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Examining the Dynamic Nature of Spillover between US and Brazilian Equity Markets

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Abstract: This paper examines the transmission mechanisms of short- and long-term price spillovers between the US and Brazilian equity markets. For the short-term relationship, we use a bivariate Generalized Autoregressive Conditionally Heteroskedastic model to test for the lead-and-lag relationship between the two markets. For the long-term relationship, we use Gonzalo and Granger's (1995) price discovery methodology. Tests are run over the sample period from January 2000 to December 2012, and for three sub-periods: January 2000 to November 2007 (before the financial crisis), December 2007 to June 2009 (during the crisis) and July 2009 to December 2012 (after the crisis). We find strong evidence of a positive unidirectional price spillover from the US to the Brazilian equity market. This spillover effect exists in both the short and long term for the period after the financial crisis (2009-2012). These findings may indicate a weaker diversification benefit from including Brazilian equities in a domestic (US) portfolio, as well as the potential for profitable trading strategies that exploit the lead-lag relationship between these two markets.

Key words: international equity; spillover effects; emerging markets

JEL codes: E3, E1, O1

1. Introduction

Understanding the spillover and co-integration relationships between countries may prove statistically and economically important for global investors operating within the global marketplace. As shown by Figure 1, the ever increasing amount of investment dollars flowing into world funds relative to US equity funds between 2000-2012 points to a growing appetite on the part of investors for foreign investment opportunities.

Historically, investors tend toward investing with a "home bias" or they tend to invest in their domestic market. However, as shown in Figure 1, new investment dollars flowed into mutual funds investing in the global markets to a greater extent and at a faster rate than those investing exclusively in US markets. Over the 2000-2012 time period net new investment dollars increased 3 times year over year for the capital appreciation objective, 10 times for the world fund objective and 5 times for the total return objective. The averaged net inflow dollar

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amounts are also significantly higher for the world fund objective. World funds gained roughly $41.45 billion on average over the time period, while total return and capital appreciation *lost* $4.42 and $2.94 billion on average, respectively. In all, these figures lend credence to the notion that understanding the dynamic nature of the relationship between key global markets can make the difference between effectively enhancing portfolio returns and efficient diversification.

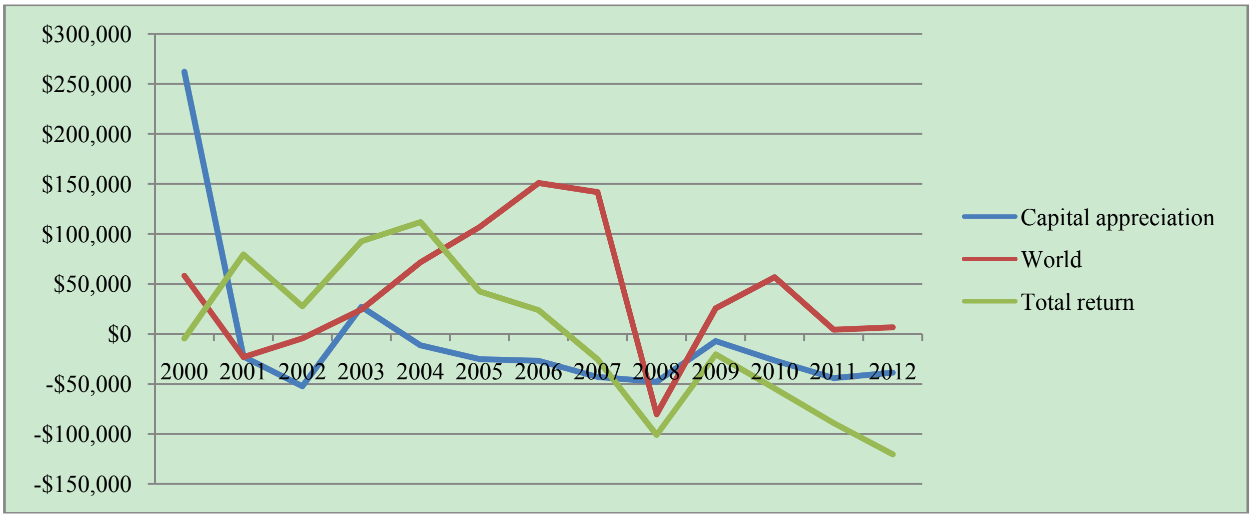

Figure 1 Net New Investment Dollars Into Equity Mutual Funds by Investment Objective

Dollars are in millions. Data provided by the Investment Company Institute (ICI).

