Covered Interest Parity and Market Volatility: Asian Evidence

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Abstract

This paper presents some empirical evidence on the covered interest parity and a dynamic GARCH model to gauge the degree of capital mobility and its volatility in seven East Asia economies. The results show that Hong Kong and Singapore have fairly mobile capital markets while the other economies exhibit financial openness only to a certain extent. The results also indicate that financial integration has been broadly enhanced among these markets following their liberalizations. However, except for Hong Kong, the degree of capital mobility in all markets has not yet returned to the level before the Asian crisis.

JEL classifications: F21; F36

Keywords: East Asia; Capital mobility; Covered interest parity; GARCH model

1. Introduction

East Asia is widely thought to have been moving towards closer financial market integration since most economies in the region began liberalizing their financial sector in the 1980s and completed most of these reforms by 1990. Singapore took a leading role, starting liberalizing its financial sector and abolishing capital controls in the 1970s. Hong Kong, Indonesia, Malaysia, the Philippines and Thailand followed suit with major reforms in the 1980s, whereas Korea undertook more gradual measures towards financial liberalization that was intensified during the early 1990s.

There is a substantial body of applied research on financial market integration and international capital mobility. However, the existing literature has been focusing narrowly on developed economies, which are already open and integrated. Tests of capital mobility in the context of East Asia emerging economies are relatively deficient albeit expanding. For instance, estimations for six East Asia countries can be found in Montiel (1994),[1] which measures saving-investment correlations for the period 1970-1990. Chinn and Frankel (1994) reports covered interest differentials for Hong Kong, Malaysia and Singapore, where forward exchange markets have already well developed. The uncovered interest differentials for Korea, Malaysia, Singapore and Thailand are examined by Faruqee (1992). The results in these studies appear to have the common ground that there is substantial integration between the domestic and the international financial markets in Hong Kong, Malaysia and Singapore, yet the views are divided in the case of Korea, the Philippines and Thailand.

The current paper investigates the extent of capital mobility in a group of seven East Asia

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[1] Altogether over fifty developing countries are studied.

emerging markets. Inferences are based on the covered interest parity condition, which is hailed as the best way to gauge capital mobility. Our findings corroborate that Hong Kong and Singapore have fairly high capital mobility. However, Malaysia, Korea and Thailand only exhibit limited degree of financial openness. As for Indonesia and the Philippines, they are much less internationally financially integrated. Furthermore, this paper achieves a compelling objective of how capital mobility has evolved over time, specifically for those markets that experienced sharp downward movements in financial prices and underwent economic contractions during the 1997-98 Asian financial crisis. As an empirical examination of capital mobility using up-to-date dataset for East Asia emerging markets, our study essentially adds to a thorough understanding of the underlying forces that drive capital across borders in the event of financial crisis.

The paper is organized as follows. Section 2 discusses the methodological issues. Section 3 presents the dataset and analyzes the empirical results of capital mobility based on the covered interest parity condition. And then the market volatility using a GARCH model is assessed. Finally, summary and some policy implications are drawn in the conclusions.

2. Methodological Issues

The essence of financial liberalization and integration is increased capital mobility and relatively open capital accounts. The basic characteristic of an integrated financial market is that the rates of return on similar assets have to be the same across different countries. This is because as markets become more open and unified, differences in rates of return should only reflect such fundamental factors as differences in asset quality, risk and so on. Thus, it is natural to examine interest parity conditions for evidence of capital mobility. The convergence of returns is typically measured by covered interest parity (CIP) and uncovered interest parity (UIP). Under CIP, interest rates across countries are equalized when contracted in a common currency, say, US dollars; while under UIP, expected rates of returns are equalized without the exchange rate risk. That is, the interest rate spread between two currencies is equal to the difference between the expected future and the current exchange rates.

