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DYNAMIC CORRELATION ANALYSIS OF FINANCIAL SPILLOVER TO ASIAN AND LATIN AMERICAN MARKETS IN GLOBAL FINANCIAL TURMOIL

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Abstract

This paper investigates the spillover of financial crises by studying the dynamics of correlation between eleven Asian and six Latin American stock markets vis-à-vis the US stock market. A regional factor that drives common movements of stock markets in each region is identified for the period from 1993 to early 2009. We then estimate the time-varying volatility correlation between the regional factor and the US stock market by an asymmetric dynamic conditional correlation model. We find that there is a significant rise in the estimated time-varying correlation in the period from August 2007 to March 2009, suggesting evidence of contagion from the US stock market to markets in the two regions during the global financial turmoil. The magnitude of the contagion effect to both regions in the global financial crisis is very similar, albeit their different economic, political and institutional characteristics. On the other hand, we find no evidence of having contagion from the US to the Asian region during the Asian financial crisis in 1997 and 1998 as expected, since the crisis was originated locally.

JEL Classification Numbers: F30; G01; G15; G12
Keywords: Principal Component, Financial Contagion, Financial Crisis, Dynamic Conditional Correlation, Asia Pacific Economies, Latin American Economies

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EXECUTIVE SUMMARY:

- *Since the collapse of Lehman Brothers in August 2008, we have seen large sell-offs of financial assets in emerging markets. This suggests the global nature of financial spillover from advanced economies to emerging economies during the recent financial crisis.*

- *This paper investigates the financial spillover by looking at the changes of volatility correlation between the US stock market and the stock markets of emerging economies in Asia and Latin America before and during financial crises. A regional factor that represents the common movement of stock markets in each of the regions is first identified. We then estimate the time-varying volatility correlation between the US stock market and each regional factor by the asymmetric dynamic conditional correlation model.*

- *Empirical results find a significant rise in the volatility correlation between the US and each region during the global financial crisis from August 2007 to March 2009. This suggests the existence of financial spillover effect from the US stock market to the Asian and the Latin American regions. Our results further show that the magnitude of spillover from the US stock market to the two regions is very similar, although economic, political and institutional characteristics of the two regions are different.*

- *Our findings do not find evidence of contagion from the US to the Asian region during the Asian financial crisis, whereas the volatility correlation between the US stock market and the Latin American stock markets actually reduced slightly during the Mexican crisis period. This confirms the worldwide nature of the recent global financial crisis.*

I. INTRODUCTION

The financial crisis originated in the US in 2007 has become a global financial turmoil and affected many economies in the globe. A large number of emerging market economies, such as Hungary, Ukraine, Latvia and Iceland, have suffered severe financial crises and sought emergency assistance from the International Monetary Fund (IMF) to restore stability and confidence in their banking systems and financial markets. Many Asian financial markets have suffered sharper losses than major developed markets, even if the banks in the region were relatively less affected by the sub-prime problem compared with those in North America and Europe. Moreover, Latin American (LA) financial markets experienced precipitous tumbles, despite that the region was enjoying strong economic growth from 2004 through to the beginning of the crisis. In fact, World Economic Outlook (April 2009) of the IMF points out that crises in advanced economies have a large common effect on the banking sectors, stock markets, and foreign exchange markets of emerging market economies. Moreover, measures taken in these economies to reduce their financial vulnerabilities in the normal times provide little insulation from the spillover of a major financial crisis from advanced economies.

Around August 2007, most Asian equity markets started falling from their recent peaks because of the repercussions of the sub-prime problem in the US. In the same month, equity markets in the LA region fell off 8 - 9% from their peaks as well and continued to see corrections. The two regions seemed to be stabilised somewhat after the announcement of the rescue plan of Bear Stearns in March 2008. However, when the US Government decided to let Lehman Brothers bankrupt in September in the same year, a worldwide large-scale sell-offs of financial assets began and asset prices over the world fell. The Asian and LA equity markets plunged again. Significant correlations between movements in Asian and LA financial markets vis-à-vis US stock markets were observed during these months. It is a piece of preliminary evidence of financial shock spillover and contagion among financial markets across different regions. In particular, the current wave of shocks to the Asian and LA emerging markets seems to emanate from one source, the US economy.

Spillover and contagion can change the correlation between cross-border financial markets rapidly. As these correlations are crucial inputs for international portfolio management and risk assessment, monitoring the change of correlations between international financial markets are important in international investment. Furthermore, at the time of financial crises, like the current episode, the cross-border contagion may have significant consequences for financial stability. Thus, it is also essential to provide policy markers with timely and appropriate measures of correlation changes and contagion. This will help design appropriate policy responses and prepare contingency plans.

One measure to assess the degree of changes in correlations between equity markets is to look at the correlation of returns between financial markets over time. Previous studies show that the correlation among asset returns is time varying (e.g. Longin and Solnik, 1995 and Engle, 2002). Multivariate GARCH (MGARCH) models are developed to study the dynamic correlations between financial time-series. However, general MGARCH models typically suffer the curse of dimensionality problem in estimation as the number of time-series increases. Engle (2002) proposes the Dynamic Conditional Correlation (DCC) model to alleviate the dimensionality problem present in the general MGARCH model. Cappiello et al. (2006) generalise the Engel (2002) DCC model and allow for the possibility of having asymmetric impacts of positive innovations and negative innovations on the dynamics of the conditional correlations, which is called asymmetric DCC model. In this study, we investigate the dynamic conditional correlations between the US equity market and the regional equity markets in Asia and LA through the asymmetric DCC model.

When correlations of asset returns in cross-border markets increase excessively during 'crisis' periods relative to correlations during 'tranquil' periods, we term these erupt jumps of cross-market correlation as contagion. The contagion effect between financial markets can be transmitted through different channels. Using the Asian financial crisis episode, Pritsker (2001) studies rational channels through which contagion might have spread. He investigates four types of transmission channels of contagion, namely the correlated information channel (King and Wadhwani, 1990), liquidity channel (Calvo, 1999), cross-market hedging channel (Kodres and Pritsker, 1999) and the wealth effect channel (Kodres and Pritsker, 1999; Masson, 1999). Some commentators opine that the contagion effect of the current financial turmoil could have passed through all these channels.