This paper examines return spillover from between the US and Brazilian equity market over the 2000-2012 time period. This is examined in the short or long term in an attempt to determine how this might alter a global money managers' decision on the timing and efficient allocation of assets in a global market portfolio. We focus on the relationship between the United States and Brazil relative to the United States and all other Latin American markets, given that Brazil (as one of the BRICS) is seen as the leading emerging economy for that region. In 2012, the International Monetary Fund ranked Brazil the seventh largest economy in the world. Its stock market has experienced rapid growth, and Brazil now has a burgeoning middle class which now constitutes over 50% of the population. Brazil is the third largest recipient of foreign direct investments (FDI), receiving an average of $66 billion per year in 2011-2012, compared to $240 billion for China and $205 billion for the United States, according to Organization for Economic Co-operative and Development (OECD) figures[1]. FDI is associated with sustainable economic growth thus Brazil would be viewed as a prime market for global market investors. The Brazilian stock exchange (BM&FBovespa) is the largest in South America and one of the largest in the world. With a market capitalization of around R$2.4 trillion in local currency (approximately US$1.0 trillion), the BM&FBovespa was the eighth largest in the world at the end of 2012. In sum, as an emerging economy, Brazil is considered to have substantial room for growth and is a key market that, unlike its counterparts throughout Europe and Asia, has received significantly less attention in the academic literature.

Knowledge of spillover and stock-market linkages may have important implications for the benefits of (global) diversification, which is a foundation of Modern Portfolio Theory. Many papers examine this relationship between the US and countries throughout Europe and Asia, i.e., Bessler and Yang (2003), Koutmos and Booth

[1] Bertrand A. & Kothe E. (2013). FDI in Figures, OECD Investment Division, April, pp. 1-8.

(1995), Worthington, Spratley and Higgs (2005) and Li (2007) to name a few, however this has been studied to a much lesser extent for the US and Latin American nations. Fernandez- Serrano and Sosvilla-Rivero (2003) examine the long-term relationship between the US and six Latin American stock markets (Argentina, Brazil, Chile, Lima, Mexico and Venezuela). Using daily return data over the 1995-2002 time period, the authors examine this relationship by applying co-integration tests to account for the consideration of structural breaks. When structural shifts were *not* considered, the authors find the strongest and most consistent long-term relationship results between the S&P 500 (United States) and the BOVESPA indices (Brazil). When structural breaks *are* considered the authors find evidence of a spillover relationship between the United States and Brazil but only find it for the period before November 1997[2].

Diamandis (2009) examines long-term linkages between the US and four Latin American stock markets (Argentina, Brazil, Chile and Mexico), following a financial liberalization in which these countries abolished foreign exchange restrictions. The author uses weekly observations over a period from January 1988 to July 2006, and adopts a multivariate co-integration methodology. Diamandis concludes, in part, that the four Latin American markets are only partially integrated with the US market, citing evidence that these markets share more 'common trends' than co-integrating relationships in the long run. Sharkasi, Ruskin and Crane (2005) examine the price interdependence among stock markets in Brazil, Hong Kong, Ireland, Japan, Portugal, the United Kingdom and the United States from May 1993 to September 2003. They identify co-movements between the US and Brazilian markets that subsequently impact the Asian markets. Modi, Patel and Patel (2010) examine co-movements between developing markets in the BRICs (Brazil, Russia, India and China and developed markets in the United States and the United Kingdom from July 1, 1997 to June 30, 2008. They employ a correlation analysis, with India as the focal/domestic market. Low co-movements are found between India and Brazil, the United States, and Mexico, making them ideal markets for diversification gains.

While the above literature examines a spillover or co-integrating relationship between the US and Brazil in some form, our research differs from the prior given we focus our analysis on the dynamic relationship between these two countries surrounding the multiple market cycles to include periods of very high volatility. With a confluence of experts purporting that volatility is here to stay[3], we need to understand how spillover between these countries change given market conditions in order to develop efficient return generating and defensive hedging strategies. We utilize structural brake analysis to determine exactly how and when the relationship between these two countries change and how. Our sample period also extends the sample period of prior work and allows us to examine this question over a longer time period and/or using greater frequency in data. Using daily data, we examine the period between January 2000 and December 2012 and use structural break analysis to break our sample into sub-periods. The analyzed sub periods correspond to the period before, during and after the financial crisis. We examine both short- and long-term price and volatility spillover effects. In the short term, we use a bivariate Generalized Autoregressive Conditionally Heteroskedastic model to test for the lead-and-lag relationship between the two markets. For the long-term relationship, we use Gonzalo and Granger's (1995) price discovery methodology. Finally, the existing literature offers mixed results with respect to the co-integrating relationship.

