CEA
CENTRO DE ECONOMÍA APLICADA

INGENIERÍA INDUSTRIAL · UNIVERSIDAD DE CHILE

DOCUMENTOS DE TRABAJO
Serie Economía

Nº 251 EMERGING MARKETS VARIANCE SHOCKS: LOCAL OR INTERNATIONAL IN ORIGIN?

VIVIANA FERNÁNDEZ Y BRIAN M. LUCEY

FACULTAD DE CIENCIAS FÍSICAS Y MATEMÁTICAS UNIVERSIDAD DE CHILE

Emerging Markets Variance Shocks: Local or International in Origin?

Viviana Fernandez

Center for Applied Economics (CEA), Department of Industrial Engineering of the University of Chile & Institute for International Integration Studies, Trinity College Dublin

vfernand@dii.uchile.cl

Brian M. Lucey

Institute for International Integration Studies and School of Business, Trinity College Dublin

blucey@tcd.ie

JEL Categories C49, E44, G15

Keywords: Variance, emerging markets, ICSS

Abstract

We examine the source of permanent shocks to the variance of a set of emerging and developed markets. By using the ICSS algorithm, Bai-Perron (2003)'s test for structural breaks in mean level, and wavelets, and analyzing weekly data for 18 countries over the January 1996 – April 2006 period, we find significant numbers of variance breaks. In very few instances, the three methods provide the same dates of variance shifts. Therefore, they can be used as complementary tools. In particular, the ICSS algorithm and wavelets tend to detect more variance shifts than Bai-Perron's. We conjecture that this is an outcome of how volatility is gauged and of the design of Bai-Perron's algorithm. We confirm earlier findings that the majority of variance breaks appear to be associated with local rather than international events.

Lucey acknowledges the support of the government of Ireland under the Programme for Research in Third Level Institutions. Fernandez acknowledges the support of SOC 06/01-2 Grant (Research Division of the University of Chile). Corresponding Author: Lucey

Emerging Markets Variance Shocks: Local or International in Origin?

1. Introduction

Over the last decade significant research into the financial economics of emerging markets has emerged. A search on EconLit using "Emerging market" as keyword returns in excess of 2000 hits. Research has concentrated on three main areas: integration of these markets into the world market (see for example De Jong and De Roon (2005)), financial architecture as it pertains to emerging markets (see for example Beck (2006)) and aspects of domestic emerging market finance (see for example Booth and Yuksel (2006)). A comprehensive review of research into emerging market finance is available in Bekaert and Harvey (2002). This paper is located in the first area. In particular, we investigate the extent to which the volatility of emerging markets equity markets are impacted by local versus international shocks.

While general research in emerging market finance is plentiful, research into equity market volatility in these markets is not nearly as well examined. More particularly, the cause of volatility persistence and of large, sudden and long-lasting changes in the variance of these equity markets has received little research attention. The importance of volatility persistence, particularly that of conditional volatility, has been discussed by among others Liu (2000), So (2000) and Banerjee and Urga (2005), all of whom note that in the case where there is persistence in volatility this characteristic needs careful modelling when volatility forecasts are made or when derivative securities are to be priced. A related line of research has shown however that observed persistence in volatility may in fact emerge when there are structural breaks in the variance series (see Lamoureux and Lastrapes (1990) et seq). The evidence is overwhelming that inclusion of structural breaks in models leads to a reduction in measured persistence (see among others Aggarwal, Inclan et al. (1999), Bacmann and Dubois (2002), Ewing and Malik (2005), Covarrubias, Ewing et al. (2006) and Fernandez (2006)).

The examination of this issue is important for at least two reasons. First, if emerging markets are integrated with developed markets then the causes of sudden changes in variance should reasonably be expected not to be dominated by local events. Second, from a policy perspective, the source of these shocks has implications for any remedies. Local shocks by definition must come from local events, which inter alia are more under the control or influence of local authorities.

In terms of modern modelling of these changes, the seminal paper is Aggarwal, Inclan et al. (1999), who apply the ICSS algorithm of Inclan and Tiao (1994) on, among others, 10 emerging markets over the 1985-2005 period. They find that the majority of changes in variance are associated with local rather than global events. This paper however was preceded by Bos, Ding et al. (1998), who showed the extent of variance changes in the Thai market was low, with only a 2% likelihood in any given day of such a change occurring. Since then relatively few papers have examined sudden changes in variance for emerging equity markets. Bacmann and Dubois (2002) study 5 emerging markets and find the variance shocks to be country specific, and thus diversifiable. Hammoudeh and Li (2006) find, in contrast to Aggarwal, Inclan et al. (1999) that the majority of changes in Gulf Cooperation Council member equity markets are associated with world events, while Fernandez (2006) finds that the effect of the Asian crisis and the September 11th events induced permanent changes in emerging market equity aggregate index volatilities. Thus, from the limited evidence available there is no consensus as to the source of these changes.

We re-address these issues, using a longer and more up-to-date dataset, and also using a new technique, wavelet analysis. We also estimate variance breaks from a parametric approach, using the Bai-Perron test on Garman-Klass variance estimators. Section 2 describes the ICSS approach, section 3 the wavelet approach, section 4 the Garman-Klass estimator, Section 5 the dataset we use and section 6 the results.

2. The ICSS algorithm

Under Inclan and Tiao (1994)'s ICSS algorithm, a time series of interest has a stationary unconditional variance over an initial time period until a sudden break takes place. The unconditional variance is then stationary until the next sudden change occurs. This process repeats through time, giving a time series of observations with a number of M breakpoints in the unconditional variance along the sample:

$$\sigma_t^2 = \begin{cases} \tau_0^2 & 1 < t < \iota_1 \\ \tau_1^2 & \iota_1 < t < \iota_2 \\ & .... \\ \tau_M^2 & \iota_M < t < n \end{cases} \tag{1}$$

In order to estimate the number of variance shifts and the point in time at which they occur, a cumulative sum of square residuals is computed, $C_k = \sum_{t=1}^{k} \varepsilon_t^2$, k=1, 2, .., n, where $[\varepsilon_t]$ is a series of uncorrelated random variables with zero mean and unconditional variance σ_t^2, as in (1). Inclan and Tiao define the statistic:

$$Đ_k = \frac{C_k}{C_n} - \frac{k}{n} \qquad k=1, 2, .., n, \qquad Đ_0 = Đ_n = 0. \tag{2}$$

If there are not variance shifts over the whole sample period, $Đ_k$ will oscillate around zero. Otherwise, if there is one or more variance shifts, $Đ_k$ will departure from zero. The ICSS algorithm systematically looks for breakpoints along the sample. A full description of the algorithm is given in Inclan and Tiao (1994) or Covarrubias, Ewing et al. (2006). The outcome from the application of the ICSS algorithm is a series of breakpoints, each representing the date of a new variance regime.

3 A wavelet-based variance shift test

Recently we have seen increased application of the wavelet method in finance. Wavelets enable us to decompose a time series into high- and low-frequency components (see, for instance, Percival and Walden 2000). High-frequency components describe the short-term dynamics whereas low-frequency components represent the long-term behavior of a series. Applications of wavelet analysis usually utilize a discrete wavelet transform (DWT). The DWT maps a vector of n observations to a vector of n smooth and detail wavelet coefficients which capture the underlying smooth behavior of the data and the deviations from it. Such decomposition also allows us to partition the variance of a time series into pieces that are localized in time.

Let $n'_j = \lfloor n/2^j \rfloor$ be the number of DWT coefficients at level j, where n is the sample size, and let $L'_j \equiv \left\lceil (L-2)(1-\frac{1}{2^j}) \right\rceil$ be the number of DWT boundary coefficients[1] at level j (provided that $n'_j > L'_j$), where L is the width of the wavelet filter. An unbiased estimator of the wavelet variance based on the DWT is given by

$$\tilde{\upsilon}^2_X(\tau_j) \equiv \frac{1}{(n'_j - L'_j)2^j} \sum_{t=L'_j}^{n'_j-1} d^2_{j,t} . \quad (3)$$

Given that the DWT de-correlates the data, the non-boundary wavelet coefficients at a given level ($\mathbf{d}_j$) are zero-mean Gaussian white-noise processes. Under the null hypothesis of variance homogeneity:

H_0: $\mathrm{var}(d_{j,L'_j}) = \mathrm{var}(d_{j,L'_j+1}) = ... = \mathrm{var}(d_{j,n'_j-1})$

whereas under the alternative

H_1: $\mathrm{var}(d_{j,L'_j}) = .. = \mathrm{var}(d_{j,t'}) \neq \mathrm{var}(d_{j,t'+1}).... = \mathrm{var}(d_{j,n'_j-1})$

where t' is an unknown breakpoint.

[1] $\lfloor x \rfloor$ and $\lceil x \rceil$ represent the greatest integer ≤x and the smallest integer ≥x, respectively. The boundary coefficients are those obtained by putting together some values from the beginning and the end of the time series.