This study focuses on examining the existence of contagion effect from the US equity market to equity markets in the EMEAP group economies in the Asian region and six equity markets in the LA region during the current crisis episode.[2] These two regions are selected because they have tighter financial and trade linkages with the US (relative to markets in the Eastern and Central Europe, which are closer and influenced more by the Western European markets). Therefore, these two regions can serve better in gauging the contagion effect of the US sub-prime crisis. Moreover, these two regions suffered from large-scale financial crises in the last twenty years; it is interesting to investigate if they are now prone to large external shocks. Similarly, the IMF (Global Financial Stability Report, October 2008) studies the spillover from advanced economies

[2] The EMEAP (Executives' Meeting of East Asia-Pacific Central Banks) consists of Australia, China, Hong Kong (of China), Indonesia, Japan, Korea, Malaysia, New Zealand, the Philippines, Singapore and Thailand. The six equity markets of the LA region are Argentina, Brazil, Chile, Mexico, Peru and Venezuela, which are selected primarily based on data availability.

to emerging equity markets using a vector autoregressive framework. Seven out of the eight emerging equity markets in the IMF sample are from the two regions.

The importance of the US equity market to the equity markets in the Asian region is studied in Cheung et al. (2007). They find that the US market leads the four Asian emerging markets (i.e. Hong Kong, Korea, Singapore and Taiwan) before, during and after the Asian financial crisis in 1997 - 98 while the four markets Granger-cause the US market during the crisis period. Regarding the LA region, using cointegration and common trends analysis, Diamandis (2009) finds out that, given the increased degree of openness of the LA emerging markets during recent years, the long-run linkages among the four markets (Argentina, Brazil, Chile and Mexico) and the US market have also increased. Thus, understanding and monitoring the dynamics of correlation between the US market and equity markets of these two regions, especially during crisis era, is important for portfolio decisions and asset allocations for international investors as well as for policy makers in the region to maintain financial stability.

Quite a number of studies have investigated the contagion in Asian equity markets during the Asian financial crisis in 1997 - 98 within the DCC framework.[3] A recent paper by Cheung et al. (2008) investigates the contagion within Asian equity markets in face of the current crisis with a DCC model and a T-test framework. They find that the average correlation of EMEAP economies with respect to other equity markets in the region rises sharply in the late 2008.[4] However, their work does not provide direct evidence on the contagion effect of shocks from US equity markets to Asian equity markets as a whole. Our approach differs from theirs. We examine the dynamic conditional correlation between the US equity market and Asian equity markets (also LA equity markets) directly within the DCC framework. Moreover, instead of estimating the DCC of the eleven Asian economies and the six LA economies vis-à-vis the US equity market at the same time and then looking at the pair-wise dynamic conditional correlations between these economies and the US, we first use principal component analysis to extract the major driving force behind the eleven Asian equity markets (also the six LA equity markets) and then estimate the dynamic conditional correlation between this driving force and the US equity market.[5] By doing so, we can eliminate the market specific component that exists in each individual market within the region and focuses only on the

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3 Yang (2005) conducts a DCC analysis on the stock market correlations between Japan and four Asian emerging markets and test the hypothesis of volatility contagion with a dummy variable during the crisis period in a regression equation of the correlation dynamics, after controlling for an upward trend. Chiang et al. (2007) investigate the evolution of the correlation dynamics of nine Asian markets with a control for the US market and test the existence of contagion in an autoregression setting with dummy variables for the periods before, during and after the Asian financial crisis and an indicator variable for the changes of sovereign credit-rating changes.

4 They estimated the DCC model over the weekly return of the eleven equity markets in the EMEAP economies together with the weekly return of the US equity market.

5 This component approach is also used by Cheung et al. (2009) in their study of the trade integration in the thirteen Asian and Oceanic economies.

interplay between the regional equity market as a whole and the US equity market. The use of principal components summarises the common movement of all stock markets in each region, and this allows meaningful comparison across these two regions in an effective and efficient way.

This paper proceeds as follows. Section II describes the asymmetric dynamic conditional correlation model, the principal component method and the autoregressive equation with dummy variables for crisis periods. Section III discusses data and empirical results. The last section concludes.

II. DCC MODELS, PRINCIPAL COMPONENTS AND AUTOREGRESSIVE EQUATION

We study the dynamic correlation between the volatility of weekly return of the two regional stock markets and that of the US stock market from February 1993 to March 2009 by adopting a two-step approach. In the first step, we assume that the returns of the regional stock markets are driven by a dominant unobservable component, which we interpret as the "Asian factor" for Asia and "LA factor" for LA. Principal component analysis is used to extract this component.[6] Specifically, the regional factor corresponds to the eigenvector that is associated with the largest eigenvalue of the correlation matrix of the regional stock market returns.

