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U.S. AND COSTA RICA STOCK MARKET COINTEGRATION

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ABSTRACT

This paper tests the stationarity and cointegration of the historical daily data on the S&P 500 and the Costa Rican Bolsa Nacional de Valores (BNV). Both the Engle-Granger and Johansen Cointegration Tests are used to estimate this relationship. Results suggest that S&P 500 data and BNV are cointegrated although causal indicators between the two methods are contradictory. Specifically, the Granger Causality test suggests the S&P 500 is causal of BNV movement, while the coefficients in the error corrected model of the Johansen test are insignificant between S&P lags and BNV movement.

JEL: G15

KEYWORDS: International Financial Markets, Financial Market Cointegration

INTRODUCTION

Financial market interdependencies have been studied at length in the literature. Both for purposes of understanding linkages, as well as volatility transmission during periods of elevated market volatility. Much of the work that has been done in this area has focused on interdependence between major world markets. For example, Becker, Finnerty and Gupta (1990) examined the relationship between the Tokyo Stock Exchange (TSE) and the New York Stock Exchange (NYSE), Tabak and Lima (2002) and Aggarwal and Rivoli (1989) examined causality and cointegration in the major Latin American markets and Asian markets, respectively. These papers found significant connections between the markets examined and the U.S. market. A much smaller body of work has focused on the less mature markets around the world and their corollary with the world's major markets (e.g. DAX, FTSE, TSE, etc.). Research on the extremely small emerging or "pioneer" markets (Boehmer, Chava and Tookes, 2012) is much more limited. Data on these markets are also somewhat more inconclusive (Agharyev, 2012).

Within the context of the America's, the countries making up Central America (Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua) have experienced increased political stabilization, growth in foreign direct investment and done so while maintaining low rates of inflation over the last decade. The body of literature examining financial market linkages of the Central American markets with other markets is very limited. This is likely the result of limited levels of financial market liberalization in nearly 70% of the Central American markets (with the exception of Costa Rica and Panama). Costa Rica and Panama have experienced significant increases in high productivity led growth in both high technology industries and knowledge intensive services (Bashir, Gindling and Oviedo, 2012). As Costa Rica's export market has matured so too has its financial market. In fact, between 1995 and 2013 the IMF's Financial Development Index indicated an approximately 80% growth rate for Costa Rica's financial markets (Heng, Ivanova, Mariscal, Ramakrishnan and Wong, 2016). Although Costa Rica still has significant strides to make in financial market development its improvement has been well documented.

As the financial market has liberalized and grown, the need for research focused on Central American financial markets has become more relevant, despite their relatively small size (when compared to the emerging markets of Africa, the Middle East and Asia). This is particularly true for Panama and Costa Rica as the most developed of Central America's financial markets. As a financial market grows sufficiently large, research begins to emerge that examines the cointegration of the emerging market with more developed markets (c.f., Diamandis (2009), Todorov (2012) and Dania and Spillan (2013)). The literature on Costa Rica's financial market cointegration with other countries is non-existent. This is likely due to the fact that the market capitalization is still small when compared to the major world markets. As a result there exists a gap in the literature. This research will contribute to the literature by examining the financial market cointegration between Costa Rica (Bolsa Nacional de Valores) and the U.S. (S&P 500). The next section will review the existing body of literature, followed by a section on the data and methodology, thereafter, results and concluding comments will be discussed.

