Long-Run Comovement of Stock Markets in Latin America and the US

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Abstract

This paper looks for evidence of cointegration between each of the stock market indices in six Latin American countries and two US benchmarks, the S&P 500 and the Nasdaq Composite. Most investigations into price index cointegration assume a linear cointegrating structure. However the relationship between two series need not be linear and in this paper we also examine the possibility of a more general long-run relationship. Nonlinear cointegration between prices may be interpreted as evidence of financial market integration that is exemplified by the nonlinear dependence of the risk premium on perceived risk as proposed by Li (2006). Results from this study suggest that when one is trying to determine whether a stable long-run relationship between two stock price series exists, standard tests for cointegration may provide misleading results.

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1 Introduction

Prior to the 1990s the financial sectors of Latin American countries were subject to tight controls as part of the Bretton Woods arrangement.[1] Capital markets consisted primarily of banks since the local equity markets were extremely underdeveloped. Stocks were traded only 2 or 3 days a week and only for a few hours a day. Governments practised interventionist policies; they controlled the interest rates and decided how private banks should distribute credit [Torre and Schmukler (2006)].

By the late 1980s most of the developed world had liberalized their financial markets and were keen on finding other countries in which to invest. This prompted Latin America, as well as other emerging economies, to institute reforms in order to attract foreign capital. Macroeconomic stabilization programs were implemented and South America opened up its capital markets to overseas investors. International corporations were then able to establish subsidiaries and branches in these emerging economies and they were also able to acquire local businesses, particularly banks. To lend credibility to their financial sectors, governments formulated and passed new laws aimed at fostering the development of a sound legal framework and a strong market infrastructure [Torre and Schmukler (2006)]. The new legislation included regulations on transparency, disclosure and accounting rules which were to be in line with international standards. Other reforms included widespread privatization and pension reform. Latin America's goal of establishing market-oriented economies was relatively successful. Net portfolio equity inflows to the region jumped from US $2.4 billion in 1990 to US $28.1 billion in 2007.[2]

On account of continued financial globalisation, there has been increasing interest

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[1] The Bretton Woods Agreement was basically a system of procedures to stabilize the international monetary system in the wake of World War II. One of the primary requirements of the Agreement was that countries adhere to an international gold standard and fix their exchange rates, plus or minus 1 % to the value of gold.

[2] Data taken from the Economic and Social Data Service.

in the extent of stock market integration across countries. Two stock markets are considered to be 'integrated' if investors can freely transact in both of them and, as a consequence, arbitrage forces ensure that similar returns adjusted for risk can be expected in both of these markets. Research in this area has important implications for diversification of financial risk. In particular, diversification across markets might result in gains from international investment for the investor not only because of the general difference in idiosyncratic factors that each economy is exposed to but also because some markets might show industry-specific features. For instance, the Swiss index puts a relatively high weight on the banking sector while the South African market has a disproportionate share of the gold and diamond industry.

The focus of this paper is to investigate the presence of long-run co-movement between selected Latin American markets and the US stock market. The majority of studies on stock market co-movements have concentrated primarily on developed markets. Comparatively less research has been done for developing and emerging economies. Financial markets play an important role in the economy and in particular, if they are well-developed, they can contribute to the efficient allocation of resources in the real economy [Levine and Schmukler (2006)]. Therefore the study of any aspect of financial markets would provide important information for both investors and policymakers. In this analysis we attempt to identify a general long-run stable relationship between six major Latin American markets (Argentina, Brazil, Chile, Mexico, Peru and Venezuela) and the US benchmark index, the S&P 500, which is chosen as a broad representative index of the US economy. We also include results for the high-tech dominated Nasdaq Composite index. In addition to the standard tests for linear cointegration, a test for nonlinear cointegration is also undertaken to help identify the existence of more complex relationships since a conclusion of no linear cointegration does not rule out the possibility of some other form of stable long-term relationship which could be exploited by investors.

2 Literature Review

Porras-Gonzalez (2004) examined the relationships between the stock markets of Peru, Chile, Mexico, Argentina, Brazil, Venezuela, Columbia and the NYSE Composite and the Dow Jones Indices. The author tested whether there was cointegration between the stock market indices of each of these emerging economies and the US stock markets. The Phillips and Perron (1988) test was used to look for the presence of the unit roots in the series under consideration. After the indices were all determined to be I(1) she tested for the presence of a linear cointegrating relationship using the technique developed by Johansen and Juselius (1990). The author found cointegration between the Dow Jones and the NYSE indices and the markets of Venezuela and Mexico. No evidence of a long-run linear relationship between the US markets and the markets of Argentina, Columbia, Chile, Brazil and Peru was found.

Tabak and Lima (2002) also investigated the presence of cointegration between the major Latin American stock indices and the Dow Jones Industrial Index using daily data over the period 1995-2001. They tested for the presence of unit roots using the Phillips - Perron test. Once the series were found to be I(1), the method of Johansen (1988) was employed to determine if any of the South American indices were cointegrated with the Dow Jones. The authors found no evidence of linear cointegration among these markets. Granger (1969) causality tests were done to ascertain whether there were contagion effects among the indices and short-run causality could not be rejected. The US markets seemed to influence the markets in Columbia, Mexico, Peru and Venezuela.

Over the period 1990 to 2000, Seabra (2001) investigated the possibility of a stable long-run relationship between the Brazilian and Argentinean stock market indices and two major stock price series - the Japanese Nikkei and the US Dow Jones. The author also examined the short-run reactions of the emerging markets to changes in the developed markets. Seabra employed the cointegration test by Johansen (1988). He found that each of the Latin American indices shared a significant common trend with the Dow Jones. Results from the estimation of an error-correction model indicated that the Brazilian index is more responsive to changes in the Dow Jones than the Argentinean index.

Sanchez-Valle (1998) examined the extent to which the stock indices in four of Latin America's largest economies (Brazil, Argentina, Chile and Mexico) displayed common long-term stochastic trends. The author applied the technique by Johansen (1988) to test for cointegration over the period 1976 to 1998. Results suggested that there was co-movement among the markets during the period under investigation and Sanchez-Valle concluded that Latin and North America constituted one large integrated financial area.

The major drawback of most of these studies is that their standard methodology is the cointegration techniques developed by Johansen (1988) and Johansen and Juselius (1990). Consequently, their inferences do not take into account 1) the presence of structural breaks and 2) the possibility of nonlinear cointegration. This paper attempts to address both of these issues.

3 Data

This study uses data on the stock market indices for 6 Latin American countries (Argentina, Brazil, Chile, Mexico, Peru and Venezuela) and two American stock indices (the S&P 500 and the Nasdaq Composite). In particular, the indices considered in this study are 1) The Standard and Poor's 500 2) The Nasdaq Composite 3) Brazil's IBOVESPA (Indice da Bolsa de Valores de Sao Paulo) 4) Mexico's IPC (Indice de Precios y Cotizanciones) 5) Argentina's MERVAL (Mercado de Valores) 6) Peru's IGBVL (Indice General de la Bolsa de Valores de Lima) 7) Venezuela's IBC (Indice de la Bolsa de Caracas) and 8) Chile's IGPA (Indice General de Precios de Acciones). The data were obtained from the ECONSTATS Database. Due to data availability, the periods of consideration for each country are different and are stated below. Daily data are used in all cases.

Argentina Argentina's Buenos Aires Stock Exchange is a self-governing non-profit civil association. It compiles several indicators, the most important one being the MERVAL, a price-weighted index derived from the market value of selected stocks. The selection criteria are based on the stocks' market capitalisation, their quotation prices and the volume of daily transactions. Data for Argentina are available from 1996 to 2008.

Brazil The Sao Paulo stock exchange, the BOVESPA, is the second largest in the Americas. It operates under the supervision of the Commission of Movable Assets which is similar to the Securities and Exchange Commission in the US. There are currently around 446 companies listed on the exchange with a market capitalization of US $1.5 trillion. The index used in this study is the IBOVESPA, a series of approximately 50 of the stocks traded on the exchange. To calculate the IBOVESPA, a portfolio is compiled using the stocks that a) account for 80 % of the total volume traded over the last year and b) were traded on 80 % or more of the trading days. Data for Brazil are available from 1993 to 2008.

Chile Chile's primary exchange, the Santiago Stock Exchange (SSE), publishes three indices; the General Stock Price Index (IGPA) is the one chosen for this study. The IGPA is constructed by classifying stocks by sector and by volume and then calculating a weighted average. Data for Chile are available from 2003 to 2008.

Mexico The Mexican Stock Exchange, Bolsa Mexicana de Valores (BMV) is the sole stock exchange in the country. It is a public company with a net worth of approximately US $600 billion and produces 13 price indices. The IPC, the index used in this study, is the benchmark for the Mexican Stock Exchange since it is the most comprehensive indicator of the exchange's overall performance. A capitalization-weighted average of selected shares is used to calculate the IPC; the portfolio of shares chosen for the calculation is broadly representative of all shares listed on the exchange. Data for Mexico are available from 1993 to 2008.

Peru Metal-rich Peru is the world's largest supplier of silver and tin. It also exports substantial amounts of zinc, copper and gold. This is reflected in the composition of the Lima Stock Exchange in which half of all share trading can be attributed to mining companies. The Lima Stock Exchange has a number of indices, but the most commonly used is the IGBVL, a value-weighted index that follows the largest and most frequently traded stocks on the exchange. Data for Peru are available from 1998 to 2008.

Venezuela The Caracas Stock Exchange, the BVC, is the only securities exchange in Venezuela. It is a private exchange with a listing of less than 100 companies, only half them being actively traded. Stock prices are measured by the IBC index which is a capitalization-weighted series of the most highly capitalized and liquid stocks on the exchange. Data for Venezuela are available from 1997 to 2008.

United States

i) *The National Association of Securities Dealers Automated Quotation System (NASDAQ)* The Nasdaq lists more companies and has a greater daily trading volume than any other exchange world-wide. It consists of more than 3200 companies and is the largest computerised equity securities trading market in the Americas. This paper employs the Nasdaq Composite, a market-value weighted index of all common stocks listed on the Nasdaq. In the US, it is one of the foremost indicators of the stocks of growth and hi-tech companies.

ii) *The Standard and Poor's 500* The S&P 500 is a market-value weighted index of 500 large-cap corporations, all of which trade on the New York Stock Exchange or the Nasdaq. The S&P 500 is one of the most regularly quoted indexes and is a component of the Index of Leading Indicators.

4 External Trade of the Latin American Economies

Argentina: Crude petroleum, vegetable oils, and chemicals are Argentina's main exports while its primary imports are consumer goods, foodstuffs and fuel. Brazil receives most of Argentina's exports (18.8 %) and provides the majority of its imports(32.8 %). However the US is Argentina's second largest trading partner, purchasing 8 % of total exports and furnishing Argentina with 18.1 % of its overall imports.

