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International Transmission Mechanism of Stock Market Movements: Evidence from Emerging Equity Markets

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ABSTRACT

This paper investigates the transmission patterns of stock market movements between developed and emerging market economies by estimating a four-variable VAR model. The underlying economic fundamentals and trade links are considered as possible determinants of differences in transmission patterns. The results of the impulse response functions and variance decompositions indicate that significant links exist between the stock markets of the USA and Mexico and weaker links between the markets of the USA, Argentina, and Brazil. Differences in the patterns of stock market responses are consistent with differences in trade flows. The response of emerging markets to a shock to the US market lasts longer than that of a developed market such as the UK. While no single emerging market can affect the US stock market, the combined effect of emerging markets on the US stock market is found to be statistically significant. These findings can be linked to differences in the speed of information processing and to the institutional structure governing the market. Overall the findings suggest that the transmission of stock market movements is in accord with underlying economic fundamentals rather than irrational contagion effects. Copyright © 2000 John Wiley & Sons, Ltd.

KEY WORDS stock market interdependence; emerging markets; VAR model

INTRODUCTION

This paper examines the international stock market interdependence between industrial and emerging market economies. Capital markets around the world have passed through an eventful period since the early 1980s. First, equity markets of developed economies have become increasingly international and more recently, the flow of portfolio investments to emerging markets increased rapidly as these economies undertook reforms to establish greater integration with the world markets. These changes, together with the global crash of equity markets in mid-October 1987, have created substantial interest in research on stock price movements that are

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propagated across world markets. Such spillovers could affect the economies of neighbouring nations or at least those who have close economic ties.

Although there are some studies on stock market interdependence, most of these deal with stock market movements that are propagated among developed countries only. How economies of developing countries are affected by stock market movements of developed economies and by other emerging economies is yet to be understood. This paper contributes to the existing literature by investigating the transmission patterns of stock market movements between developed and emerging market economies in a multivariate framework by estimating a four-variable VAR model.

Most studies in the literature employ univariate analyses and therefore implicitly ignore the effect of other countries in their conclusions. For example, a shock originating in a third country not considered in the analysis might mistakenly be seen as a disturbance originating from one of the markets included in the study. In such cases, correlations in the rates of return may not imply that markets are integrated or segmented but may simply reflect responses to common international shocks. As Jeon and von Furstenberg (1990) and others argue, to deal with these problems a more appropriate approach would be to employ a dynamic simulation model such as a vector autoregression (VAR) model that is multivariate in nature. Moreover, the VAR models like the one used in this study captures the 'pure' effects of artificial shocks introduced by the researcher in a similar manner to dynamic simulations.

While a number of studies (Eun and Shim, 1989; Chowdhury, 1994) argue that weekly time period returns are too long to investigate rapid interactions that take place among stock markets of industrialized countries, the findings in this study show that this is not the case for emerging markets. The US market is found to strongly influence the Latin American markets but the strength of this effect varies substantially across borders. The US market effect on Mexico is much larger than that on Argentina and Brazil. As expected, emerging markets respond more quickly to shocks originating in their own market than from foreign market disturbances. Thus emerging markets seem to be faster processors of information when shocks originate domestically rather than externally. This finding is consistent with the asymmetric information hypothesis suggested in the aftermath of the 1994 Mexican crisis, implying that local investors reacted faster than international investors to news about the Mexican economy because local investors were more alert and sensitive to potential warning signals, when shocks originate domestically.

An important implication of the results found here is that emerging market economies that have opened their markets to achieve greater financial integration are more prone to external shocks. Moreover, the findings challenge the view that the transmission of shocks from one market to another is not affected by the underlying economic fundamentals.

PREVIOUS RESEARCH

Although researchers have previously analysed the transmission patterns of financial market shocks, the underlying economic fundamentals are hardly questioned. This could help us understand to what extent differences in the transmission patterns of shocks are justified by economic fundamentals.

Another problem is that studies by Eun and Shim (1989), Jeon and von Furstenberg (1990) do not report confidence bands around variance decompositions (VDCs) and impulse response functions (IRFs). According to Runkle (1987), reporting VDCs and IRFs without confidence

intervals is equivalent to reporting regression coefficients without *t*-statistics. Eun and Shim (1989) use a VAR model to study the transmission mechanisms of stock market movements among developed economies of the world. They find that the US stock market influences heavily the stock markets of the UK and Japan. Chowdury (1994) uses a VAR model to examine the transmission of shocks between newly industrialized nations and developed markets and finds evidence in favour of stock market interdependence. Chowdury reports confidence bands that are two standard deviations away from the mean IRFs and VDCs. However, reporting the bands as such makes them seem as if they are crossing the horizontal axis much quicker than bands that are one standard deviation away from the mean IRFs and VDCs. This biases the results in favour of the conclusion that these markets are faster processors of information. The study also does not consider economic fundamentals and trade links as possible determinants of differences in transmission patterns.

Frankel and Schmukler (1996) examine how a negative shock in Mexican equities is transmitted to Asia and Latin America and find that such shocks seem to have a stronger impact in countries with weak fundamentals. Cashin, Kumar, and McDermott (1995) use Johansen cointegration tests and a VAR model to measure the degree of international integration of industrial and emerging country equity markets. They find that linkages have strengthened in recent years. However, their study ignores the effect of trade links and other fundamentals on transmission patterns.

This study is an improvement over the existing research in that it uses Monte Carlo methods to specify confidence bands around impulse response functions and variance decompositions for statistical inference. Moreover, the study considers underlying economic fundamentals and differences in trade links as possible determinants of transmission patterns of stock market movements for a set of both developed and developing countries.

INSTITUTIONAL FRAMEWORK

International differences in the institutional framework of emerging market economies may play an important role on the magnitude of shocks transmitted across countries. The emerging equity market (EEM) criterion is defined by the International Finance Corporation (IFC) of the World Bank as the equity markets of countries that can be termed to be still in the economic development stage. Typically in these markets, price–earning ratios are higher than in developed markets, there is lower presence of liquidity, and market concentration tends to be higher than developed markets. In most developing countries, banks play the dominant role in the short-term allocation of credit. Mainly banks hold the securities issued by the government with little or no secondary market activity. Also, interest rates are normally tightly regulated and do not reflect market-determined rates well.

During the 1989–94 period, foreign investor participation in the Latin American financial markets was relatively high in Argentina, Brazil and Mexico when compared to Colombia and Venezuela. In particular, Chile had the most significant capital controls. The Chilean authorities provided incentives for foreign capital to stay over the long term. A foreign investor had to put a certain amount of collateral in the central bank before investing in Chile which reduced the ability of capital to flow out of the country rapidly. In addition Mexico, Argentina and Brazil also lowered their regulatory and institutional barriers to financial flows coming from the rest of the world.

Table I reports the direction of trade flows between selected Latin American and industrialized countries. Mexico has the highest trade links with the USA among the Latin American countries. The volume of exports and imports of Mexico to the USA is close to that of the UK and Germany. Argentina and Brazil have strong trade links, but the trade links of these two countries with Mexico is roughly around one tenth of the Argentina–Brazil trade. Also, the volume of exports and imports of Argentina and Brazil with the USA is much smaller than that of Mexico's.

Given these differences in trade flows, and the stock prices as reflectors economic fundamentals, *a priori* one would expect the US stock market to influence the stock market of Mexico more heavily than the stock markets of Brazil and Argentina. Since the Mexican economy is more open to the USA than Argentina and Brazil, Mexico would be relatively more vulnerable to external shocks originating from the US economy. Moreover, the trade ties between Argentina and Brazil are much stronger than that of Mexico with Argentina or Brazil (Brazil's exports to Argentina was $1124 million, whereas Mexico's exports to Argentina was only $112 million). Given the differences in trade ties of Brazil with Argentina and Mexico, one would expect Brazil to be influenced from the shocks originating in Argentina more than in Mexico.