[2] The authors also examine these relationships relative to the Dow Jones Index. However, the relationships between all markets are most consistent when considering the S&P 500 relative to the six Latin American markets. Thus, these are the results noted here.

[3] http://money.cnn.com/2015/01/18/investing/stocks-markets-volatility;
http://www.cnbc.com/2015/07/09/market-volatility-is-here-to-stay-experts.html;
http://www.cnbc.com/2014/10/15/why-all-this-market-volatility-is-here-to-stay.html.

Our longer sample period covers multiple market cycles and should allow us to shed additional light on the conflicting evidence from prior papers.

The remainder of the paper is organized as follows. Section 2 outlines the nature of the data and presents relevant descriptive statistics. Details of the methodology and empirical results are described in Sections 3 and 4. Section 5 offers concluding remarks.

2. Data and Descriptive Statistics

The daily end-of-day closing price for the S&P 500 and the BOVESPA are collected from Bloomberg. Our sample period covers January 2000 through December 2012. Using a time period of approximately 13 years allows us to capture and analyze the relationship between these two markets over market cycles. Figure 2 shows the time series of the daily end-of-day closing prices for the SPY (S&P 500 ETF) and the BOVESPA. We see that the closing price trend for the BOVESPA remains relatively stable from 2000-2003 and experiences upward momentum from 2003 until the financial crisis of 2008. From that point through the end of our sample period the IBOVESPA becomes more volatile.

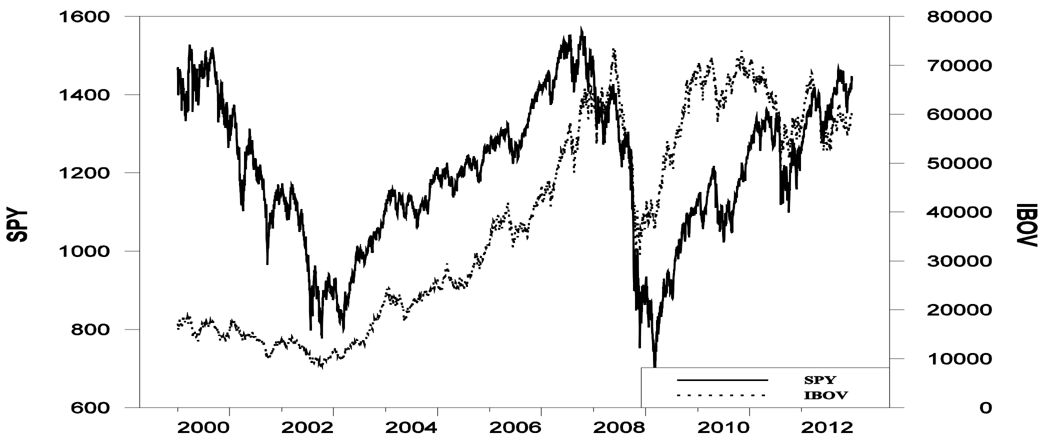

Figure 2 Daily End-of-day Close for S&P 500 and BOVESPA Indices

We begin our analysis by tackling the problem of spurious regression pointed out by Granger and Newbold (1974). We examine whether our series in non-stationary by utilizing the augmented Dickey-Fuller (DF) test (1979, 1981) and the Philips-Perron (PP) test (1988). The PP test is a generalized formation of the DF test in which there is no requirement that the disturbance term be serially uncorrelated and homogenous. We account for the non-stationarity of the variables by taking the first difference in the case of a one-unit root and the second difference in the case of a two-unit root.

Table 1 displays the results of the DF and PP tests for the whole sample period and the three sub-samples. The Akaike information criterion (AIC) is used to determine the number of lags of the unit root test. At the 5% significance level, most variables have a one-unit root that can be removed by taking the first difference of the series. Henceforth, we will proceed under the assumption that the S&P 500 and BOVESPA series are integrated of order 1, i.e., they are I(1).

