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# Stock Market Interlinkages in Emerging Markets

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## 1. INTRODUCTION

Among all type of markets, the stock markets are the most volatile and most sensitive to external as well as internal news. This is because stock markets work on spot and the potential for instant profits (or losses) makes them a platform for intense speculative activities. How can one predict the future trends in a stock exchange and its influences on the other stock exchanges, has always been a fascinating question. With the never exhausting innovations in communication and information technology, it could be expected that the stock exchanges all over the world are closely interlinked and no stock exchange can be immune to external influences. The recent experience of stock markets crash in the Far East and its repercussions for the neighbouring markets is but one example of how the so-called 'mass psychology' can make stock markets so fragile.

The literature has provided several theories to explain stock markets interlinkages. According to the Perfect Arbitrage proposition, under the conditions of free capital mobility financial capital will continue to be transferred from the low-return markets towards the high-return markets until the rates of return are equalized across markets. Capital Assets Pricing Models, applied to national stock indices throws some light on the reasons for the failure of perfect arbitrage outcomes on the basis of differential risks in various markets. The market specific risk could differ due to differences in the institutional factors, economic conditions and political set-up within which various markets operate. Nevertheless how closely interlinked are the world stock markets remains an empirical question and the evidence is not conclusive.

Stock market interlinkages provide a great deal of information. If, for example, two weak and fragile markets are closely interlinked then they would react to each other's noise. This information is useful for the investors who have diversified their portfolio of investment in the many markets. From the nature of inter-market correlation structure the investors can determine their optimal portfolios. Furthermore, they can also adjust their portfolios in the light of shocks emanating from any one market.

The size and direction of correlation coefficient between the rates of return in two markets determine the degree by which risk can be reduced through diversification. A perfect negative correlation is the ideal situation and a less than perfect negative correlation is also desirable. A positive correlation is not desirable while a perfect positive correlation implies that the risk cannot be reduced by diversification.

Several studies have been undertaken to investigate the nature of stock markets interlinkages for the developed world. But most of the work on emerging markets is based on descriptive analysis of stock markets data. With the recent opening up of so-called less developed markets, the concept of emerging markets has attracted a lot of attention in the economics and finance literature. Coupled with recent developments in time series econometrics suitable for the analysis of financial markets, it is not surprising that financial economics has taken a very important position in economics literature.[1]

With the above background the present study attempts to provide a systematic analysis of stock price co-movements in a sample of fifteen emerging markets. Nine of these markets are from Asia while the remaining six are from Latin America. The purpose of taking this sample is not only to study the intra-continental interlinkages but also to compare these interlinkages with the inter-continental interlinkages.

In addition to the interlinkages among the emerging stock markets, the study also analyzes their relationship with the world and major regional indices and with the leading country indices. The study uses monthly stock indices for the sample countries over the period January 1990 to December 1996 and uses a variety of statistical tests to investigate various aspects of stock market integration.

Our specific objective is to address the following questions: How significant are the co-movements in stock returns within and across the two sets of emerging markets? Is the degree of co-movements dependent on time horizon? That is, are the interlinkages across stock markets stronger or weaker in the long run as compared to the short-run? Are the stock markets co-movements stable? Does the level of stability in stock markets co-movements increase in the long run as compared to the short-run? To answer these questions a variety of statistical tests are used. Most of the results on inference are derived from the application of advanced tests on correlation matrices. However, for detailed analysis we also apply various tests on the individual correlation coefficients.

The paper is planned as follows. Section 2 provides a review of literature on stock markets integration. In this section some of the studies on international

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[1]Two popular developments in econometrics, namely the Co-integration Analysis and ARCH family of models has served as convenient tools of analysis in financial economics. These techniques have been rigorously used for the study of market integration and risk return analysis. [See, for example, Arshanapalli and Doukas (1993), DeFusco, Geppert and Tsetsekos (1993) and Uppal (1993)].

portfolio diversification and relative market performance will also be reviewed. In Section 3, we describe the methodology based on descriptive analysis and statistical tests. Data and the results of descriptive analysis are explained in Section 4. Section 5, which is the focus of the report, provides the results of statistical tests. Finally, Section 6 consists of concluding remarks.

## 2. REVIEW OF LITERATURE

A large number of studies on market integration have been conducted using descriptive as well as sophisticated statistical methods. We shall discuss a few of them in this section. We start our review with the studies that are based on correlation structure among stock price indices. These studies typically apply statistical tests to find out the departure of correlation matrices from orthogonality or their stability over time. For example, Haney and Llyod (1978) examined the interrelationship among the stock price indices of twenty-two countries, mostly developed, by testing the stability of correlation coefficients. The study used monthly data on industrial share price indices over the period January 1966 to June 1975. The finding showed that 86 out of 231 coefficients or 37 percent were not equal to zero. Since most of the statistically significant correlation coefficients were positive, the study concluded that it is difficult to achieve substantial gains through international diversification of assets.

Kaplanis (1988) examined the issue of intertemporal stability of the co-movements among ten developed markets. The stability was examined both for the correlation and the covariance matrices of the rates of returns. The sample period 1967 to 1982 was divided in two six sub-periods to apply two alternative $\chi^2$-tests, namely Box-test and Jennich-test in order to examine the stability. The results show that the correlation structure of international equity return was quite stable over time while the covariance structure was relatively less stable. The study observed that instability of the covariances was due to significant changes in the ranking, rather than the level, of market pairs with respect to the covariance.

The study also compared the performance of various models for forecasting rates of return. The study considered a historic model, which assumes that correlation coefficients for the forecasting period t are the same as in period t–1, and the naïve mean model which assumes that each correlation coefficient in period t is equal to the average of all the correlation coefficients in period t–1. In addition the study also applies a Bayesian model and a regression model. The study concludes that the Bayesian model provides somewhat better forecasts for the correlation coefficients than the other models, although the regression model estimates could potentially improve if adjusted for order bias.

In a similar study, Meric and Meric (1989) analyzed the inter-temporal stability of the matrix of correlation coefficients among international stock markets. Using monthly data for 17 stock markets from developed countries for the period January

1973 to December 1987, the study applies $\chi^2$-test based on Box-M to the correlation matrix.[2] The evidence shows that the longer the time period considered, better will the ex-ante patterns of co-movement of international stock markets approximate the ex-post co-movement. The findings show that diversification across countries yields larger gains than the gains from diversification across industries. Furthermore, diversification across countries even within an industry results in greater risk than diversification across industries within a country.

Shaked (1985) examined the intertemporal stability of correlation coefficients based on monthly total returns on sixteen developed stock markets. The monthly stock market returns were used for the period from January 1960 to December 1979. The results indicate that the degree of stability in the international correlation structure increases consistently as the investment horizon is lengthened. The higher degree of stability observed for longer periods might reflect some frictions in the transmission of international common factors in which case the underlying stability in the correlation structure is temporarily disturbed by lagged responses to economic shocks.

Using correlation matrices for stock price indices and rates of return, Dwyer Jr. and Hafer (1988) investigated the connection among stock prices in the United States, Germany, Japan and the United Kingdom. The statistical relationships between the levels and movements of stock price indices were based on two data sets: daily stock prices from July 1987 through January 1988 and monthly stock prices from 19[illegible] through 1987. Daily data for three months before and after the October 1987 crash showed no evidence that the levels of indices for the United States, Japan, Germany and United Kingdom were related. The same result was found on the basis of monthly data for 31 years. This means that the level of indices showed no tendency to return to any particular value related to each other. The study, therefore, concludes that using different holding period does not affect fundamentally the results regarding link between the markets.

A number of studies have also analyzed stock markets integration using time series models such as vector autoregressive models (VAR), co-integration and autoregressive conditional heteroskedastic (ARCH) models. Applying vector autoregressive (VAR) model to the rates of return measured by the first difference of the natural logs of daily stock price indices, Jeon and Fuerstenberg (1990) analyzed interrelationship among stock prices in the major world stock exchanges. The markets included in the analysis were Tokyo, Frankfurt, London and New York and covered the period January 1986 to November 1988. The evidence showed that a significant shift had taken place in the correlation structure of returns after the stock market crash of October 1987. Evidence of this changing pattern in the interrelationship of the major world stock exchange was found consistent with both the impulse response function

[2] This test is explained in detail in Section 3.

analysis in the VAR model and with the OLS form of the lagged price change model. The study concludes that the rationale for international portfolio diversification must be re-examined in the light of the greater national co-movements in stock prices.

Using weekly data for the period January 1989 to May 1993, DeFusco, Geppert and Tsetsekos (1993) examined long run diversification potential in thirteen emerging capital markets. Applying ADF (Augmented Dickey-Fuller) tests for unit roots, the study found that stock prices in all the markets are integrated of order one. These markets were then grouped into three regions: Latin America, Pacific Basin and the Mediterranean; and Johansen's cointegration tests were applied. In no region were the stock prices indices found to be co-integrated. The study, therefore, concludes that national equity markets are not linked by common stochastic trends within any region.

Arshanapalli and Doukas (1993) studied the linkages among stock prices in major world stock exchanges, namely the USA, UK, Germany, France and Japan, using daily closing data from January 1980 to May 1990. The paper also examined the relationship of stock price indices before and after the October 1987 crash. For testing co-integration among the stock markets, Augmented Dickey-Fuller tests for cointegration were applied. The study found that for the pre-crash period, three major European stock markets i.e., France, Germany and UK were not related with the US stock market. However, for the post-crash period the results showed that these three markets were indeed strongly co-integrated with the US market. Finally, the finding shows that the Japanese equity market has no link with both the US stock market and the stock markets in France, Germany and UK during the pre- and post-October crash period.

Uppal (1993) examined the relationship between prices in the Pakistani equity markets and international equity markets. In this study the countries selected for focusing on the relationship to the Pakistani stock market are Australia, India, Japan, Korea, UK and USA Except for India and Korea, the selected countries are major trading partners of Pakistan. The data used consist of monthly share price indices from July 1960 to June 1992. The author used the GARCH (p, q) model to investigate the spillover effects in mean stock return and volatility from these markets to the Pakistani market. The results indicate that in the recent period there is evidence of integration of the Pakistani market with the stock markets in Japan and Korea. The integration with other markets is, however, lacking. The study concludes that regional stock markets may be exerting a greater influence on the Pakistani stock market than the more distant markets.

A substantial amount of research on the subject is based on regression analysis applied to stock market data. For example Chan, Karolyi and Stulz (1992) and Harvey (1995) applied international capital assets pricing model (ICAPM) to analyze stock-market interlinkages. Chan, Karolyi and Stulz (1992) examined foreign influence on the risk premium on the US assets. They considered Nikkei, 225 Stock Average (for Japan), Morgan Stanley Japan index in Yen and Morgan Stanley EAFE (Europe, Australian and the Far East) index in dollars. Using daily data over the period January 1978 to December 1989, the study found that the excess returns on the US stocks are positively related to the conditional covariance between the return on these stocks and the return on a foreign indices but are not related to own conditional variance. The authors were unable to reject the ICAPM at the 5 percent level of significance. These tests support the hypothesis that markets are internationally integrated over the sample period.

Using monthly data from 1976 though 1992 for twenty-one industrial markets and twenty emerging markets, Harvey (1995) explored the sensitivity of returns in the emerging market to a measure of the global economic risk. The study examined the model of five global risk factors: the world-market equity return, the return on a foreign currency index, a change in the price of oil, growth in the world industrial production and the world inflation rate. Tests of the conditional ICAPM revealed that only few emerging markets had significant exposures to these factors. However the study found that many emerging markets were integrated into the global capital market during the sub-period 1985-91.

The study concludes that, although many of the emerging markets are not well integrated into the global market, the level of integration has increased over time. Thus large capital inflows from industrial economies, beginning in the late 1980s have caused prices in emerging markets to reflect covariance risk with the world portfolio.

In a more refined framework Korajczyk (1996) suggested a measure of the deviations from the law of one price or the 'pricing error' across potentially segmented capital markets. The pricing error is defined as the deviation of true expected return from the return implied by asset pricing model. To estimate the pricing error, the study proposes to regress stock price return on a set of realized state variables or factors. The estimated part of the equation represents the expected return while the random variations around the estimated equation measure the effects of unexpected shocks. If the markets are integrated and the multi-factor asset pricing model describes expected asset returns then the arbitrate pricing conditions would hold and the intercept of the equation will be zero. A non-zero intercept, therefore, represents pricing error, which could arise due to differential price of risk across markets. Thus the estimated intercept in the equation can be taken as a measure of pricing error. A smaller pricing error implies greater market integration. Also an increase (decrease) in pricing error over time implies a shift towards market segmentation (integration).

This measure was applied to stock returns from twenty-four national markets consisted of four developed markets and twenty emerging markets. The results showed that market segmentation was much larger for emerging markets than for the developed markets. The study observed that this result is consistent with larger barriers to capital flows into or out of the emerging markets. Furthermore, the proposed measure yields results that are consistent with reasonable a priori expectations about the relations between effective integration and explicit capital controls, capital market development and economic growth.

King, Sentana and Wadhwani (1994) studied the role of economic variables in accounting the time-variation in covariances between markets and accessed the extent of capital market integration. Data on sixteen national stock markets of developed countries were used to estimate a multivariable factor model in which the time-varying volatility of returns was induced by changing volatility in the underlying factors. The monthly data used over the period 1970 to 1988 of ten macroeconomic variables that might have affected stock returns were analyzed. These variables are: (i) yield on the US Treasury Bills; (ii) an index of yields on long-term bonds for the $G_3$ group of countries; (iii) the dollar-deutschmark exchange rate; (iv) the dollar-yen exchange rate; (v) industrial production for the $G_3$ group of countries; (vi) inflation in $G_3$ countries; (vii) the US trade deficit; (viii) real money supply in $G_3$ countries; (ix) real oil price in the US dollars; and (x) an index of real commodity prices. Unanticipated returns were assumed to depend on innovations and observable variables. The risk premium on an asset was made a linear combination of the risk premia associated observable and unobservable factors. The research findings show that unobservable factors are more important in explaining stock returns than the observable factors. The study also found that idiosyncratic risk was significantly priced and that the price of risk was not common across countries. These results are consistent with the view that global stock markets were not integrated.

Bekaert (1995) attempted to identify the relationship between a stock market's integration with international financial market; broadly defined investment barriers and other return characteristics. A multi-factor model was used to derive expected returns. The study identified the following effective barriers to global equity-market integration: poor credit rating, high and variable inflation, exchange rate controls, lack of high quality regulatory and accounting framework, the lack of sufficient country funds and the limited size of some stock markets.

Using data on nineteen emerging markets over the period December 1976 to December 1992, the study concluded that improvements in the provision of information to the potential investors, accounting standards and investment protection can significantly contribute to integration of emerging markets with the global equity market. The study also concluded that the increased openness dces not have any significant effect on the level of volatility in stock return. Thus the fear that foreign-market access leads to increased volatility does not find empirical support. The policy prescription was that an economy should try to eliminate or lessen the impact of barriers that can effectively segment the local market from the global capital market.

The study also observed that the measure of capital market integration was positively related to capital flows and negatively related to domestic capital costs. The article did not detect significant correlation between the market-integration measure and cumulative capital flows. This implies that while, the extent of market integration is influenced by the current size of capital flow, the past capital flows have no affect on the current state of market integration.

