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Cointegration Analysis of Bovespa and Istanbul Stock Exchanges

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ABSTRACT

This paper investigates the long term financial integration of Bovespa and Istanbul Stock Exchanges. In the research, Engle-Granger (1987) causality and Johansen (1991) cointegration tests are employed to analyze the comovement of mentioned stock markets in the period covering the past ten years. The results of cointegration test present no evidence of pairwise cointegration at the 5% level indicating that there is no linear long-term relationship between the IBX and ISE100 indexes. However, the results of causality test show that IBX index granger cause ISE100 index unidirectional at the 5% significance level, suggesting a short-run lead-lag relationship amongst.

INTRODUCTION

International diversification suggests that low correlations between international stock markets result in lower risk for a given level of return. Accordingly low correlations between developed and emerging markets have attracted the attention of international investors to the emerging market assets. However, recent studies have proven that correlations are time-varying and accordingly investors need a more accurate measure of international stock market interdependence /comovement.

Cointegration measure answers the question of a long-term common stochastic trend between nonstationary time series. If a linear combination of two nonstationary series that is stationary exists, these series are called cointegrated series and the vector of this relationship is called the cointegrating vector. In this respect it provides a long-term measure of diversification opportunities between international financial markets as well as short-term deviations amongst within an error correction model.

Many studies have used the cointegration measure to analyze long-term relations between developed markets, between developed and emerging markets, and on regional basis. Recent studies have focused on integration of Pacific Rim, Asean and European regions, especially with US equity markets and major European equity markets.

This study focuses on the integration of Bovespa and Istanbul stock exchanges. Despite being in different and distance regions of the world, these markets have been showing similar patterns in response to recent global crisis and their relations with the IMF have had considerable effect on their macroeconomic fundamentals as well as their stock market developments. Both countries are classified as emerging markets and have been heavily indebted to IMF, and accordingly have been implementing IMF-backed stabilization programs. The mentioned markets have also similar economic histories. Following the Russian '98 crisis first Brazil in Jan'99 then Turkey in Oct'00 and in Feb'01 experienced liquidity crises. These crises led to major devaluations which resulted in the free float of respective exchange rates. Since then Brazil stock market has been closely followed by traders in Istanbul Stock Exchange and has been considered to contain information on the direction of global liquidity. In this respect, Brazil and Turkish stock markets are observed to be susceptible to developments as well as crisis in each other. Thus the nature of this relationship needs to be analyzed for portfolio diversification opportunities. In this paper the cointegration approach of Johansen (1991) and Engle-Granger (1987) methodology are employed to respectively investigate whether or not these markets possess a common stochastic trend in the long-run and have a lead-lag relationship in the short-run.

LITERATURE REVIEW

Modern portfolio theory builds upon the correlation between financial assets where low correlation results in diversification. In the mean-variance framework correlation is the measure of comovement in returns. Yet correlation is a short-term measure and gives no clue about the long term behavior between financial markets. In fact, risk-return analyses in standard mean-variance approach use return data where long-term trends are lost while price data is differenced.

On the other hand, cointegration, first introduced by Engle and Granger (1987), is a long-term measure of diversification based on price data. If there exist a linear combination of two nonstationary series integrated of order one that is stationary, these series are called cointegrated series. It follows that these two series will not drift apart too much, meaning that even they may deviate from each other in the short-term, they will revert to the long-run equilibrium. This fact makes cointegration a very powerful approach for portfolio diversification purposes especially for the long-term. Meanwhile, cointegration does not imply high correlation; two series can be cointegrated and yet have very low correlations.

