IMF Working Paper

Global Volatility and Forex Returns in East Asia

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Asia and Pacific Department

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Abstract

During 2001–07, increases in mature market volatility were associated with declines in forex returns for East Asian countries, consistent with an overall "flight to safety" effect. Estimates from GARCH models suggest that a 5 percentage point increase in mature market equity volatility generated an exchange rate depreciation of up to ½ percent. This sensitivity rose during the latter period in the sample, suggesting greater integration of Asian financial markets with global markets. Unconditional standard deviations estimated from these models also provide operational measures of "long-term" and "excess" volatility in forex markets. Long-run forex volatility declined as Asian economies settled down with generally stronger fundamentals in the post-crisis period to more flexible regimes along with a generally lower level of mature market volatility.

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[1] I wish to thank Nissanke Weerasinghe, Erik Lueth, and seminar participants at the Bank of Thailand for their helpful comments. All remaining errors are my own.

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I. INTRODUCTION

Volatility in mature equity markets has risen since late 2006, with a noticeable spike in mid-2007 in the wake of the subprime crisis in the United States and the unfolding global credit crunch. Volatility levels have remained elevated into 2008, across asset classes, although at levels lower than during the peaks witnessed in 1998, and over 2001–03. In addition, global commodity markets have also witnessed higher volatility. Going forward, markets continue to price in elevated levels of volatility across a range of asset and commodity markets.

Volatility shifts in mature markets transmit to emerging market foreign exchange returns through various channels, including through movements in investment portfolios across asset classes, which in turn induce shifts in capital flows across countries. This happens as investors—at home and abroad—

Global Volatility, 2001-07
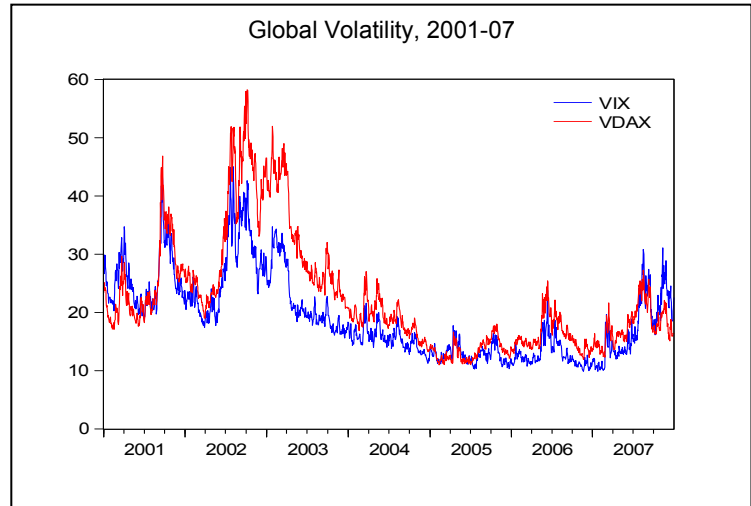
readjust their portfolios along risk-return frontiers. These developments are often couched as "search-for-returns" and "flight-to-safety" hypotheses. The higher levels of volatility, therefore, have implications for asset markets in emerging markets, including foreign exchange markets. The relationships, in turn, have implications for monetary and exchange rate management in these countries.

Against this background of higher volatility in mature equity markets, this paper examines forex returns for five East Asian countries—Indonesia (IDN), Korea (KOR), Philippines (PHL), Singapore (SGP), and Thailand (THA). The full sample period for the analysis is 2001–07.

Empirical estimates of the sensitivity of exchange rate returns to global volatility have recently been derived in the literature. Most recently, Cairns et al. (2007) estimates elasticities of *weekly* bilateral U.S. dollar exchange rates to equity market volatility measures in mature markets for a range of countries for the period 2000–06. One of the conclusions is that currencies which are considered "safe havens" appreciate with an increase in global volatility, while high-yielding currencies tend to depreciate suggesting the dominance of a "flight-to-safety" effect. The results are derived from a single linear equation framework.

This paper reexamines the hypotheses in a generalized autoregressive conditional heteroscedasticity (GARCH) framework, which better captures the time series properties of forex returns. The GARCH framework has the additional merit of providing long-run estimates of volatility of the exchange rate processes. These estimates are useful from an operational

standpoint to benchmark movements in forex markets by providing a measure of "long term' volatility of the exchange rate and, by comparison, of "excess" volatility.

The remainder of the paper is organized as follows. Section II describes the methodology of the paper and data properties. Section III discusses the results of the estimated GARCH forex returns models. Section IV addresses robustness issues and extensions. Section V concludes.

II. METHODOLOGY AND DATA

Following the seminar contribution of Engel (1982) and its extension by Bollerslev (1986), modeling of financial asset returns has been cast in the GARCH framework. A key element of this framework is the accounting for persistence and clustering in the data, suggesting the presence of time varying heteroscedasticity.[2] For asset returns, the GARCH class of models involves the estimation of an equation for asset returns and a conditional variance (σ_t^2) specification. The dynamics of σ_t^2 for a wide range of financial asset returns has been found to be adequately modeled as a GARCH(1,1) processes. In the case where asset returns follows an autoregressive process and are dependent on other variables, the model specification takes the following form:

$$\text{Exchange rate return:} \quad dlx_t = \phi_0 + \sum_{i=1}^{m} \phi_i \, dlx_{t-1} + \sum_{i=1}^{n} \theta_i \, z_{it} + \sum_{i=1}^{k} \pi_i \, \Omega_{it} + \varepsilon_t$$

$$\text{where } \varepsilon_t = \sigma_t^{1/2} \eta_t \text{ and } \eta_t \sim \text{i.i.d. } (0, 1).$$

$$\text{Conditional variance:} \quad \sigma_t^2 = \alpha_0 + \alpha_1 \, \varepsilon_{t-1}^2 + \beta_1 \, \sigma_{t-1}^2$$

where dlx_t is the forex return (percentage change in spot rate), z_{it} are control variables and regressors, Ω_{it} represents a measure of mature market volatility, and ε is the error term in the return equation. The long-run elasticity of forex returns to this market volatility—a key parameter for this paper—can be computed as $\sum_{i=1}^{k} \pi_i /(1 - \sum_{i=1}^{m} \phi_i)$. For σ_t^2 to be well defined, α_0, α_1, and β_1 need to be nonnegative. In addition, for the unconditional variance, defined as $\alpha_0/(1-\alpha_1 - \beta_1)$, to be finite and positive, requires that $\alpha_1 + \beta_1 < 1$. In the empirical section of the paper, forex returns for the euro and the yen as included in the estimation equations to proxy for global developments that affect the evolution of daily forex returns. Interest rate differentials could also be included among the regressors, but this is not done here with the assumption that the lagged forex returns can proxy for these differentials.

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[2] Stock and Watson (2007) provides a recent introduction; Anderson et al. (2006) provides an advanced treatment.

Global volatility and risk aversion

Mature market volatility is proxied in the first instance by the VIX, the Chicago Board Options Exchange (CBOE) volatility index, which is a forward-looking measure of market expectations for the S&P500 equities.[3] The VDAX index is used a second measure of mature equity market.[4] Figure 1 presents the VIX and VDAX indices and the daily changes in the indices. Summary statistics for the two indices over sample period, and individual years are provided in Table 2. The VIX and the VDAX are meant to be forward looking, and are widely used measures of market risk and often taken in markets as gauges of "investor fear."

Broadly speaking, annual average volatility in mature equity markets peaked in 2002, and fell through 2003 to 2006, and rose in 2007. The higher levels of global volatility over 2001–03 were associated first with September 2001 attacks, during June–July 2002 with geopolitical tensions and the WorldCom accounting scandal and bankruptcy, and in May 2006 with the multimarket sell-off (Cairns, et al., 2007). Volatility rose after the outbreak of the subprime crisis in mid-2007, and has remained at elevated levels since then.

Forex returns

Summary statistics for daily returns for bilateral spot exchange rates for East Asian currencies vis-à-vis the U.S. dollar are reported in Table 1 for the full sample period. Amongst these currencies, the average daily return was the highest for the Korean won (4¼ percent on annualized basis, assuming 260 trading days), followed by the Thai baht (3½ percent). The average daily appreciation of East Asian currencies was lower than the euro (6¼ percent), but higher than the yen (¼ percent) over the sample period. Overall, the variability of the returns (0.4 percent) was lower than the major currencies (0.6 percent), reflecting in part tighter management of exchange rates. Figure 2 shows the exchange rates. Figure 3 plots the daily forex returns series.

III.   GARCH MODELS OF EAST ASIAN DAILY FOREX RETURNS

Pre-estimation

Autocorrelation functions for forex returns implied persistence in the series and suggested an AR formulation for the returns equation. Augmented Dickey-Fuller (ADF) tests (Table 3) suggested that the log exchange rate series (lx_t) were I(1); the first differences were I(0). The ADF tests also suggested that the VIX index was I(1). The Akaike Information Criteria

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[3] The index is calculated as a weighted average of the implied volatility for S&P500 calls and puts.