Brazil: Brazil's chief exports are transport equipment, iron ore and coffee whereas its main imports are machinery, electrical equipment and chemicals. The US is Brazil's foremost trading partner, receiving 17.8 % of its exports and supplying 16.2 % of its imports.

Chile: Chile's primary exports are copper, fruit and fish products. The US purchases the largest share of total exports (16.7 %). Chile also receives the highest proportion of imports (25.1 %), mostly petroleum, from the US.

Mexico: Mexico is the largest exporter and importer in Latin America. It mainly exports crude oil and oil products while its primary imports are machinery, electrical equipment and car parts for assembly. The US receives the overwhelming majority of Mexico's exports (90.0 %) and provides more than half (53.4 %) of its imports.

Peru: Gold, copper and zinc are Peru's main exports. The US receives the largest portion of Peru's exports (33 %) and it is also Peru's largest supplier of imports (33 %), providing mostly consumer goods, food and fuel.

Venezuela: Venezuela's main exports are petroleum, aluminium and steel and its primary imports are consumer goods, machinery and transport equipment. The US is Venezuela's major trading partner, receiving 57.5 % of its exports and providing

30.2 % of its imports.

Thus, the US is the major trading partner for all of the countries except Argentina, in which case it is the second most important trading partner after Brazil. Through these real economic linkages, a relationship between stock markets may be established to the extent that there is a link between the real economy and financial markets.

5 Notable Economic Events in Latin America

The Mexican Peso Crisis of 1994-1995 At the end of the 1980s Mexico liberalized both its trade and financial sectors and instituted a stabilization program based on a fixed exchanged peg [Edwards (1997)]. This stimulated economic growth in subsequent years which, in turn, attracted foreign investors. A rapid expansion in credit ensued; credit to the private sector rose by an average of 25 % per annum between 1988 and 1994 [Martinez (1998)]. However banking supervision was poor since, in most cases, upper management was appointed by the government and many loans were issued to institutions and individuals who were not credit-worthy [Calvo (1996)]. The escalating credit growth put pressure on the international reserves and this precipitated a balance-of-payments crisis, rendering Mexico unable to defend its fixed peg. A floating exchange rate was adopted at the end of 1994 and the value of the peso plummeted. The devaluation caused inflation to accelerate, prompted a significant contraction in economic activity and triggered unprecedented levels of capital flight; in one day, the Banco de Mexico lost US $4 billion. Loans totalling US$ 50 billion from various international organizations eventually stabilized the Mexican economy [Edwards (1997)].

Asian and Russian Crises and Their Effects on Mexico and Brazil Three external factors affected the economies of Brazil and Mexico in 1998. First, the Asian financial crisis impacted both countries via the contagion effect. Next, declining international oil prices reduced capital inflows - particularly in Mexico where proceeds from oil account for more than 30 % of total revenue. Finally the Russian crisis caused by Russia's debt default adversely affected these economies.

In the early 1990's, the Southeast Asian countries offered high interest rates, attracting volumes of international investors. Indeed, more than half of the total capital inflows to developing countries was captured by the Asian tigers. This gave rise to a phenomenon coined the 'Asian economic miracle', in which the GDP of these countries grew by more than 10 % per annum. However, at the same time, many of these nations were experiencing pressure on their international reserves. Inflation rates were high and most of the Asian economies were running enormous trade deficits. This resulted in extensive external borrowing and overvalued currencies. On account of these weak macroeconomic fundamentals, most of the Asian countries were unable to maintain their fixed pegs and allowed their currencies to float against the dollar. Depreciation of their currencies ensued, triggering massive capital flight [Corsetti *et al.* (1999)]. Since investors tend to view emerging markets as one risk class, the financial contagion quickly spread to Latin America.

Beginning in August 17, 1998, Russia experienced a severe crisis as a result of poor economic policies and the fallout from the Asian Crisis. At the time, Russia was running large fiscal deficits and was shoring up an unjustifiably high fixed exchange rate between the ruble and the US dollar.

The contraction in world demand following the Asian crisis (and the corresponding contraction in prices) precipitated a rapid decline in the revenues of countries that relied heavily on the export of raw materials for their growth. Oil, timber, natural gas and nonferrous metals constituted more than 80 % of Russia's exports. The fall-off in export proceeds exhausted the international reserves and an economic crisis followed [Komulainen (1999)]. Similar to the situation in Asia, Russia was forced to abandon its fixed exchange rate and allowed the ruble to float against the dollar. Within a month of the floating exchange rate regime the ruble lost two-thirds of its value. Foreign investors went into a panic, selling not only Russian financial instruments but the stocks and bonds of all emerging economies. This contributed to the following crises in Mexico and Brazil.

Mexican Crisis 1998 As a result of the Asian financial crisis, Mexico saw its capital inflows fall due to the so-called contagion effect. Also, the crisis-afflicted countries reduced their demand for oil and as a consequence, its price dropped sharply. In particular, the average price of oil exported by Mexico fell by about 50 % between early 1997 and early 1998, and since oil revenues represented about a third of the Mexican government revenues, the public finances of the country became substantially strained [FED Dallas (1999)]. In addition, the Russian debt crisis of 1998 sent shock-waves throughout the emerging markets and the result of this contagion was, once again, the withdrawal of capital by foreign investors. Net foreign capital inflows in Mexico fell substantially and despite a sharp increase in interest rates in order to counterbalance this effect, the exchange rate depreciated by more than 20 % during 1998 from 8.08 pesos/USD to 10.18 pesos/USD. On the whole, however, relatively sound economic policies restored Mexico's growth path and in the first months of 1999, the stock index recovered by almost 40 %.[3]

Brazilian Currency Crisis 1998-1999 In 1994, Brazil had reissued its currency (the real) and instituted a devaluating crawling peg. This, in combination with interest rates higher than 30 %, stabilized inflation after a turbulent decade of price instability. The high rates of return attracted a massive flow of foreign direct investments in the first half of the 1990s and the country quickly accumulated sizable foreign reserves. However, despite successful reduction of inflation, the country still suffered from macroeconomic problems such as high unemployment, high current account deficits and poorly managed public finance. By 1999, the country held almost half of

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[3] The data are taken from the World Bank's World Development Indicators.

its GDP in foreign debt. In the second half of the 1990s, current account deficits were not fully financed by inflow of foreign capital and the country started depleting its foreign reserves. Brazil overcame the Asian financial crisis relatively well but when Russia declared a moratorium on its debt in 1998, investor confidence in the country's ability to maintain its crawling peg was heavily undermined and capital flight ensued [Evangelist and Sathe (2006)]. In a few months, the central bank devalued the currency and shortly thereafter was forced to abandon the fixed exchange rate regime. In January 1999, the currency depreciated against the US dollar by approximately 70 %, falling from 1.2 Real/USD in December 1998 to 2.1 Real/USD in January 1999 [Gruben and Welsh (2001)].

The Argentinean Crisis Argentina was predominantly under military rule until the early 1980s. The government which was democratically elected in 1983 inherited tremendous debt from the military dictatorship regime. With the new government came the creation of a new currency, the Austral. However, huge loans were needed to facilitate the launching of the Austral and, when it came to light that the state could not service its debt, confidence in the new currency started to fall. By the end of 1989, Argentina's year-on-year inflation rate was in excess of 5000 % and real wages had fallen to the lowest levels recorded in the previous half-century.[4]

As a result of the hyperinflation people were reluctant to accept Australs and demanded payment in US dollars instead. In order to restore confidence in the local currency, a law was passed which pegged the monetary value of the Austral to the US dollar. This move protected the value of the Austral, reduced inflation significantly and increased the standard of living for most Argentineans. However, the fixed peg also made imports more affordable, resulting in a steady outflow of dollars. This made it harder for Argentina to finance its foreign debt and, to maintain the exchange rate peg, the government found itself in the position of having to continually borrow

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[4] The data are taken from the IMF's International and Financial Statistics.

[Kiguel (2002)]. Complicating matters even further, the country was plagued with corrupt politicians and Central Bank officials. Vast sums of money vanished from Argentina, managing to find itself in various offshore accounts. As the 1990s came to a close, the country's debt-to-GNI ratio continued to balloon, growing from 38 % in 1995 to 52 % in 2000. Also, as mentioned previously, two of Argentina's major trading partners, Brazil and Mexico, had recently battled their own crises, resulting in a wariness of Latin American economies in general. By 2001, Argentina was in the throes of a recession. GDP had contracted by 4 %, following declines of 1 % and 3 % in 2000 and 1999, respectively. The debt-to-GNI ratio stood at 156 %, stable prices had given way to deflation and unemployment had skyrocketed.[5]

Despite the bleak state of affairs, the President refused to abandon the fixed peg. Understandably, investor confidence fell to an all time low and capital flight accelerated. Citizens cleared out their bank accounts and converted their savings to US dollars, initiating several bank runs. In response, the government froze all personal bank accounts for a year, allowing citizens to withdraw only maintenance amounts [IMF (2003)]. This initiative was not well received by the Argentineans and full-scale riots broke out. The government completely collapsed in December 2001.

These and potentially other less significant crises in all the economies under consideration may have introduced a break in the normal structure of the data series and, therefore, in the econometric methodology, techniques accounting for this possibility will be employed as well.

6 Brief Summary of Historical Performance

The graphs of the (log-)series are presented in the Appendix. The summary statistics for continuously compounded daily returns are provided in Table 1. These are

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[5] The data are taken from the World Bank's World Development Indicators.

calculated as

$$r^i_{t,d} = 100 \cdot \log \frac{P^i_{t,d}}{P^i_{t,d-1}} \tag{1}$$

where $P^i_{t,d}$ is the stock market index of the i^{th} country, in year t, on trading day d.

	Argentina	Brazil	Chile	Mexico	Peru	Venezuela	S&P 500	Nasdaq
mean	-0.038	-0.203	-0.075	-0.079	-0.077	-0.062	-0.026	-0.032
variance	3.287	4.470	0.807	1.873	1.043	2.350	0.820	1.843

Table 1: First Two Moments of the Continuously Compounded Returns

As expected, all mean returns are insignificantly different from zero.[6] The majority of Latin Indices appear to be more volatile than the US benchmarks. The average volatility across the Latin countries is 2.305 %, compared to 0.82 % for the S&P 500 and 1.84 % for the Nasdaq Composite.

Although the exchanges in the Latin American countries came about in different ways, they have, in general, experienced similar problems over the course of their development. In their infancy, liquidity of newly established markets was relatively low and trading volume was small. Consequently, markets tended to be open for only a few days a week and only for a few hours a day. This is one likely explanation why, on average, stock prices are more volatile in Latin America than in the US. Additionally, at the inception of the markets, there was a dearth of reliable information about the companies trading on these emerging stock markets. Information disseminated by businesses tended to be inaccurate or incomplete, and was often based on dissimilar accounting standards and practices [Torre *et al.* (2007)]. In other words, dependable corporate governance structures that existed in developed economies were not yet well established and businesses had to adhere to relatively few disclosure requirements.

