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Financial Market Linkages in South Asia: Evidence Using a Multivariate GARCH Model

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1. INTRODUCTION

The economic and social benefits of more openness and internationalisation are well supported by both academics and policy-makers. Many countries are also trying to become part of the world trade bloc such as the World Trade Organisation (WTO) or AFTA. Efforts are also made to strengthen the existing regional economic and trade coordination or establish new regional economic and financial integration. Unfortunately, at the time (during the 1980s and 1990s) when many emerging economies in East Asia were involved in openness, internationalisation and regional economic and financial integration, the South Asian countries wasted their resources in dealing with political crisis (such as Bangladesh), internal conflicts (such as Sri Lanka) or border issues (such as India and Pakistan). It is only recently that regimes have realised that a peaceful economic environment is essential to attract foreign investment, pursue a pro-growth policy and achieve a sustainable growth. The recent dialogue between Pakistan and India and some progress in SAARC consultation are a few steps towards these goals.[1]

Another important and related argument of the emerging globalisation and the new financial architecture is to enhance currency coordination among developed and emerging economies in the global world. Some leading international finance economists such as Robert Mundell [Mundell (2003)] and Larry Sjaastd, suggests that the world will gradually converge to a tri-polar regime where US dollar, euro and Japanese yen will dominate the currency market in the world. Obviously, most of the countries in the American region to link their currency with the US dollar while euro is already dominating the Europe. Japanese yen is expected to lead the Asian region under this scenario. Pound sterling is expected to serve as an anchor currency for some African and Asian countries. These researchers anticipate that 60 percent of the world currencies will converge to euro within the next two

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[1]Reader may refer to Khan and Khan (2003) and Stevenson (2004) for more discussion on regional cooperation.

decades. Whatever the outcome might be, this will be a return to some kind of Bretton Woods system with three anchor currencies ruling the world rather than US dollar under the old system.

If these perceptions are true, then the emerging economies in the South Asian region such as India, Pakistan, Bangladesh, and Sri Lanka will have to make a choice for an anchor currency for their financial dealings and transactions. Some academics are already working on the feasibility of a single currency for Southeast Asia. Their research focus is whether Southeast Asian countries particularly ASEAN provides a basis for an optimum currency area (OCA) which is a pre-requisite and an essential argument for any discussion on a 'single currency' arrangement. There is no doubt that the Southeast Asian region presents a reasonable degree of economic and financial interdependence.[2] The simultaneous fall of most of the regional currencies during the 1997 Asian financial crisis is an evidence of the how closely the currencies of this region are interlinked. Whether South Asia provides a similar common economic and financial environment is not so obvious.

Given these regional developments, it is imperative to initiate academic research to help design and implement medium to long-term economic policies to establish some regional economic and financial integration. The issue of regional economic and financial integrations has a wide research spectrum and cannot be covered in one paper. At this point, we do not investigate whether the South Asian region qualifies as an OCA or look into complete economic and financial integration or the trade interdependence. We leave these important issues to be investigated in a separate research paper. In this paper, we only look into the possibility of regional currency integration. Such an analysis is important in view of an anticipated tri-polar regime. Any future economic policies will be dependent on the choice of an anchor currency for an individual country or for the region as a whole. In this paper, our focus is to investigate the currency integration within South Asian region. With this as the main objective of this paper, we use a sample of four South Asian countries, namely, India, Pakistan, Bangladesh and Sri Lanka to investigate any possible currency integration within this region. We try to answer three important questions. One, are there any currency linkages within the currencies of the sample countries. Two, how are these currencies linked to their major trading partners. And three, is there any single major currency that influences currencies of the region and may provide a basis for an anchor currency. For analytical purposes, we use high frequency data (daily observations) and apply some recently developed econometric tests (Multivariate GARCH model).

The remainder of the paper is organised in the following manner. Section 2 provides a brief overview of the recent currency market reforms and developments in the sample countries. Section 3 details the methodology and the data. Section 4 discusses the results of the empirical tests. Finally, Section 5 concludes the report.

2. CURRENCY MARKET REFORMS AND DEVELOPMENTS IN SOUTH ASIA

[2]See Eichengreen and Bayouni (1996); *Hindustan Times* (2004); Kwack (2004) and Wang (2004) for more details on regional currency integration.

A close look at the economic performance of the four sample countries since independence suggest that all four countries being studied in this paper embarked on some significant economic and financial sector reform policies in the early 1990s [see Ariff and Khalid (2005)]. Although, the pace and sequence of these reforms varies across countries, these reforms were expected to have some positive effect on these economies. A summary of economic performance of the four countries is provided in Table 1 and gives an idea of how these economies have grown over the last 5 decades. In this section, we exclusively look at the currency market reforms and developments in each of the South Asian countries being studied in this paper. A summary of these reforms is provided in Table 2.

2.1. India[3]

Exchange rate policy was the leading candidate for reform initiated in 1991. Reforms to the multiple exchange rates and controls on producers and individuals were lifted after a massive devaluation of the rupee by 23 percent in 1991. Steps soon followed to unify the multiple exchange rates into one in 1992. By March 1993, further reforms were put in place to remove controls on restrictions on producers holding foreign exchange. The managed exchange rate adopted against a basket of currencies has led to greater stability of currency. The exchange rate in early 2004 was Rupee 41 = US$1.00, a gain of 3 percent per year on the average over three years.