Table II reports the ratio of trade account to GDP, which may partially reflect a given country's ability to sterilize an exogenous shock coming from abroad during the 1989–94 period. The deficit/GDP ratio was negative and highest in absolute value for Mexico, Argentina, Chile and Brazil respectively. According to average ratios of exports and imports to GDP, after Chile, Mexico is the most open economy of the region. Thus, one would expect the Mexican financial market to be more sensitive to shocks originating from abroad.

Table II, Part B reports the ratio of foreign reserves to GDP for Argentina, Brazil, Chile and Mexico. The ratio of foreign reserves to GDP for Mexico and Brazil decrease sharply in 1994 whereas for Chile it remains steady over the same sample period. In the case of Brazil, there is a slight decrease in this ratio. In all, these statistics are consistent with the view that given an external shock (such as a negative capital account shock), Chile would be able to sterilize the effects on domestic credit better than Mexico and Brazil.

Table III reports the opening dates and number of stocks traded in each market. As a result of improved economic performance and institutional reforms in many emerging economies, notable flows of capital began entering into many emerging markets. The access of emerging economies to international capital markets led capital inflows to quadruple in the period between 1990 and 1993 (Folkerts-Landau and Ito, 1995). For example, Mexico alone received about 20% of total net capital flows to all emerging economies. Given that Mexico receives a higher share of foreign capital than any other emerging market, an unexpected outflow of capital would also have a large detrimental effect on the Mexican economy.

Table IV reports net portfolio and foreign direct investment in emerging markets. There is agreement in the literature that the recent upsurge in the supply of capital to developing economies appears to have been driven largely by three factors: (1) the success of some Western Hemisphere countries and the Philippines in implementing sound macroeconomic policies and structural reforms; (2) the sluggishness in economic activity of industrial economies and the decline in the interest rate in industrial countries; (3) the ongoing international diversification of rapidly expanding institutional portfolios.

Securitization of international finance meant that international syndicated bank lending was giving way to direct debt and equity as the preferred instrument of fast capital transfer to emerging markets. One implication of securitization is that disturbances originating from a

Table I. Direction of trade flows

	1989		1990		1991		1992		1993		1994	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
USA												
Argentina	1037	1539	1179	1664	2049	1410	3222	1370	3772	1298	4466	1835
Brazil	4799	9001	5002	8586	6154	7232	5740	8145	6084	8021	8119	9307
Chile	1411	1503	1672	1571	1840	1525	2455	1627	2605	1702	2776	2073
Mexico	24969	27590	28375	30797	33276	31866	40598	35886	41635	40745	50840	50336
Germany	16883	25672	18752	29080	21317	26895	21236	29516	18957	29462	19237	32690
Japan	44584	97110	48585	93070	48147	95010	47764	99481	47950	110418	53481	122470
UK	20866	18881	23484	20932	22063	19051	22808	20694	26376	22392	26833	25858
Mexico												
Argentina	112	160	113	346	181	401	180	265	278	275	244	303
Brazil	192	325	167	394	184	829	408	1220	291	1312	376	1326
Chile	44	117	58	101	44	138	90	178	130	210	212	264
Brazil												
Argentina	1124	721	1413	718	1489	1532	1671	3339	2814	3568	3658	4286
Chile	523	703	487	564	448	698	451	996	406	1060	685	1000

Source: IMF, Direction of Trade Flows statistics, 1996.

Table II. Ratio of trade account to GDP and Central Bank foreign reserves (% change over the previous year

	1989	1990	1991	1992	1993	1994	Avg (M/GDP)	Avg (X/GDP)
(A) Trade account/GDP								
Argentina	0.065	0.057	0.017	−0.013	−0.018	−0.023	0.066	0.084
Brazil	0.0375	0.0178	0.0203	0.0350	0.0223	0.0118	0.065	0.09
Chile	0.045	0.034	0.039	0.014	−0.022	0.014	0.29	0.29
Mexico	−0.001	−0.011	−0.0317	−0.0547	−0.0418	−0.050	0.17	0.13
(B) Foreign reserves/GDP								
Argentina	—	0.059	0.049	0.049	0.059	0.052*		
Brazil	0.12	0.06	0.069	0.179	0.28	0.09		
Chile	0.16	0.24	0.243	0.265	0.257	0.27		
Mexico	0.035	0.043	0.063	0.057	0.068	0.025		

*As of third quarter of 1994. *Source*: IMF, International Financial Statistics, 1996.

Table III. Degree of openness

Country	Opening date	Degree of openness	Number of stocks in the Index October 1993
Argentina	October 1991	Fully open	31
Brazil	May 1991	100% non-voting preferred stock 49% of voting common stock	70
Chile	December 1988	25% of shares for listed companies	35
Mexico	May 1989	30% for banks 100% for other stocks	71

Source: IFC Index Methodology, 1993.

Table IV. Net portfolio investment and foreign direct investment (in millions of US dollars)

	Portfolio Investment 1989	1990	1991	1992	1993	1994
Net						
Argentina	−1098	1346	−34	−680	7988	—
Brazil	−361	512	3808	7366	12322	44732
Chile	87	359	186	452	747	1022
Mexico	298	3985	12138	16876	28355	7574
Foreign direct investment						
Argentina	1028	1836	2439	4179	6305	—
Brazil	1131	989	1103	2061	1292	3072
Chile	1289	590	523	699	841	1795
Mexico	2785	2549	4742	4393	4389	7978

Source: International Financial Statistics, July 1996.

developed country (or developing country) financial crisis can cause major setbacks in developing country security markets particularly when the foreign reserve position of the central bank is not strong.

The growth of global institutional investors has meant that capital flows to emerging markets are now predominantly driven by liquidity and performance considerations, rather than by longer-term banking relationships. According to the IMF report on International Capital Markets (1995), institutional investors in the USA, Japan, Germany, France, and the UK together increased their international investments from around $100 billion (or 4.8% of assets) in 1980 to roughly $900 billion (7.2% of assets) in 1993. This outpaced the growth in total assets under management over the same period. In 1987, about $0.50 out of each $100 of foreign investment was invested in emerging markets, whereas by 1993 more than $16 out of each incremental $100 of foreign investment was invested in emerging markets. An implication of these magnitudes is that significant capital flows to emerging economies can have adverse effects on the real exchange rate and on inflation, as these flows constitute a significant portion of those countries foreign reserves. The ability of capital to move fast out of the emerging economies also makes adjustment difficult for these countries. As a consequence, servicing international debt obligation is likely to become even more difficult in times of crisis in today's world.

ECONOMETRIC METHODOLOGY

The VAR model was developed by Sims (1980) with the purpose of estimating unrestricted reduced-form equations that have uniform sets of lagged dependent variables as regressors. The VAR model thus estimates a dynamic simultaneous equation system, free of *a priori* restrictions on the structure of relationships. Since no restrictions are imposed on the structural relationships between variables, the VAR system can be viewed as a flexible approximation to the reduced form of the correctly specified but unknown model of the actual economic structure. Considering that structural models are very often misspecified, it is appealing to use the VAR for the purpose of stylizing empirical regularities among time-series data.

VAR models that are estimated with non-stationary data pose a problem because differencing to achieve stationarity could introduce distortions into multivariate models. Two approaches have been suggested for estimating such models that are not Bayesian. Engle and Granger (1991) suggest using vector error correction models with differenced data to achieve stationarity and using an error correction term to replace the long-run information lost through differencing. Phillips and Durlauf (1986) suggest that VAR models can be estimated with data in levels if the non-stationary data is also cointegrated because recent theoretical work proves that estimation with such data will yield consistent parameter estimates.

As noted by Lastrapes and Koray (1990) and McMillin (1991), the VAR modelling technique is an effective means of characterizing the dynamic interactions among economic variables by introducing very few restrictions on the model. Runkle (1987) has argued that reporting the VDCs and IRFs without standard errors or confidence intervals is equivalent to reporting regression coefficients without *t*-statistics. However, Monte Carlo methods can be used to estimate confidence bands for statistical inference.