LITERATURE REVIEW

Since the South American and Asian financial crises, there has been an abundance of work on both contagion and cointegration. For example, Diamandis (2009) found that four major Latin American (Chile, Argentina, Brazil and Mexico) stock exchanges were partially cointegrated and shared common components with U.S. markets. While these markets are still fairly small relative to TSE, NYSE, DAX standards, their importance in the world financial system is growing rapidly. According to a capital markets report by PriceWaterhouseCoopers, there will be nearly 25% growth over the next five years in companies offering IPO's on medium sized emerging market exchanges. The primary markets in Latin America (i.e. Brazil, Mexico and Chile) are still large relative to true "emerging" market standards. In particular, there is very little in the literature as it relates to Central American markets and their co-movement with U.S. and other primary international financial markets. A likely reason for this is due the extremely small size of Central American markets and the limited volumes in which they trade. The combined market volume on Central American exchanges accounts for less than 1% of the volume on the NYSE (CIA Fact book, 2013). The oldest and most well developed market in Central America is the Bolsa Nacional de Valores (BNV) in Costa Rica. The BNV has been opened since 1974 and as of 1993 is wholly owned by private investors (Fiabnet, 2012). Although, the volume of shares traded is still relatively small (and below its 2006 peak), the Costa Rican market will play a significantly important role in the financial development of the region, along with Panama and El Salvador (Ascher and Hubbard, 1989) (Figure 3 below describes the characteristics of the BNV). This is not only evidenced by the large numbers of American and European retirees moving into Costa Rica, but also the result of increasing levels of European and American Foreign Direct Investment into Costa Rica. Currently American FDI accounts for approximately 70% of all FDI into Costa Rica, which is up significantly from only ten years earlier (CIA World Fact book, 2013). These facts not only make Costa Rica an interesting case to examine, but also a very relevant growing market in the Central American financial landscape.

With much of the work on the Latin American market dynamic focused on high impact markets (e.g. Mexico, Brazil, etc.), an opportunity exists in the literature to focus on smaller financial (and in particular Central American financial) market characteristics. It has been suggested that smaller economies are not only impacted by lagged movements of the S&P 500, but also by S&P futures markets (Todorov, 2012). This suggests that while findings in Latin America generally indicate market co-movement with major U.S., European and Asian markets, smaller emerging markets may be less impacted than larger markets by historical trends. For example a 2013 paper by Dania and Spillan found that Middle East and North African (MENA) markets were not fully integrated with more mature markets in Europe, the Americas and Asia. While this may be due to the lack of liquidity in these markets and/or lack of external influence (e.g. FDI), the growth trajectory of these markets will be important to understand in the context of their emerging predecessor markets.

DATA AND METHODOLOGY

Data

The data used are daily closing prices of the S&P 500 index and the BNV. The data for the S&P 500 are taken from Yahoo finance (finance.yahoo.com). The data for the BNV are taken from Banco Central de Costa Rica (BCCR). According to the IMF (2011) Costa Rica has been a managed float exchange rate regime, which has been largely tied to the dollar. The government is currently in the process of liberalizing the exchange management regime, although there have been struggles as a result of fiscal imbalances and political party misalignment. Since approximately 2007 the Costa Rican Colon (CRC) has been loosely pegged to the USD. The period covered is from January 3, 1995 through March 6, 2013**.** Historical log levels can be seen in Figure 1 below.Figure 1 shows the log daily values for the BNV from 1/3/1995 through 3/6/2013. When compared to the log daily values of the S&P 500 over the same time interval, it is clear that the tech bubble that afflicted the U.S. market was far less pronounced in the Costa Rican market. On the other hand, the most recent financial crisis of 2009 was observed in the BNV as can be observed in Figure 2. The trends in Figures 1 and 2 illustrate that there are marginal similarities between the log daily values of the S&P 500 and the BNV. Table 5 (as well as Figures 3 and 4 below), show the summary statistics for each market, as well as the histograms for the distribution of the daily returns over the period being examined.

