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FINANCIAL LIBERALISATION AND BREAKS IN STOCK MARKET VOLATILITY

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Financial Liberalisation and Breaks in Stock Market Volatility*

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Abstract

This paper proposes a new statistical procedure which aims at providing robust estimates of volatility around official liberalisation dates, by using data driven techniques to identify the number and timing of structural breaks in the variance dynamics of stock market returns. The paper illustrates the usefulness of the procedure by providing an empirical application that focuses on five East Asian emerging markets, all of which liberalised their financial markets in the late 1980s or early 1990s, namely (South) Korea, Malaysia, Philippines, Taiwan and Thailand. It is shown that (i) the detected breakdates in the volatility of stock market returns do not correspond to official liberalisation dates and (ii) the use of official liberalisation dates as breakdates is likely to result in inaccurate inference. By using data driven techniques to detect multiple structural changes a richer -and inevitably more accurate - pattern of volatility dynamics emerges in comparison to focussing on official liberalisation dates.

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1. Introduction

The effects of financial liberalisation on stock market volatility, which are of interest to policy makers worldwide, have been the subject of controversy ever since emerging market economies began liberalising their financial markets in the 1980s and early 1990s.[1] Following Keynes[2], several authors have proposed that financial liberalisation could attract speculators and investors with short-term horizons, resulting in asset price bubbles and financial instability (e.g. Allen and Gale, 2000; Arestis and Demetriades, 1997, 1999; Singh, 1997, 2003). Stock market volatility could, however, decline following financial liberalisation if the number of traders increases (see Tauchen and Pitt, 1983). Empirical evidence on the subject is mixed, depending on the countries and periods that are studied, with recent studies showing that the outcome may depend on market characteristics, such as transparency and investor protection (e.g. Jayasuriya, 2005).

Previous empirical studies on the effects of financial liberalisation on stock market volatility implicitly assume that (i) there is a single break in the properties of the stock market returns; (ii) the timing of the break (breakdate) is known and coincides with the official stock market liberalisation date (or in some instances the announcement date). However, these assumptions are unlikely to be realistic for a number of reasons. With respect to (i), it is likely that there may be more than one break, which may or may not be directly due to stock market liberalisation. This could be because *financial liberalisation* is a broader concept than *stock market liberalisation*, in that it also includes other important areas of the financial system, such as the deregulation of banking activities, the lifting of interest rate controls, the removal of directed credit programmes, all of which have been widespread in emerging market economies.[3] It may also be due to changes in the political or institutional environment, which may impact on investor behaviour. With respect to

[1] While the effects of financial liberalisation on stock market volatility are debatable, the view that increased volatility is undesirable is less controversial. Increased volatility is associated with higher capital costs and, consequently, lower investment; the latter may also decline because the 'option to wait' increases (Bekaert and Harvey, 1997). Empirical evidence provides some credence to this view. See, for example, Arestis *et al* (2001) who show that stock market volatility has negative effects on long run economic growth using quarterly data from five developed economies.

[2] Keynes (1964) regards liquidity as having destabilising effect on the market because of the assumption of market imperfection, particularly in relation to the availability of information to all participants.

[3] The typical sequencing of financial reforms in these economies usually starts from the lifting of interest rate controls and other banking restraints (see, for example, Arestis and Demetriades, 1999). This may well result in breaks in stock market volatility since the shares of banks frequently represent a large fraction of stock market capitalisation.

(ii), the breakdate in the data may or may not coincide with official liberalisation dates because financial market participants may adjust their behaviour well before or even after the official liberalisation dates, depending, for example, on the timing and credibility of announcements. For these reasons, the estimates of volatility changes due to financial liberalisation obtained by previous studies are likely to be biased or inefficient.[4] One of the purposes of this paper is to demonstrate that this is indeed the case using East Asian emerging markets as an example.

The main purpose of the paper is to propose a statistical procedure which aims at providing more robust estimates of volatility around official liberalisation dates than those available in the literature by identifying the number and timing of structural breaks that occur.[5] The procedure starts by utilising a number of CUSUM-type non-parametric tests to detect potential breaks in the unconditional variance of the returns process. Once the potential breaks have been identified, robustness tests are carried out using a set of more powerful tests to verify that the unconditional variance of each regime is statistically different. The last step is to measure volatility in each regime by using different estimators of volatility.

We illustrate the usefulness of the procedure by proving an empirical application that focuses on five East Asian emerging markets, all of which liberalised their financial markets in the late 1980s or early 1990s, namely (South) Korea, Malaysia, Philippines, Taiwan and Thailand. These countries have been extensively studied in the broader literature on financial development, not least because of their importance to the world economy and the availability of reliable data.[6] They can therefore provide an excellent platform from which to highlight the importance of correctly identifying the number and timing of structural breaks.

The paper is organised as follows. Section 2 outlines the statistical procedure for obtaining robust estimates of stock market volatility when multiple breaks may be present. Section 3 describes the data and data sources and provides the official financial liberalisation dates in each of the five East Asian countries studied, drawing on relevant literature. Section 4 presents the findings of the empirical application while Section 5 summarises and concludes.

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[4] It is an established fact that not taking into account structural breaks in the estimation of GARCH-type models may result in over-estimating volatility persistence (Lamoureux and Lastrapes, 1990).

[5] Because we use three different estimators of volatility which are valid under different sets of assumptions, we prefer not to refer to these estimators as 'unbiased', even though at least one of these is likely to be depending on the true underlying data generating process, which is of course unknown.

[6] See, for example, Demetriades and Luintel (2001) and Demetriades, Devereux and Luintel (1998).

2. Obtaining Robust Volatility Estimates

This section outlines a statistical procedure which aims at providing more robust estimates of volatility around official liberalisation dates. Section 2.1 describes the first step of the procedure, which is to identify the number and timing of all the potential breaks. Section 2.2 refers to the second step of the procedure, which is to verify the existence of each break using a battery of robustness tests. Finally, Section 2.3 contains the third step of the procedure, which is to measure volatility in each of the segments that have been defined in the previous steps.

2.1. The number and timing of breaks

The techniques that are employed to detect the number and identify the timing of structural breaks draw on the literature that aims at detecting a single break in the volatility dynamics. Specifically, we use the following tests.

(1) I&T (Inclan and Tiao, 1994)
(2) SAC_1 (The first test of Sansó, Aragó, and Carrion, 2003)
(3) SAC_2^{BT} (The second test of Sansó, Aragó, and Carrion, 2003, which uses the Bartlett kernel)
(4) SAC_2^{QS} (The second test of Sansó, Aragó, and Carrion, 2003, which uses the Quadratic Spectral kernel)
(5) K&L (Kokoszka and Leipus, 2000).

Karoglou (2006b) shows that the relative performance of each of the above tests depends on the underlying data generating process (DGP). For example, the I&T is found to be the most sensitive to the existence of volatility breaks for independent and identically distributed data but suffers severe size distortions for strongly dependent data. In contrast, the K&L and the SAC_2 variants do not exhibit size distortions but their power is smaller, while the performance of SAC_1 lies somewhere in between.[7] As a result, when the DGP is not known, it is preferable to

[7] Sansó, Aragó, and Carrion, (2003) derive some theoretical results on the properties of I&T, SAC_1, and SAC_2 for data generating processes with different kurtosis while Andreou and Ghyssels (2002) provide some simulation evidence for I&T and K&L.

use all of the tests and to select the breakdate based on an appropriate rule, depending on the specific objective of the exercise.

The above tests can also be used to identify multiple breaks in a series. However, in this case it would be necessary to incorporate these tests in an iterative scheme (algorithm) and to apply them to sub-samples of the series, defined by the detected breakpoints. Inclan and Tiao (1994) propose a version of such an algorithm, which they name Iterative Cumulative Sums of Squares (ICSS). However, Karoglou (2006a) shows that ICSS may not be robust to the presence of transitional periods between volatility regimes. Such periods are likely to exist when the response of market participants to new information is a gradual one, which may be particularly relevant in emerging market economies. For this reason, this paper employs an algorithm that is more robust to the existence of transitional periods introduced by Karoglou (2006a). When there are no transitional periods, Karoglou's algorithm produces identical results as ICSS, assuming the underlying tests detect the true breakdate. This algorithm involves the following six steps:

1. Calculate the test statistic under consideration.

2. If the statistic is above the critical value split the particular data segment into two parts at the corresponding point.