In the second step, we first pre-whiten the regional factor and the return series of the US market by a vector-autoregressive (VAR) filter. The VAR filter allows us to demean the regional factor and US stock market return series and removes the serial-correlation that may present in these two series. Specifically, the VAR filter assumes the following:

$$\begin{bmatrix} F_t \\ US_t \end{bmatrix} = \begin{bmatrix} \mu_F \\ \mu_{US} \end{bmatrix} + \sum_{j=1}^{p} A_j \begin{bmatrix} F_{t-j} \\ US_{t-j} \end{bmatrix} + \begin{bmatrix} \varepsilon_{F,t} \\ \varepsilon_{US,t} \end{bmatrix}$$

where μ_F is the unconditional mean of the regional factor (F) and μ_{US} the unconditional mean of the return of US stock market (US). The order of lags (p) is selected so as to eliminate the autocorrelation of the residual. The pair of residuals is assumed to be normally distributed with a time-varying variance-covariance. Specifically,

$$\begin{bmatrix} \varepsilon_{F,t} \\ \varepsilon_{US,t} \end{bmatrix} | I_{t-1} \sim N(0, H_t), H_t \equiv \begin{bmatrix} \sigma^2{}_{F,t} & \sigma_{F,US,t} \\ \sigma_{F,US,t} & \sigma^2{}_{US,t} \end{bmatrix},$$

[6] For an introduction to the theory and applications of principal component analysis, see Jolliffe (2002).

where I_{t-1} is the information set up to time t-1. H_t denotes the conditional variance-covariance matrix and can be decomposed as follows:

$$H_t = D_t P_t D_t$$

where D_t is a diagonal matrix of time-varying standard deviations from an univariate GARCH(p,q) model on each series, i, with $\sqrt{d_{i,t}}$ on the i-th diagonal, and P_t is the conditional correlation matrix, which may or may not be time-varying. Specifically, the dynamics of $d_{i,t}$ is as follows:

$$d_{i,t} = \omega_i + \sum_{j=1}^{p} \alpha_{i,j} \varepsilon^2{}_{i,t-j} + \sum_{j=1}^{q} \beta_{i,j} d_{i,t-j}$$

The estimation procedure of asymmetric DCC(s,u) is identical to the original DCC. The univariate GARCH model is first estimated for $\varepsilon_{F,t}$ and $\varepsilon_{US,t}$. The standardised residuals, $\bar{\varepsilon}_{i,t}$, for *F* and *US*, are defined as

$$\bar{\varepsilon}_{i,t} = \frac{\varepsilon_{i,t}}{\sqrt{d_{i,t}}}$$

To model the asymmetric impact of negative shocks on the dynamic conditional correlation, we need to construct the standardised negative residuals, $\bar{\eta}_{i,t}$ as

$$\bar{\eta}_{i,t} = \begin{cases} \bar{\varepsilon}_{i,t} & if\ \bar{\varepsilon}_{i,t} < 0 \\ 0 & otherwise \end{cases}$$

Given the standardised residuals and standardised negative residuals, the dynamics of P_t in the asymmetric DCC model of order (s,u) is given by the following two equations:

$$Q_t = (1 - \sum_{j=1}^{s} a_j - \sum_{j=1}^{u} b_j)\bar{P} - \sum_{j=1}^{s} g_j \bar{N} + \sum_{j=1}^{s} a_j \bar{\varepsilon}_{t-j} \bar{\varepsilon}_{t-j}{}' + \sum_{j=1}^{s} g_j \eta_{t-j} \eta_{t-j}{}' + \sum_{j=1}^{u} b_j Q_{t-j}$$

$$P_t = Q_t^{*-1} Q_t Q_t^{*-1}$$

where $\overline{P_t} = E[\bar{\varepsilon}_t \bar{\varepsilon}_t{}']$, $\overline{N_t} = E[\bar{\eta}_t \bar{\eta}_t{}']$ and Q_t^* is a diagonal matrix with the square root of the i-th diagonal element of Q_t on its i-th diagonal position. The necessary and sufficient conditions to ensure Q_t to be positive definite at all times is:

$$\left[\sum_{j=1}^{s}(a_j+\delta g_j)+\sum_{j=1}^{u}b_j\right]<1$$

where δ is the maximum eigenvalue $[\bar{P}^{-\frac{1}{2}}\overline{N}\bar{P}^{-\frac{1}{2}}]$. The log-likelihood of the asymmetric DCC model is identical to the original DCC except modifications in the dynamics of Q_t. Denote θ as the vector of parameters to be estimated and the log-likelihood is given by

$$L(\theta)=-\frac{1}{2}\sum_{t=1}^{T}[(n\log(2\pi)+2\log\det(D_t)+\varepsilon_t{}'D_t^{-1}D_t^{-1}\varepsilon_t)+(\log\det(P_t)+\bar{\varepsilon}_t{}'P_t^{-1}\bar{\varepsilon}_t-\bar{\varepsilon}_t{}'\bar{\varepsilon}_t)]$$

where n is the number of series (in our case, two) and T the number of observations. Denote the $\hat{\rho}_{F,US,t}$ as the estimated dynamic conditional correlation coefficient (the off-diagonal element of P_t) from the system.

Finally, we model $\hat{\rho}_{F,US,t}$ as an autoregressive model with intercept break to test for the hypothesis that a regional financial crisis and the current global financial crisis have significant impact on the dynamics of $\hat{\rho}_{F,US,t}$, which is considered an evidence of "contagion". Specifically, we estimate the following model for $\hat{\rho}_{F,US,t}$:

$$\hat{\rho}_{F,US,t}=\gamma_0+\sum_{j=1}^{p}\gamma_j\hat{\rho}_{F,US,t-j}+\xi_1 Crisis1_t+\xi_2 Crisis2_t+\nu_t,$$

where, for Asia the Crisis1 is a dummy variable of the Asian financial crisis period (from October 1997 to December 1998) and Crisis2 is a dummy variable of the current global financial turmoil period (from August 2007 to March 2009), for LA the Crisis1 is a dummy variable of the Mexican Peso crisis period (from December 1994 to October 1995) and Crisis2 is a dummy variable of the current global financial turmoil period. The lagged terms are added to remove the serial correlation of the error term that may exist.

III. DATA AND EMPIRICAL RESULTS

Similar to Cappiello et al. (2006), the data used in this study are Wednesday-on-Wednesday percentage returns of the benchmark equity indexes of the eleven EMEAP economies, the six LA economies as well as the US equity market. The benchmark equity index for each economy is listed in Table 1. We use Wednesday-on-Wednesday returns because weekly returns are not as noisy as the daily returns while preserving the adequacy of data frequency. All indexes are denominated in local currency, dividend-unadjusted, and compiled from the daily closing price in each market. For the US equity market, we extract the largest component from S&P500 and Dow Jones as the benchmark index. The extracted component accounts for about 99% of the total variations in these two stock indexes and represents movements of the US equity market as a whole since the constituencies of these two indexes include some different stocks.