Table 1 Phillips and Perron (PP) and the Dicky Fuller (DF) Unit Root Tests of the Daily Closing Price for S&P 500 and BOVESPA

Time Period	S&P 500				BOVESPA		
	Test	AIC	Level	First Difference	AIC	Level	First Difference
01-03-2000 to 12-19-2012	PP	2	-2.252	-62.501***	0	-0.790	-57.964***
	DF		-2.050	-35.652***		-0.790	-57.947***
01-03-2000 to 11-31-2007	PP	2	-1.486	-46.479***	0	0.609	-44.573***
	DF		-1.328	-27.639***		0.609	-44.552***
12-01-2007 to 06-31-2009	PP	2	-1.243	-23.477***	0	-1.462	-20.685***
	DF		-1.200	12.647***		-1.458	-20.634***
07-01-2009 to 12-19-2012	PP	2	-2.262	-31.714***	0	-2.775*	-30.575***
	DF		-2.544	-18.689***		-2.772*	-30.541***

Note: This table shows the results of the Phillips and Perron (PP) and Dicky Fuller (DF) tests, in which the number of lags is determined by the Akaike information criterion (AIC). ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

3. Short-Term Spillover

We examine the price and volatility spillovers between the US and Brazilian equity markets by utilizing the bivariate AR(1)-GARCH with a BEKK specification. This specification imposes positive-definiteness on the covariance matrix in the optimization process. Accordingly, our empirical model can be stated as follows:

$$\Delta \ln P_{1,t} = \alpha_{1,0} + \alpha_{1,1}\Delta \ln P_{1,t-1} + \alpha_{1,2}\Delta \ln P_{2,t-1} + \varepsilon_{1,t} \quad (1)$$

$$\Delta \ln P_{2,t} = \alpha_{2,0} + \alpha_{2,1}\Delta \ln P_{1,t-1} + \alpha_{2,2}\Delta \ln P_{2,t-1} + \varepsilon_{2,t} \quad (2)$$

$$H_t = C'C + A'\varepsilon_t\varepsilon_t' A + B'H_t B \quad (3)$$

Where P_1 and P_2 represent the S&P 500 and BOVESPA (IBOV) indices, respectively; $\varepsilon_{i,t}$ is the innovation in market i at time t; H_t is the conditional variance covariance matrix at time t; and Δ is the first difference operator. Equations (1) and (2) describe the mean equation in the respective markets, where the price process is influenced by each market's own historical pricing and past prices from the other market. Accordingly, the coefficients $\alpha_{i,j}$ capture the price spillover effects between the US and Brazilian equity markets where $i \neq j$, and the effect of each market's own historical prices where $i = j$.

The conditional variance and covariance process are given by equation (3), where the variance covariance matrix depends on the squares and cross-products of innovations (ε_{t-1}) and volatilities (H_{t-1}). Equation 3 can be represented in matrix form as:

$$\begin{bmatrix} H_{11,t} & H_{12,t} \\ H_{21,t} & H_{22,t} \end{bmatrix} = C'C + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon^2_{1,t-1} & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon^2_{2,t-1} \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}' \begin{bmatrix} H_{11,t-1} & H_{12,t-1} \\ H_{21,t-1} & H_{22,t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \quad (4)$$

Where $a_{i,j}$ and $b_{i,j}$ measure the volatility spillover effect between US and Brazilian markets where $i \neq j$, and the effect of each market's own past innovations (squared) and volatility where $i = j$. Assuming that the conditional joint distribution of the prices in each country is normal, the log likelihood for the bivariate GARCH model can be stated as follows:

$$L(\theta) = -\frac{Tn}{2} + \ln(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\left(\ln\left|H_t\right| + C'\left|H_t^{-1}\right|C\right) \quad (5)$$

Where T is the number of observations, n is the number of countries, and θ is the vector of estimated parameters. We estimate the log likelihood function using the Broyden, Fletcher, Goldfarb and Shanno algorithm (BFGS), and we calculate the time-varying conditional correlation between the ε_t estimated with the bivariate GARCH. Table 2 reports the estimates of the model.