Figure 1: Log Index Values Over Time: BNV

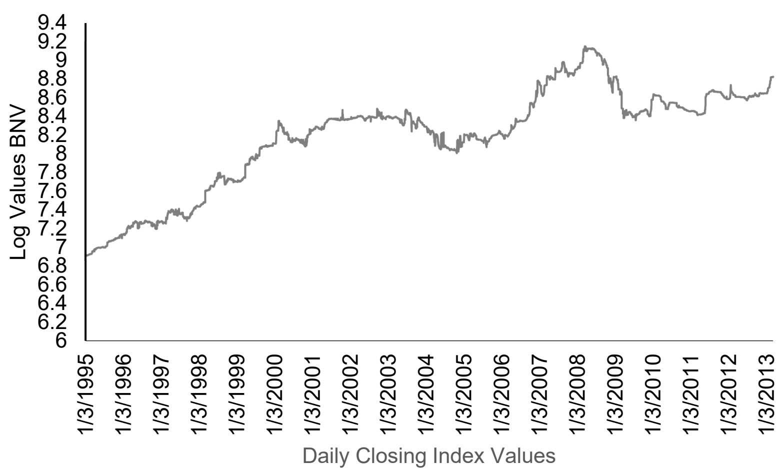

Figure 1 exhibits the log daily values for the BNV from 1/3/1995 through 3/6/2013.

Data in Table 1 characterize the more normally distributed S&P index (skewness=-0.049 and kurtosis=7.82) versus the BNV (Skewness=1.74 and kurtosis=50.38). Mean daily returns in the S&P are lower than the BNV (0.04% versus 0.03%) with nearly equivalent standard deviation 1.25% in the S&P as compared to 1.26% in the BNV.

Figure 2: Log Index Values Over Time: S&P 500

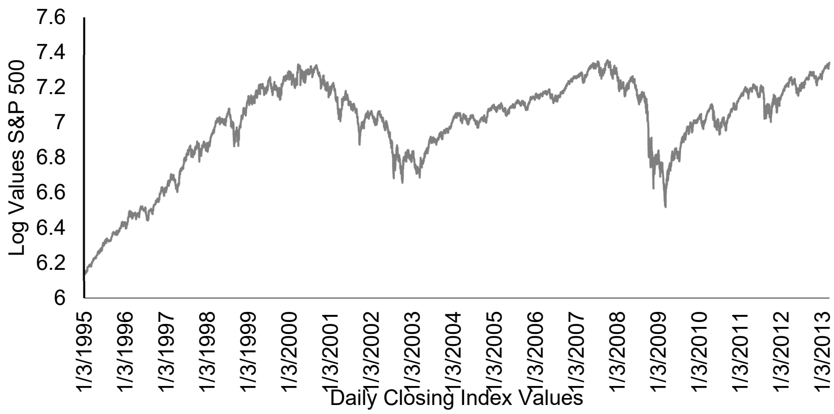

Figure 2 exhibits the log daily values for the S&P 500 from 1/3/1995 through 3/6/2013.

Table 1: Summary Statistics for Daily Returns for BNV and S&P 500

Measure	BNV	S&P 500
Mean	0.04%	0.03%
Median	0.0%	0.07%
Maximum	17.12%	11.58%
Minimum	-15.52%	-9.03%
Standard Deviation	1.25%	1.26%
Skewness	1.74	-0.049
Kurtosis	50.38	7.82

Table 5 shows summary statistics for daily return data for the BNV and the S&P500. Mean average daily returns are similar between both BNV and the S&P 500 (.04% and .03%, respectively). Range of returns is higher for the BNV than for the S&P 500.

Both daily return histograms illustrate different levels of skewness and kurtosis, despite similar mean return and standard deviation values. While clearly not normally distributed, the S&P 500 exhibits skewness and kurtosis statistics closer to Gaussian. This can also be seen in the histograms in Figures 3 and 4 as well.