3. Repeat steps 1 and 2 for the first segment until no more (earlier) change-points are found.

4. Mark this point as an estimated change-point of the whole series.

5. Remove the observations that precede this point (i.e. those that constitute the first segment).

6. Consider the remaining observations as the new sample and repeat steps 1 to 5 until no more change-points are found.

The above algorithm is implemented with each of the (single breakdate CUSUM-type) test statistics described above, i.e. I&T, SAC_1, SAC_2^{BT}, SAC_2^{QS}, K&L.

2.2. Robustness Tests

After detecting the potential breakdates and corresponding volatility regimes using the Karoglou algorithm, we use a battery of robustness tests in order to confirm

that neighbouring regimes have different variances. These robustness tests involve a different approach to the CUSUM-type tests in that they test for the homogeneity of variances of distinct samples (in our case these samples are two successive regimes) without considering the time-series dimension of the data. In this paper we use (1) the standard F-test, (2) the Siegel-Tukey test with continuity correction (Siegel and Tukey, 1960, and Sheskin, 1997), (3) the adjusted Bartlett test (see Sokal and Rohlf, 1995, and Judge, et al., 1985), and (4) the Levene test (1960).[8]

The F-test requires equal sample sizes and is sensitive to departures from normality. This is not the case for the Siegel-Tukey test, which however assumes that the samples are independent and have equal median. The Bartlett test is also robust when the sample sizes are not equal, however it is still sensitive to departures from normality. Its adjusted version considers a correction factor for the critical values and the arcsine-square root transformation of the data in order to conform with the normality assumption. The Levene test is an alternative to the Bartlett test and is less sensitive than the Bartlett test to departures from normality.

2.3. Volatility Estimators

The magnitude and direction of the change in volatility is proxied by the unconditional variance in each regime, utilising three alternative estimators: (i) the sample standard deviation; (ii) the square root of a Heteroskedasticity and Autocorrelation Consistent (HAC) estimator of the variance –there are a lot of options to choose from but in this paper we use the VARHAC estimator of den Haan, 1997 that bypasses the problem of selecting an appropriate bandwidth; (iii) the square root of the unconditional variance of the best fitting GARCH specification and calculating the unconditional variance that it suggests.[9] This allows us to examine the evolution of volatility throughout the sample period.

3. East Asian Data and Liberalisation Dates

It is widely accepted that the conditional mean of the returns exhibits little predictability from the past (Bekaert and Harvey, 1997). However, we also consider

[8] These tests are calculated in Eviews.

[9] We define the 'best fitting GARCH' as the GARCH with the largest log-likelihood and with statistically significant coefficients (at the 5% level). Information criteria are not used mainly because of their limited ability to identify the true structure of GARCH-type processes (Mitchell and McKenzie, 2003).

the possibility of moving average error terms induced by calendar effects. We therefore follow the procedure suggested by Pagan and Schwert (1990) to remove potential day-of-the-week effects.

The data used in this paper are the continuously compounded daily stock returns obtained by the daily closing stock price indexes, expressed in the local currency[10] of: (i) Korea Stock Price Index; (ii) Taiwan Weighted Stock Index; (iii) Kuala Lumpur Composite Index; (iv) Stock Exchange of Thailand Index and (v) the Philippines Stock Exchange Composite Index. The sample period spans four years before and after official financial liberalisation dates. The data is obtained from *Datastream*.

Financial Liberalisation Dates of East Asian Emerging Markets

The selection of the official liberalisation dates for five Asian emerging markets draws on the following papers: Santis and Imrohoroglu (1997), Henry (2000), Kim and Singal (2000), Bekaert and Harvey (2000), Fuchs-Schundeln and Funke (2001), Kassimatis (2002) and Bhattacharya and Daouk (2002). Table 1 summarises the liberalisation dates used in each of these papers and lists those that we adopt in the rest of this paper, namely the ones that most papers agree on. These are as follows: January 1992 for South Korea, January 1991 for Taiwan, December 1988 for Malaysia, September 1987 for Thailand and June 1991 for the Philippines.

Table 1: Official Financial Liberalisation Dates in East Asia

Source / **Country**	*Santis and Imrohoroglu (1997)*	*Henry (2000)*	*Kim and Singal (2000)*	*Bekaert and Harvey (2000)*
Korea	Jan-92	Jun-87	Jan-92	Jan-92
Malaysia	Dec-88	May-87	Dec-88	Dec-88
Philippines	Oct-89	May-86	Jul-86	Jun-91
Taiwan	Jan-91	May-86	Jan-91	Jan-91
Thailand	Dec-88	Jan-88	Aug-88	Sep-87
Work of / **Country**	*Fuchs-Schundeln and Funke (2001)*	*Kassimatis (2002)*	*Bhattacharya and Daouk (2002)*	***ADOPTED***
Korea	Jan-92	Jan-92	Jan-92	***Jan-92***
Malaysia	Dec-88	NA	Dec-88	***Dec-88***
Philippines	Jun-91	Nov-91	Jun-91	***Jun-91***
Taiwan	Jan-91	Jan-91	Jan-91	***Jan-91***
Thailand	Sep-87	NA	Sep-87	***Sep-87***

Table 2 presents some descriptive statistics for the stock returns in these markets for the full sample and the two sub-sample periods defined by the official

[10] US dollar indexes are not employed in order to avoid introducing exchange rate volatility effects.

liberalisation dates. Based on this preliminary description of the data, it appears that (i) the mean of stock returns increased in the cases of Korea, Malaysia and the Philippines following financial liberalisation while it decreased in the cases of Taiwan and Thailand; (ii) the stock return volatility (as measured by the standard deviation) appears to have declined after liberalisation in four of the five countries, the exception being Thailand, where it appears to have increased considerably.

Table 2: Descriptive Statistics of Stock Returns

		Period	Mean	St. Deviation	Skewness	Kurtosis	Observations
Korea	*Full Sample*	(Jan 88 – Dec 95)	0.0108	0.5969	0.2929	2.9882	2086
	Pre-Lib	(Jan 88 – Dec 91)	0.0063	0.6231	0.1928	3.0126	1043
	Post-Lib	(Jan 92 – Dec 95)	0.0153	0.5694	0.4275	2.8626	1043
Malaysia	*Full Sample*	(Dec 84 – Nov 92)	0.0158	0.6326	-2.0698	24.6773	2086
	Pre-Lib	(Dec 84 – Nov 88)	0.0062	0.7442	-2.1061	21.6072	1043
	Post-Lib	(Dec 88 – Nov 92)	0.0254	0.4967	-1.4075	18.6465	1043
Philippines	*Full Sample*	(Jun 87 – May 95)	0.0314	0.8577	-0.1761	10.5878	2088
	Pre-Lib	(Jun 87 – May 91)	0.027	1.0506	-0.2043	8.5135	1045
	Post-Lib	(Jun 91 – May 95)	0.0357	0.6064	0.1088	2.2532	1043
Taiwan	*Full Sample*	(Jan 87 – Dec 94)	0.04	1.04	-0.0905	1.8429	2087
	Pre-Lib	(Jan 87 – Dec 90)	0.0613	1.2187	-0.1363	0.9397	1043
	Post-Lib	(Jan 91 – Dec 94)	0.0187	0.8237	-0.0161	2.8274	1044
Thailand	*Full Sample*	(Sept 83 – Aug 91)	0.0329	0.6073	-0.8298	11.5289	2087
	Pre-Lib	(Sept 83 – Aug 87)	0.0371	0.2689	0.1676	8.1141	1043
	Post-Lib	(Sept 87 – Aug 91)	0.0287	0.8157	-0.6779	5.8025	1044

4. Empirical Application

4.1. The number and timing of breaks

Table 3 reports the results of applying the Karoglou (2006a) algorithm outlined in Section 2, utilising the five non-parametric tests also described in the same section. Not all the breakdates suggested by the algorithm are adopted because some of the tests may exaggerate the number of breakdates if there is volatility persistence or the innovation term is not Gaussian (SAC, 2002, Karoglou 2006).[11] The adopted breakdates satisfy the following two conditions (Rule A):

i) Segment size: The two derived segments (before and after the breakdate) contain at least 50 observations each.

ii) Significance: Two or more statistics indicate the existence of the break at the 5% level

We also adopt the following subsidiary rule (Rule B) in cases where no breakdate has been detected in the pre or post liberalisation period by Rule A:

[11] The I&T test for example has been found to diverge in such cases.

iii) Segment size: The two derived segments (before and after the breakdate) contain at least 50 observations each.

iv) Significance: One statistic indicates the existence of the break at the 1% level and it is the first (before) after the official liberalisation date suggested by this statistic.