Kasa (1992) has pointed out that for investors with long term investment horizons, low correlations could suggest overestimated gains if equity markets shared a common stochastic trend in the long term. Following Kasa, cointegration rather than correlation has been used in the literature to analyze the long-term diversification opportunities between and amongst the developed and emerging equity markets as well as the integration and convergence across regions. Arshanapalli and Doukas (1993) suggest that as a result of financial liberalizations and October 1987 crash, linkage among international markets is strengthened. While Kanas (1998) claims that US and major six European markets are not pairwise cointegrated in the pre- and post- 1987 crash periods as well as in the full period covering 1983-1996, Bessler and Yang (2003) investigate the cointegration among Australia, Japan, Hong Kong, UK, Germany, France, Switzerland, US and Canada and present evidence of one cointegrating vector and suggest that US has a consistent long-run impact on the other markets. Phylaktis and Ravazzolo (2005) employing a multivariate cointegration model, examine the stock market linkages between certain Pacific-Basin countries with US and Japan. It is found that relaxation of foreign ownership restrictions have strengthened the international market interrelations. Serletis and King (1997) provide evidence of cointegration among ten European Union countries and suggest a strengthening link towards convergence. Masih and Masih (2004) examining the effect of 1987 crash on the cointegration of five European stock markets, suggest unique cointegrating vectors before and post the crash eras but not in the entire sample period of 1979 to 1994. In the context of EU Enlargement process there has been a growing attention towards the integration level of Central and Eastern European stock markets with the European Union. Verchenko (2000) studying the potential for portfolio diversification across Eastern European Stock markets, presents evidence of non-cointegration and accordingly significant diversification possibilities amongst. Gilmore and McManus (2002) investigate the short and long-term linkages between the Central European equity markets and US stock market in the period from July 1995 to August 2001. Neither bilateral nor multilateral cointegration is found. However, causality from Hungarian to Polish market is evidenced. Yuce and Simga-Mungan (2000) also present evidence that Eastern European markets are non-cointegrated across each other and with major stock markets including Russia in the period from 09:1994 to 12:1999. The study also reveals non-cointegration between Turkish and Russian stock markets despite the luggage trade between them.

Metin and Muradoglu (2001) investigate the degree of market integration of emerging markets with the major world stock exchanges and with their regional counterparts. It is found that all national markets in the study including Brazil and Turkey are cointegrated with world leaders as well as with their regional counterparts in the period starting from 1988 and extending to 1998. The results also indicate that emerging equity markets are affected from the shocks to world leaders and to their emerging counterparts in the long run. On the other hand, the results of the ECM and VAR models for forecasting show that only Latin American and Far Eastern markets had parameter constancy in the short term horizons, indicating better integration with world markets and among each other. Tuluca and Zwick (2001) study the effects of Asian crisis on Asian and non-Asian equity markets within the Granger (1983) causality framework. Seven-fold increase in bidirectional causality is observed following the crash. While in the pre-crisis period unidirectional causality from US to Brazil and from Brazil to Malaysia, Hong Kong and Singapore were evident, in the post-crisis period bi-directional flows between Brazil and Japan, Korea, Hong-Kong and UK and unidirectional flows from Taiwan to Brazil and from Brazil to Indonesia and Singapore are observed. The study also examines the sub-periods including the Russian crisis in July 1998 and attack on Brazilian real in the fall of 1998. The authors claim that the increase in comovement in the post-crisis period is due to subperiod transitory shocks rather than being the result of a single long one. Meanwhile, Baig and Goldfain (2000) suggest that crisis in Brazil was triggered by the Russian crisis rather than the Long Term Capital Management Crisis. Muradoglu et al. (2000) examining the causality between stock returns and macro economic variables, present that inflation, interest rates and foreign exchange rates granger cause Brazil stock market returns. This finding is attributed to the higher integration level of Brazil with the world markets. Tabak and Lima (2002) study the

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cointegration of Latin American markets with US between 1995:01 and 2001:03 and present evidence of non-cointegration among them while short term causality is observed. Causality flows from Brazilian stock market to other Latin American stock markets. On the other hand, Fernandez-Serrano and Sosvilla-Rivero (2003) studying the same period find bivariate cointegration between Brazilian and S&P500 as well as DJ indices. However, introduction of structural breaks into the model reveal cointegration between Brazil and S&P500 index before Asian crisis. Soydemir (2000) employing a four variable VAR model, find that US and Brazil have weaker linkages compared to other Latin American markets according to the results of impulse response functions. Tabak (2003) test the efficiency of BOVESPA and suggest that it has become more efficient after 1994 due to release of capital controls and increase in capital inflows. Within an ECM bivariate causality is evident between BOVESPA and inflow of foreign capital.