The D-test statistic quantifies the maximum deviation (positive or negative) of a normalized cumulative sum of squares, C_k, from a hypothetical linear cumulative energy[2] trend:

$$D=\max(D^+,D^-) \qquad D^+ = \max_k\left(\frac{k-L_j'+1}{n_j'-1}-C_k\right),\ D^- = \max_k\left(C_k-\frac{k-L_j'}{n_j'-1}\right) \qquad (4)$$

with $C_k = \dfrac{\sum_{t=L_j'}^{k} d_{j,t}^2}{\sum_{t=L_j'}^{n_j'-1} d_{j,t}^2}$, $k=L_j',\dots, n_j'-2$.

Under the null hypothesis, the ratio of the expected value of the numerator of C_k and the expected value of its denominator is $(k+L_j'+1)/(n_j'-L_j')$, which is a linear function of k. Therefore, the null hypothesis will be rejected when D departures from this expected linear increase. Details on the computation of the critical values of the test are given in Percival and Walden, chapter 9.

4 Bai-Perron breakpoint test on Garman-Klass volatility estimator

Given that volatility is unobservable, we resort to one of Garman-Klass (1980)'s variance estimators, given by

$$\hat{\sigma}^2=0.5(u-đ)^2-(2\ln(2)-1)c^2 \qquad (5)$$

which corresponds with formulation $\hat{\sigma}_5^2$ in their article. u represents the normalized high and equals H_1-O_1, đ is the normalized low and equals L_1-O_1, and c is the normalized close and equals C_1-O_1, where H_1, O_1, and C_1 are today's high, opening and closing prices, respectively. The Garman-Klass estimator is a range based estimator of variance, a class that includes estimators by Parkinson (1980), Rogers and Satchell (1991) and Yang and Zhang (2000). This class of estimator has recently been comprehensively examined by Shu and Zhang (2006) and Corrado and Truong (2007) who conclude that they perform very well as estimators of realized volatility.

Under Garman and Klass' framework, the price of an asset, P, is governed by a diffusion process of the form $P(t)=\varphi(B(t))$, where $\varphi(.)$ is a monotonic, time-invariant transformation, $dB(t)=\sigma dW(t)$, and $dW(t)$ is the increment of a Wiener process. In other words, price changes over a time interval are normally distributed with zero mean and variance proportional to the length of the interval. Under the assumption that prices are

---

[2] The energy-concentration function of a vector $\mathbf{x}=(x_1, x_2, \dots, x_n)'$ is defined as $E_x(K)=\sum_{i=1}^{K} x_{(i)}^2 \Big/ \sum_{i=1}^{n} x_i^2$, where $x_{(i)}$ is the ith-largest absolute value in $\mathbf{x}$

continuously observed, Garman and Klass propose some alternative estimators of σ^2 which are more efficient that the classical estimator $\hat{\sigma}^2 = (C_1 - C_0)^2$, where C_1 and C_0 are today's and the previous closing prices, respectively. Garman and Klass' estimators utilize information on the low and high prices, and on the high, low, opening and closing prices

However, in practice, transactions takes place at discrete points in time and stock exchanges are open during certain business hours a day. Therefore, price paths cannot be monitored continuously and, as a consequence, the relatively more efficient estimators proposed by Garman and Klass will exhibit some bias. Such bias will depend on the frequency with which prices are observed, that is, on the number of transactions taking place per day (i.e., volume effect).[3] If transactions are relatively large (say, around 500), $\hat{\sigma}_5^2$=0.89σ^2. Therefore, as a practical matter, Garman and Klass suggest dividing the empirical estimate by 0.89 in such a case. (Table 1 of their article reports the bias of each variance estimator as a function of the number of transactions).

We follow Bai and Perron (2003)'s approach to determine the number of structural breaks. This consists of regressing the Garman-Klass volatility estimate (v_t) on a constant and test for the presence of structural breaks in mean. Let us consider the existence of m breaks, which give rise to m+1 regimes:

$$v_t = \alpha_i + \varepsilon_t \qquad t = T_{j-1} + 1, ..., T_j \tag{6}$$

where i=1, ..., m+1, v_t is the volatility estimate at time t and α_i is the mean level of volatility in regime i. The breakpoints (T_1,.., T_m) are treated as unknown, and, by convention, T_0=0 and T_{m+1}=T. For each m-partition (T_1,..., T_m), the unknown coefficients α_i, i=1,..., m, and breakpoints are estimated by least squares:

$$SSR_T(T_1,...,T_m) = \sum_{i=1}^{m} \sum_{t=T_{i-1}+1}^{T_i} (v_t - \alpha_i)^2 \tag{7}$$

Let us denote the estimate of the vector $\alpha=(\alpha_1, ..., \alpha_{m+1})'$ as $\hat{\alpha} = \hat{\alpha}(\{T_j\})$, which represents the vector of estimates associated with estimated partition $(\hat{T}_1,...,\hat{T}_m)$, such that $(\hat{T}_1,...,\hat{T}_m) = \arg\min_{T_1,...,T_m} SSR_T(T_1,...,T_m)$. In other words, the minimization is taken over all partitions (T_1, ..., T_m), and the breakpoints are global optimizers of SSR_T.

Bay and Perron presents an example in their article where the number of breaks of the US ex-post real interest rate over 1961:1-1986:3 is selected by three different methods: a sequential F-statistic, a modified Schwarz criterion (LWZ), and a Bayesian Information

[3] Garman and Klass think of the time interval [0, 1] as one trading day. The assumption of a finite volume per day implies that transactions are randomly scattered throughout [0, 1].

Criterion (BIC). In this article, we computed the breakpoints by the sequential method and a BIC. In general, both routes gave the same answer. However, the sequential method tended to be more conservative and yielded a fewer number of breakpoints. In such instances, we relied on the BIC, given that the two other methods we resort to i.e., the ICSS algorithm and wavelet, suggested the presence of a greater number of variance shifts.

5. Data

We examine data at a weekly frequency, over the period 3/1/1996 to 5/4/2006, giving in total 536 observations. All data are MSCI indices, sourced from Datastream. The use of MSCI indices, designed to facilitate comparison of actual investible securities across countries, allows us to have greater confidence in any inferences regarding the diversification potential of shocks. In addition, the spread of countries analysed is the largest that we know of in this literature. We examine data for 10 emerging markets: Argentina, Brazil, Chile, India, Indonesia, Mexico, Philippines, Singapore, South Africa, and Turkey, and we also examine returns for the USA as a proxy for world market events. To isolate potential dollarization or dollar regime issues, we measure in a neutral currency, Swiss Franc. Data are calculated as on a Wednesday-Wednesday return, to avoid potential issues such as non synchronous trading, weekend and Monday effects.

Table 1 provides descriptive statistics. As might be expected the developed markets demonstrate higher average returns, higher risk and more pronounced skewness. For developed markets local currency returns are lower, as are local currency standard deviations. However, for emerging markets the local currency mean returns are much higher, with lower risk, than Swiss Franc denominated returns.

6. Variance Breaks

6.1. ICSS Break Detection

Application of the ICSS algorithm to the series of weekly returns generates a number of breaks in the series variance. The number of breaks varies significantly between countries, with no significant evidence that instability in emerging markets variance is clearly greater than that for the USA. The number of breaks is shown in Table 2 , with the time distribution shown in Table 3. The largest number of breaks occurs in early 1997 and in early 2005.

6.2 Bai Perron Results

Shown in Table 2 are the results of the Bai-Perron test. We note that there are many fewer breaks detected using this model than are detected using the ICSS approach. We elaborate on this issue below.

6.3 Wavelet-based break detection

We use a rolling window of 450 observations[4] and compute the value of the D-test statistic in equation (4), along with its corresponding 95-percent significance level, at scales 2 and 4 (i.e., 2-8 weeks and 16-32 weeks time, respectively) for the ten aforementioned countries. If the computed D statistics crosses the 95-percent critical value, it is taken as evidence against the null hypothesis of no variance shifts.

Figure 1, (a)-(k), depicts the results for the time period August 2004-April 2006. Recall that the wavelet test requires a significant number of observations to initialize, which limits us to the two years noted. We find that the countries that exhibited least variance shifts were India, the U.S., and South Africa, and Turkey. Specifically, India experienced five breaks at scale 2 (i.e., 2-8 weeks), but none at scale 4 (i.e., 16-32 weeks); the US exhibited about three breaks at scales 2 and 4 towards the end of 2005/beginning 2006; while South Africa only experienced one break at scale 2, but exhibited much more variance instability at scale 4. A pattern similar to South Africa's is that exhibited by Turkey. The countries that experienced multiples variance shifts along this time period were Chile, Brazil, Philippines, and Indonesia. Somewhere in between the more stable countries and the latter were Mexico, Singapore, and Argentina. Table 3 reports the breakpoint dates for some selected countries.