The VAR model is expressed as:

$$Z(t) = C + \sum_{s=1}^{m} A(s)Z(t-s) + e(t) \tag{1}$$

where $Z(t)$ is a 4×1 column vector of rates of return of four stock markets, C is the deterministic component comprised of a constant, $A(s)$ are respectively, 4×1 and 4×4 matrices of coefficients, m is the lag length, and $e(t)$ is the 4×1 innovation vector. By construction, $e(t)$ is uncorrelated with all the past $Z(s)$.

The estimated VAR is inverted to form the moving average representation of the system expressed as

$$Z(t) = \sum_{s=0}^{x} B(s)e(t-s) \tag{2}$$

where $Z(t)$ is a linear combination of current and past one-step-ahead forecast errors or innovations. The i,jth component of $B(s)$ shows the response of the ith market in s periods after a unit random shock in the jth market. The $e(t)$s are serially uncorrelated by construction, although they may be contemporaneously correlated.

In order to capture 'pure' responses, it is important to transfer the error terms. A lower triangular matrix V is chosen to obtain the orthogonalized innovations u from $e = VU$. The i,jth component of $B(s)V$ in equation (3) represents the impulse response of the ith market in s periods to a shock of one standard error in the jth market:

$$Z(t) = \sum_{s=0}^{x} B(s)Vu(t-s) \tag{3}$$

The orthogonalization also provides $\Sigma C_{ij}^2(s)$, which is the component of forecast error variance in the $t+1$-step-ahead forecast of Z_i that is accounted for innovation in Z_j. This decomposition of the forecast error variance gives a measure of how important one variable is in generating fluctuations in its own and other variables. The advantage of using orthogonalized innovation is that it is possible to allocate the variance of each element in Z to sources in elements of u, since u

is serially and contemporaneously uncorrelated. Monte Carlo methods can be used to infer the distribution of the matrix of impulse response coefficients. Implementation of this procedure involves first estimating the VAR and saving the coefficient estimates and the fitted residuals, then considering an artificial random variable u that has probability $(1/T)$ of taking on each of the particular values in the distribution, next, taking a random draw with replacement from this distribution, and using this to construct the first innovation in an artificial sample. Proceeding in this fashion, a full sample of u can be generated. A VAR can be fitted by OLS to these simulated data producing an OLS estimate from which the magnitude of the impulse response coefficients can be calculated.

Impulse responses are highly non-linear functions of the estimated parameters. Thus Monte Carlo integration techniques are recommended to calculate the confidence bands. A technique similar to that suggested by Genberg, Salemi and Swoboda (1987) is employed in this study to assess the meaningfulness of estimates. This technique is used to generate the 25th, 50th, and 75th percentile estimates for VDCs and standard errors of the IRFs. Five hundred draws are employed in the Monte Carlo procedures. Variance decompositions reported without separating into percentiles always add up to 100 in these estimations. However, when VDCs are reported in a specific percentile for each variable, the summation of the VDCs may not exactly add up to 100.[1] The purpose in generating different percentile estimates is similar to reporting standard errors.

DATA

The data source for this study is the Emerging Markets database constructed by the International Finance Corporation (IFC). This contains monthly and weekly stock market indexes for a large number of developing countries. The indexes are consistently computed across different countries and, therefore, directly comparable. The stocks included in the indexes are selected on the basis of market size, trading activity and sector representation. All indexes are weighted by market capitalization.

The sample interval covers the period from the last week of December 1988 to the second week of September 1994 for a total of 297 observations. All the countries in the Emerging Markets database use a Monday–Friday trading week with the exception of Jordan, Korea, Taiwan, China.

In order to have a benchmark for the results, the analysis is extended to weekly return series from four developed markets: the USA, Germany, Japan, and the UK. For the USA the weekly observations on the S&P 500 index is used. For the remaining countries, returns are computed from the daily Financial Times Actuaries World Indices (FTAWI). The FTAWI indexes are constructed following two criteria: investibility and market representation. Stocks, which are available to foreign investors, are included in the index in descending order of size. The selection continues until the sample included in the index represents approximately 85% of the capitalization of the investible sample. All returns are continuously compounded.

Three emerging stock markets (Mexico, Brazil, and Argentina) and the USA are included in the four-variable vector autoregression (VAR) model. Lag length tests to determine the optimal lag length indicate that estimating the system with four lags was not statistically different from estimating it with six or twelve lags.

[1] The interested reader can contact the author on how this occurs.

Table V. Summary statistics: weekly returns from 01/06/89 to 09/09/94

Country	Mean	Std. dev.	Skew	Kurt.	Max	Min
Argentina	2.97	11.6	1.88	11.70	76.1	−40.3
Brazil	5.57	8.78	−0.63	6.54	30.1	−45.7
Mexico	0.84	2.94	−0.34	3.42	8.87	−9.73
USA	0.24	1.66	−0.34	4.50	5.32	−7.21
Germany	0.18	2.35	−0.48	4.13	5.71	−8.89
Japan	−0.13	2.84	−0.01	5.53	11.2	−11.6
UK	0.27	1.99	0.4	4.21	8.29	−5.19

Table VI. Cross-correlations of returns from 01/06/89 to 09/09/94

Country	USA						
USA	1.0	UK					
UK	0.72	1.0	Germany				
Germany	0.29	0.50	1.0	Japan			
Japan	0.32	0.85	0.29	1.0	Argentina		
Argentina	0.11	0.05	−0.03	0.15	1.0	Brazil	
Brazil	0.09	0.16	0.035	0.00	0.093	1.0	Mexico
Mexico	0.32	0.38	0.33	0.21	0.18	0.094	1.0

SUMMARY STATISTICS

Table V reports the summary statistics for the weekly return series (in local currency returns). Not surprisingly, emerging markets exhibit greater volatility compared to developed markets. Argentina and Brazil are the two most volatile markets in the sample, their standard deviations being 11.6 and 8.78, respectively, while the same measure for the US market is only 1.66. In most countries higher average returns are associated with higher level of volatility, suggesting that investors are compensated for bearing higher risk. The average weekly returns are 2.97% in Argentina and 5.57% in Brazil, but only 0.24% in the USA. The kurtosis index, although high for all the countries, is considerably higher in the emerging markets.

Table VI reports cross-correlations of market returns for both industrialized and emerging economies. The stock market returns of Mexico appear to be more correlated with the US stock market returns than the stock market returns of Argentina and Brazil. The correlation coefficients of the stock market returns for Mexico are as high as the correlation coefficients of the stock market returns for Germany, Japan and the UK. Correlations *per se*, however, do not alone indicate whether there are any links between any pair of markets. Although there may not be a link among a set of national markets these high correlations may be present because such markets may simultaneously respond to global shocks. For this purpose a VAR model is needed to investigate the existence of stock market linkages.

ESTIMATION RESULTS

In the estimation stage, unit root and cointegration tests are run to analyse time-series properties of the data. The results from the Augmented Dickey–Fuller test reveal that all the series are not

Table VII. Innovations in US stock returns explaining Mexico's stock returns

Horizon	First ordering			Second ordering			Third ordering		
	25%	50%	75%	25%	50%	75%	25%	50%	75%
2	11.77	14.24	17.33	12.06	14.63	17.10	11.84	14.81	17.75
3	11.93	14.66	17.84	12.08	15.16	18.11	12.22	15.00	18.215
4	12.20	14.85	18.00	12.22	15.17	17.81	12.14	15.01	17.78

Ordering 1: USA, Mexico, Argentina, Brazil
Ordering 2: USA, Argentina, Brazil, Mexico
Ordering 3: USA, Argentina, Mexico, Brazil

Table VIII. Innovations in Japan's returns explaining UK stock returns

Horizon	First ordering			Second ordering			Third ordering		
	25%	50%	75%	25%	50%	75%	25%	50%	75%
2	0.05	0.28	0.99	39.06	42.13	44.68	0.05	0.21	0.72
3	0.38	0.76	1.39	38.39	42.37	44.31	0.23	0.59	1.40
4	0.81	1.52	2.04	37.45	40.46	42.62	0.59	1.12	1.77

Ordering 1: USA, UK, Japan, Germany
Ordering 2: USA, Japan, Germany, UK
Ordering 3: USA, Germany, UK, Japan

stationary in the form of logarithmic levels but stationary in the form of logarithmic first differences. Because the series are integrated of order one, the Johansen 1988 multivariate cointegration test is performed to see whether there is cointegration among the variables used in VAR model estimations. However, the multivariate cointegration tests on the set of four variables for both developed and emerging markets suggest that there were no cointegrating vectors present among these variables; thus a VAR system estimated in the log-differences form could not be misspecified.[2]

If the residuals are close to being uncorrelated, the order of factorization makes little difference. Table VII reports the results of different orderings of the USA, Mexico, Argentina, and Brazil. The indication is that a particular ordering does not bias results in favour of one market or another. The range between 25th and 75th percentiles is less than 5 percentage points, which further supports the strength of the results.