[4] The VDAX index is a measure of the implied volatility of the DAX index and is computed from 30 days DAX option contracts.

suggested two lags of the dependent variable and regressors in the estimation equations (Table 4). Granger Causality tests did not reject the null hypothesis that the VIX index does not Granger cause East Asian exchange rates.

The squared returns also exhibited patterns of persistence and clustering within countries over time (Figure 4), also common in asset returns; ARCH tests confirmed the appropriateness of a GARCH formulation. The distributions of squared returns were also markedly skewed and leptokurtic, suggesting that the error term was nonnormally distributed.

Estimation

In all country cases, the AR(2)-GARCH(1,1) specifications yielded acceptable models of returns and conditional variance for the entire sample period (Table 5).[5] The coefficients on the VIX were highly significant in all models. The coefficients in the conditional variance equation were significant in all cases, confirming the presence of time-varying heteroscedasticity in the exchange rate processes. The coefficients of these equations were also nonnegative in all cases, as required, to ensure that the conditional variances are well defined. In addition, in all cases, α_1 + β_1 was less than 1, producing (positive) finite estimates of unconditional variances.

Post-estimation

The model (standardized) residuals and squared residuals showed no evidence of serial correlation and heteroscedasticity (Figures 5 and 6). The specifications were also tested for neglected ARCH using the Lagrange Multiplier (LM) test.

IV. EMPIRICAL RESULTS

A. Sensitivity of Forex Returns to Mature Equity Market Volatility

For the East Asian economies, a strong result emerges from the empirical models. An increase in mature market equity volatility was associated with lower forex returns in all cases. Alternatively put, an increase in the VIX index generated a tendency for exchange rate depreciation, suggesting that higher mature market equity volatility was generally associated with a "flight" from East Asian currency denominated assets. The range of long-run elasticities of East Asian forex returns to mature equity market volatility was 0.03 to 0.1. In other words, a 5 percentage point increase in the VIX index (close to a one standard deviation change) was associated, on average, with 0.15–0.4 percentage point exchange rate depreciation. There were differences across countries in the sensitivity of exchange rates to mature market volatility, with IDN at the higher end of the spectrum, KOR and SGP forming the middle, and PHL and THA at the lower end.

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[5] Following Nelson (1991), the error term is modeled as a generalized exponential distribution to capture "fat tails."

East Asian Exchange Rates: Elasticities
VIX_GARCH Models
Sample period: 2001-07

	IDN	KOR	PHL	SGP	THA
VIX	-0.08	-0.06	-0.03	-0.04	-0.03
Euro/$	0.07	0.14	0.02	0.08	0.07
Yen/$	0.04	0.13	0.03	0.00	0.00

B. Conditional and Unconditional Volatility of Forex Returns

The estimated models provide useful historical benchmarks of "average" levels of volatility for Asian exchange rates, taking into account the shifts in global volatility and domestic market conditions. The estimated unconditional standard deviation from the models can be used as measures of the "long-term" volatility of the exchange rate processes, and the excess of the conditional standard deviation over the unconditional standard deviation can then be used as a measure of "excess" volatility. The unconditional variances and standard deviations are reported below. The unconditional and conditional standard deviations are shown in Figure 7.

East Asian Exchange Rates: Unconditional Variance and Standard Deviation
VIX_GARCH Models
Sample period: 2001-07

	IDN	KOR	PHL	SGP	THA
Unconditional Variance	1.00	0.14	0.12	0.07	0.09
Unconditional SD	1.00	0.37	0.34	0.27	0.30

For KOR, SGP, and THA, the conditional volatilities appear to "converge" to the unconditional volatility over the sample period, with periods of "excess" volatility, followed by moderation in exchange rate volatility. For PHL, and more so for IDN, the higher levels of conditional volatility in the early part of the sample appear to give an upward "bias" to the level of unconditional volatility. The robustness of the unconditional volatility estimates for IDN and PHL is examined for subsamples in the next section.

C. Subsamples

The full sample period was broken down into two subsamples, corresponding to generally elevated levels of the VIX/VDAX indices during 2001 to 2003Q2 and more moderate levels thereafter.[6] The AR(2)-GARCH(1,1) models continue to provide acceptable fits for both sample periods for all countries (Tables 6 and 7), with the exception of IDN during the earlier subsample where the conditional variances are well defined, but the estimate of unconditional

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[6] The models were estimated only with the VIX as a regressor; models with VDAX in the equation could be estimated as well.

standard deviation appears to be distorted by the presence of large outlier movements in the exchange rate in 2001 and 2002.[7]

East Asian Exchange Rates: Elasticities, Unconditional Variance and Standard Deviation
VIX_GARCH Models

	IDN	KOR	PHL	SGP	THA
Sample period: 2001-03Q2					
VIX	-0.04	-0.03	0.00	-0.03	-0.03
Unconditional Variance	…	0.21	0.23	0.08	0.07
Unconditional SD	…	0.45	0.48	0.28	0.27
Sample period: 2003Q3-07					
VIX	-0.09	-0.08	-0.05	-0.05	-0.02
Unconditional Variance	0.25	0.11	0.13	0.06	0.24
Unconditional SD	0.50	0.33	0.36	0.25	0.49

A few stylized facts and hypotheses emerge:

• The general result remains valid that with an increase in mature market volatility; for East Asian currencies, the "flight-to-safety" effect predominates and there is a tendency for their exchange rates to depreciate with an increase in global risk.

• The estimated elasticities of forex returns to the VIX index were generally higher during the latter subsample, potentially reflecting greater integration of East Asian asset markets into the global economy.

• The elasticities remained negative during the 2006–07 period of rising risk in mature markets, and even increased in magnitude for some countries (especially the Philippines) suggesting that East Asian exchange rates were not altogether immune to the "fears" associated with the subprime crisis.

• In general, "long-run" exchange rate volatility in the East Asian countries was higher during the earlier subsample, possibly reflecting a hangover from the Asian crisis period and early experiences with flexible exchange rates. As the economies settled down to a steadier pace of economic activity with generally stronger fundamentals and foreign exchange markets were acclimatized to the new regimes, forex volatility appears to have fallen. In addition, mature market volatility was also lower during the latter subsample.[8]

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[7] The unconditional variance and standard deviation are therefore not reported here. The issue is further addressed in the next subsection on I-GARCH models.

[8] This conjecture could be tested by explicitly modeling the impact of mature market volatility on conditional volatilities in the East Asian countries by including the VIX/VDAX in the conditional variance equations, which is not done here.

- Country-specific factors were important and were reflected in evolution of conditional volatilities. IDN experienced the highest levels of forex volatility among the sample countries, SGP the lowest in part due to tighter management of the exchange rate. Both KOR and SGP were marked by steady levels of conditional and unconditional volatility. For the PHL, while the unconditional volatility fell during the latter subsample, the time pattern of conditional volatility in the two subsamples was nearly the opposite—falling in earlier subsample, rising in the latter. THA experienced an increase in unconditional and conditional volatility levels, in part related to political uncertainties in 2006 (Figures 8 and 9).

V. ROBUSTNESS

The estimation of the models over the two subsamples provides in itself a robustness test of the results. In addition, robustness was tested by replacing the VIX index with the VDAX. For this, the VDAX index was substituted for the VIX in the estimation equations, keeping the model specification the same as a first cut. The VIX and the VDAX indices are highly correlated (correlation coefficient: 0.88), but capture market sentiment in different bourses across the Atlantic. The VDAX was more volatile than the VIX over the sample period.

With the high correlation between the VIX and VDAX indices, the estimation results are nearly the same (with a lag length of two). The individual parameter estimates in the GARCH models are marginally different (Table 8). The long-run elasticities of the exchange rates to the VDAX were generally a bit smaller than the VIX; differences in the unconditional variances and standard deviations of the exchange rate processes were negligible (Figure 10).

East Asian Exchange Rates: Elasticities, Unconditional Variance and Standard Deviation
VDAX_GARCH Models
Sample period: 2001-07

	IDN	KOR	PHL	SGP	THA
VDAX	-0.06	-0.07	-0.02	-0.02	-0.02
Unconditional Variance	0.97	0.14	0.13	0.07	0.10
Unconditional SD	0.99	0.37	0.36	0.27	0.31

Robustness was further tested with a shorter lag length (one) for KOR, PHL, SGP, and THA as suggested by the AIC. For IDN, the AIC suggested a longer lag length (three). These specifications led to nearly the same parameter estimates of VDAX elasticities, and unconditional variances and standard deviations as in the case of two lags. Finally, the models were estimated with over the two subsamples (Tables 9 and 10), with the following results.