Table 2 Estimated Coefficients for the Conditional Mean

Time Period	$\alpha_{1,1}$	$\alpha_{1,2}$	$\alpha_{2,1}$	$\alpha_{2,2}$
01-03-2000 to 12-19-2012	-0.061***	0.01	0.066**	-0.025
	(0.002)	(0.393)	(0.031)	(0.184)
01-03-2000 to 11-31-2007	-0.056**	0.008	0.064	-0.004
	(0.015)	(0.56)	(0.134)	(0.87)
12-01-2007 to 06-31-2009	-0.148**	-0.019	0.098	-0.109
	(0.011)	(0.743)	(0.195)	(0.87)
07-01-2009 to 12-19-2012	-0.009	0.017	0.098*	-0.031
	(0.837)	(0.6)	(0.097)	(0.468)

Note: This table reports the estimated coefficients from the mean equations. Coefficients $\alpha_{i,j}$ capture the price spillover effects between the US and Brazilian equity markets, where i ≠ j, and the effects of each market's own historical prices, where i = j. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

The results indicate that the S&P 500 exhibits a negative and statistically significant spillover from its own lagged value, as measured by the estimated $\alpha_{1,1}$. There is also a positive and significant lagged mean spillover from the S&P 500 index to the IBOV index as measured by $\alpha_{2,1}$, but only for the subsample from 1 July 2009 to 19 December 2012 at the 10% level. Thus, the return spillover from US to Brazilian markets implies that changes in the returns in the US market signal important information about future price changes in Brazil.

On the other hand, there is no significant return spillover from Brazilian to US markets as measured by $\alpha_{1,2}$[4]. The finding is confirmed by Figure 3, which shows that the time-varying correlation between the two markets is stronger between 2009 and 2012 (.69) relative to that during the early period (.58).

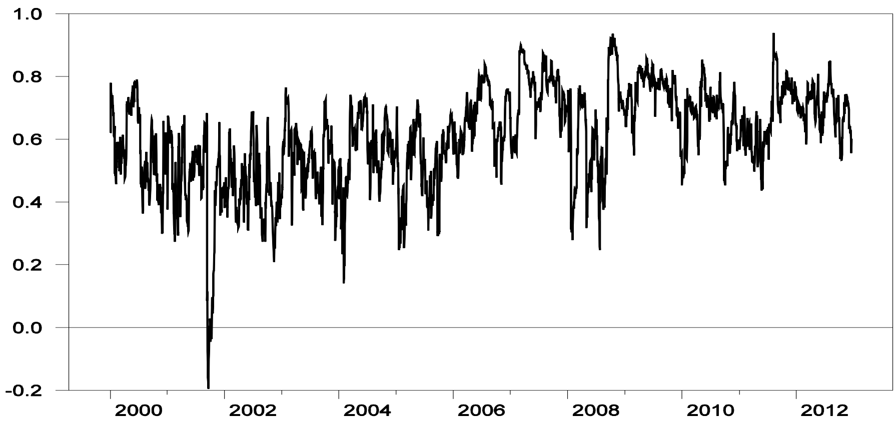

Figure 3 Time-varying Correlation between S&P 500 and BOVESPA Indices

These findings would indicate that, in the short term and prior to 2009, Brazil was likely a reasonable source

[4] The results also indicate that there are insignificant volatility spillovers between the two markets.

of diversification gains for a US based equity portfolio. However, after 2009, these gains are less than clear and investors looking to efficiently diversify may want to look to less correlated markets.

4. Long-term Spillover

Co-integration analysis is conducted to examine the long-term relationship between the US and Brazilian markets. Johansen (1988) introduces a full Maximum Likelihood technique to estimate the long-term equilibrium relationship and short-term linkages simultaneously. Following Johansen and Juselius (1990), in this paper, X_t is co-integrated by order of CI(1,1) with the following VAR representation:

$$X_t = \Pi_1 X_{t-1} + \ldots + \Pi_k X_{t-k} + \Phi D_t + \varepsilon_t \tag{6}$$

Where ε is identically and independently distributed in a p -dimensional process, $IIN_p(0, \Lambda)$, with fixed X; $k$is the number of lags; D_t are centered seasonal dummies that sum to zero over the entire sample period; and $\Pi = \sum_{i=1}^{n} A_i - I_P$ and $\Gamma_i = -\sum_{i=i+1}^{n} A_i$. If all time series in the VAR have a one-unit root that can be removed by taking the first difference, then the VAR can be expressed in the following first-difference form:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_k \Delta X_{t-k+1} + \Pi X_{t-k} + \Phi D_t + \varepsilon_t \tag{7}$$