India has followed a fixed adjustable exchange rate regime, which, when adjusted frequently by the authorities, reflected the market rates quite closely. The Indian rupee declined systematically against the dollar over the decades except in 1985, 1987 and 1997 when it rose by small amounts. The real rate of interest was 6.5 percent (relative to much lower real deposit rates in the United States). However, the high demand for foreign exchange on account of the deficits in fund to the tune of 3.6 percent of GDP, the need for foreign debt servicing, and the generally lower productivity levels (figures not available) drove the rupee down over the years.

The average depreciation of the rupee against the dollar was some 10.6 percent per year over the decade to 1991. In ten years, the currency declined in value by half.

Table 1

Basic Economic Indicators of Development (1961–2002)

Indicators	1961-70	1971-80	1981-90	1991-95	1996-2000	2000	2001	2002
India								
GDP Growth (%)	4.11	3.06	4.72	6.71	5.73	4.20	5.49	4.4
Per Capita GDPC (US$)	97.82	167.70	314.56	348.37	441.20	467.23	478.20	–
Gross Domestic Savings/GDP	–	22.3	21.9	23.1	24.1	23.4	24.0	24.5
Fixed Capital Formation/GDP	14.8	16.98	20.78	27.0	21.9	21.9	21.7	23.9
Inflation (per Year)	6.36	8.16	8.88	12.29	7.61	4.01	3.69	4.39
M2/GDP	22.40	30.23	42.11	54.23	50.34	55.57	58.22	–
Fiscal Balance/GDP	–4.15	–4.29	–7.43	–6.68	–5.14	–5.17	–4.70	–7.4
Trade Balance/GDP	–	–	–2.26	–1.70	–2.42	–2.60	–2.6	–
Current Account Balance/GDP	–	–	–1.77	–1.46	–1.10	–0.90	0.3	0.6

[3]Exchange rate reforms in India are discussed in detail in Ariff and Khalid (2005), Chapter 4, and Kohli (2003).

Debt/GDP	–	–	47.89	59.83	51.43	55.30	57.31	–
Pakistan								
GDP Growth (%)	3.35	4.81	6.19	4.85	3.07	4.26	2.72	4.41
Per Capita GDP (US$)	138.86	180.18	327.06	404.85	438.82	426.64	380.54	439
Gross Domestic Savings/GDP	–	13.81	13.83	14.81	13.29	14.4	14.6	13.6
Fixed Capital Formation/GDP	15.37	15.38	16.96	18.07	15.41	14.37	14.29	12.33
Inflation (per Year)	3.51	12.42	6.98	11.20	7.30	4.37	3.15	3.29
M2/GDP	36.14	41.76	41.25	43.39	46.63	46.92	48.30	51.74
Fiscal Balance/GDP	–5.17	–7.41	–6.74	–7.67	–6.91	–5.47	–4.71	–4.62
Trade Balance/GDP	–	–8.06	–9.31	–5.15	–3.73	–2.4	–2.3	–0.5
Current Account Balance/GDP	–	–5.35	–2.91	–4.49	–3.17	–0.14	3.41	4.5
Debt/GDP	33.91	61.96	64.15	–	–	90.00	–	–
Bangladesh								
GDP Growth (%)		4.15	4.01	4.39	5.21	5.95	5.27	4.80
Per Capita GDP (US$)			164	281	329	331	324	
Gross Domestic Savings/GDP								
Fixed Capital Formation/GDP			11.22	17.93	21.51	23.02	23.09	23.16
Inflation (per Year)			2.95	5.37	5.11	3.90	1.10	6.79
M2/GDP			26.60	26.68	31.01	34.71	37.22	39.39
Fiscal Balance/GDP								
Trade Balance/GDP			–9.42	–4.51	–4.37	–3.64	-4.51	
Current Account Balance/GDP			–3.28	0.07	–0.95	–0.67	–1.18	
Debt/GDP								
Sri Lanka								
GDP Growth (%)	8.83	4.39	4.65	5.55	5.07	6.58	–1.45	3.53
Per Capita GDP (US$)	153	241	382	607	816	844	820	–
Gross Domestic Savings/GDP								
Fixed Capital Formation/GDP	15.17	17.53	24.91	24.71	25.74	28.04	22.03	22.47
Inflation (per Year)	2.95	8.91	12.36	10.29	9.15	6.18	14.16	9.55
M2/GDP	26.39	24.65	30.49	32.83	37.78	38.18	39.22	–
Fiscal Balance/GDP	–6.32	–8.63	–10.14	–7.61	–7.34	–9.46	–9.87	–
Trade Balance/GDP	–	–	–9.34	–8.06	–4.90	–6.39	–3.53	–
Current Account Balance/GDP	–	–	–6.43	–5.46	–3.79	–6.39	–1.69	–
Debt/GDP	–	–	87.25	96.03	92.19	96.90	–	–

Source: Ariff and Khalid (2005).
Note: '–' not available.