Figure 3: Histogram of Returns: BNV

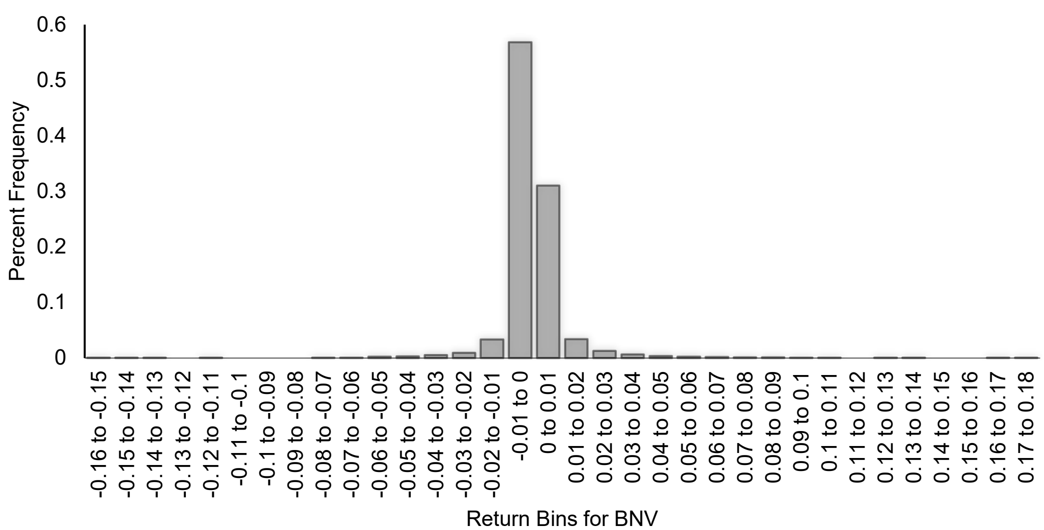

Figure 100 shows the frequency of returns for different return bins, ranging from -.16 to 0.17. Relative to the S&P 500, exhibits less variability, on average

Figure 4: Histogram of Returns-S&P 500

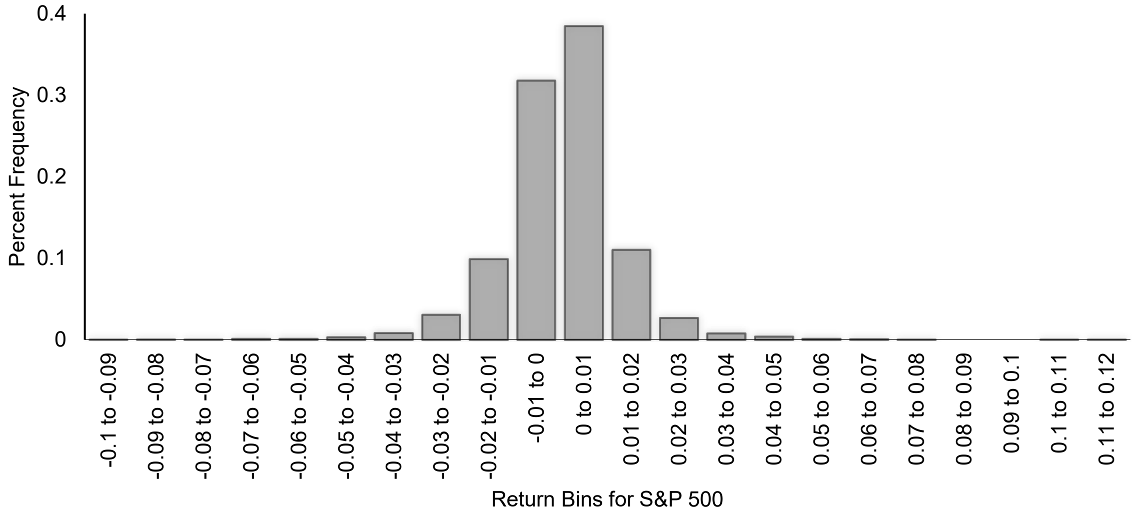

Figure 4 shows the frequency of returns for different return bins, ranging from -0.1 to 0.12.