East Asian Exchange Rates: Elasticities, Unconditional Variance and Standard Deviation
VDAX_GARCH Models

	IDN	KOR	PHL	SGP	THA
Sample period: 2001-03Q2					
VDAX	-0.02	-0.05	-0.00	-0.02	-0.02
Unconditional Variance	7.98	0.20	0.28	0.08	0.07
Unconditional SD	2.82	0.45	0.53	0.28	0.27
Sample period: 2003Q3-07					
VDAX	-0.09	-0.08	-0.04	-0.04	-0.02
Unconditional Variance	0.25	0.11	0.13	0.07	0.31
Unconditional SD	0.50	0.33	0.36	0.26	0.56

VI. CONCLUSIONS

The paper satisfies two objectives. First, it examines the sensitivity of forex returns for five East Asian countries—Indonesia, Korea, Philippines, Singapore, and Thailand—to measures of mature equity market volatility. It establishes that during 2001-07, forex returns for East Asian currencies fell when mature market volatility rose, consistent with an overall "flight to safety" effect. Estimates from GARCH models estimated in the paper suggest that 5 percentage point increase in mature market equity volatility was associated with an exchange rate depreciation of up to ½ percent. This sensitivity rose during a later sample period, suggesting greater integration of Asian financial markets with global markets. The elasticities remained negative during the 2006-07 period of rising risk in mature markets, and even increased in magnitude for some countries suggesting that East Asian exchange rates were not altogether immune to the "fears" associated with the subprime crisis. Second, it uses the estimated GARCH models to compute unconditional standard deviations which provide operational measures of "long-term" and "excess" volatility in the sample countries' forex markets. A key finding is that long-run forex volatility declined, possibly as these economies settled down with generally stronger fundamentals in the post-crisis period to more flexible regimes along with a lower level of mature market volatility.

Figure 1. VIX and VDAX Indices
(In percent)
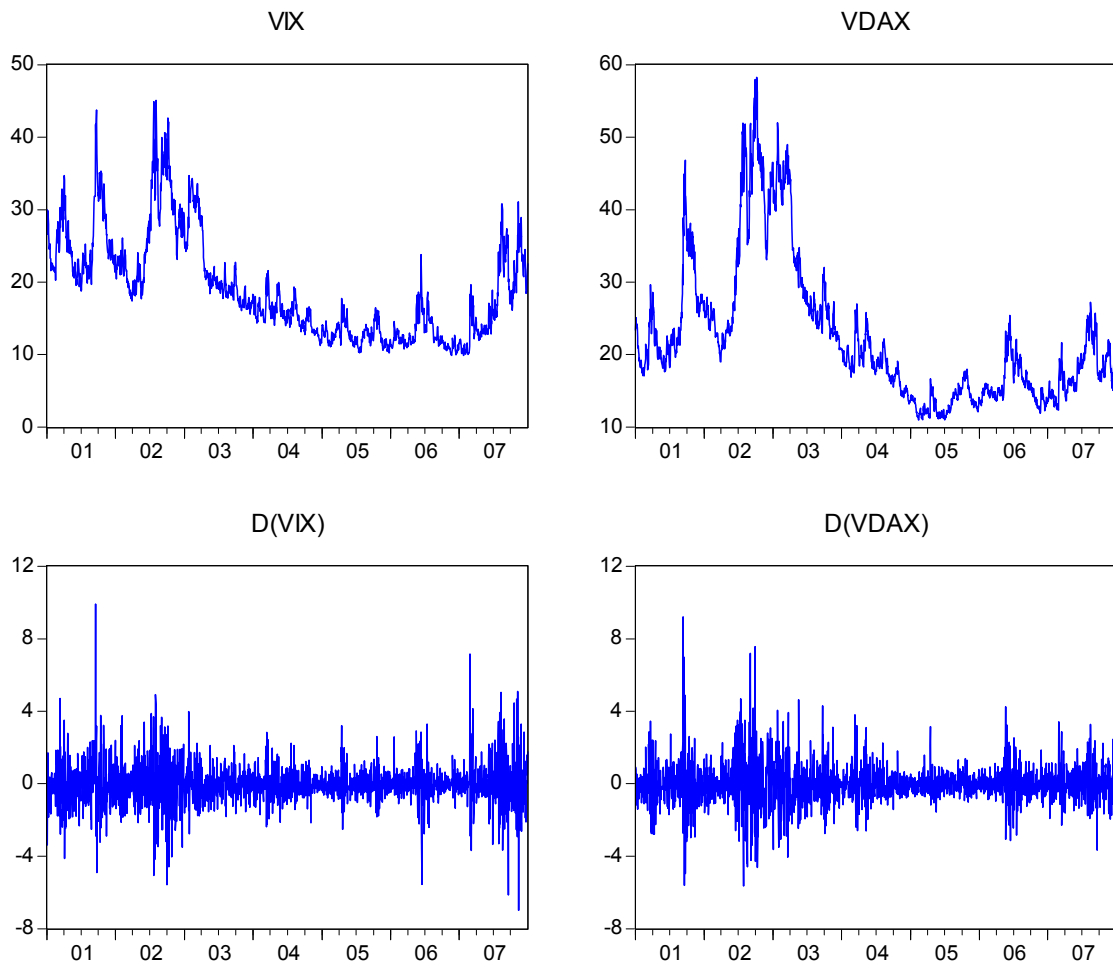
Figure 2. Exchange Rates
(Logs, Index: Jan 1, 2001 = 100)

13
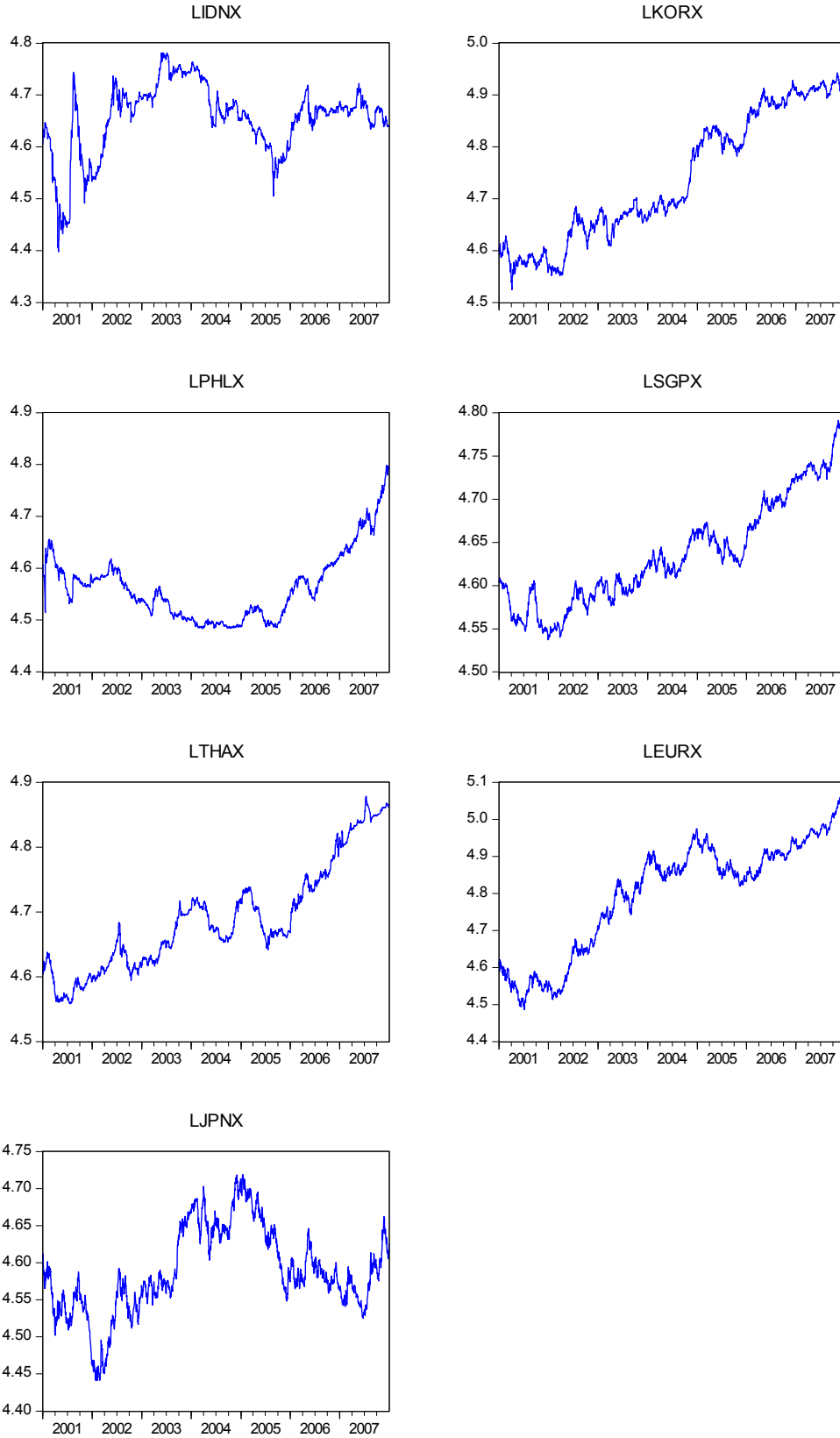
Figure 3. Daily Forex Returns
(In percent)

