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The Effect of Financial Liberalization On Cross-Autocorrelation in the Brazilian Equity Market

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This study examines the effect of financial liberalization on cross-autocorrelation in the Brazilian equity market. The sample consists of daily data from January 1986 through December 1999. Prior studies have found conflicting evidence of cross-autocorrelation in U.S. data. Differences in size-based portfolios are tested through correlation, cross-autocorrelation, Granger-causality, asymmetric responses, and trading volume. The results confirm that large stock portfolio returns lead small stock portfolio returns, but the lagged response of small stock portfolio returns diminish following financial liberalization.

INTRODUCTION

In an efficient market stock prices should rapidly incorporate new information as it becomes available. Prior research indicates that market efficiency varies between countries. Agrawal and Tandon (1994) examine market efficiency across 18 countries, Urrutia (1995) tests for random walks in Latin America, and Butler and Malaikah (1992) find inefficiency in thinly traded stock markets.

Studies also indicate that stock efficiency varies within markets. Lo and MacKinlay (1990) demonstrate that the returns of small capitalization stocks are correlated with the lagged returns of large capitalization stocks using weekly data. They conclude that large capitalization stocks react faster than small firm stocks to information that has market-wide implications. Conrad et al. (1991) find that the volatility of weekly small stock returns is affected by the returns of large firms. Both of these studies concur that nonsynchronous trading cannot account for their results, and that “aggregate” market information effects large firms before small firms. Boudoukh et al. (1994) extend Lo and MacKinlay’s (1990) work and conclude that nonsynchronous trading or other market microstructure imperfections cause the

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small firm stock price delay. However, Mech (1993) finds that even "synchronized" portfolios exhibit a significant cross-autocorrelation effect.

Badrinath et al. (1995) find that stock returns from firms with a greater institutional following lead firms with low institutional ownership. They believe that there is a greater amount of information available regarding firms that have a high institutional following. Two studies extend the methodology of Conrad et al. (1991). Kroner and Ng (1998) find that the volatility spillover from large to small firm stocks is due only to negative information shocks. McQueen et al. (1996) find significant directional asymmetry, showing that large stocks lead small stocks after good news, but not bad news. McQueen et al. (1996) also demonstrate that cross-autocorrelation exists after correcting for time-varying risk premium. Ibbotson et al. (1997) confirm significant cross-autocorrelation in monthly data.

Fargher and Weigand (1998) find significant cross-autocorrelation in daily data, sorting firms by both market capitalization and trading volume. The authors further conclude that regulatory and technological improvements in the capital markets have increased the speed at which small firms absorb new information. Chordia and Swaminathan (2000) also sort portfolios of daily and weekly stock return data by trading volume. They conclude that returns of stocks with high trading volume lead firms with low trading volume because high volume stocks react faster to market-wide information.

The international evidence regarding cross-autocorrelation is relatively limited in the mainstream literature. Chang et al. (1999) evaluate six Asian stock markets using monthly data. The authors find that significant cross-autocorrelation exists *within*, but not *between* the Asian countries studied.

Extending the efficient markets hypothesis, emerging stock markets should become more efficient as a larger pool of investors with greater access to financial information is available to trade equities, i.e., financial liberalization. The opening of financial markets effects equity returns positively without increasing volatility, reducing financial market segmentation (Bekaert and Harvey, 1997; Bekaert, 1995). Market opening can be achieved through both economic and financial reforms. Trade liberalization is among the usual market opening economic reforms that has a positive impact on market valuations (Henry, 2000).

Local factors still seem to dominate the pricing of emerging market securities. Harvey (1995) examines several international risk factors to predict returns in emerging markets including the world equity market return, foreign exchange, the price of oil, world industrial production, and world inflation. His results indicate that very few emerging markets have any significant exposure to these risk factors and seem to be more influenced by local rather than international risk factors. Aggarwal et al. (1999) and Bekaert and Harvey (1997) also present evidence that local shocks are the predominant drivers of emerging market volatility rather than worldwide shocks.

Findings such as these are based on time series of emerging market prices initiated in the late 1970s and early 1980s. Studies that look at emerging equity market prices before and after financial liberalization find evidence of greater market integration (Bekaert and Harvey, 2000, 1997; Bekaert,1995). There is no consensus in the literature regarding the impact of financial liberalization on market efficiency. Kawakatsu and Morey (1999a), using a sample of 16 emerging markets, find no evidence of greater information efficiency following financial liberalization. Kim and Singal (2000), however, conclude that their sample of 11 emerging markets is more efficient after financial liberalization.