Ammer and Mei (1996) developed a new framework for measuring financial and real economic integration by estimating co-variation between components of returns on national stock markets. Using the state variables: treasury bill rate, equity excess return (over the treasury bill rate) and dividend yield, the study-decomposed returns in the three parts. The return associated with dividend yield is labeled as the long-run real component while the one associated with excess return and treasury bill rate are called the future expected return innovation and future interest rate innovation respectively. Using monthly data for the United States and the United Kingdom from 1957 to 1989, the study measured real integration between two countries by the correlation between the long-run real components of the two stock returns. By examining the co-movements of future expected return, the study could detect co-movements in expected returns and more accurately measure the degree of financial integration.

The study found a substantial degree of both real and financial integration between the United States and the United Kingdom economies. Although common news about future risk premia accounted for the bulk of the covariance between the two countries' stock markets, the divided growth components of the two returns were also highly correlated. The article also discovered that the correlation between future dividend growth in the two countries was stronger than the correlation between real outputs. This result was also confirmed by the application of the model to a set of fifteen developed countries. This suggested that there were lags in the international transmission of real economic shocks. The results implied that contemporaneous output correlation may in general understate the magnitude of international integration.

Using the framework of factor analysis, Ripley (1973) investigated systematic co-variation between stock prices in a set of 19 developed countries.[3] The article attempted to measure the extent of co-variation in national stock markets and to isolate and identify the patterns of linkages between these markets. Monthly stock price indices were used over the period 1960 to 1970. The four countries in the sample with high level of common movement were the USA, Canada, Switzerland and the Netherlands, while those with exceptionally low levels of common movement included Finland, South Africa and Denmark.

A substantial amount of research on the subject is also based on general descriptive review on stock price data and for the sake of variety we shall discuss a few of such studies. Claessens (1995) found that equity flows to developing countries have increased during the early 1990s. Reviewing the earlier empirical evidence, the study observed that markets of developing countries have become more integrated with the world financial markets and this integration has reduced the risk-adjusted cost of capital. Further more, the empirical evidence did not support the view that equity flows

[3] Factor analysis is a multivariate procedure to identify the sources of common movements in a variable. For details see Ripley (1973).

were more volatile than other types of capital flows. The study concludes that foreign equity investment can benefit developing countries and in order to further increase the benefits, developing countries should lower barriers to foreign equity flows.

Tesar and Werner (1995) examined the US equity flows to emerging markets. They used both annual and quarterly data from 1978 to 1991 to analyze the trends in emerging markets' statistics and the flow of US capital to these markets. It was observed that, despite an increase in the US equity investment in foreign equities, including investment in emerging stock markets, the U. S. portfolio remained strongly biased towards domestic equities. The study also found that the increase in U. S. equity investment in emerging stock markets has been roughly in proportion to the share of emerging stock markets in the global market capitalization value. However, volatility of the US transactions was found to be higher in emerging-market equities than in other foreign equities. Finally, the study did not find any relationship between the volume of US transaction in foreign equity and local turnover rates or volatility of stock returns.

Mullin (1993) examined the effects of structural reforms during late the 1980s and the early 1990s on equity portfolio inflows in nine of the most highly capitalized emerging markets: Argentina, Brazil, Chile, Mexico, South Korea, Taiwan, Malaysia, Thailand and India. The article explained broad trends in developing countries' equity markets, giving attention to the integration of these markets with the global financial system, and analyzed how these markets had become more like the developed countries' markets. Between 1976-92 annualized equity return exceeded 20 percent in Argentina, Chile, Mexico, South Korea and Thailand. Equity returns in Chile and Mexico soared to almost 50 percent per year during 1990-92. The study concludes that the structural changes that had encouraged equity portfolio flows into emerging markets had helped in the integration of these markets with the global financial system.

# 3. METHODOLOGY

## 3.1. Introduction

In this Section we shall discuss various statistical procedures to address a number of issues related to integration of a sample of emerging stock markets in Asia and Latin America. The methods of measuring market integration vary both in terms of statistical methods and the level of sophistication. A naïve procedure, which is still popular in finance literature, is to use descriptive statistics. More advanced statistical procedures include parametric and non-parametric tests based on correlation matrices and the co-integration techniques. We shall follow a variety of statistical methods, both descriptive and inference based, to analyze stock market integration.

For the above reasons, we shall apply only statistical tests for our analysis. Although no econometric technique will be used in the report, yet we shall be able to perform our main task in a satisfactory manner. In the following sections we shall explain step by step, various statistical procedures that we shall follow in the report.

### 3.2. Descriptive Measures of Market Integration

A very simple procedure to assess market integration is to study the time profile of some key variables, such as stock price indices or the rates of return, with the help of tables and graphs. This simple procedure provides meaningful information in the simplest terms.[4] A more useful information can be revealed through the profiles of stock price returns and volatility, measured by variance, along with other descriptive statistics for the markets under consideration (e.g., DeFusco, Geppert and Tsetsekos (1993), Grubel and Fadner (1971), Korajczyk (1996), Richards (1996) and Tesar and Werner (1995). For the market integration the most revealing descriptive statistic is correlation coefficient between the stock returns of two countries. This information is usually provided through correlation matrices [e.g., Dwyer Jr. and Hefer (1988), Haney Jr. and Lloyd (1978), Harvey (1995) and Mullin (1993)].

Following this convention, we shall start with descriptive analysis of the emerging markets. In particular, we shall present the time profiles of stock price indices, rates of return, variances and simple correlation coefficients.

### 3.3. Preliminaries for Testing Stock Market Integration

Most of the statistical tests for stock market integration are based on correlation coefficients and their transformations. A standard procedure is to test the null hypothesis that the population correlation coefficient between the two variables is zero. However when the objective is to test the significance of relationship among more than two variables, one would need to apply a joint test that can determine the significance of the whole correlation matrix. The objective is to determine if the departure of a sample correlation matrix from the identity matrix is systematic or it can be attributed to sampling error. For this purpose, we shall make use of a number of $\chi^2$ tests [See Meric and Meric (1989) and Jenrich (1970)].

In the context of stock market integration, what are important are not only the existence of co-movements in stock prices across nations, but also the stability of this relationship over time. As a matter of fact, the literature on stock market integration is concerned more with the stability of correlation matrices than with their departure from orthogonality. A variety of statistical procedures can be used for testing the stability of co-movements in stock prices.

Another issue that must be settled before we move to technical jargons is to decide as to which particular variable relating to stock markets is best suited for the

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[4] See for example Errunza and Losq (1985), Gerard, Dwyer, Jr. and Hafer (1988), Hartmann and Khambata (1993) and Solnik (1974).

analysis of stock market integration. Two variables that can be relevant are the stock prices and capital movements. The data on inter-country capital movements are not as readily and as reliably available as on stock price indices, especially on the temporally disaggregated level such as on monthly or weakly basis. Another factor that favours the use of stock price indices against the use of capital movements is that most of the statistical procedures especially useful in this context are applicable on the stock price movements. Another argument in favour of using stock price data is that one of the objectives of studying stock market co-integration is to test the perfect arbitrage hypothesis, whereby under free capital mobility, the stock price indices across countries are equalized except for a scalar transformation. Finally, the stock prices are determined on spot in competitive markets and, therefore, they fully absorb and reflect the effects of capital movements.

Given that the stock price data are suitable for the proposed analysis, the next question is as to whether the stock price indices should be used in absolute terms or they should be somehow transformed for the statistical analysis. Since the objective is to determine co-movements in stock prices from period to period, a stronger test would be based on the relative changes in stock prices over time. The standard practice is to consider the logarithmic first difference of stock price indices over a sequence of time periods called the holding periods. The logarithmic changes approximate the percentage changes and measure the rate of return over the holding period.

### 3.4. Testing the Significance of Stock Price Co-movements

Our first task is to determine if there exists a significant relationship among the rates of return within our sample of fifteen countries and within the two sub-samples comprising of Asian and Latin American countries. Posing the null hypothesis that the correlation matrix is an identity matrix against the alternative that at least one of the off-diagonal terms in the matrix is non-zero can test the significance of correlation among a group of variables. This null hypothesis can be tested using Kullback-Jenrich $\chi^2$-statistic. Kullback (1967) originally proposed the test and later on Jenrich (1970) proposed a correction. The test proceeds as follows.

Suppose there is a k-variate normal population with the correlation matrix P. Suppose this correlation matrix is estimated using a sample of 'n' observations. The null and alternative hypotheses are as follows.

$$\textit{Hypothesis 1} \qquad H1_0: \quad P = I_k$$
$$H1_A: \quad P \neq I_k$$

where $I_k$ is a k×k identity matrix. If the estimate of the correlation matrix based on a random sample of n observations is denoted R then Kullback $\chi^2$-statistic is given by

$$\chi^2 = \tfrac{1}{2} tr(Z^2) \tag{3.1}$$

where

$$Z = \sqrt{n}\mathrm{P}^{-1}(R - \mathrm{P}) \tag{3.2}$$

and $tr(Z^2)$ means trace of the matrix $Z^2$.

Jenrich (1970) has shown that the statistic in (3.1) has an asymptotic $\chi^2$ distribution with k(k-1)/2 degrees of freedom if the correlation matrix is replaced by the covariance matrix for testing the null hypothesis that the population has a specific covariance matrix. For the correlation matrix, Jenrich has shown that if the matrix P has non-zero off-diagonal terms, the Kullback's statistic does not have the desired properties to make an exact asymptotic $\chi^2$ distribution. Jenrich's $\chi^2$ test for the correlation matrix is based on the following statistic, which adds a correcting term to Kullback's statistic

$$\chi^2 = \tfrac{1}{2}tr(Z^2) - dg'(Z)T^{-1}dg(Z) \tag{3.3}$$

where

$$T = [\delta_{ij} + \rho_{ij}\rho^{ij}] \tag{3.4}$$

Z is defined in (3.2); dg(Z) is the diagonal of the matrix Z written as a column vector with dg′(Z) being its transpose; $\delta_{ij}$ is Kronecker delta which is indexed unit for the diagonal terms (i = j) and zero for the off-diagonal terms ($i \neq j$); $\rho_{ij}$ represents the element in row i and column j of the matrix P while $\rho^{ij}$ denotes the corresponding element in the inverse of the correlation matrix $P^{-1}$. The above $\chi^2$-statistic also has degrees of freedom equal to k(k-1)/2 where k is the number of variables in the correlation matrix.

If the sample correlation matrix R happens to be equal to the population correlation matrix P under the null hypothesis $H1_0$ then Z would be a null matrix. In this limiting case the value of $\chi^2$ will be equal to zero. For example under the above null hypothesis P is an identity matrix and if R is also an identity matrix then we shall have $\chi^2 = 0$. For all the departures of R from P, the $\chi^2$-statistic taken on a positive value. But to distinguish between the systematic departures of the correlation matrix from orthogonality and the departures that could have resulting from sampling error, we shall apply the test with the standard 5 percent type-I error. The calculated $\chi^2$-statistic exceeding the 5 percent critical value would be taken as the evidence of a relationship in stock returns across the sampled countries. On the other hand, as insignificant $\chi^2$-statistic would mean the absence of any such relationship.

Since there is no reference covariance matrix to put in the null hypothesis, we shall use the corrected $\chi^2$-statiscic in (3.3) for the correlation matrix. It is, however, to be noted that if our null hypothesis is that P is an identity matrix then dg(Z) would be a null vector. In this case, the two $\chi^2$ statistics in (3.1) and (3.3) will coincide.

### 3.5. Testing the Stability of Stock Price Co-movements

In order to test the stability of relationship in stock prices across a group of country, we shall apply a number of tests. First consider a simple case wherein we are interested in comparing the degree of relationship in stock price movements within a group of countries across two periods, referred to as period 1 and period 2. If the relationship is stable over time then the degree of correlation in the two periods should be the same. Thus we pose the following null and alternative hypotheses.

*Hypothesis* 2 $\quad H2_0: \quad P_1 = P_2$

$\qquad\qquad\qquad\quad H2_A: \quad P_1 \neq P_2$

where $P_1$ and $P_2$ are the correlation matrices for periods 1 and 2 respectively.

Two well-known statistics to test the above hypothesis currently used in the finance literature are Box-M statistic and Kullback-Jenrich $\chi^2$ statistic. Box test is explained in Meric and Meric (1989) while Kullback-Jenrich test is given in Jenrich (1970) and has also been used by Kaplanis (1988). Both the tests are based on $\chi^2$-statistic. We shall first discuss Kullback-Jenrich test, because it is an extension of the test we have just discussed in the above section.

Denoting the estimate of the correlation matrix $P_i$ (i = 1, 2) based on a random samples of size $n_i$ by $R_i$, Jenrich-$\chi^2$ statistic is given by

$$\chi^2 = \tfrac{1}{2} tr(Z^2) - dg'(Z) S^{-1} dg(Z) \tag{3.5}$$

where

$$Z = \sqrt{\tfrac{n_1 n_2}{n_1 + n_2}} \overline{R}^{-1} (R_1 - R_2) \tag{3.6}$$

$$\overline{R} = \frac{n_1 R_1 + n_2 R_2}{n_1 + n_2} \tag{3.7}$$

$$S = [\delta_{ij} + \overline{r}_{ij} \overline{r}^{ij}] \tag{3.8}$$

$\overline{R}$ is the average of the two sample correlation matrices; $\overline{r}_{ij}$ is the element in row i and column j of the matrix $\overline{R}$; $\overline{r}^{ij}$ is the corresponding element in the inverse of the correlation matrix $\overline{R}^{-1}$; while other notations are the same as defined earlier. The degrees of freedom for this $\chi^2$-statistic is equal to k(k-1)/2 where k is the number of variables considered in the correlation matrix. The second term in the $\chi^2$-statistic given by (3.5) is the correction over Kullback's (1967) $\chi^2$-statistic.[5]

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[5] Jenrich (1970) has also shown that for testing the equality of two covariance matrices, the second term from (3.5) should be dropped. Thus denoting the sample covariance matrix by C, we have $\chi^2$-statistic for covariance matrix:

$$\chi^2 = \frac{1}{2} tr(W^2) \text{ where } W = \sqrt{\tfrac{n_1 n_2}{n_1 + n_2}} \overline{C}^{-1} (C_1 - C_2) \text{ and } \overline{C} = \frac{n_1 C_1 + n_2 C_2}{n_1 + n_2}.$$

Consider now the test based on Box-M statistic. The test as explained in Meric and Meric (1989), is designed to test the equality among any number of correlation matrices. But in this section, we consider its simpler version for two correlation matrices:

$$M = \left[1 - \left(\frac{2k^2+3k-1}{6(k+1)}\right)\left(\frac{1}{n_1-1} + \frac{1}{n_2-1} - \frac{1}{n_1+n_2-2}\right)\right] \times \left[(n_1-1)\ln\left|R_1^{-1}\tilde{R}\right| + (n_2-1)\ln\left|R_2^{-1}\tilde{R}\right|\right] \tag{3.9}$$

where

$$\tilde{R} = \frac{(n_1-1)R_1 + (n_2-1)R_2}{n_1+n_2-2} \tag{3.10}$$

In the above formulation ln stands for natural log and for any matrix A, $|A|$ means determinant of matrix A, while all the other notations are the same as before.[6] The degrees of freedom for the Box-M statistic is k(k+1)/2.