DLIDNX

DLKORX

DLPHLX

DLSGPX

DLTHAX

14
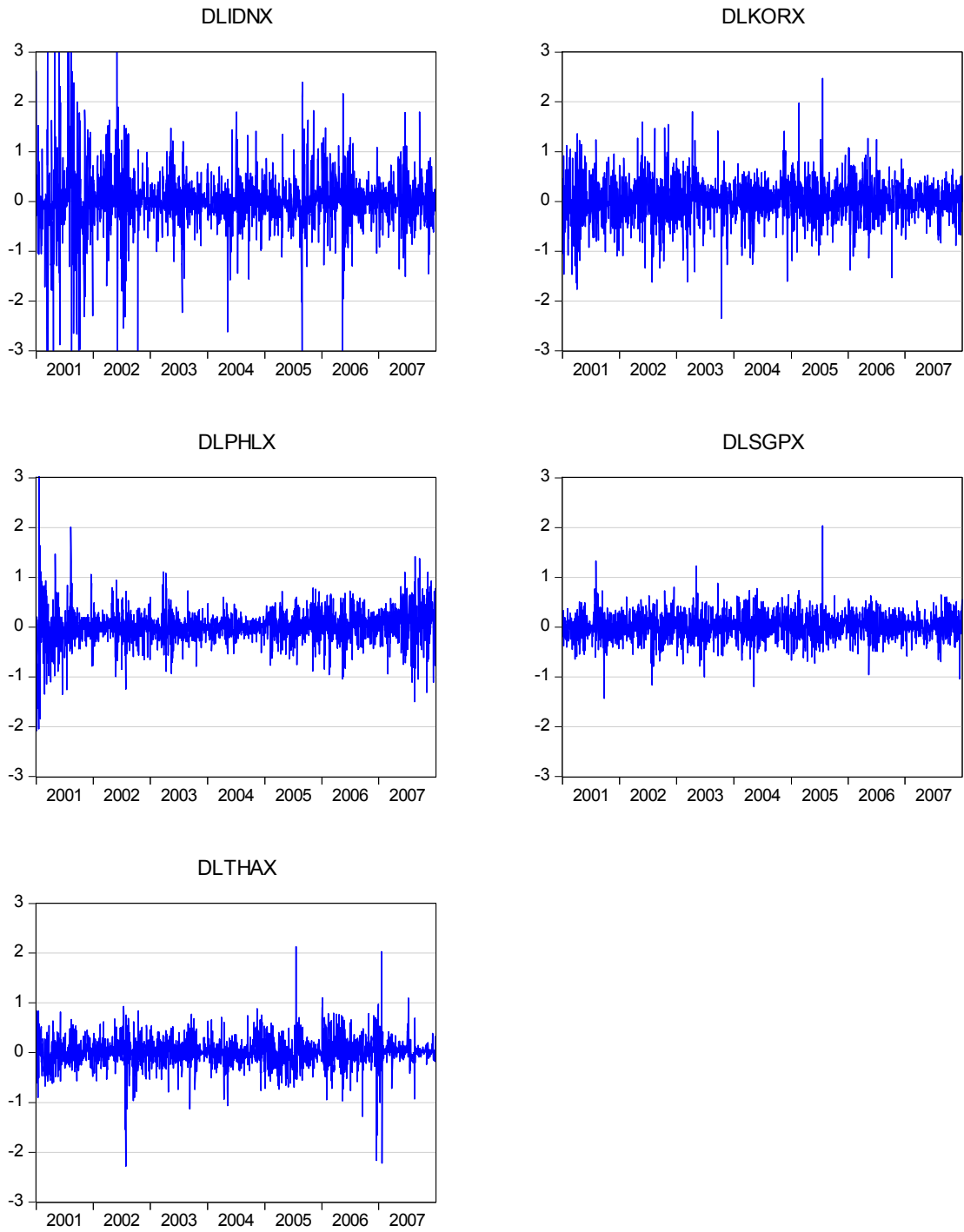
Figure 4. Daily Squared Forex Returns
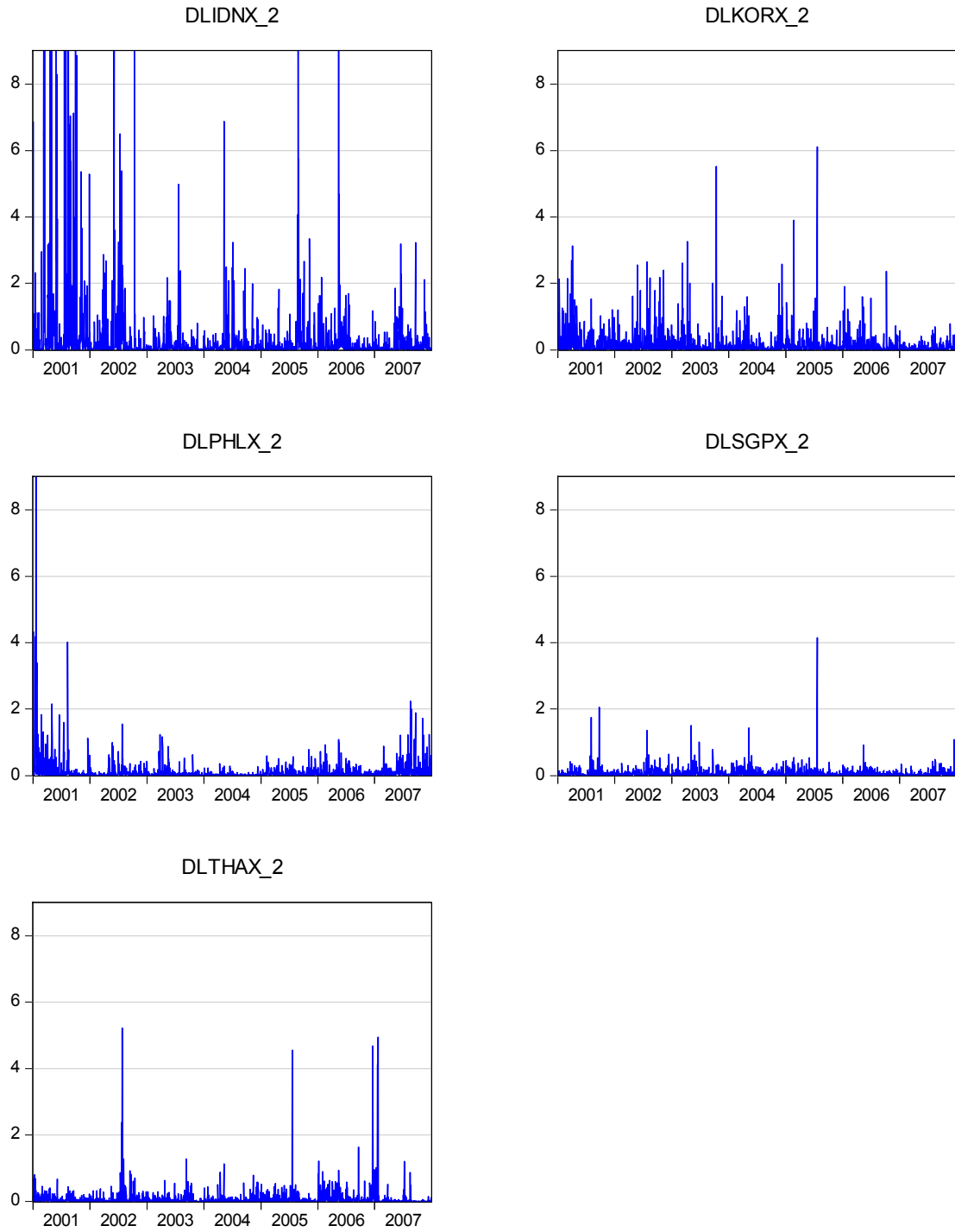
Figure 5. VIX_AR(2)-GARCH(1,1) Models
Residuals