Following Rule A, we adopt three breakdates in the case of Korea, 16 April 1990, 10 December 1992 and 1 March 1994. The first two are suggested by all five tests, with four of the statistics significant at the 1% level. The third breakdate is suggested by four tests, one of which at the 1% level.

Applying Rule A we adopt two breakdates in the case of Malaysia, 19 October 1987 and 19 January 1988. Both breakdates are suggested by four tests, of which three are significant at the 1% level. Rule B is applicable in the case of Malaysia because Rule A does not result in a breakdate being adopted after the official liberalisation date of 1 December 1988. This rule suggests a third breakdate of 26 August 1991, since the I&T test is significant at the 1% level and the derived segments contain more than 50 observations each.

In the case of the Phillipines, the application of Rule A results in four breakdates being adopted, 20 December 1987, 25 September 1991, 4 October 1993 and 6 May 1994. The first one is suggested by four statistics at the 1% level, the second one by all five at the 1% level, the third and fourth also by five tests, albeit only three at the 1% level.

The application of Rule A in the case of Taiwan results in three breakdates being adopted, 2 April 1990, 12 March 1991, and 29 October 1991. The first two are suggested by all five tests at the 1% level. The third is also suggested by all five tests, albeit only three at the 1% level.

Finally, the application of Rule A to the case of Thailand results in three breakdates being adopted, 28 August 1986, 1 August 1990 and 27 February 1991. The first two are suggested by all five tests at the 1% level, while the third is also suggested by all five tests, of which four at the 1% level. Three of the tests detect a fourth breakdate that is, however, not adopted because the resulting segment contains only 43 observations, hence condition (i) is not satisfied.

Table 3: Detected Structural Changes

	datapoint	I&T	SAC_1	SAC_2^{BT}	SAC_2^{QS}	K&L	adopted
korea	597	√	√	√*	√	√	yes (16-04-90)
	1291	√	√	√*	√	√	yes (10-12-92)
	1607	√	√*	-	√*	√*	yes (01-03-94)
	1828	√*	-	-	-	-	no
	1873	√*	-	-	-	-	no
malaysia	751	√	√	-	√	√*	yes (19-10-87)
	818	√	√	-	√	√*	yes (19-01-88)
	1756	√	-	-	-	-	yes (26-08-91)
	1818	√*	-	-	-	-	no
phillipines	110	√	-	-	-	-	no
	149	-	√	√	√	√	yes (20-12-87)
	1128	√	√	√	√	√	yes (25-09-91)
	1656	√	√	√*	√	√*	yes (04-10-93)
	1810	√	√	√*	√	√*	yes (06-05-94)
	1952	√	-	-	-	-	no
	2037	√*	-	-	-	-	no
taiwan	848	√	√	√	√	√	yes (02-04-90)
	1094	√	√	√	√	√	yes (12-03-91)
	1259	√	√	√*	√	√*	yes (29-10-91)
	1558	√	-	-	-	-	no
	1647	√	-	-	-	-	no
	1803	√	-	-	-	-	no
	1875	√	-	-	-	-	no
	2025	√	-	-	-	-	no
	2046	√	-	-	-	-	no
thailand	781	√	√	√	√	√	yes (28-08-86)
	1805	√	√	√	√	√	yes (01-08-90)
	1955	√	√	√*	√	√	yes (27-02-91)
	2044	√	√	-	√	-	no

Note: √ denotes statistical significance at 1% level, √* at 5% level, and - no statistical significance.

4.2. Robustness Tests

Table 4 reports the results of carrying out the robustness tests outlined in Section 2. The same table also reports the results of applying the robustness tests to the segments defined by the official liberalisation dates. These tests confirm that the neighbouring segments resulting from the adopted breakdates have different variances, with the differences being significant at the 1% level. The same tests also suggest that with the exception of Korea the variances in the pre and post liberalisation periods are statistically different at the 1% level. In the case of Korea three of the tests suggest no variance change after the official liberalisation date. Thus, by focussing on the official liberalisation date, one may fail to detect the regime switches that have taken place before and after this date.

Table 4: Robustness Tests

		F-statistic	Siegel-Tukey	Bartlett	Levene	change in variance
korea	before & after liberalisation	1.19†	0.41†	7.69	0.95†	no
	Regime 1 & 2	2.21	4.94	96.03	38.85	yes
	Regime 2 & 3	1.93	2.56	42.94	15.02	yes
	Regime 3 & 4	1.50	2.58	15.92	10.70	yes
malaysia	before & after liberalisation	2.21	8.60	159.66	48.42	yes
	Regime 1 & 2	10.21	4.89	296.10	114.05	yes
	Regime 2 & 3	13.38	6.96	420.20	166.18	yes
	Regime 3 & 4	2.41	4.60	52.77	37.38	yes
phillipines	before & after liberalisation	3.02	5.97	303.13	68.56	yes
	Regime 1 & 2	6.75	8.61	344.44	176.72	yes
	Regime 2 & 3	2.27	5.50	103.82	42.33	yes
	Regime 3 & 4	2.41	4.60	52.77	37.38	yes
	Regime 4 & 5	2.13	3.15	29.69	18.67	yes
taiwan	before & after liberalisation	2.13	10.61	145.00	114.14	yes
	Regime 1 & 2	3.69	10.67	195.62	201.98	yes
	Regime 2 & 3	3.45	7.27	65.98	66.59	yes
	Regime 3 & 4	2.06	4.86	41.89	32.13	yes
thailand	before & after liberalisation	9.09	16.44	1072.55	265.60	yes
	Regime 1 & 2	9.51	16.13	873.02	224.07	yes
	Regime 2 & 3	5.55	8.31	278.93	170.04	yes
	Regime 3 & 4	4.11	4.53	62.88	30.82	yes

Note: † denotes statistical insignificance (i.e. not significant at 5% level). In all other cases, the statistical significance is found below 1% level.

4.3. Volatility Estimates

For each country we present the results using two figures, which report and illustrate the three alternative measures of volatility in (i) the pre and post liberalisation periods and (ii) each of the identified regimes. In addition we also plot the stock returns in a separate figure, alongside one of the volatility estimates, to illustrate the evolution of stock returns in each regime.[12]

{Figure 1}

Figure 1 shows that the estimated measures of volatility before and after the official liberalisation date of 1 January 1992 have declined slightly. The GARCH-

[12] In this type of figure we include just one of the volatility estimates, for clarity of exposition. It turns out that the three estimates are similar, so that the choice of estimator does not matter.

derived estimate shows a decline of 9.8%, the standard deviation a decline of 8.3% and the VARHAC estimate shows a marginal decline of 0.3%.[13]

{Figure 2}

In contrast, Figure 2 illustrates a much richer evolution of volatility in the pre and post liberalisation periods. The volatility measures in the first segment, which covers the period 1 January 1988 – 15 April 1990, was, in fact considerably lower than suggested by Figure 1. In the second segment, which covers a twenty month period before the official liberalisation data and an eleven month period after the official liberalisation date, volatility increased substantially: the GARCH measure shows an increase of 51.6%, the standard deviation an increase of 48.7% and the VARHAC an increase of 33.3%. The third segment, however, which starts almost a year after the official liberalisation date is one of decreasing volatility, with the three measures decreasing by 29.5%, 28% and 20% respectively. Finally, the fourth segment which starts twenty six months after the liberalisation date exhibits a further decline in volatility of 18.5% in both the first two measures and 18.0% in the third. As a result, a comparison of the first and fourth segment shows that volatility has declined by around 12.7% (12.9%, 12.7% and 12.5%, respectively). Figure 3 illustrates the evolution of volatility through time, alongside the stock returns.