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[6] By Jensen's inequality, if two indices have the same mean path but one is more volatile, its mean continuously compounded return is lower.

7 Econometric Approach

For the sake of clarity, we start with a preview of the section and the major findings, and then proceed in more detail since several steps are involved. Firstly, we test for cointegration in levels using both the standard augmented Dickey-Fuller (ADF) and the Gregory-Hansen test, which allows for structural breaks. We fail to find any evidence of cointegration. Secondly, we repeat the exercise after a logarithmic transformation of the data. This is motivated by the fact that financial time series are often modeled as a geometric Brownian motion and, therefore, linear cointegration in levels seems unlikely. In this case, the Gregory-Hansen test suggests cointegration in three of the Latin American countries investigated. Thirdly, we apply Breitung's rank test for nonlinear cointegration on the level series and it suggests some stable long-run nonlinear relationship between all of the Latin American indices and the US benchmarks. For lack of space and time allowed for this project, we do not attempt to further identify the specific nature of nonlinearity but refer to the results previously obtained under the logarithmic transformation as a specific form of nonlinearity in the level series that seems to be supported by our study for some of the countries.

Let the stock market index in a given Latin American country be represented by P_t and let P_t^* represent the stock market index of the benchmark exchange, in this case the S&P500 or the Nasdaq Composite Index. If P_t and P_t^* are determined to be integrated of order one, we examine the model

$$P_t = \alpha \cdot P_t^* + e_t. \tag{2}$$

If the error term is found to be integrated of order zero, then there exists a bivariate cointegrating relationship between the two series and hence some linkage between that particular Latin American index and the corresponding US benchmark.

The most widely used cointegration test is the ADF t-ratio test. It is based on the residuals from a cointegration regression and is constructed to test the null of the presence of a unit root in the residuals against the alternative that the root is less than unity. The cointegrating regression (2) is estimated by ordinary least squares and the null hypothesis of no cointegration is tested using a scalar unit root test $t(\alpha)$ on the residuals

$$\Delta e_t = \beta \cdot e_{t-1} + \sum_{i=1}^{m} \gamma \cdot \Delta e_{t-i} + v_t. \tag{3}$$

The lag length m is chosen sufficiently large in order for v_t to be serially uncorrelated.[7] The distribution of $t(\alpha)$ depends on the number of regressors. The asymptotic critical values are taken from MacKinnon (1991).

If there are structural breaks in the data, the standard ADF tests will be biased toward non-rejection of the null hypothesis of a unit root [Perron (1989)]. Therefore, in addition to the ADF tests we employ the Zivot and Andrews (1992) test for unit roots in the presence of a break.

The Zivot-Andrews test involves estimating,

$$\Delta y_t = \mu_1 + \mu_2 \cdot D_{\lambda t} + \delta \cdot y_{t-1} + \sum_{i=1}^{q} \gamma_i \cdot \Delta y_{t-i} + \varepsilon_t \tag{4}$$

where the dummy variable $D_{\lambda t}$ is defined as

$$D_{\lambda t} = \begin{cases} 0 & \text{if } t < [\lambda \cdot T] \\ 1 & \text{if } t \geq [\lambda \cdot T] \end{cases}$$

with $\lambda \in (\tau, 1-\tau)$ where μ_1 and μ_2 are the intercepts before and after the break and [ ] is the integer operator. T represents the sample size and, by convention, the

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[7] The 'varsoc' command in Stata reports the final prediction error (FPE), Aikaike's Information Criterion (AIC), Schwarz's Bayesian Information Criterion (SBIC) and the Hannan and Quinn Information Criterion (HQIC) lag-order selection statistics. This was used to select the optimal lag length.

interval $(\tau, 1-\tau)$ is chosen to be $(0.15 \cdot T, 0.85 \cdot T)$. The hypothesis test is:

H_0: Unit root

H_1: Trend stationary process with a structural break

The Zivot-Andrew procedure generates the minimum ADF t-statistic $\inf_{\lambda \in \Lambda} t(\lambda)$. The null of a unit root is rejected if

$$\inf_{\lambda \in \Lambda} t(\lambda) < K(\alpha)$$

where $K(\alpha)$ is the left-tailed critical value of the the asymptotic distribution of $\inf_{\lambda \in \Lambda} t(\lambda)$.[8]

Since most tests for cointegration depend heavily on the sample,[9] the test for cointegration in the presence of a structural break by Gregory and Hansen (1996) is utilized. The motivation for this procedure is to try to isolate periods of co-movement that may be lost in the aggregate test of cointegration because the structural break is not accounted for.

The Gregory and Hansen model allows for a general type of structural change; the authors allow for variation in the intercept term, in the slope coefficient and in the trend variable. Consider the bivariate cointegration model

$$y_t = \mu + \beta \cdot t + \gamma \cdot x_t + u_t. \tag{5}$$

We wish to examine the possibility that cointegration exists over a certain subsample of the series under review but then switches, at a certain point, to another long-run relationship. Gregory and Hansen (1996) allow for a structural break by accounting for changes in the intercept term μ, in the slope coefficient γ and in the trend term β

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[8] Critical values for this test can be found in Zivot and Andrews (1992).

[9] Stephon and Larsen (1991).

at some breakpoint. To accomplish this, they define the indicator variable

$$\phi = \begin{cases} 0 & \text{if } t \leq [n \cdot \theta] \\ 1 & \text{if } t > [n \cdot \theta] \end{cases}$$

where n is the length of the series under consideration, θ represents the timing of the structural break and [ ] is the integer operator. The regime and trend shift alternative is given by

$$y_t = \mu_1 + \mu_2 \cdot \phi_{t\theta} + \beta_1 \cdot t + \beta_2 \cdot t \cdot \phi_{t\theta} + \gamma_1 \cdot x_t + \gamma_2 \cdot x_t \cdot \phi_{t\theta} + e_t \tag{6}$$

where μ_1, γ_1 and β_1 are the intercept, slope and trend terms before the structural break and μ_2, γ_2 and β_2 are the corresponding coefficients after the shift. In line with the literature, the test statistic is calculated for every break point in the interval $([0.15 \cdot n], [0.85 \cdot n])$.

Equation (6) is estimated by ordinary least squares for each $\theta \in ([0.15 \cdot n], [0.85 \cdot n])$, yielding residuals $\widehat{e}_{t\theta}$. The ADF statistic is computed from the regression of $\Delta\widehat{e}_{t\theta}$ on $\widehat{e}_{t-1,\theta}$ and $\Delta\widehat{e}_{t-1,\theta}, \ldots, \Delta\widehat{e}_{t-K,\theta}$. The optimal lag length K is determined using the 'varsoc' command in Stata. The t-statistic for the $\widehat{e}_{t-1,\theta}$ term is the required ADF statistic:

$$\inf_{\theta} \mathrm{ADF}(\theta) = \mathrm{tstat}(\widehat{e}_{t-1,\theta}). \tag{7}$$

The null and alternative hypotheses are defined as follows:

H_0: no cointegration

H_1: cointegration with or without a structural break

Note that this test also has power against a time-invariant cointegrating relationship. Since the smallest value of the test statistic provides evidence against the null

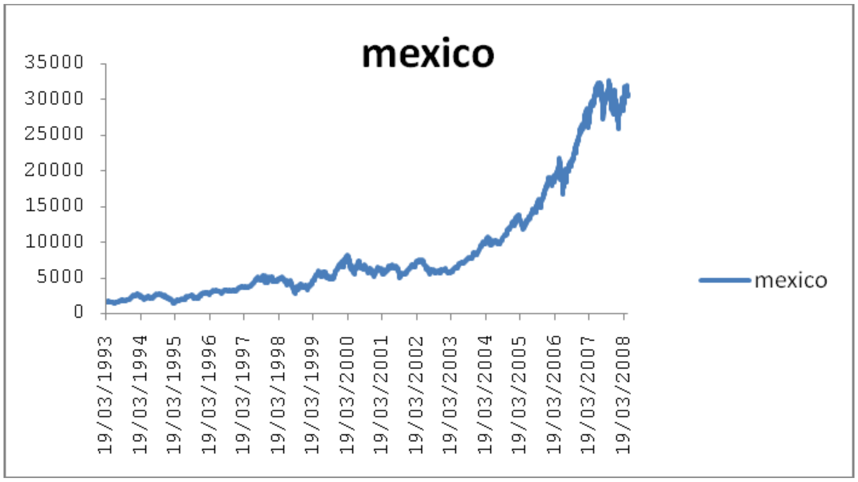

Figure 1: Mexican stock index

hypothesis, Gregory and Hansen define the test statistic as

$$\mathrm{ADF} = \inf_{\theta \in T} \mathrm{ADF}(\theta) \tag{8}$$

where $T \in ([0.15 \cdot n], [0.85 \cdot n])$. The critical values are provided in the Appendix.

Stock prices/indices are often modeled as a geometric Brownian motion and, therefore, it is possible that the above tests of linear cointegration applied on the level series may not find a stable long-run linear relationship. Figure 1 shows an example of such a nonlinear series. It is therefore more plausible that one would find linear cointegration if the logged series are used. Hence, the logs are generated and the previous procedures are repeated on the new series, i.e. first the ADF and then the Gregory-Hansen test.

Li (2006) demonstrates that "the cointegrating relationship between two exchanges may be log-linear and deterministic, log-linear and stochastic or nonlinear in the price indices, depending on whether the risk premium is a linear or nonlinear function of domestic and foreign risks." He constructs a model with two markets, one domestic and one foreign. He denotes the domestic and foreign indices by P and P^*, and the corresponding rates of return by r and r^*. Investors' perceptions of differences in risk lead to the following relationship between expected rates of return:

$$\overline{r} = \overline{r}^* + \varphi \tag{9}$$

where φ is the risk premium which generally depends positively on the standard deviation σ of local stocks and negatively on the standard deviation σ^* of international stocks, i.e. $\varphi = \varphi(\sigma, \sigma^*)$ with

$$\frac{\partial \varphi}{\partial \sigma} > 0 \quad \text{and} \quad \frac{\partial \varphi}{\partial \sigma^*} < 0. \tag{10}$$

He then assigns various functional forms to the risk premium. For example, it could take the linear form

$$\varphi(\sigma, \sigma^*) = \alpha \cdot \sigma - \beta \cdot \sigma^*. \tag{11}$$

Then, using the equation for the Capital Market Line, the postulated functional form for the risk premium and the fact that $r = \mathrm{d} \log P$, he formulates a differential equation. The solution to the equation provides the relationship between $\log \overline{P}$ and $\log \overline{P}^*$ (and therefore $\overline{P}$ and $\overline{P}^*$). The nature of this cointegrating relationship depends on the functional form specified for the risk premium. Li goes on to test for nonlinear cointegration between the stock price indices of Japan, New Zealand, Australia, the United Kingdom and the US using the methodology employed in Breitung (2001). He concludes that significantly more evidence of market integration is found from nonlinear as opposed to linear cointegration analysis, indicating that comovement among various markets may largely take nonlinear form.