7 Break Events

To further investigate the extent to which these breaks are local or internationally based we show in the dates for which we measure a break, and against each date we note significant event. For emerging market events we examine Geert Bekaert and Campbell R. Harvey's Chronology of Economic, Political and Financial Events in Emerging Markets, available at http://www.duke.edu/~charvey/ . We further check events against the Financial Times and Economist newspaper archive pages. We classify each event, where possible, into Local or Global, denoted L or G respectively. Each date below is the date of the start of the weekly period, so a date of say 5-September-2001 encompasses for example the events of 11-September-2001. Results are presented in Table 4 for the ICSS, Bai-Perron, and waivelets

[4] The algorithm developed in S-Plus 7.0 requires at least that many observations.

breaks: events are suffixed L or I for local or international events, and where no clear event has taken place we colour code the break yellow.

One immediate result that is clear is the significantly lower number of breaks that are detected by the Bai-Perron method. As noted earlier, direct comparison may not be possible: the Garman-Klass measure of volatility is one of "within period" as opposed to the "between period" measure of squared differences. In addition, the Bai-Perron method sets some constraints on the number of potential breakpoints. For instance, their algorithm assumes that there exists a certain distance "q" between breakpoints.

Second, regardless of the method by which the break is detected, in a significant number of cases we cannot ascertain any major political or economic event, local or global, which might plausibly cause the break. Third, where we can ascribe an event to the break, as has been found with Aggarwal, Inclan et al. (1999) that these are overwhelmingly local in origin. This reinforces that while these breaks may be problematic, they are idiosyncratic and therefore in principle diversifiable. Some exceptions are countries that appear to be more integrated with the U.S. than with other countries in their corresponding regions. We explore this issue next.

Third, we note that while some countries (especially Singapore) have no breaks detected by he ICSS, the Wavelet method detects much greater instability in the variance process. For almost every country the wavelet variance estimator is highly unstable for the period estimated. The exception is Turkey, which is surprising given the apparent instability detected there via the ICSS method.

Fourth, where we can find or ascribe events associated with the break period, as many are political as opposed to economic in nature. However, some countries, notably turkey and the Philippines, appear to be much more susceptible to political event induced variance breaks than others.

8. Returns co-movement and its incidence on variance shifts

We look into the issue of whether there was significant return co-movement between those countries that experienced more variance shifts. Figure 2 (a)-(e) depicts rolling wavelet-based pair-wise correlations for the raw data and the decomposition at scales 2 and 5 for some selected countries. For instance, we observe that Chile and Brazil's returns exhibited high correlation, particularly at scale 5. By contrast Philippines and Indonesia, despite the fact of both having experienced many variance shifts, do not exhibit as much co-movement as Brazil and Chile did. Interestingly, India seems more integrated with the U.S than with Indonesia (panels (c) and (d)). Similarly, Turkey also displayed significant co-movement with the U.S, particularly at scale 5 (32-64 day dynamics), with a maximum correlation of about 0.77. Both the U.S and Turkey displayed a few or no breaks at a short-term horizon (i.e., scale 2 or 2-4 day time span).

9 Conclusions

Three alternative methods of measuring and detecting variance breaks are presented in this paper. A striking feature is how few of the results overlap. We conclude that the ICSS method alone therefore cannot be relied on as an unambiguous test for variance breaks. The nature of the breaks appear to be local in origin, but with a significant number of breaks not appearing to be associated clearly with any determining event. Where we can determine events a significant number appear to be political as opposed to economic.

Overall, we confirm earlier research that, by whatever metric and howsoever caused, variance breaks in emerging markets seem to be a function of local as opposed to international events, and as such are inherently diversifiable.

Table 1 : Descriptive Statistics, Weekly Returns 1996-2006

	MEAN	MIN	MAX	ST DEV	SKEW
Argentina	0.1359%	- 0.5445	0.2457	5.9432%	- 1.4778
Brazil	0.2347%	- 0.3154	0.1999	5.4884%	- 0.8619
Chile	0.0792%	- 0.1567	0.1487	3.4167%	- 0.2828
India	0.2462%	- 0.1612	0.1602	4.1660%	- 0.2875
Indonesia	-0.0572%	- 0.3972	0.3001	7.3432%	- 0.4557
Mexico	0.2946%	- 0.2228	0.2184	4.5066%	- 0.2913
Philippines	-0.1827%	- 0.2153	0.2383	4.6893%	0.0667
Singapore	0.0122%	- 0.1390	0.1311	3.6658%	- 0.2316
South Africa	0.1200%	- 0.2016	0.1110	3.8367%	- 0.8238
Turkey	0.3299%	- 0.3114	0.2524	7.5540%	- 0.4405
USA	0.1579%	- 0.1335	0.1253	3.0676%	- 0.2345

Table 2: Number of Variance Breaks detected by Series

COUNTRY	ICSS	BAI-PERRON
Argentina	6	2
Brazil	8	1
Chile	9	3
India	8	2
Indonesia	7	3
Mexico	7	3
Philippines	7	2
South Africa	12	3
Singapore	0	3
Turkey	10	3
USA	8	2

Table shows the number of breaks detected by country using the ICSS or the Bai-Perron model over the 1996-2006 period.

Table 3: Dating of the Breaks

		ICSS		Bai Perron	
		Emerging	USA	Emerging	USA
1996	Q1	1			
	Q2				
	Q3				
	Q4				
1997	Q1	6	1		
	Q2	2		2	
	Q3	4	1	2	
	Q4	2		3	
1998	Q1	3	1	2	
	Q2	1			
	Q3	1			1
	Q4				
1999	Q1	4	1	3	
	Q2	2			
	Q3	1			
	Q4	3			
2000	Q1	3			
	Q2	1			
	Q3	4		1	
	Q4	2		1	
2001	Q1			1	
	Q2	1		1	
	Q3	4	1		
	Q4	1			
2002	Q1	1			
	Q2	5			
	Q3	2	1	1	
	Q4			2	
2003	Q1			1	
	Q2	1			1
	Q3	4	1		
	Q4	5			
2004	Q1				
	Q2	1		3	
	Q3	4			
	Q4	5			
2005	Q1	3			
	Q2	6	1		
	Q3	3			
	Q4	2			

Table shows distribution of the breaks overall.

Table 3 continued: breaks at scale 2:—Selected countries

		Argentina	India	Mexico	South Africa	Turkey	USA
2004	Q1	--	--	--	--	--	--
	Q2	--	--	--	--	--	--
	Q3	--	--	--	--	--	--
	Q4	--	2	--	--	--	--
2005	Q1	--	2	2	--	--	--
	Q2	--	--	2	--	--	--
	Q3	--	2	4	--	--	--
	Q4	1	3	4	1	--	1
2006	Q1	1	2	--	1	--	2
	Q2	--	--	--	1	--	--

The time period is August 2004-April 2006. 450 observations at the beginning of the sample are missing due to the computation of the algorithm.

Table 4 : Ascribing events to the calculated breaks

		Argentina	Brazil	Chile	India	Indonesia	Mexico	Phillipines	Singapore	Turkey	South Africa	USA
1996	Q1										14-Feb-96 L Rand weakness	
	Q2											
	Q3											
	Q4											
1997	Q1	08-Jan-97 L Bank restrictions eased		01-Jan-97 L Stock Market Liberalisation 21-Feb-97 *			08-Jan-97 L : Mexico repays final tranche of US emergency "peso crisis" loan			15-Jan-97 L: Legal challenges continue to privatisation of state assets	05-Feb-97	15-Jan-97
	Q2		02-Apr-97 L Sovereign bond ratings upgrade and Tax Cut				25-Jun-97 : L Early repayment of foreign debt *	15-June-97				
	Q3					5-Aug-97 G Asian market instability ; Pressure on rupiah leads to devaluation 24-Sep-97		27-Aug-97 G: Asian Stock markets plunge on currency crises	5-Aug-97*	30-Sep-97*	10-Sep-97 L SA loses out in Olympic race	09-Jul-97
	Q4		22-Oct-97 G Asian market instability fallout				21-Oct-97 G Asian market instability fallout				21-Oct-97 G Asian market instability fallout	
1998	Q1		24-March-98 L Central Bank cuts rates on recovery of foreign reserves *								25-Mar-98	14-Jan-98
	Q2			31-March-98 L Further market liberalization *								
	Q3						29-Jul-98 : L Budget cuts due to oil price falls.			26-Aug-98		28-July-98 *
	Q4											