Both the tests will be applied with 5 percent level of significance. If the calculated $\chi^2$-statistic falls in the rejection range, we shall conclude that the correlation matrix is unstable over the two periods under consideration and, therefore, the extent of co-movements in stock returns across the sample countries has changed in the two periods. An insignificant value of $\chi^2$-statistic, on the other hand, would mean a stable relationship in stock returns over the two period.

### 3.6. Testing the Homogeneity of Stock Price Co-movements

In the above section we have discussed two alternative tests for the stability of correlation matrices over two sub-periods. Both the test can be extended to test correlation stability over more than two periods. Following Jenrich (1970), we refer to this test as the test of homogeneity of correlation matrices. Our null hypothesis to be tested is as given below.

*Hypothesis* 3 $\quad H3_0$: $P_1 = P_2 = \ldots = P_m$

$\quad\quad\quad\quad\quad\quad H3_A$: $P_i \neq P_j$ *for at least some* $i \neq j$

where $P_i$ is the correlation matrix for period i and m is the number of periods considered.

The Kullback-Jenrich test is given by [see Jenrich (1970)]:

$$\chi^2 = \sum_{i=1}^{m}\left[\tfrac{1}{2}tr(Z_i^2) - dg'(Z_i)S^{-1}dg(Z_i)\right] \tag{3.11}$$

---

[6] Notice that the Box-M statistic fails if the number of observations in any period ($n_1$ or $n_2$) is less than the number of variables in the correlation matrix because in this case the correlation matrix $R_1$ or $R_2$ becomes singular and its inverse does not exist.

where

$$Z_i = \sqrt{n_i}\,\overline{R}^{-1}(R_i - \overline{R}) \tag{3.12}$$

$$\overline{R} = \frac{\sum_{i=1}^{m} n_i R_i}{\sum_{i=1}^{m} n_i} \tag{3.13}$$

$$S = [\delta_{ij} + \overline{r}_{ij}\overline{r}^{ij}] \tag{3.14}$$

$\overline{R}$ is the average of the m sample correlation matrices; $\overline{r}_{ij}$ is the element in row i and column j of the matrix $\overline{R}$ ; $\overline{r}^{ij}$ is the corresponding element in the inverse of the correlation matrix $\overline{R}^{-1}$ ; $n_i$ is the number of observations in sample i (for i = 1, ..., m), while all other notations are the same as before. The above $\chi^2$-statistic has degrees of freedom equal to (m-1)k(k-1)/2 where k is the number of variables in each of the m correlation matrices.

As before, the first term in (3.11) is Kullback's (1967) $\chi^2$-statistic, while the second term is the correction made by Jenrich (1970).

The general form of Box-M statistic is as follows [see Meric and Meric (1989)].

$$M = \lambda \sum_{i=1}^{m} \left[ (n_i - 1)\ln\left| R_i^{-1}\widetilde{R} \right| \right] \tag{3.15}$$

where

$$\lambda = 1 - \left( \frac{2k^2 + 3k - 1}{6(k+1)(m-1)} \right) \left( \sum_{i=1}^{m} \left( \frac{1}{n_i - 1} \right) - \frac{1}{\sum_{i=1}^{m}(n_i - 1)} \right) \tag{3.16}$$

$$\widetilde{R} = \frac{\sum_{i=1}^{m} (n_i - 1)R_i}{\sum_{i=1}^{m}(n_i - 1)} \tag{3.17}$$

All other notations are the same as before.[7] This statistic has degrees of freedom equal to k(k+1)(m-1)/2.

---

[7] See footnote 6.

As before, we shall apply both the tests with 5 percent level of significance. A significant $\chi^2$-statistic means that the relationship in stock price returns across a set of countries has changed at least somewhere during the periods 1, 2,..., m. On the other hand, an insignificant value of $\chi^2$-statistic means that no such change has taken place and, therefore, the correlation structure in stock return is homogeneous.

## 4. DATA AND DESCRIPTIVE STATISTICS

### 4.1. Data

We have chosen a sample of fifteen emerging markets for the analysis. Nine of these emerging markets are taken from Asia and the remaining six from Latin America. The specific purpose of using the two sub-samples is to determine if the geographic distance matters in integration of the markets. Thus we shall be able to determine the level of integration across the Asian and Latin American markets as well as within each of the two sets of markets. In addition to these two sets of markets we also include some of the major financial markets, broader regional markets and the world market in our data set. The sampled countries and regions are:

| | |
|---|---|
| **Asian**: | India, Indonesia, Japan, Korea, Malaysia, Pakistan, Philippines, Taiwan, and Thailand; |
| **Latin American**: | Argentina, Brazil, Chile, Columbia, Mexico, and Venezuela; |
| **Major Markets**: | USA, UK, Japan; |
| **Regional Markets**: | Asia, Latin America, and Europe-Australia-Far East; |
| **World** | |

We use monthly price indices for our analysis. International Finance Corporation (IFC) collects the indices from various issues of Emerging Stock Markets Factbook. All the country indices are labeled by the name of the country. The world and regional indices are named as follows:

World composite index: IFC composite.
Composite index for Asia: IFC Asia.
Composite index for Latin America: IFC Latin America.
Composite index for Europe, Australia and the Far East: EAFE.

The study is conducted over the period January 1990 to December 1996. This gives a sample of 84 monthly observations. All the monthly price indices are given in U.S. Dollar. These indices are calculated with the base of December 1984, whereas the base period for Indonesia is December 1989. For an easy comparison all the stock indices are converted to the common base of January 1990. The rates of return, that is, the growth rates of price indices are calculated as follows.

$$R_t = \ln(P_t) - \ln(P_{t-1}) \tag{4.1}$$

where $P_t$ is the price index, $R_t$ is rate of return, ln denotes natural log and t refers to period.

## 4.2. Stock Prices, Returns, and Volatility

In order to study the trends in stock prices we present the time profiles of four indicators. In Figures 1 in the left panels we present the profiles of stock prices for each month along with the moving standard deviations over the past twelve months. In the right panel are the rates of return for each month over the holding period of twelve months, along with the moving standard deviations of monthly rates of return over the past twelve months.

The monthly rate of return for month t is calculated using (4.1) while the rate of return over one year holding period is estimated as follows.

$$R_t^Y = 100(Ln(P_t) - Ln(P_{t-12})) \tag{4.2}$$

where the superscript Y means that the rate of return is based one year holding period. Likewise the moving standard deviation over the past one-year holding period is estimated as follows.

$$S_t^Y = \left[ \sum_{i=0}^{11} (X_{t-i} - \overline{X}_t) \right]^{1/2} \tag{4.3}$$

where $X_i$ represents alternatively the price index and monthly rate of return and $\overline{X}_t$ is the moving average over the past twelve months for the month t. The standard deviation formula as given above represents the size of variation in stock prices over a period of whole year. The reason is that for comparison with the rate of return over one year holding period, we need to measure volatility over one year [see Merton (1980)].

Since all the stock indices are measured with the common base of January 1990, their levels and fluctuations can be compared across countries. The Figure reveals a number of interesting patterns. We observe that stock price indices in the Latin American markets are much more volatile than in the Asian markets. The high level of volatility in the country stock markets in Latin America is also reflected in the high rate of volatility in the Latin American regional index. Likewise the regional index for Asia shows low level of volatility due to relative stability in the individual country indices, specially the price index of Japan which has a dominant share in the Asian stock index.

**Figure 1: Stock Price Indices, Rates of Return, and Standard Deviations**

Level: —— Standard Deviation: ------

**Stock Price Index and Standard Deviation** **Return and Standard Deviation**

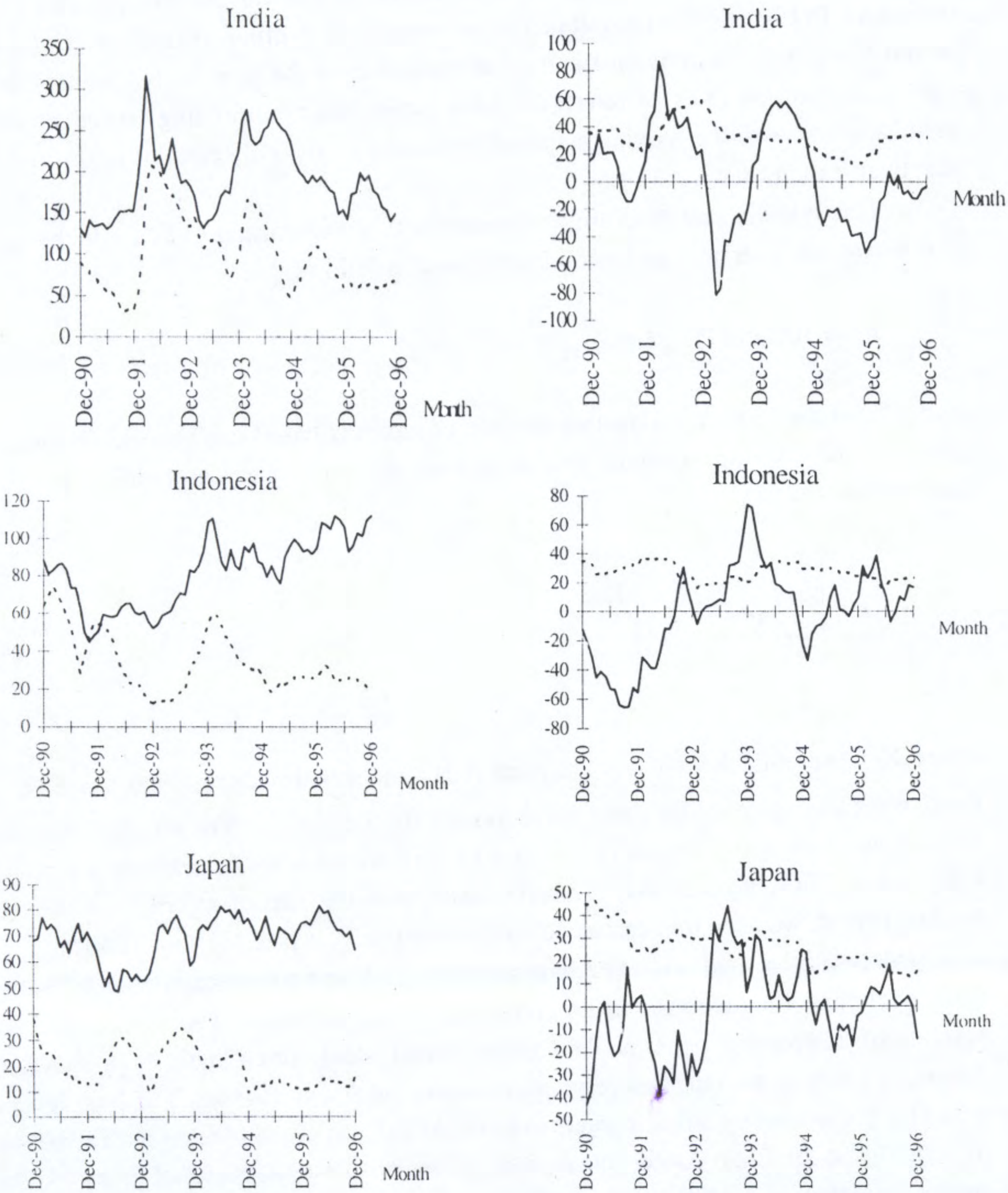


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Figure 1—(*Continued*)

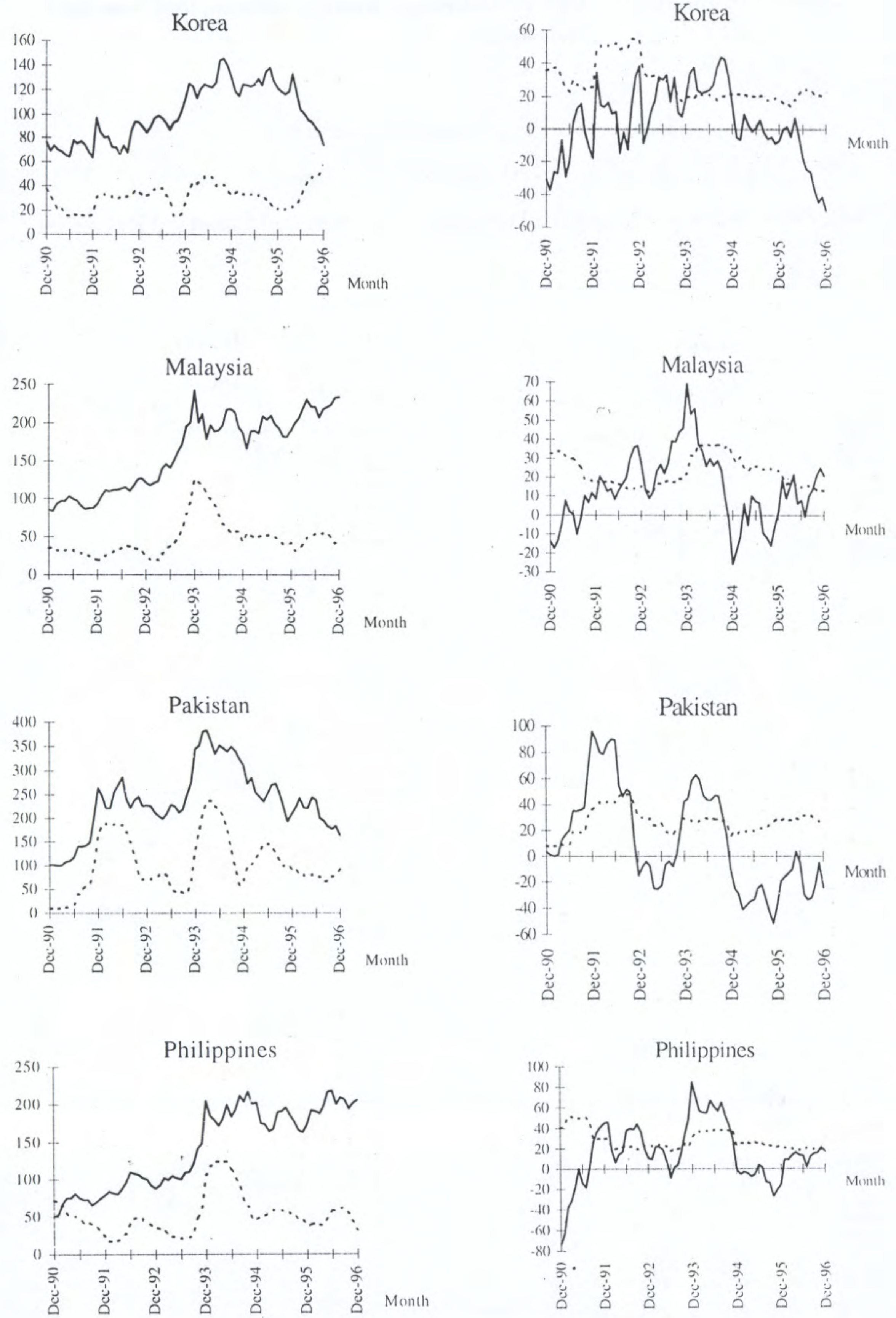


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**Figure 1 (Continued): Stock Price Indices, Rates of Return, and Standard Deviations**