IDN_GARCH_RES1

KOR_GARCH_RES1

PHL_GARCH_RES1

SGP_GARCH_RES1

THA_GARCH_RES1

16
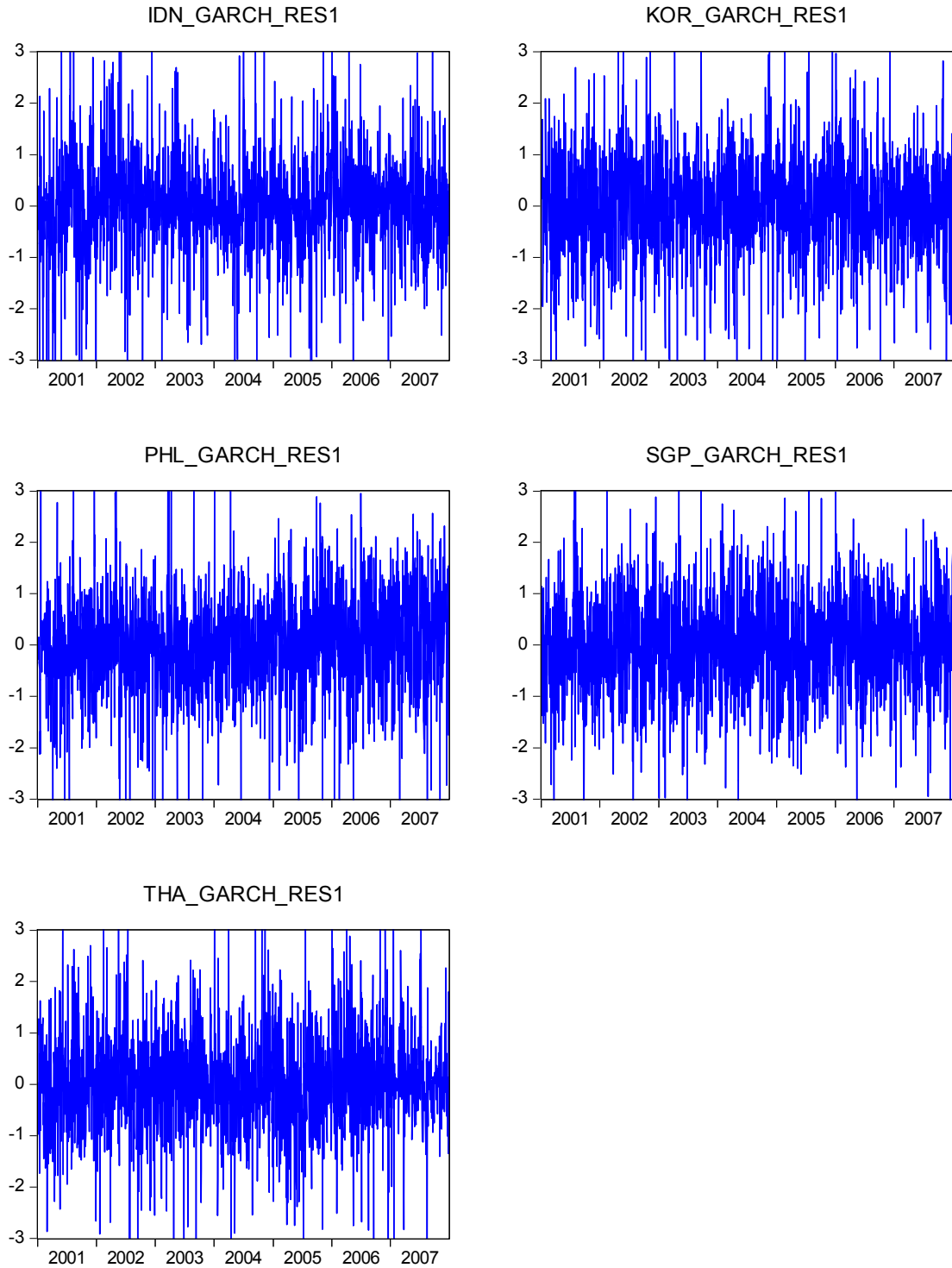
Figure 6. VIX_AR(2)-GARCH(1,1) Models
Squared Residuals