Table 2

Major Currency Reforms in South Asia—1960–2002

Date of Reforms	Liberalisation Policies Implemented
India	• India operated a fixed exchange rate regime despite most countries choosing managed floats in the late 1970s and early 1980s; during this phase, India's currency depreciated at an annul rate of about 10 percent • **1991**: currency crisis led to a 23 percent devaluation of the currency • **1993**: Foreign exchange controls on producers and individuals were slowly relaxed • **1994**: Currency was free floated satisfying the IMF article 8 conditions • Capital controls on producers removed substantially • Exchange controls on individuals eased for travel and education • Further easing of capital controls shelved in the face of the 1997 Asian financial crisis • Insurance sector is the next one to be reformed; limited reforms being introduced in this sector by easing entry barriers
Pakistan	• **1 July 1994:** Pakistan rupee made convertible on current international transactions • **1996-97:** Residents allowed to open and maintain Foreign Currency Accounts Authorised Dealers, Development Financial Institutions and Housing Finance Institutions allowed to extend local currency credit to non-resident nationals in real estate sector • **19 May 1999:** Market based unified exchange rate system adopted • **1December 2000:** SBP introduced spot value convention for all foreign exchange and foreign-currency money market transactions • **18 April 2001:** SBP authorised all bank branches to purchase or sell foreign currency notes, coins, travellers' cheques and foreign demand drafts • **13 February 2002:** Authorised Dealers allowed to issue foreign currency travellers' cheques to foreign and Pakistan nationals against foreign exchange in cash
Bangladesh	• Article VIII conditions accepted. Multiple exchange rates unified 1994 • Daily fixing of rate on real effective exchange rate suggested by a 15 country trading partners' exchange rates. Volatility reduced, but not depreciation • No controls on holding or trading in foreign currencies
Sri Lanka	• **1977:** Relaxation of Exchange Controls • Dual Exchange Rate system abolished and a unified Exchange Rate system adopted fixed exchange rate system replaced by Floating Rate system • **1979:** Foreign Currency Banking Units (FCBUs) established • **1994:** Remaining restrictions on current international transactions removed

Sources: Ariff and Khalid (2000) and Ariff and Khalid (2005).

Depreciation halved to about 4 percent during 1992-99. The partial free-float of the rupee in March 1993 sent it to its all-time low as it corrected the past misalignment with the market and partly also on account of the current account crisis just prior to that reform. Since 1996, this depreciation has slowed, and the rupee started to appreciate from about 1998. Another often-quoted problem at the root of the inflation, and hence the depreciation of the currency, was the high level of monetary expansion caused by the Keynesian deficit budgeting for years under the import substituting policies. The rupee declined by some 19.66 percent in 1993, but subsequently stabilised against the dollar. Contrary to expectations before the reforms, the Rupee held steady against the dollar, and on several occasions in the second half of the 1990s the RBI had to intervene to keep the Rupee from appreciating. One report said that the RBI spent US$ 1,000 million protecting the rupee in the first half of 1994: see RBI reports. RBI interventions have occurred whenever inflows through portfolio investments and export receivables surged. As part of exchange rate reforms, authorised dealers in foreign exchange have now been permitted to write cross-currency options to provide customers a hedge on their foreign exchange exposure.

The rupee is expected to stabilise, given the open current and capital accounts, against the dollar, and is not expected to appreciate. On the other hand, the experience on exchange rate management in other countries suggests that unless productivity improves in the economy along with a low inflation rate with high external reserve to support the currency, it is unlikely that the currency can halt the downward moves. But, the depreciation of the currency since 1993 has been about 1.4 percent, which is a vast improvement. The RBI is pursuing a monetary policy based on sterilising the inflationary effect through foreign exchange swap operation. This is also helpful.

2.2. Pakistan[4]

During the 1991-92 reforms, the authorities announced bold measures to eliminate the black market for domestic currency and provided incentives to attract foreign direct investment. The country moved gradually to capital and current account convertibility. The State Bank of Pakistan (SBP) also issued US dollar denominated bearer certificates with a rate of return of quarter of a percent over the prevailing LIBOR. Restrictions on holding foreign currency and operating foreign currency accounts were abolished. Liberalised rules governing private sector's foreign borrowing came into effect. Authorities authorised dealers to operate and trade in foreign currencies.

These policies worked well and resident and non-residents opened foreign currency accounts. However, the confidence was completely lost when the government decided to freeze all foreign currency accounts in May 1998, when the country reached near bankruptcy as a result of economic sanctions for test firing an atomic device. Initially, the SBP fixed the exchange rate at R46 per US dollar while the open market rate reached R70. This was probably the highest difference between the official and open market rates since 1973 when the country switched to a floating rate regime. Foreign reserves fell to their lowest level, just equivalent to two weeks of imports. This was an alarming situation in itself. During closing two years of the last century, the IMF agreed to extend partial loans and reserve the situation slightly. In 1999, the government relaxed foreign currency restriction for

[4]See Ariff and Khalid (2005), Chapter 8, for a detailed discussion on currency market reforms in Pakistan.

exporters and travellers. At the same time, in order to discourage the black market for US dollars and to reduce the gap between the official and open market rates, the SBP devalued the currency and fixed it at R50 to one dollar. The currency touched a record low level of R62 to one dollar in 2001. Later, the global factors in the post September 11 scenario changed this trend. In 2002, for the first time in history, the currency gained some value in the foreign exchange market with the rupee appreciating by almost 4 percent against the US dollar. Since then, the currency movement seems to have stabilised.