Table VIII reports the results of different orderings for the USA, the UK, Japan, and Germany. When the ordering of the variables is changed, it affects the results significantly. This indicates the presence of strong contemporaneous relationships among the VAR residuals. Previous studies using daily data for developed markets do not find that the results are sensitive to the ordering of the variables. One explanation could be that the use of weekly data is not appropriate for capturing potential interactions in the case of developed markets, because a week may be too long to see the volatility that may have taken place within the week and settled by the end of it. Thus, weekly data would somewhat be smoother than daily data.

[2] To conserve space, results of the unit root and cointegration tests are not reported. However, if requested they can be obtained from the author.

Table IX. Innovations in the UK explaining stock returns of Mexico

Horizon	First ordering			Second ordering			Third ordering		
	25%	50%	75%	25%	50%	75%	25%	50%	75%
2	14.35	17.25	20.43	15.69	18.24	20.96	13.96	17.45	19.54
3	15.12	17.89	20.75	13.63	17.86	20.10	14.58	17.89	20.46
4	15.45	18.25	21.02	14.85	17.66	20.93	15.07	18.17	21.29

Ordering 1: UK, Mexico, Argentina, Brazil
Ordering 2: UK, Argentina, Brazil, Mexico
Ordering 3: UK, Argentina, Brazil, Mexico

Table X. Innovations in Japan explaining stock returns of Mexico

Horizon	First ordering			Second ordering			Third ordering		
	25%	50%	75%	25%	50%	75%	25%	50%	75%
2	4.75	6.26	8.41	4.15	6.67	7.70	4.46	5.94	8.57
3	4.91	6.69	8.38	4.91	3.79	7.96	4.98	6.29	8.23
4	5.13	6.91	8.82	5.19	6.64	8.68	4.33	5.76	8.03

Ordering 1: Japan, Mexico, Argentina, Brazil
Ordering 2: Japan, Argentina, Brazil, Mexico
Ordering 3: Japan, Argentina, Brazil, Mexico

Table IX reports the results of the estimations using different orderings of the UK, Mexico, Argentina, and Brazil. The results of the variance decompositions are not affected when the ordering of the variables are changed. The range between the 25th and the 75th percentiles is approximately around 5 percentage points, further supporting the strength of the results.

Table X reports the results of the estimations using different orderings of the variables for Japan, Mexico, Argentina and Brazil. The results of the variance decompositions again are not affected when the ordering of the variables are altered. The range between the 25th and the 75th percentiles is less than 5 percentage points indicating that the results of the variance decompositions do not vary significantly to interfere with the reliability of these estimates.

After excluding Japan, Germany and the UK individually from the system, and testing for the sensitivity of results to different orderings, it became clear that once the UK is excluded from the system, there was a substantial improvement in the robustness of the results to the way the variables are ordered. Thus, strong contemporaneous relationships between the VAR residuals can be partially attributed to the UK stock market. It is not surprising to obtain such results for developed markets using weekly data because one would expect these markets to be relatively more efficient in processing information.

Table XI reports the results of the variance decompositions of a system with three developed markets: the USA, Japan, and Germany after excluding the UK market. When there is strong correlation among innovations in variables, the decomposition of one-step variance depends strongly on the order of factorization in which case no conclusions can be drawn. The system was initially estimated with four variables including the UK stock market. However, as the ordering of the variables was changed (to determine whether ordering mattered), most of the variance of the third variable was attributed to whichever variable came second. This problem disappeared

Table XI. Innovations in Japan explaining UK stock returns

Horizon	First ordering			Second ordering		
	25%	50%	75%	25%	50%	75%
2	4.62	6.19	8.72	0.78	1.84	3.22
3	4.52	6.52	8.57	0.87	2.14	3.40
4	5.4	7.11	8.52	1.55	2.80	4.00

Ordering 1: USA, Japan, Germany
Ordering 2: USA, Germany, Japan

Table XII. Variance decompositions: emerging stock markets

Horizon								
Week 2			Week 3			Week 4		
Dependent variable: US								
97.21	98.45	99.20	94.88	96.21	97.38	93.44	95.31	96.58
0.06	0.25	0.72	0.35	0.81	1.50	0.50	1.05	1.95
0.12	0.50	1.28	0.90	1.72	2.70	1.09	1.91	2.92
0.05	0.21	0.61	0.29	0.70	1.42	0.60	1.09	1.95
Dependent variable: Mexico								
11.77	14.24	17.33	11.93	14.66	17.84	12.20	14.85	18.00
79.36	82.16	85.07	78.25	81.70	84.50	77.34	80.41	83.31
0.81	1.77	2.90	1.16	1.95	3.33	1.38	2.45	3.74
0.18	0.62	1.38	0.50	1.03	1.91	0.75	1.46	2.34
Dependent variable: Argentina								
0.61	1.28	2.46	1.82	2.90	4.53	2.17	3.53	5.29
0.73	1.54	2.72	1.29	2.27	3.52	1.76	2.82	4.13
93.79	95.72	97.27	90.82	93.14	94.93	88.91	91.29	93.28
0.16	0.57	1.24	0.45	0.97	1.83	0.92	1.55	2.65
Dependent variable: Brazil								
0.52	1.19	2.45	1.15	2.11	3.44	1.48	2.39	3.84
0.57	1.13	2.02	1.07	2.10	3.07	1.74	2.80	4.27
3.99	6.06	8.30	4.77	6.64	8.94	4.91	7.10	9.46
88.35	90.81	93.15	85.43	88.35	91.11	83.65	86.85	89.39

when the UK was excluded from the system. Other variables were also excluded individually but as long as the UK variable stayed, the results became sensitive to the way the variables were ordered in the system.

VARIANCE DECOMPOSITIONS

Table XII reports the results of the VDCs at the 25th 50th and 75th percentiles. There is substantial influence coming from the USA, and as expected, no emerging market alone significantly affects the US stock market. However, the combined effect of emerging markets on the US stock market is statistically significant. This result is not surprising given that in the recent past the combined effect of South-east Asian stock market crisis had a significant negative effect on the USA and other developed markets around the globe.

Table XIII. Variance decompositions: developed stock markets

Horizon								
Week 2			Week 3			Week 4		
Dependent variable: USA								
98.80	99.45	99.77	97.39	98.27	99.03	94.72	96.16	97.33
0.38	1.19	0.55	0.37	0.90	1.70	0.61	1.19	2.10
0.43	1.17	0.50	0.21	0.54	1.08	1.29	2.28	3.49
Dependent variable: Japan								
8.94	11.35	14.26	9.59	11.78	14.75	9.65	12.18	14.82
85.16	88.14	90.71	84.41	87.26	89.47	83.75	86.65	88.99
0.55	1.19	0.56	0.24	0.56	1.16	0.48	1.00	1.70
Dependent variable: Germany								
11.67	14.55	17.06	12.34	14.94	17.86	12.21	14.68	17.68
4.62	6.20	8.32	5.09	6.63	8.57	5.41	7.12	8.93
76.13	78.87	81.65	75.04	77.93	80.69	74.77	78.09	80.76

In Table XII, the innovations in the USA explain approximately 20% of the innovations in the Mexican stock market. The innovations in the stock market of Argentina explain approximately 10% of the Brazilian stock market. The innovations in the Mexican stock market can explain approximately 5% of the innovations of the stock market of Argentina. Because these markets have similar economic structures one would expect the transmission of shocks to be significant. Nonetheless, Mexico is not able to influence Argentina when the US market is included in the system. These findings are consistent with the strength of trade links observed between these economies.