17
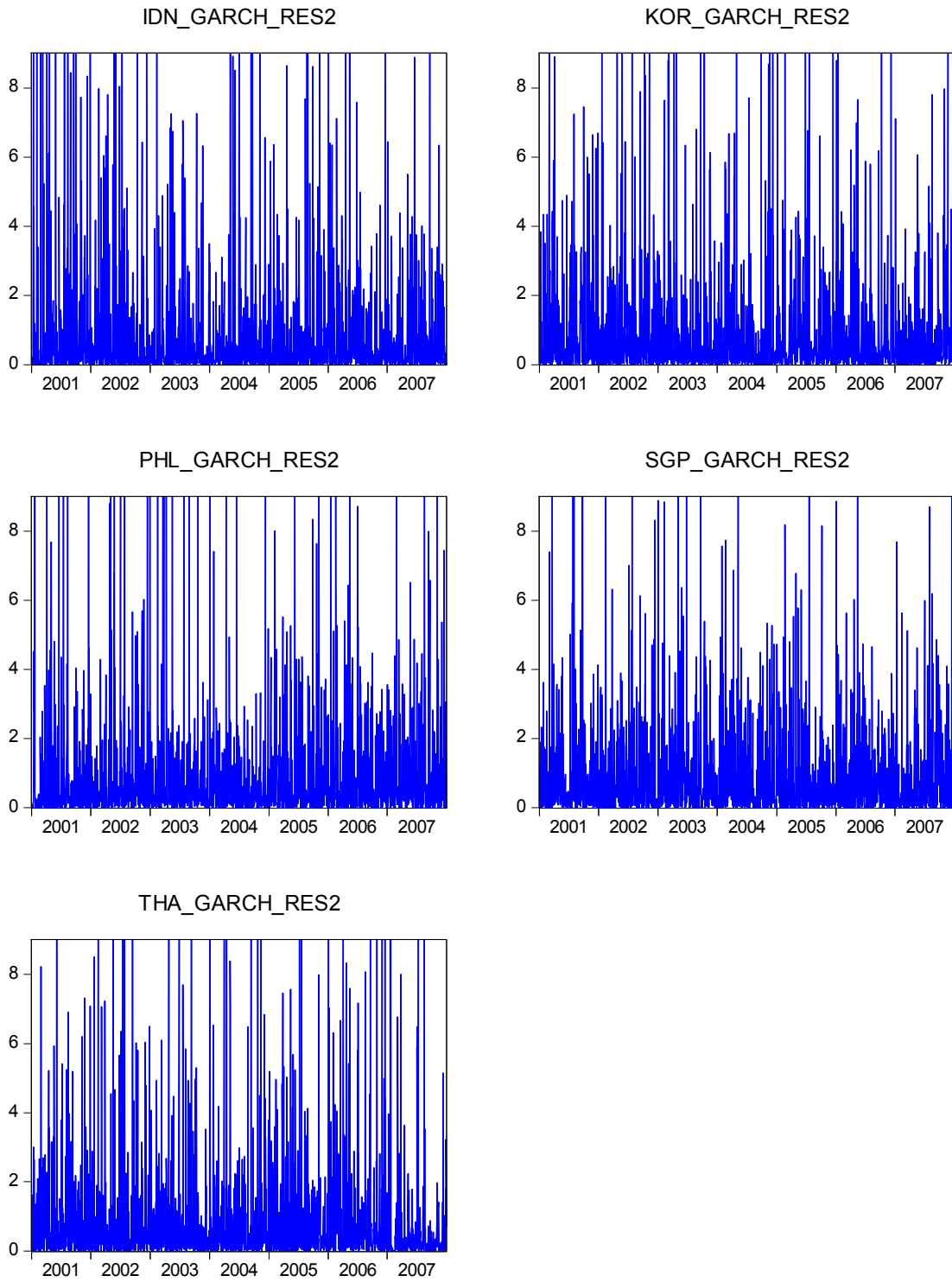
Figure 7. Daily Conditional and Unconditional Volatilities
VIX_AR(2)-GARCH(1,1) Models
Sample 2001–07
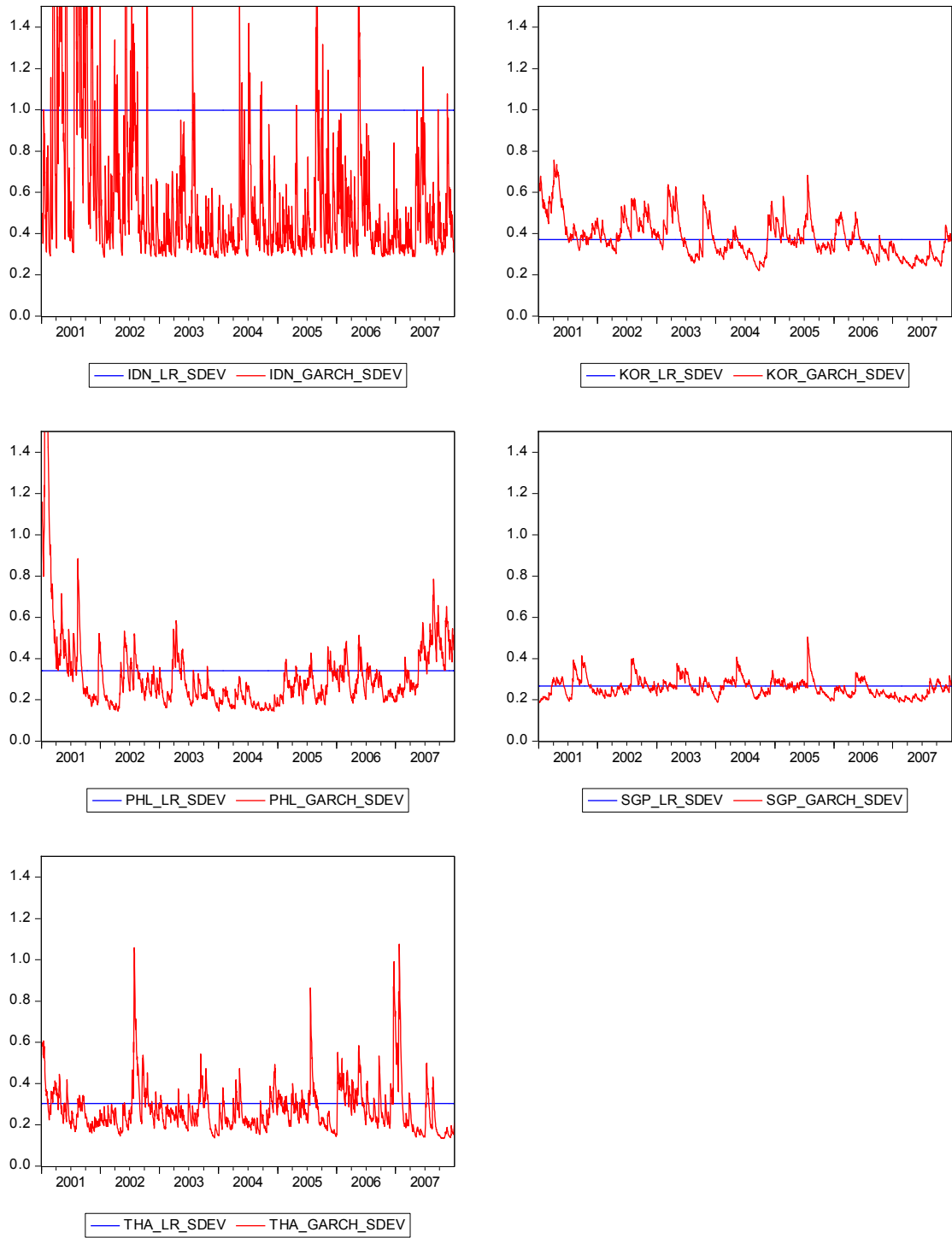
Figure 8. Daily Conditional and Unconditional Volatilities
VIX_AR(2)-GARCH(1,1) Models
Sample 2001–03Q2
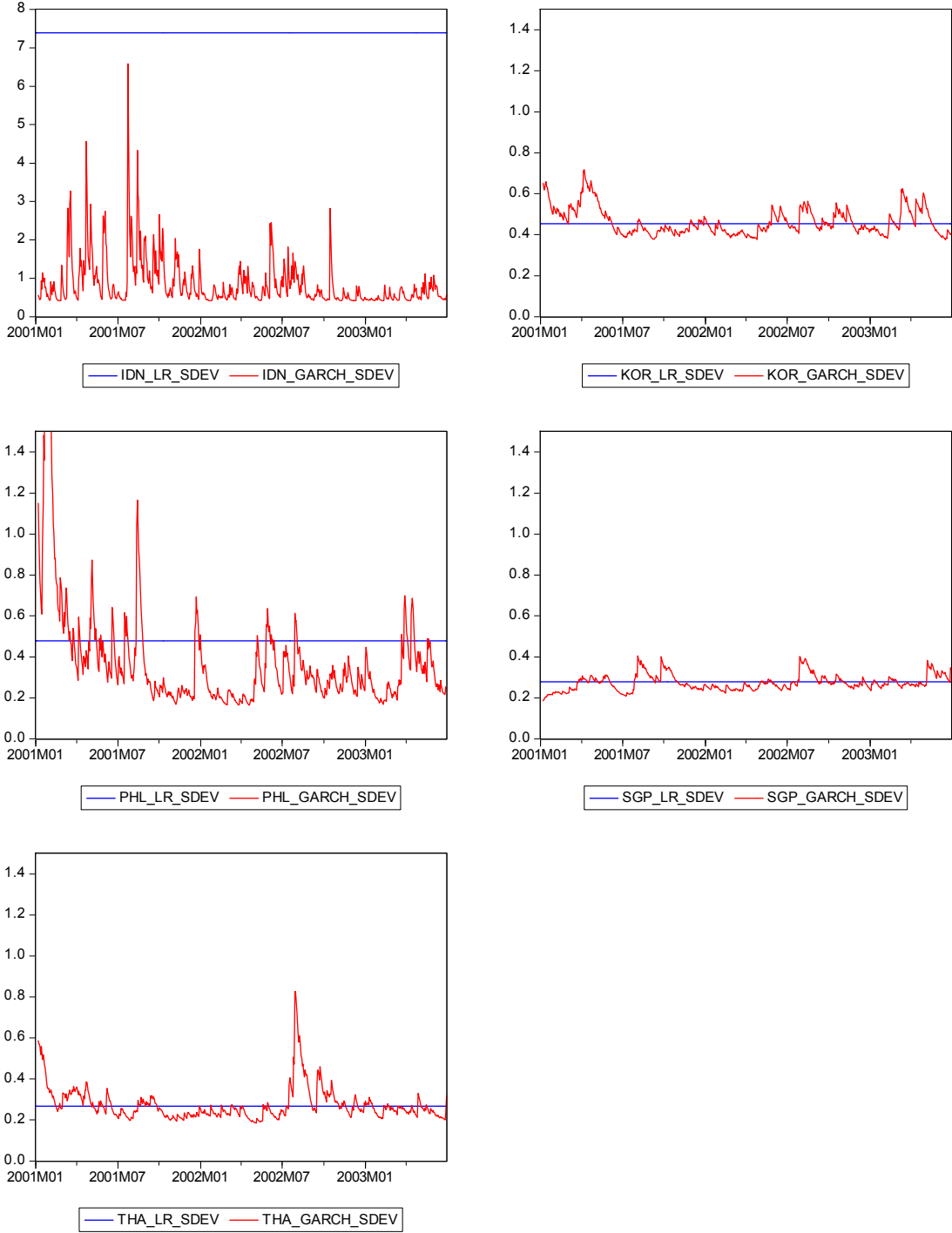
Figure 9. Daily Conditional and Unconditional Volatilities
VIX_AR(2)-GARCH(1,1) Models
Sample 2003Q3–07
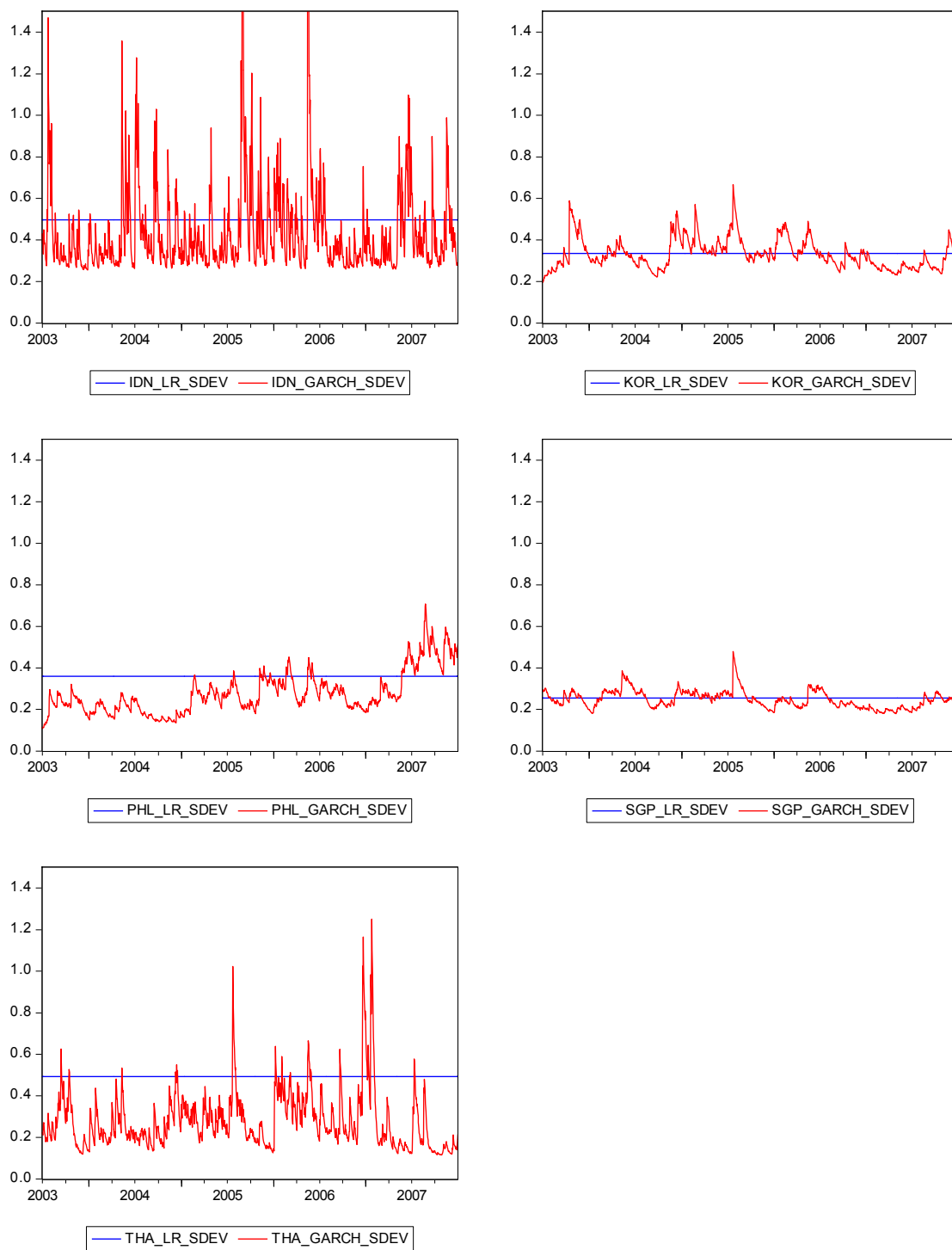
Figure 10. Daily Conditional and Unconditional Volatilities
VDAX_AR(2)-GARCH(1,1) Models
Sample 2001–07

