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An Analysis of the Short- and Long-Run Relationships Between South Asian and Developed Equity Markets

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ABSTRACT

In this paper, I conduct a detailed, large sample analysis of the short- and long-run relationships between the South Asian markets of India, Pakistan and Sri Lanka and the major developed markets during July 1997 - December 2003. Using a multivariate cointegration framework and vector error-correction modeling I find that the Indian market is influenced by the US, UK and Japan and that this influence has persisted following the September 11, 2001 terrorist attacks on the US. For Pakistan and Sri Lanka I find that these markets are relatively isolated from the major developed markets during the entire sample period. I also find that the three South Asian equity markets are becoming more integrated with each other but at a relatively slow pace.

JEL: F30, F36, G15

Keywords: South Asian markets; Emerging markets; Cointegration; Vector error-correction model

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I. INTRODUCTION

Previous researchers have examined the short- and long-run relationships among the major developed equity markets and markets in the Asian region for several years. Some researchers, including Eun and Shim (1989), Cheung and Mak (1992), Park and Fatemi (1993), Chung and Liu (1994), Arshanapalli, Doukas and Lang (1995), and Janakiramanan and Lamba (1998), use vector autoregression (VAR) modeling and impulse response analysis to examine these relationships. The main focus of these studies is to examine the short-run causal linkages among equity markets to better understand how shocks in one market are transmitted to other markets. These studies typically find that the US influences most markets in the Asian region, while markets in this region have little influence on the US market. The UK appears to exert some influence on markets in Japan, Australia, and Hong Kong. Previous studies also find that Japan, the second largest equity market, has little influence on other equity markets. In addition, the linkages among Pacific-Basin equity markets can often be attributed to the direct and indirect influences of the US market.

Other studies, including Chan, Gup and Pan (1992, 1997), Kasa (1992), Hung and Cheung (1995), and Masih and Masih (2001), use the cointegration framework to examine the long-run relationships and the level of market integration among markets in the Asian region and between these markets and developed markets. Some researchers, such as Arshanapalli and Doukas (1993), Masih and Masih (1997, 1999) and Sheng and Tu (2000), have specifically focused their attention on the effect of market crashes on the relationships among these markets.[1] These studies generally tend to find a long-run relationship among Asian equity markets and the major developed markets of Japan, US, and UK.

While previous researchers have examined the linkages among various equity markets in the Pacific-Basin region, South Asian markets have received very little interest resulting in few studies that have examined the short- and long-run behavior of these markets in any detail. One exception is Ghosh, Saidi and Johnson (1999) who examine the long-run relationship between the US and Japan and the Indian market during the Asian financial crisis period of 1997. They find a long-run cointegrating relationship between the US and the Indian market but not between Japan and India. However, their conclusions are limited in scope because of the very short time period of 201 trading days examined. In addition, they examine the relationship among these markets in a bivariate, rather than multivariate, setting.[2]

Countries in the South Asian region have experienced considerable political and social turmoil over the past few years. At the same time, these countries have also deregulated their capital markets and removed barriers to international investment. In addition, the Asian financial crisis in 1997 and the substantial market falls following the terrorist attacks on the US on September 11, 2001 may have exerted influence on these markets potentially making them more integrated with major developed markets.

Previous studies have also documented an increase in correlation among the world's equity markets.[3] These results imply that the benefits of international diversification are declining because of the increased comovement among equity markets. Since the South

Asian markets have relatively low correlations with major developed markets (see Table 2) it suggests that foreign investors can achieve substantial risk diversification benefits with an exposure to these markets.

Taking these factors into account, a detailed examination of the evolution and changes in the short- and long-run relationships between South Asian markets and major developed markets is topical and of immediate relevance. The main research questions addressed in this study are as follows:

- What are the short- and long-run relationships between the selected equity markets in the South Asian region and the major developed markets?
- Do markets in the South Asian region exert significant short- and long-run influences on each other?
- Have the above relationships been significantly influenced by events such as the Asian financial crisis in 1997 and, more recently, the terrorist attacks on the US in September 2001?

To examine these relationships, a multivariate cointegration framework is used with vector error-correction (VEC) models estimated to analyze the long-run equilibrium relationships and the short-run causal effects among the major developed markets and South Asian markets. The study's main contribution is to examine the short- and long-run relationships between equity markets in the South Asian region, which have been relatively neglected by previous researchers. The results have implications on how interdependent these markets are on each other and on the major developed markets, and on whether the level of this interdependence has changed over time and as a result of events that can significantly alter market volatility. The results also have implications for international portfolio diversification and portfolio management in the South Asian region.

The remainder of this paper is organized as follows. Section II provides details on the data and method used, while Section III presents and discusses the empirical results. Section IV concludes the paper.

II. DATA AND METHOD

The analysis focuses on the short- and long-run relationships between major developed markets and South Asian markets during July 1997 - December 2003. Daily data on the CNX Nifty 50 index (India), Karachi 100 index (Pakistan) and All Share index (Sri Lanka) are obtained from Bloomberg.[4] The choice of which developed equity markets to include in the analysis is determined mainly by the relative size of these markets as well as the expected economic and financial linkages between these markets and South Asian markets. The specific developed equity markets included in the analysis are France (FR), Germany (GE), Japan (JP), the UK, and the US. Data on these daily market indices are obtained from Bloomberg.[5] Table 1 provides information on the markets examined.[6]

Table 2 provides some descriptive statistics for the continuously compounded daily returns in each market along with the correlation coefficients among daily returns. The South Asian markets' returns have relatively low correlations with the returns of the major developed markets. As mentioned earlier, previous studies have documented an

increase in correlation among the world's equity markets. The results of these studies imply that the benefits of international diversification are reducing because of the increased correlation. Hence, the low correlations between South Asian markets and major developed markets suggest that foreign investors can achieve substantial risk diversification benefits with an exposure to these South Asian markets.