2.3. Sri Lanka[5]

Sri Lanka started with a fixed exchange rate regime where rupee was 100 percent pegged in 1948 to the pound sterling: this was similar to the policies followed in most neighbouring countries. Until 1966, the regime managed to keep the rupee-sterling parity without any devaluation, though the rupee was devalued against the US dollar. This resulted in overvaluation of domestic currency and losses were visible in the trade and current account balances. The first devaluation of 20 percent against pound sterling took place in 1967 triggered by a widening trade deficit and declining export prices. In 1968, the government introduced Foreign Exchange Entitlement Certificate Scheme (FEECS), which meant a dual exchange rate system with one official exchange rate applicable to essential imports and non-traditional exports while the other rate, a bit higher, was applied to the trade related transactions. This dual exchange rate system continued until 1977 when the government decided to de-link the rupee from the pound sterling. Eventually, in November 1977, the exchange rate was unified with a managed float system. The US dollar was made the intervention currency and the rupee was devalued by a huge 46 percent. Sri Lankan rupee faced further devaluation during the 1990s. The currency market has shown some signs of stability since 1999.

2.4. Bangladesh[6]

The exchange rate has declined continually under the fixed exchange rate regime in force over most of the 23 years. The exchange rate was about 15 Taka in 1976-80 period. In the recent years, 1996-97, it takes 45 Taka to buy one US dollar, in 1999, it was Taka 48.50. The rate of decline of about 10 percent per year was rapid. The exchange value has declined to a third of its level 20 year ago. The fixed exchange rate regime was sustained with a system of multiple administered rates. These rates were unified in 1994, a year after India freed the exchange rate from controls. The secondary market in exchange rates was abolished and the rates were unified. Though accepting IMF Article 8 conditions, the exchange rate is determined by a system of daily fixing of the Taka, the currency, against the US dollar. The fix is done on the basis of the currency's real effective exchange rate, REER, a status measured on a trade weighted basket of currencies of 15 major trading partners. In this, it is a managed float of the type that is followed by almost all managed floaters.

Introduction of this managed float based on the REER led to a steadying of the exchange rate. There were continuing depreciations but at half the previous rate of declines in exchange rate in real

[5]Currency market reforms and developments in Sri Lanka are discussed on detail in Ariff and Khalid (2000), Chapter 15.

[6]Exchange rate reforms in Bangladesh are discussed in detail in Ariff and Khalid (2000), Chapter 11.

terms even after the 1994 change. But the exchange rate improved for a little while during October 1994 and March 1995 before resuming its decline thereafter. However, the volatility in the currency market has improved since 2000.

3. EMPIRICAL METHODOLOGY AND DATA

Unit Roots and Co-integration

It is well known that the data generating process for most macroeconomic time series are characterised by unit roots, which puts the use of standard econometric methods under question. Therefore, it is important to analyse the time series properties of the data in order to avoid the spurious results generated by unbounded variances of parameters estimates due to unit roots in the data. To ensure the robustness of the test results, three most commonly used unit-root tests are applied here, namely the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and KPSS unit root tests on the relevant variables. The departing feature of these three test procedures is that the null hypothesis in ADF and PP is the alternative hypothesis in KPSS. In particular, while the former (ADF and PP) is derived under the null hypothesis of unit roots the latter (KPSS) is obtained under stationary null hypothesis. If all variables are I(1) then the linear combination of one or more of these series may exhibit a long-run relationship. The multivariate co-integration test based on the Johansen-Juselius (1990) method is used to test for these long-run relationships. The maximum eigenvalue test and trace test are employed to establish the number of co-integrating vectors. If the exchange rates are co-integrated then the Multivariate GARCH model within Error Correction framework will be estimated to examine the nature of the mean transmission (Granger Causality) between these variables. However, in the absence of co-integration the Multivariate GARCH model in differenced form within VAR framework will be employed to establish the relationships (Granger Causality) between exchange rates. As we shall see latter in Section 4, the variables of exchange rates are not co-integrated and hence the multivariate GARCH in VAR framework is employed to establish the linkages among exchange rates.

Multivariate GARCH Models

Time-varying volatility properties of univariate economic time series are widely analysed through autoregressive conditional heteroskedasticity (ARCH) and generalised autoregressive conditional heteroskedasticity (GARCH) models. While the univariate GARCH models examines the time-varying nature of economic time series its multivariate extension, commonly known as multivariate GARCH (MGARCH) models, analyses the time-varying conditional cross moments. In this paper, we analyse the linkages between the exchange rates of South Asian countries of India, Pakistan and Sri Lanka and Bangladesh with their major trading partners through vector autoregressive MGARCH models. The departing feature of this technique is that it not only analyses the linkages between first moment of the variables of interest through VAR representation but also the volatility transmission between the exchange markets though GARCH specifications.

Consider the following mean equation of the VAR-MGARCH model,

$$Y_t = \alpha + \sum_{i=1}^{p} \Phi_i Y_{t-i} + \varepsilon_t \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (1)$$

Where Y_t is an $n\times1$ vector of changes in daily exchange rates at time t, $\varepsilon_t \sim N(0, \Sigma_t)$ and

$$\Phi_i = \begin{pmatrix} \varphi_{11}^{(i)} & \varphi_{12}^{(i)} & . & . & . & \varphi_{1n}^{(i)} \\ \varphi_{21}^{(i)} & \varphi_{22}^{(i)} & . & . & . & \varphi_{22}^{(i)} \\ . & & . & & & . \\ . & & & . & & . \\ . & & & & . & . \\ \varphi_{n1}^{(i)} & \varphi_{n2}^{(i)} & . & . & . & \varphi_{nn}^{(i)} \end{pmatrix}, \; i=1,2,\ldots, p.$$