Level: —— Standard Deviation: ------

**Stock Price Index and Standard Deviation** **Return and Standard Deviation**

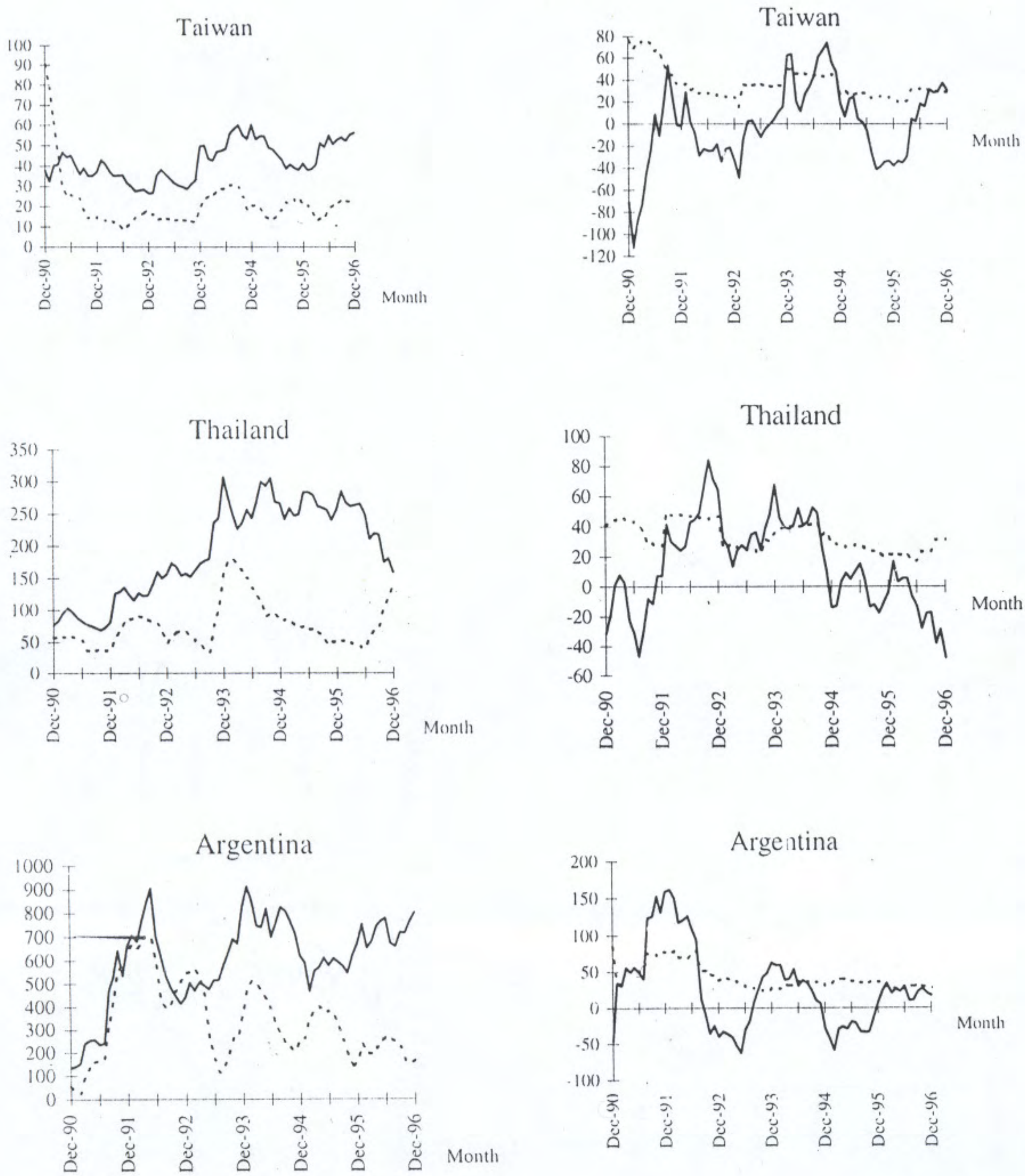


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Figure 1—(*Continued*)

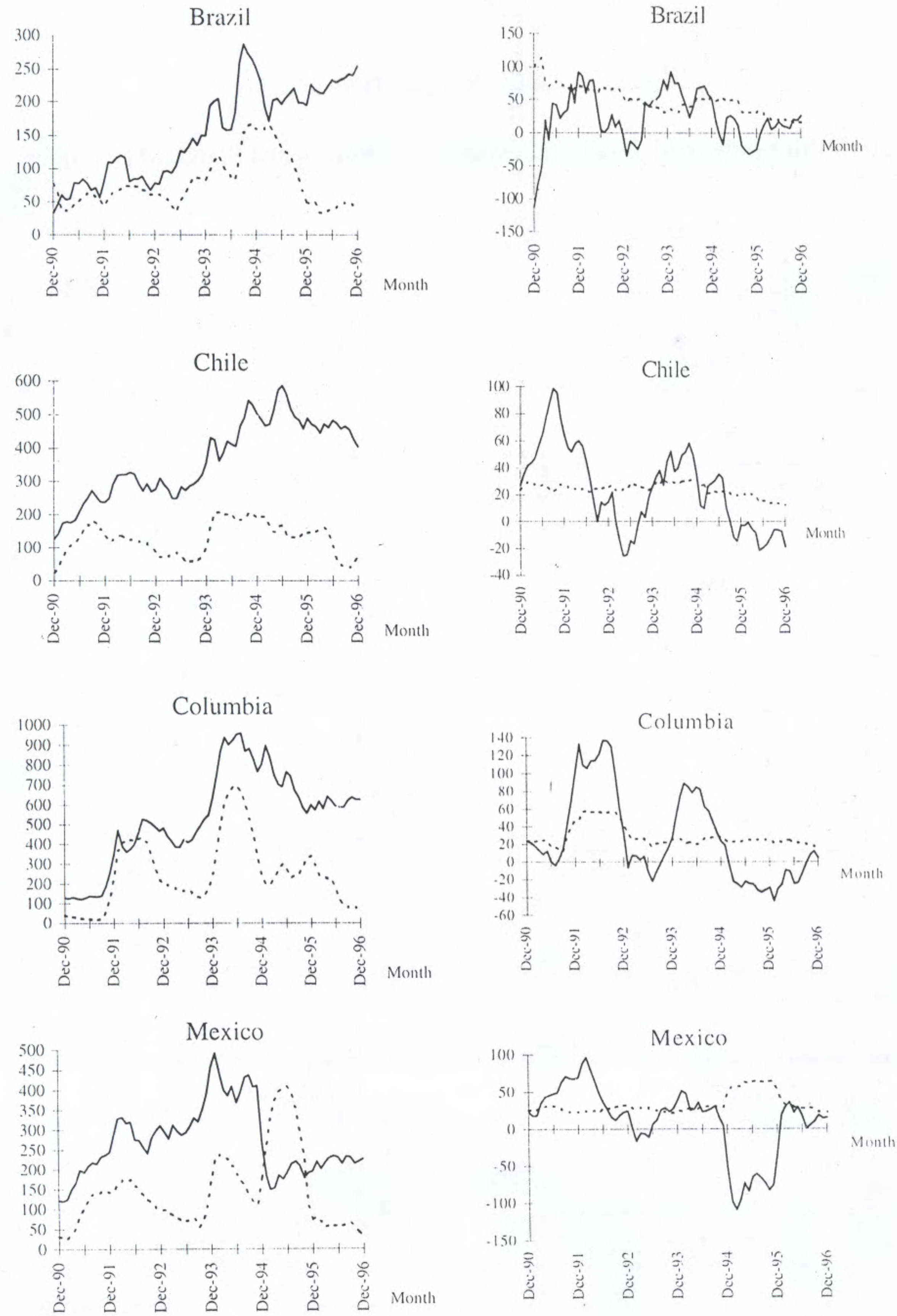


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**Figure 1 (Continued): Stock Price Indices, Rates of Return, and Standard Deviations**

Level: —— Standard Deviation: ------

**Stock Price Index and Standard Deviation** **Return and Standard Deviation**

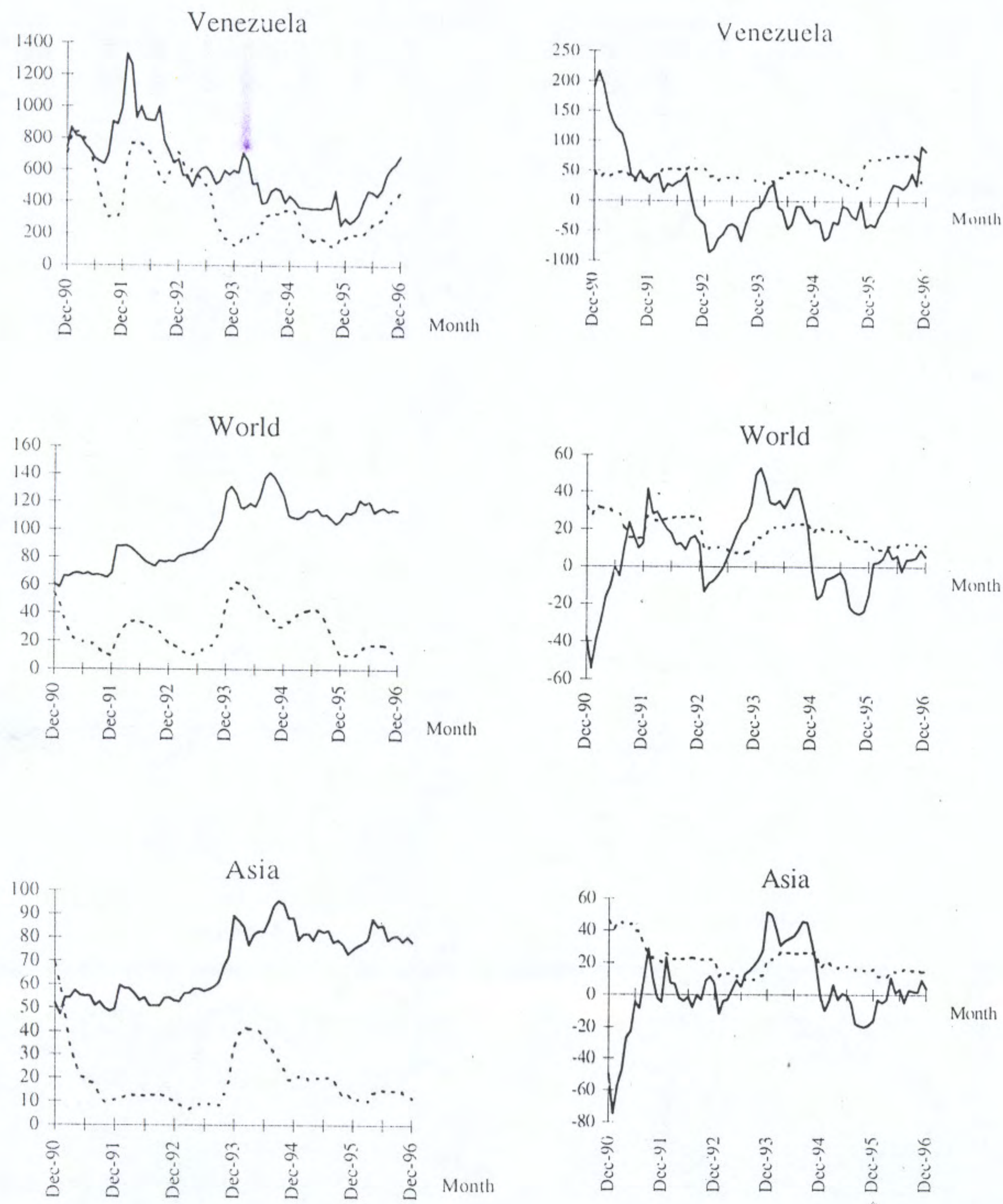


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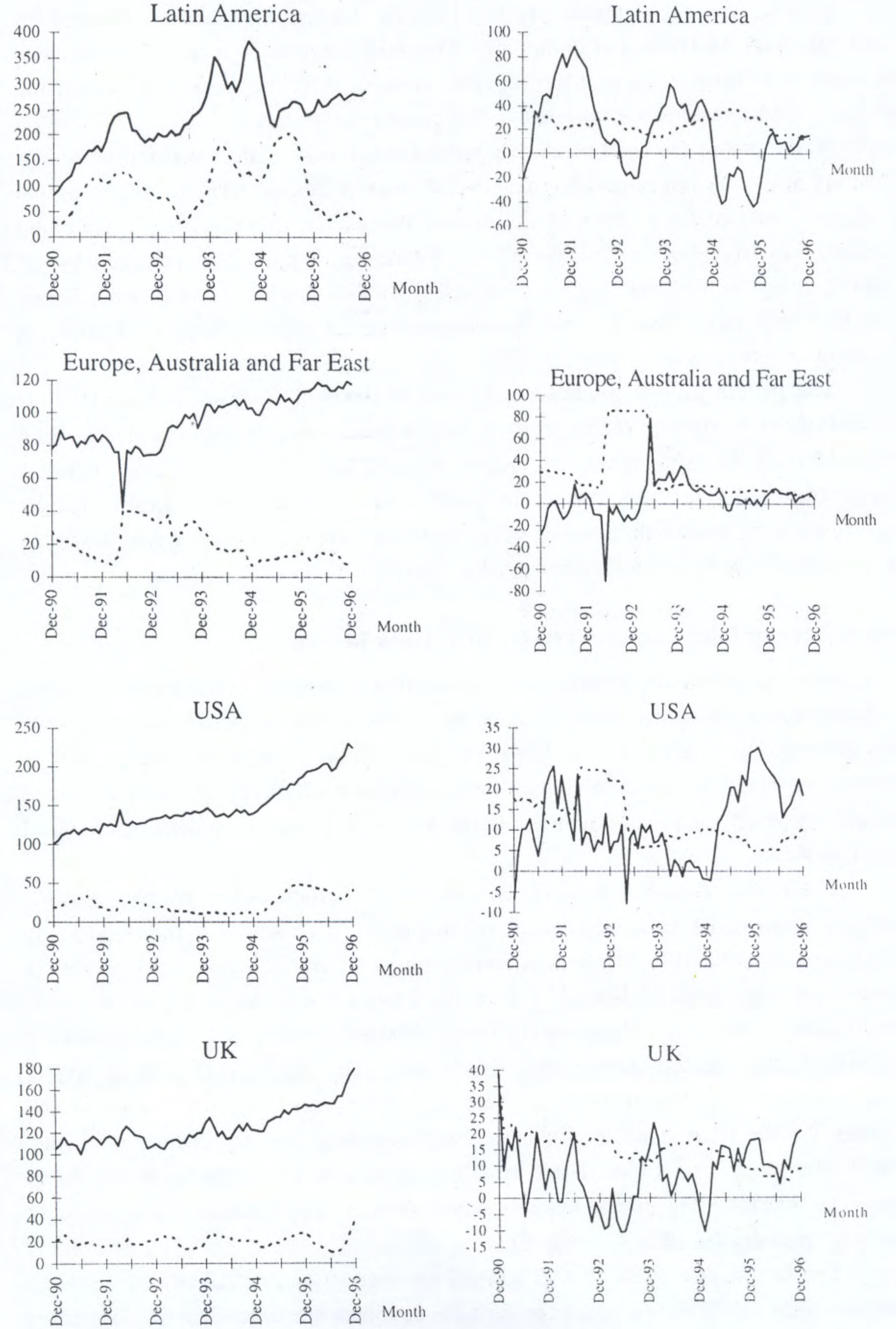
Figure 1—(*Continued*)



In Asia the level of volatility has been the highest in Pakistan, followed by Thailand, India, Malaysia and Philippines. The most stable stock markets are found to be Japan and Taiwan. Among the regional markets, Asia has been the most stable market while Latin America appears to be the most volatile market.