The purpose of this study is to complement and extend the prior literature by examining the correlation structure of the Brazilian equity market before and after financial liberalization. Specifically, daily individual stock data is used to test the correlation, cross-autocorrelation, Granger-causality, directional asymmetry, and trading volume between size-based portfolios. The results demonstrate that large firm stock returns lead small firm stock returns in Brazil. A delay in stock price reaction of small firms suggests varying levels of efficiency or independence within the Brazilian stock market. However, the price response of small firms improves after financial liberalization. The remainder of this study is organized as follows: Section II contains a description of the data; the methodology and results are in Section III; Section IV concludes.

DATA

The sample consists of daily stock returns from the Brazilian equity market from January 1986 through December 1999. The beginning date of the data is based on the limited availability of individual firm stock returns provided by *Economatica*. The following procedure is used to form the dataset: individual stocks available in the database are rank ordered by market capitalization. Selected firms are then sorted into two portfolios representing the largest and smallest 10% of stocks traded.

Biases due to nonsynchronous trading arise when small stocks do not trade as frequently as large stocks. The potential bias due to nonsynchronous trading is handled in the following two ways. First, the dataset is filtered to include only firms that trade consistently throughout the sample period. Firms that do not trade consistently are removed from the sample entirely and are replaced by a similar sized firm that does trade consistently. Second, as high frequency (daily) data is utilized, it is far less likely that critical trading data is missed as is possible with weekly or monthly returns.

To account for the high level of inflation observed in Brazil, and to maintain consistency with the emerging markets literature, the data is stated as U.S. dollar excess returns by: *natural log* $(p_t/p_{t-1})-r_f$ where p_t are the individual Brazilian equity prices converted into U.S. dollars, and r_f is the risk-free rate of return. All prices are adjusted to reflect dividends, stock splits, and special events.

Table 1 reports descriptive statistics for the market and size ranked portfolios.

Brazil contains 465 firms with a market capitalization of $208 billion. The daily mean return of the small stock portfolio is 0.499%, while the large stock portfolio is 0.564%. The daily standard deviations of the small and large portfolios are 2.20% and 2.47%, respectively. Augmented Dickey-Fuller tests confirm the stationarity of all portfolio returns (results not reported here).

Table 1 - Descriptive statistics for Brazilian equities. SMRET and LGRET represent portfolios of small firms and large firms in U.S. dollar excess returns, respectively.[1]

SMRET mean (%)	*SMRET* stdev (%)	*LGRET* mean (%)	*LGRET* stdev (%)	Market Cap. (USbil.)	Total # of Firms
.499	2.200	.564	2.470	208	465

[1]Market data provided by the Bovespa Stock Exchange.

To analyze the effect of financial liberalization on stock returns, it is necessary to identify the date of the market opening. Prior studies employ a variety of empirical and non-empirical methods to assess the opening dates of emerging stock markets. Non-empirical methods include a legal announcement date of market opening, the date investors could first purchase equities, the establishment of country funds, etc. Depending on the study, the actual opening date tends to vary, depending on the method selected. Realistically, markets open gradually, not necessarily on one specific date.

Henry (2000), and Kim and Singal (2000) utilize empirical methodologies to determine market openings, but also consider the earlier findings of Bekaert (1995) and Buckberg (1995). Kawakatsu and Morey (1999b) utilize tests by Bai (1996), and Bai and Perron (1998) to identify the endogenous structural breaks compared with official opening dates. In this study, two break dates are tested based on a survey of the literature. The first date selected is January 1991, as suggested by Kawakatsu and Morey (1999b). The second date is May 1991, proposed by Kim and Singal (2000), and Bekaert and Harvey (1997) as the market opening. Given the closeness of these dates, the empirical results are nearly identical. The reported findings are based on January 1, 1991, selected arbitrarily between the two dates.

Table 2 contains the first five daily lags of small stock portfolio autocorrelations, and cross-autocorrelations between small stock and lagged large stock portfolio returns.
Small stock portfolio autocorrelation varies from .28 at lag_{t-1} to .09 at lag_{t-5}. McQueen et al. (1996) state that if small stock portfolios react slowly to macroeconomic news, then small stocks will be both autocorrelated and cross-autocorrelated with large stock portfolios. The first daily lag of the large stock portfolio confirms this with a full sample cross-autocorrelation of .28. The cross-autocorrelation between the small stock portfolio and the one-day lagged large stock portfolio returns are .34 before financial liberalization, and .21 afterwards.