Summary statistics of the weekly returns in the eleven EMEAP economies and the US are presented in Table 2a. One of our interests is comparing the difference between the impact of the Asian financial crisis and the current financial crisis on the dynamics of the correlation between the Asian markets and the US market. To this end, we adopt a dummy variable regression framework to answer this question. For the current global financial turmoil, it is commonly agreed that its effect on the Asian region, as well as the LA region, began in August 2007 because of the outbreak of the sub-prime problem. Thus, we define the second crisis dummy variable (Crisis2) takes value of 1 from August 2007 to the end of March 2009 and zero otherwise. On the other hand, it is difficult to come out with a unanimous agreement on the period of the Asian financial crisis for different economies in the group in defining the first crisis dummy variable. Although the Thai government gave up defending the value of Baht in July 1997, the large-scale attack on the Asian currencies only happened after Taiwan decided to depreciate its currency value to increase the competitiveness of its exports in October 1997. So, we use October 1997 as the beginning of the Asian financial crisis and the last day of 1998 as the ending date to define the first crisis dummy variable (Crisis1)

Comparing the first two moments for the tranquil and crisis periods in our sample, we can see that weekly returns are generally higher in the two tranquil periods whereas the standard deviations are larger in the crisis periods. It is also interesting to compare the first two moments for the current global crisis and the Asian financial crisis. The EMEAP markets and the US market suffer bigger losses in the current episode. Actually in the former crisis, Australia, China, Korea and the Philippines were having positive weekly returns on average. On the other hand, the markets in Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand were more volatile in the Asian financial crisis than in the current crisis.

Regarding the LA region, Table 2b shows summary statistics of the six LA markets and the US market. The first large regional crisis in the sample was the Mexican Peso crisis in the period from December 1994 to October 1995. In the tranquil periods, all the mean returns of the six LA equity markets were positive, while most of them had negative mean returns in the crisis periods. Standard deviations during the crisis were in general higher than those in the tranquil period. Moreover, regional markets also experienced more extreme returns during the current global crisis as the Kurtosis statistics were higher than those in other periods.

Tables 3a and 3b report the five largest principal components computed for the eleven Asian weekly returns series and the six LA weekly returns series respectively. The largest principal component of the Asian group explains 46% of the total variation while these five largest principal components altogether explain 78%. Similarly, the largest principal component of the LA group explains 48% of the total variation. Together with the next four components, they account for about 93%. For both cases, the explanatory power of these principal components drops dramatically after the first components, indicating that a substantial amount of the weekly returns of these markets is driven by one common factor. Thus, in subsequent analysis, the largest principal component is taken as the overall movement of all these markets and called the "Asian factor" or "LA factor". To visualise the Asian factor, the LA factor and the weekly returns of selected economies, we depict them in Figure 1.

Table 4 presents estimates of the DCC(1,1) models for the Asian region and DCC(2,2) models for the LA region.[7] We present not only the DCC models of the Asian factor and the LA factor versus the US market but also the DCC models of four selected economies versus the US for comparison. Since the symmetric DCC model is a special case of the asymmetric DCC model, we only report results of the asymmetric DCC in Table 4. The last six rows of the table show estimates of the asymmetric DCC parameters whereas the other rows are the parameter estimates of the univariate GARCH models of the Asian factor, the LA factor and the individual stock market return of the selected economies. Most of the estimated parameters of the GARCH models are statistically significant. However, in all these models, the parameter estimates of the standardised negative residuals, g_i, are statistically not significant. It indicates that negative innovations to returns do not play a different role from positive innovations to returns in determining the dynamics of conditional correlation between the regional factors and US market. In plain terms, this result shows that the Asian equity market and the LA equity market as a whole are not shocked more in face of a piece of bad news than by a piece of good news from the US market. Our findings are consistent with the findings reported in Cappiello et al. (2006, P.555, Table 6a), where coefficients of the asymmetric impact terms are generally insignificant.[8]

Figure 2 depicts the time-varying conditional correlations of the US stock market versus the Asian factor, the LA factor and the selected economies. These graphs show that there are some variations and some possible structural breaks in the dynamic correlations. Nevertheless, according to these correlation graphs, the effect of the US

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7 We do not report the estimates of the VAR filters here since the filters are mainly used to obtain serially uncorrelated residuals for the DCC models. Furthermore, the order of the DCC models for the two regions is determined by using the likelihood ratio test.

8 Cappiello et al. (2006) also find that the coefficient of the innovations in dynamics of Q_t is also generally insignificant. Again, please refer to Table 6a in their paragraph.

stock market on the Asian markets as a whole (the Asian factor) and the selected Asian economies in the sample period seem to be relatively stable albeit some clustering effects. On the other hand, the dynamic correlations between the US stock market and the LA factor, and the selected LA economies exhibit level shifts in some periods of time. The upward level shifts in the current crisis seem quite obvious.

Lastly, Table 5 shows estimation results of the autoregressive equations of the estimated conditional correlations. For the Asian region, the mean terms, γ_0, are all statistically significant at the 1% level, thus, revealing that shocks in the US market are positively correlated with those in the Asian factor and the selected economies. Moreover, the correlation between the US and the Asian factor is the highest with a value of 0.14, implying the dominant effect of the US market in the Asian region. The autoregressive parameters in each equation are also significant at the 1% level and the root of each of them is reasonably below unity, ensuring the stationary of the model. The R^2 ranges from 0.56 to 0.69, showing that the autoregressive representation of each dynamic conditional correlation equation is reasonably adequate. The residuals in each equation, ν_t, though not reported here, have all passed the serial correlation test. The autoregressive representation of the estimated conditional correlation of the LA region is similar to that for the Asian region but with higher order of lags for removing the serial correlation in the error terms.