The $n\times1$ vector α represents the long-term drift coefficients. The error term ε_t denotes the $n\times1$ vector of innovation at each market at time t with its corresponding $n\times n$ conditional variance covariance matrix Σ_t. The elements of the matrix Φ_i's are the degree of mean spillover effect across markets and measures the transmission in mean from one market to another. Bauwens, *et al.* (2003) provides the survey of various MGARCH models with variations to the conditional variance-covariance matrix of equations. In particular, in this paper, we adopt the model by Baba, Engle, Kraft and Kroner (hereafter BEKK), whereby the variance-covariance matrix of system of equations at time t depends on the squares and cross products of innovation ε_{t-1} and volatility Σ_{t-1} for each market [see Engle and Kroner (1995) and Bauwens, *et al.* (2003) for more details]. The BEKK parameterisation of MGARCH model is given by:

$$\Sigma_t = B'B + C'\varepsilon_{t-1}\varepsilon_{t-1}C + G'\Sigma_{t-1}G \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (2)$$

where

$$\Sigma_t = \begin{pmatrix} \sigma_{11,t} & \sigma_{12,t} & . & . & . & \sigma_{1n,t} \\ \sigma_{21,t} & \sigma_{22,t} & . & . & . & \sigma_{2n,t} \\ . & & . & & & \\ . & & & . & & \\ . & & & & . & \\ \sigma_{n1,t} & \sigma_{n2,t} & . & . & . & \sigma_{nn,t} \end{pmatrix}, \quad B_t = \begin{pmatrix} b_{11} & b_{12} & . & . & . & b_{1n} \\ b_{21} & b_{22} & . & . & . & b_{2n} \\ . & & . & & & \\ . & & & . & & \\ . & & & & . & \\ b_{n1} & b_{n2} & . & . & . & b_{nn} \end{pmatrix},$$

$$C = \begin{pmatrix} c_{11} & c_{12} & . & . & . & c_{1n,} \\ c_{21} & c_{22} & . & . & . & c_{2n} \\ . & & . & & & \\ . & & & . & & \\ . & & & & . & \\ c_{n1} & c_{n2} & . & . & . & c_{nn} \end{pmatrix}, \quad G = \begin{pmatrix} g_{11} & g_{12} & . & . & . & g_{1n,} \\ g_{21} & g_{22} & . & . & . & g_{2n} \\ . & & . & & & \\ . & & & . & & \\ . & & & & . & \\ g_{n1} & g_{n2} & . & . & . & g_{nn} \end{pmatrix} \text{ and}$$

$$\varepsilon_t'\varepsilon_t = \begin{pmatrix} \varepsilon_{1t}^2 & \varepsilon_{1t}\varepsilon_{2t} & . & . & . & \varepsilon_{1t}\varepsilon_{nt} \\ \varepsilon_{2t}\varepsilon_{1t} & \varepsilon_{2t}^2 & . & . & . & \varepsilon_{2t}\varepsilon_{nt} \\ . & & . & & & \\ . & & & . & & \\ . & & & & . & \\ \varepsilon_{nt}\varepsilon_{1t} & \varepsilon_{nt}\varepsilon_{2t} & . & . & . & \varepsilon_{nt}^2 \end{pmatrix}.$$

The elements c_{ij} of the $n \times n$ symmetric matrix C measures the degree of innovation from market i to j. The elements g_{ij} of the $n \times n$ symmetric matrix G measures the persistence in conditional volatility between market i and market j. The model represented by Equations (1) and (2) are estimated through maximum likelihood estimation procedures.

The log-likelihood for MGARCH model under Gaussian errors is given by

$$L(\theta) = -\frac{Tn}{2} + \ln(2p) - \frac{1}{2}\sum\left(\ln\left|\Sigma_t\right| + \varepsilon_t'\left|\Sigma^{-1}{}_t\right|\varepsilon_t\right) \quad \ldots \qquad \ldots \qquad \ldots \qquad (3)$$

where T represents the effective sample size, n is the number of markets and θ is the vector of parameters defined in (1) and (2) to be estimated. As in traditional approach, we use Berndt, Hall, Hall and Hausman (hereafter BHHH) algorithm to produce the maximum likelihood parameters and the corresponding standard errors. The Q-statistic developed by Ljung-Box is used to test the randomness of residuals of the estimated MGARCH model.

Granger Causality Tests

The linkages between the exchange markets are analysed using Granger causality tests. For example, the null of Granger non-causality from variable 2 to variable 1 is examined by estimating the restricted system of equations represented by (1) and (2). The null and alternative hypotheses are given by

$H_0 : \varphi_{12}^{(1)} = \varphi_{12}^{(21)} = ... = \varphi_{12}^{(p)} = 0$ (i.e., Granger non-causality from variable 2 to variable 1).

$H_1 : \varphi_{12}^{(i)} \neq 0$ for some i=1,2,…, p (there exists a causality from variable 2 to variable 1).

The likelihood ratio test statistic to test the above hypothesis is given by $LR = -2(l_R - l_U)$, where l_R and l_U represents the maximised values of the log-likelihood function, denoted by (3), of

the restricted and unrestricted system of equation specified by (1) and (2) respectively. Under H_0, the *LR* statistic has an asymptotic χ^2 with degrees of freedom equal to the number of restrictions *p*.