Table 2 - Correlations of Brazilian small firm portfolio returns with lagged small and large firm portfolio returns. (First 5 daily lags reported)

Daily lags	Autocorrelation ($SMRET_t$, $SMRET_{t-1...5}$)	Cross-Autocorrelation ($SMRET_t$, $LGRET_{t-1...5}$)		
	1986-1999	**1986-1999**	**1986-1990**	**1991-1999**
Lag_{t-1}	.28	.28	.34	.21
Lag_{t-2}	.12	.12	.11	.12
Lag_{t-3}	.08	.07	.04	.10
Lag_{t-4}	.08	.08	.06	.11

Lag_{t-5}	.09	.10	.10	.10

METHODOLOGY AND RESULTS

Cross-Autocorrelation

Lo and MacKinlay (1990) find positive cross-autocorrelation between small and large stock returns. Their model is duplicated using generalized least squares (GLS) as:

$$SMRET_t = \alpha + \beta_1 LGRET_t + \beta_2 LGRET_{t-1} + \varepsilon_t \qquad (1)$$

where *SMRET* represents the returns of a portfolio of small stocks in time period *t*, and *LGRET* are the large stock portfolio returns. The returns from the small stock portfolio are regressed on the contemporaneous large stock portfolio returns and the lagged large stock portfolio returns.

The results in Table 3 indicate that small stock returns are significantly related to both current and lagged large stock returns. The contemporaneous β_1 coefficient is significant at the 1% level for the full sample and subsamples. A significant β_2 suggests that lagged large firm returns are statistically related to current small firm returns. The β_2 coefficients are also significant at the 1% level for the full sample and subsamples. The R-squares range from .57 to .64, which demonstrates a strong influence of large stock returns on small stock returns. The results indicate that small stock portfolio returns react more slowly than large stock portfolio returns to common information.

These findings are consistent with those of Lo and MacKinlay (1990), and lend further support to the global nature of cross-autocorrelation and inefficiency of small company stocks. However, there is a noticeable reduction in the magnitude of the lagged large stock return coefficients between the 1986-1990 subsample (.11) and the 1991-1999 subsample (.04). The Chow breakpoint test indicates significant structural change at the 1% level in the model following financial liberalization with an F-statistic of 41.38.

Table 3 - Test of basic cross-autocorrelation in Brazilian equities. Small stock returns regressed on contemporaneous large stock returns and one day lagged large stock returns.[1,2] *, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.**

$$SMRET_t = \alpha + \beta_1 LGRET_t + \beta_2 LGRET_{t-1} + \varepsilon_{,t}$$

	1986-1999	1986-1990	1991-1999
Constant	.00	.00	.00
β_1 **$LGRET_t$**	.67***	.76***	.57***
β_2 **$LGRET_{t-1}$**	.07***	.11***	.04***
Adjusted R^2	.60	.64	.57
Chow Test	NA	41.38***	

[1]Model initially specified by Lo and MacKinlay (1990)
[2]Chow test is a breakpoint test for structural change between the two subsamples.

Granger-Causality

Boudoukh et al. (1994) assert that cross-autocorrelation is actually induced by small stock autocorrelation and contemporaneous correlation with large stock returns. They argue that the term "cross-autocorrelation" is a misnomer and that most of the predictability is the result of market microstructure biases. Thus, following Richardson and Peterson (1999), we employ Granger causality tests to determine if large stock returns lead small stock returns while controlling for the autocorrelation in the small stock portfolios.

Granger (1969) states that an independent variable *X* Granger-causes changes in dependent variable *Y*, if *Y* can be better forecasted with past values of *X* and *Y*, than just past *Y* values alone. Thus, causality in the Granger sense does not imply a cause and effect relationship, but one of predictability. Unidirectional causality tests are applied empirically using GLS as:

$$SMRET_t = \alpha + \sum_{j=1}^{J} \beta_j SMRET_{t-j} + \sum_{k=1}^{K} \gamma_k LGRET_{t-k} + \varepsilon_t \qquad (2)$$

where *J* and *K* are the lags of the small stock portfolio returns (*SMRET*) and the large stock portfolio returns (*LGRET*), respectively. The optimal lag length structure is determined by Akaike's (1973) criterion.