Erdem et al. (2005) show that there exists unidirectional volatility spillover from inflation and interest rate to ISE indexes under EGARCH model in the period from 1991 to 2004. While negative spillover is observed from the inflation, positive spillover is observed from interest rate. Darrat and Benkato (2003) examine the integration of Turkish stock market with US, UK, Japan and German stock markets in the period 1986:01-200:04. The results indicate one cointegrating vector in the multivariate case. Further examination of the full period within subperiods of pre-liberalization and post-liberalization reveals that Turkish stock market have become integrated after stock market liberalization. The post-liberalization period includes the Asian-Russian crises and volatility clustering behviour examined with GARCH processes indicate that ISE has become more volatile in this period. Finally, Granger causality tests identify US and UK as the main sources of volatility spillovers to ISE. Maneschiold (2005) investigate the short and long term diversification opportunities between US, Turkey and Egypt within the cointegration approach of Johansen. The investigation is performed at the general index level as well as at the three sub-indexes namely services, financial and manufacturing sector indexes. The results indicate that these markets are cointegrated at the general index level mainly due to industry sub-index. Granger tests however show a casual flow from US general and sub-indexes to Turkish indexes, suggesting long-term diversification benefits rather than short-term investment horizons. For the Egyptian market, short and long term diversification opportunities are found at the sub-index levels. Finally, Drakos and Kutan (2001) present evidence on the cointegration of Greek and Turkish stock markets but not contagion in the period of 1988-2000. In fact, Greek stock market Granger causes Turkish stock market. On the other hand, both cointegration and contagion exist between TL and Drachma markets.

METHODOLOGY

The precondition for application of cointegration tests is that series should be integrated of the same order. Accordingly, unit root tests of Augmented Dickey-Fuller (1981) and Phillips-Perron (1988) are employed to test the stochastic properties of time series. Unit root tests are first applied to levels and then to first differences of series.

If non-stationary series *x* and *y* are both integrated of same order and there is a linear combination of them that is stationary, they are called cointegrated series. Accordingly, cointegrated series share a common stochastic trend. Two basic methodologies are evident for testing cointegration; Engle-Granger and Johansen methodologies. Engle-Granger (1987) building upon the representation theorem of Granger (1983) introduce a two-step procedure where first an OLS regression is estimated on the integrated (1) data and then residuals of the regression are checked for stationarity. Granger (1983) representation theorem suggests that in a bivariate system of I(1) series *x* and *y,* if lagged *x* improves the estimation of y , then *x is said to Granger cause y.* The Engle-Granger (1987) test for causality is

$$\begin{aligned} x_t &= \alpha_0 + \sum \alpha_i x_{t-i} + \sum \beta_j y_{t-j} + \varepsilon_t \\ y_t &= a_0 + \sum a_i y_{t-i} + \sum b_j y_{t-j} + u_t \end{aligned} \qquad (1)$$

Granger causality suggests a lead-lag relationship between time series and there may be granger causality between asset prices without the presence of a cointegrating vector. However, cointegration implies a granger casual flow between the integrated assets.