{Figure 3}

A plausible interpretation of the Korean results is as follows. The first regime is likely to correspond to the period before any news regarding stock market liberalisation had reached the market. The second regime may correspond to the period in which information about liberalisation reached market participants, creating uncertainty. It is interesting, however, that the second regime continues well after the official liberalisation date. Even in the third regime, which begins eleven months after the liberalisation date, uncertainty appears to be higher than in the first regime. It takes more than two years after the official liberalisation date before uncertainty is reduced to pre-liberalisation levels. Thus, focusing on the regimes that are based on the official liberalisation dates completely masks this rich volatility pattern.[14]

[13] Note, however, that the tests reported in Table 4 suggest that these changes may not be statistically significant in this particular case.

[14] It may also be argued that the four regimes found for Korea using data driven techniques correspond to different *financial* as opposed to *stock market* liberalisation periods. The financial liberalisation indices constructed by Abiad and Mody (2005), which take on board credit controls, interest rate controls, entry barriers, regulations and

A similar conclusion, if more pronounced, emerges by analysing the results for Malaysia that are presented in Figures 4-6. Figure 4 suggests that liberalisation led to a decline in volatility of between 28.4% and 40.3%, depending on which measure is used. Figure 5, on the other hand, reveals a much more striking evolution of volatility. Volatility increases very substantially, for a period of three months, about a year before the official liberalisation date. The standard deviation suggests an increase in volatility of 219.7% while VARHAC shows an increase of 128.1% and GARCH a smaller increase of 53.1%, which is nevertheless also rather large. About a year before the liberalisation date of 1 December 1988 volatility declines quite substantially and remains low for a period of three and a half years: the GARCH measure shows a decline of 45.1%, the standard deviation a decline of 72.6% and the VARHAC a decrease of 61.8%. A further decline in volatility, in the range of 35-40% depending on the measure used, occurs in the fourth regime, which starts approximately two years and nine months after the official liberalisation date. As a result, volatility exhibits a decline in the range of 45.3-47.5%, depending on measure used, when the first and the last (fourth) regimes are compared.

The Philippines exhibits an even richer evolution of volatility, given that there are five different regimes. Figure 7 shows a decline in volatility in the post liberalisation period that ranges from 34.9% in the case of the GARCH measure to 42.5% for the standard deviation. This masks a much more considerable drop in volatility when one compares the first regime with the last (fifth) one, which ranges between 69.2% and 73.4% depending on the measure used. In between the first and fifth regimes there are two consecutive periods of declining volatility, followed by a period of increasing volatility, ending with a period of declining volatility. The official liberalisation date falls three months before the end of the second regime. The period of increased volatility, which lasts for about seven months, occurs more than two years after the official liberalisation date.

The case of Taiwan is very similar to that of Malaysia and to some extent, Korea. The pre-liberalisation period includes a regime of substantially increased volatility which starts about nine months before the official liberalisation date and ends three months after. The increase in volatility ranges from 35.3% in the case of the GARCH measure to 51.4% for the standard deviation. This period is then

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privatization, as well as controls on international transactions, would however suggest only three different regimes for Korea: 19986-88, 1989-90, and 1991-96.

followed by two regimes of declining volatility, lasting about seven months and more than three years, respectively. The decline in volatility between the first and fourth regimes ranges from 43.3% to 51.6% depending on which measure is used. Comparing the pre and post liberalisation periods shows a decline in volatility in the range of 31.4% to 42.8%, which masks all the aforementioned changes.

Thailand presents a sharp contrast to the other countries in that the results suggest an increase in volatility, following the financial liberalisation of 1 September 1987. The comparison of the pre and post liberalisation periods in Figure 13 shows an increase of 201.5% for the standard deviation and 140.8% for the VARHAC measure. The GARCH measure indicates a change to an infinite unconditional variance, which further illustrates the limitations of artificially imposing a single breakdate in the sample period. The measures in Figure 14 show that volatility more than trebled about a year before the official liberalisation date. This regime continues for almost three years after the liberalisation date. Moreover, it is followed by a seven-month period where volatility increases by 91.8%-135.4%, depending on the measure used. In the final period, which lasts about six months, volatility declines by about 50%, but this is not sufficient to bring it back to its pre-liberalisation level. In fact, comparison of the first and last regimes suggests that volatility increased by 189.1%-257.6%, depending on the measure employed. Once again, a before and after comparison masks several important volatility swings.

5. Conclusions

This paper highlights the importance of correctly identifying the number and timing of structural breaks when analysing changes in stock market volatility that may be directly or indirectly related to financial liberalisation. The volatility dynamics that emerge when breakdates are carefully extracted from the data are much richer than those suggested by studying the pre and post stock market liberalisation periods. In three of the five countries analysed - Korea, Malaysia and Taiwan – volatility increases before the official liberalisation date and subsequently declines below its original level. Focussing only on the pre and post stock market liberalisation period altogether fails to detect a period of increased volatility, which in the case of Korea

exceeds two years. In the case of the Philippines, analysing the pre and post liberalisation periods, masks an initial marked decline in volatility and fails to pick up a period of substantially increased volatility that occurs more than two years after the official liberalisation date. In the case of Thailand, focussing on the official liberalisation date fails to pick up a decline in volatility that occurs in the fourth (final) regime, which nevertheless is not sufficient to reduce volatility to its pre-liberalisation level. In all cases the analysis of pre and post liberalisation periods results in an 'averaging-out' of volatility patterns. Thus, important changes in volatility may not be detected, resulting in inaccurate inference, potentially misleading policy makers. Our findings would therefore suggest that the analysis of the effects of financial liberalisation on stock market uncertainty remains fertile ground for further research.

An area where further research would be fruitful would be to examine whether the different volatility regimes that we detect using data driven techniques correspond to - or are indeed caused by - broader financial reforms, which are not directly linked to the opening of stock markets to foreign investors, such as the relaxation of credit and interest rate controls, entry barriers in banking, financial sector privatisation etc. The financial liberalisation literature now provides indices of financial liberalisation, albeit at frequencies that do not match well with the frequency of stock market returns.[15] Such an exercise would therefore require some additional data work as well as novel econometric approaches to address the causality issue.

[15] See for example Abiad and Mody (2005), who provide such an index for 35 economies, on an annual basis for the period 1973-1996.

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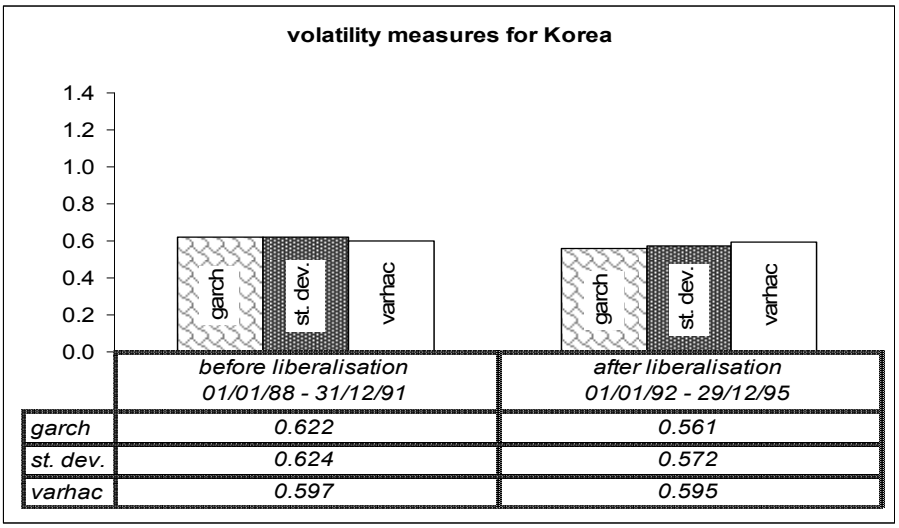
Appendix I – the GARCH models

The table that follows presents the GARCH model that best fits the data of each segment. Note that * denotes insignificance at 10% level; in its place the standard deviation is used.