It is important to note that the volume of trades (in terms of $US) are less than one half of one percent than the S&P indicating a somewhat low liquidity market relative to the S&P 500 index. Figure 5 below from Fiabnet shows some characteristics of the BNV market over time. The current market trading hours are from 9:00AM to 3:00PM. Costa Rica does not participate in daylight savings time (DST). During DST in the U.S., Costa Rica is one hour ahead of Pacific Time. During standard time, Costa Rica is two hours ahead of Pacific Time, hence there is significant overlap with the U.S. in trading time during the trading day.

Table 2: Summary Market Data BNV

Item	2000	2005	2010	2011
Total Market Cap (Millions of US$)*	2,924	2,202	1,445	1,498
Number of Listed Companies	21	19	9	9
BNV Stock Index	3,813.77	3,679.29	4,687.98	5,350.24
Number of Brokerage Companies	21	19	17	17
Total Value of Share Trading (Millions of US$)*	63	203	160	196
Total Value of Bond Trading (Millions of US$)*	n.a.	1,897	5,158	6,397

*Source: Fiabnet, 2012 *In 2012 Dollars The historical data (fiabnet.org, 2012) show high-level characteristics of the BNV market, over time.*

METHODOLOGY

A majority of the tools utilized in previous research to test market interdependencies is based on work done by Engle and Granger (1987), Dickey and Fuller (1979) and Johansen (1991). In order to test cointegration between the S&P 500 and BNV, two approaches will be taken. First of all, the test to determine whether or not the series are stationary will be done using the Augmented Dickey Fuller (ADF) test for unit root. Thereafter, the Engle-Granger two-step method (EGTSM) will be conducted. Finally, the more comprehensive Johansen Cointegration Test (JCT) will be done to ensure cointegration result stability between the two methods.

ADF and the Engle Granger Method

In order to test whether or not the two series (S&P 500 and BNV) are stationary, the ADF test for unit root will be examined. The process for testing the existence of unit root is as follows:

$$\Delta Y_t = \alpha + \beta_t + \gamma Y_{t-1} + \delta_1 \Delta Y_{t-1} + \cdots + \delta_{p-1} \Delta Y_{t-p+1} + u_t \tag{1}$$

where, α is an intercept term, β is the coefficient on the time trend (assuming intercepts and time trends are included). The null hypothesis of unit root is γ=0. The ADF statistic is calculated as,

$$\frac{\hat{\gamma}}{SE(\hat{\gamma})} \tag{2}$$

If t*>ADF, then we fail to reject the null hypothesis of unit root (i.e. the series is non-stationary). If t*<ADF, then the null hypothesis is rejected and the series is assumed stationary. In the case above, non-stationarity does not necessarily imply series cointegration. The subsequent step is to determine whether or not the series are integrated of the same order. By definition integration is the number of series differences required in order to observe a stationary series. A time series is integrated of order *t* if, $(1\text{-d})^k Y_t$ is integrated of order k, where d is a lagged value. The first difference (1-d) =(1-d)Y_t= Y_t- Y_{t-1}= ΔY. Assuming d=1 then the series is integrated of order one (I(1)). Testing that the series of the S&P 500 and the BNV are I(1) can be done in two ways. The first is simply to difference the series and rerun the ADF test. If the series is I(1) then the ADF on the level value of the variables of interest should indicate a failure to reject the null and the differenced ADF should yield a rejection of the null hypothesis. Alternatively, in the EGTSM one could take the model, $Y_t=\beta Xt+u_t$, where Y_t is the value of the BNV and X_t is the value of the S&P 500. Obtaining the residuals, the relationship of the first differenced error can then be tested on the lagged value of the error, $\Delta u_t=\delta u_{t-1}+\varepsilon_t$. From this step, the null hypothesis of δ=0 is tested. If the null hypothesis is rejected this implies that the series are cointegrated. This result will be equivalent to differencing the series and testing the null hypothesis of stationarity on the first difference (results shown in the Results section of the paper).