Table 1. Daily Foreign Exchange Return: Summary Statistics

	IDN	KOR	PHL	SGP	THA	EUR	JPN
Mean	0.002	0.016	0.011	0.010	0.014	0.024	0.001
Median	0.000	0.017	0.000	0.013	0.000	0.031	-0.009
Maximum	9.0	2.5	11.1	2.0	2.1	2.3	2.4
Minimum	-5.9	-2.3	-2.1	-1.4	-2.3	-2.5	-2.2
Std. Dev.	0.7	0.4	0.4	0.3	0.3	0.6	0.6
Skewness	0.8	-0.2	9.4	0.1	-0.5	-0.1	0.2
Kurtosis	27.3	5.8	251.8	6.1	11.6	3.9	4.0
Jarque-Bera	45065	624	4733798	734	5723	65	92
Probability	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	3.7	29.9	19.2	18.7	25.9	44.6	2.1
Sum Sq. Dev.	903.2	327.9	332.9	131.1	167.3	623.2	594.6
Observations	1825	1825	1825	1825	1825	1825	1825

Table 2. VIX and VDAX Indices: Summary Statistics

VIX

YEAR	Mean	Median	Max	Min.	Std. Dev.	Skew.	Kurt.	Obs.
2001	25.8	24.3	43.7	18.8	4.8	1.1	4.0	260
2002	27.2	26.3	45.1	17.4	6.9	0.5	2.2	261
2003	22.0	19.8	34.7	15.6	5.2	1.0	2.7	261
2004	15.5	15.3	21.6	11.2	1.9	0.5	3.3	262
2005	12.8	12.5	17.7	10.2	1.5	0.7	3.2	260
2006	12.8	12.0	23.8	9.9	2.2	1.7	6.1	260
2007	17.5	16.1	31.1	9.9	5.4	0.5	2.2	261
All	19.1	17.4	45.1	9.9	7.1	1.0	3.3	1825

VDAX

YEAR	Mean	Median	Max	Min.	Std. Dev.	Skew.	Kurt.	Obs.
2001	24.8	22.6	46.9	17.1	6.5	1.2	3.6	261
2002	34.6	33.3	58.3	19.0	11.1	0.3	1.6	261
2003	31.8	28.6	52.0	20.7	8.5	0.7	2.0	261
2004	18.7	18.6	27.0	13.2	2.8	0.4	3.1	262
2005	13.4	13.2	18.0	11.0	1.7	0.7	2.7	260
2006	16.0	15.1	25.4	11.9	2.7	1.2	3.9	260
2007	17.9	17.4	27.2	12.3	3.2	0.6	2.8	261
All	22.5	19.6	58.3	11.0	9.7	1.4	4.3	1826

Table 3. Exchange Rates and Volatility Indices: Augmented Dickey-Fuller Test Statistics
Sample period: 2001–07

Logs, levels

Series	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
LIDNX	-3.3	0.07	-2.1	0.7	20	24	1805
LKORX	-3.0	0.14	-2.2	0.6	1	24	1824
LPHLX	0.0	1.00	-2.1	0.7	24	24	1801
LSGPX	-2.9	0.18	-2.2	0.6	2	24	1823
LTHAX	-2.1	0.55	-2.2	0.6	2	24	1823
LEURX	-2.0	0.59	-2.2	0.6	1	24	1824
LJPNX	-2.3	0.41	-2.2	0.6	0	24	1825
VIX	-2.9	0.17	-2.1	0.7	11	24	1813
VDAX	-2.7	0.23	-2.1	0.7	6	24	1819

Logs, first difference

Series	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
D(LIDNX)	-7.1	0.00	-1.5	0.8	24	24	1800
D(LKORX)	-45.1	0.00	-1.5	0.7	0	24	1824
D(LPHLX)	-7.6	0.00	-1.5	0.8	24	24	1800
D(LSGPX)	-31.6	0.00	-1.5	0.7	1	24	1823
D(LTHAX)	-28.5	0.00	-1.5	0.7	1	24	1823
D(LEURX)	-45.3	0.00	-1.5	0.7	0	24	1824
D(LJPNX)	-43.4	0.00	-1.5	0.7	0	24	1824
D(VIX)	-14.8	0.00	-1.5	0.8	10	24	1813
D(VDAX)	-19.2	0.00	-1.5	0.8	5	24	1819

Notes:

Null Hypothesis: Unit root (individual unit root process)
Automatic selection of maximum lags
Automatic selection of lags based on AIC: 0 to 24

Table 4. VAR Lag Order Selection Criteria

Endogenous variables: LTHAX LEURX LJPNX VIX
Exogenous variables: C

	IDN	KOR	PHL	SGP	THA
LR Test	12	11	12	12	12
Final Prediction Error	3	3	3	3	3
Akaike Information Criterion	3	3	3	3	3
Schwartz Information Criterion	1	2	1	2	1
Hannan-Quinn Information Criterion	2	2	2	2	2

VAR Lag Order Selection Criteria
Endogenous variables: LTHAX LEURX LJPNX VDAX
Exogenous variables: C

	IDN	KOR	PHL	SGP	THA
LR Test	12	4	12	3	2
Final Prediction Error	4	2	2	2	2
Akaike Information Criterion	4	2	2	2	2
Schwartz Information Criterion	1	2	1	1	1
Hannan-Quinn Information Criterion	1	2	2	2	2

Table 5. East Asia: Forex Returns and VIX

AR(2)-GARCH(1,1) Models
Sample period: 2001–07

Variable	IDN	KOR	PHL	SGP	THA
ϕ_0	-0.004	0.022**	0.001	0.013*	0.012*
ϕ_1	-0.057	-0.143**	-0.057*	-0.087**	0.007
ϕ_2	-0.057*	-0.025	-0.026	-0.065*	0.001
D(LEURX(-1))*100	0.041*	0.103**	0.019	0.065**	0.044**
D(LEURX(-2))*100	0.033*	0.058**	0.005	0.025*	0.028**
D(LJPNX(-1))*100	0.050**	0.146**	0.039**	0.007	0.021
D(LJPNX(-2))*100	-0.007	0.004	-0.005	-0.006	-0.018
D(VIX(-1))	-0.059**	-0.053**	-0.020**	-0.029**	-0.015**
D(VIX(-2))	-0.025**	-0.018**	-0.009	-0.014**	-0.012*
α_0	0.034**	0.002**	0.002**	0.002*	0.003**
α_1	0.403**	0.049**	0.122**	0.050**	0.149**
β_1	0.563**	0.934**	0.861**	0.923**	0.819**
$\alpha_1+\beta_1$	0.966	0.983	0.983	0.973	0.968
Mean dependent var	0.000	0.017	0.011	0.010	0.014
S.D. dependent var	0.701	0.423	0.425	0.268	0.303
S.E. of regression	0.702	0.401	0.421	0.264	0.299

Dependent Variable: D(LX)*100
Method: ML - ARCH (BHHH) - Generalized error distribution (GED)
Included observations: 1822 after adjustments
GED parameter fixed at 1.5
* significant at 10 percent.
** significant at 5 percent.