		μ	ω	$(\varepsilon_{t-1})^2$	$(\varepsilon_{t-2})^2$	$(\sigma_{t-1})^2$	$(\sigma_{t-2})^2$	$(\sigma_{t-3})^2$
Korea	before liberalization	-	0.0263	0.2296	-0.1140	0.8165	-	-
		-	(0.0052)	(0.04)	(0.0435)	(0.0261)	-	-
	after liberalization	-	0.0093	0.0537	-	2.1200	-1.8877	0.6843
		-	(0.0025)	(0.0094)	-	(0.0738)	(0.1238)	(0.0655)
	segment 1	-	0.0776	0.1474	-	0.5569	-	-
		-	(0.0289)	(0.0431)	-	(0.1347)	-	-
	segment 2	-	0.0487	0.1811	-	0.7380	-	-
		-	(0.0109)	(0.0273)	-	(0.0305)	-	-
	segment 3	-	0.2975	0.0070	-	-	-	-
		-	(0.0220)	(0.0463)	-	-	-	-
	segment 4	-	0.1820	0.0844	-	-	-	-
		-	(0.0121)	-0.0508	-	-	-	-
Malaysia	before liberalization	-	0.0104	0.1649	-0.1147	0.9279	-	-
		-	(0.0021)	(0.0226)	(0.019)	(0.0107)	-	-
	after liberalization	-	0.0913	0.2758	-	0.3470	-	-
		-	(0.0094)	(0.0446)	-	(0.0705)	-	-
	segment 1	-	0.0149	0.0439	-	0.9172	-	-
		-	(0.0058)	(0.0128)	-	(0.0244)	-	-
	segment 2	-	0.2805	-	-	-0.1165	0.8029	-
		-	(0.0678)	-	-	(0.018)	(0.0297)	-
	segment 3	-	0.0878	0.2045	-	0.4695	-	-
		-	(0.0149)	(0.0377)	-	(0.0876)	-	-
	segment 4	-	0.0865	0.2413	-	-	-	-
		-	(0.0061)	(0.0716)	-	-	-	-
The Phillipines	before liberalization	-	0.0127	0.1546	-0.0883	0.9193	-	-
		-	(0.003)	(0.035)	(0.0359)	(0.0098)	-	-
	after liberalization	-	0.0090	0.0625	-	0.9133	-	-
		-	(0.0028)	(0.0125)	-	(0.0167)	-	-
	segment 1	-	2.6168	0.3842	-	-	-	-
		-	(0.2608)	(0.1102)	-	-	-	-
	segment 2	-	0.0285	0.0713	-	0.8806	-	-
		-	(0.007)	(0.0112)	-	(0.0201)	-	-
	segment 3	-	0.0244	0.1563	-	0.1821	0.5788	-
		-	(0.0101)	(0.0423)	-	(0.0829)	(0.0991)	-
	segment 4	-	0.6700*	-0.0437*	-	-	-	-
		-	(0.074)	(0.0646)	-	-	-	-
	segment 5	-	0.0075	-	-	1.9538	-0.9788	-
		-	(0.0025)	-	-	(0.0175)	(0.0175)	-
Taiwan	before liberalization	0.1301	0.0250	0.1190	-	0.8665	-	-
		(0.0278)	(0.0081)	(0.0235)	-	(0.0247)	-	-
	after liberalization	-	0.0152	0.0579	-	0.9156	-	-
		-	(0.0032)	(0.0083)	-	(0.0104)	-	-
	segment 1	0.1267	0.0220	0.1107	-	0.8777	-	-
		(0.0277)	(0.007)	(0.0208)	-	(0.0212)	-	-
	segment 2	-	0.0308	-0.0285	-	1.0196	-	-
		-	(0.0045)	(0.0017)	-	(0.0027)	-	-
	segment 3	-	0.0497	-0.0701	-	0.1443	0.8825	-
		-	(0.0117)	(0.029)	-	(0.0026)	(0.0247)	-
	segment 4	-	0.0120	0.0344	-	1.3999	-0.4589	-
		-	(0.0045)	(0.0125)	-	(0.2336)	(0.2145)	-
Thailand	before liberalization	-0.0174	0.0011	0.2546	-0.1260	0.8689	-	-
		(0.0049)	(0.0002)	(0.0405)	(0.0429)	(0.0136)	-	-
	after liberalization	0.0455	0.0073	0.2019	-0.0687	0.8695	-	-
		(0.0154)	(0.0016)	(0.0277)	(0.0311)	(0.0116)	-	-
	segment 1	-0.0224	0.0037	0.1981	-	0.7190	-	-
		(0.0051)	(0.0009)	(0.0248)	-	(0.0402)	-	-
	segment 2	0.0694	0.0076	0.1274	-	0.8579	-	-
		(0.0133)	(0.0018)	(0.0134)	-	(0.0125)	-	-
	segment 3	-	1.5078	0.2117	-	-	-	-
		-	(0.1943)	(0.1242)	-	-	-	-
	segment 4	-	0.3125	0.2273	-	-	-	-
		-	(0.0353)	(0.0935)	-	-	-	-

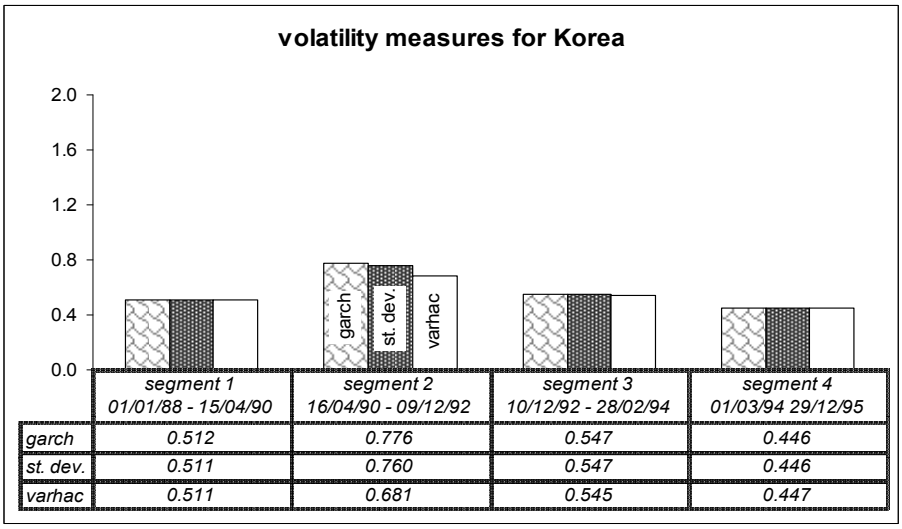
Appendix II - Figures

Figure 1



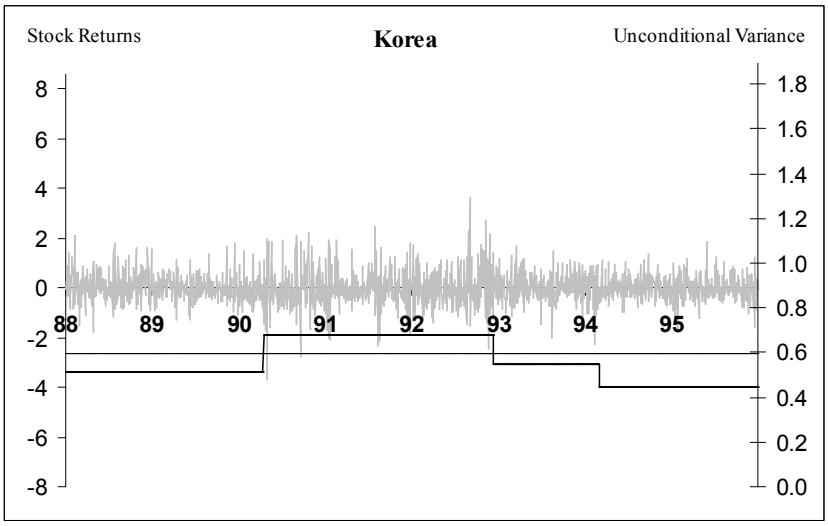
	before liberalisation 01/01/88 - 31/12/91	after liberalisation 01/01/92 - 29/12/95
garch	0.622	0.561
st. dev.	0.624	0.572
varhac	0.597	0.595