Variations in the level of stock price indices, however, do not result in similar volatility in the rates of return. For example, if stock prices are relatively stable at low level, as in case of Japan, even small absolute fluctuations in stock price index could translate into large fluctuations in the rate of return as the latter is measured by the relative change in the level of stock price index. On the other hand, if the index is very high then even large absolute price fluctuations may not result in large fluctuations in the rate of return.

The pattern shown by the second panel of Figure 1 suggests that the level of fluctuations in the rates of return does not vary as much across markets as the variation in the level of fluctuations in price indices. By and large, the level of price index is higher (lower) in the markets where stock prices are also more (less) volatile. Nevertheless, in general the level of volatility in the rates of return in Latin American markets is relatively higher than in the Asian markets.

### 4.3. Pattern of Inter-market Correlation in Stock Returns

Now we present information on the pattern of correlation in stock returns across various markets. For this purpose we study the profile of simple correlation coefficients over the period Jan 1990 to Dec 1996. The information is presented in Figures 2 in terms of vertical bars. For each country the correlation coefficients are divided in three groups, one each for Asian countries, Latin American countries, and Composite and major markets.

The results show that most of the correlation coefficients are positive with the notable exceptions being the negative correlation between the returns in India and Japan and Argentina and EAFE. The highest correlation coefficient is between the markets of Taiwan and Asia, closely followed by the pairs: Taiwan-World, Mexico-Latin America, Brazil-Latin America, Malaysia-Thailand, Malaysia-Philippines, Malaysia-Asia, Malaysia-World, Korea-World, and Korea-Asia. The markets that have higher correlation with the other markets are Malaysia, Philippines, Thailand, Indonesia and Taiwan. On the other hand, the countries with relatively low correlation are Japan, Brazil, Venezuela and India. These results suggest that as compared to the Latin American markets, the Asian markets have stronger interlinkages with the other markets, specially the other Asian markets.

The results also show that in general the correlation coefficients between the rates of return across the markets from the same continent are larger than the correlation coefficients for the countries from different continents, though the cross continental correlation coefficients are also strong in many cases. The highest cross continental correlation is between Pakistan and Columbia. This high correlation, which is also reported in the International Finance Corporation (1997), does not necessarily result from direct capital flows between the two markets. Both the markets were opened for foreign investment at the same time in 1991. The huge amounts of capital inflows during 1992 resulted in high rates of return in both the markets. The rates of returns declined sharply during 1993 when foreign investors realized the weaknesses of the two markets. Incidentally the two markets rose and fell together in the later periods as well as can be seen from the trends in Figure 1.

**Figure 2: Correlation Coefficients of Returns across Markets (Jan. 1990 to Dec. 1996)**

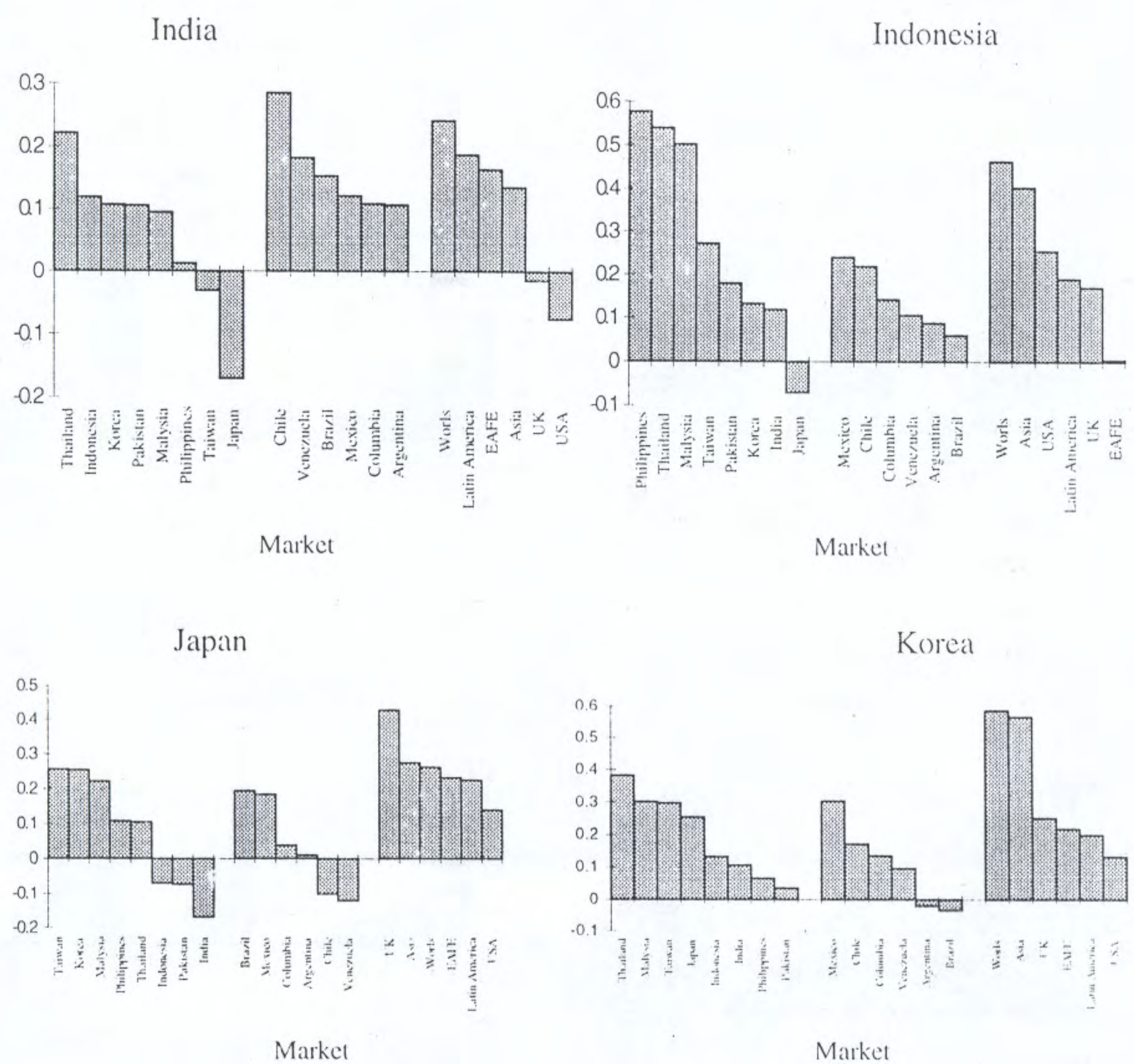



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**Figure 2: Correlation Coefficients of Returns across Markets (Jan. 1990 to Dec. 1996)**

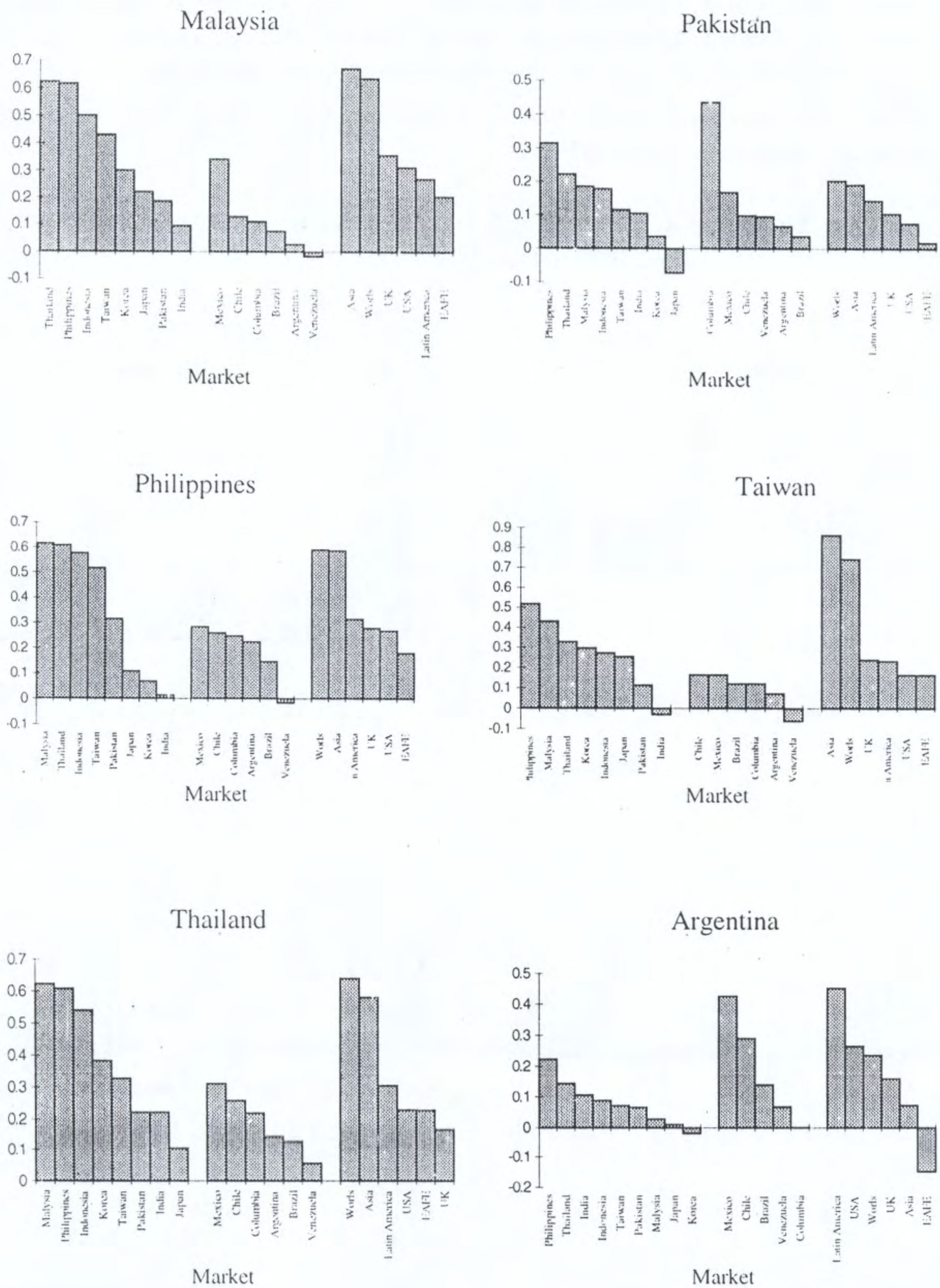


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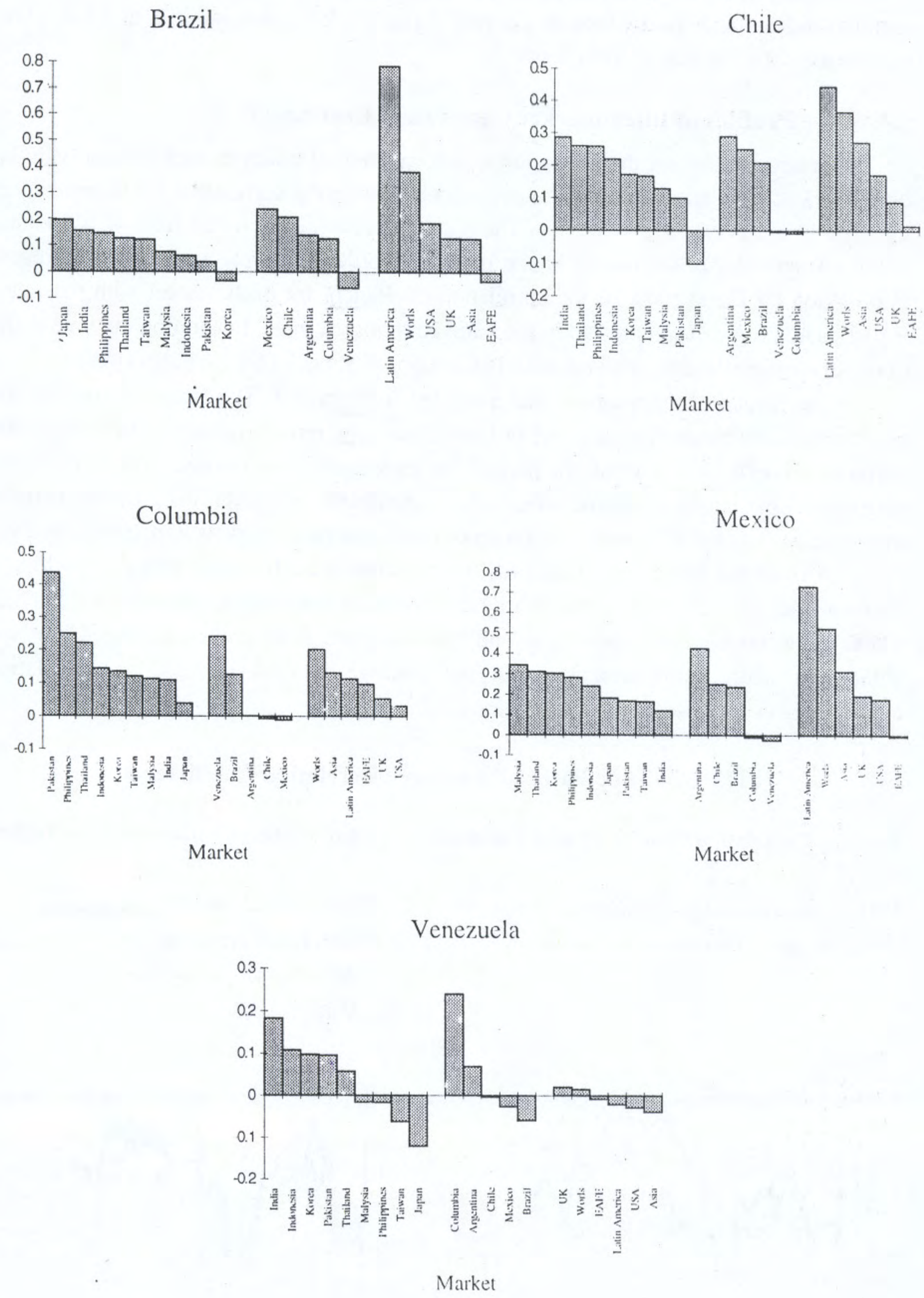
Figure 2—(*Continued*)



Finally most of the countries have strong correlation with the world index, major regional indices and the indices of the two major markets, that is USA and UK. The notable exception is that of Venezuela.

### 4.4. Time Profiles of Inter-market Correlation Coefficients

Finally, we discuss the time pattern of correlation of return in each market with the other markets. For this purpose we have calculated moving correlation coefficients over the periods of 12 consecutive months. The correlation coefficient for each set of 12 months is placed against the last month in the period. In order to be precise, we shall present information on the average of the correlation coefficient for each market with the other countries in the Asian sample and in the Latin American sample. In addition the time paths of correlation coefficients with the world and major regional indices are also studied.

The results of this exercise are presented in Figures 3. The figures show that the correlation coefficients fluctuate but in most cases they remain positive. On average the correlation coefficients over all the periods for each market are positive. The trend in the correlation coefficients is not the same for all the markets. However, for most markets the average correlation coefficients with Asian or Latin American markets appears stationary.