Johansen Cointegration Test

Confirmation of cointegration is tested using JCT and the Vector Error Correction Model (VECM). The JCT allows tests of multiple I(1) process to be tested. In the previous ADF/EGTSM only one cointegrating relationship is allowed. This makes the JCT much more flexible. Johansen's method uses a vector autoregression (VAR) as a starting point. The VAR takes the following form,

$$y_t = \alpha + \beta_1 y_{t-1} + \cdots + \beta_p y_{t-p} + u_t, \tag{3}$$

where y_t is an nx1 vector of variables assumed to be I(1) (although, according to Hjalmarsson and Österholm (2007), the JCT doesn't require all variables to be integrated of the same order due to the maximum likelihood estimation of the cointegrating equations.
Equation (3) above can be rewritten as,

$$\Delta y_t = \alpha + \Pi y_{t-1} + \sum_{i-1}^{p-1} \Gamma_i \Delta y_{t-1} + u_t \tag{4}$$

Where

$$\Pi = \sum_{i-1}^{p} \alpha_i - \mathrm{I} \tag{5}$$

and,

$$\Gamma_i = -\sum_{j-i+1}^{p} \alpha_j \,. \tag{6}$$

If Π, the coefficient matrix, has reduced rank *r*<*n*, then there exists *nxr* matrices. Where r is the number of cointegrating relationships and n is the number of variables. Then A and B are matrices each with a particular rank *r*, such that Π is stationary (Johansen, 1993). From this, there are two tests that are promoted by Johansen, the max-eigenvalue test and the max-trace test, defined in the following two equations.

$$J_{trace} = -T \sum_{i-r+1}^{n} \ln(1-\lambda_i) \tag{7}$$

and,

$$J_{\max} = -T \ln(1-\lambda_{r+1}) \tag{8}$$

Where (7) is the trace test statistic and (8) is the max eigenvalue. Given that cointegrating equations are identified in the Johansen test (via either significant trace or eigen statistics. This step allows us to test the following null and alternative hypotheses (Brooks, 2008).

H_0: r=0	H_1: 0<r≤n
H_0: r=1	H_1: 1<r≤n
H_0: r=2	H_1: 2<r≤n
H_0: r=n-1	H_1: r=n

Where the first statement tests the null hypothesis of no cointegrating vectors (Π having zero rank). If the null hypothesis is rejected then the hypothesis of r=1 is tested, if r=1 is rejected then r=2 is tested and so on. This cycles until the null fails to be rejected, at which point the number of cointegrating vectors is determined. If it is determined that the cointegrating equations are non-zero, then the VECM (the first differenced VAR), then needs to be run in order to capture the vector error correction model. Once this takes place the VECM can be run in OLS and the results can be interpreted as normal.

HYPOTHESES

Three primary hypotheses will be tested.

Hypothesis 1: The series for the S&P 500 and BNV will be I(1)

Hypothesis 2: S&P 500 and BNV series are cointegrated

Hypothesis 3: Lagged S&P 500 values will "Granger cause" BNV

The hypotheses will be tested via the methods listed above. First, an ADF test will be run on both series to test for unit root. Then (assuming unit root exists) the first differenced series will be tested in order to ensure an I(1) process. If confirmed, a second check will be done using the EGTSM to test for cointegration.

Next, a Granger Causality test will be run to test the hypothesis of causality between the two series. Finally, to test for consistency among the different methods of cointegration testing, the JCT will be run on the series to determine (1) if they are integrated, (2) how many cointegrating equations exist and (3) determine the causality between BNV and the S&P 500.

RESULTS

The ADF test results for the BNV and the S&P 500 in Table 1 indicate that unit root exists in both series, in other words, the series are non-stationary. Table 3 shows that the BNV series are both non-stationary in the log level (ADF>t-critical of 2.15>-2.56) measure and significant (-37.14<-2.56) implying the series first difference is stationary. It can thus be inferred that the series is also integrated of order 1. As a result of the four ADF tests above the series on the S&P 500 and BNV are both non-stationary and I(1). As a result it is possible to test the cointegration of the series using the Engle-Granger two-step method (EGTSM) described in the methodology section.