On the other hand as mentioned by Alexander (2001) it is only valid to regress log asset prices on log prices when these prices are cointegrated, then the regression will define the long-run equilibrium amongst. Yet Engle-Granger (1987) methodology, based on OLS regression, is most suitable for bivariate settings where the choice of the dependent variable is not a question and it can identify only one cointegration vector while there can be more in multivariate analyses. The Johansen (1991) methodology is a maximum likelihood approach for testing cointegration in multivariate autoregressive models. Its objective is to find the linear combination which is most stationary, relying on the relationship between the rank of a matrix and its eigenvalues. In an unrestricted VAR (k) model letting X_t as a vector of I(1) variables, X_t can be modeled by

$$X_t = A_1 X_{t-1} + \ldots + A_k X_{t-k} + \varepsilon_t \qquad (2)$$

Rewriting in VECM form

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + u_t$$

where

$$\Pi = \sum_{i=1}^{k} A_i - I \qquad (3)$$

$$\Gamma_i = -\sum_{j=i+1}^{k} A_j$$

Granger's representation theorem states that if the coefficient matrix Π has reduced rank $r < m$, there exist $(m \times r)$ matrices α and β each with rank *r* such that $\Pi = \alpha\beta'$ and $\beta' X_t$ is stationary. Then *r* gives the number of cointegrating relations, β gives the cointegrating vectors and α gives the parameters in the model. The rank of Π will be full rank if all the variables in X_t are stationary, will equal zero if there are no linear combinations of I(1) variables that is stationary and will equal to *r* if series are cointegrated. The Johansen (1991) methodology provides two statistics to determine the number of cointegrating vectors. Johansen and Juselius (1990) advise "Trace" statistic which tests the null hypothesis of *r* cointegrating relations against the alternative of *n* cointegrating relations, where *n* is the number of variables in the system for *r* = 0,1,2…*n*-1.

$$\lambda_{tr}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \lambda_i) \qquad (4)$$

where *T* is the sample size and λ are the estimates of the eigenvalues of Π. The second statistic provided by the Johansen methodology is called "Maximum Eigenvalue" which tests the null hypothesis of *r* cointegrating relations against the alternative of *r+1* cointegrating relations.

$$\lambda_{\max}(r, r+1) = -T \log(1 - \lambda_{r+1}) \qquad (5)$$

for *r* = 0,1,2…*n*-1.

It follows that when eigenvalues are all zero, rank of the matrix will be zero implying non-cointegration. In some cases Trace and Maximum Eigenvalue statistics may yield different results and Alexander (2001) indicates that results of trace test should be preferred. The critical values are presented by Johansen and Julieus (1990) and Osterwald-Lenum (1992).

DATA

The data of the study includes weekly closing stock price series of IBX and ISE100 indexes of respectively Brazil and Istanbul stock exchanges. Both indexes are value indexes including most liquid top 100 shares of each country. The investigation period starts from 29/12/1995 and extends to 26/08/2005, covering the recent ten years data. The stock price indexes are denominated in local currencies following Voronkova (2003) and converted to natural logarithms. The objective in using local currencies is to obtain co-integration results just based on movements on asset prices by eliminating the effect of exchange rate changes especially if exchange rate is highly volatile. Considering the countries under examination, they have been through various devaluations which could have distorted the findings. Furthermore, Alexander (2001) stresses the importance of making cointegration analysis in local currencies for detecting asset price co-movements. The descriptive statistics provided in table 1 are calculated with first-differenced series which give continuous rates of return.

Table- 1: Full period descriptives

	IBX	ISE100
Mean	0.004	0.009
Median	0.007	0.009
Maximum	0.196	0.258
Minimum	-0.260	-0.304
Std. Dev.	0.044	0.066
Skewness	-0.820	-0.176
Kurtosis	7.620	5.446
Excess Kurtosis	4.620	2.446
Jarque-Bera	504.759	128.206
Probability	0.000	0.000

Examination of the descriptives table reveal that both indexes had positive yet volatile returns during the investigation period. Considering the fact that this period includes the recent global crises of Latin America, Asia, Russia as well as local crises of 01:1999 Brazil and 10:200 and 02:2001 of Turkey, this is an expected outcome. Both countries were heavily affected especially from the Russian crisis. Since Turkey and Russia have had close economic linkages due to being in the same region this contagion effect can be explained but for the Brazil market it has been an interesting outcome. The negative skewness and excess kurtosis indicate non-normality in the series which is confirmed by the significant probability values of Jarque-Bera test statistic.