Almost the same trend holds for the correlation coefficients with the world and regional indices. Only for a few markets correlation coefficients show upward trend. These countries are India, Indonesia and Pakistan from Asia, and Argentina, Chile and Venezuela from Latin America. But the average rate of increase in correlation coefficients in all these cases is generally small.

**Figure 3: Time Paths of Average Correlation Coefficients**

**Average Correlation Coefficient with Countries** | **Correlation Coefficients with Regions**

With Latin American Countries: ————
With Asian Countries: — — —

With World Index: ▬▬▬▬
With Latin America: ————
With Asia: — — —
With EAFE: ------------------

India

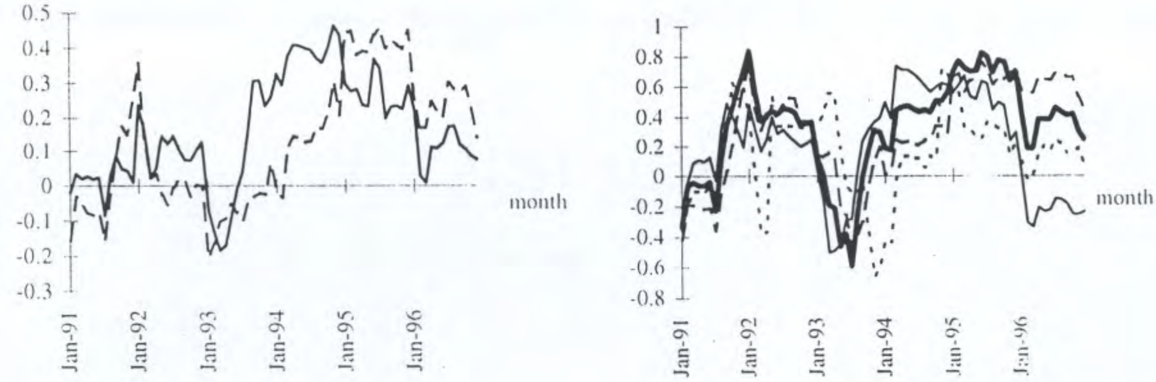



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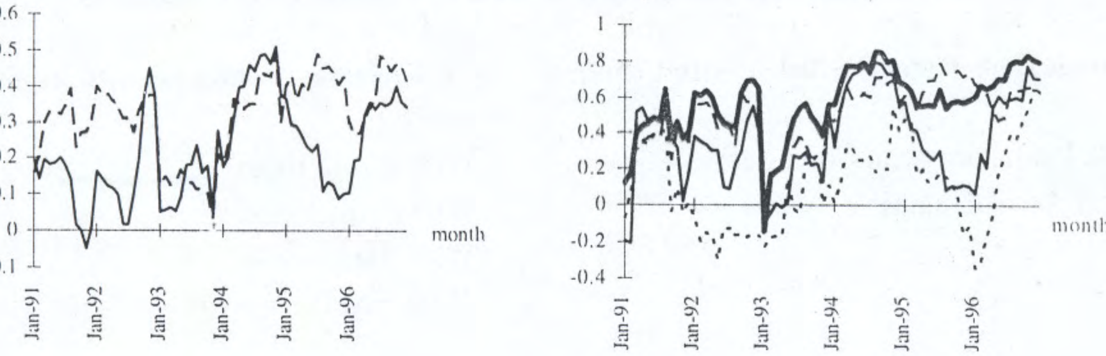
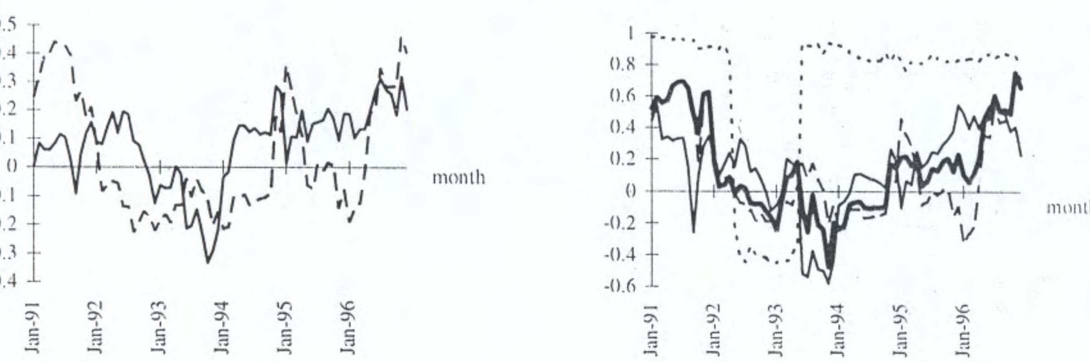
Figure 3—(*Continued*)

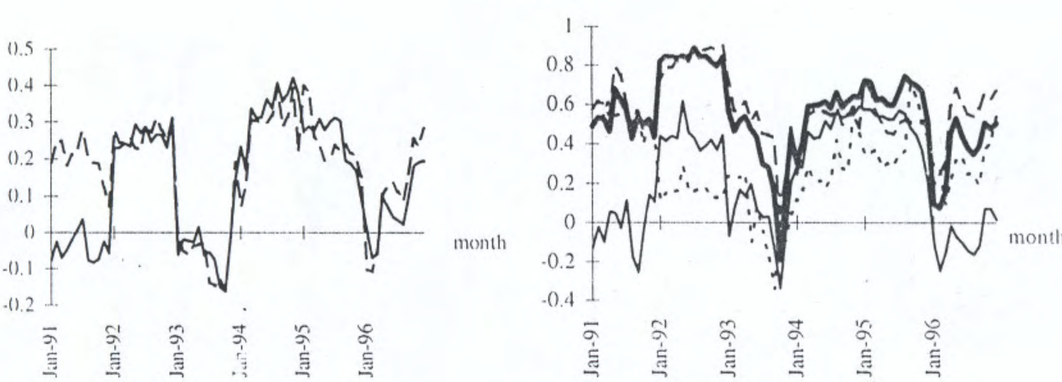
Indonesia




Japan




Korea




Malaysia

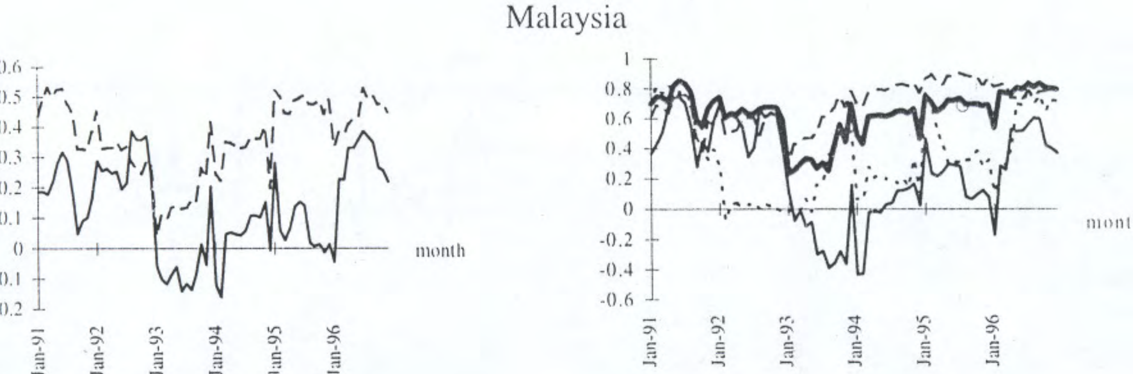



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**Figure 3 (Continued): Time Paths of Average Correlation Coefficients**

**Average Correlation Coefficient with Countries**

With Latin American Countries: ————

With Asian Countries: — — —

**Correlation Coefficients with Regions**

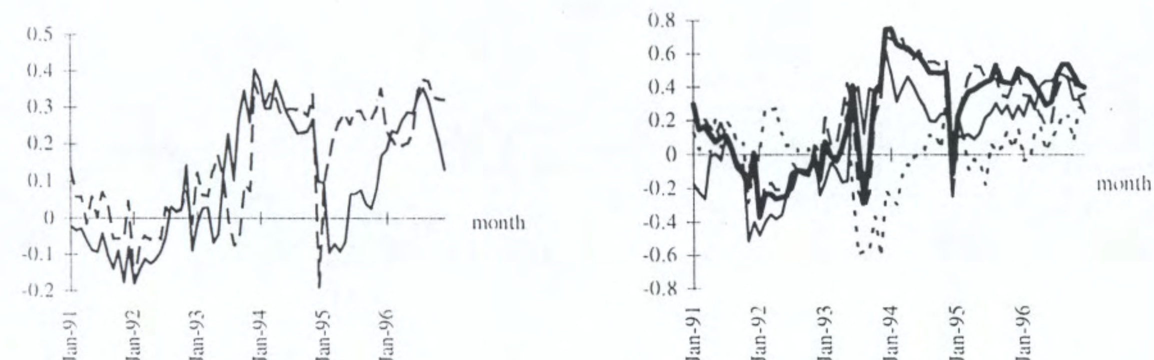
With World Index: ▬▬▬▬

With Latin America: ————

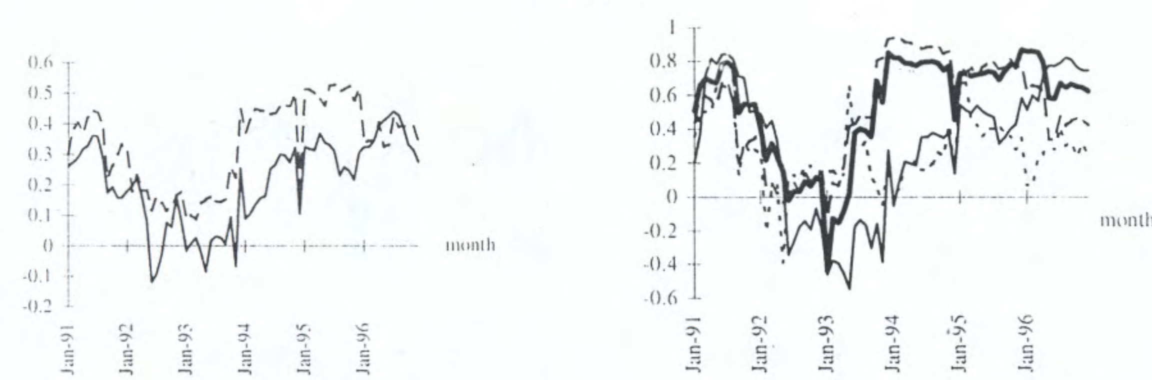
With Asia: — — —

With EAFE: -----------------

Pakistan




Philippines




Taiwan

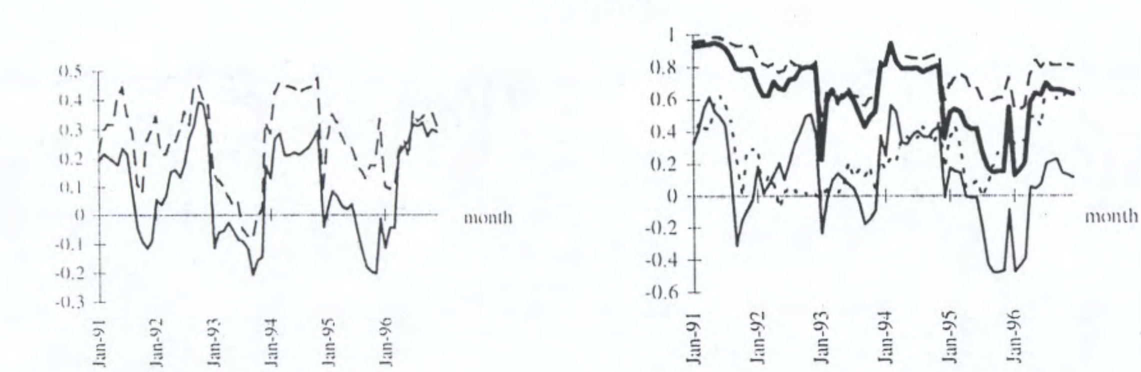



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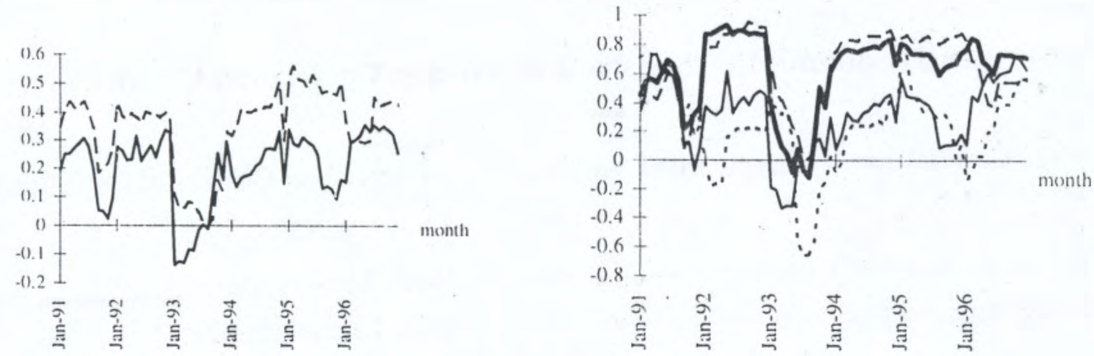
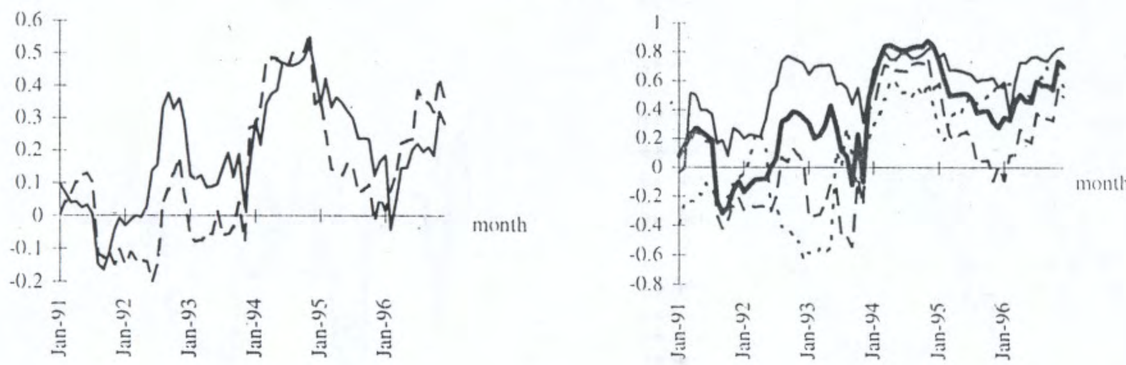
Figure 3—(*Continued*)