Where

$$\Gamma_i = -(I - \Pi_1 - \ldots - \Pi_i),\ i = 1,\ldots,\mathrm{k}-1,\ \text{and}\ \Pi = -(I - \Pi_1 - \ldots - \Pi_k)$$

Then, testing the hypothesis of co-integration is equivalent to testing the rank of the long-term impact matrix (Π). More specifically, the number of distinct co-integrating (stationary) vectors is equal to the rank of (Π), or the number of characteristic roots of (Π) that are statistically different from zero. If $0 < rank(\Pi) < P$, then the reduced form of the error correction model is:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_k \Delta X_{t-k+1} + \alpha\beta' X_{t-1} + \mu + \Phi D_t + \varepsilon_t \tag{8}$$

Where β and α are $p \times r$ matrices of the co-integrating parameters and the speed of adjustment parameters, respectively.

Gonzalo and Granger (1995) introduce a methodology extending Johansen's (1988) work to estimate the common long-memory components that drive movements in large systems of cointegrated series. They show that the series (X_t) in an error correction model can be decomposed as follows:

$$X_t = A_1 f_t + A_2 \beta' X_{t-1} \tag{9}$$

Where f_t is a ($k \times 1$) vector of the common integrating factors (i.e., permanent components of X_t), A_1 and A_2 are loading matrices, ($A_2 \beta' X_{t-1}$) are the temporary components of X_t, and $k = p - r$. Next, Gonzalo and Granger (1995) show that the vector f_t can be identified under the following two conditions:

f_t is a linear function of observable variables X_t:

$$f_t = B_1 X_t \tag{10}$$

The temporary components ($A_2 \beta' X_{t-1}$) do not Granger-cause the permanent components ($A_1 f_t$) at low frequencies. Thus, $A_1 f_t$ is the only linear combination of X_t such that the temporary component has no long-run effect on X_t:

$$f_t = \phi X_t = \alpha'_{\perp} X_t \tag{11}$$

In other words, the orthogonality condition ($\alpha'_{\perp}\alpha = 0$) concentrates out the effect of the error correction term on X_t and, therefore, satisfies the second requirement for identification. Thus, equation (4) can be written as:

$$\underset{p\times 1}{X_t} = \underset{p\times k}{A_1}\underset{k\times p}{\alpha'_\perp}\underset{p\times 1}{X_t} + \underset{p\times r}{A_2}\underset{r\times p}{\beta'}\underset{p\times 1}{X_{t-1}} \tag{12}$$

The contribution of each market to price discovery is obtained by normalizing the *statistically significant* common factor weights (ϕ), as follows:

$$w_{it} = \frac{|\phi_{it}|}{\sum_{i=1}^{m}|\phi_{it}|},\ 0 < m \le p, \tag{13}$$

Where m is the number of significant common factor weights, and w_{it} is the fraction of price discovery attributable to the i^{th} market at time t. For example, if ϕ_i is the only significant coefficient in the common integrating factor, then market i contributes 100% to price discovery.

To determine what price discovery relationships exist among the p variables, we utilize a form of the x^2 test statistic (Q_{GG}) introduced by Gonzalo and Granger (1995). This method tests the null hypothesis that the common factor weights are not statistically different from zero. If the coefficients are statistically different from zero for only one market in the common factor, then this market contributes 100% to price discovery. This “leading” or “dominant” market processes news of shocks faster than the other markets; thus, it does not respond to changes in the other markets’ prices. The other markets, however, do respond to deviations in the dominant market’s price, to restore the long-run equilibrium. If the coefficients are statistically significant for more than one market, then the relative magnitudes of their normalized values can still be utilized to determine price leadership.

Panel A of Table 3 reports the results of the trace tests for co-integration, which reveal the presence of a single co-integrating vector at the 5% level only during the third subsample, from 1 July 2009 to 19 December 2012. As shown in Panel B, the null hypothesis — that the common factor weights of the SP500 and IBOV indices are not statistically different from zero — is rejected at the 1% level. Thus, both markets contribute to the price discovery process. Panel B also shows that the S&P 500 contributes 65%, whereas the BOVESPA contributes only 35% to price discovery. Therefore, in the period after the financial crisis of 2008, our findings indicate that the US market is the leading market.