Table XIII reports the results of the variance decompositions of a system with three developed markets—the USA, Japan and Germany—to provide a benchmark for the variance decompositions of emerging markets. Innovations in the US market can explain approximately 15% of the stock market of Japan and approximately 20% of the German stock market. Japan and Germany together are able to explain a little over 5% of the US stock market changes. These results suggest that there is substantially greater interaction among the developed markets when compared with that of emerging markets.

Table XIV reports the results of the VDCs for the UK, Mexico, Argentina and Brazil. Innovations in the UK appear to explain approximately 21% of innovations in the Mexican market. This finding is about the same magnitude of the influence of the USA on Mexico. Innovations in the UK are able to explain a greater percentage of the innovations in Brazil than Argentina. Innovations in Mexico are able to explain a greater percentage of Argentina when the US was included in the system rather than the UK. The effect of the US market may be transmitted to Mexico through the UK market and this may partially explain why the UK appears to have substantial influence on Mexico.

Table XV reports the results of the VDCs for Japan, Mexico, Argentina and Brazil. When compared with the previous results, Japan is only able to influence 8.82% of the innovations in Mexico. This finding is consistent with the view that compared to the influences of the UK and the US markets, the Japanese market influence is much weaker in line with the existence of trade between these nations. When the UK and the USA are absent from the system the effect of Mexico on Argentina increases. The market for Japan is able to influence the market of

Table XIV. Variance decompositions: the UK, Mexico, Argentina, Brazil

Horizon								
Week 2			Week 3			Week 4		
Dependent variable: UK								
95.987	97.361	98.334	93.039	94.802	96.353	92.579	94.124	95.337
0.24018	0.71993	1.5237	0.47346	1.1146	2.034	0.74013	1.3895	2.5178
0.0319	0.14052	0.37307	0.4112	0.94074	1.7615	0.74298	1.4011	2.1957
0.60811	1.3778	2.2756	1.2909	2.3602	3.7025	1.4875	2.4351	3.7059
Dependent variable: Mexico								
14.359	17.255	20.434	15.123	17.896	20.759	15.453	18.259	21.027
75.274	78.252	81.536	74.132	76.949	80.008	72.652	75.752	78.861
1.1396	2.1447	3.7649	1.6942	2.8443	4.4066	2.1023	3.4394	5.0904
0.50036	1.182	2.3374	0.79845	1.6319	2.694	1.1136	1.8337	2.7805
Dependent variable: Argentina								
0.26064	0.61591	1.2871	1.8764	3.1412	4.8432	2.485	3.538	4.9682
1.2813	2.1588	3.3711	2.1573	3.4595	5.2161	2.6779	4.149	6.2511
93.122	94.816	96.292	87.886	90.24	92.515	85.683	88.577	91.03
0.85441	1.8433	3.1919	1.1899	2.1494	3.4056	1.7817	2.8384	4.6433
Dependent variable: Brazil								
2.3977	4.192	6.0423	2.9417	4.7139	6.8377	3.8781	5.9225	8.1559
0.30339	0.71801	1.2983	0.78581	1.3219	1.994	0.9827	1.5738	2.4416
1.2624	2.3492	3.6143	1.6836	2.6877	4.0553	1.7295	2.7802	4.3331
90.017	92.288	94.268	87.773	90.578	92.679	86.388	88.644	91.297

Table XV. Variance decompositions: Japan, Mexico, Argentina, Brazil

Horizon								
Week 2			Week 3			Week 4		
Dependent variable: Japan								
94.886	96.492	97.831	93.438	95.267	96.547	92.076	93.953	95.257
0.18464	0.66932	1.4929	0.46848	1.0266	1.8614	0.78591	1.4145	2.3898
0.0990	0.35114	0.96165	0.35205	0.84479	1.6722	0.59015	1.2727	2.0066
0.84037	1.7393	2.8666	1.3979	2.2908	3.5584	1.7735	2.9006	4.3472
Dependent variable: Mexico								
4.7546	6.2678	8.4184	4.9127	6.6937	8.3847	5.1517	6.9113	8.8224
87.637	89.946	92.02	86.045	88.614	90.82	84.642	87.299	89.805
1.1302	2.0933	3.3349	1.633	2.8723	4.264	2.1481	3.4954	5.2805
0.25928	0.88227	1.8081	0.57761	1.1976	2.0792	0.86371	1.581	2.5945
Dependent variable: Argentina								
0.31552	0.83885	1.4042	1.3373	2.1186	3.217	1.4861	2.3425	3.4014
1.3407	2.3023	3.7248	2.8973	4.7583	6.7696	3.5189	5.1639	7.2769
92.329	94.433	95.795	87.422	90.178	92.275	86.201	88.575	90.792
0.95949	1.8934	3.0677	1.3482	2.3292	3.4928	1.8826	3.0014	4.6364
Dependent variable: Brazil								
2.5528	4.0086	5.5835	2.6675	4.2885	5.954	3.9598	5.5154	7.5691
0.43882	0.94628	1.8366	1.1386	1.8578	3.0036	1.4086	2.0826	3.2273
1.4906	2.5146	4.11	1.634	2.8716	4.372	1.8772	3.0326	4.5917
89.743	91.8	93.595	87.967	90.335	92.393	85.774	88.624	90.908

Argentina less than the market for Brazil. The individual influence of each emerging market on Japan does not exceed 5 percentage points and therefore are not significant. However, the joint effect of these three markets is approximately 10% and is significant.

IMPULSE RESPONSE FUNCTIONS

Figures 1–18 show the impulse responses and their upper and lower bands. If the upper or lower bands cross the horizontal axis, the response becomes statistically insignificant.

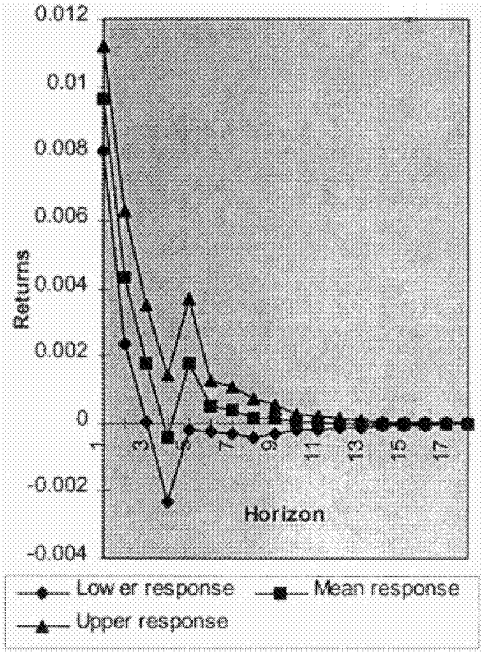

Figure 1. Response of Mexico to USA

Figure 1 shows the response of Mexico to a shock US stock market shock. The peak effect occurs in the first week and remains significant for two weeks. The lower bound crosses the horizontal axis following that week indicating that the shocks are not statistically significant after two weeks. The dispersion around the mean response (relative to the responses of Brazil and Argentina) to a shock to the USA are small. These responses are consistent with the relative magnitudes of the trade links of Mexico, Argentina, and Brazil with the USA.