On the other hand, the correlation analyses given in Table 2 show that series' correlation has been quite low (0.34) over the full period. Further analyses of most recent crises periods give some insight on the interaction of respective stock markets. Considering the crisis periods as 3 month windows including the one month before and after the peak of each crisis, the following table is obtained. However, the consecutive crises of Turkey in 11:2000 and 02:2001 are also considered as a single crisis period for which also correlation analysis is made. The findings indicate that the correlation between IBX and ISE100 reach at its peak (0.58) during the Turkish crisis of 2000, followed by the Russian crisis (0.48). In the overall period of Turkish crisis, the correlation reaches 0.45 while during Brazilian crisis it falls below the full period average.

Table- 2: Correlation Analysis of IBX and ISE100

Full period correlations	0.35
Russian Crisis Period Correlations (3 month)	0.48
Brazilian Crisis Period Correlations (3 month)	0.34
Turkish Crisis Period Correlations (6 month period)	0.45
Turkish 2000 Crisis Period Correlations (3 month)	0.58
Turkish 2001 Crisis Period Correlations (3 month)	0.22

While correlations reveal an increase during crisis periods, it does not necessarily mean that these markets are cointegrated. The long-run relationship between the respective stock markets need to be examined to arrive at a conclusion that these markets share a long-run equilibrium from which short-term deviations can be forecasted. Presence of such a relationship would imply that short-term deviations would revert to the long run equilibrium and series will not drift away from each other.

Table 3 presents the results of unit root analyses. The pre-condition of series being integrated of same order is verified with the ADF (1981) and PP (1988) tests. The tests are applied to levels and first differences where the model includes a constant and a trend. The appropriate lag lengths are chosen according to AIC- Akaike Information Criterion and the critical values are obtained from MacKinnon (1996). For all series presence of a unit root cannot be rejected in levels, while no unit root is found in first differenced series at the 5% level, indicating that all series are integrated of order one.

Table- 3: Unit Root Tests

	ADF		PP	
	levels	**first differences**	**levels**	**first differences**
IBX	-2.581	-14.290	-2.473	-22.399
ISE100	-2.370	-14.059	-2.437	-21.447

*MacKinnon (1996) one-sided p-values.

EMPIRICAL FINDINGS

Proven that all series are integrated of order one, the analysis proceeded with the bivariate cointegration analysis of Johansen (1991). Analyses are made under the model with a constant and linear trend in the cointegration vector and the optimal lags are chosen to minimize AIC and set at 2 in first differences while it is also found that results are robust to alternative lags. Table 4 presents the Johansen (1991) cointegration analysis. The Trace test result 7.81 is found to be less than the 5% critical value of 15.41 and accordingly the null hypothesis that IBX and ISE100 indexes are not pairwise cointegrated (r=0) is accepted. This finding is also supported with the Maximum Eigenvalue test result 7.00 which is also smaller than the respective 5% critical value of 14.07. Both test results suggest that these stock markets still do not have a long-run equilibrium. It means that they do not share a common stochastic trend despite the increased correlation in periods of high volatility, thus it is beneficial for an international investor to make portfolio investment in these markets' assets for diversification purposes.

Table- 4: Bivariate Cointegration of IBX and ISE100

Hypothesis		5% critical values	1% critical values	
H_0	H_A	Trace test		**IBX-ISE100**
$r = 0$	$r \geq 1$	15.41	20.04	7.813338
$r \leq 1$	$r \geq 2$	3.76	6.65	0.805964
		Maximum Eigenvalue		
$r = 0$	$r = 1$	14.07	18.63	7.007375
$r \leq 1$	$r = 2$	3.76	6.65	0.805964

As cointegration theory suggests absence of a cointegration relation means that these markets do not share long-run equilibrium from which short-term deviations can be forecasted and to which series will converge in the long term. However these results do not imply any conclusion with the short-term lead-lag relationships. While the findings suggest no cointegration, Alexander(2001) points out that cointegration is not a pre-condition for lead-lag relationship to exist, that other common features between time series could result in causality. In this respect, following Gilmore and Mcmanus (2002) Engle-Granger (1987) causality tests is employed to the first differences of the series to verify if there has been a causality running from one market to another in the short-run.