		Argentina	Brazil	Chile	India	Indonesia	Mexico	Phillipines	Singapore	Turkey	South Africa	USA
1999	Q1			10-Mar-99 L Pension funds allowed to invest more freely		16-Feb-99 L Privatisation announcements *	24-Mar-99	26-Jan-99	23-Feb-99*	10/02/1999 24/3/1999 L Kurdish seperatist issues		03-Mar-99
	Q2				2-June-98 *	14-Apr-99 L Political violence, calls for independence in in East Timor		07-Apr-99 L : Easing of banking restrictions.			07-Apr-99 4-May-99 *	
	Q3							04-Aug-99 L : Political instability				
	Q4				22-Dec-99 L Electoral results	13-Oct-99 L : ongoing political instability regarding presidential succession				03-Nov-99		
2000	Q1	30-Jan-01 *		05-Jan-00 L Telefonica consolidates holdings in Latin America		29-Mar-00					01-Mar-00 L Portfolio investment restrictions lifted	
	Q2			31-May-00 L Easing of restrictions on foreign investments			4-July-00 L : Presidential election					
	Q3		11-Oct-00 L Currency, Electoral instability		19-Jul-00	25-Oct-00		19-Jul-00				
	Q4									15-Nov-00 L Turkish banks liquidity crisis		
2001	Q1											
	Q2		07-Mar-01 L Monetary Tightening		8-May-01*							
	Q3		04-Jul-2001 L Central bank announcements re intervention 05-Sep- 2001 G US Terrorist Attacks	12-Sep-01 G US terrorist attacks				18-Jul-01 L S&P issue downgrading of economic outlook			05-Sep-01 G US terrorist attacks	08-Aug-01
	Q4		28-Nov-01									
2002	Q1	27-Feb-02 L Capital Controls										

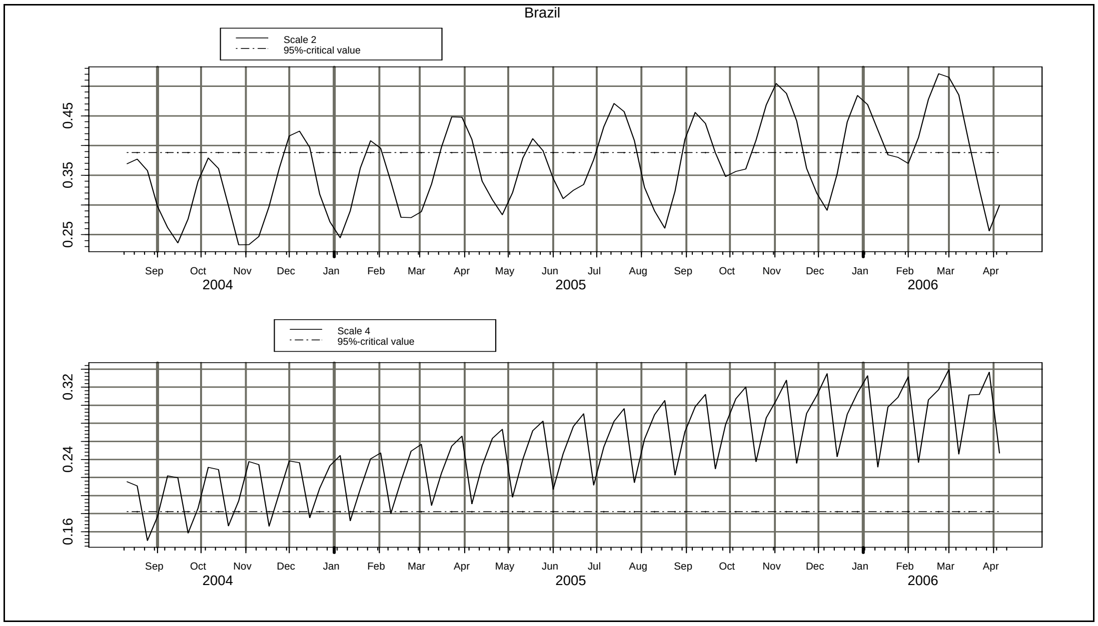
		Argentina	Brazil	Chile	India	Indonesia	Mexico	Phillipines	Singapore	Turkey	South Africa	USA
2002	Q2		12-Jun-02 L Tax reductions, IMF Loans	29-May-02L Wage, tax law passed	12-Jun-02 L Indo-Pakistani Tension eases			22-May-02		05-Jun-02 L Political concerns re PM health		
	Q3	15-August-02 *										18-Sep-02
	Q4					12-Nov-02 L Peace talks with separatist rebels in Aceh province. *	3-Dec-02					
2003	Q1									15-March-03 G US invasion of Iraq *		
	Q2						28-May-03					20-May-03 *
	Q3		20-Aug-03 L Social Security Reform		02-Jul-03 L India now a creditor nation with IMF					03-Sep-03		02-Jul-03
	Q4	10-Sep-03 L IMF Agreements Signed		01-Oct-03 L VAT increase		31-Dec-03 L : international aid pledges realised.					22-Oct-03 L New Labour laws	
2004	Q1											
	Q2			18-May-04 L Telecoms m&a *	05-May-04 L Kashmiri Terrorism				25-May-04 *		11-May-04 L :Formation of new government	
	Q3			August: highly unstable#	15-Sep-04			01-Sep-04 L Bond market instability on political commentary	Sep-04#	25-Aug-04 L Bond ratings increased	15-Sep-04 L Political risk comments	
	Q4		Dec: highly unstable#		Dec-04 # 01-Dec-04 L FPI pushes equity market to record highs	29-Dec-04 L Tsunami #	08-Dec-04 L : Political instability over government budget	Sep-04 # L Presidential Election	Dec-04 #	15-Dec-04 L EU accession talks	10-Nov-04 L Gold mining m&a talks	
2005	Q1	02-Feb-05 L End of public debt restructuring	March: highly unstable#	02-Feb-05 #	2-Feb-05 # 30-Mar-05 #	highly unstable #	Mar-05 # Privatisation Announcements L	Mid Dec-04 #		12-Jan-05 L Concern over EU constitution		

		Argentina	Brazil	Chile	India	Indonesia	Mexico	Phillipines	Singapore	Turkey	South Africa	USA
	Q2			May05 # Political maneuvering in coalitions L 15-Jun-05 L Earthquake causes concern re copper production	25-May-05 L Privatisation plans approved		18-May-05 18-May-05# 25-May-05#	April-05 #				11-May-05
	Q3	20-Jul-05 L resumption of Argentine foreign borrowing 14-Sep-05	27-Jul-05 # Concerns re government corruption L	July-05 highly unstable# Sep: # Constitutional Amendment L	20-Jul-05 # 27-Jul-05 #	highly unstable#	Late July highly unstable # Mid Sept Highly unstable#	July-05# L Vote rigging allegations	July-05#	24-Aug-05	27-Jul-05	
	Q4	26-Oct-05 # Elections L	Nov 05 #	Nov-05 # L Concerns re pension provision	Nov highly unstable #	28-Dec-05 # L Terrorist bombings	26-Oct-05 Hurricane L Nov-05 # 28-Dec-05	Dec-05 #	Nov-05 #		16-Nov-05# 14-Dec-05	2-Nov-05#
2006	Q1	15-Feb-06#	Feb-March: highly unstable # L Concerns re corruption	Feb-March:05 # L Presidential change	Early March # L US-Indian nuclear cooperation	Mar06- highly unstable#		March-06#	Feb-06#		29-Mar-06#	Feb-06 #
	Q2										5-Apr-06# L Mbeki announces intention to retire	

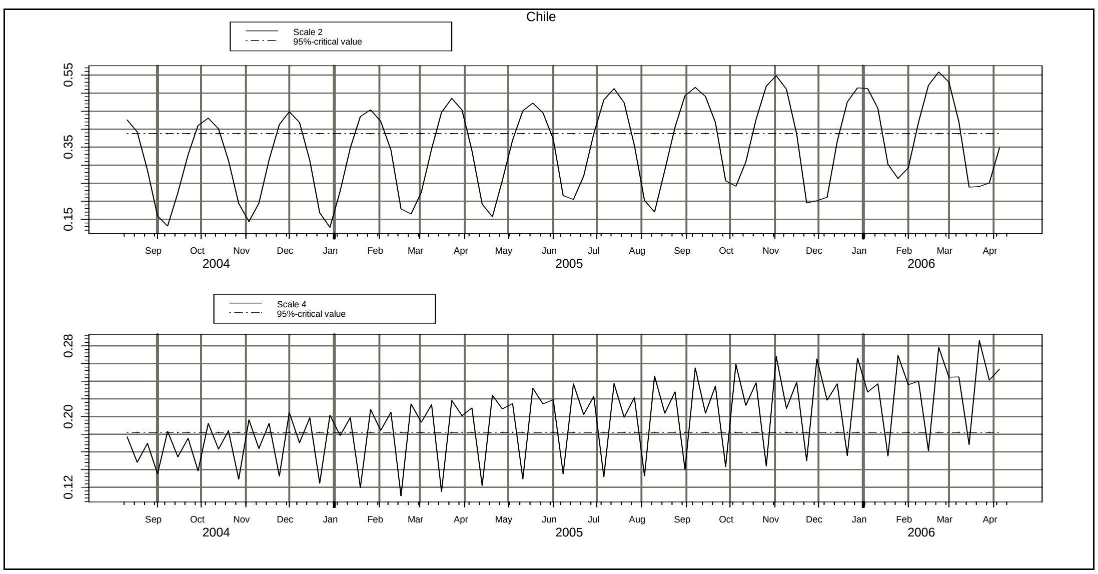
Table shows the dates of variance breaks identified as per Table 2 and the events occurring around these; * indicates a break detected only by the Bai-Perron method. Color yellow indicates a break for which we have not been able to find an explanation. # indicates breakpoints detected by wavelets during the period August 2004-April 2006, while absence of these indicates ICSS estimation