Figure 2 shows the response of Argentina to a US stock market shock. The initial response is significant in the first week and then becomes insignificant. This is followed by a significant peak response in the second week and then it becomes insignificant after the third week. This zig-zag response may be attributed to the fact that the stock market of Argentina is one of the most volatile emerging markets around the globe. Further, the USA–Argentina trade links are not as strong as the USA–Mexico trade links. In 1994, the US imports from Mexico were more than ten times the US imports from Argentina. The US exports to Mexico were twenty-three times more

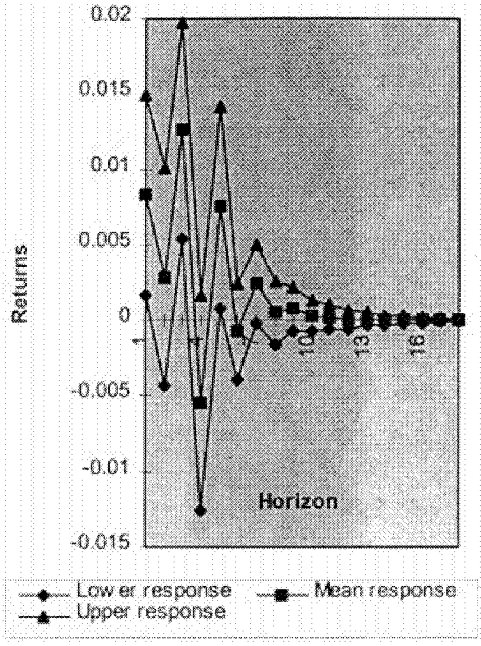

Figure 2. Response of Argentina to USA

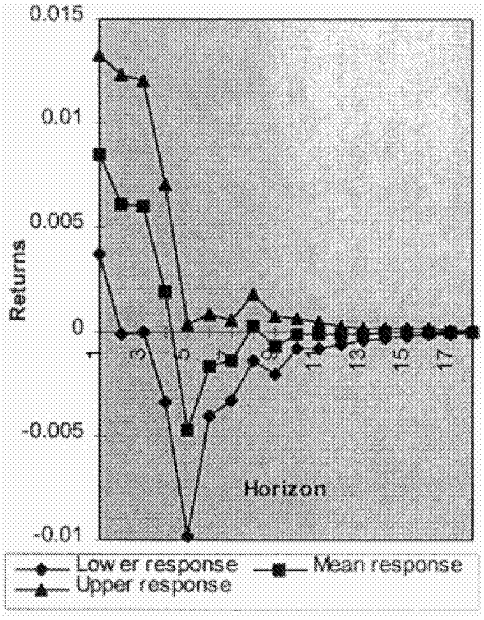

Figure 3. Response of Brazil to USA

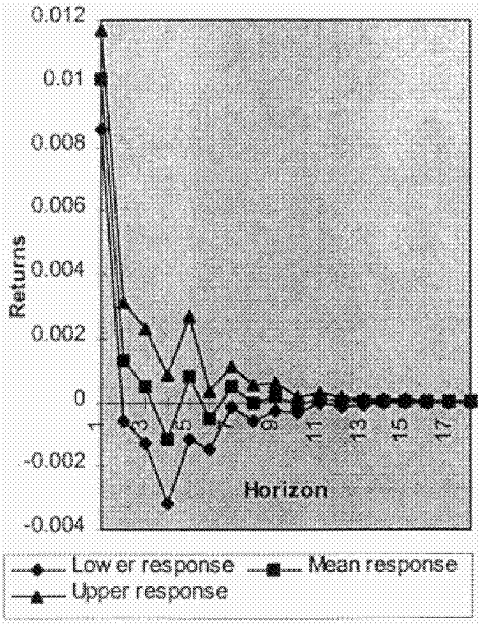

Figure 4. Response of Japan to USA

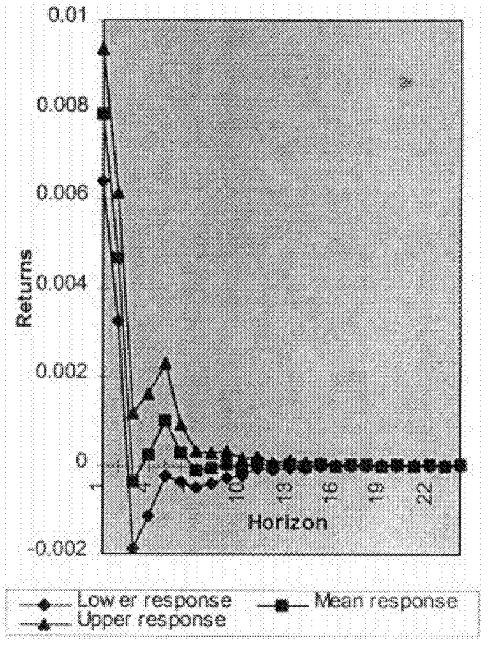

Figure 5. Response of Germany to USA

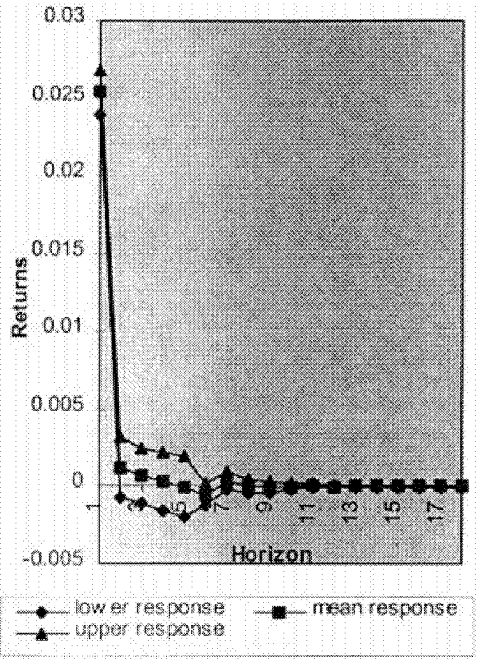

Figure 6. Response of Japan to UK

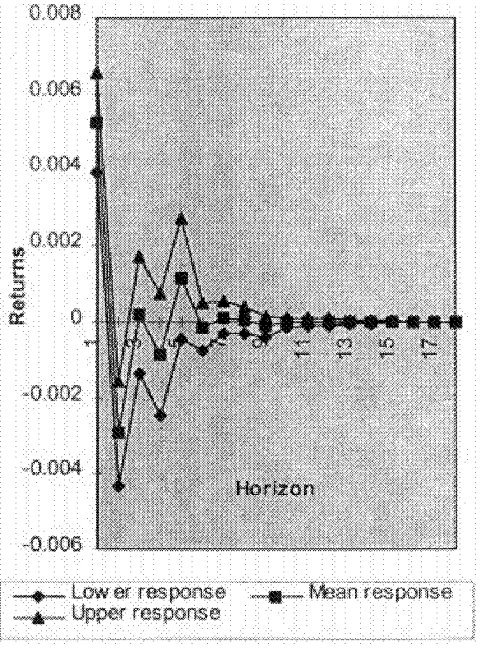

Figure 7. Response of Germany to Japan

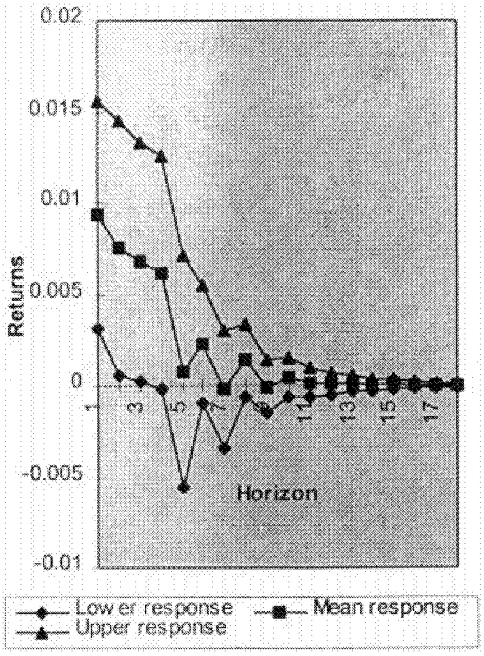

Figure 8. Response of Argentina to Mexico

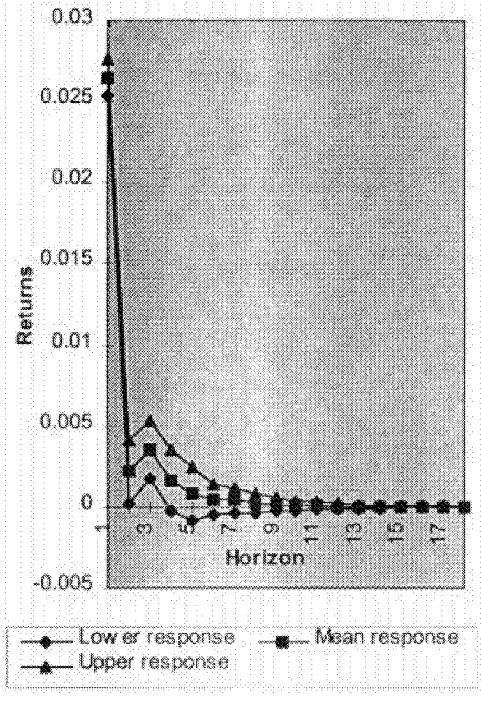

Figure 9. Response of Mexico to Mexico

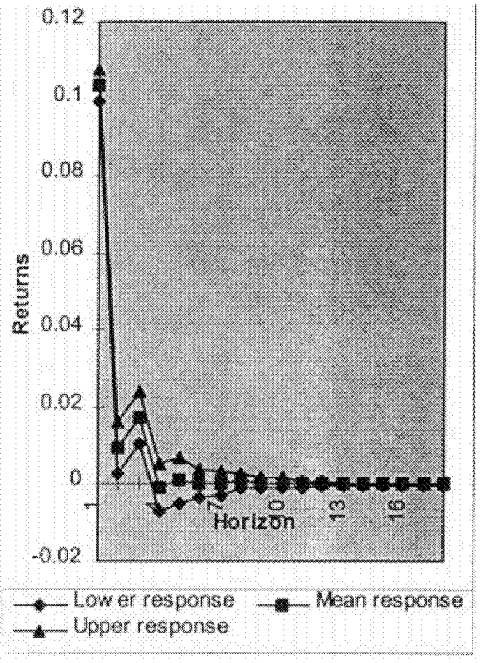

Figure 10. Response of Argentina to Argentina

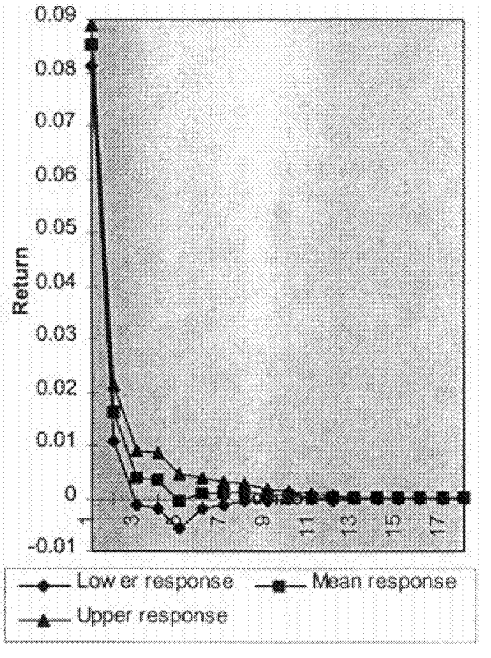

Figure 11. Response of Brazil to Brazil

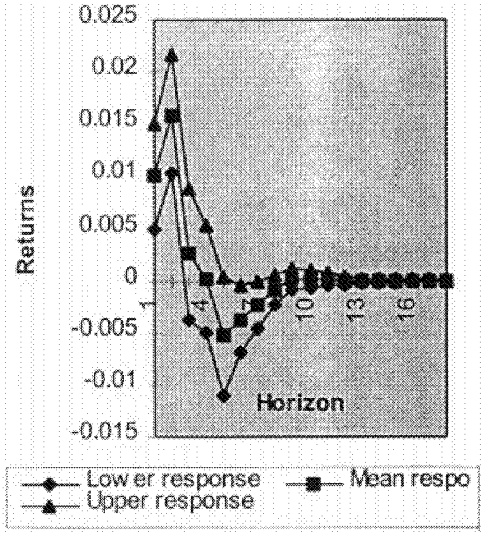

Figure 12. Response of Brazil to Argentina

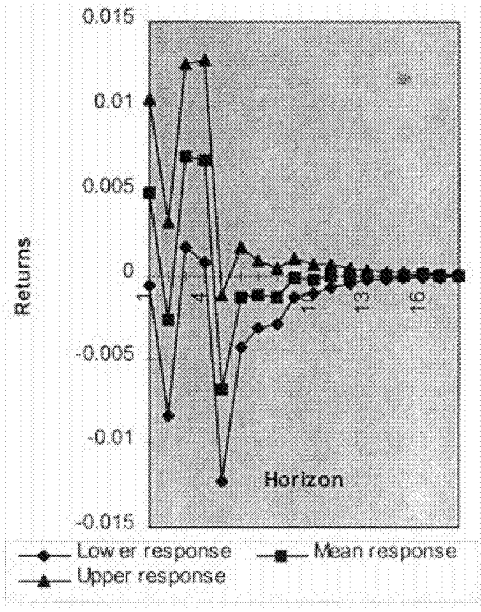

Figure 13. Response of Brazil to Mexico

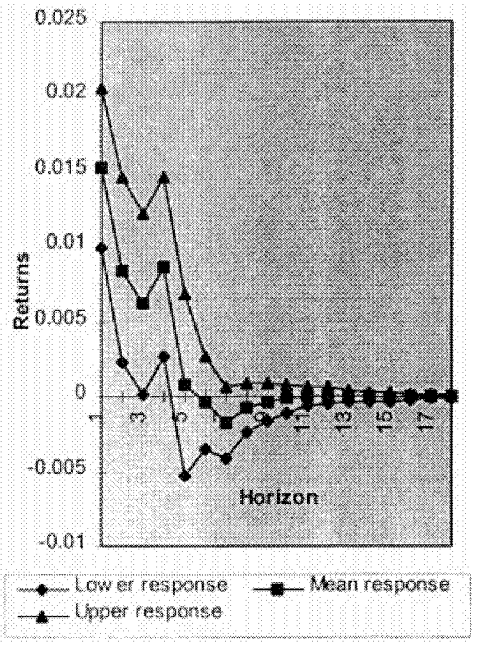

Figure 14. Response of Brazil to UK

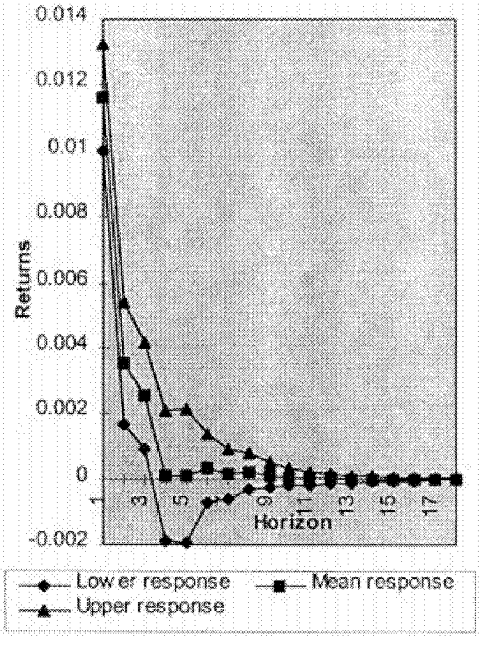

Figure 15. Response of Mexico to UK

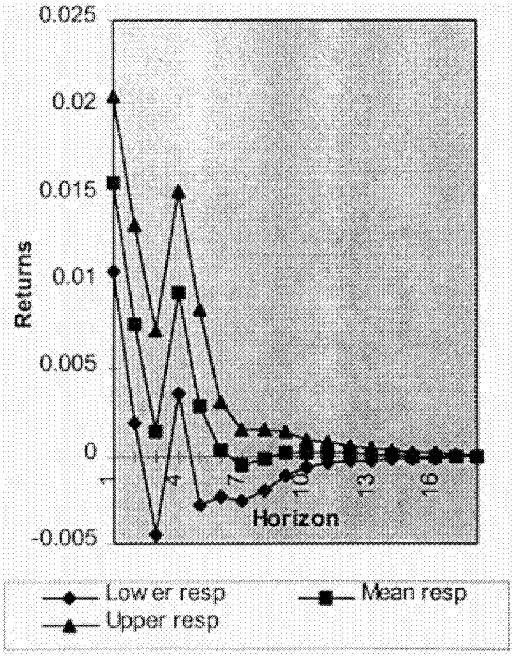

Figure 16. Response of Brazil to Japan

than the US exports to Argentina. Consistent with these weaker USA–Argentina trade links, Argentina's responses contain more noise relative to Mexico's response as there is greater dispersion around the mean.

Figure 3 shows the response of the Brazilian stock market to a US stock market shock. As in the previous two markets, the initial response is significant but dies away gradually after the first week. The USA–Brazil trade links are almost five times as large as Argentina's and this may partially explain cross-country differences in response patterns. The dispersion around the mean response of Brazil to a shock to a US shock is larger than Mexico's response to the USA but lower than Argentina's response to the USA.

Figures 4 and 5 show the market responses of Japan and Germany to a US stock market shock. As expected, the upper and lower responses are very close to the mean response. These responses and the dispersion around their mean responses are substantially different from the previous three figures showing emerging markets' responses.