The crisis dummy of the current global turmoil, Crisis2, in the two equations is positive and significant at least at 5% level in the two regions. It shows that the contagion effect of the US equity market on the both regions is very apparent in the current crisis episode. However, Crisis2 is not significant in the case of Hong Kong.[9] One possible explanation is that the Hong Kong equity market was extremely buoyant in September and October of 2007 which masked the contagion effect from the US market.

In the case of Asia-US correlation, the crisis dummies of the Asian financial crisis, Crisis1, are not significant, which reflects the fact that Asian financial crisis was originated locally in the region and the financial linkage between the Asian markets and the US market was not strong enough to shake the US market. On the other hand the Mexican Crisis dummy is statistically significant with a negative sign for the Latin American Factor. We speculate that the significant and negative impact of the Mexican crisis may be due to flight for quality between the US and the LA region, though the effect was mild for some individual LA economies. When the Mexican economy was under financial stress from the late 1994 to 1995, investors in other markets in the region might withdraw their investments and move to the US markets due to the fear of intra-regional contagion impact spread out from Mexico, which in turn implied a negative correlation

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9 If the current crisis dummy starts in November 2007 for Hong Kong, the parameter is positively significant at the 5% level.

between the equity markets in the region and the US equity market. Therefore the Mexican crisis dummy is negative and significant in the case of LA-US correlation.

IV. CONCLUDING REMARKS

To international investors, predicting volatilities in different markets and correlations between them is essential. Our factor framework is expected to be useful since it can greatly reduce the dimensionality problem present in the general MGARCH framework. To policy markers, the predictions of the dynamic correlation between their economies and the US are relevant and could be a useful input for predicting financial contagion in crisis episodes. Our results indicate that the volatility correlation between the US financial market and Asian financial markets as well as the volatility correlation between the US financial market and the LA financial markets are positive and jump up substantially during the recent financial crisis originated from the US. This, therefore, shows evidence of financial contagion in the international dimension during the crisis period.

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Table 1: Benchmark Equity Market Indexes

Equity market	Benchmark index
Australia	Australian All Ordinaries Index
Argentina	Merval Index
Brazil	Bovespa Stock Index
Chile	IPSA Index
China	Shanghai A-share Index
Hong Kong SAR	Hang Seng Index
Indonesia	JSX Composite Index
Japan	Nikkei 225 Stock Average
Korea	KSE Composite Index
Malaysia	KLSE Composite Index
Mexico	Mexican Bolsa Index
New Zealand	New Zealand All Ordinaries Index
Peru	IGBVL Index
The Philippines	PSE Index
Singapore	Straits Time Index
Thailand	SET Index
United States	S&P500 Index
	Dow Jones Index
Venezuela	IBC Index

Sources: Bloomberg and CEIC

Table 2a: Descriptive Statistics on Weekly Equity Market Returns of the EMEAP Economies (August 1993 – March 2009)

	Mean	Standard deviation	Skewness	Kurtosis
Panel A: Aug1993 – Sept 1997				
Australia	0.200	1.773	0.088	-0.017
China	0.379	7.349	1.764	9.628
Hong Kong	0.403	3.566	-0.070	0.483
Indonesia	0.250	3.350	1.152	14.436
Japan	-0.026	2.620	0.505	2.825
Korea	-0.237	5.686	1.495	5.458
Malaysia	0.083	3.430	0.155	2.278
New Zealand	0.177	1.898	0.285	0.763
Philippines	0.129	3.729	0.053	1.800
Singapore	0.151	2.740	-0.019	2.655
Thailand	-0.168	4.091	0.606	2.266
Standard & Poor's	0.355	1.494	-0.225	0.449
Dow Jones	0.328	1.397	-0.355	0.686
Panel B: October 1997 – Dec 1998 (Asian Financial Crisis Period)				
Australia	0.051	3.162	-0.712	5.564
China	0.142	3.166	-0.269	3.183
Hong Kong	-0.278	7.910	-0.095	1.446
Indonesia	-0.190	7.888	0.483	0.151
Japan	-0.335	3.457	0.584	0.679
Korea	2.159	16.857	1.452	4.858
Malaysia	-0.177	8.956	0.932	2.455
New Zealand	-0.218	3.956	-0.485	5.558
Philippines	0.169	7.018	0.571	0.151
Singapore	-0.248	6.583	0.243	0.909
Thailand	-0.390	7.774	1.548	4.317
Standard & Poor's	0.453	2.670	-0.932	2.109
Dow Jones	0.316	2.619	-0.776	2.147

	Mean	Standard deviation	Skewness	Kurtosis
Panel C: Jan 1999 – July 2007				
Australia	0.192	1.567	-0.622	1.880
China	0.359	3.403	0.259	2.078
Hong Kong	0.225	2.917	0.049	1.167
Indonesia	0.463	3.614	0.031	2.659
Japan	0.092	2.935	0.007	0.710
Korea	0.509	8.024	0.390	1.572
Malaysia	0.233	2.652	-0.057	4.139
New Zealand	0.114	1.529	-0.424	1.804
Philippines	0.181	3.256	0.298	2.211
Singapore	0.249	2.764	-0.204	3.043
Thailand	0.271	3.777	-0.008	2.738
Standard & Poor's	0.065	2.432	0.272	3.710
Dow Jones	0.117	2.223	0.230	4.222
Panel D: Aug 2007 – Mar 2009 (Current Financial Crisis)				
Australia	-0.576	3.955	-0.230	1.964
China	-0.586	5.717	-0.127	-0.424
Hong Kong	-0.422	5.826	-0.108	0.358
Indonesia	-0.386	6.042	-0.102	4.084
Japan	-0.698	4.984	0.441	3.829
Korea	-0.416	7.513	0.336	0.039
Malaysia	-0.471	3.113	-0.369	1.379
New Zealand	-0.637	2.322	-0.405	0.598
Philippines	-0.579	4.836	-0.251	4.066
Singapore	-0.755	4.293	-0.008	0.417
Thailand	-0.689	4.289	-0.052	3.369
Standard & Poor's	-0.616	3.659	-0.806	2.386
Dow Jones	-0.654	3.997	-0.554	2.146