We examined one particular specification of nonlinearity in the previous section, namely the logarithmic one. The tests, however, indicated cointegration between only three of the six Latin American markets considered and the US benchmarks. Therefore, along the lines of Li (2006), we also investigate the possibility of more general nonlinear relationships by employing Breitung's rank test of nonlinear cointegration.

Equation (2) can be expressed as

$$f(P_t) = h(P_t^*) + e_t \tag{12}$$

where $f(\cdot)$ and $h(\cdot)$ must be increasing functions of their arguments. So, if $e_t \sim$ I(0), then a nonlinear cointegrating relationship exists between the two series. We cannot observe $f(\cdot)$ and $h(\cdot)$. However, based on the ranks of the observed series, Breitung (2001) developed a two-stage test of nonlinear cointegration.

In the first stage, he applies a rank transformation to the two series. He defines a ranked series as $R_T(x_t) = \text{Rank}$ [of x_t among $x_1, \ldots, x_T$]. A rank statistic is constructed by replacing $f(\cdot)$ and $h(\cdot)$ by the ranked series

$$R_T[f(P_t)] = R_T(P_t) \tag{13}$$

and

$$R_T[h(P_t^*)] = R_T(P_t^*). \tag{14}$$

Breitung (2001) then formulates the following two test statistics:

$$\kappa_T = \frac{1}{T} \cdot \sup |d_t| \tag{15}$$

and

$$\varepsilon_T = \frac{1}{T^3} \cdot \sum_{t=1}^{T} d_t^2 \tag{16}$$

where

$$d_t = R_T(P_t) - R_T(P_t^*). \tag{17}$$

The hypothesis test is as follows:

H_0: no cointegration

H_1: (linear or nonlinear) cointegration

The critical values for the test statistics are found in Breitung (2001).[10] The null hypothesis of no cointegration between P_t and P_t^* is rejected if the test statistics are too small. Note that the alternative hypothesis captures nonlinearity in general, rather than specifying a particular nonlinear function which may not necessarily be correct in any case.

The above test indicates whether or not there is a stable long-run relationship. It is the second stage of the test that determines the nature of cointegration, i.e. whether it linear or nonlinear. Breitung employs the following equation to test for nonlinearity:

$$P_t = \gamma_0 + \gamma_1 \cdot P_t^* + g^*(P_t^*) + v_t \tag{18}$$

Where $\gamma_0 + \gamma_1 \cdot P_t^*$ is the linear part of the relationship. The appropriate hypothesis test is

H_0: $\forall t : g^*(P_t^*) = 0$, i.e. only a linear relationship exists

H_1: $g^*(P_t^*) \neq 0$

The multiple of the rank transformation $\theta \cdot R_T(P_t^*)$ is used instead of $g^*(P_t^*)$. We assume that P_t^* is exogenous and $v_t \sim \mathrm{N}(0, \sigma^2)$. To test the hypothesis, we:

1. Estimate the least squares regression

$$P_t = \alpha + \beta \cdot P_t^* + u_t \tag{19}$$

---

[10] These are also in the Appendix.

2. Regress the residuals from part 1) on P_t^* and $R_T(P_t^*)$, i.e.

$$\widetilde{u}_t = c_0 + c_1 \cdot P_t^* + c_2 \cdot R_T(P_t^*) + e_t \tag{20}$$

A score statistic $T \cdot R^2$ is obtained from the regression in part 2). It is asymptotically χ^2-distributed with one degree of freedom.[11]

8 Empirical Results and Analysis

Series in Levels - ADF and Gregory-Hansen Tests: Unit root tests, with and without trend,[12] are carried out on all of the price indices expressed in levels and the Schwarz-Bayesian criterion is used to determine the optimal lag length for the test. For all of the stock price indices, the null hypothesis of a unit root could not be rejected. The series are expressed in differences and the above procedure is repeated. In this instance, the null hypothesis of a unit root is rejected in every case.[13] Since stationarity is achieved after first differencing, both the Latin American and US indices are determined to be integrated of order one. The Zivot-Andrews unit root test also indicated that, in all of the indices, we could not reject the null hypothesis of a unit root.[14]

The augmented Dickey-Fuller test is used to determine if each of the individual Latin American indices is cointegrated with the S&P 500 and the Nasdaq stock price series. Again, the Schwarz-Bayesian criterion is used to determine the optimal lag length. The null hypothesis of no cointegration with the US markets cannot be rejected for any of the Latin American countries under review. The same results were obtained from the Gregory-Hansen test applied to the level series (see Table 42 and subsection A.4 in the Appendix). This is in line with Tabak and Lima (2002) who

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[11] Power results for this test can be found in Breitung (2001).

[12] Tests are done with and without trend as recommended by Engle and Granger (1987).

[13] This roughly corresponds to the empirical observation that daily returns are almost uncorrelated.

[14] See subsections A.2 and A.3 in the Appendix for unit root results.

also failed to find evidence of stock market cointegration between the same countries being examined in this study and the US. However, as mentioned previously in this paper, given that the US is a major trading partner with all of the Latin American countries under consideration, and to the extent that there is a link between real and financial markets, it is likely that some form of cointegration exists between the stock markets.

Series in Logs - ADF and Gregory-Hansen Tests: When the ADF cointegration test was performed, we could not reject the null of no cointegration in any of the cases (see subsection A.5 in the Appendix). However, when we took into account the possibility of the existence of a structural break by employing the Gregory-Hansen test, we found that Brazil's Ibovespa was cointegrated with both the S&P 500 and the Nasdaq. The results were significant at the 1% level as shown in Table 43 and Table 44. With regard to the S&P 500, the Gregory-Hansen test found a structural break in August, 1998. This is consistent with the result when we consider cointegration with the Nasdaq; the Gregory-Hansen test indicates the presence of a structural break in August 1998 in this instance as well. This break is probably capturing the 1998 Brazilian crisis that was discussed at length earlier in the paper. A slight dip in the series at this point can be seen in Figure 3.

Mexico's IPA index was also found to be cointegrated with the S&P 500 and the Nasdaq, with the structural break in both cases occurring in August 1998. The results were significant at the 1% level as shown in Table 43 and Table 44. This was at exactly the same time that the Brazil series experienced a structural break. Similarly to Brazil, this break seems to reflect the aftermath of the Asian and Russian crises as discussed in detail previously. Note that the Gregory-Hansen test picked the 1998 global crisis rather than the 1995 Mexican Peso crisis as a break in the structure. However, Figure 5 shows clear dips in the Mexican stock index at both of these time points. Interestingly, the 1998 global shock wave resulted in similar dips in the US indices whereas this was not the case in the 1995 Mexico crisis.

The Argentinean Merval was not found to be cointegrated with the S&P 500, although it was found to be cointegrated with the Nasdaq. The latter result was significant at the 5% level as shown in Table 43 and Table 44. The test pointed to a structural break in Argentina's stock price series in April 2001, at the time of the country's economic crisis. The plunge in the Argentinean stock market can be seen clearly in Figure 2.

The null hypothesis of no cointegration between the stock market indices of Peru, Chile, Venezuela and the US benchmarks could not be rejected.

Series in Levels - Breitung's Test of Nonlinear Cointegration: Since we found linear cointegration between the logged price series of Brazil, Mexico and Argentina, we expected, a priori, to find nonlinear cointegration between these price series in levels. This was indeed the case when Breitung's test was applied. In addition, there was evidence of either linear or nonlinear cointegration (since Breitung's test has this general alternative hypothesis) between Peru's IGBVL, Chile's IGPA, Venezuela's IBC indices and the US benchmarks. However, since we rejected linear cointegration based on both the standard ADF and the Gregory-Hansen test, we conclude that the cointegration identified by Breitung's test is nonlinear. While we do not know the exact functional form, a long-run stable relationship seems to exist. This is not entirely surprising considering the close ties between the economies of Latin America and the US as discussed in Section 4.

9 Conclusion

In this paper we examined whether a long-run relationship exists between the indices of six Latin American countries and two US benchmarks - the S&P 500 and the

Nasdaq Composite. The standard augmented Dickey Fuller test found no evidence of cointegration in any of the cases when the series in levels were considered. The Gregory-Hansen test, which considers the presence of a structural break, also indicated that there was no linear cointegration between the stock market series in levels.

Stock prices/indices are often modeled as a geometric Brownian motion and, therefore, we repeated the exercise for logarithmic transformations of the indices to account for this nonlinear feature. Again, the standard ADF cointegration test failed to reject the null of no cointegration. However, once the possibility of a regime shift was accounted for by the Gregory-Hansen technique, we found that cointegration exists between the US indices and three of the Latin American series - Argentina, Mexico and Brazil. The fact that there was linear cointegration between the logged series indicated that there was nonlinear cointegration between the series in levels.

This prompted us to test for nonlinear cointegration in general; it was possible that cointegration also existed between the remaining Latin American and US indices, although the functional transformations required to use the standard tests may be more complex than the simple logarithm. Therefore, Breitung's rank test for nonlinear cointegration was employed and it was determined that a long-run relationship did exist between the US and all six Latin American markets. In view of the fact that the US is a major trading partner of these countries, this outcome was not entirely surprising.

These results raise an important point. The characteristics of data must be correctly determined and modeled in order for tests of cointegration to guide us towards the correct conclusion. Notice that when the tendency towards exponential growth of such financial series was not considered, the ADF test on levels indicated that there was no stable long-run relationship between the stock market series of the US and Latin America. Additionally, when we ignored the possibility of a structural break, we failed to identify cointegration, even in logs. It was only when we both logged the series and allowed for a structural break by means of the Gregory-Hansen test that we identified cointegration for some of the markets. In particular, the logged indices of Mexico, Brazil and Argentina were found to be cointegrated with the S&P 500 and the Nasdaq Composite.

Moreover, Breitung's rank test for general nonlinear cointegration revealed that a long-run relationship exists between the markets under consideration and the US indices, albeit not necessarily a straightforward one. This seems to support the conclusion Li (2006) who posited that "much more evidence of market integration emerges from nonlinear than linear cointegration analysis, suggesting that comovements among various national stock markets may well take nonlinear forms" (p. 174). In some of the literature reviewed in this paper the authors concluded that no long-run relationship exists between the Latin American and US indices [Tabak and Lima (2002), Porras-Gonzalez (2004)]. However, they failed to take into account the nonlinearity of the data and neglected to consider the possibility of a trend and regime shift. Addressing these issues obviously yields different results.