Table 3: ADF of S&P 500 (Log Level Series) and First Difference of S&P 500 Series

Augmented Dickey Fuller Test-S&P 500		**t-Statistic**	**Prob.**
ADF Test Statistic		1.485	0.9665
Test Critical Values	1% Level	-2.565	
	5% Level	-1.941	
	10% Level	-1,617	
Augmented Dickey Fuller Test-S&P 500 First Difference		**t-Statistic**	**Prob.**
ADF Test Statistic***		-52.039	0.0001
Test Critical Values	1% Level	-2.565	
	5% Level	-1.941	
	10% Level	-1.617	

**** indicates significance at the 5% level. Table 3 reports the ADF results for the S&P 500 and the first difference of the S&P 500. For the S&P 500 (log level series) The ADF statistic is greater than the critical values at all levels of significance, which implies a failure to reject the null hypothesis. This implies that the S&P 500 series (log level values) are non-stationary and exhibit a unit root. The ADF (differenced series) statistic is significant at the 1% and 5% levels (-2.65 and -1.94, respectively). The first difference of the S&P series is stationary indicating that it is an I(1) process. In table's 3 and 4 below are the results for the ADF test on the log level and first differenced series of the BNV.*

Table 4: ADF of BNV (Log Level Series) and First Difference of BNV Series

Augmented Dickey Fuller Test-BNV		**t-Statistic**	**Prob.**
ADF Test Statistic		2.151	.9929
Test Critical Values	1% Level	-2.565	
	5% Level	-1.941	
	10% Level	-1.617	
Augmented Dickey Fuller Test-BNV First Difference		**t-Statistic**	**Prob.**
ADF Test Statistic***		-37.139	0.0000
Test Critical Values	1% Level	-2.565	
	5% Level	-1.941	
	10% Level	-1.617	

**** indicates significance at the 1% level.*

The EGTSM results indicate that the series are cointegrated. The p-value on both S&P 500 and BNV are statistically significant indicating that we reject the null hypothesis of non-cointegration. The results for the EGTSM are listed in table 5 below.

Table 5: Engle-Granger Single Equation Cointegration Test

Dependent	Tau-Statistic	Prob.	Z-Statistic	Prob.
BNV	-37.232***	0.0	-3982.622***	0.0
S&P 500	-52.076***	0.0001	-5426.527***	0.0

**** indicates significance at the 1% level.*

Finally, in order to identify whether a causal relationship exists, table 6 displays the results of the Granger Causality test. Results in table 6 above indicate that we reject the null hypothesis that the S&P 500 does not Granger Cause the BNV. This result implies that BNV does not impact movements in the S&P but the S&P does impact movements in the BNV. Results for the EGTSM were all consistent with expectations both in terms of outcome and magnitude.

Table 6: Granger Causality BNV and S&P 500

Null Hypothesis	Observations	F-Statistic	Prob.
BNV does not Granger Cause S&P 500	4210	0.0823	0.9923
S&P 500 does not Granger Cause BNV***	4210	1.160	0.0249

**** indicates significance at the 5% level.*

A shortcoming of the EGTSM is that it can only test one cointegrating relationship. The JCT is able to overcome this and test multiple cointegrating relationships. Although there are not additional variables of interest within this paper, the test will be run to examine the stability of the results. Table 7 below shows the results of the JCT.

It is clear from table 7 that more than one cointegrating relationship exists. Furthermore, both the trace and max-eigenvalue tests yield similar results, both of which are statistically significant, which supports results from the EGTSM method above.