Figure 2



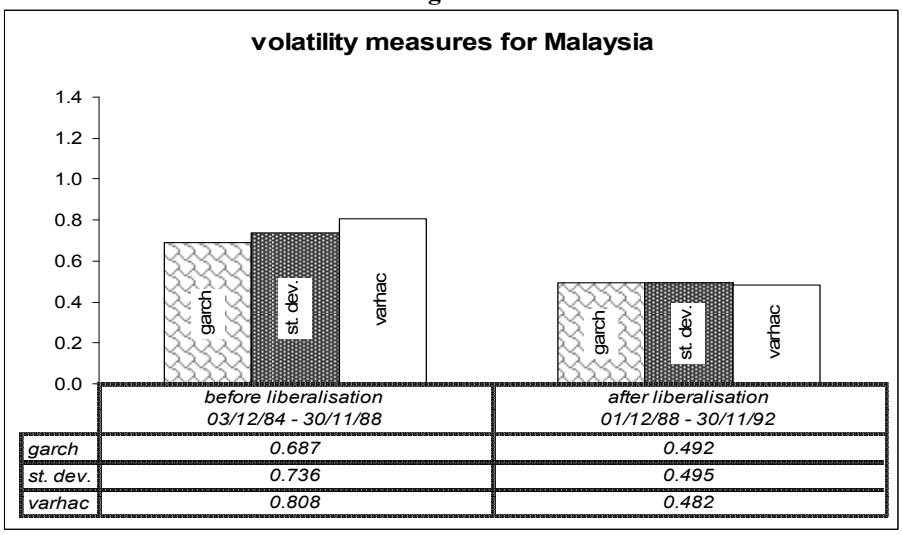
	segment 1 01/01/88 - 15/04/90	segment 2 16/04/90 - 09/12/92	segment 3 10/12/92 - 28/02/94	segment 4 01/03/94 29/12/95
garch	0.512	0.776	0.547	0.446
st. dev.	0.511	0.760	0.547	0.446
varhac	0.511	0.681	0.545	0.447

Figure 3



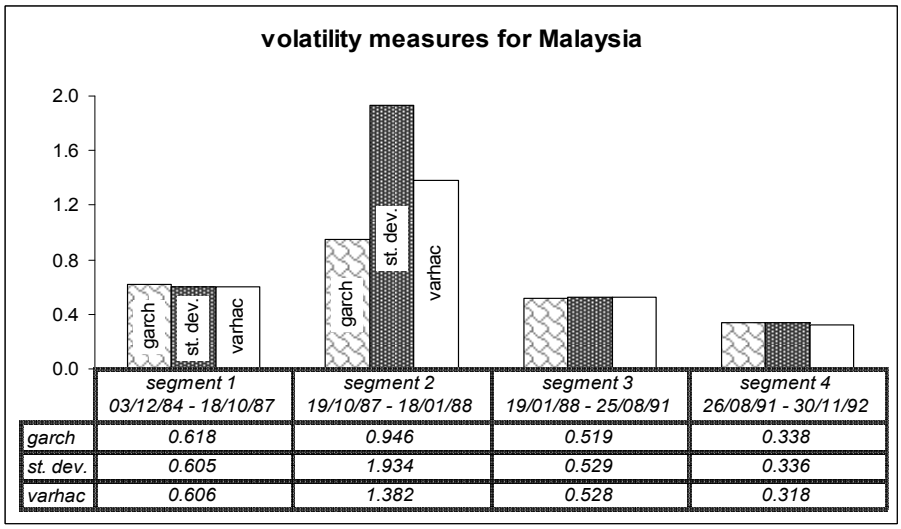
Note: the magnitude of the volatility that is depicted in all cases is the VARHAC estimate of den Haan. Also, the dashed line presents the volatility as given by the two segments defined by the official liberalisation date. The continuous line presents the volatility as given by the segments identified by the procedure of Section 2.

Figure 4



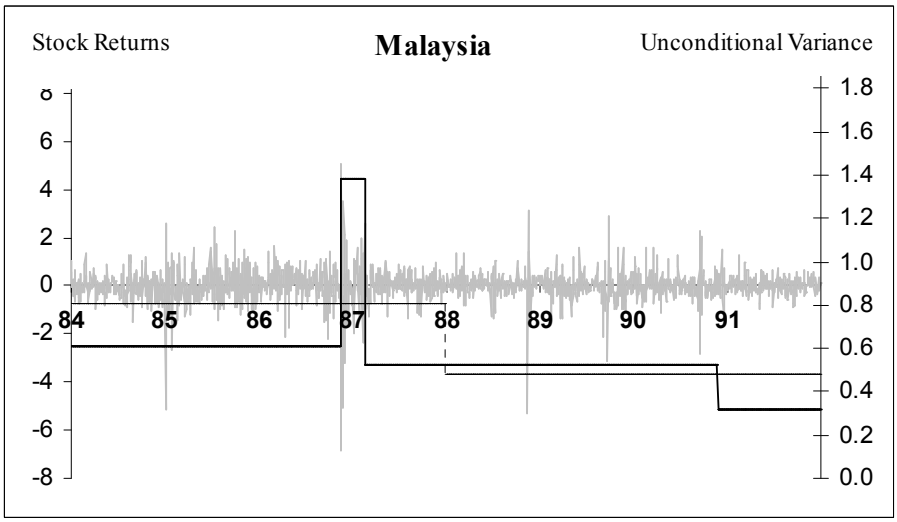
	before liberalisation 03/12/84 - 30/11/88	after liberalisation 01/12/88 - 30/11/92
garch	0.687	0.492
st. dev.	0.736	0.495
varhac	0.808	0.482

Figure 5



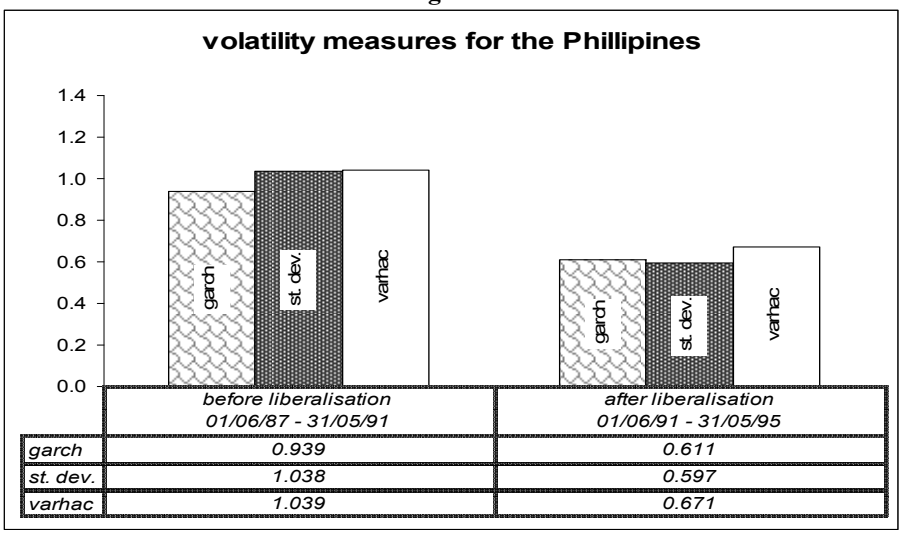
	segment 1 03/12/84 - 18/10/87	segment 2 19/10/87 - 18/01/88	segment 3 19/01/88 - 25/08/91	segment 4 26/08/91 - 30/11/92
garch	0.618	0.946	0.519	0.338
st. dev.	0.605	1.934	0.529	0.336
varhac	0.606	1.382	0.528	0.318