We seem to have uncovered some cointegrating structures between the Latin American and US indices, which could potentially have useful implications for trading and diversification. For example, we know that the Brazilian IBOVESPA and the S&P 500 are cointegrated, i.e., the two series cannot move in different directions for very long without returning to the same distance apart. Of course, this does not suggest that the prices move in synchrony. To determine this, the correlations must be examined. If the series are both cointegrated and perfectly positively correlated, then as one rises, so will the other, and no gains can be reaped from diversification. However, if they are cointegrated but imperfectly correlated then on some days they may move together while at other times they may move in opposite directions - although they eventually revert to the same mean distance apart. This temporary widening of the spread that occurs in series that are cointegrated but not perfectly positively correlated is the principle on which statistical arbitrage is based. If the investor knows that series (or their nonlinear transformations) will trend together in the long run, but they are imperfectly correlated, she can exploit their short-run divergences by going short on the over-performer and long on the under-performer. In-sample simulations of such pair trading strategies could be performed to evaluate their profitability. For series where the transformation is non-logarithmic, research into the approximate nature of the nonlinearity would be required. Due to space limitations, this investigation could not be pursued here. However, this remains a plan for further extension of the paper by the author.

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A Appendix

A.1 Graphs of Log-Series

Figures 2 to 7 depict logarithms of the Latin American series and their US counterparts.

A.2 Unit Root Tests

Tables 2 to 9 summarize the output of Augmented Dickey-Fuller tests applied on the relevant stock market indices.

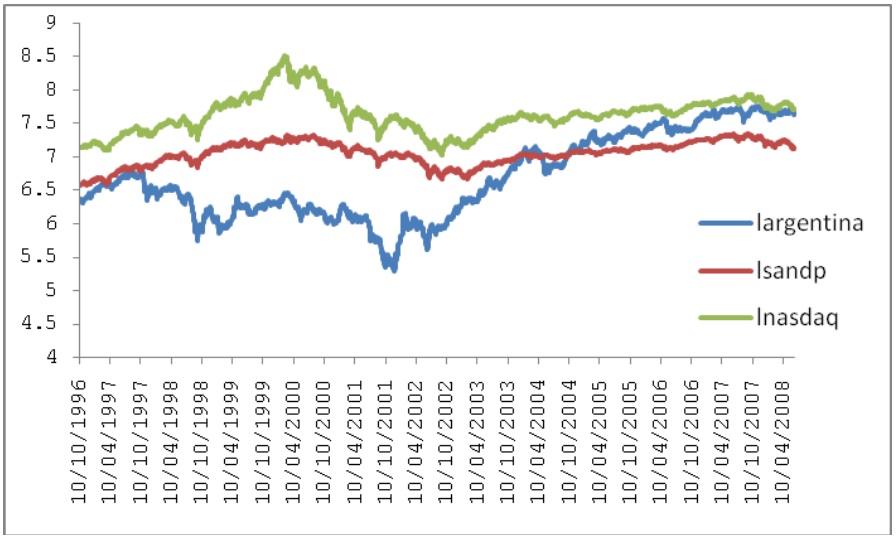

Figure 2: Logarithm of the Argentinean stock index, S&P500 and Nasdaq

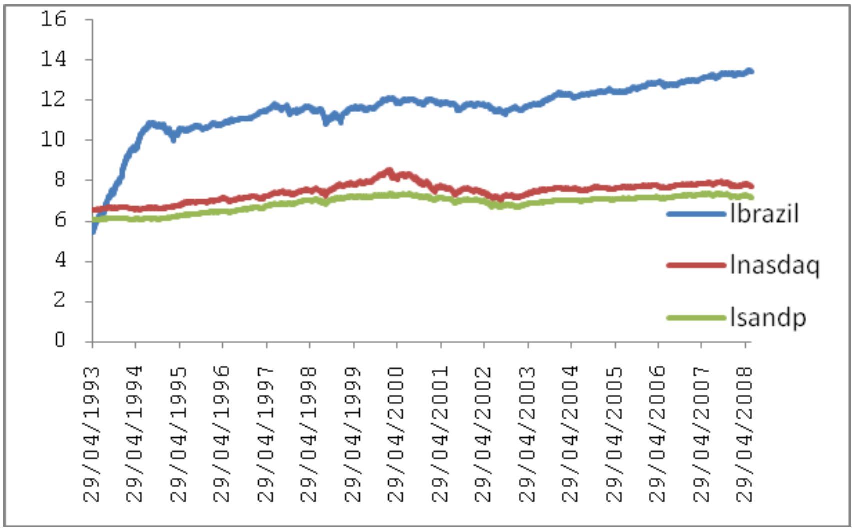

Figure 3: Logarithm of the Brazilian stock index, S&P500 and Nasdaq

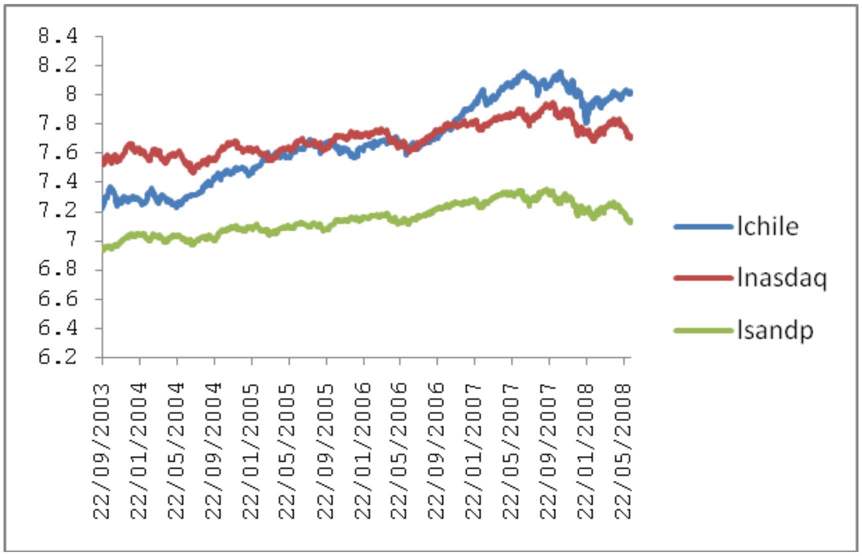

Figure 4: Logarithm of the Chilean stock index, S&P500 and Nasdaq

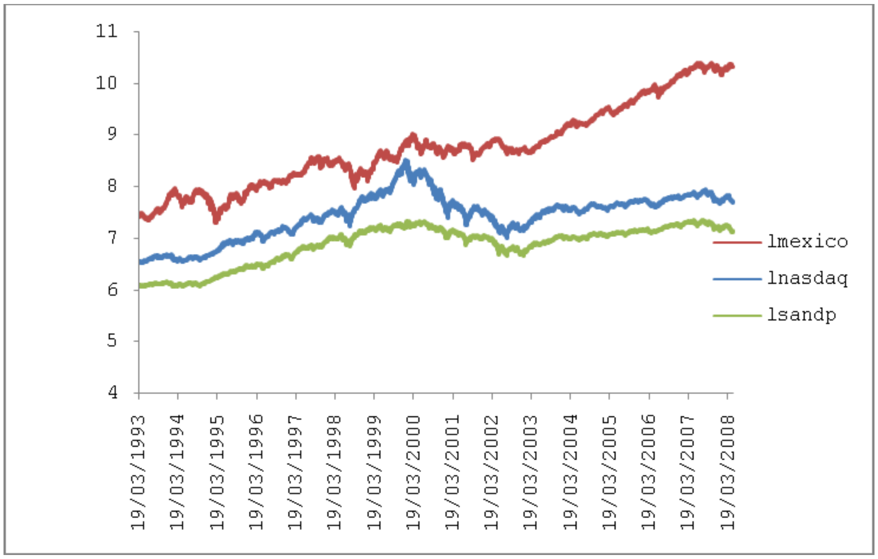

Figure 5: Logarithm of the Mexican stock index, S&P500 and Nasdaq

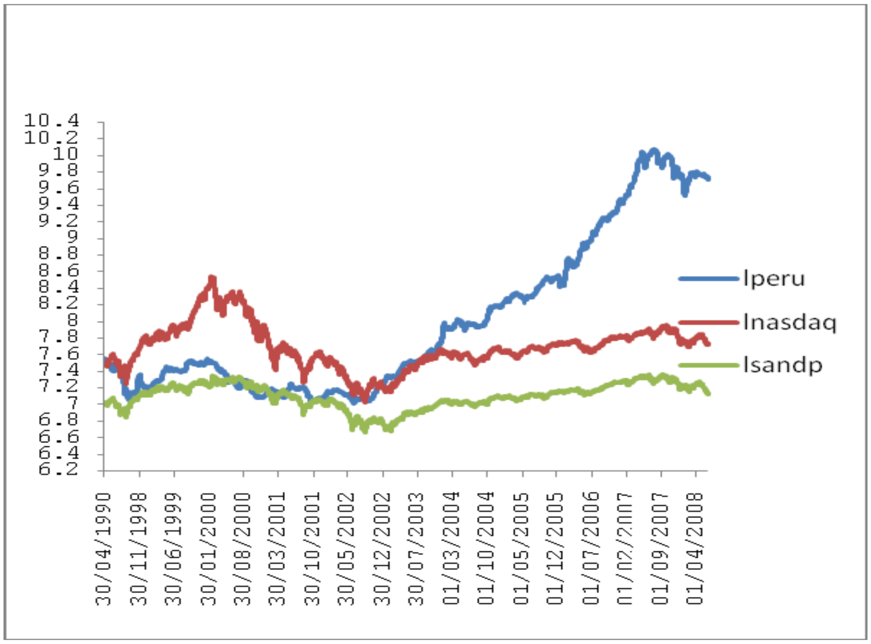

Figure 6: Logarithm of the Peruvian stock index, S&P500 and Nasdaq

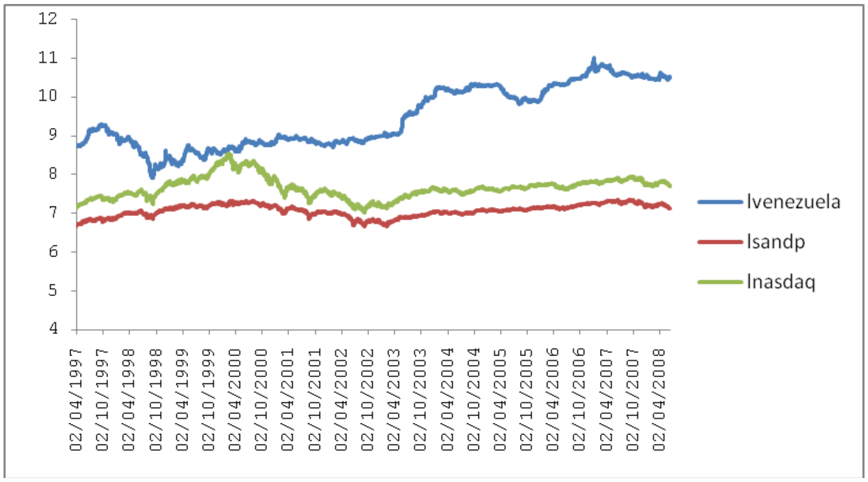

Figure 7: Logarithm of the Venezuelan stock index, S&P500 and Nasdaq

Augmented Dickey-Fuller test for unit root				Number of obs = 2428		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-1.441	-3.960	-3.410	-3.120		
MacKinnon approximate p-value for $Z(t) = 0.8485$						
D.argentina	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
argentina L1.	-.0011656	.000809	-1.44	0.150	-.0027521	.0004209
LD.	.3551448	.0202864	17.51	0.000	.3153644	.3949252
L2D.	-.1195054	.0210822	-5.67	0.000	-.1608464	-.0781644
L3D.	.0531732	.0199247	2.67	0.008	.014102	.0922444
_trend	-.0002864	.0005599	-0.51	0.609	-.0013844	.0008117
_cons	1.250866	1.597852	0.78	0.434	-1.882433	4.384165