Table- 5: Pairwise Granger Causality Tests

Null Hypothesis:	F-Statistic	Probability
ISE100 does not Granger Cause IBX	0.70457	0.40165
IBX does not Granger Cause ISE100	6.32795	0.0122

The optimal lag length is again set according to Akaike information criterion. Table 5 provides the results of pairwise analysis. Significant probability value of 0.012 denote rejection of the null hypothesis that IBX does not Granger cause ISE100 while the null hypothesis that ISE100 does not Granger cause IBX is accepted. It is found that there is unidirectional flow from IBX to ISE100 at the 5% significance level. It means that ISE100 index follow IBX in the short-run that there exists a lead-lag relationship between them.

CONCLUSION

This study focuses on the integration of Bovespa and Istanbul stock exchanges and sheds light on the diversification opportunities they provide in the long-term. These markets' economies have been sharing similar economic fundamental problems like high inflation and high interest rates for the past decade. Analyzing the recent global crises, it is also noteworthy that they displayed similar responses especially to Russian crisis. After it both of the markets went through serious devaluations accompanied by stock market crashes. Since then Brazil and Turkey have been implementing IMF-backed stabilization programs and it is observed in weekly correlations that during crises periods, Bovespa and ISE have higher correlations. This fact could be a result of convergence of economies in response to IMF programs and policies that are quite parallel in each respective market. Therefore, a closer examination is required to investigate if these markets in fact share a long-term stochastic trend.

The modern portfolio theory says that low correlations between assets result in diversification of portfolio risk. However, recent studies of Erb et al. (1994) prove that correlation is a time-varying short-term measure and portfolios built accordingly may underestimate long term gains and require frequent rebalancing. In fact, risk-return analyses in standard mean-variance approach use return data where long-term trends are lost while price data is differenced. Accordingly, cointegration which is a long term measure of asset price co-movements, is a more reliable approach to portfolio investment decisions. It establishes a long-run equilibrium between asset prices and then short run deviations are estimated, thereby providing dynamic short- and long-run relationships. The analyses start with unit root tests to check that all series are integrated of order one and this precondition is verified at the 5% confidence level. First the Johansen (1991) cointegration test is employed to weekly stock price indexes of IBX and ISE100 on bivarite settings. The cointegration analyses reveal that series are not pairwise cointegrated. On the other hand, Engle-Granger (1987) causality tests reveal a casual flow from IBX index to ISE100 index, suggesting a short-run one-way lead-lag relationship amongst. This is an interesting finding because analyses of local crises periods in respective markets have shown that during Brazil'99 crisis correlation between IBX and ISE100 have decreased below the long-term average while in Turkish'00 crisis it has reached its peak. Yet, causality is observed from IBX to ISE100 not the other way. Before arriving further conclusions it is important to note that causality analysis is made for the full period while correlation analyses focus on the 3 month crisis periods. Albeit the finding confirms that high correlations does not imply cointegration, and also shows that while proposing long-term diversification opportunities within cointegration framework, crises periods need to be examined in detail for portfolio diversification decisions.

Absence of cointegration does not exclude the negative effect of a possible local crisis within these markets on the portfolio diversification opportunities because stock prices are still dominated by country specific factors as they are still characterized as emerging markets. Insufficient market depth, high country risk and contagion continue to be the major sources of risk for portfolio investment decisions in respective stock markets in the short-run.

This research basically provides evidence that Brazilian and Turkish stock markets are not cointegrated within 12:1995 – 08:2005 period covering the past ten years. However portfolio investment decisions should be made combining the implications of cointegration and causality tests with the mentioned risks that still prevail in these emerging markets.

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