As pointed out by Frankel (1992) and Obstfeld (1995), all but covered interest parity tests cannot be interpreted unambiguously as tests of a country's integration into the world capital market. CIP, in essence, states that capital flows should equalize returns on assets with equal maturity and default risk across countries, once currency risk has been eliminated by hedging the transaction through the use of forward contracts. Since the transaction is almost riskless (only subject to default risk), CIP is usually considered to be an arbitrage condition and deviations from CIP are regarded as reflecting barriers to cross-border capital flows.

However, the main difficulty in testing for covered interest parity has been that liquid forward foreign exchange markets with publicly quoted prices were not in existence until recently for most East Asia emerging markets. Hence, the related studies for East Asia have been restricted basically to the examination of uncovered interest parity condition, which provides little information about the degree of capital mobility if there is risk premium.[2] As capital markets become more integrated, one

[2] Dooley and Isard (1980), Hansen and Hodrick(1980) are among the many papers which reject uncovered interest parity for

possibility is that assets denominated in different currencies become more substitutable. This has the effect of lowering risks and reducing interest differentials. Consequently a tightening in the covered interest differential over time would be associated with an increasing level of capital mobility and is conducive to growing financial integration of the home currency vis-à-vis the rest of the world.

We begin from covered interest parity (CIP) hypothesis, which holds if the forward premium or discount equals the difference between the domestic and the foreign nominal interest rates. CIP is a direct consequence of covered interest arbitrage. Based on the pure arbitrage argument, CIP can be expressed as:

$$F_{t,\ t+k} / S_t = (1 + I_{t,\ k}) / (1 + I^*_{t,\ k}) \tag{1}$$

where S_t is the spot exchange rate at time t denoted as domestic currency per unit of foreign currency; $F_{t,\ t+k}$ is the forward exchange rate at time t for delivery of the foreign currency at time $t+k$; and $I_{t,\ k}$ and $I^*_{t,\ k}$ are the domestic and the foreign interest rates respectively at time t for k-period maturity. Moreover, the domestic asset, the foreign asset and the forward contract all have the same maturity, and it is assumed that the securities are identical except for the currencies in which future payments are denominated.[3] Taking the logarithm of Equation (1) yields Equation (2):

$$f_{t,\ t+k} - s_t = i_{t,k} - i^*_{t,k} \tag{2}$$

open markets, arguing that rejection would appear to be due to time-varying currency risk premium or non-rationally formed expectations about exchange rate movement.

[3] In reality, one of the causes of the Asian financial crisis is the "double mismatch" of currencies and maturities. It has been observed that long-term local investments were financed with short-term dollar loans.

If the domestic nominal interest rate is higher than the foreign nominal interest rate, the higher domestic nominal interest rate will be offset by a forward discount. For simplicity, we rewrite Equation (2) as follows:

$$i_{t,k} = i^*_{t,k} + fd_{t,\ t+k} \qquad (3)$$

where $fd_{t,\ t+k}$ is the forward discount, i.e. $f_{t,\ t+k} - s_t$ in Equation (2), on the domestic currency. The covered interest differential (CID) can therefore be defined as:

$$CID = i_{t,k} - i^*_{t,k} - fd_{t,\ t+k} \qquad (4)$$

According to Frankel (1992), national barriers, such as capital controls, transaction costs, information costs, default risk, to full integration of financial markets would lead to deviations from CID. Otherwise, the covered interest rate differential should be zero if well-integrated financial markets exist. If CID < 0, the rate of return on home assets is lower than foreign assets, indicating capital outflows from the home country. Similarly, there tends to be capital inflows if CID > 0. CID will vary over time and therefore it can be used as a measure of dynamic capital mobility.