Similar to the short term spillover results, long term results indicate a shift in the relationship between the US and Brazil with respect to price contribution after July of 2009. Prior to this period there lacked a co-integrating vector tying these two markets together. However, subsequent to this period the US market contributed more to price discovery in the Brazilian equity markets indicating that there US markets lead the Brazilian equity market. There are 2 potential important take always from these findings. First, with Brazil markets currently in the spotlight and the a major recipient of FDI in recent years, investors may be inefficiently allocating assets to a market that was likely once a potentially good source of return gains through diversification. However, as more and more investment dollars flow into the Brazilian equity markets, undoubtedly a significant portion of these funds will originate from the US market. These investors may be misinformed and inefficiently allocating assets to this market when in fact Brazilian equity market returns follow that of US return patterns in the long run. Thus, these investors are not only inefficiently diversifying their portfolio but they are also taking on additional risks often associated with investing in a foreign and emerging market. This is likely the very opposite of what these investors are intending to do.

Table 3 Results of Tests for Co-integration and Price Discovery

Panel A: Trace test statistics in different time periods		
Time period	H_2	Trace Test
3 Jan 2000 to 19 Dec 2012	r ≤ 1	1.6943
	r = 0	8.437
3 Jan 2000 to 31 Nov 2007	r ≤ 1	0.07
	r = 0	7.8266
1 Dec 2007 to 31 Jun 2009	r ≤ 1	2.3873
	r = 0	6.5825
1 Jul 2009 to 19 Dec 2012	r ≤ 1	1.0381
	r = 0	15.8492**
Panel B: Information share for S&P 500 and BOVESPA		
Index	Information Share [2009:07:01 - 2012:12:19]	
S&P 500	0.65096***	
BOVESPA	0.34904***	

Note: The trace test in Panel A examines the null hypothesis that the number of distinct co-integrated vectors between the S&P 500 and IBOV indices is ≤ r rather than ≥ r+1. Panel Breports the information share of the SP500 and IBOV indices in the subsample from 1 Jul 2009 to 19 Dec 2012. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

The second likely take away relates to potential hedging strategies. Although there may be little diversification benefit in the long term, the speed of information transmission will tell us something about whether gains can be made by taking advantage of a delayed response in price discovery. For example, it may be possible for very short term investors to make a return by taking advantage of a delayed response in the price discovery process. In this way, long term investors may not benefit but an intraday investor very well may be able to able to capture gains. Some evidence for this notion may be provided by Diamandis (2009) who concluded that the speed of transmission may be delayed between these the US and Brazil. Thus, a short term investor might be able to watch for movements in the US market and exploit the delay in the transmission to the Brazilian market.

5. Conclusions

In this paper we investigate the transmission mechanisms of short- and long-term price spillovers between the US and Brazilian equity markets, using a daily sample that covers the period from January 2000 to December 2012. Structural break analysis indicates allows us to break the sample up into three sub-periods: before, during and after the financial crisis. Structural break analysis indicates that the height of the financial crisis occurred between 2007 and June of 2009. We conduct our analysis over these sub-periods. To test for the short-term effects, we used a bivariate GARCH method. For the long-term relationship in terms of returns, we adopted Gonzalo and Granger's (1995) price discovery model.

We find strong evidence of a positive unidirectional price spillover from the US to the Brazilian equity market, although only for the period after the height of the financial crisis (2009-2012). This result differs from the findings of Sharkasi et al. (2005), who identify a spillover relationship between the United States and Brazil for the period between 1993 and 2003. Similar to the findings of Diamandis (2009) who examines long term spillover using weekly data between 1988 to July 2006 between the US and 4 Latin American, we fail to find a co-integrating relationship between US and Brazil prior to July 2009. We extend the data and note that this relationship can be dynamic and find one co-integrating factor subsequent to July 2009 through the end of our sample in 2012. One potential explanation for this change is that price spillover relationship between these countries often strengthen after a financial crisis/adverse news, consistent with Booth (2005).

Several implications may be derived from our study. First, there may be weaker diversification benefits from the inclusion of Brazilian equities in a domestic (US) portfolio subsequent to July of 2009. Second, there may be the potential for profitable trading strategies that exploit the unidirectional, lead-lag relationship between these two markets given a delayed response to price transmission. The short- and long-term spillovers could attract investors, who may design profitable trading strategies that account for the leading nature of the US market.

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