Data

The focus of this paper is to investigate a linkage among exchange rates of the four South Asian countries. As discussed elsewhere in this paper, we link these exchange rates to their major trading partner and try to answer three questions raised in Section 1 of this paper. Based on each country's trade statistics, we include a sample of selected countries within Asian regions, Europe, and the middle east (for imports of oil) in the VAR to test for Granger causality. Besides, India, Pakistan, Bangladesh and Sri Lanka, the other countries included in the sample are Singapore, China, Belgium, Germany, Honk Kong, Saudi Arabia, United Arab Emirates (UAE), Japan, and the United Kingdom (UK). We use WM/Reuters closing spot rates against US dollar for the above sample countries. Sample period spans from 1 January 1996 to 31 December 2003, daily observations (5-day week), a total of 2080 observations. All exchange rates are obtained from Datastream database and all variables are in log form.

4. EMPIRICAL RESULTS

Before using MGARCH model to test the Granger causality in VARs, we look at the cross correlations of the log of exchange rates (with one lag) for the sample countries. These cross correlations are reported in Table 3 and suggest a strong positive correlation among exchange rate of all sample countries. This preliminary test provides an indication of some currency market linkage. A more sophisticated multivariate GARCH will show if these preliminary tests are robust or not. The univariate time series properties of the relevant data series are analysed through ADF, PP and KPSS unit root test procedures. The results reported in Table 4 shows that all variables which are in logarithmic form are non-stationary. The test result based on first-differenced series also reaffirms that all variables are I(1) and the linear combination (cointegrating vectors) of one or more of these series may exhibit a long-run relationship. The maximum eigenvalue and trace test results to establish the numbers of co-integrating vectors are reported in Table 5. The results show that there does not exist a long run relationship among exchange rates and hence the Multivariate GARCH model in differenced form within VAR framework is estimated.

Table 3

Asian Exchange Rates (Levels)
(1st March 1994 to 31 December 1999)

	ERHON	ERIDN	ERJAP	ERMLY	ERPHI	ERSIN	ERKOR	ERTAI	ERTHA	ERIND	ERPAK
ERHON	1.00										
ERIDN	0.69	1.00									
ERJAP	0.38	0.66	1.00								

ERMLY	0.63	0.93	0.59	1.00							
ERPHI	0.70	0.97	0.66	0.94	1.00						
ERSIN	0.57	0.87	0.58	0.91	0.91	1.00					
ERKOR	0.64	0.95	0.73	0.89	0.95	0.85	1.00				
ERTAI	0.68	0.97	0.77	0.92	0.96	0.85	0.95	1.00			
ERTHA	0.66	0.93	0.70	0.90	0.96	0.86	0.95	0.95	1.00		
ERIND	0.79	0.89	0.69	0.85	0.89	0.72	0.84	0.93	0.84	1.00	
ERPAK	0.80	0.86	0.71	0.84	0.87	0.71	0.84	0.90	0.85	0.97	1.00

Table 4

Unit Root Test Results

	Levels			Differences		
	ADF	PP	KPSS	ADF	PP	KPSS
India	–0.04	–0.18	1.02***	–40.26***	–40.56***	0.11
Pakistan	–0.82	–0.71	1.12***	–45.88***	–45.88***	0.05
Singapore	–1.35	–1.29	1.03***	–47.58***	–47.96***	0.04
Sri Lanka	–1.12	–1.07	0.52***	–42.47***	–43.49***	0.12*
Bangladesh	–2.07	–2.18	0.80***	–45.31***	–45.39***	0.03
China	–1.79	–1.81	0.99***	–54.22***	–54.81***	0.07
Belgium	–0.19	–0.19	0.99***	–44.85***	–44.31***	0.10
Germany	–0.19	–0.28	0.99***	–44.93***	–44.90***	0.11
HK	–1.85	–1.92	0.69***	–51.34***	–51.32***	0.06
Saudi Arabia	–1.39	–1.24	0.55***	–24.21***	–24.42***	0.05
UAE	–2.49	–2.48	0.34***	–18.39***	–19.31***	0.06
Japan	–1.97	–2.18	0.34***	–44.28***	–44.15***	0.06
UK	–0.64	–0.73	0.66***	–42.77***	–43.12***	0.16**

Notes:

1. *, ** and *** denote 10 percent, 5 percent and 1percent levels of significance respectively.
2. The lag length for ADF is justified by Akaike's Information Criterion (AIC) and Schwartz Criteria (SC).
3. The trend characteristics are not reported here and can obtained from authors.

Table 5

Trace/Maximum Eigenvalue Tests for Cointegration

Trace Test		Maximum Eigenvalue Test	
Hypothesis	Test Statistic	Hypothesis	Test Statistic
r = 0	751.59***	r = 0	393.48***
r $\leq$ 1	358.11	r = 1	52.20

$r \leq 2$	305.91	$r = 2$	59.19
$r \leq 3$	246.72	$r = 3$	56.66
$r \leq 4$	190.06	$r = 4$	44.21
$r \leq 5$	145.85	$r = 5$	41.79
$r \leq 6$	104.06	$r = 6$	31.15
$r \leq 7$	72.91	$r = 7$	23.13
$r \leq 8$	49.79	$r = 8$	18.70
$r \leq 9$	31.08	$r = 9$	11.91
$r \leq 10$	19.17	$r = 10$	11.36
$r \leq 11$	7.81	$r = 11$	7.76
$r \leq 12$	0.05	$r = 12$	0.05

Notes: 1. *, ** and *** denote 10 percent, 5 percent and 1 percent levels of significance respectively.