Finally, financial returns tend to exhibit periods of relative volatility and stability, and this suggests that estimation can be made more efficient by modeling a generalized autoregressive conditional heteroscedasticity (GARCH) framework. Along with interest parities, we also take a look at the conditional variance of such differentials to measure dynamic capital mobility. With greater capital mobility, not only covered differential rates but also the variance would decline over time. If we denote y generically as the differential from the covered interest parity, a time series model that captures the autoregressive (AR) structure in both the mean and the variance can be written as:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_h y_{t-h} + \xi_t, \quad \xi_t \sim N(0, \sigma^2_t) \tag{5}$$

$$\sigma_t^2 = \beta_0 + \sum_{i=1}^{q} \beta_1 \xi_{t-i}^2 + \sum_{j=1}^{p} \beta_2 \sigma_{t-j}^2 \tag{6}$$

where $\sum \beta_1 \xi_{t-i}^2$ is the ARCH term (the squared error term in the previous time period) of q order, generally being news about volatility from the previous period; $\sum \beta_2 \sigma_{t-j}^2$ is the GARCH term (the conditional variance in the previous time period) of p order. Thus, y_t follows an AR (h) process with a conditional variance equation described by a GARCH (p, q) process. The GARCH model is implemented via maximum likelihood estimation of the log likelihood function. The estimated conditional variance σ^2_t will give us an indication of the evolution of capital mobility. In this paper, GARCH (1, 1) model is adopted, which is sufficient to capture the dynamics of the conditional variance of y.

3. Empirical Results

3.1 Data

Monthly data are used in the testing of the covered interest parity condition. The domestic interest rates used for the seven East Asia markets[4] are three-month market interest rates from the *International Financial Statistic CD-ROM* of IMF, while the 91-day Treasury bill rates are used for the Philippines due to its data availability. The foreign interest rates are three-month interbank offered US dollar interest rates in London market (LIBOR) from US *Federal Reserve Board of Governors.* Spot exchange rates are taken from the end of period and forward exchange rates are monthly

[4] Test of covered interest parity for China has been excluded because of incomplete forward exchange rate data.

three-month forward rates. The exchange rates data for East Asia emerging markets examined in this paper are all retrieved from *Reuters*, though the time span for each country varies.

The sample covers monthly data from January 1990 to June 2003 in light of the tremendous financial liberalization process and unstable financial structural changes in East Asia. Intending to capture the dynamic changes before and after the Asian financial crisis, we partition the interest rate observations into three sub-periods: the pre-crisis period (January 1990 - December 1996), the crisis period (January 1997 - December 1998) and the post-crisis period (January 1999 - June 2003). Though the disaster in East Asia originated from Thailand in mid-1997, the Thai baht had been under speculative attack for several months before its final collapse and the speculative pressure transmitted rapidly to the rest of the region. Therefore, we regard the time period up to the end of the year of 1996 as the period of relative stability.

The properties of the dataset are examined before the analysis of the empirical results. We employ Phillips–Perron (PP) test, which corrects, in a non–parametric way, any possible presence of autocorrelation in the standard ADF test. It is found that the null hypothesis of one unit root cannot be rejected in most of the time series.[5] The only exception is the market interest rate for Hong Kong.

3.2 Test of covered interest parity results

For the post-liberalization period, we explicitly investigate the extent to which covered interest rate parity (CIP) holds in each emerging market since the early 1990s. We begin the examination by

[5] To conserve space, the unit root test results are not presented here but are available upon request.

checking the means and the standard deviations of the covered interest differentials over the full sample. The results are reported in Table 1. We find that the mean differentials are generally positive and different from zero in East Asia except for Singapore, suggesting that the rates of return on domestic assets have been generally higher than the covered rate on US assets and hence some sort of domestic control on capital inflows into these economies. The likely explanation for negative CID in Singapore is that Singaporean commercial banks, for instance, have maintained the lowest returns on their deposit rates for the most part. Apart from a low inflationary environment, the relatively stable currency and overall macroeconomic climate are all contributory factors that lead to a negative CID rate.