Table 1
Summary information on equity markets analyzed

A. Total Market Capitalization, Total Value Traded and Number of Domestic Listed Companies at the end of 2002[a]

	Total Market Capitalization (USD millions)	Percent	Total Value Traded (USD millions)	Percent	Number of Domestic Listed Companies	Percent
France	966,962	4.1	934,767	2.4	772	1.6
Germany	685,970	2.9	1,233,056	3.2	715	1.5
Japan[b]	2,126,075	9.1	1,573,279	4.1	3,058	6.3
UK	1,864,134	8.0	2,721,342	7.0	1,701	3.5
USA	11,052,403	47.2	25,371,270	65.7	5,685	11.8
India[c]	131,011	0.6	197,118	0.5	5,650	11.7
Pakistan	10,200	< 0.1	26,030	< 0.1	712	1.5
Sri Lanka	1,681	< 0.1	318	< 0.1	238	0.5
World	23,391,914	100.0	38,645,472	100.0	48,375	100.0

B. Information on Indices Examined and Current Market Opening and Closing Times

	Market Index	Local Time	Greenwich Mean Time
France	CAC 40 Index	09:00 - 17:30	08:00 - 16:30
Germany	DAX Index	09:00 - 17:30	08:00 - 16:30
Japan	Nikkei 225 Index	09:00 - 11:00	00:00 - 02:00
		12:30 - 15:00	03:30 - 06:00
UK	FTSE 100 Index	08:00 - 16:30	08:00 - 16:30
USA	Standard and Poor's 500 Index	09:30 - 16:00	14:30 - 21:00
India	CNX Nifty 50 Index	09:55 - 15.30	04:55 - 10.30
Pakistan[d]	Karachi 100 Index	09:30 - 13:00	04:00 - 07:30
Sri Lanka	All Share Index	09:30 - 12:30	03:30 - 06:30

[a] *Source:* Standard and Poor's Global Stock Markets Factbook, 2003. The *Percent* columns provide information on a particular market's share relative to the world total at the end of 2002.
[b] Starting in 2002, Japan includes data from JASDAQ listed companies as well.
[c] Starting in 1994, total value traded for India includes data from the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE).
[d] Times are for Mondays through Thursdays. For Fridays the local trading times are 9:00 - 12:00.

Table 2
Descriptive statistics for daily market returns in local currency terms during July 1997 - December 2003

A. Summary Statistics for Daily Market Returns

Market	Mean	Median	Maximum	Minimum	Std Dev	Skewness	Kurtosis
France	0.01%	0.00%	7.00%	-7.68%	1.64%	-0.05	4.72
Germany	0.00	0.00	7.55	-9.58	1.84	-0.10	4.61
Japan	-0.04	0.00	7.66	-7.23	1.56	0.04	4.72
UK	0.00	0.00	5.90	-5.59	1.31	-0.09	4.49
US	0.01	0.00	5.57	-7.11	1.31	-0.05	5.23
India	0.03	0.01	7.63	-8.20	1.60	-0.08	5.86
Pakistan	0.06	0.00	12.76	-13.21	1.90	-0.36	9.09
Sri Lanka	0.02	0.00	18.29	-13.91	1.26	1.20	47.09

B. Correlation Coefficients Between Daily Market Returns

Market	France	Germany	Japan	UK	US	India	Pakistan	Sri Lanka
Germany	0.80**							
Japan	0.24**	0.22**						
UK	0.81**	0.72**	0.25**					
US	0.47**	0.55**	0.12**	0.44**				
India	0.15**	0.12**	0.19**	0.14**	0.04			
Pakistan	0.04	0.03	0.03	0.03	-0.02	0.12**		
Sri Lanka	0.01	0.01	0.04*	0.00	0.01	0.03	0.06**	
France (-1)	0.02	0.01	0.28**	0.03	0.02	0.11**	0.01	0.02
Germany (-1)	0.09**	0.00	0.27**	0.07**	0.01	0.13**	0.02	0.03
Japan (-1)	-0.06*	-0.05*	-0.04	-0.07**	-0.04	-0.02	0.04	0.00
UK (-1)	0.03	0.02	0.26**	0.01	0.02	0.14**	0.02	0.04
US (-1)	0.30**	0.19**	0.34**	0.31**	-0.03	0.17**	0.06*	0.05*

* Significant at the 5% level.
** Significant at the 1% level.

Table 3
Stationarity tests for market index levels and first differences based on the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test statistics[a]

A. Augmented Dickey-Fuller Test Statistics

Market	Market Index Levels	First Differences
France	-1.44	-25.63*
Germany	-1.86	-40.50*
Japan	-1.97	-30.72*
UK	-2.31	-19.07*
US	-1.99	-25.59*
India	-0.89	-11.91*
Pakistan	-0.34	-12.27*
Sri Lanka	-1.55	-13.60*

Table 3 (continued)

B. Phillips-Perron Test Statistics

Market	Market Index Levels	First Differences
France	-1.42	-40.63*
Germany	-1.82	-40.53*
Japan	-1.94	-42.99*
UK	-2.40	-40.47*
US	-2.03	-42.16*
India	-0.64	-38.88*
Pakistan	-0.05	-39.60*
Sri Lanka	-1.38	-38.12*

[a] The critical values for the test statistics are -3.41 and -3.96 at the 5% and 1% levels, respectively.
* Significant at the 1% level.