If large stocks lead small stocks, then the γ coefficients will be positive and significantly different than zero. The returns of a portfolio of large stocks is said to Granger-cause changes in small stock returns if the lagged coefficients of *LGRET,* as a group, are significantly different than zero. The results of the Granger-causality tests are provided in Table 4. Evidence of significant cross-autocorrelation is observed in the full sample, 1986-1999. The Granger F-statistic (21.79) rejects the null hypothesis that the lagged *LGRET* coefficients ($\gamma_{i,k}$) are jointly equivalent to zero and is significant at the 1% level. This finding is consistent with the Lo and MacKinlay (1990) model presented in Table 3, where significant cross-autocorrelation is observed in the full sample.

However, the subsample results demonstrate that significant cross-autocorrelation is present only before the financial liberalization break point, January 1991. The one-day lag of the *LGRET* coefficient (.26) in the first subsample is significant at the 1% level. The one-day lag of the *LGRET* coefficient (.06) in the second subsample is significant at the 10% level. Moreover, the Granger F-statistic (24.25) is significant at the 1% level before the breakpoint, and insignificant (4.08) after the breakpoint. The Chow test statistic (13.42) indicates a structural change in the Granger model before and after financial liberalization at the 1% level of significance. The significance levels of the lagged *LGRET* coefficients are also indicative of the relative strength of cross-autocorrelation over time. Significant cross-autocorrelation is only observed with a one-day lag, regardless of the sample period. Significant *LGRET* coefficients over a longer period of time would imply a greater degree of inefficiency with regards to common information flow. (Badrinath et al., 1995 find that large firm returns may lead small firm returns by as much as two months).

Table 4 - Coefficient estimates from Granger-causality tests. Brazilian large firm returns lead small firm returns.[1,2] ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

$$SMRET_t = \alpha + \sum_{j=1}^{J} \beta_j SMRET_{t-j} + \sum_{k=1}^{K} \gamma_k LGRET_{t-k} + \varepsilon_t$$

	1986-1999	1986-1990	1991-1999
Constant	.00	.00	.00
$SMRET_{t-1}$	.14***	.10	.15***
$SMRET_{t-2}$	.02	-.01	.09***
$SMRET_{t-3}$	.02	.03	.03
$LGRET_{t-1}$	.14***	.26***	.06*

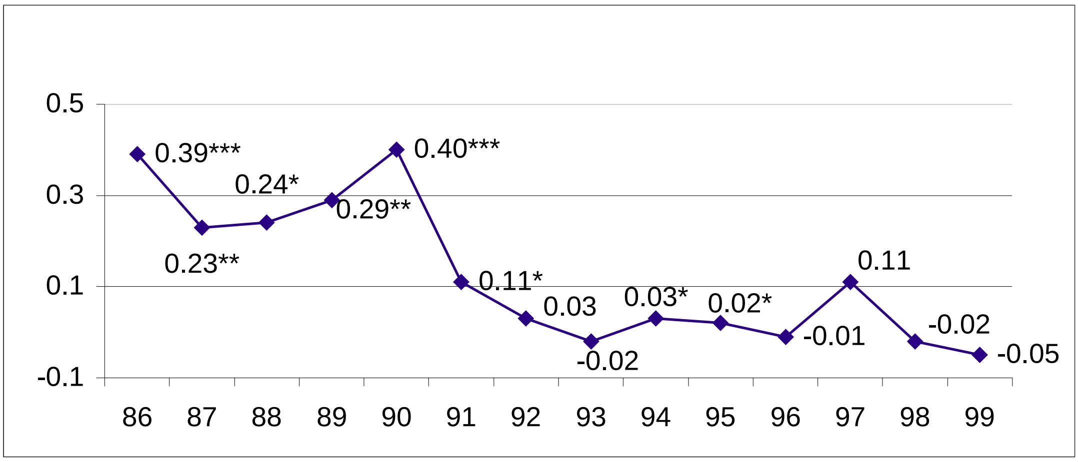
$LGRET_{t-2}$	.00	.00	-.01
$LGRET_{t-3}$	.01	-.02	.02
F-Statistic	21.79***	24.25***	4.08
Adjusted R^2	.09	.12	.07
Chow Test	NA	13.42***	

[1]Chow test is a breakpoint test for structural change between the two subsamples.
[2]F-Statistic tests the null hypothesis that the lagged large stock returns are jointly significantly different than zero.