Since mean differentials may mask deviations of opposite signs, we also report the average absolute means. The larger the absolute value of CID, the higher capital or foreign exchange control in that country, and therefore the lower capital mobility. The results reveal that Hong Kong and Singapore are by far the most integrated capital markets in East Asia over the entire period because of their smallest CID rates in absolute terms. This is not surprising given that they are two regional financial centers and have fairly open economic systems. Due to limited forward data obtained on Korea, its results are not directly comparable with the others for the whole sample. In contrast with the numbers for Hong Kong and Singapore, the absolute deviations from CIP for Thailand, the Philippines, Malaysia and Indonesia are quite substantial. It is clear that they are induced mainly by significant spreads against US interest rates under the high interest rate policy adopted in these markets.

As mentioned previously, it is of great interest to see the intertemporal evolvement of the CIDs, especially during the 1997-98 financial crisis, therefore we break down the full sample into three sub-periods: the pre-crisis period, the crisis period and the post-crisis period. Inspection of the plots in Figure 1 shows that the CIDs all spiked up and reached record-high levels during the Asian financial crisis. A combination of sharply weakened currencies and high interest rates stance in the midst of the financial crisis led to dramatically increased CIDs. Indonesia and the Philippines, in particular, witnessed extended periods of exceptionally large positive deviations from CIP. It is noted that these two countries traditionally tend to have high interest rate policies, reflecting a country premium required for holding the assets in these two countries. It may very well explain why the Indonesian rupiah and the Philippine peso devalued a lot in the past.

The CID results are contained in Table 2. A much clearer picture emerges due to the split of the sample — the markets became more segmented during the crisis period as the CIDs exhibit sizeable deviations from the covered interest parity condition compared with those in the pre-crisis period. For example, the differentials for Indonesia and Malaysia went up by a striking 100 percent and 300 percent respectively. Factors that may have contributed to the considerable upward swing in CIDs during this period include the continued high degree of foreign exchange volatility tied to increased concerns regarding sustainability and stability, coupled with the adopted high interest rate policy intended to bring about capital inflows. All these East Asia markets under analysis become somewhat more insulated than in the pre-crisis period, mirroring imperfect capital mobility triggered by the currency crisis.

The results for the post-crisis period are mixed. On the one hand, the lowering of interest rates in many markets after the crisis and the recovery of these currencies against the US dollar are responsible for declining CID rates, as we compare the post-crisis period with the crisis period. On the other hand, if the pre-crisis period is picked as the benchmark level, one notable exception would be Hong Kong, which shows a higher degree of capital mobility (smaller CID in absolute terms). Indonesia, Malaysia, the Philippines, Singapore and Thailand all have slightly larger differentials from the covered interest parity. It signals that the degree of capital mobility in each of these markets has failed to return to the pre-crisis level.

3*.3 GARCH model test results*

Our unit root test results[6] show that covered interest differentials for most markets are non–stationary series at levels, or *I (1)*. Thus we fit an autoregressive process with GARCH residuals. The rationale for adopting the GARCH approach is that, firstly, it addresses the issue of heteroscedasticity of the data; and secondly, it has the additional advantage that allows the checking of the volatility of differentials from covered interest parity. Table 3 presents the estimation of the AR model in Equation 5 for East Asia markets and the dependent variables are CID rates. We can see that most CID rates are driven by AR (1) processes with exceptions for Malaysia and Thailand, where the CID rates follow AR (2) processes. It is also identified that most of the estimated coefficients are highly significant and all the diagnostic statistics are reasonable.

Table 4 exhibits the results of the GARCH model. The GARCH model is jointly implemented

[6] To conserve space, the unit root test results are not presented here but are available upon request. Note that the order of autoregressive process is based on a well–established selection criterion: Akaike information criteria.

using maximum likelihood of the log likelihood function. Numerical maximization is completed through the algorithm developed by Bollerslev (1986) to get the final parameter estimates. The estimated conditional variance σ^2_t gives us an indication of the changing conditions for capital mobility. Figure 2, which plots out the GARCH conditional variance for each East Asia market, confirms our earlier finding that all markets experienced substantial volatilities between 1997 and 1998. The conditional heteroscedasticities jumped to extremely high levels, reflecting sudden increased capital market risks and decreased capital mobilities during the financial crisis. Indonesia and Malaysia are considered to be the markets that had the most drastic movements in conditional variances. The continued higher degree of foreign exchange volatility and the upward swing in interbank rates during the financial crisis have more or less played important roles in this setting.