2. The lag length (4) is justified by Akaike's Information Criterion (AIC) and Schwartz Criteria (SC). Both criteria lead to similar conclusion.

In order to examine the linkages between the exchange rate markets, we consider two competitive models. In the first model, the lag length *p* is justified by AIC and SC criteria and it suggests the parsimonious representation of lag 1 in the VAR representation described by (1). In the second model, we restrict the lag length to be 4. In both models, the volatility equation described by (2) is restricted to GARCH (1,1) specification. For brevity, the estimated coefficients for the mean equations with lag 1 and lag 4 are not reported here. However, these results are available from the first author upon request. And the corresponding Granger causality test results are presented in Table 6 and Table 7, respectively. Obviously, Table 6 and Table 7 are of more interest for the purpose of this paper. We therefore focus our discussion on the Granger causality results.

The results of Table 6 are less supportive to a case for currency integration. The results suggest that Chinese yuan is the only currency that influences Indian rupee. Pakistan rupee is not influenced by any currency in the sample. Sri Lankan rupee is affected by changes in Chinese yuan and Japanese yen while Bangladesh is only affected by Japanese yen. The results do not find any cause or effect within four South Asian currencies. The results in Table 7 are more interesting. These results suggest that Indian rupee is affected by changes in Singapore dollar, yen and pound sterling. Given that Singapore has made significant investment in India during the late 1990s to early 2000s and that the Singapore dollar has been volatile during the period under study, this result is not surprising. Pakistan rupee is also influenced by Singapore dollar, yen, the pound sterling and Bangladesh taka. Although, Singapore does not have much investment in Pakistan, but has been one of the major trading partner in the region. Japan is a major import market for Pakistan. Pakistan also receives aid and loans from Japan. These two factors may exert sufficient influence on the currency, especially, given Pakistan's high indebtedness. The currency in Sri Lanka is influenced by changes in Chinese yuan and Japanese yen, while Bangladesh taka is only affected by Chines yuan.

Table 7 also looks into how the four South Asian currencies affect the other currencies in the sample. The results suggest that Indian rupee has some effect on Chinese yuan, Hong Kong dollar, and Saudi Arabian riyal. It should be noted that India has developed as one of the major software market in the world. They have also taken up a big share in meeting world's demand for floppies and disks. They are, in a way, a competitor to China in this industry. Saudi Arabia is a major oil

exporter for India and provides a basis for some currency links. With the same token, Saudi riyal does not affect Pakistan rupee. Changes in Pakistan rupee causes Hong Kong dollar, yen and pound sterling to change. This could be due to huge external borrowing of the country which poses a high risk to the creditors and hence may exert some effect on their currencies. Although, Saudi Arabia is a major oil exporter to Pakistan, the riyal does not seem to affect the Pakistan rupee. This probably is due to the concessional oil import arrangements Pakistan enjoys with

Table 6

Parsimonious Model: Granger Causality Test Results

VAR(1)–MGARCH(1,1)

Effect → Cause ↓	India	Pakistan	Singapore	Sri Lanka	Bangladesh	China	Belgium	Germany	HK	Saudi Arabia	UAE	Japan	UK
India	34.21***	1.47	0.02	0.13	0.07	5.17***	0.39	0.32	3.57**	0.07	0.02	0.14	0.00
Pakistan	0.19	0.01	0.02	0.02	2.24*	0.26	0.14	0.18	0.44	0.90	0.23	0.29	1.58
Singapore	1.14	2.11	6.54***	0.39	1.02	1.32	0.19	0.19	5.68***	0.03	1.01	10.72***	0.16
Sri Lanka	0.87	1.65	0.03	4.57***	0.08	0.19	0.79	0.78	0.00	0.06	0.00	0.08	2.24*
Bangladesh	0.41	1.08	0.36	0.51	0.23	0.27	1.43	1.49	0.17	0.02	0.04	0.65	1.43
China	2.71*	1.91	0.47	2.69*	0.46	60.58***	0.90	0.99	0.00	0.29	0.01	0.28	0.47
Belgium	0.92	0.40	1.77	1.34	0.36	0.84	0.19	3.08*	0.37	0.01	19.15***	1.17	1.85
Germany	0.83	0.43	1.61	1.25	0.36	0.87	0.08	2.58*	0.40	0.01	19.44***	1.12	1.46
HK	0.01	0.05	0.07***	1.31	0.29	0.03	0.44	0.42	29.47***	0.45	0.04	0.94	1.23
Saudi Arabia	0.02	0.68	9.28	0.05	0.27	0.26	0.03	0.01	5.41***	2.64*	1.77	2.70*	0.29
UAE	0.44	0.01	0.55	0.42	0.76	3.62**	0.69	0.98	0.23	0.30	586.24***	0.01	5.06***
Japan	0.16	0.30	0.19	5.58***	3.24*	0.14	3.63**	3.51**	7.12	8.30***	0.13	8.85***	0.12
UK	0.03	0.70	4.11***	1.09	0.40	0.17	0.96	0.83	3.33*	0.57	1.95	0.40	2.18*

*, ** and *** represents rejection of the Granger non-causality at 10 percent, 5 percent and 1 percent respectively.