Figure 1 Rolling wavelet-based test of volatility breakpoints

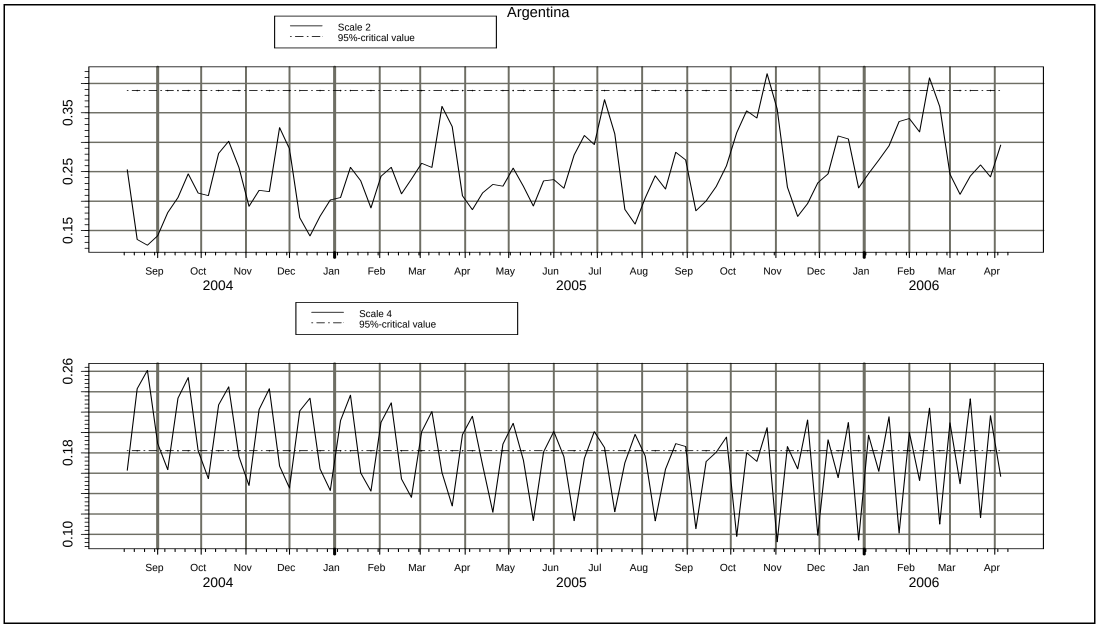
(a)



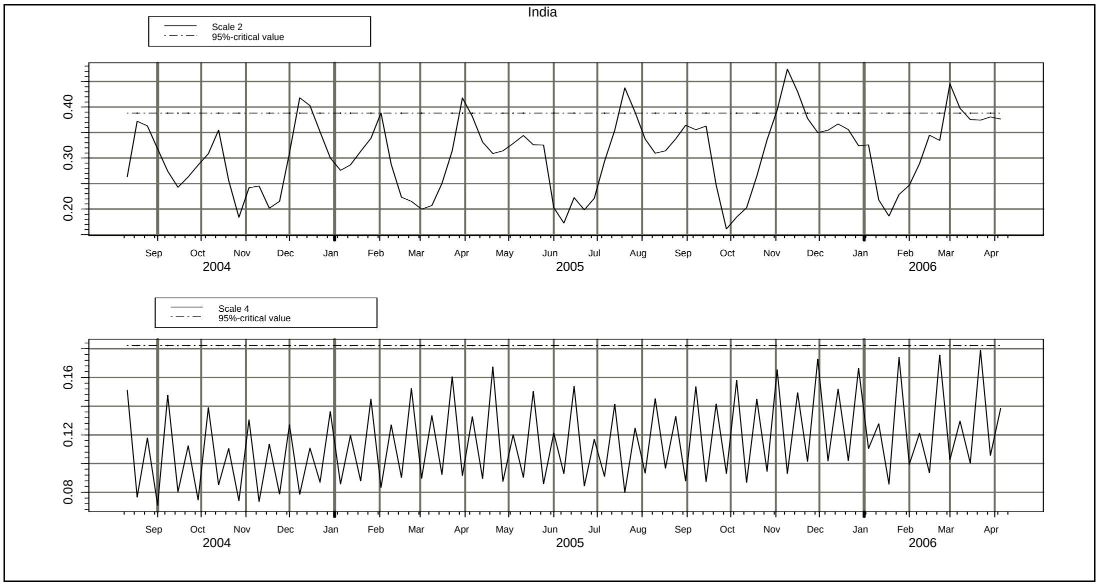
(b)



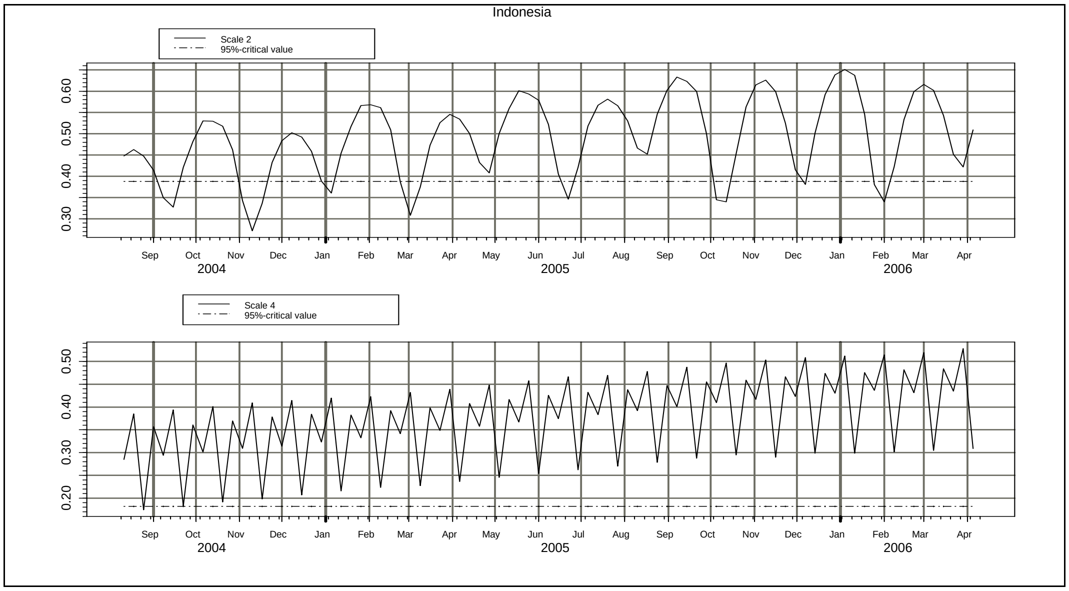
(c)


Argentina
Scale 2
95%-critical value
0.15
0.25
0.35
Scale 4
95%-critical value
0.10
0.18
0.26
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
2004
2005
2006

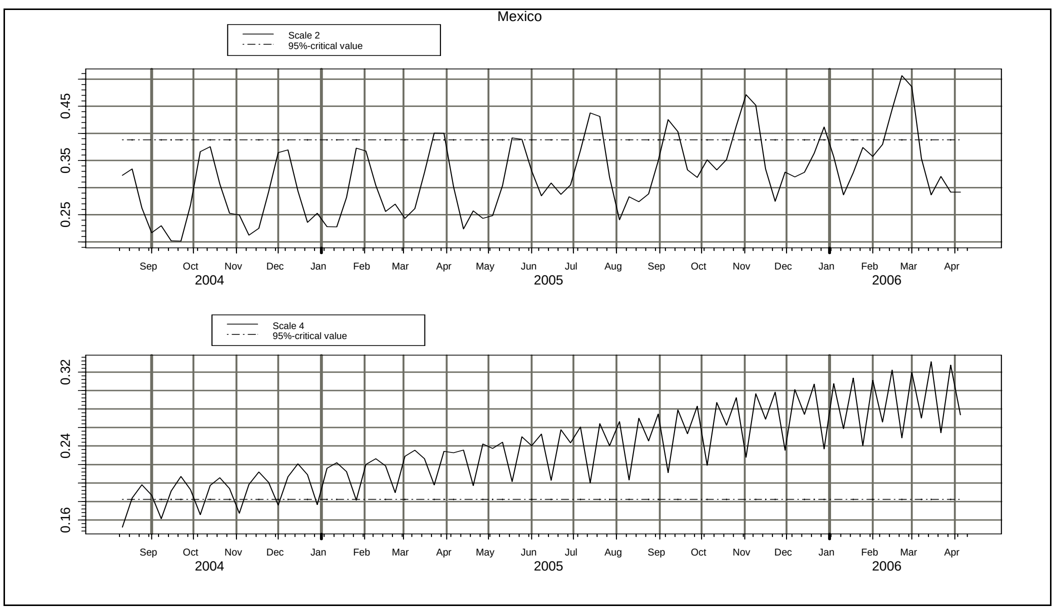
(d)