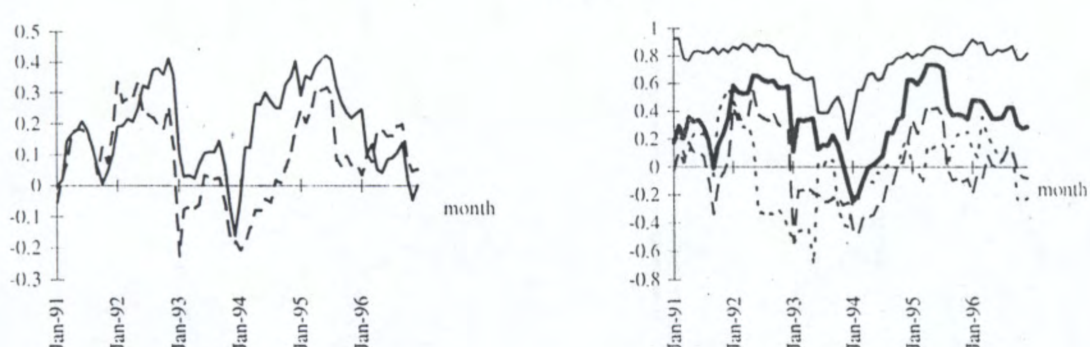
Thailand



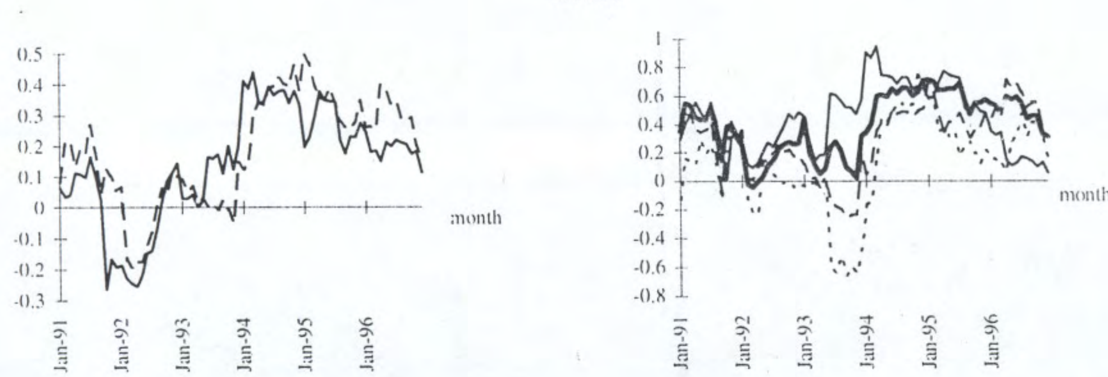

Argentina




Brazil




Chile

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## Figure 3 (Continued): Time Paths of Average Correlation Coefficients

**Average Correlation Coefficient with Countries**

With Latin American Countries: ————

With Asian Countries: — — —

**Correlation Coefficients with Regions**

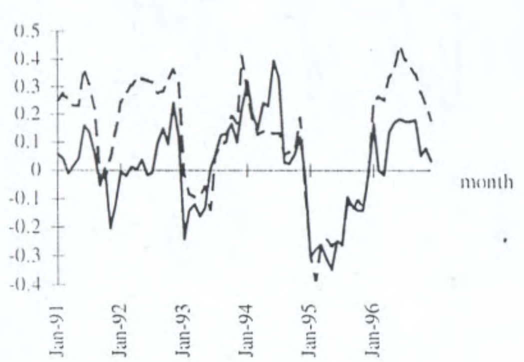
With World Index: ▬▬▬▬

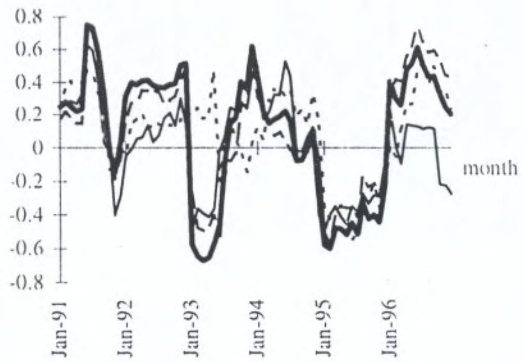
With Latin America: ————

With Asia: — — —

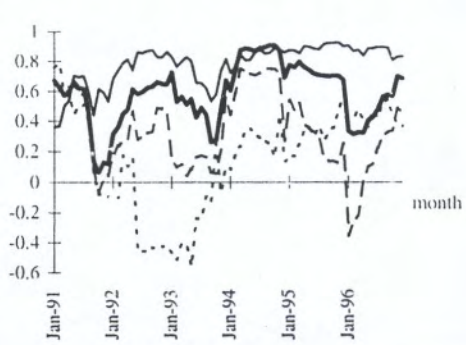
With EAFE: -----------------

Columbia

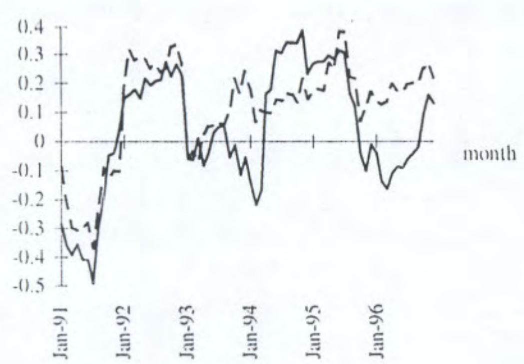


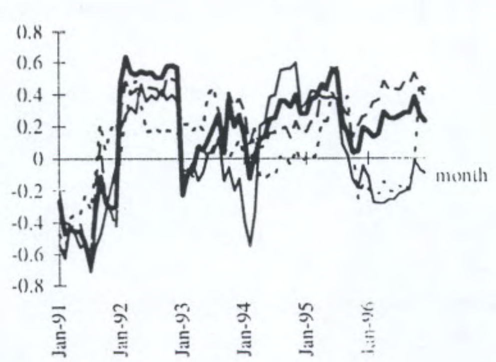




Mexico


Venezuela



There is a clear evidence of cyclical variations in the correlation coefficients for all the markets. Thus during short periods of time the correlation coefficients appear to be quite volatile and unstable. The stock markets in Asia and Latin America appear to have some co-movements in stock returns. These co-movements are mostly pro-cyclical. The inter-relationships among the stock markets are generally stable over the long periods of time but unstable over the short periods. Only few markets have increased their level of integration with the other markets in the sample and/or with the world or regional markets.

### 4.5. Concluding Remarks

The results show that the Latin American markets are much more volatile than the Asian markets, though in some Asian countries (India, Malaysia, Pakistan, Philippines, and Thailand) also the level of volatility is high. The most stable market is found to be Japan.

The results on inter-market co-movements show that stock return in most pairs of countries have pro-cyclical variations; a sizable negative correlation is found only in the pairs India-Japan and Argentina-EAFE. Most of the markets also appear to be interlinked with the world and regional indices. The Asian markets have stronger interlinkages with the other markets, specially the other Asian markets, than the Latin American markets. The intra-continental co-movements, appear to be stronger than the inter-continental co-movements, though the latter are not negligible either. The time profiles of stock markets interlinkages suggest that in most cases the co-movements in stock returns are stationary. Finally, the stock market interlinkages appear to be volatile and unstable in the short run but there is some evidence of long-run stable relationship across the markets.

## 5. RESULTS OF STATISTICAL TESTS

### 5.1. Introduction

Following the procedure explained in Section 3, we now present the results of our statistical tests. All the tests are applied on the monthly rates of return as calculated by the logarithmic first difference of the monthly stock price indices. This means that the stock price co-movement is meant to represent the relationship in relative changes in stock prices or in the rates of return over a holding period of one month. For the inter-periods comparison of correlation matrices, we shall divide our sample period into various sub-periods of equal lengths. This sub-division will be based on the sets of 12 months, 18 months, 24 months and 36 months periods.

### 5.2. Results of the Significance of Correlation Coefficients

The results of Kullback-Jenrich $\chi^2$-test based on equation (3.3) for the full sample period and various sub-periods are given in Table 1. A significant $\chi^2$-statistic indicates rejection of the null hypothesis that stock returns in the stock markets move independent of each other. The results show that this proposition is overwhelmingly rejected. That is, there is strong evidence to suggest that stock returns in the sampled emerging markets are inter-related, though one cannot predict the direction of relationship from the results.

Table 5.1

*Kullback-Jenrich $\chi^2$-Test for the Significance of Correlation Matrix*

| Period | Asia | Latin America | Asia and Latin America |
|---|---|---|---|
| Full Period | | | |
| Jan 90 to Dec 96 | 124.76* | 15.55 | 197.77* |
| Periods of 36 Months | | | |
| Jan 90 to Dec 92 | 130.09* | 15.19 | 227.73* |
| Jan 93 to Dec 96 | 142.45* | 47.00* | 310.97* |
| Periods of 24 Months | | | |
| Jan 91 to Dec 92 | 123.39* | 35.85* | 232.00* |
| Jan 93 to Dec 94 | 158.96* | 54.43* | 383.17* |
| Jan 95 to Dec 96 | 193.70* | 43.44* | 356.30* |
| Periods of 18 Months | | | |
| Jan 91 to Jun 92 | 154.87* | 47.78* | 318.57* |
| Jul 92 to Dec 93 | 197.97* | 45.41* | 456.92* |
| Jan 94 to Jun 95 | 172.45* | 79.37* | 456.26* |
| Jul 95 to Dec 96 | 201.82* | 74.40* | 513.63* |
| Periods of 12 Months | | | |
| Jan 90 to Dec 90 | 195.96* | 44.89* | 467.60* |
| Jan 91 to Dec 91 | 172.08* | 43.05* | 348.60* |
| Jan 92 to Dec 92 | 208.79* | 69.88* | 486.38* |
| Jan 93 to Dec 93 | 215.95* | 58.23* | 552.26* |
| Jan 94 to Dec 94 | 198.07* | 93.49* | 564.85* |
| Jan 95 to Dec 95 | 303.99* | 48.66* | 536.63* |
| Jan 96 to Dec 96 | 237.08* | 86.61* | 588.33* |

*Note*: The $\chi^2$ values significant at 5 percent level are indicated by *.

For the Asian sample the inter-relationship is significant in all the periods considered while for the Latin American sample the relationship is significant for the smaller sub-periods not exceeding 24 months. For the three-year period 1990-92 and for the full sample period 1990-96, the relationship in stock returns of the Latin American markets does not appear to be strong. When we pool the Asian and Latin American countries together, the relationship again becomes significant for all the periods.

A number of conclusions follow from these results, some of which will be discussed further in the following sections. The relatively weak relationship in the Latin American stock markets in early 1990s could most probably be due to high level of volatility in the markets as evident from Figure 1 in Section 4. With high volatility in returns, the market trends become less predictable and they do not provide reliable signals to investors. With such a lack of information content in the prices, especially during financial crises, international capital is not necessarily allocated in an efficient manner across nations. This means that the capital movements do not serve to produce arbitrage conditions across markets.

The above result along with the evidence that the relationship in stock returns is significant for the pooled sample of Asian and Latin American countries provides at least an indirect evidence of some association in stock returns across the two continents. The nature of inter-continental co-movements will become more evident in the later part of our analysis.

Finally, notice that the correlation coefficients among the rates of return in Latin American countries are not significantly different from zero for the full sample and for the three-year period 1990-92. However, they become significant for each of the sub-periods of shorter intervals. Also noticeable is the observation that for all the group of countries (Asian, Latin American or Asian and Latin American combined), the average value of $\chi^2$-statistic increases monotonically with the decrease in the length of sample period. This means that as we move to shorter time periods, the correlation matrix further departs from the identity matrix and, therefore, the hypothesis of orthogonality in stock returns can be rejected with an increased level of confidence since the degrees of freedom for the test is independent of the time period considered.

There are two possible explanations for this result. The first one is purely statistical which suggests that as a general rule the absolute value of correlation coefficient declines with the increase in sample size as is generally observed in regression analysis. The second explanation, which is at least as plausible as the first one, is that in the short run stock markets could over-react to news from the other stock markets and this reaction is based mostly on perceptions and, at least partly, on sentiments. However, with the passage of time, more precise information comes through and by and large rationality over-rides sentiments. Thus the adjustment process towards the long-run equilibrium in each market could follow a partially independent time path. This explanation specially applies to Latin American markets in early 1990s and is further strengthened by our observation that the Latin American markets were highly volatile during this period.[8]

### 5.3. Results on Homogeneity of Stock Price Co-movements

We now test the null hypothesis that the correlation matrix of stock returns in our sampled emerging markets is homogeneous over a set of periods. The estimated values of Kullback-Jenrich and Box-M $\chi^2$-statistics given by equations (3.11) and (3.15) respectively, are presented in Table 5.2.

Table 5.2

*$\chi^2$-Test for Correlation Homogeneity*

| Period | Asia | Latin America | Asia and Latin America |
|---|---|---|---|
| **7 periods of 12 months each (Jan 90 to Dec 96)** | | | |
| Kullback-Jenrich Test | 282.53* | 14.19 | 755.09* |
| Box-M Test | 278.58 | 103.56 | |
| **4 periods of 18 months each (Jan 91 to Dec 96)** | | | |
| Kullback-Jenrich Test | 89.37 | 8.17 | 250.76 |
| Box-M Test | 133.78 | 64.55 | 443.66* |
| **3 periods of 24 months each (Jan 91 to Dec 96)** | | | |
| Kullback-Jenrich Test | 40.74 | 1.67 | 114.42 |
| Box-M Test | 71.28 | 27.38 | 234.70 |

*Note*: The $\chi^2$ values significant at 5 percent level are indicated by *. Box M is not applicable for the pooled sample of Asian and Latin American countries with 12-month periods because the number of variables exceeds the number of observations.

Before interpreting these results a technical point would be worth noting. As Kaplanis (1988) has pointed out, both the statistics have asymptotic $\chi^2$ distribution but their small sample properties are not known. If the sample size is small, the two tests can produce contradictory results. Thus the disparity in the results could mean that the sample size is not sufficiently large in relation to the number of countries considered. Our results confirm this suspición as well. The two tests produce contradictory results when the correlation matrices for nine countries (Asia) are computed using only 12 monthly observations or when the correlation matrices for 15 countries are computed with 18 months data. With the correlation matrices of 6 countries (Latin America), no contradiction is evident from the results.

[8] See Figures 1 in Section 4 for details on volatility of the markets.

From these results we find no evidence of significant changes in the correlation structure within Latin American markets. For the Asian markets and for the combined sample of Asian and Latin American markets the evidence seems to be mixed. In the case of Asian sample correlation structure could possibly have changed when annual correlation coefficients are compared over the seven-year period. The same is the case with the combined sample of Asian and Latin American markets for the periods of 18 months.

However all these cases fall into the category where the sample size is not sufficiently large as mentioned above. Thus, if we ignore these suspect cases, we can conclude that the correlation structure is homogeneous over the seven-year period and there exists a long run relationship in stock returns.

The above result does not imply by any means that the correlation structure does not change from year to year or over any other short time intervals. Although the homogeneity of correlation matrix over the seven-year period implies that there is a long run relationship in stock price returns in the sampled markets, yet over the short periods the relationship can temporarily deviate from its long run path.[9] The period to period stability of correlation matrix is discussed in the following section.

## 5.4. Results of Correlation Stability

We now apply statistical tests on the period-to-period stability of correlation matrices. The results of these tests, based on Kullback-Jenrich and Box-M $\chi^2$ statistics given by equations (3.5) and (3.9), are presented in Tables 5.3, 5.4 and 5.5. These results are rather difficult to interpret because the two tests produce contradictory results in most of the cases with small to medium sample sizes (that is 12 to 24 months). Since there is no clear basis to prefer any one of the tests to the other for the small samples, we cannot be categorical in our conclusions. However, the following conclusions are at least plausible.