Figure 6



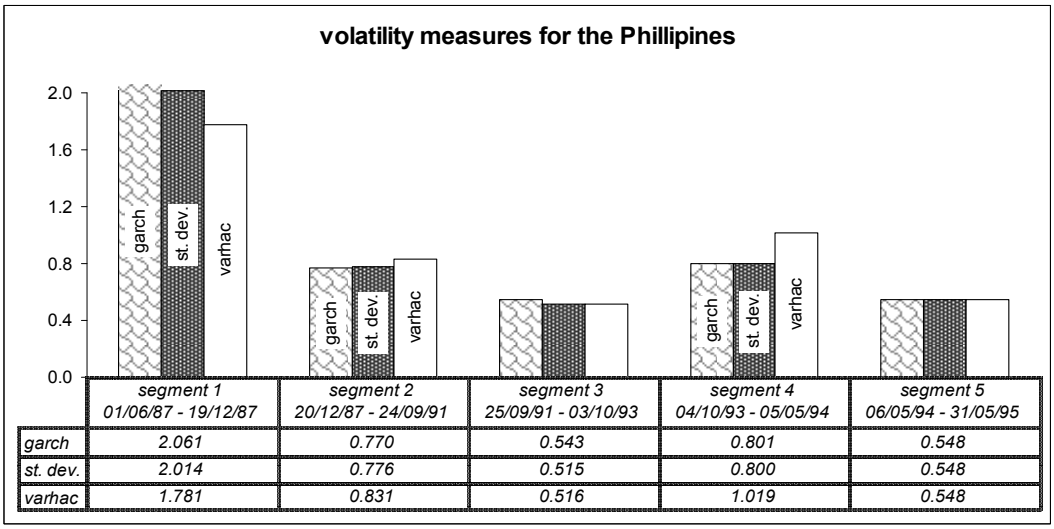
Note: the magnitude of the volatility that is depicted in all cases is the VARHAC estimate of den Haan. Also, the dashed line presents the volatility as given by the two segments defined by the official liberalisation date. The continuous line presents the volatility as given by the segments identified by the procedure of Section 2.

Figure 7



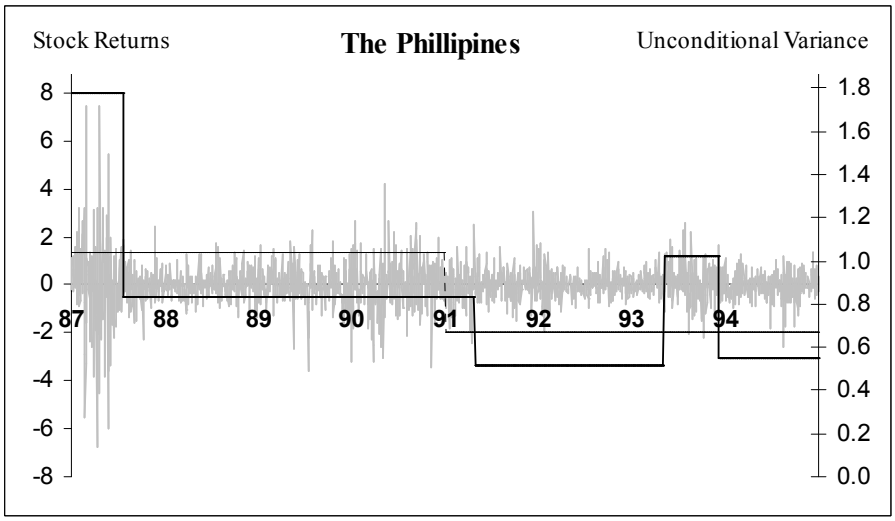
	before liberalisation 01/06/87 - 31/05/91	after liberalisation 01/06/91 - 31/05/95
garch	0.939	0.611
st. dev.	1.038	0.597
varhac	1.039	0.671

Figure 8



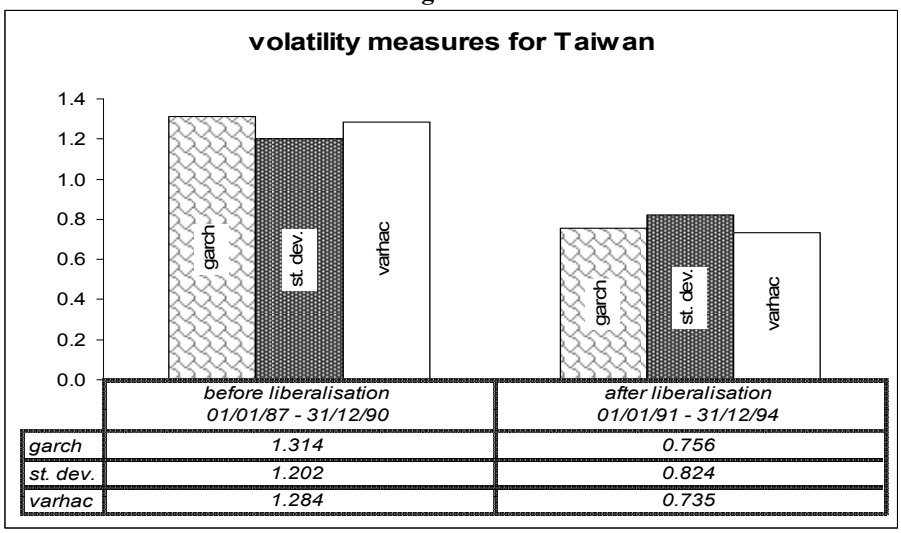
	segment 1 01/06/87 - 19/12/87	segment 2 20/12/87 - 24/09/91	segment 3 25/09/91 - 03/10/93	segment 4 04/10/93 - 05/05/94	segment 5 06/05/94 - 31/05/95
garch	2.061	0.770	0.543	0.801	0.548
st. dev.	2.014	0.776	0.515	0.800	0.548
varhac	1.781	0.831	0.516	1.019	0.548

Figure 9



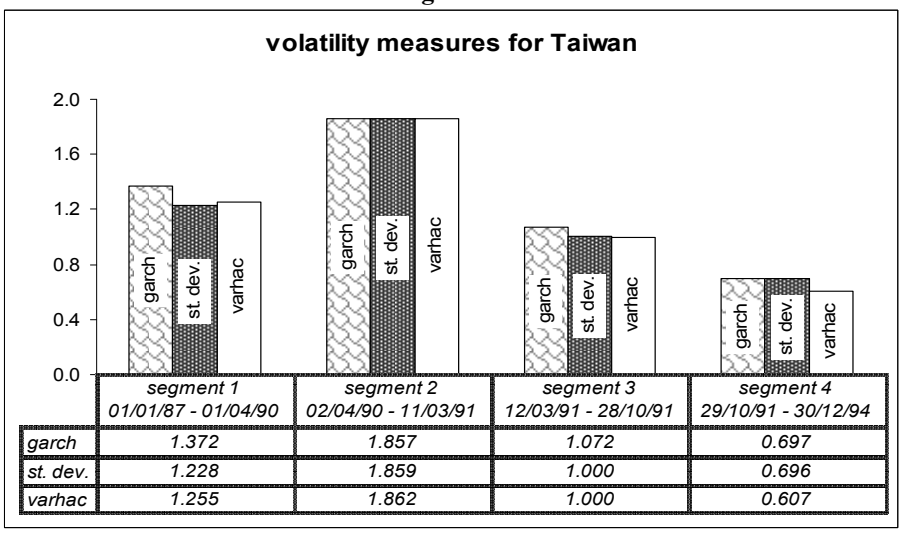
Note: the magnitude of the volatility that is depicted in all cases is the VARHAC estimate of den Haan. Also, the dashed line presents the volatility as given by the two segments defined by the official liberalisation date. The continuous line presents the volatility as given by the segments identified by the procedure of Section 2.