India
Scale 2
95%-critical value
0.20
0.30
0.40
Scale 4
95%-critical value
0.08
0.12
0.16
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
2004
2005
2006

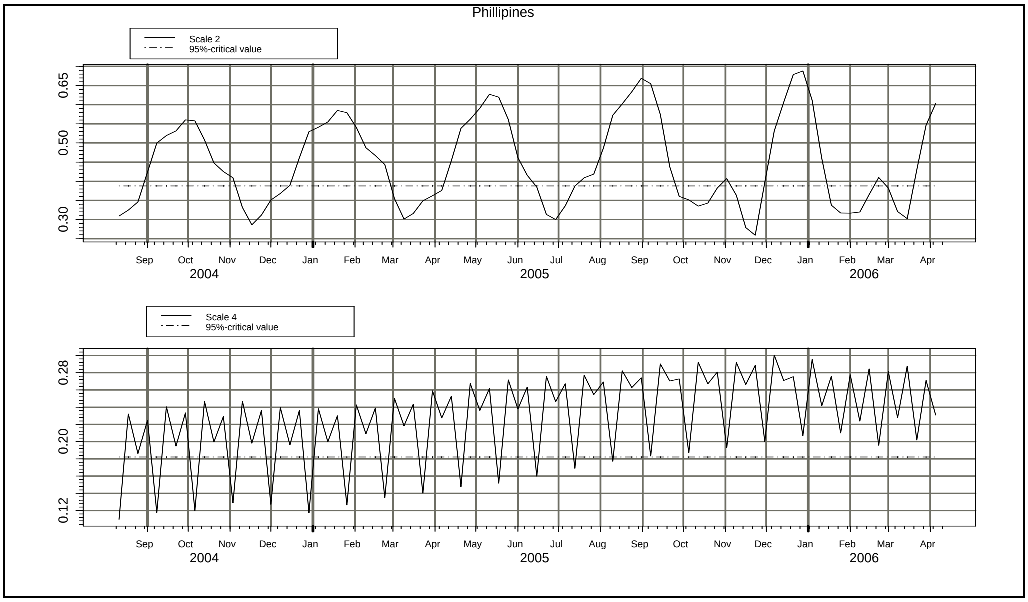
(e)


Indonesia
Scale 2
95%-critical value
0.30
0.40
0.50
0.60
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2004
2005
2006
Scale 4
95%-critical value
0.20
0.30
0.40
0.50

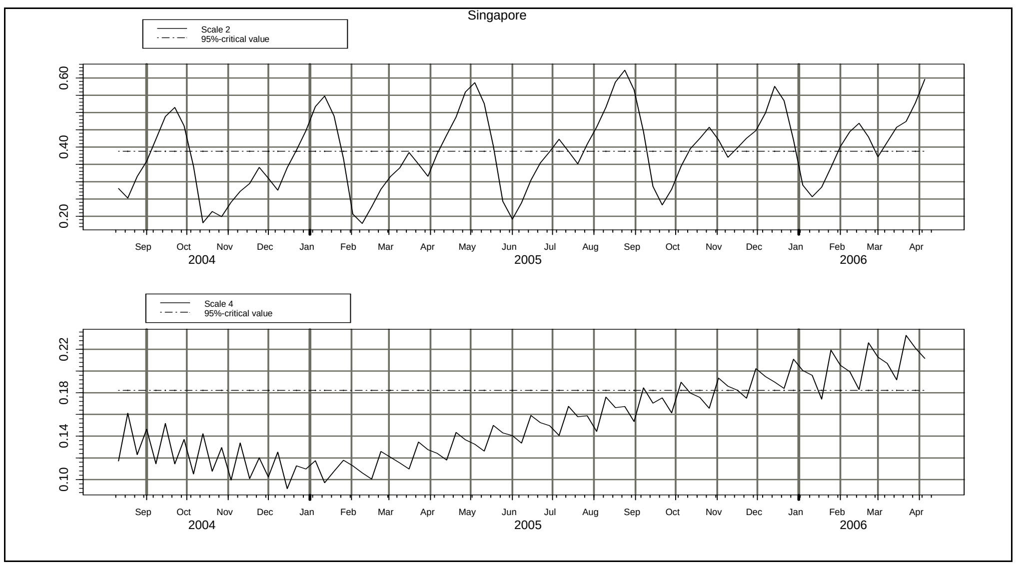
(f)


Mexico
Scale 2
95%-critical value
0.25
0.35
0.45
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2004
2005
2006
Scale 4
95%-critical value
0.16
0.24
0.32

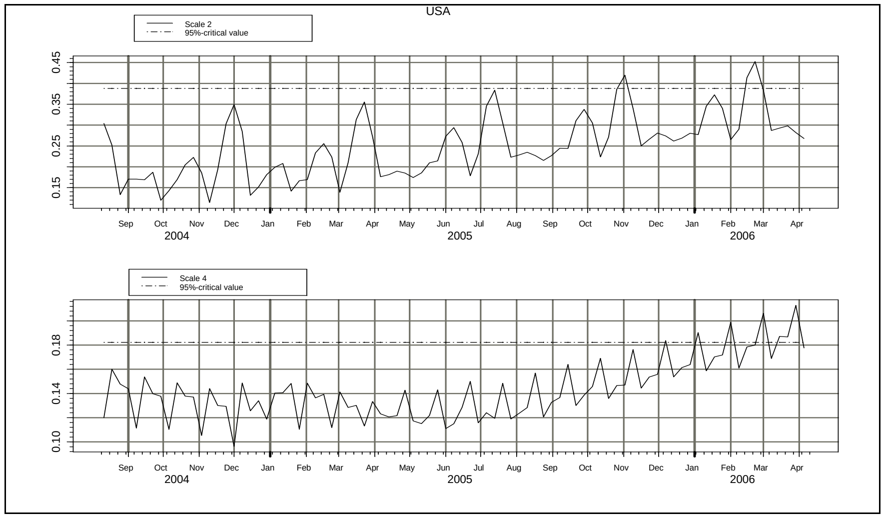
(g)


Phillipines
Scale 2
95%-critical value
0.65
0.50
0.30
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
2004
2005
2006
Scale 4
95%-critical value
0.28
0.20
0.12

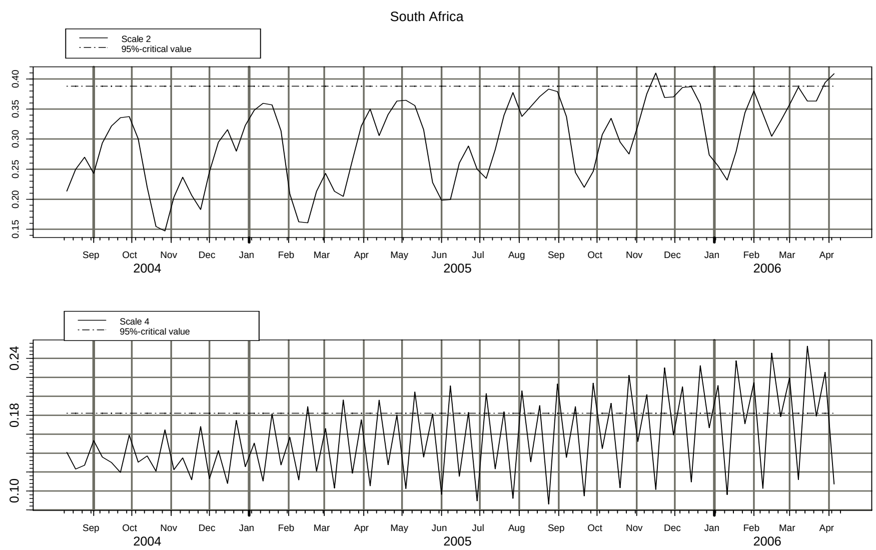
(h)


Singapore
Scale 2
95%-critical value
0.60
0.40
0.20
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
2004
2005
2006
Scale 4
95%-critical value
0.22
0.18
0.14
0.10

(i)


USA
Scale 2
95%-critical value
0.15
0.25
0.35
0.45
Scale 4
95%-critical value
0.10
0.14
0.18
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2004
2005
2006

(j)


South Africa
Scale 2
95%-critical value
0.15
0.20
0.25
0.30
0.35
0.40
Scale 4
95%-critical value
0.10
0.18
0.24
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2004
2005
2006

(k)