Table 6. East Asia: Forex Returns and VIX

AR(2)-GARCH(1,1) Models
Sample period: 2001–03Q2

Variable	IDN	KOR	PHL	SGP	THA
ϕ_0	0.012	0.021	-0.019	-0.007	0.016
ϕ_1	-0.025	-0.152**	-0.101*	-0.039	-0.026
ϕ_2	-0.082	-0.048	-0.052	-0.002	0.044
D(LEURX(-1))*100	0.016	0.010	-0.004	0.053**	0.035
D(LEURX(-2))*100	0.020	0.039	-0.004	0.027	0.031
D(LJPNX(-1))*100	0.027	0.194**	0.066**	-0.020	0.026
D(LJPNX(-2))*100	-0.001	-0.011	-0.022	-0.018	-0.050*
D(VIX(-1))	-0.037*	-0.022	-0.005	-0.015*	-0.016*
D(VIX(-2))	-0.012	-0.009	0.001	-0.021**	-0.015*
α_0	0.091**	0.010	0.006**	0.004	0.005**
α_1	0.533**	0.043*	0.219**	0.049*	0.090**
β_1	0.465**	0.908**	0.756**	0.905**	0.843**
$\alpha_1+\beta_1$	0.998	0.952	0.976	0.954	0.934
Mean dependent var	0.021	0.009	-0.008	-0.002	0.005
S.D. dependent var	0.972	0.495	0.586	0.283	0.300
S.E. of regression	0.979	0.480	0.585	0.281	0.297

Dependent Variable: D(LX)*100
Method: ML - ARCH (BHHH) - Generalized error distribution (GED)
Sample (adjusted): 1/05/2001 6/30/2003
Included observations: 647 after adjustments
GED parameter fixed at 1.5
*: significant at 10 percent.
**: significant at 5 percent.

Table 7. East Asia: Forex Returns and VIX

AR(2)-GARCH(1,1) Models
Sample period: 2003Q3–07

Variable	IDN	KOR	PHL	SGP	THA
ϕ_0	-0.009	0.023*	0.009	0.024**	0.010
ϕ_1	-0.068	-0.157**	-0.055	-0.138**	0.025
ϕ_2	-0.040	-0.009	-0.019	-0.101**	-0.021
D(LEURX(-1))*100	0.046*	0.132**	0.024	0.076**	0.047**
D(LEURX(-2))*100	0.034	0.060**	0.007	0.029	0.028*
D(LJPNX(-1))*100	0.064**	0.135**	0.027*	0.025	0.019
D(LJPNX(-2))*100	-0.020	0.015	-0.000	-0.004	-0.004
D(VIX(-1))	-0.067**	-0.066**	-0.037**	-0.045**	-0.011*
D(VIX(-2))	-0.032**	-0.026**	-0.021*	-0.015*	-0.008
α_0	0.029**	0.003**	0.001*	0.001	0.003**
α_1	0.331**	0.049**	0.080**	0.044**	0.215**
β_1	0.552**	0.925**	0.913**	0.936**	0.773**
$\alpha_1+\beta_1$	0.883	0.974	0.993	0.980	0.989
Mean dependent var	-0.011	0.021	0.022	0.017	0.019
S.D. dependent var	0.493	0.378	0.301	0.260	0.304
S.E. of regression	0.484	0.349	0.295	0.253	0.302

Dependent Variable: D(LX)*100
Method: ML - ARCH (BHHH) - Generalized error distribution (GED)
Sample: 7/01/2003 12/31/2007
Included observations: 1175
GED parameter fixed at 1.5
* significant at 10 percent.
** significant at 5 percent.

Table 8. East Asia: Forex Returns and VDAX

AR(2)-GARCH(1,1) Models, 2 lags
Sample period: 2001–07

Variable	IDN	KOR	PHL	SGP	THA
ϕ_0	-0.005	0.021*	0.001	0.013*	0.012*
ϕ_1	-0.062*	-0.152**	-0.058*	-0.071*	0.011
ϕ_2	-0.060*	-0.028	-0.033	-0.068*	-0.002
D(LEURX(-1))*100	0.050**	0.111**	0.019	0.067**	0.046**
D(LEURX(-2))*100	0.026	0.059**	0.005	0.021	0.024*
D(LJPNX(-1))*100	0.050**	0.149**	0.041**	-0.000	0.018
D(LJPNX(-2))*100	-0.005	0.015	-0.004	-0.005	-0.015
D(VDAX(-1))	-0.050**	-0.061**	-0.014**	-0.023**	-0.014**
D(VDAX(-2))	-0.021*	-0.018*	-0.003	-0.003	-0.007
α_0	0.031**	0.003**	0.002**	0.002**	0.003**
α_1	0.377**	0.051**	0.134**	0.051**	0.155**
β_1	0.590**	0.929**	0.849**	0.921**	0.812**
$\alpha_1+\beta_1$	0.968	0.980	0.984	0.971	0.968
Mean dependent var	0.001	0.017	0.012	0.010	0.014
S.D. dependent var	0.701	0.423	0.425	0.268	0.303
S.E. of regression	0.702	0.400	0.422	0.265	0.300

Dependent Variable: D(LX)*100
Method: ML - ARCH (BHHH) - Generalized error distribution (GED)
Included observations: 1823 after adjustments
GED parameter fixed at 1.5
*: significant at 10 percent.
**: significant at 5 percent.

Table 9. East Asia: Forex Returns and VDAX

AR(2)-GARCH(1,1) Models, 2 lags
Sample period: 2001–03Q2

Variable	IDN	KOR	PHL	SGP	THA
ϕ_0	0.011	0.019	-0.019	-0.005	0.016
ϕ_1	-0.022	-0.155**	-0.101*	-0.036	-0.014
ϕ_2	-0.063	-0.039	-0.054	-0.010	0.036
D(LEURX(-1))*100	0.005	0.016	-0.006	0.057**	0.037*
D(LEURX(-2))*100	0.008	0.053	-0.004	0.020	0.025
D(LJPNX(-1))*100	0.033	0.204**	0.066**	-0.019	0.025
D(LJPNX(-2))*100	-0.001	-0.010	-0.022	-0.015	-0.047*
D(VDAX(-1))	-0.022	-0.045**	-0.002	-0.015*	-0.014*
D(VDAX(-2))	-0.005	-0.013	0.001	-0.003	-0.003
α_0	0.092**	0.008	0.006**	0.004	0.004**
α_1	0.517**	0.043*	0.238**	0.051*	0.088**
β_1	0.472**	0.916**	0.740**	0.898**	0.851**
$\alpha_1+\beta_1$	0.989	0.959	0.979	0.949	0.939
Mean dependent var	0.022	0.010	-0.007	-0.003	0.006
S.D. dependent var	0.971	0.495	0.586	0.282	0.300
S.E. of regression	0.978	0.475	0.585	0.281	0.298

Dependent Variable: D(LX)*100
Method: ML - ARCH (BHHH) - Generalized error distribution (GED)
Sample (adjusted): 1/04/2001 6/30/2003
Included observations: 648 after adjustments
GED parameter fixed at 1.5
*: significant at 10 percent.
**: significant at 5 percent.

Table 10. East Asia: Forex Returns and VDAX

AR(2)-GARCH(1,1) Models, 2 lags
Sample period: 2003Q3–07

Variable	IDN	KOR	PHL	SGP	THA
ϕ_0	-0.012	0.022*	0.008	0.023**	0.010
ϕ_1	-0.084*	-0.174**	-0.046	-0.121**	0.022
ϕ_2	-0.058	-0.020	-0.026	-0.114**	-0.023
D(LEURX(-1))*100	0.065**	0.150**	0.031*	0.084**	0.047**
D(LEURX(-2))*100	0.029	0.055**	0.006	0.027	0.023
D(LJPNX(-1))*100	0.057**	0.131**	0.022	0.011	0.017
D(LJPNX(-2))*100	-0.015	0.032	0.001	-0.001	-0.000
D(VDAX(-1))	-0.065**	-0.072**	-0.032**	-0.037**	-0.010
D(VDAX(-2))	-0.036**	-0.028*	-0.008	-0.010	-0.013*
α_0	0.030**	0.004**	0.001*	0.001*	0.003**
α_1	0.337**	0.051**	0.084**	0.049**	0.232**
β_1	0.545**	0.917**	0.909**	0.930**	0.758**
$\alpha_1+\beta_1$	0.882	0.968	0.993	0.979	0.991
Mean dependent var	-0.011	0.021	0.022	0.017	0.019
S.D. dependent var	0.493	0.378	0.301	0.260	0.304
S.E. of regression	0.484	0.349	0.298	0.256	0.302

Dependent Variable: D(LX)*100
Method: ML - ARCH (BHHH) - Generalized error distribution (GED)
Sample: 7/01/2003 12/31/2007
Included observations: 1175
GED parameter fixed at 1.5
*: significant at 10 percent.
**: significant at 5 percent.

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