Table 2: ADF - Argentina

Augmented Dickey-Fuller test for unit root				Number of obs = 3083		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-2.402	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.1412$						
D.brazil	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
brazil L1.	-.0036211	.0015077	-2.40	0.016	-.0065773	-.0006649
LD.	.020726	.0180293	1.15	0.250	-.0146248	.0560768
L2D.	-.0012656	.0180445	-0.07	0.944	-.036646	.0341149
L3D.	-.0157231	.0180369	-0.87	0.383	-.0510886	.0196424
_cons	88.91404	49.05698	1.81	0.070	-7.273697	185.1018

Table 3: ADF - Brazil

Augmented Dickey-Fuller test for unit root				Number of obs = 1087		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-2.316	-3.960	-3.410	-3.120		
MacKinnon approximate p-value for $Z(t) = 0.4254$						
D.chile	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
chile L1.	-.0068783	.0029704	-2.32	0.021	-.0127067	-.0010498
LD.	.2859208	.029405	9.72	0.000	.2282236	.3436181
_trend	-.0114828	.0051316	-2.24	0.025	-.0215518	-.0014139
_cons	21.45047	9.743426	2.20	0.028	2.332335	40.5686

Table 4: ADF - Chile

Augmented Dickey-Fuller test for unit root				Number of obs = 3271		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-1.917	-3.960	-3.410	-3.120		
MacKinnon approximate p-value for $Z(t) = 0.6459$						
D.mexico	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
mexico L1.	-.0010127	.0005283	-1.92	0.055	-.0020485	.0000232
LD.	.342644	.0171634	19.96	0.000	.3089918	.3762962
L2D.	-.1760625	.0177531	-9.92	0.000	-.2108708	-.1412542
L3D.	.0336268	.0170628	1.97	0.049	.0001719	.0670816
_trend	-.0014242	.003785	-0.38	0.707	-.0088454	.005997
_cons	6.17265	12.06411	0.51	0.609	-17.48133	29.82663

Table 5: ADF - Mexico

Augmented Dickey-Fuller test for unit root				Number of obs = 2129		
Test Stat.		1 % Critical Val.	5 % Critical Val.	10 % Critical Val.		
Z(t)	-0.520	-3.960	-3.410	-3.120		
MacKinnon approximate p-value for $Z(t) = 0.9826$						
D.peru	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
peru L1.	-.0002838	.0005457	-0.52	0.603	-.0013539	.0007862
LD.	.612901	.0215744	28.41	0.000	.5705918	.6552102
L2D.	-.214912	.0248716	-8.64	0.000	-.2636873	-.1661368
L3D.	.0696391	.0218186	3.19	0.001	.0268509	.1124272
_trend	.0016599	.0042414	0.39	0.696	-.0066578	.0099776
_cons	-3.619783	8.18146	-0.44	0.658	-19.6643	12.42473

Table 6: ADF - Peru

Augmented Dickey-Fuller test for unit root				Number of obs = 1935		
Test Stat.		1 % Critical Val.	5 % Critical Val.	10 % Critical Val.		
Z(t)	-1.909	-3.960	-3.410	-3.120		
MacKinnon approximate p-value for $Z(t) = 0.6502$						
D.venezuela	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
venezuela L1.	-.0021273	.0011146	-1.91	0.056	-.0043132	.0000586
LD.	.5274067	.0229793	22.95	0.000	.4823398	.5724736
L2D.	-.3428824	.0261777	-13.10	0.000	-.3942219	-.2915428
L3D.	.1312003	.0264977	4.95	0.000	.0792331	.1831675
L4D.	.0611324	.0243605	2.51	0.012	.0133567	.1089081
_trend	-.0204556	.0171825	-1.19	0.234	-.0541538	.0132426
_cons	58.11314	44.09218	1.32	0.188	-28.36024	144.5865

Table 7: ADF - Venezuela

Augmented Dickey-Fuller test for unit root				Number of obs = 3266		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-0.019	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.9570$						
D.S&P500	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
S&P500 L1.	-8.69e-06	.0004685	-0.02	0.985	-.0009273	.0009099
LD.	.3069373	.0174619	17.58	0.000	.2727	.3411747
L2D.	-.1502633	.0182223	-8.25	0.000	-.1859916	-.1145351
L3D.	.0155299	.0176738	0.88	0.380	-.019123	.0501828
_cons	-.1411361	.5067852	-0.28	0.781	-1.134786	.8525135

Table 8: ADF - S&P500

Augmented Dickey-Fuller test for unit root				Number of obs = 3266		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-0.469	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.8980$						
D.nasdaq	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
nasdaq L1.	-.0003369	.0007187	-0.47	0.639	-.001746	.0010721
LD.	.2144302	.0173062	12.39	0.000	.1804981	.2483623
L2D.	-.0899959	.0176889	-5.09	0.000	-.1246784	-.0553134
L3D.	.0312924	.0174492	1.79	0.073	-.0029202	.0655049
_cons	.5073518	1.4682	0.35	0.730	-2.371335	3.386039

Table 9: ADF - Nasdaq

A.3 Zivot-Andrews Unit Root Test

Tables 10-17 provide the results of the Zivot-Andrews test applied on the individual series.

Zivot-Andrews unit root test for Argentina allowing for break in intercept			
Lag selection via TTest: lags of D.argentina included = 7 Minimum t-statistic -3.101 at 1938 (obs 1938)			
Critical values:	1 %: -5.43	5 %: -4.80	

Table 10: Zivot-Andrews Unit Root Test for Argentina

Zivot-Andrews unit root test for Brazil allowing for break in intercept			
Lag selection via TTest: lags of D.brazil included = 7 Minimum t-statistic -1.872 at 3028 (obs 3028)			
Critical values:	1 %: -5.43	5 %: -4.80	

Table 11: Zivot-Andrews Unit Root Test for Brazil

Zivot-Andrews unit root test for Chile allowing for break in intercept			
Lag selection via TTest: lags of D.chile included = 3 Minimum t-statistic -3.381 at 785 (obs 785)			
Critical values:	1 %: -5.43	5 %: -4.80	

Table 12: Zivot-Andrews Unit Root Test for Chile

Zivot-Andrews unit root test for Mexico allowing for break in intercept			
Lag selection via TTest: lags of D.mexico included = 7 Minimum t-statistic -3.169 at 3152 (obs 3152)			
Critical values:	1 %: -5.43	5 %: -4.80	

Table 13: Zivot-Andrews Unit Root Test for Mexico

Zivot-Andrews unit root test for Peru allowing for break in intercept			
Lag selection via TTest: lags of D.peru included = 5 Minimum t-statistic -3.824 at 1971 (obs 1971)			
Critical values:	1 %: -5.43	5 %: -4.80	

Table 14: Zivot-Andrews Unit Root Test for Peru

Zivot-Andrews unit root test for Venezuela allowing for break in intercept			
Lag selection via TTest: lags of D.venezuela included = 7			
Minimum t-statistic -3.129 at 1456 (obs 1456)			
Critical values:	1 %: -5.43	5 %: -4.80	

Table 15: Zivot-Andrews Unit Root Test for Venezuela

Zivot-Andrews unit root test for S&P500 allowing for break in intercept			
Lag selection via TTest: lags of D.sandp included = 6			
Minimum t-statistic -3.252 at 1941 (obs 1941)			
Critical values:	1 %: -5.43	5 %: -4.80	

Table 16: Zivot-Andrews Unit Root Test for S&P500

Zivot-Andrews unit root test for Nasdaq allowing for break in intercept			
Lag selection via TTest: lags of D.nasdaq included = 7			
Minimum t-statistic -3.975 at 1838 (obs 1838)			
Critical values:	1 %: -5.43	5 %: -4.80	

Table 17: Zivot-Andrews Unit Root Test for Nasdaq

A.4 Linear Cointegration in Levels Tests

Tables 18 to 29 summarize the output of Augmented Dickey-Fuller tests applied on the residuals from the regressions of the S&P500 Index and the Nasdaq Composite Index, respectively, on the relevant country indices.

Augmented Dickey-Fuller test for unit root					Number of obs = 1961	
Test Stat.		1 % Critical Val.	5 % Critical Val.	10 % Critical Val.		
Z(t)	-1.248	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.6525$						
D.errorSArgent	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorSArgent L1.	-.0015987	.0012807	-1.25	0.212	-.0041104	.0009131
LD.	.3167408	.0226277	14.00	0.000	.2723639	.3611178
L2D.	-.1466366	.02334	-6.28	0.000	-.1924105	-.1008626
L3D.	.0245897	.0226999	1.08	0.279	-.0199289	.0691083
_cons	-.1169099	.2289585	-0.51	0.610	-.5659381	.3321183

Table 18: ADF on the residuals from the regression of S&P500 on the Argentinean index

Augmented Dickey-Fuller test for unit root					Number of obs = 1961	
Test Stat.		1 % Critical Val.	5 % Critical Val.	10 % Critical Val.		
Z(t)	-1.692	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.4354$						
D.errorNArgent	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorNArgent L1.	-.0020665	.0012216	-1.69	0.091	-.0044624	.0003293
LD.	.2238305	.0221777	10.09	0.000	.1803361	.2673248
L2D.	-.0877897	.022509	-3.90	0.000	-.1319339	-.0436455
L3D.	.0690997	.0222773	3.10	0.002	.0254099	.1127896
_cons	-.0606443	.8574964	-0.07	0.944	-1.742347	1.621058

Table 19: ADF on the residuals from the regression of the Nasdaq Composite on the Argentinean index

Augmented Dickey-Fuller test for unit root					Number of obs = 2538	
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-0.592	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.8729$						
D.errorSBraz	Coef.	Std. Err.	t	$P > \lvert t \rvert$	95 % Conf. Interval	
errorSBraz L1.	-.0003149	.0005322	-0.59	0.554	-.0013584	.0007286
LD.	.324631	.0198592	16.35	0.000	.2856891	.3635729
L2D.	-.1678805	.0208562	-8.05	0.000	-.2087775	-.1269836
L3D.	.0434638	.0201734	2.15	0.031	.0039058	.0830218
_cons	-.314841	.1746736	-1.80	0.072	-.6573586	.0276765

Table 20: ADF on the residuals from the regression of S&P500 on the Brazilian index