4. Concluding Remarks

Existent tests of capital mobility in East Asia emerging markets are *de facto* quite few. Thus, there is scope for this paper to contribute to the ongoing exploration of the openness of the East Asia capital market and its integration with the rest of the world in the wake of various liberalization measures taken in each economy. Our main concern is to see whether these markets have become more integrated into the world capital market since the 90s, and especially how the degree of capital mobility has changed after the fallout of the 1997-98 financial crisis. By measuring the deviations from the covered interest parity and modeling CIDs in a GARCH framework, the following conclusions have been derived from our analysis:

First, it is noted that Hong Kong and Singapore are highly integrated with the world market, while Korea, Malaysia and Thailand exhibit financial openness only to a certain extent. On the other hand, the lower income countries, Indonesia and the Philippines are acknowledged to be relatively less financially integrated. Specifically, these two countries have been implementing extensive capital control measures and are not financially integrated with the rest of the world.

Second, the period between 1990 and 2003 is characterized by decreasing capital mobility in the majority of the markets under study. Covered interest differentials after the 1997-98 Asian crisis fail to resume their pre-crisis levels. For those countries that incurred heavy losses from the financial crisis, namely Indonesia, Malaysia, the Philippines, Singapore and Thailand, larger covered interest differentials are found.

At least two relevant policy implications from this study should be put on these governments' agenda. Historically, countries with capital controls, in general, tend to have higher real interest rates than do those with free markets. This implies higher costs of capital and constitutes an impediment to growth as the financial markets are liberalized. Thus, single-mindedly pursuing a high fixed domestic interest rate may make the domestic economy more vulnerable with exposure to concomitant external shocks. Capital control cannot serve as a panacea and should not be exercised on a rigid, longer term basis. Another important lesson arises from the perspective of the exchange rate management. Since capital mobility is always associated with less volatile exchange rates and lower foreign exchange risk, for prudent East Asia policymakers, maintaining a stable exchange rate system calls for more supervision in order to meet the challenges posed by financial integration.

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Table 1. Covered Interest Differentials in East Asia (full sample)

Country	***Period***	***Mean***	***s.d.***	***Absolute Mean***	***s.d.***
Hong Kong	90M5-03M6	0.02	0.21	0.13	0.16
Indonesia	95M3-03M6	1.26	0.61	1.26	0.62
Korea	00M2-03M6	0.38	0.39	0.45	0.29
Malaysia	93M5-03M6	0.38	0.18	0.42	0.49
Philippines	96M3-03M6	0.81	0.28	0.81	0.28
Singapore	93M5-03M6	-0.24	0.42	0.37	0.29
Thailand	95M3-03M6	0.03	0.67	0.56	0.37

Table 2. Dynamic Changes of CIDs in East Asia

	Pre-crisis period		**Crisis period**		**Post-crisis period**	
Country	*Mean*	*Absolute Mean*	*Mean*	*Absolute Mean*	*Mean*	*Absolute Mean*
Hong Kong	-0.03	0.13	0.27	0.29	-0.01	0.06
	(0.18)	(0.12)	(0.29)	(0.27)	(0.09)	(0.07)
Indonesia	0.82	0.82	1.79	1.79	1.20	1.20
	(0.08)	(0.08)	(0.68)	(0.68)	(0.55)	(0.55)
Korea	*n.a.*	*n.a.*	*n.a.*	*n.a.*	0.38	0.45
					(0.39)	(0.29)
Malaysia	0.11	0.16	0.67	0.67	0.49	0.53
	(0.18)	(0.13)	(0.59)	(0.59)	(0.58)	(0.55)
Philippines	0.75	0.75	0.86	0.86	0.80	0.80
	(0.08)	(0.08)	(0.24)	(0.64)	(0.32)	(0.32)
Singapore	-0.21	0.26	0.12	0.47	-0.42	0.43
	(0.22)	(0.18)	(0.54)	(0.28)	(0.38)	(0.37)
Thailand	0.47	0.47	0.70	0.76	-0.46	0.50
	(0.20)	(0.20)	(0.48)	(0.37)	(0.45)	(0.39)