The relationships between the South Asian markets and major developed markets are analyzed using a cointegration framework and vector error-correction modeling which allow for an examination of the long-run equilibrium relationships between these markets as well as the short-run adjustments over time. The behavior of the market index series is examined to first determine whether they are stationary using the augmented Dickey and Fuller (1979, 1981) and Phillips and Perron (1988) tests on the market index levels and their first differences. Table 3 reports the results, which show that the hypothesis of non-stationarity in the market indices cannot be rejected. However, the hypothesis of non-stationarity in first differences is rejected for all markets implying that the variables are integrated of order one.

Since the index series are found to be non-stationary, I next examine whether the index series are stationary in a linear combination, using Johansen's (1991) procedure. Johansen provides two different test statistics that can be used to test the hypothesis of the existence of *r* cointegrating vectors. The trace test statistic tests the null hypothesis that the number of distinct cointegrating relationships is less than or equal to *r* against the alternative hypothesis of more than *r* cointegrating relationships, while the maximum eigenvalue test statistic tests the null hypothesis that the number of cointegrating relationships is less than or equal to *r* against the alternative of *r+1* cointegrating relationships.

The results from the Johansen cointegration tests are presented in Table 4.[7] Panel A reports the results for India and the major developed markets, while panels B and C report the corresponding results for Pakistan and Sri Lanka, respectively. The test statistics generally lead to a rejection the null hypothesis of no cointegrating relationships, but not the null hypothesis of at least one cointegrating vector. Both test statistics lead to the rejection of the null hypothesis of no cointegration for the three markets. However, the two test statistics give conflicting evidence on the number of cointegrating vectors for India. Given this, I adopt the more conservative position that,

at the 1% level, there is only one cointegrating vector in the error-correction model estimated below.

Since the market index series are found to have a single cointegrating relationship, they will have a tendency to move together in the long-run even though they may experience short-run deviations from the common "equilibrium" path. Thus, the causal relationship between the Indian equity market and the major developed markets is examined using the following error-correction model:

$$\Delta IN_t = \alpha_0 + \gamma Z_{t-1} + \sum_{j=1}^{p} \alpha_{1j} \Delta IN_{t-j} + \sum_{j=1}^{p} \alpha_{2j} \Delta FR_{t-j} + \sum_{j=1}^{p} \alpha_{3j} \Delta GE_{t-j} + \sum_{j=1}^{p} \alpha_{4j} \Delta JP_{t-j} + \sum_{j=1}^{p} \alpha_{5j} \Delta UK_{t-j} + \sum_{j=1}^{p} \alpha_{6j} \Delta US_{t-j} + \varepsilon_t \quad (1)$$

where $Z_{t-1} = IN_{t-1} - \beta_1 FR_{t-1} - \beta_2 GE_{t-1} - \beta_3 JP_{t-1} - \beta_4 UK_{t-1} - \beta_5 US_{t-1}$. α_0 is the constant representing a linear trend, and ε_t is the error term representing unanticipated movements in the Indian market index, ΔIN_t. Z_{t-1} contains the error-correction term which is derived from the long-run cointegrating relationship among the market indices using the Johansen procedure. The economic intuition behind the specification in equation (1) is that if the Indian market and the other markets are cointegrated, part of the current changes in the Indian market index reflects the "alignment" that the Indian market attempts to achieve with trends in other markets. Similarly, the short- and long-run relationships between equity markets in Pakistan and Sri Lanka and the major developed markets is examined using the above error-correction model after substituting changes in these market indices (ΔPK_t and ΔSL_t, respectively) for the Indian market index (ΔIN_t) in equation (1). In addition to the above analysis, which considers each of the South Asian markets individually, the three markets are included in a single error-correction model.[8] Thus, for the Indian market the error-correction model estimated is as follows:

$$\Delta IN_t = \alpha_0 + \gamma Z_{t-1} + \sum_{j=1}^{p} \alpha_{1j} \Delta IN_{t-j} + \sum_{j=1}^{p} \alpha_{2j} \Delta FR_{t-j} + \sum_{j=1}^{p} \alpha_{3j} \Delta GE_{t-j} + \sum_{j=1}^{p} \alpha_{4j} \Delta JP_{t-j} + \sum_{j=1}^{p} \alpha_{5j} \Delta US_{t-j} + \sum_{j=1}^{p} \alpha_{6j} \Delta UK_{t-j} + \sum_{j=1}^{p} \alpha_{7j} \Delta PK_{t-j} + \sum_{j=1}^{p} \alpha_{8j} \Delta SL_{t-j} + \eta_t \quad (2)$$

where $Z_{t-1} = IN_{t-1} - \beta_1 FR_{t-1} - \beta_2 GE_{t-1} - \beta_3 JP_{t-1} - \beta_4 UK_{t-1} - \beta_5 US_{t-1} - \beta_6 PK_{t-1} - \beta_7 SL_{t-1}$.
Similar models are estimated for Pakistan and Sri Lanka. The purpose of this analysis is to verify whether any short- and long-run relationships exist among the three South Asian markets or whether they are relatively isolated from each other.