For the longer periods of 36 months co-movements in stock returns in the Asian and Latin American samples have been relatively stable. Co-movements in the Latin American markets are also relatively stable for the periods of 24 months. For the shorter periods of 12 or 18 months the evidence of instability in the Asian market is stronger than in the Latin American markets. Finally, the relative instability in the correlation matrix in the combined sample of Asian and Latin American markets over the 36 months period means that the cross continental co-movements could possibly be unstable. We also observe that in case of comparison over shorter periods (that is year to year or 18 months to 18 months) the co-movements in stock returns are quite likely to be unstable.

[9] It might appear at the first thought that, for example, if the value of $\chi^2$ statistic is insignificant for 7 periods of 12 months, it cannot become significant for any two consecutive periods of 12 months. This is possible, however, because with a decrease in the number of correlation matrices in the $\chi^2$ statistic from 7 to 2, the degrees of freedom is reduced to one sixth of the original degrees of freedom. If the value of $\chi^2$ statistic does not decline enough, it might turn out to be significant.

Table 5.3

*Two-Period $\chi^2$-Test for Correlation Stability (Asia)*

| Period | Kullback-Jenrich $\chi^2$ Test | Box-M $\chi^2$ Test |
|---|---|---|
| **Periods of 12 Months** | | |
| Jan 90 to Dec 90 and Jan 91 to Dec 91 | 133.61* | 52.26 |
| Jan 91 to Dec 91 and Jan 92 to Dec 92 | 145.57* | 58.60 |
| Jan 92 to Dec 92 and Jan 93 to Dec 93 | 158.11* | 72.01* |
| Jan 93 to Dec 93 and Jan 94 to Dec 94 | 189.88* | 89.06* |
| Jan 94 to Dec 94 and Jan 95 to Dec 95 | 127.35* | 44.14 |
| Jan 95 to Dec 95 and Jan 96 to Dec 96 | 113.33* | 40.54 |
| **Periods of 18 Months** | | |
| Jan 91 to Jun 92 and Jul 92 to Dec 93 | 83.07* | 44.38 |
| Jul 92 to Dec 93 and Jan 94 to Jun 95 | 108.09* | 61.89* |
| Jan 94 to Jun 95 and Jul 95 to Dec 96 | 94.33* | 50.63 |
| **Periods of 24 Months** | | |
| Jan 91 to Dec 92 and Jan 93 to Dec 94 | 58.27* | 27.76 |
| Jan 93 to Dec 94 and Jan 95 to Dec 96 | 57.08* | 37.73 |
| **Periods of 36 Months** | | |
| Jan 91 to Dec 92 and Jan 94 to Dec 96 | 47.90 | 49.42 |

*Note*: The $\chi^2$ values significant at 5 percent level are indicated by *.

Table 5.4

*Two-Period $\chi^2$-Test for Correlation Stability (Latin America)*

| Period | Kullback-Jenrich $\chi^2$ Test | Box-M $\chi^2$ Test |
|---|---|---|
| **Periods of 12 Months** | | |
| Jan 90 to Dec 90 and Jan 91 to Dec 91 | 65.36* | 23.93 |
| Jan 91 to Dec 91 and Jan 92 to Dec 92 | 62.67* | 21.66 |
| Jan 92 to Dec 92 and Jan 93 to Dec 93 | 59.64* | 19.62 |
| Jan 93 to Dec 93 and Jan 94 to Dec 94 | 54.20* | 16.96 |
| Jan 94 to Dec 94 and Jan 95 to Dec 95 | 37.72* | 10.99 |
| Jan 95 to Dec 95 and Jan 96 to Dec 96 | 41.05* | 11.86 |
| **Periods of 18 Months** | | |
| Jan 91 to Jun 92 and Jul 92 to Dec 93 | 47.74* | 25.28 |
| Jul 92 to Dec 93 and Jan 94 to Jun 95 | 28.89* | 14.14 |
| Jan 94 to Jun 95 and Jul 95 to Dec 96 | 40.60* | 20.51 |
| **Periods of 24 Months** | | |
| Jan 91 to Dec 92 and Jan 93 to Dec 94 | 23.38 | 13.35 |
| Jan 93 to Dec 94 and Jan 95 to Dec 96 | 23.61 | 14.58 |
| **Periods of 36 Months** | | |
| Jan 91 to Dec 92 and Jan 94 to Dec 96 | 14.49 | 13.99 |

*Note*: The $\chi^2$ values significant at 5 percent level are indicated by *

Table 5.5

*Two-Period $\chi^2$-Test for Correlation Stability (Asia and Latin America)*

| Period | Kullback-Jenrich $\chi^2$ Test | Box M $\chi^2$ Test |
|---|---|---|
| **Periods of 12 Months** | | |
| Jan 90 to Dec 90 and Jan 91 to Dec 91 | 390.06* | |
| Jan 91 to Dec 91 and Jan 92 to Dec 92 | 397.80* | |
| Jan 92 to Dec 92 and Jan 93 to Dec 93 | 386.66* | |
| Jan 93 to Dec 93 and Jan 94 to Dec 94 | 423.46* | |
| Jan 94 to Dec 94 and Jan 95 to Dec 95 | 416.78* | |
| Jan 95 to Dec 95 and Jan 96 to Dec 96 | 382.00* | |
| **Periods of 18 Months** | | |
| Jan 91 to Jun 92 and Jul 92 to Dec 93 | 251.89* | 168.45* |
| Jul 92 to Dec 93 and Jan 94 to Jun 95 | 257.07* | 184.29* |
| Jan 94 to Jun 95 and Jul 95 to Dec 96 | 256.16* | 178.71* |
| **Periods of 24 Months** | | |
| Jan 91 to Dec 92 and Jan 93 to Dec 94 | 176.44* | 121.83 |
| Jan 93 to Dec 94 and Jan 95 to Dec 96 | 176.01* | 134.72 |
| **Periods of 36 Months** | | |
| Jan 91 to Dec 92 and Jan 94 to Dec 96 | 123.96* | 137.28 |

*Note*: The $\chi^2$ values significant at 5 percent level are indicated by *. Box-M $\chi^2$ test is not applicable for the pooled sample of Asian and Latin American countries with 12-month periods because the number of variables exceeds the number of observations.

The above result along with our results in Section 5.3 means that we can draw the following general conclusion. While the correlation matrices are relatively stable over a long period, they are subject to short period instability. Thus by and large the co-movements in stock returns are relatively stable in the long run but this long run relationship is subject to frequent short-term deviations. In other words we can conclude that the degree of stability in co-movements increases with the length of investment horizon. This result is consistent with the findings in Shaked (1985) based on the analysis of sixteen developed markets over the period January 1960 to December 1979.

Relating this conclusion to the results of section 5.2 leads us to draw the following additional conclusion. Although the short term relationship between stock returns is stronger than the long-term relationship but the latter seems to be more stable than the former. This conclusion again confirms our earlier assertion that the short term interlinkages across stock markets are mostly based on sentiments and perceptions while the longer term interlinkages, though weaker, are based on more precise and considered assessments. This is so because the market signals in short run are more like news, which may or may not confirm to realisation. Most of the trading activities in stock markets are driven by spontaneous reactions to what the investors believe how the market will react to the news. An average investor is satisfied if he can "guess better than the crowd how the crowd will behave; and, given equal intelligence, he may make more disastrous mistakes" (Keynes (1939)). The so-called "mass psychology", as Keynes (1939) puts it, usually leads to over-reaction to the news. In the long run, on the other hand, the news is replaced by information as the realisation is revealed gradually. Since the realisation does not necessarily match the news, the short-term stock market interlinkages are most likely to be temporary.

Although there is not enough empirical evidence on the emerging markets in our framework of analysis, a rough comparison can still be made with a recent study by DeFusco, Geppert and Tsetsekos (1993). This study has applied co-integration analysis to stock prices of emerging markets for the period January 1989 to May 1993. The study did not find evidence of co-integration in stock prices indices. This result is consistent with our finding that the long period relationships in the stock markets are weak.

With lack of sufficient empirical work on the emerging markets, our study can be taken as a stepping stone to build further work on the subject. Specially, there is a need to study the subject with more rich data set in terms of longer time series of shorter period returns and compare the pattern of interlinkages between short and long holding periods.

## 6. CONCLUSION

This report has been an attempt to study the pattern of stock markets integration among the emerging markets in Asian and Latin America. For this purpose the monthly stock prices of nine Asian and six Latin American markets are analysed. This means that the stock price co-movements are meant to represent the relationship in the relative changes in stock prices or in the rates of return over a holding period of one month. The stock market interlinkages are investigated for the markets within Asia, within Latin America and across the two continents. The study uses a variety of statistical methods, descriptive as well as inference based.

One of the main results of our analysis is that the short period stock market interlinkages in our sample of Asian and Latin American emerging markets are quite strong. The markets within Asia as well as Latin America are closely interlinked. Furthermore, there is also some evidence of inter-relationship across the Asian and Latin American markets, though the intra-continental co-movements in stock prices are stronger than the inter-continental co-movements.

Our second major conclusion is that the stock markets interlinkages are unstable in the short run but relatively stable in the long run. This means that in the short run the markets are closely inter-related but the relationships are unstable. In the long run the relationships becomes more stable but weaker at the same time.

In the short-run stock markets are likely to over-react to news from the other stock markets while the reaction in the long-run is more considered. Therefore the interlinkage in the short run is stronger than the one is the long run. However, the long run interlinkages are more sustainable while the short run interlinkages are mostly temporary, as deviations from the long run relationship. This result holds especially for the more volatile Latin American markets.

This result has an important implication for the international diversification of financial assets. With relatively high and unstable correlation in the rates of return across emerging markets in the short-run, the expected gains from diversification in terms of reducing the risk are not very attractive. On the other hand, in the long run the interlinkages among the markets become weaker but more stable. Thus at least some benefits from international diversification of portfolio can be realised in the long run. Thus an investment strategy from the long run perspective is more likely to pay dividends than the one driven by reaction to short term changing in the markets' performance.

## REFERENCES

Ammer John and Jianping Mei (1996) "Measuring International Economic Linkages with Stock Market Data". *The Journal of Finance* 51 (5): 1743-1761.

Arshanapalli, Bala and John Doukas (1993) "International Stock Market Linkages: Evidence from the Pre-and Post-October 1987 Period". *Journal of Banking and Finance* 17 (1): 193-208.

Bekaert, Geert (1995) "Market Integration and Investment Barriers in Emerging Equity Markets". *The World Bank Economic Review* 9(1): 75-108.

Chan, K.C., Andrew Karolyi and Rene Stulz (1992) "Global Financial Markets and the

Risk Premium on U. S. Equity". *Journal of Financial Economics* 32: 137-167.

Claessens, Stijn (1995) "The Emergence of Equity Investment in Developing Countries: Overview". *The World Bank Economic Review* 9(1): 1-17.

DeFusco, R., J. M. Geppert and G. P. Tsetsekas (1993) "Emerging Capital Markets: Results from Co-integration Tests." Presentation at the Annual Meeting of the Financial Management Association, October 1993.

Dwyer, G. P., Jr and R. W. Hafer (1988) "Are National Stock Markets Linked?" *Federal Reserve Bank of St. Louis* 70: 3-14.

Errunza, V. and E. Losq (1985) "The Behaviour of Stock Prices on LDCs Markets". *Journal of Banking and Finance* 9 (4): 561-575.

Greene, W. H. (1993) *Econometric Analysis*, Second Edition. New York: MacMillan.

Grubel, Herbert G. and Kenneth Fadner (1971) "The Interdependence of International Equity Markets". *The Journal of Finance* 26: 89-94.

Haney, R. L., Jr. and W. P. Lloyd (1978) "An Examination of the Stability of the International Relationships Among a National Stock Market Indices". *Nebraska Journal of Economics and Business* 17: 55-65.

Harvey, Campbell R. (1995) "The Risk Exposure of Emerging Equity Markets". *The World Bank Economic Review* 9(1): 19-50.

Hartmann, M. and Dara Khambata (1993) "Emerging Stock Markets: Investment Strategy of the Future." *Columbia Journal of World Business* 82-104.

International Finance Corporation (1990-1997) *Emerging Stock Markets Factbook*. Washington, D. C.

Jeon, B. N. and G. M. V. Fuerstenberg (1990) "Growing International Co-Movement in Stock Price Indices." *Quarterly Review of Economics and Business* 30(3): 15-30.

Jenrich, Robert I. (1970) "An Asymptotic Chi-Square Test for the Equality of Two Correlation Matrices". *Journal of the American Statistical Association* 65: 904-912.

Kaplanis, E. (1988) "Stability and Forecasting of the Co-movement Measures of International Stock Market Returns". *Journal of International Money and Finance* 7: 63-75.

Keynes, John Maynard (1939) *The General Theory of Employment Interest and Money*. London: MacMillan.

Korajczyk, Robert A. (1996) "A Measure of Stock Market Integration for Developed and Emerging Markets". *The World Bank Economic Review* 10(2): 267-289.

King, M. Sentana, E and Wadhwani, S. (1994) "Volatility and Links Between National Stock Markets". *Econometrica* 62(4): 901-933.

Kullback, S. (1967) "On Testing Correlation Matrices". *Applied Statistics* 16: 80-85.

Meric, Ilhan and Gulser Meric (1989) "Potential Gains from International Portfolio Diversification and Inter-temporal Stability and Seasonality in International Stock Market Relationships". *Journal of Banking and Finance* 13 (4): 627-640.

Merton, R. C. (1980) "On Estimating the Expected Return on the Market: An Exploratory Investigation". *Journal of Financial Economics* 8: 323-361.

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Ripley, D. (1973) "Systematic Elements in the Linkage of National Stock Market Indices". *Review of Economics and Statistics* 55(3): 356-361.

Shaked, Israel (1985) "International Equity Markets and the Investment Horizon". *The Journal of Portfolio Management*: 80-84.

Snedesor, George W. and William G. Cochran (1967) *Statistical Methods*, Sixth Edition. AMES Iowa, USA.

Solnik, Bruno H. (1974) "Why Not Diversify Internationally Rather than Domestically?" *Financial Analyst Journal* 48-54.

Tesar, Linda, and Ingrid Werner (1995) "U.S. Portfolio Investment and Emerging Stock Markets". *The World Bank Economic Review* 9(1): 109-130.

Uppal, J. (1993) "The Internationalization of the Pakistani Stock Market: An Empirical Investigation". *The Pakistan Development Review* 32(4): 605-618.

## ABSTRACT

This study analyses stock price co-movements in a sample of fifteen emerging markets in Asia and Latin America using monthly data over the period January 1990 to December 1996. In addition interlinkages of the emerging stock markets with the world, regional and leading country markets are also studied. The first major result of the study is that in the short period stock market interlinkages are quite strong. The markets within Asia as well as Latin America are closely interlinked. Furthermore, there is also some evidence of inter-relationship across the Asian and Latin American markets, though the intra-continental co-movements in stock prices are stronger than the inter-continental co-movements. Our second major result is that in the short run the markets are closely inter-related but the relationships are unstable, while in the long run the relationships becomes more stable but weaker at the same time.

Our results have important implications for the international diversification of financial assets. With relatively high and unstable correlation in the rates of return across emerging markets in the short-run, the expected gains from diversification in terms of reducing the risk are not very attractive. On the other hand, in the long run the interlinkages among the markets become weaker but more stable. Thus at least some benefits from international diversification of portfolio can be realised in the long run. Thus an investment strategy from the long run perspective is more likely to pay dividends than the one driven by reaction to short term changing in the markets' performance.