Figures 6 and 7 show the response of Japan to a UK stock market shock and of Germany to a Japanese market shock respectively. These responses are very similar to the responses developed markets resulting from a US stock market shock.

Figure 8 shows the response of Argentina to a shock to Mexican stock market. When this response is compared with those of developed markets, the response of Argentina lasts longer and is more volatile. The trade links of Argentina with Mexico are not very strong, which is consistent with the response pattern of Argentina to a Mexican stock market shock.

Figures 9–11 show the own response of emerging markets. The upper and lower responses are closer to the mean response than when these markets respond to a shock coming from abroad. Thus, these markets appear to be fast processors of information when shocks originate

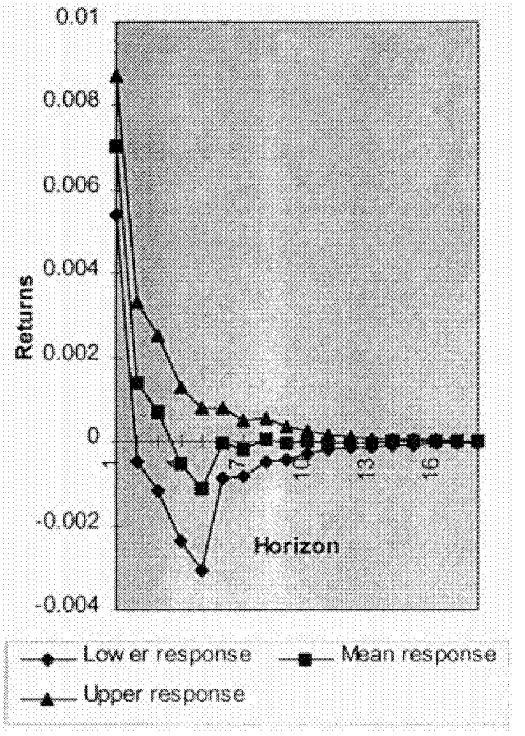

Figure 17. Response of Argentina to Germany

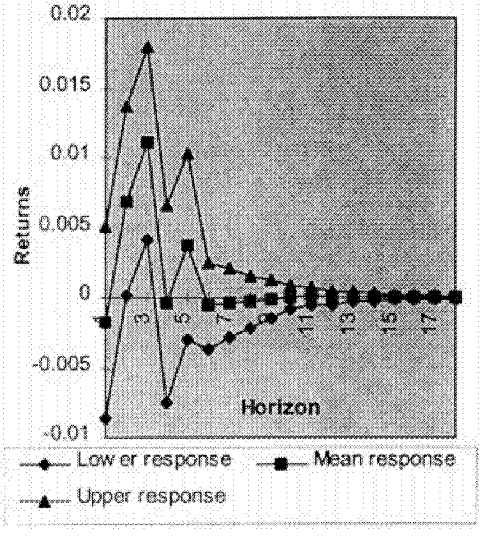

Figure 18. Response of Argentina to UK

domestically. This finding is consistent with the asymmetric information hypothesis in which local investors have a different information set from foreign investors and thus are more alert about developments in their own country.

Figure 12 shows the response of Brazil to a shock to stock market of Argentina. The trade ties of Argentina and Brazil are much stronger than the trade ties observed between the pairs of Argentina, Mexico and Mexico, Brazil and this is reflected by the response patterns of these pairs. The shocks are transmitted more rapidly and they die away faster in the case of the Argentina and Brazil pair than others.

Figures 13 and 14 show the response of Brazil to shocks originating from Mexico and the UK stock market. Brazil has stronger trade ties with Argentina and the response of the Brazilian stock market to a shock to the stock market of Argentina is statistically significant. Moreover, these responses have a much clear and predictable pattern than that of the Brazilian response to a shock to the Mexican stock market.

Figures 15–18 show the response of emerging markets to shocks originating in developed economies other than the US. The responses are statistically significant with the exception of the response of Argentina to shocks originating from the UK and Germany. These significant responses of emerging markets may indicate that shocks originating from the USA are transmitted via other developed markets since they are also strongly affected by the US stock market movements.

SUMMARY AND CONCLUSIONS