Table 4

Johansen's test for multiple cointegrating vectors for the long-run relationship among market indices[a]

A. Trace and Maximum Eigenvalue Statistics for India and Developed Equity Markets

Null Hypothesis	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value	Maximum Eigenvalue Statistic	5 Percent Critical Value	1 Percent Critical Value
No Cointegrating Vector, $r = 0$	111.72**	94.15	103.18	41.84*	39.37	45.10
At Most 1 Cointegrating Vector, $r \leq 1$	69.88*	68.52	76.07	35.19*	33.46	38.77
At Most 2 Cointegrating Vectors, $r \leq 2$	34.69	47.21	54.46	18.81	27.07	32.24
At Most 3 Cointegrating Vectors, $r \leq 3$	15.88	29.68	35.65	11.93	20.97	25.52
At Most 4 Cointegrating Vectors, $r \leq 4$	3.94	15.41	20.04	3.79	14.07	18.63
At Most 5 Cointegrating Vectors, $r \leq 5$	0.16	3.76	6.65	0.16	3.76	6.65

B. Trace and Maximum Eigenvalue Statistics for Pakistan and Developed Equity Markets

Null Hypothesis	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value	Maximum Eigenvalue Statistic	5 Percent Critical Value	1 Percent Critical Value
No Cointegrating Vector, $r = 0$	116.24**	94.15	103.18	54.57**	39.37	45.10
At Most 1 Cointegrating Vector, $r \leq 1$	61.67	68.52	76.07	26.07	33.46	38.77
At Most 2 Cointegrating Vectors, $r \leq 2$	35.60	47.21	54.46	17.20	27.07	32.24
At Most 3 Cointegrating Vectors, $r \leq 3$	18.40	29.68	35.65	13.27	20.97	25.52
At Most 4 Cointegrating Vectors, $r \leq 4$	5.13	15.41	20.04	3.63	14.07	18.63
At Most 5 Cointegrating Vectors, $r \leq 5$	1.50	3.76	6.65	1.50	3.76	6.65

Table 4 (Continued)

C. Trace and Maximum Eigenvalue Statistics for Sri Lanka and Developed Equity Markets

Null Hypothesis	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value	Maximum Eigenvalue Statistic	5 Percent Critical Value	1 Percent Critical Value
No Cointegrating Vector, $r = 0$	111.40**	94.15	103.18	49.20**	39.37	45.10
At Most 1 Cointegrating Vector, $r \leq 1$	62.20	68.52	76.07	25.23	33.46	38.77
At Most 2 Cointegrating Vectors, $r \leq 2$	36.97	47.21	54.46	17.39	27.07	32.24
At Most 3 Cointegrating Vectors, $r \leq 3$	19.58	29.68	35.65	15.27	20.97	25.52
At Most 4 Cointegrating Vectors, $r \leq 4$	4.31	15.41	20.04	3.94	14.07	18.63
At Most 5 Cointegrating Vectors, $r \leq 5$	0.37	3.76	6.65	0.37	3.76	6.65

[a] r denotes the number of cointegrating relationships. The optimal lag structure of the vector autoregression (VAR) model is selected by minimizing the Akaike information criterion. The critical values for the test statistics are from Osterwald-Lenun (1992).

* Significant at the 5% level.

** Significant at the 1% level.

III. RESULTS AND DISCUSSION

A. Influences on Individual South Asian Markets

The results for the Indian, Pakistani and Sri Lankan markets appear in Tables 5 through 7, respectively. Panel A of each table shows the influence of developed markets on the specified market while Panel B shows whether there is a bi-directional causality between the specified market and developed markets. For India, based on standard diagnostic checking, I use an eight-lag specification for the VEC model (see Table 5). I find that the error-correction term is statistically significant at the 1% level, indicating the presence of a long-run relationship between India and the major developed markets. An examination of the individual *t*-statistics of the lagged index changes in the major developed markets shows that contemporaneous changes in the Indian market are influenced by changes in Japan, the UK and the US during the previous day.

These results suggest that uni-directional causality exists between the Indian market and developed markets, with the developed markets leading the Indian market. However, it is possible that a bi-directional relationship also exists among these markets. To ascertain these bi-directional relationships, I reestimate VEC models with each market included as the dependent variable in the error-correction model in equation (1). The summary results show that that the Indian market is Granger-caused by Japan, the UK and the US (see Panel B of Table 5) with the US exerting the most influence followed by the UK and Japan.[9]

For Pakistan, the appropriate VEC model specification is a four-lag model, while for Sri Lanka a six-lag model specification is appropriate. While the error-correction term for Pakistan is moderately significant at the 10% level, for Sri Lanka I do not observe a long-run relationship with the major developed markets. An examination of the individual *t*-statistics of the lagged index changes in the major developed markets shows that contemporaneous changes in the Pakistani and Sri Lankan markets are not influenced by changes in any developed markets during the previous day. The results for the bi-directional relationships appear in Panel B of the two tables and show that none of the developed markets appear to exert any influence on either Pakistan or Sri Lanka. Overall, these results tend to suggest that neither market is significantly influenced by the major developed markets over the full sample period of July 1997 - December 2003.