Table 2b: Descriptive Statistics on Weekly Equity Market Returns of six Latin American Economies (August 1993 – March 2009)

	Mean	Standard deviation	Skewness	Kurtosis
Panel A: Aug 1993 – Nov 1994				
Argentina	0.504	4.497	-0.458	0.148
Brazil	6.835	8.929	0.006	0.355
Mexico	0.632	4.704	0.770	2.693
Peru	1.069	4.838	-0.386	0.045
Chile	1.164	3.423	0.188	1.549
Venezuela	0.596	5.572	0.831	0.962
Standard & Poor's	0.027	1.258	-0.378	0.148
Dow Jones	0.005	1.210	-0.486	0.259
Panel B: Dec 1994 – Oct 1995				
Argentina	-0.284	7.834	1.057	3.199
Brazil	0.237	8.774	-0.117	1.973
Mexico	-0.191	5.575	0.403	0.037
Peru	-0.151	4.701	0.123	2.153
Chile	-0.043	3.826	-0.244	5.543
Venezuela	0.593	4.099	2.226	7.103
Standard & Poor's	0.545	0.932	0.145	-0.976
Dow Jones	0.492	0.904	0.143	-0.813
Panel C: Nov 1995 – July 2007				
Argentina	0.400	4.880	-0.003	3.279
Brazil	0.529	4.714	0.195	9.129
Mexico	0.494	3.528	0.151	1.962
Peru	0.522	2.980	0.230	3.912
Chile	0.230	2.628	0.007	2.910
Venezuela	0.651	4.861	1.325	9.438
Standard & Poor's	0.182	2.367	0.034	3.320
Dow Jones	0.203	2.184	-0.012	3.803
Panel D: Aug 2007 – Mar 2009				
Argentina	-0.605	5.956	0.120	3.679
Brazil	-0.194	5.259	-0.774	2.723
Mexico	-0.400	4.213	-0.765	2.884
Peru	-0.943	6.336	0.600	3.424
Chile	-0.231	4.022	-1.095	5.358
Venezuela	0.072	2.805	0.976	2.594
Standard & Poor's	-0.652	3.652	-0.778	2.331
Dow Jones	-0.688	3.986	-0.531	2.123

Table 3a: The Five Largest Principal Components of Stock Market Returns of the EMEAP Economies from February 1993 to March 2009

	First Principal Component	Second Principal Component	Third Principal Component	Fourth Principal Component	Fifth Principal Component
Eigenvalue	5.121	1.004	0.967	0.861	0.665
Cumulative Value	5.121	6.125	7.092	7.952	8.617
Variance Proportion	0.466	0.091	0.088	0.078	0.060
Cumulative Proportion	0.466	0.557	0.645	0.723	0.783

Table 3b: The Five Largest Principal Components of Stock Market Returns of six Latin American Economies from August 1993 to March 2009

	First Principal Component	Second Principal Component	Third Principal Component	Fourth Principal Component	Fifth Principal Component
Eigenvalue	2.886	0.935	0.679	0.586	0.486
Cumulative Value	2.886	3.822	4.501	5.087	5.573
Variance Proportion	0.481	0.156	0.113	0.098	0.081
Cumulative Proportion	0.481	0.637	0.750	0.848	0.929

Table 4: DCC Estimates of the US Stock versus the Asian Factor, Latin American Factor and Four Selected Economies

Coefficient	A. Factor	HK	Japan	LA Factor	Argentina	Brazil
ω_i	0.195* (0.103)	0.257** (0.12)	0.525** (0.26)	0.305 (0.226)	4.939** (2.36)	2.577*** (0.948)
α_{i1}	0.168*** (0.058)	0.145*** (0.037)	0.11*** (0.029)	0.094 (0.061)	0.126*** (0.045)	0.111** (0.044)
α_{i2}				0.169** (0.069)	0.238*** (0.053)	0.128** (0.054)
β_{i1}	0.802*** (0.058)	0.844*** (0.032)	0.84*** (0.041)	0 (0.01)	0 (0.005)	0.117 (0.216)
β_{i2}				0.63*** (0.174)	0.454*** (0.123)	0.538*** (0.194)
ω_{US}	0.041 (0.027)	0.041 (0.025)	0.042 (0.03)	0.051 (0.047)	0.036 (0.034)	0.048 (0.045)
α_{US1}	0.154*** (0.045)	0.157*** (0.042)	0.153*** (0.048)	0.197** (0.092)	0.167*** (0.062)	0.17** (0.067)
α_{US2}				0 (0.005)	0 (0.004)	0 (0.003)
β_{USi1}	0.839*** (0.047)	0.837*** (0.041)	0.84*** (0.051)	0.364*** (0.136)	0.372** (0.15)	0.465*** (0.163)
β_{USi2}				0.432*** (0.108)	0.459*** (0.129)	0.356*** (0.133)
a_{i1}	0.042 (0.038)	0.075 (0.055)	0.042 (0.027)	0.023 (0.043)	0.065* (0.037)	0.011 (0.019)
a_{i2}				0 (0.042)	0 (0.028)	0 (0.021)
g_{i1}	0 (0.257)	0 (0.076)	0 (0.043)	0.036 (0.094)	0 (0.052)	0 (0.03)
g_{i2}				0 (0.057)	0.004 (0.052)	0.029 (0.034)
b_{i1}	0.713 (1.894)	0.778*** (0.12)	0.89*** (0.065)	0.175 (0.162)	0.004 (0.074)	0 (0.074)
b_{i2}				0.712*** (0.171)	0.872*** (0.057)	0.907*** (0.071)

Note: The numbers in parentheses are robust standard errors. *, **, and *** indicate statistical significance at 10%, 5% and 1% level, respectively