To examine the time-varying nature of cross-autocorrelation, the Granger model is re-estimated on a year-by-year basis from 1986-1999. The first daily lag of the large stock portfolio($LGRET_{t-1}$) coefficients from equation (2) are plotted in Figure 1. The figure depicts coefficients with relatively larger magnitude and higher significance levels prior to financial liberalization (1991). Before 1991 the *LGRET* coefficients are in the range of .23 to .40, with significance at mostly the 1% or 5% level. The coefficient in 1991 drops off to .11 in 1991, significant at the 10% level. The majority of the annual coefficients after 1991 are close to zero and are mostly insignificant.

Figure 1 - Time-varying one-day lagged large stock portfolio regression coefficients ($LGRET_{t-1}$) from year-by-year Granger-causality tests. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

$$SMRET_t = \alpha + \sum_{j=1}^{J} \beta_j SMRET_{t-j} + \sum_{k=1}^{K} \gamma_k LGRET_{t-k} + \varepsilon_t$$



Asymmetric Response

One shortcoming of the prior tests is that the estimated coefficients do not depend on the sign of the coefficients, i.e., changes in large stock returns are assumed to have symmetrical effects on small stock returns. There is some controversy in the literature regarding the asymmetric response of the cross-autocorrelations. Boudoukh et al.(1994), Mech (1993), and Chan (1993) argue that small stock returns will respond to both good and bad news. Grinblatt et al. (1995), Keim and Madhavan (1995), and McQueen et al. (1996) find a significant response to good news, but not bad news. Chang et al. (1999) confirm a response to good news in the U.S., and to either good news *or* bad news in Asia.

In order to detect asymmetrical relationships, define two series (*LGRETPOS* and *LGRETNEG)* that contain only positive and negative returns, respectively:

$$LGRETPOS = \begin{Bmatrix} LGRETPOS....if\,(LGRET > 0) \\ 0................if\,(LGRET \le 0) \end{Bmatrix}$$
$$LGRETNEG = \begin{Bmatrix} LGRETNEG....if\,(LGRET < 0) \\ 0................if\,(LGRET \ge 0) \end{Bmatrix}$$

Tests for directional asymmetry are conducted by regressing the current small stock returns on the one-day lagged small stock returns, and the one-day lagged positive and negative large stock returns:

$$SMRET_t = \alpha_t + \beta_{t-1} SMRET_{t-1} + \gamma_{t-1} LGRETPOS_{t-1} + \delta_{t-1} LGRETNEG_{t-1} + \varepsilon_t \qquad (3)$$

The variable $SMRET_{t-1}$ is included to control for the small stock autocorrelation.

Coefficients for the one-day lagged *SMRET, LGRETPOS, LGRETNEG*, and equality tests are provided in Table 5. It is clear from the table that the asymmetric response is dependent on the time period selected. Significant asymmetrical cross-autocorrelation following only positive changes in large stock returns is indicated in the full sample, 1986-1999. This is evident as the *LGRETPOS* coefficient (.20) is positive and significant at the 1% level, while the *LGRETNEG* coefficient (.05) is insignificant. The last row of Table 5 contains the results of an F-test for equality of *LGRETPOS* and *LGRETNEG* coefficients. The significant F-statistic (14.13) for the full sample implies that the *LGRETPOS* and *LGRETNEG* coefficients are not equivalent and that asymmetrical cross-autocorrelation may exist.

The small stock returns in the first subsample respond to both positive and negative changes in the lagged large stock returns. This is evidenced as the *LGRETPOS* (.26) and *LGRETNEG* (.27) coefficients are both significant at the 1% level. The positive *LGRETPOS* coefficients indicate that small stock returns react positively to positive changes in large stock returns. The positive *LGRETNEG* coefficients indicate that small stock returns react negatively to negative changes in large stock returns. The F-statistic confirms no significant difference between the positive and negative variables, which supports the notion of symmetrical cross-autocorrelation responses in small stock returns prior to financial liberalization.

The results for the second subsample indicate asymmetry, with significant *LGRETPOS* (.16) and *LGRETNEG* (-.09) coefficients at the 10% level. The negative sign in the *LGRETNEG* coefficient implies that small stock returns react positively to negative changes in large stock returns. The positive reaction to negative changes in large stock returns is puzzling, but not particularly robust at the 10% level of significance. The F-statistic (9.82) indicates that the *LGRETPOS* and *LGRETNEG* coefficients are significantly different from each other. The results in this section help clear up some of the controversy in the literature; that is, universal symmetry or asymmetry is not a given. The response of small stocks to large stock movements is more likely dependent on the particular market microstructures of the individual country.

