursive sup ADF statistic and generalized sup ADF statistic of the telecommunication services sector**

This figure plots the time series of the ADF t-statistics for the logarithmic price index of MSCI Latin America Telecommunication Services Sector Index for the period from April 1997 until February 2018. The time series are based on a supremum ADF test (SADF) and on the generalized supremum ADF test (GSADF). The critical values are obtained by applying Equation (7) to the number of observations.



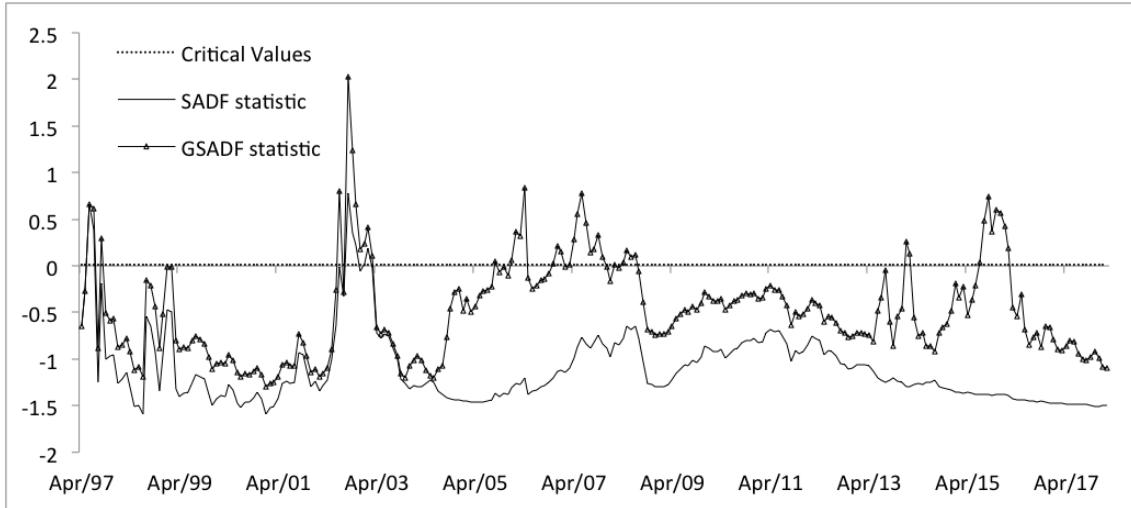
**Figure 8: Recursive sup ADF statistic and generalized sup ADF statistic of the industrials sector**

This figure plots the time series of the ADF t-statistics for the logarithmic price index of MSCI Latin America Industrials Sector Index for the period from April 1997 until February 2018. The time series are based on a supremum ADF test (SADF) and on the generalized supremum ADF test (GSADF). The critical values are obtained by applying Equation (7) to the number of observations.



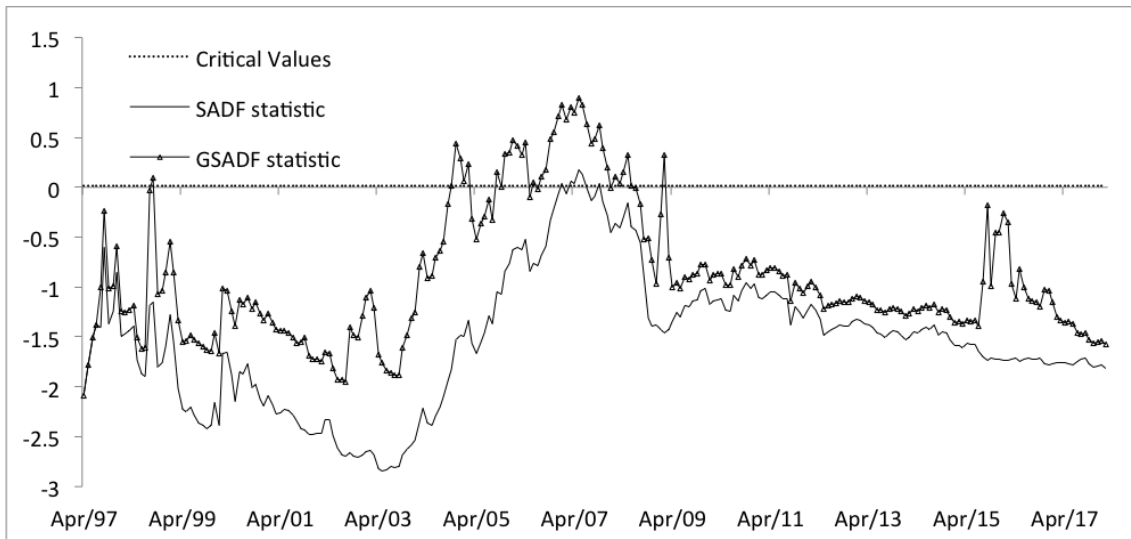
**Figure 9: Recursive sup ADF statistic and generalized sup ADF statistic of the utilities sector**

This figure plots the time series of the ADF t-statistics for the logarithmic price index of MSCI Latin America Utilities Sector Index for the period from April 1997 until February 2018. The time series are based on a supremum ADF test (SADF) and on the generalized supremum ADF test (GSADF). The critical values are obtained by applying Equation (7) to the number of observations.



**Figure 10: Recursive sup ADF statistic and generalized sup ADF statistic of the consumer discretionary sector**

This figure plots the time series of the ADF t-statistics for the logarithmic price index of MSCI Latin America Consumer Discretionary Sector Index for the period from April 1997 until February 2018. The time series are based on a supremum ADF test (SADF) and on the generalized supremum ADF test (GSADF). The critical values are obtained by applying Equation (7) to the number of observations.



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