Table 5: Regression of Correlation Evolution for US Stock Market versus Asian Factor, Latin American Factor and Selected Economies

Coefficient	Asian Factor	Hong Kong	Japan	Coefficient	Latin American Factor	Argentina	Brazil
γ_0	0.140*** (0.013)	0.084*** (0.010)	0.040*** (0.007)	γ_0	0.059*** (0.011)	0.037*** (0.008)	0.058*** (0.010)
γ_1	0.742*** (0.024)	0.827*** (0.020)	0.912*** (0.014)	γ_1	0.261*** (0.035)	0.117*** (0.035)	0.397*** (0.035)
				γ_2	0.696*** (0.027)	0.853*** (0.019)	0.704*** (0.037)
				γ_3	-0.061* (0.035)	-0.070** (0.035)	-0.276*** (0.044)
ξ_1	0.003 (0.004)	0.005 (0.007)	0.006 (0.004)	ξ_1	-0.011** (0.004)	-0.014* (0.008)	-0.003 (0.002)
ξ_2	0.007** (0.003)	0.008 (0.006)	0.008** (0.004)	ξ_2	0.008** (0.003)	0.016** (0.007)	0.008*** (0.002)
R-squared	0.564	0.687	0.852	R-squared	0.776	0.803	0.840

Figure 1: Weekly Stock Return of Asian Factor, Latin American Factor and Selected Economies

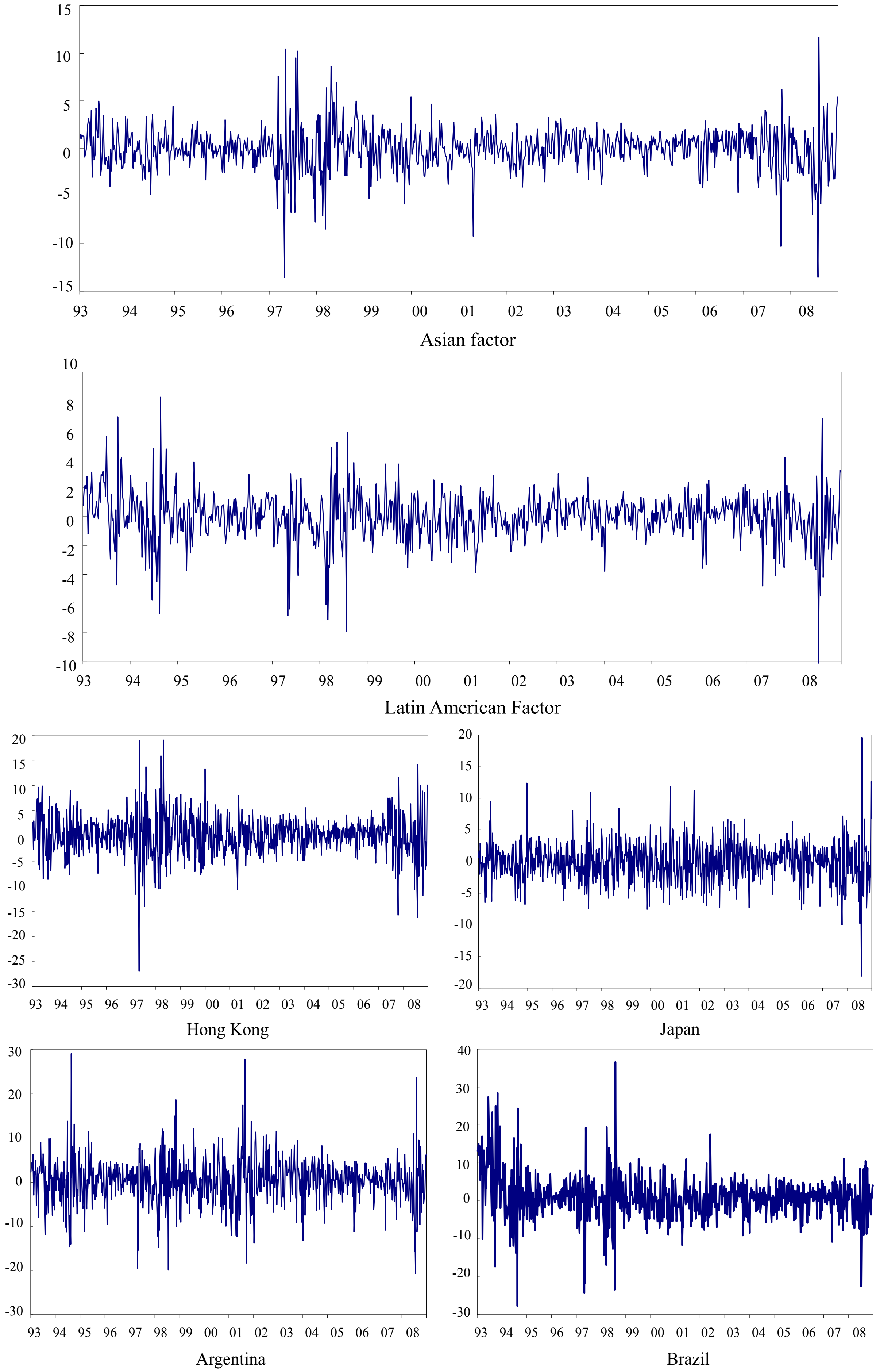
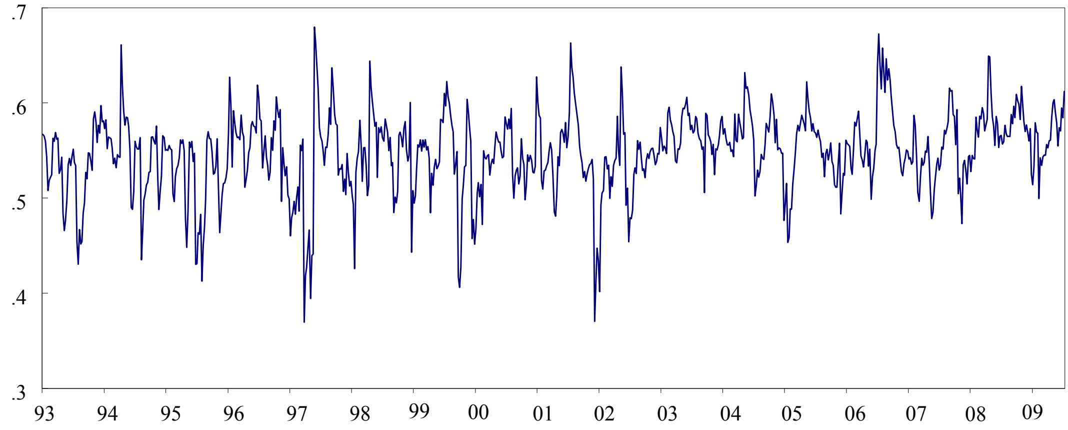
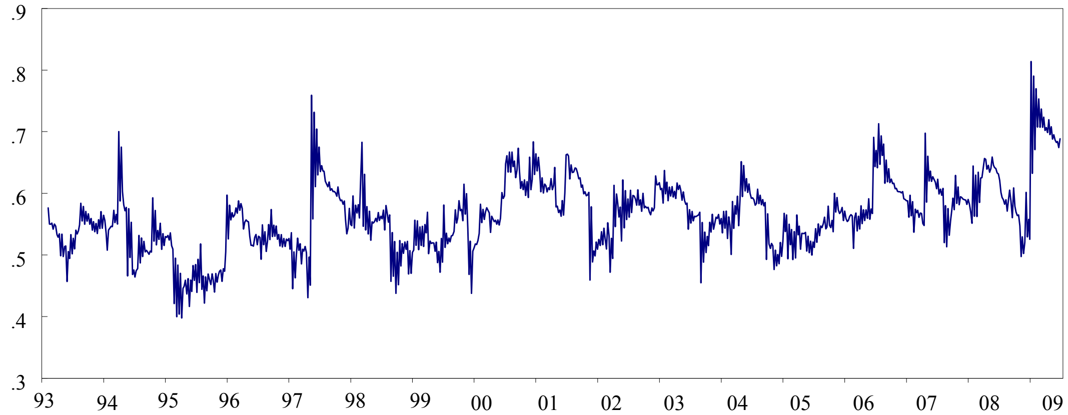