Table 7

Table 7

VAR(4)–MGARCH(1,1): Granger Causality Test Results

Effect → Cause ↓	India	Pakistan	Singapore	Sri Lanka	Bangladesh	China	Belgium	Germany	HK	Saudi Arabia	UAE	Japan	UK
India	42.5***	2.2	1.7	0.7	2.8	14.3***	1.6	1.4	8.4*	16.6***	1.5	2.2	1.6
Pakistan	3.6	7.4*	2.0	2.6	3.2	0.4	3.2	3.0	8.4*	0.7	3.4	13.1***	7.9*
Singapore	12.4***	9.3**	17.8***	1.0	1.9	2.5	7.3*	7.6*	13.6***	14.9***	2.3	5.2	7.8*
Sri Lanka	1.2	2.5	6.7*	10.9**	0.3	0.7	1.4	1.3	2.2	2.5	0.4	3.4	4.5
Bangladesh	5.1	8.1*	0.8	4.3	1.5	2.0	5.6	5.8	0.4	1.4	3.9	4.9	2.8
China	4.1	2.6	1.4	9.1**	2.3	72.1***	1.7	1.8	2.3	0.8	14.9***	0.2	8.8*
Belgium	3.5	0.7	6.4*	2.9	2.7	4.1	2.0	4.2	4.9	1.6	16.9***	4.8	2.8
Germany	3.9	0.5	6.4*	2.7	3.1	4.0	2.1	3.9	36.9***	1.8	4.2	5.5	2.5
HK	4.3	0.3	12.9***	4.6	0.6	2.7	2.6	2.2	13.5***	13.6***	1.1	4.7	1.2
Saudi Arabia	0.3	3.1	74.6***	0.3	0.5	0.3	2.7	2.7	4.8	356.2***	118.7***	11.5**	12.2***
UAE	1.7	3.7	0.7	1.1	1.7	7.2*	2.7	2.8	10.7**	13.2***	448.9***	11.8***	0.3
Japan	11.0**	9.9**	6.7*	6.4*	6.1*	0.9	9.4**	9.6**	12.2***	0.9	1.4	5.4	5.9
UK	6.6*	7.0*	14.3***	1.5	1.3	3.1	5.5	5.2	8.4*	2.6	0.9	9.8**	9.2**

*, ** and *** represents rejection of the Granger non–causality at 10 percent, 5 percent and 1 percent respectively.

Saudi Arabia. Singapore dollar is the only currency caused by Sri Lankan rupee. Bangladesh taka only affect Pakistan rupee. Surprisingly, we could not find any empirical support of a close link among the four South Asian currencies expect some weak support between Pakistan rupee and Bangladesh taka.

Moving our attention to the next important question. If the world currency market converges to a try polar regime, as predicted by some economists, which currency would be is a good candidate to be an anchor currency in the South Asian region. Germany and Belgium represent euro in our sample. The empirical findings of this paper did not find any cause or effect between the four currencies and the euro. The results suggest that a change in pound sterling would affect only Indian and Pakistani rupee. However, yen turns out to be a strong link for all four countries. Another interesting observation is the cross linkages of these currencies. It is evident from our empirical results reported in Table 7 that yen has a strong influence on other currencies such as Singapore dollar, Hong Kong dollar and euro. Interestingly, both Singapore dollar and Hong Kong dollar are also influenced by euro and pound sterling. We also found a bi-directional causality between Singapore dollar and Hong Kong dollar.[7] Finally, Singapore dollar seems to have significant influence on both Indian and Pakistani rupee.

Summarising these results, it is evident that yen has strong influence on the four currencies and causes movement in the exchange rates of these countries. This could mean that if these countries have to choose one currency, yen, probably, would be the best choice.

5. CONCLUDING REMARKS

The recent developments in the international currency markets indicate that in the next decade or two, the world's exchange rate regimes will converge to three major currency regions. The first will be dominated by the US dollar, the second, with euro and the third with Japanese yen, with a small fraction still using Pound sterling as the anchor currency. These widely anticipated developments will have important implications for some emerging economies such as the South Asian region. In this paper, we focus on four South Asian economies, namely, India, Pakistan, Bangladesh and Sri Lanka. Besides providing a comprehensive overview of the reforms and developments that took place in the currency markets of the four during the last 55 years, we provide some empirical evidence to the questions raised in this paper using high frequency data and recently developed econometrics test procedure to investigate any causal relationship among regional currencies. The empirical evidence found in this paper are not very conclusive to support a close interlink among the regional currencies. However, these results single out Japanese yen to serve as the main link among the four currencies. These findings may have important implications for future policy design.

However, the empirical tests performed in this paper have some limitations. We did not include US dollar in this analysis. A more meaningful exercise would be to include US dollar and then compare the results. To make a strong case for financial market integration, one should also extend this research to include other indicators such as stock prices and interest rate.

[7]Such bi-directional causality between the two currencies is also supported by Khalid and Kawai (2003).

Another possible avenue is to identify some specific shocks and then see the responses on these four markets. Some of these extensions are underway by the authors and will be presented at a later stage. Nevertheless, this paper serves as an initial step to investigate some important issues in the South Asian context and have important implications for any future policy design. This is an important contribution of this research.

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