Augmented Dickey-Fuller test for unit root					Number of obs = 2538	
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-2.478	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.1210$						
D.errorNBraz	Coef.	Std. Err.	t	$P > \lvert t \rvert$	95 % Conf. Interval	
errorNBraz L1.	-.001969	.0007947	-2.48	0.013	-.0035273	-.0004107
LD.	.2036036	.0195415	10.42	0.000	.1652848	.2419225
L2D.	-.1115776	.0200986	-5.55	0.000	-.150989	-.0721663
L3D.	.067631	.0199118	3.40	0.001	.028586	.1066761
_cons	-.9647213	.6503755	-1.48	0.138	-2.240043	.3106006

Table 21: ADF on the residuals from the regression of the Nasdaq Composite on the Brazilian index

Augmented Dickey-Fuller test for unit root				Number of obs = 996		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-2.687	-3.960	-3.410	-3.120		
MacKinnon approximate p-value for $Z(t) = 0.0232$						
D.errorSChil	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorSChil L1.	-.0211743	.0057428	-3.69	0.000	-.0324437	-.009905
LD.	.171404	.0319084	5.37	0.000	.1087884	.2340197
_trend	-.0003743	.0014515	-0.26	0.797	-.0032227	.002474
_cons	.1205452	1.04268	0.12	0.908	-1.925567	2.166658

Table 22: ADF on the residuals from the regression of S&P500 on the Chilean index

Augmented Dickey-Fuller test for unit root				Number of obs = 848		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-3.116	-3.960	-3.410	-3.120		
MacKinnon approximate p-value for $Z(t) = 0.1025$						
D.errorNChil	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorNChil L1.	-.0196036	.0062915	-3.12	0.002	-.0319524	-.0072548
LD.	.1573393	.034779	4.52	0.000	.0890756	.225603
L2D.	-.0162761	.0358056	-0.45	0.650	-.0865548	.0540025
L3D.	-.0589127	.0358729	-1.64	0.101	-.1293236	.0114982
_trend	-.00076	.0015752	-0.48	0.630	-.0038518	.0023318
_cons	1.102513	1.139735	0.97	0.334	-1.134542	3.339569

Table 23: ADF on the residuals from the regression of the Nasdaq Composite on the Chilean index

Augmented Dickey-Fuller test for unit root				Number of obs = 2624		
Test Stat.		1 % Critical Val.	5 % Critical Val.	10 % Critical Val.		
Z(t)	0.562	-3.960	-3.410	-3.120		
MacKinnon approximate p-value for $Z(t) = 0.9969$						
D.errorSMex	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorSMex L1.	.0004707	.0008376	0.56	0.574	-.0011718	.0021131
LD.	.2290204	.0192192	11.92	0.000	.191334	.2667068
L2D.	-.0655065	.0197421	-3.32	0.001	-.1042182	-.0267948
L3D.	.0450608	.0190811	2.36	0.018	.0076452	.0824764
L4D.	-.0620438	.0188133	-3.30	0.001	-.0989342	-.0251534
_trend	-.0003047	.0005228	-0.58	0.560	-.0013299	.0007205
_cons	.8765552	1.185855	0.74	0.460	-1.448754	3.201864

Table 24: ADF on the residuals from the regression of S&P500 on the Mexican index

Augmented Dickey-Fuller test for unit root				Number of obs = 2645		
Test Stat.		1 % Critical Val.	5 % Critical Val.	10 % Critical Val.		
Z(t)	0.552	-3.960	-3.410	-3.120		
MacKinnon approximate p-value for $Z(t) = 0.9969$						
D.errorNMex	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorNMex L1.	.0004581	.00083	0.55	0.581	-.0011695	.0020857
LD.	.2288777	.0191423	11.96	0.000	.1913423	.266413
L2D.	-.0655379	.0196614	-3.33	0.001	-.1040912	-.0269845
L3D.	.0450548	.0190037	2.37	0.018	.0077912	.0823185
L4D.	-.0619926	.0187369	-3.31	0.001	-.0987332	-.0252521
_trend	-.0002973	.000515	-0.58	0.564	-.0013071	.0007125
_cons	.8710481	1.176881	0.74	0.459	-1.436655	3.178751

Table 25: ADF on the residuals from the regression of the Nasdaq Composite on the Mexican index

Augmented Dickey-Fuller test for unit root				Number of obs = 1753		
Test Stat.		1 % Critical Val.	5 % Critical Val.	10 % Critical Val.		
Z(t)	-2.262	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.1844$						
D.errorSPer	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorSPer L1.	-.0037613	.0016625	-2.26	0.024	-.0070221	-.0005006
LD.	.3425752	.0237521	14.42	0.000	.2959897	.3891608
L2D.	-.1721453	.0249762	-6.89	0.000	-.2211317	-.1231588
L3D.	.0339954	.0240111	1.42	0.157	-.013098	.0810888
_cons	-.0526533	.2457758	-0.21	0.830	-.5346989	.4293923

Table 26: ADF on the residuals from the regression of S&P500 on the Peruvian index

Augmented Dickey-Fuller test for unit root				Number of obs = 1753		
Test Stat.		1 % Critical Val.	5 % Critical Val.	10 % Critical Val.		
Z(t)	-1.802	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.3797$						
D.errorNPer	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorNPer L1.	-.0025498	.0014153	-1.80	0.072	-.0053257	.0002261
LD.	.2437452	.0234503	10.39	0.000	.1977516	.2897388
L2D.	-.1019565	.0240618	-4.24	0.000	-.1491495	-.0547635
L3D.	.0793371	.0238359	3.33	0.001	.0325873	.1260869
_cons	-.2157961	.9654942	-0.22	0.823	-2.109441	1.677849

Table 27: ADF on the residuals from the regression of the Nasdaq Composite on the Peruvian index

Augmented Dickey-Fuller test for unit root				Number of obs = 1675		
Test Stat.		1 % Critical Val.	5 % Critical Val.	10 % Critical Val.		
Z(t)	-1.016	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.7472$						
D.errorSVen	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorSVen L1.	-.0015003	.001476	-1.02	0.310	-.0043953	.0013947
LD.	.3334468	.0243538	13.69	0.000	.2856795	.3812141
L2D.	-.1730433	.0251498	-6.88	0.000	-.2223717	-.123715
L3D.	.0353786	.0243668	1.45	0.147	-.012414	.0831713
_cons	-.0358911	.248919	-0.14	0.885	-.5241173	.4523351

Table 28: ADF on the residuals from the regression of S&P500 on the Venezuelan index

Augmented Dickey-Fuller test for unit root				Number of obs = 1675		
Test Stat.		1 % Critical Val.	5 % Critical Val.	10 % Critical Val.		
Z(t)	-2.134	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.0241$						
D.errorNVen	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorNVen L1.	-.004114	.0013125	-3.13	0.002	-.0066884	-.0015397
LD.	.2573897	.0240033	10.72	0.000	.21031	.3044694
L2D.	-.1274863	.024124	-5.28	0.000	-.1748028	-.0801697
L3D.	.0471948	.023878	1.98	0.048	.0003609	.0940287
_cons	-.8266309	.9095642	-0.91	0.364	-2.610637	.9573751

Table 29: ADF on the residuals from the regression of the Nasdaq Composite on the Venezuelan index

A.5 Linear Cointegration in Logs Tests

Tables 30 to 41 summarize the output of Augmented Dickey-Fuller tests applied on the residuals from the regressions in logarithms of the S&P500 Index and the Nasdaq Composite Index, respectively, on the relevant country indices.

Augmented Dickey-Fuller test for unit root				Number of obs = 1799		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-0.421	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.9066$						
D.errorlSlArg	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlSlArg L1.	-.0005206	.001238	-0.42	0.674	-.0029486	.0019074
LD.	.3296517	.02376	13.87	0.000	.2830515	.376252
L2D.	-.1564884	.0247083	-6.33	0.000	-.2049485	-.1080283
L3D.	.0477942	.0246291	1.94	0.052	-.0005105	.0960989
L4D.	-.0531492	.0236375	-2.25	0.025	-.0995092	-.0067892
_cons	-.0001526	.0002071	-0.74	0.461	-.0005588	.0002535

Table 30: ADF on the residuals from the regression in logs of S&P500 on the Argentinean index

Augmented Dickey-Fuller test for unit root				Number of obs = 1799		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-1.029	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.7425$						
D.errorlNlArg	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlNlArg L1.	-.0012139	.0011796	-1.03	0.304	-.0035274	.0010996
LD.	.2144306	.0237536	9.03	0.000	.1678429	.2610183
L2D.	-.0826857	.0238377	-3.47	0.001	-.1294383	-.0359332
L3D.	.0365149	.0236222	1.55	0.122	-.0098151	.0828449
L4D.	-.0141877	.0233079	-0.61	0.543	-.0599011	.0315258
_cons	2.06e-06	.0003421	0.01	0.995	-.0006689	.000673

Table 31: ADF on the residuals from the regression in logs of the Nasdaq Composite on the Argentinean index

Augmented Dickey-Fuller test for unit root				Number of obs = 2329		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-0.312	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.9238$						
D.errorlSlBra	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlSlBra L1.	-.0002705	.0008677	-0.31	0.755	-.001972	.0014311
LD.	.3340488	.0209323	15.96	0.000	.2930009	.3750968
L2D.	-.1618431	.022106	-7.32	0.000	-.2051927	-.1184934
L3D.	.082257	.0221874	3.71	0.000	.0387478	.1257661
L4D.	-.0578619	.0213824	-2.71	0.007	-.0997925	-.0159313
_cons	-.0000648	.0001907	-0.34	0.734	-.0004387	.0003091

Table 32: ADF on the residuals from the regression in logs of S&P500 on the Brazilian index

Augmented Dickey-Fuller test for unit root				Number of obs = 2329		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-1.706	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.4278$						
D.errorlNlBra	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlNlBra L1.	-.0016522	.0009682	-1.71	0.088	-.0035509	.0002464
LD.	.2203284	.0210592	10.46	0.000	.1790316	.2616252
L2D.	-.094247	.0216094	-4.36	0.000	-.1366227	-.0518713
L3D.	.0483234	.0216666	2.23	0.026	.0058354	.0908113
L4D.	-.0420527	.0215507	-1.95	0.051	-.0843134	.000208
_cons	-.0001767	.000295	-0.60	0.549	-.0007552	.0004019

Table 33: ADF on the residuals from the regression in logs of the Nasdaq Composite on the Brazilian index

Augmented Dickey-Fuller test for unit root				Number of obs = 738		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-2.326	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.0004$						
D.errorlSlChil	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlSlChil L1.	-.0316564	.0073171	-4.33	0.000	-.0460215	-.0172913
LD.	.2523125	.0364029	6.93	0.000	.180846	.3237791
L2D.	-.095591	.0396244	-2.41	0.016	-.173382	-.0177999
L3D.	.0366108	.0400537	0.91	0.361	-.042023	.1152447
L4D.	-.0133383	.0381676	-0.35	0.727	-.0882692	.0615926
_cons	.0003668	.0002495	1.47	0.142	-.0001231	.0008568