Notes:

1. Pre-crisis period: 1990M1 - 1996M12. Crisis period: 1997M1 - 1998M12. Post-crisis period: 1999M1 - 2003M6.
2. Standard errors are in parentheses.
3. Tests on Korea before and during the crisis have been excluded due to incomplete forward exchange rate data.

Table 3. Estimation of the AR Model for CIDs in East Asia

Dependent Variables (y_t)	α_0	α_1	α_2	**AIC**	$\bar{R}^2$	**D.W.**	**S.E. of regression**
CHK	0.03*	0.67*	-	-1.33	0.64	2.00	0.12
	(0.05)	(0.08)					
CIN	1.38*	0.86*	-	-0.11	0.87	1.98	0.22
	(0.38)	(0.10)					
CKO	1.26*	1.44*	-	-3.45	0.98	2.03	0.04
	(0.76)	(0.17)					
CMA	0.41*	0.98*	-0.31*	-1.54	0.78	2.00	0.25
	(0.22)	(0.09)	(0.01)				
CPH	0.92*	0.64*	-	-1.03	0.75	1.93	0.14
	(0.25)	(0.11)					
CSI	0.25*	0.75*	-	-0.37	0.78	2.01	0.19
	(0.16)	(0.09)					
CTH	-0.09*	0.74*	0.33*	-0.38	0.92	2.01	0.19
	(0.49)	(0.10)	(0.12)				

Notes:

1. Dependent variables are differentials from covered interest parity (CID) and follow AR processes: $y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_h y_{t-h} + \xi_t$
2. Standard errors are reported in parenthesis; * denotes significance at the 1 percent critical level
3. CHK, CIN, CKO, CMA, CPH, CSI, CTH stand for covered interest rate differentials of Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, Thailand respectively.