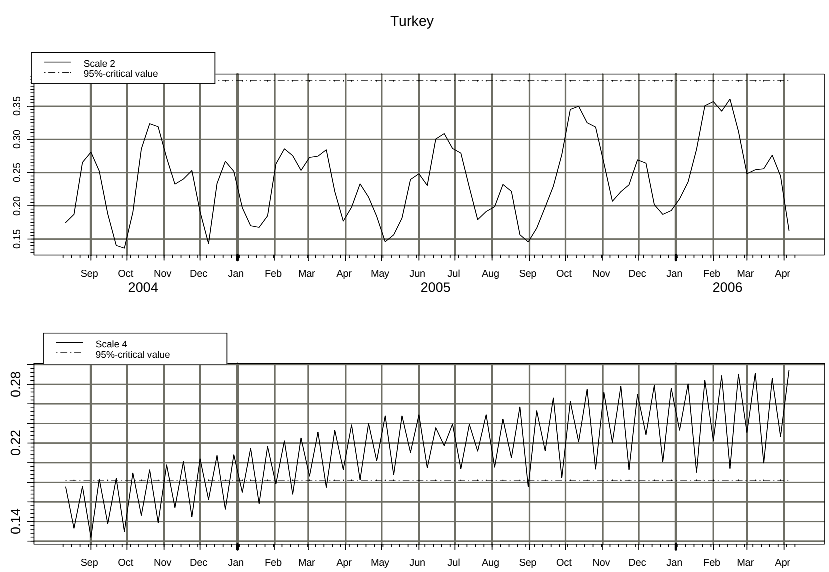
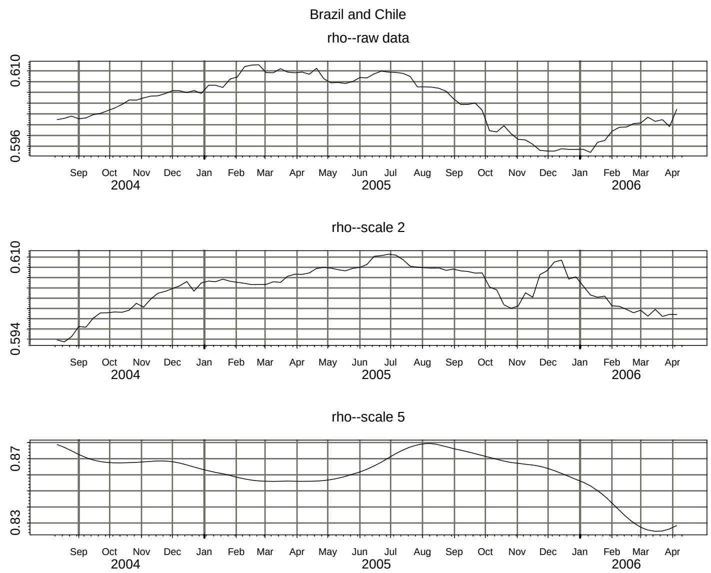
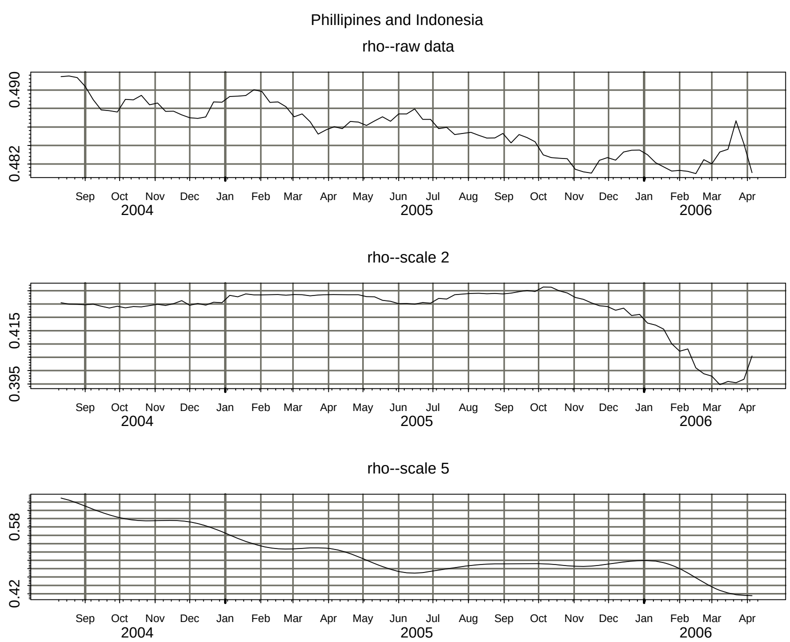

Turkey
Scale 2
95%-critical value
0.15
0.20
0.25
0.30
0.35
Scale 4
95%-critical value
0.14
0.22
0.28
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2004
2005
2006

Figure 2 Rolling wavelet-based estimates of pair-wise correlation

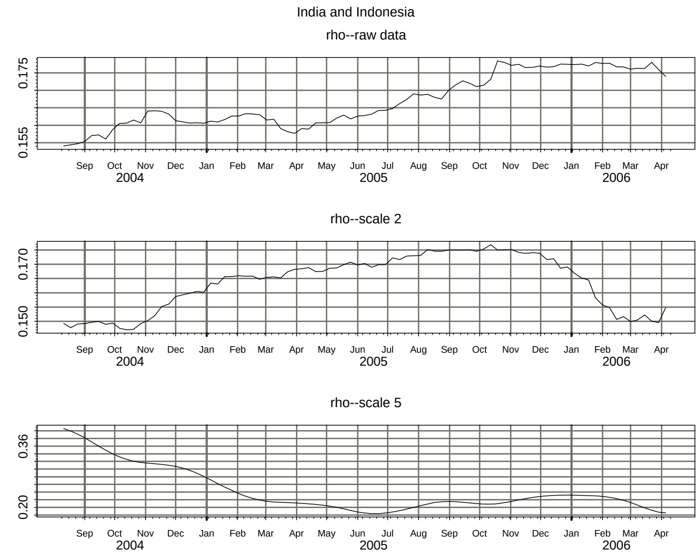
(a)



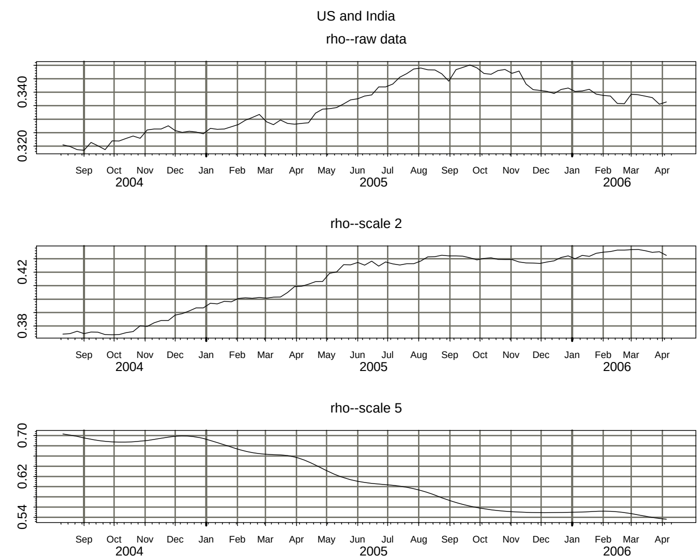
(b)



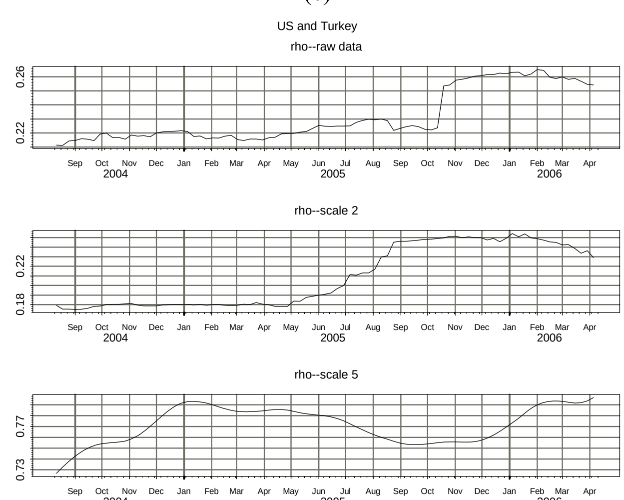
(c)


India and Indonesia
rho--raw data
0.155
0.175
rho--scale 2
0.150
0.170
rho--scale 5
0.20
0.36
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2004
2005
2006

(d)


US and India
rho--raw data
0.320
0.340
rho--scale 2
0.38
0.42
rho--scale 5
0.54
0.62
0.70
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2004
2005
2006

(e)


US and Turkey
rho--raw data
0.22
0.26
rho--scale 2
0.18
0.22
rho--scale 5
0.73
0.77
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2004
2005
2006

References

Aggarwal, R., C. Inclan, et al. (1999). "Volatility in Emerging Stock Markets." Journal of Financial and Quantitative Analysis **34**(1): 33-55.

Bacmann, J.-F. and M. Dubois (2002). Volatility in Emerging Stock Markets Revisited. EFMA Annual Conference

Banerjee, A. and G. Urga (2005). "Modelling Structural Breaks, Long Memory and Stock Market Volatility: An Overview." Journal of Econometrics **129**(1-2): 1-34.

Beck, T. (2006). Creating an efficient financial system : challenges in a global economy, The World Bank, Policy Research Working Paper Series: 3856.