Table 34: ADF on the residuals from the regression in logs of S&P500 on the Chilean index

Augmented Dickey-Fuller test for unit root				Number of obs = 738		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-2.269	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.0016$						
D.errorlNlChil	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlNlChil L1.	-.0296274	.0074653	-3.97	0.000	-.0442834	-.0149715
LD.	.2080018	.0365806	5.69	0.000	.1361865	.2798172
L2D.	-.0596555	.0389106	-1.53	0.126	-.1360452	.0167341
L3D.	.0033595	.0394725	0.09	0.932	-.0741333	.0808523
L4D.	.0087117	.0383051	0.23	0.820	-.0664892	.0839126
_cons	.0003353	.0003215	1.04	0.297	-.0002958	.0009664

Table 35: ADF on the residuals from the regression in logs of the Nasdaq Composite on the Chilean index

Augmented Dickey-Fuller test for unit root				Number of obs = 2510		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-1.298	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.6303$						
D.errorlSlMex	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlSlMex L1.	-.0010414	.0008026	-1.30	0.195	-.0026154	.0005325
LD.	.3380875	.0201724	16.76	0.000	.2985311	.3776439
L2D.	-.1712186	.0212457	-8.06	0.000	-.2128794	-.1295577
L3D.	.0466424	.021142	2.21	0.027	.0051848	.0881
L4D.	-.0432715	.0199642	-2.17	0.030	-.0824195	-.0041235
_cons	-.0000546	.0001812	-0.30	0.763	-.0004099	.0003007

Table 36: ADF on the residuals from the regression in logs of S&P500 on the Mexican index

Augmented Dickey-Fuller test for unit root				Number of obs = 2510		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-1.643	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.4609$						
D.errorlNlMex	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlNlMex L1.	-.001388	.000845	-1.64	0.101	-.0030451	.000269
LD.	.246191	.0201057	12.24	0.000	.2067655	.2856165
L2D.	-.1022985	.0205778	-4.97	0.000	-.1426497	-.0619474
L3D.	.047141	.0202507	2.33	0.020	.0074311	.086851
L4D.	-.0393522	.0196962	-2.00	0.046	-.0779747	-.0007297
_cons	-.0000849	.0002728	-0.31	0.756	-.0006199	.0004501

Table 37: ADF on the residuals from the regression in logs of the Nasdaq Composite on the Mexican index

Augmented Dickey-Fuller test for unit root				Number of obs = 1625		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-1.634	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.4653$						
D.errorlSlPer	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlSlPer L1.	-.0026904	.0016464	-1.63	0.102	-.0059197	.0005389
LD.	.3666133	.0246583	14.87	0.000	.3182477	.4149789
L2D.	-.1774194	.0260264	-6.82	0.000	-.2284685	-.1263704
L3D.	.0488206	.0261086	1.87	0.062	-.0023896	.1000308
L4D.	-.0425743	.0251062	-1.70	0.090	-.0918184	.0066699
_cons	-.0000755	.000213	-0.35	0.723	-.0004932	.0003421

Table 38: ADF on the residuals from the regression in logs of S&P500 on the Peruvian index

Augmented Dickey-Fuller test for unit root				Number of obs = 1625		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-1.295	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.6313$						
D.errorlNlPer	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlNlPer L1.	-.0017952	.0013859	-1.30	0.195	-.0045136	.0009231
LD.	.2450592	.0249117	9.84	0.000	.1961967	.2939217
L2D.	-.0901895	.0251597	-3.58	0.000	-.1395386	-.0408405
L3D.	.0505951	.0253039	2.00	0.046	.0009633	.1002269
L4D.	-.0219228	.0249916	-0.88	0.381	-.0709421	.0270965
_cons	-.0000737	.0003748	-0.20	0.844	-.0008088	.0006614

Table 39: ADF on the residuals from the regression in logs of the Nasdaq Composite on the Peruvian index

Augmented Dickey-Fuller test for unit root				Number of obs = 1499		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-0.737	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.8369$						
D.errorlSlVen	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlSlVen L1.	-.0010858	.0014729	-0.74	0.461	-.0039749	.0018034
LD.	.3457121	.0260842	13.25	0.000	.2945466	.3968777
L2D.	-.1817839	.0271112	-6.71	0.000	-.2349639	-.1286039
L3D.	.0663763	.0268928	2.47	0.014	.0136246	.119128
L4D.	-.0501106	.0262192	-1.91	0.056	-.101541	.0013198
_cons	-.0001402	.0002257	-0.62	0.535	-.0005828	.0003025

Table 40: ADF on the residuals from the regression in logs of S&P500 on the Venezuelan index

Augmented Dickey-Fuller test for unit root				Number of obs = 1499		
Test Statistic		1 % Critical Value	5 % Critical Value	10 % Critical Value		
Z(t)	-2.384	-3.430	-2.860	-2.570		
MacKinnon approximate p-value for $Z(t) = 0.1463$						
D.errorlNlVen	Coef.	Std. Err.	t	$P > \|t\|$	95 % Conf. Interval	
errorlNlVen L1.	-.0031998	.0013422	-2.38	0.017	-.0058326	-.000567
LD.	.2462669	.0265718	9.27	0.000	.1941449	.2983889
L2D.	-.1014716	.0263998	-3.84	0.000	-.1532561	-.049687
L3D.	.0441323	.0259552	1.70	0.089	-.0067803	.0950449
L4D.	-.0257611	.0260853	-0.99	0.324	-.0769289	.0254067
_cons	-.0002953	.0003783	-0.78	0.435	-.0010374	.0004467

Table 41: ADF on the residuals from the regression in logs of the Nasdaq Composite on the Venezuelan index

A.6 Gregory-Hansen Test

Tables 42-44 provide a summary of results and the critical values for the Gregory-Hanson test.

	Min. ADF Stat.	
	S&P500	Nasdaq Composite
Argentina	-4.739	-4.426
Brazil	-5.135	-3.257
Chile	-5.011	-4.463
Mexico	-5.103	-3.529
Peru	-4.38	-4.985
Venezuela	-1.546	-0.741

Table 42: Series in Levels: Gregory-Hansen Test of Cointegration in the Presence of a Structural Break

	S&P500		Nasdaq Composite	
	Min. ADF Stat.	Struct. Break	Min. ADF Stat.	Struct. Break
Argentina	-4.11		-5.855^{**}	April, 2001
Brazil	-7.185^{***}	August, 1998	-7.581^{***}	August, 1998
Chile	-4.874		-4.88	
Mexico	-6.052^{***}	August, 1998	-6.177^{***}	August, 1998
Peru	-4.439		-5.197	
Venezuela	-1.107		-1.76	

Table 43: Series in Logs: Gregory-Hansen Test of Cointegration in the Presence of a Structural Break (*,** and *** signify 10%, 5% and 1% level of significance, respectively)

	Significance level			
	1 %	2.5 %	5 %	10 %
m=1	-6.02	-5.72	-5.5	-5.24
m=2	-6.45	-6.17	-5.96	-5.72
m=3	-6.89	-6.65	-6.32	-6.16
m=4	-7.31	-7.06	-6.84	-6.58

Table 44: Gregory-Hansen Test: Approximate Asymptotic Critical Values for Regime and Trend Shift

A.7 Nonlinear Cointegration Tests

Tables 45 and 46 provide a summary of results and critical values for the Breitung's test.

	S&P500		Nasdaq Composite	
	k	*e*	*k*	*e*
Argentina	0.134	0.001	0.188	0.012
Brazil	0.0931	0.021	0.2439	0.0095
Chile	0.253	0.002	0.3764	0.0087
Mexico	0.22	0.017	0.3324	0.016
Peru	0.326	0.009	0.182	0.0132
Venezuela	0.227	0.0113	0.2592	0.0073

Table 45: Breitung's Rank Test of Nonlinear Cointegration

	1 %	5 %	10 %
k	0.6442	0.5524	0.422
e	0.0573	0.0423	0.0238

Table 46: Critical Values for Breitung's Test

A.8 Code

A.8.1 Gauss Code for Nonlinear Cointegration

```
@       ====================================                 @
@       GAUSS Program:      Rank test for Cointegration      @
@       ====================================                 @
@       Input:         y, x:      T x 1 vectors of time series    @
@       Output:      kap,xi:   Test statistics               @
@       subprogram:           Rankx returns the ranks        @
@       ====================================                 @

proc(2)=rankci(y,x);

  local n,z,dz,xi,sig,kap,t,dx,dy,Rankrho;
  x=rankx(x);
  y=rankx(y);
  n=rows(y);
  dx=x[2:n]-x[1:n-1];
  dy=y[2:n]-y[1:n-1];
  Rankrho=dx'dy/sqrt(dx'dx*dy'dy);
```

```
  z=y-x;
  dz=z[2:n]-z[1:n-1];
  sig=dz'dz/n;

  kap=maxc(abs(z))/sqrt(sig*n);
  xi=z'z/sig/n^2;
  kap=kap/(1-0.174*Rankrho^2);
  xi=xi/(1-0.462*Rankrho);

 retp(kap,xi);
endp;


proc rankx(x);
  local n,z,y;
  n=rows(x);
  x=x~seqa(1,1,n);
  z=sortc(x,1);
  y=seqa(1,1,n)~z[.,2];
  y=sortc(y,2);
  retp(y[.,1]);
endp;
```

A.8.2 Stata Code for the Gregory-Hansen Test

```
* This is for Argentina

local minadf=100

local optbreak=0.15*3047

local break=0.15*3047

* Gregory Hansen Test

while(`break'<=0.85*3047){
quietly gen cons1=1 if _n <=`break'
quietly replace cons1=0 if cons1==.

quietly gen cons2=1 if _n >`break'
quietly replace cons2=0 if cons2==.

quietly gen trend1=_n if _n <=`break'
```

```
quietly replace trend1 =0 if trend1 ==.

quietly gen trend2 =_n-‘break’ if _n >‘break’
quietly replace trend2 =0 if trend2 ==.

    quietly gen argentinaa=argentina if _n <=‘break’
quietly replace argentinaa=0 if _n > ‘break’

quietly gen argentinab=argentina if _n >‘break’
quietly replace argentinab=0 if _n <= ‘break’

quietly regress sandp cons1 cons2 trend1 trend2 argentinaa argentinab, noc
quietly predict residuals, resid
      *varsoc residuals
quietly dfuller residuals, lags(3)

* Keep if current ADF stat is smaller

if(r(Zt) < ‘minadf’){
local minadf=r(Zt)
local optbreak=‘break’
scalar minadf_val=‘minadf’
scalar optbreak_val=‘optbreak’
}

local break=‘break’+1
drop cons1 cons2 trend1 trend2 argentinaa argentinab residuals


}

* OPTIMAL BREAK POINT
display optbreak_val
display minadf_val
```