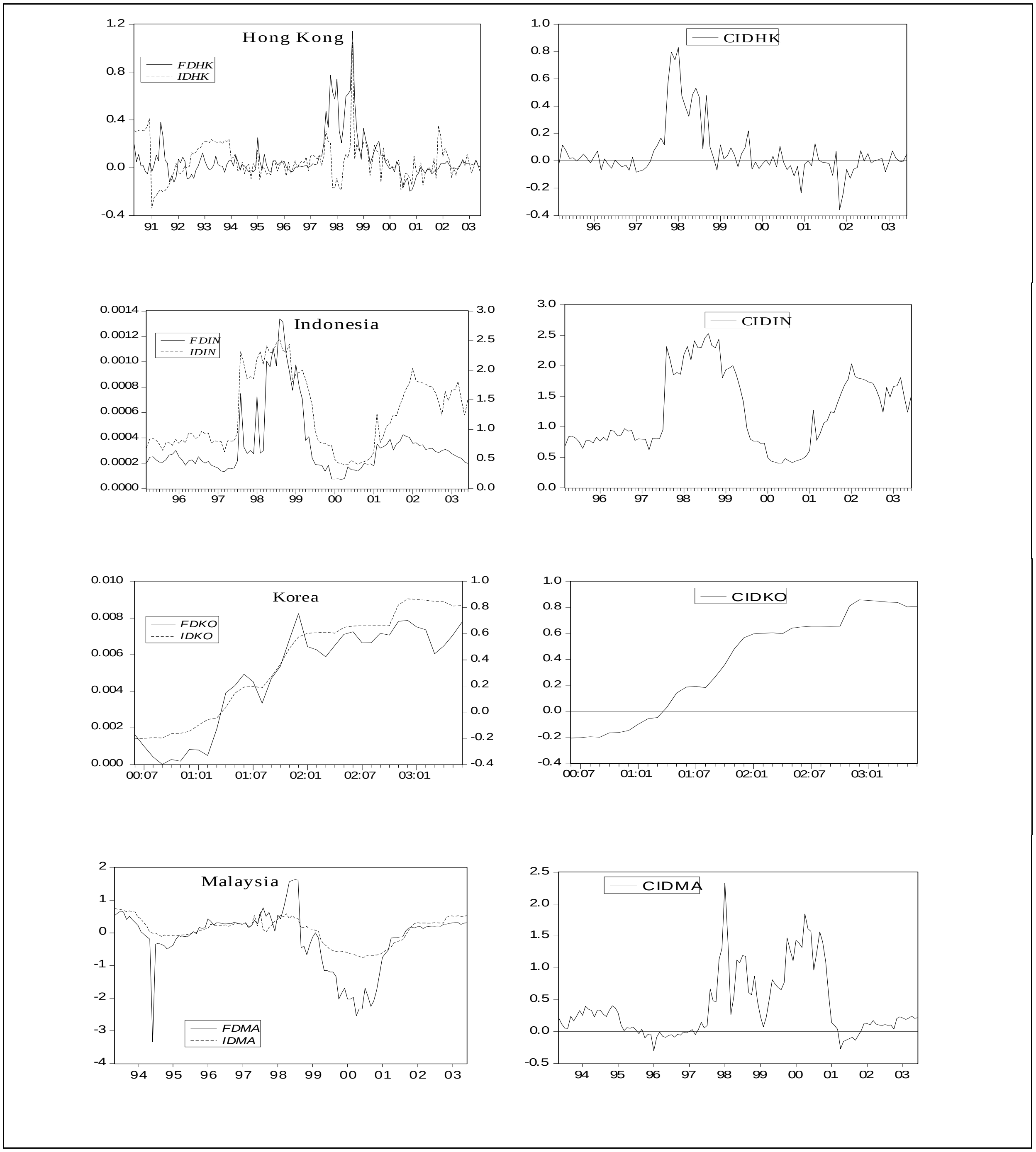
Table 4. Estimation Results of the GARCH Model

Dependent Variables (σ^2_t)	Parameters β_0	β_1	β_2	$\bar{R}^2$	D.W.	S.E. of Regressions
Hong Kong	0.0015	0.94	0.023	0.02	0.39	0.21
	(0.007)	(0.22)	(0.000)			
Indonesia	0.05	1.12	-0.08	4.29	0.02	1.42
	(0.052)	(1.36)	(1.37)			
Korea	0.009	1.44	-0.47	0.95	0.08	0.56
	(0.001)	(0.109)	(0.161)			
Malaysia	0.013	1.08	0.02	0.58	0.15	0.61
	(0.0002)	(0.067)	(0.07)			
Philippines	0.002	1.07	0.04	8.64	0.03	0.87
	(0.0006)	(0.06)	(1.88)			
Singapore	0.001	0.62	0.48	0.35	0.17	0.49
	(0.002)	(0.127)	(0.12)			
Thailand	0.001	0.19	0.26	0.85	0.08	0.68
	(0.003)	(0.03)	(0.03)			

Notes:

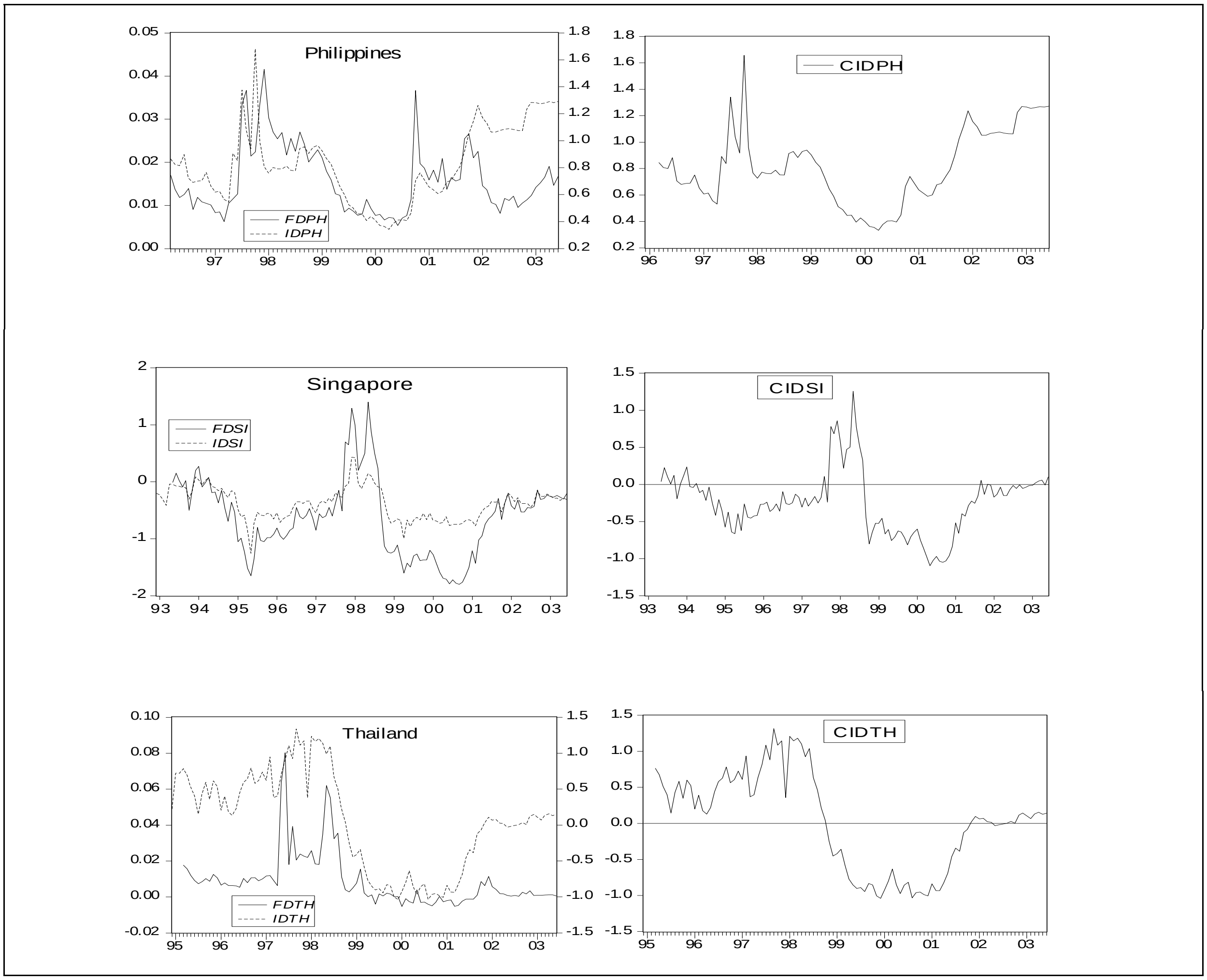
1. The GARCH (1, 1) model is $\sigma^2_t = \beta_0 + \beta_1\zeta^2_{t-1} + \beta_2\sigma^2_{t-1}$, and ζ^2_{t-1} is the residual variance from Table 3; algorithm developed by Bollerslev (1986).
2. Standard errors are reported in parenthesis.

Figure 1. Covered Interest Differentials in East Asia



Note: FD represents forward discount and ID represents interest rate differential.

Figure 1. Covered interest differentials in East Asia (continued)



Note: FD represents forward discount and ID represents interest rate differential.

Figure 2 GARCH Conditional Variance (σ^2_t)