Table 5
Results testing the long- and short-run relationships between India and selected developed markets during July 1997 - December 2003[a]

A. Vector error-correction model estimated with India as the dependent market

Lag Order		Independent Markets				
(Days)	ΔIN	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS
1	0.04*	-0.00	-0.00	-0.01**	0.03**	0.19***
	(1.73)	(-0.08)	(-0.07)	(-2.41)	(2.23)	(5.02)
2	-0.05**	0.02	-0.01	-0.00	-0.01	0.04
	(-2.04)	(1.34)	(-0.88)	(-0.32)	(-0.91)	(0.94)
3	-0.02	0.03***	-0.01	0.01**	-0.01	0.13***
	(-0.64)	(2.57)	(-1.42)	(2.18)	(-0.82)	(3.09)
4	0.04*	0.00	-0.00	-0.00	-0.01	0.02
	(1.74)	(0.25)	(-0.22)	(-0.46)	(-0.54)	(0.40)
5	0.01	-0.01	0.00	0.00	-0.00	0.06
	(0.50)	(-1.03)	(0.10)	(1.62)	(-0.08)	(1.43)
6	-0.07***	0.01	0.02	0.00	-0.02**	-0.03
	(-2.68)	(0.46)	(1.65)	(0.95)	(-1.98)	(-0.77)
7	0.02	-0.00	-0.01	-0.00	0.01	0.02
	(0.59)	(-0.17)	(-0.64)	(-0.34)	(1.09)	(0.41)
8	-0.07***	0.02*	0.01	0.00	-0.04***	0.03
	(-2.61)	(1.84)	(0.53)	(0.98)	(-3.59)	(0.78)
ECT	0.01***					
	(3.05)					
Intercept	0.37					
	(0.80)					

B. Pairwise Granger-causality tests based on the estimated error-correction models[b]

Independent Markets	Dependent Markets					
(Lags 1 - 8)	ΔIN	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS
	χ^2 Statistics					
ΔIN	-	3.74	7.49	6.87	5.22	13.78*
ΔFR	12.94	-	14.55*	15.83*	13.99*	15.62**
ΔGE	6.63	10.89	-	6.09	17.46**	17.22**
ΔJP	15.74**	8.76	13.14	-	17.71**	10.68
ΔUK	25.20***	10.47	12.17	10.34	-	15.71**
ΔUS	37.55***	190.29***	119.25***	111.83***	226.89***	-

[a] The country codes used are: IN - India, FR - France, GE - Germany and JP - Japan. The numbers in parentheses are *t*-statistics. The adjusted R^2 and *F*-statistic for the error-correction model are 0.066 and 3.40, respectively.

[b] The pairwise Granger-causality tests are based on the error-correction models estimated in equation (1) with each market in the system included as the dependent market.

* Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

Table 6

Results testing the long- and short-run relationships between Pakistan and selected developed markets during July 1997 - December 2003[a]

A. Vector error-correction model estimated with Pakistan as the dependent market

Lag Order		Independent Markets				
(Days)	ΔPK	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS
1	0.05**	0.00	-0.00	0.00	0.00	0.11
	(1.98)	(0.02)	(-0.22)	(0.66)	(0.19)	(1.59)
2	-0.02	0.00	0.02	-0.00	-0.02	0.03
	(-0.61)	(-0.02)	(0.96)	(-0.29)	(-1.16)	(0.42)
3	0.01	-0.02	0.01	-0.00	0.03*	0.03
	(0.52)	(-0.99)	(0.59)	(-0.34)	(1.69)	(0.33)
4	0.03	-0.01	0.02	0.00	0.01	-0.02
	(1.04)	(-0.28)	(0.97)	(0.74)	(0.39)	(-0.21)
ECT	-0.00*					
	(-1.83)					
Intercept	1.55*					
	(1.91)					

B. Pairwise Granger-causality tests based on the estimated error-correction models[b]

Independent Markets	Dependent Markets					
(Lags 1 - 4)	ΔPK	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS
	χ^2 Statistics					
ΔPK	-	6.04	0.89	3.17	4.53	0.85
ΔFR	1.01	-	3.90	8.41*	7.48	3.18
ΔGE	2.05	5.96	-	2.19	12.40**	0.98
ΔJP	1.25	8.71*	10.95**	-	15.66***	2.07
ΔUK	4.74	6.86	7.56	8.62*	-	2.96
ΔUS	2.73	175.74***	127.28***	102.50***	218.00***	-

[a] The country codes used are: PK - Pakistan, FR - France, GE - Germany and JP - Japan. The numbers in parentheses are *t*-statistics. The adjusted R^2 and *F*-statistic for the error-correction model are 0.001 and 1.08, respectively.

[b] The pairwise Granger-causality tests are based on the error-correction models estimated in equation (1) with each market in the system included as the dependent market.

* Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

Table 7
Results testing the long- and short-run relationships between Sri Lanka and selected developed markets during July 1997 - December 2003[a]

A. Vector error-correction model estimated with Sri Lanka as the dependent market

Lag Order		Independent Markets				
(Days)	ΔSL	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS
1	0.09***	-0.01	-0.00	-0.00	0.01	0.02
	(3.55)	(-0.96)	(-0.10)	(-0.79)	(1.29)	(0.96)
2	-0.10***	-0.02**	0.00	0.00	0.01*	0.02
	(-3.90)	(-1.98)	(0.76)	(-0.36)	(1.85)	(0.83)
3	0.04	0.00	0.00	0.00	0.01	-0.00
	(1.48)	(0.08)	(0.66)	(1.29)	(0.85)	(-0.05)
4	0.11***	0.00	-0.00	-0.00	0.00	-0.01
	(4.23)	(0.25)	(-0.12)	(-0.77)	(0.03)	(-0.43)
5	-0.02	0.00	-0.00	-0.00	0.01	-0.01
	(-0.94)	(0.12)	(-0.51)	(-0.79)	(0.99)	(-0.23)
6	0.04	-0.00	0.00	0.00	-0.00	-0.01
	(1.54)	(-0.35)	(0.29)	(0.48)	(-0.14)	(-0.48)
ECT	-0.00					
	(-1.07)					
Intercept	0.13					
	(0.49)					

B. Pairwise Granger-causality tests based on the estimated error-correction models[b]

Independent Markets	Dependent Markets					
(Lags 1 - 6)	ΔSL	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS
	χ^2 Statistics					
ΔSL	-	2.14	5.00	2.38	3.47	4.46
ΔFR	4.73	-	5.29	8.88	7.17	8.96
ΔGE	1.35	6.91	-	3.21	15.51**	6.29
ΔJP	4.11	9.09	11.44*	-	18.52***	4.80
ΔUK	5.70	8.82	9.61	8.34	-	7.73
ΔUS	1.91	175.58***	128.52***	101.24***	216.56***	-

[a] The country codes used are: SL - Sri Lanka, FR - France, GE - Germany and JP - Japan. The numbers in parentheses are *t*-statistics. The adjusted R^2 and *F*-statistic for the error-correction model are 0.022 and 2.00, respectively.
[b] The pairwise Granger-causality tests are based on the error-correction models estimated in equation (1) with each market in the system included as the dependent market.
* Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

B. Influences on all Three South Asian Markets

To examine the influence among the three South Asian markets the error-correction model in equation (2) is separately estimated for each market. The results for the Indian, Pakistani and Sri Lankan markets appear in Tables 8 through 10, respectively. As before, Panel A of each table shows the influence of developed markets on the specified market while Panel B shows whether there is a bi-directional causality between the specified market and developed markets. Overall, the results are similar to those reported earlier for India. For Pakistan, I find that contemporaneous changes in that market are now moderately influenced by changes in the US, India and Sri Lanka during the previous day (see Panel A of Table 9). For Sri Lanka, the error-correction term is now statistically significant at the 1% level, indicating the presence of a long-run relationship between Sri Lanka and the markets in the system (see Panel A of Table 10). An examination of the bi-directional relationships shows that the Indian (Pakistani) market does not exert any significant influence on Pakistan and Sri Lanka (India and Sri Lanka). However, the Sri Lankan market appears to exert some influence on Pakistan (see Panel B of Table 9). Overall, it appears that the equity markets of the three South Asian countries, which are located in close geographical proximity and are influenced by political and economic events in that region, are becoming more integrated with each other but at a relatively slow pace.

C. Sensitivity Analysis

To verify the effects of the Asian financial crisis and events around September 11, 2001 the error-correction models in equations (1) and (2) are re-estimated after excluding data for the months of July - December 1997 and September 2001.[10] This analysis allows a verification of whether or not these events have substantially altered the relationships between the South Asian and developed equity markets. The results, which are not reported in detail here, show that excluding these periods does not alter the main findings reported above, implying that the above relationships are persistent across periods characterized by increased volatility and uncertainty.

IV. SUMMARY AND CONCLUSIONS

In this paper, I conduct a detailed, large sample analysis of the short- and long-run relationships between the South Asian markets of India, Pakistan and Sri Lanka and the major developed markets during July 1997 - December 2003. Using a multivariate cointegration framework and vector error-correction modeling I find that the Indian market is influenced by the US, UK and Japan and that this influence has persisted following the September 11, 2001 terrorist attacks on the US. For Pakistan and Sri Lanka I find that these markets are relatively isolated from the major developed markets during the entire sample period. I also find that the three South Asian equity markets are becoming more integrated with each other but at a relatively slow pace.

Table 8

Results testing the long- and short-run relationships between India, selected developed markets and Pakistan and Sri Lanka during July 1997 - December 2003[a]

A. Vector error-correction model estimated with India as the dependent market

Lag Order (Days)	ΔIN	Independent Markets ΔFR	ΔGE	ΔJP	ΔUK	ΔUS	ΔPK	ΔSL
1	0.05**	-0.00	0.00	-0.01***	0.02**	0.19***	-0.01	0.02
	(2.14)	(-0.26)	(0.25)	(-2.57)	(2.11)	(4.98)	(-0.46)	(0.49)
2	-0.04*	0.02	-0.01	-0.00	-0.01	0.04	-0.00	0.03
	(-1.69)	(1.08)	(-0.47)	(-0.39)	(-0.97)	(0.86)	(-0.08)	(0.72)
3	-0.00	0.03**	-0.01	0.01**	-0.01	0.12***	-0.02	0.02
	(-0.05)	(2.43)	(-1.11)	(2.12)	(-0.84)	(2.84)	(-1.52)	(0.48)
4	0.06**	0.00	0.00	-0.00	-0.01	0.01	-0.01	0.02
	(2.23)	(0.17)	(0.05)	(-0.39)	(-0.65)	(0.18)	(-0.66)	(0.53)
5	0.02	-0.01	0.00	0.00	-0.00	0.05	-0.01	-0.03
	(0.94)	(-0.98)	(0.32)	(1.59)	(-0.24)	(1.15)	(-0.76)	(-0.79)
6	-0.06**	0.01	0.02*	0.00	-0.02**	-0.05	0.01	0.10**
	(-2.42)	(0.40)	(1.89)	(0.84)	(-2.04)	(-1.04)	(0.90)	(2.33)
7	0.02	-0.00	-0.00	-0.00	0.01	0.01	0.03**	-0.01
	(0.63)	(-0.24)	(-0.37)	(-0.41)	(0.95)	(0.18)	(2.43)	(-0.29)
8	-0.06**	0.03*	0.01	0.00	-0.04***	0.02	-0.00	0.04
	(-2.37)	(1.89)	(0.72)	(0.89)	(-3.72)	(0.49)	(-0.07)	(0.95)
ECT	-0.01***							
	-2.89)							
Intercept	0.32							
	(0.69)							