Table 5 - Asymmetric response of Brazilian small stock portfolio regressed on positive and negative changes in the lagged large stock portfolio.[1] ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

$$SMRET_t = \alpha_t + \beta_{t-1} SMRET_{t-1} + \gamma_{t-1} LGRETPOS_{t-1} + \delta_{t-1} LGRETNEG_{t-1} + \varepsilon_t$$

	1986-1999	1986-1990	1991-1999
Constant	.00	.00	.00
$SMRET_{t-1}$	.16***	.10**	.17*
$LGRETPOS_{t-1}$	.20***	.26***	.16*
$LGRETNEG_{t-1}$	.05	.27***	-.09*
F-statistic	14.13***	.05	9.82***

(POS=NEG)			

[1]The F-statistic tests the hypothesis that the *LGRETPOS* coefficients are equivalent to the *LGRETNEG* coefficients.

Trading Volume

The finance literature establishes that trading volume is a significant factor in explaining cross-autocorrelation in U.S. stock returns (see e.g., Chordia and Swaminathan, 2000). The key conclusion is that stocks with high trading volume react faster to market-wide information than low trading volume stocks. Non-trading of small stocks may account for some of the cross-autocorrelation in general. However, as indicated earlier in Section II, this dataset only includes small firms that actively trade throughout the sample period. To examine the impact on Brazilian equities, trading volume is compared between large and small stock portfolios before and after financial liberalization.

As raw trading volume is highly correlated with firm size, *relative* trading volume in this sample is defined as the ratio of daily trading volume divided by firm market capitalization at the end of that day. In this sample, the correlation between raw trading volume and market capitalization is .95; the correlation between *relative* trading volume and market capitalization is .07. Thus, relative trading volume is essentially uncorrelated with firm size, which is necessary for this analysis.

Table 6 contains the results for the mean-difference tests. For the full sample, the mean trading volume is 4.09% for small firms, and 5.84% for large firms. The t-statistic (2.14) confirms a significant mean-difference between the trading volume of small and large firms at the 5% level. Prior to financial liberalization the trading volume for small firms (3.09%) is noticeably lower than the trading volume for large firms (8.35%). The t-statistic (5.50) indicates a significant mean-difference between small and large firms at the 1% level. After financial liberalization, trading volume increases for small firms (4.55%) and decreases for large firms (4.61%). The t-statistic (.06) demonstrates no mean-difference in trading volume between small and large firms following financial liberalization.

Table 6 - Trading volume of Brazilian equities. Mean-difference tests of small firm and large firm portfolios before and after financial liberalization.[1] ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	1986-1999	1986-1990	1991-1999	t-statistic for mean-difference between subsamples
Mean small firm trading volume	4.09%	3.09%	4.55%	2.93***
Mean large firm trading volume	5.84%	8.35%	4.61%	3.78***
t-statistic for mean-difference (small=large)	2.14**	5.50***	.06	

[1]Trading volume is defined as the raw trading volume divided by market capitalization.

The t-statistic (2.93) comparing the mean-difference in small firm trading volume before and after financial liberalization is significant at the 1% level. Likewise, the t-statistic (3.78) that tests for mean-difference in large firm trading volume is also significant at the 1% level. The results in this section help explain why cross-autocorrelation appears to diminish after financial liberalization. That is, while overall raw trading volume has increased in Brazil, relative trading volume for small firms has increased for small firms and decreased for large firms following financial liberalization. The more actively traded small stocks are, the greater the likelihood that they will incorporate common information as fast as larger firms.

CONCLUSIONS

This study complements and extends the prior literature by examining the effect of financial liberalization on the cross-autocorrelation in Brazilian equities from 1986-1999. Specifically, daily return data are employed to test the correlation, cross-autocorrelation, Granger-causality, directional asymmetry, and trading volume between two size-based portfolios. The findings demonstrate that cross-autocorrelation is not exclusive to U.S. data, and show that large firm stock returns lead small firm stock returns in Brazil. A delay in stock price reaction of small firms implies varying levels of efficiency or independence within security markets.

Additional tests demonstrate that financial liberalization has reduced the effect of cross-autocorrelation in the Brazilian equity markets. One possible reason for the diminished cross-autocorrelation is that relative trading volume is shown to increase for small firms and decrease for large firms following financial liberalization.

This may result in small firms reacting faster to common information. Thus, the opening of Brazil's markets may have improved one aspect of stock price efficiency of smaller firms.

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