Table 7: Johansen Test of Cointegration –BNV and S&P 500

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized Number of Cointegrating Equations	Eigenvalue	Trace Statistic	.05 Critical Value	Prob.
None***	0.0048	29.043	15.495	0.0003
At Most 1***	0.0015	6.933	3.841	0.0085
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized Number of Cointegrating Equations	Eigenvalue	Max Eigenvalue	.05 Critical Value	Prob.
None***	0.00483	22.110	14.265	0.0024
At Most 1***	0.00152	6.933	3.841	0.0085

**** indicates significance at the 1% level. Trace and Max Eigenvalue test indicate two cointegrating equations exist*

The VECM was run, although the results are an intermediate step and will not be shown here. The corrected model was specified in equation 7 below.

$$d\ln BNV = \beta_0 + \beta_1 * (\ln BNV_{t-1} - 1.85 * \ln SP500_{t-1} + 4.77) + \beta_2 * d\ln BNV_{t-1} + \beta_3 * d\ln BNV_{t-2} + \beta_4 d\ln SP500_{t-1} + \beta_5 d\ln SP500_{t-2} \quad (7)$$

where, dlnBNV is the change in log values of the BNV in the current period (in this case trading day). This is dependent on values of the variables on the right hand side of equation. Variables that include *d* are changes, *ln* refers to the natural logarithm of the index levels and subscripts *t-n* represent values from the prior period. The results from the corrected model are shown in table 8.

Table 8: Error Correction Model –BNV and S&P 500

Variable	Coefficient	Standard Error	t-Statistic	Prob.
β_0**	0.00042	0.0002	2.42	0.0156
β_1 ***	-0.002	0.0005	-5.06	0.000
β_2 ****	-0.103	0.0148	-6.95	0.000
β_3***	0.0383	0.0148	2.59	0.010
β_4	0.0095	0.0145	0.65	0.515
β_5	0.0065	0.0145	0.44	0.659

**** and ** indicate significance at the 1% and 5% levels, respectively. The coefficient on β_1 is significant and negative. This is the error correction variable from the prior steps vector autoregression. Variables that include lag values of the S&P 500 were not significant in the model, which was counter to results from the EGTSM.*

The term beginning at the RHS of the equation is the error correction parameter. The model then includes lags on BNV and S&P (denoted SP500). Interestingly, and inconsistently, the results for the coefficients on the lags of the S&P are not significant (β_4 and β_5). These parameters were jointly tested to be equal to zero and the null hypothesis was not rejected indicating that these variables jointly are not different from zero on their impact on BNV. There are a number of potential reasons for this. First of all, Todorov (2012) found that for small emerging markets S&P futures had more impact on these markets than the S&P index. Moreover, there could be a problem of spuriousness in the regression. There are a number of markets correlated to the S&P 500 that could be more highly related to the value of the BNV than the S&P 500. These are ideas for future research and are not in the scope of this paper.

CONCLUDING COMMENTS

This paper evaluated the market comovement between the S&P 500 and the Costa Rican BNV. Specifically the stationarity of the historical daily data on the S&P 500 and the Costa Rican BNV were evaluated and found both series to be non-stationary. After differencing the cointegration of these markets was examined and found significant in both the EGTSM and the JCT. Results are somewhat conflicting, however, in that the Granger Causality tests suggests that movement in the S&P 500 causes movement in the BNV. The error correction model suggests that the lagged S&P values do not have an impact on the BNV. While the results definitively suggest cointegration exists, potential spuriousness and/or omitted variable bias in the JCT could be causing these conflicting results. Another possible reason for the conflicting the results are the number of periods over which the cointegrating relationship was evaluated (in this paper approximately 18 years of closing prices). Breaking the time periods up into temporal segments (i.e., every five years) may yield different results. In addition, a shortcoming of this paper is that variability in the USD/CRC were not accounted for and this could be another cause of inconsistency in the results. The rationale for not incorporating this was due to the limited trading volume observed for the BNV in the earlier period evaluated (1995-2000).

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