Figure 10



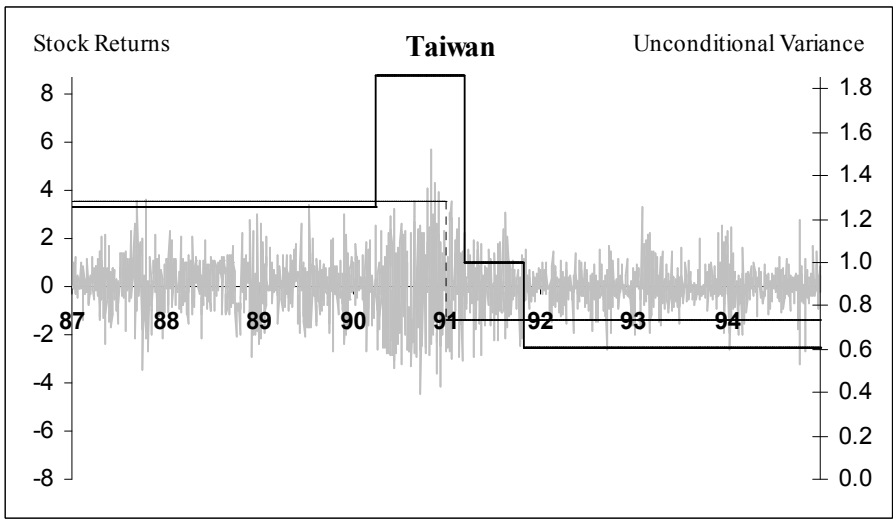
	before liberalisation 01/01/87 - 31/12/90	*after liberalisation 01/01/91 - 31/12/94*
garch	*1.314*	*0.756*
st. dev.	*1.202*	*0.824*
varhac	*1.284*	*0.735*

Figure 11



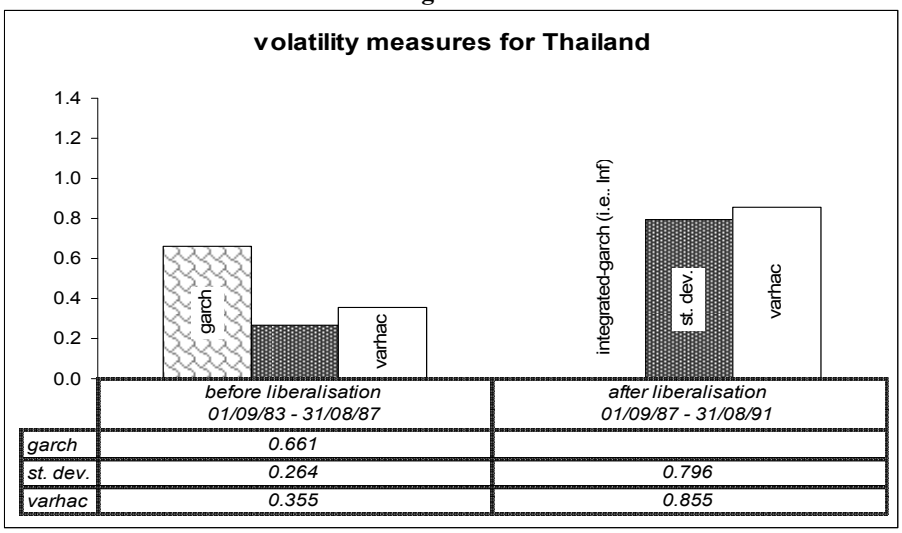
	segment 1 01/01/87 - 01/04/90	*segment 2 02/04/90 - 11/03/91*	*segment 3 12/03/91 - 28/10/91*	*segment 4 29/10/91 - 30/12/94*
garch	*1.372*	*1.857*	*1.072*	*0.697*
st. dev.	*1.228*	*1.859*	*1.000*	*0.696*
varhac	*1.255*	*1.862*	*1.000*	*0.607*

Figure 12



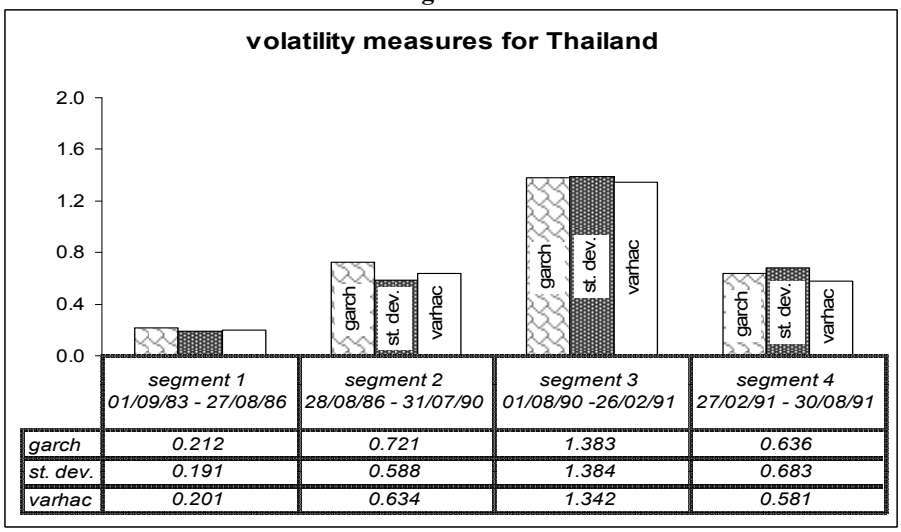
Note: the magnitude of the volatility that is depicted in all cases is the VARHAC estimate of den Haan. Also, the dashed line presents the volatility as given by the two segments defined by the official liberalisation date. The continuous line presents the volatility as given by the segments identified by the procedure of Section 2.

Figure 13



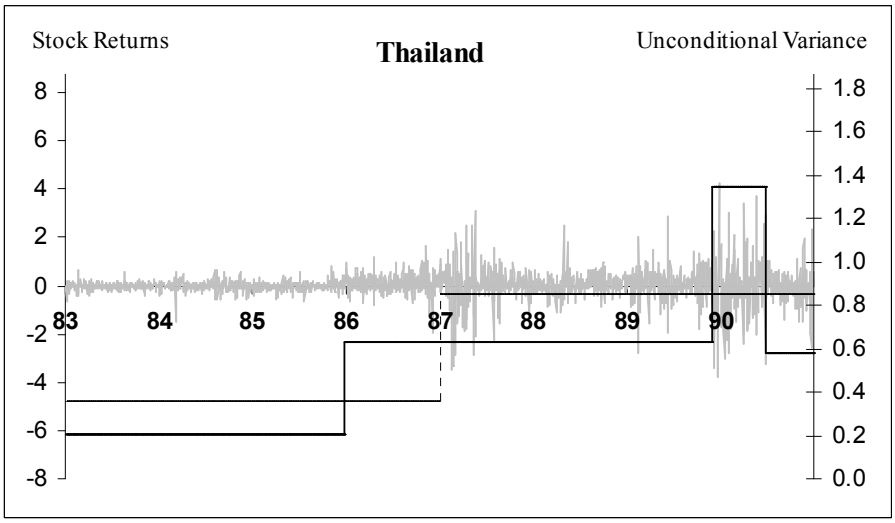
	before liberalisation 01/09/83 - 31/08/87	after liberalisation 01/09/87 - 31/08/91
garch	0.661	
st. dev.	0.264	0.796
varhac	0.355	0.855

Figure 14



	segment 1 01/09/83 - 27/08/86	segment 2 28/08/86 - 31/07/90	segment 3 01/08/90 -26/02/91	segment 4 27/02/91 - 30/08/91
garch	0.212	0.721	1.383	0.636
st. dev.	0.191	0.588	1.384	0.683
varhac	0.201	0.634	1.342	0.581

Figure 15



Note: the magnitude of the volatility that is depicted in all cases is the VARHAC estimate of den Haan. Also, the dashed line presents the volatility as given by the two segments defined by the official liberalisation date. The continuous line presents the volatility as given by the segments identified by the procedure of Section 2.