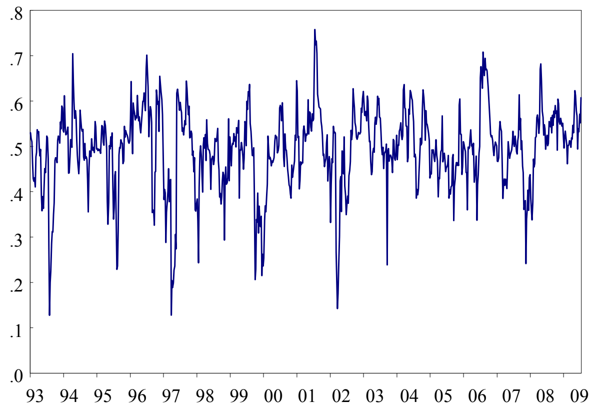
Figure 2: Dynamic Conditional Correlations of Asian Factor, Latin American Factor and Selected Economies versus the U.S. respectively



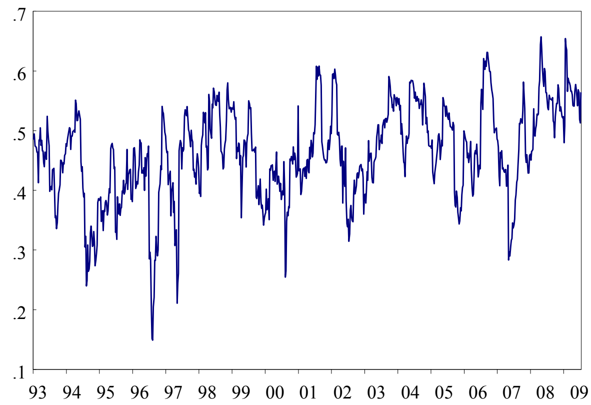
Asian Factor



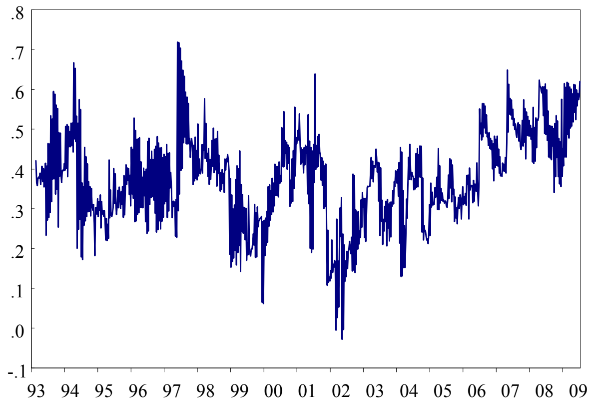
Latin American Factor



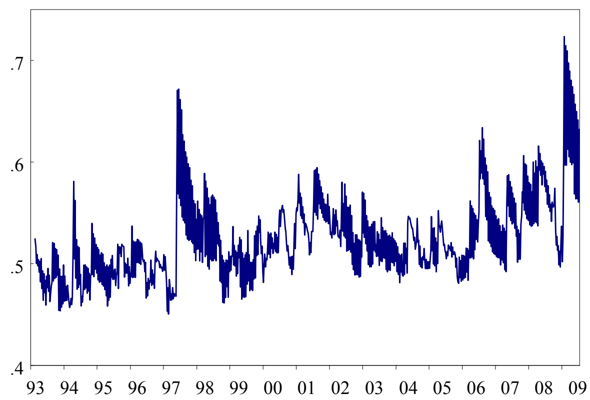
Hong Kong



Japan



Argentina



Brazil