In this study a four-variable VAR model is estimated to investigate to what extent stock market movements originating in one market are transmitted to stock markets of other economies. The results indicate that the US stock market strongly influences the developed markets and responses last up to the first week only. The responses of emerging markets to a shock to developed markets are significant up to the second week. A surprising finding is that although no emerging market is able to influence the US stock market alone, the combined effect of emerging markets on the USA and other developed market can be statistically significant.

The results from the IRFs are consistent with the VDCs and also with the tests of cointegration and unconditional correlations. In all the emerging markets, 'own' shocks are transmitted within the first week. The Mexican stock market does not seem to influence the Argentinean stock market significantly. This finding may be the result of weak trade links between Argentina and Mexico.

The findings are consistent with the view that differences in institutional structures cause emerging markets to respond differently to shocks originating from foreign stock markets. For instance, Mexico is more responsive to the US stock movements than Argentina. This can be linked to the fact that institutions in Mexico are more geared towards the US economy (e.g. NAFTA) than Argentina. Mexico has much stronger trade ties with the USA than the trade ties of Argentina and Brazil with the USA. This may offer some explanation of why Argentina and Brazil respond less to the shocks originating from the USA than Mexico, Brazil, who has much stronger trade ties with Argentina than Mexico, responds more strongly to a shock originating from Argentina than to a shock originating from Mexico. This lends support to the argument that transmission patterns between any two countries are much more predictable for countries that have strong and well-established trade ties.

As expected, stock markets of developed economies tend to be more informationally efficient than stock markets of emerging economies and this is reflected in the differences in the transmission patterns of both countries. Developed markets respond and disseminate information much more rapidly than emerging markets as reflected by the IRFs. The deviation around the mean response is much larger for Argentina and Brazil than the deviation around the mean response of the UK and Japan because the former markets are characterized by high volatility as the summary statistics indicate.

In all, the results suggest that—contrary to many studies which argue that stock market interdependencies are the result of contagion—economic fundamentals play an important role in determining international transmission patterns of stock market movements.

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