B. Pairwise Granger-causality tests based on the estimated error-correction models[b]

Independent Markets (Lags 1 - 8)	Dependent Markets ΔIN	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS	ΔPK	ΔSL
	χ^2 Statistics							
ΔIN	-	3.64	8.20	8.09	6.00	13.76*	14.40*	3.02
ΔFR	12.05	-	13.57	15.60**	13.05	14.98*	1.97	5.82
ΔGE	6.32	10.32	-	5.97	16.33**	15.83**	2.43	2.32
ΔJP	15.89**	8.82	13.30*	-	17.65**	10.93	1.58	6.28
ΔUK	25.60***	10.38	12.09	9.97	-	13.95*	4.93	3.63
ΔUS	35.99***	188.11***	116.96***	108.60***	224.90***	-	6.65	2.73
ΔPK	10.25	9.78	4.06	6.47	6.69	2.82	-	10.03
ΔSL	7.97	4.56	5.91	5.61	4.45	5.13	21.92***	-

[a] The country codes used are: IN - India, FR - France, GE - Germany, JP - Japan, PK - Pakistan and SL - Sri Lanka. The numbers in parentheses are *t*-statistics. The adjusted R^2 and *F*-statistic for the error-correction model are 0.068 and 2.88, respectively.

[b] The pairwise Granger-causality tests are based on the error-correction models estimated in equation (2) with each market in the system included as the dependent market.

* Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

Table 9

Results testing the long- and short-run relationships between Pakistan, selected developed markets and India and Sri Lanka during July 1997 - December 2003[a]

A. Vector error-correction model estimated with Pakistan as the dependent market

Lag Order		Independent Markets						
(Days)	ΔPK	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS	ΔIN	ΔSL
1	0.04	-0.00	-0.00	0.00	-0.00	0.13*	0.09*	0.16**
	(1.52)	(-0.14)	(-0.12)	(0.43)	(-0.13)	(1.92)	(1.94)	(2.15)
2	-0.02	0.00	0.02	-0.00	-0.03*	0.03	0.05	0.00
	(-0.89)	(-0.01)	(1.07)	(-0.40)	(-1.67)	(0.39)	(1.25)	(0.03)
3	0.01	-0.02	0.01	-0.00	0.03	0.02	0.01	0.09
	(0.47)	(-0.92)	(0.71)	(-0.27)	(1.24)	(0.30)	(0.20)	(1.18)
4	0.02	-0.01	0.02	0.00	0.00	-0.02	0.03	-0.19**
	(0.95)	(-0.42)	(1.10)	(0.47)	(0.08)	(-0.25)	(0.63)	(-2.52)
ECT	0.00							
	(1.21)							
Intercept	1.49*							
	(1.84)							

B. Pairwise Granger-causality tests based on the estimated error-correction models[b]

Independent Markets	Dependent Markets							
(Lags 1 - 4)	ΔPK	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS	ΔIN	ΔSL
	χ^2 Statistics							
ΔPK	-	5.68	0.91	4.63	5.37	0.90	3.01	1.92
ΔFR	0.96	-	4.27	8.79*	7.28	3.49	7.28	3.92
ΔGE	2.50	5.96	-	2.41	11.40**	0.87	1.21	1.55
ΔJP	0.68	8.63*	11.01**	-	14.72***	2.23	10.65**	3.49
ΔUK	4.65	8.14*	6.78	9.05*	-	3.18	7.27	3.39
ΔUS	3.97	186.42***	124.29***	105.43***	228.65***	-	28.34***	1.07
ΔIN	5.88	2.34	4.15	4.53	2.91	6.22	-	1.04
ΔSL	11.36**	0.83	0.79	1.59	1.40	2.84	2.42	-

[a] The country codes used are: PK - Pakistan, FR - France, GE - Germany, JP - Japan, IN - India and SL - Sri Lanka. The numbers in parentheses are *t*-statistics. The adjusted R^2 and *F*-statistic for the error-correction model are 0.005 and 1.27, respectively.

[b] The pairwise Granger-causality tests are based on the error-correction models estimated in equation (2) with each market in the system included as the dependent market.

* Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

Table 10

Results testing the long- and short-run relationships between Sri Lanka, selected developed markets and India and Pakistan during July 1997 - December 2003[a]

A. Vector error-correction model estimated with Sri Lanka as the dependent market

Lag Order		Independent Markets						
(Days)	ΔSL	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS	ΔIN	ΔPK
1	0.08***	-0.01	0.00	-0.00	0.00	0.02	0.00	-0.00
	(3.23)	(-1.08)	(0.41)	(-0.80)	(0.64)	(0.94)	(-0.03)	(-0.37)
2	-0.10***	-0.02*	0.01	0.00	0.01	0.02	-0.01	-0.01
	(-4.16)	(-1.93)	(1.14)	(-0.33)	(1.34)	(0.69)	(-0.74)	(-0.77)
3	0.03	0.00	0.01	0.00	0.00	-0.00	-0.00	0.01
	(1.06)	(0.00)	(0.99)	(1.16)	(0.44)	(-0.06)	(-0.30)	(1.06)
4	0.10***	0.00	0.00	-0.00	-0.00	-0.01	0.01	0.00
	(3.83)	(0.37)	(0.17)	(-0.93)	(-0.51)	(-0.49)	(0.47)	(0.47)
5	-0.03	0.00	-0.00	-0.00	0.00	-0.01	-0.01	0.00
	(-1.24)	(0.26)	(-0.30)	(-0.79)	(0.59)	(-0.33)	(-0.92)	(0.32)
6	0.03	-0.00	0.00	0.00	-0.00	-0.01	-0.00	0.01
	(1.08)	(-0.24)	(0.44)	(0.25)	(-0.51)	(-0.42)	(-0.11)	(1.49)
ECT	-0.01***							
	(-4.48)							
Intercept	0.11							
	(0.42)							

B. Pairwise Granger-causality tests based on the estimated error-correction models[b]

Independent Markets	Dependent Markets							
(Lags 1 - 6)	ΔSL	ΔFR	ΔGE	ΔJP	ΔUK	ΔUS	ΔIN	ΔPK
	χ^2 *Statistics*							
ΔSL	-	2.57	4.96	2.63	3.94	4.52	6.60	14.28**
ΔFR	4.84	-	5.47	9.04	6.47	9.19	8.32	1.57
ΔGE	2.27	7.25	-	3.69	14.24**	6.38	5.72	2.91
ΔJP	3.79	8.50	11.42*	-	17.04***	4.06	14.39**	1.64
ΔUK	3.23	9.56	8.65	8.94	-	8.49	11.20*	4.56
ΔUS	1.70	187.74***	121.87***	107.74***	229.42***	-	34.37***	7.04
ΔIN	1.73	3.39	6.74	4.18	4.99	11.66*	-	10.03
ΔPK	4.36	7.54	1.95	5.44	5.28	3.10	5.40	-

[a] The country codes used are: SL - Sri Lanka, FR - France, GE - Germany, JP - Japan, IN - India and PK - Pakistan. The numbers in parentheses are *t*-statistics. The adjusted R^2 and *F*-statistic for the error-correction model are 0.031 and 2.09, respectively.

[b] The pairwise Granger-causality tests are based on the error-correction models estimated in equation (2) with each market in the system included as the dependent market.

* Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

ENDNOTES

1. Some researchers have focused their attention on specific developing equity markets, such as Niarchos, *et al* (1999) who examine the Greek market and Lamba and Otchere (2001) who examine the South African market.
2. Goldberg and Delgado (2001) adopt a different approach and examine whether selected individual stocks listed on the Bombay Stock Exchange exhibit evidence of financial integration by analyzing for the existence of structural breaks in their return series over 1979-95. While they do not find evidence consistent with the existence of financial integration their conclusions are limited because their analysis focuses on the largest fourteen listed stocks.
3. See, for example, Oldier and Solnik (1993) and Solnik, Boucrelle and Le Fur (1996).
4. Data on only these South Asian markets are available from Bloomberg and the data are available only from July 1997 onwards. For India, the Bombay Stock Exchange (BSE) Sensex is the other widely reported market index. To verify whether the choice of market index influences the results I redid the analysis using the BSE Sensex index. The results are very similar to those reported here which is not surprising given the relatively high correlation between changes in the CNX Nifty 50 and BSE Sensex indices of over 0.90 during the sample period.
5. The market index series are measured in local currency terms and all data are screened for errors using filter tests. No major discrepancies were found in the data.
6. The relatively small sizes of markets in Pakistan and Sri Lanka may be of some concern because of the potential for infrequent trading. An examination of the daily data shows that the indices of these markets tend to change on most days indicating that there is some market activity taking place in the component stocks on a daily basis.
7. The selection of the order of lags in the Johansen test and, subsequently, the error-correction model is important, as the choice of the lag can have an important impact on the outcome of these tests (Enders, 2004). I use the following criteria suggested by Engle and White (1999) to select the optimum lag structure: (i) residual diagnostic tests to ensure the regression residuals are white noise, (ii) the Akaike information criterion (AIC) to optimize the goodness of fit, and (iii) the statistical significance of coefficients of lagged variables.
8. The results from the Johansen cointegration test where all three South Asian markets are included in the system with the major developed markets indicate the presence of at least one cointegrating vector. For brevity, these results are reported here. All unreported results are available from the author upon request.
9. It has been argued that during the “dot com” boom of 1999-00 the Indian equity market was more closely related to the US NASDAQ market index rather than to the S&P 500 index. To verify this contention I examined the NASDAQ Composite index instead of the S&P 500 index for the US market. The results (not shown) indicate no long-term relationship between the NASDAQ Composite and NSE indices.

10. The results are insensitive to excluding a longer period for the Asian financial crisis (July 1997 - July 1998) and a shorter period for September 2001 (September 10 - 21, 2001).

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