Bekaert, G. and C. R. Harvey (2002). "Research in emerging markets finance: looking to the future." Emerging Markets Review **3**(4): 429-448.

Booth, G. G. and A. Yuksel (2006). "Price Resolution in an Emerging Market: Evidence from the Istanbul Stock Exchange." European Journal of Finance **12**(2): 137-52.

Bos, T., D. Ding, et al. (1998). "Searching for periods of volatility: A study of the behavior of volatility in Thai stocks." Pacific-Basin Finance Journal **6**(3-4): 295-306.

Corrado, C. and C. Truong (2007). "Forecasting stock index volatility: Comparing implied volatility and the intraday high-low price range." Journal of Financial Research **30**(2): 201-215.

Covarrubias, G., B. T. Ewing, et al. (2006). "Modeling volatility changes in the 10-year Treasury." Physica A: Statistical Mechanics and its Applications **In Press, Corrected Proof**.

De Jong, F. and F. A. De Roon (2005). "Time-Varying Market Integration and Expected Returns in Emerging Markets." Journal of Financial Economics **78**(3): 583-613.

Ewing, B. T. and F. Malik (2005). "Re-examining the asymmetric predictability of conditional variances: The role of sudden changes in variance." Journal of Banking & Finance **29**(10): 2655-2673.

Fernandez, V. (2006). "The impact of major global events on volatility shifts: Evidence from the Asian crisis and 9/11." Economic Systems **30**(1): 79-97.

Hammoudeh, S. and H. Li (2006). "Sudden changes in volatility in emerging markets: The case of Gulf Arab stock markets." International Review of Financial Analysis **In Press, Corrected Proof**.

Inclan, C. and G. C. Tiao (1994). "Use of Cumulative Sums of Squares for Retrospective Detection of Changes of Variance." Journal of the American Statistical Association **89**(427): 913-923.

Lamoureux, C. G. and W. D. Lastrapes (1990). "Persistence in Variance, Structural Change, and the GARCH Model." Journal of Business and Economic Statistics **8**(2): 225-234.

Liu, M. (2000). "Modeling Long Memory in Stock Market Volatility." Journal of Econometrics **99**(1): 139-71.

Parkinson, M. (1980). "The extreme value method for estimating the variance of the rate of return." Journal of Business **53**(1): 61-65.

Rogers, L. C. G. and S. E. Satchell (1991). "Estimating variance from high, low and closing prices." Annals of Applied Probability **1**(4): 504-512.

Shu, J. and J. E. Zhang (2006). "Testing range estimators of historical volatility." Journal of Futures Markets **26**(3): 297-313.

So, M. K. P. (2000). "Long-Term Memory in Stock Market Volatility." Applied Financial Economics **10**(5): 519-24.

Yang, D. and Q. Zhang (2000). "Drift-independent volatility estimation based on high, low, open, and close prices." Journal of Business **73**(3): 477-491.

Centro de Economía Aplicada
Departamento de Ingeniería Industrial
Universidad de Chile

2008

251. Emerging Markets Variance Shocks: Local or International in Origin?
Viviana Fernández y Brian M. Lucey

250. Economic performance, creditor protection and labor inflexibility
Ronald Fischer

249. Loyalty inducing programs and competition with homogeneous goods
N. Figueroa, R. Fischer y S. Infante

248. Local social capital and geographical mobility. A theory
Quentin David, Alexandre Janiak y Etienne Wasmer

247. On the planner's loss due to lack of information in bayesian mechanism design
José R. Correa y Nicolás Figueroa

246. Política comercial estratégica en el mercado aéreo chileno
Ronald Fischer

245. A large firm model of the labor market with entry, exit and search frictions
Alexandre Janiak

244. Optimal resource extraction contracts under threat of expropriation
Eduardo Engel y Ronald Fischer

2007

243. The behavior of stock returns in the Asia-Pacific mining industry following the Iraq war
Viviana Fernandez

242. Multi-period hedge ratios for a multi-asset portfolio when accounting for returns comovement
Viviana Fernández

241. Competition with asymmetric switching costs
S. Infante, N. Figueroa y R. Fischer

240. A Note on the Comparative Statics of Optimal Procurement Auctions
Gonzalo Cisternas y Nicolás Figueroa

239. Parental choice and school markets: The impact of information approximating school effectiveness
Alejandra Mizala y Miguel Urquiola

238. Marginal Cost Pricing in Hydro-Thermal Power Industries: Is a Capacity Charge Always Needed?
M. Soledad Arellano and Pablo Serra

237. What to put on the table
Nicolas Figueroa y Vasiliki Skreta

236. Estimating Discount Functions with Consumption Choices over the Lifecycle
David Laibson, Andrea Repetto y Jeremy Tobacman

235. La economía política de la reforma educacional en Chile
Alejandra Mizala

234. The Basic Public Finance of Public-Private Partnerships
Eduardo Engel, Ronald Fischer y Alexander Galetovic

233. Sustitución entre Telefonía Fija y Móvil en Chile
M. Soledad Arellano y José Miguel Benavente

232. Note on Optimal Auctions
Nicolás Figueroa y Vasiliki Skreta.

231. The Role of Outside Options in Auction Design
Nicolás Figueroa y Vasiliki Skreta.

230. Sequential Procurement Auctions and Their Effect on Investment Decisions
Gonzalo Cisternas y Nicolás Figueroa

2006

229. Forecasting crude oil and natural gas spot prices by classification methods
Viviana Fernández

228. Copula-based measures of dependence structure in assets returns
Viviana Fernández

227. Un Análisis Econométrico del Consumo Mundial de Celulosa
José Ignacio Sémbler, Patricio Meller y Joaquín Vial

226. The Old and the New Reform of Chile's Power Industry. (Por aparecer en el International Journal of Global Energy Issues (forthcoming 2007)).
M. Soledad Arellano

225. Socioeconomic status or noise? Tradeoffs in the generation of school quality information. (Por aparecer en el Journal of Development Economics).
Alejandra Mizala, Pilar Romaguera y Miguel Urquiola.

224. Mergers and CEO power
Felipe Balmaceda

123. Task-Specific Training and Job Design.
Felipe Balmaceda

122. Performance of an economy with credit constraints, bankruptcy and labor inflexibility
Felipe Balmaceda y Ronald Fischer

121. Renegotiation without Holdup: Anticipating spending and infrastructure concessions
Eduardo Engel, Ronald Fischer y Alexander Galetovic

220. Using School Scholarships to Estimate the Effect of Government Subsidized Private Education on Academic Achievement in Chile
Priyanka Anand, Alejandra Mizala y Andrea Repetto

219. Portfolio management implications of volatility shifts: Evidence from simulated data
Viviana Fernandez y Brian M Lucey

218. Micro Efficiency and Aggregate Growth in Chile
Raphael Bergoeing y Andrea Repetto

2005

217. Asimetrías en la Respuesta de los Precios de la Gasolina en Chile
Felipe Balmaceda y Paula Soruco

216. Sunk Prices and Salesforce Competition
Alejandro Corvalán y Pablo Serra

215. Stock Markets Turmoil: Worldwide Effects of Middle East Conflicts
Viviana Fernández

214. The Competitive Role of the Transmission System in Price-regulated Power Industries
M. Soledad Arellano y Pablo Serra

213. La Productividad Científica de Economía y Administración en Chile. Un Análisis Comparativo (Documento de Trabajo Nº 301. Instituto de Economía, Pontificia Universidad Católica de Chile)
Claudia Contreras, Gonzalo Edwards y Alejandra Mizala

212. Urban Air Quality and Human Health in Latin America and the Caribbean
Luis A. Cifuentes, Alan J. Krupnick, Raúl O'Ryan y Michael A. Toman

211. A Cge Model for Environmental and Trade Policy Analysis in Chile: Case Study for Fuel Tax Increases
Raúl O'Ryan, Carlos J. de Miguel y Sebastian Millar

210. El Mercado Laboral en Chile Nuevos Temas y Desafíos
Jaime Gatica y Pilar Romaguera

209. Privatizing Highways in The United States
Eduardo Engel, Ronald Fischer y Alexander Galetovic

208. Market Power in Price-Regulated Power Industries
M. Soledad Arellano y Pablo Serra

207. Market Reforms and Efficiency Gains in Chile
Raphael Bergoeing, Andrés Hernando y Andrea Repetto

206. The Effects on Firm Borrowing Costs of Bank M&As
Fabián Duarte, Andrea Repetto y Rodrigo O. Valdés

205. Cooperation and Network Formation
Felipe Balmaceda

204. Patrones de Desarrollo Urbano: ¿Es Santiago Anómalo?
Raphael Bergoeing y Facundo Piguillem

203. The International CAPM and a Wavelet-based Decomposition of Value at Risk
Viviana Fernández

202. Do Regional Integration Agreements Increase Business-Cycle Convergence? Evidence from Apec and Nafta
Viviana Fernández y Ali M. Kutan

* Para ver listado de números anteriores ir a http://www.cea-uchile.cl/.