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The Effect of Capital Flow Management Measures in Five Asian Economies on the Foreign Exchange Market

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Abstract

This paper examines the effects of the capital flow management measures (CFMs) introduced by five Asian economies (Indonesia, Korea, Malaysia, the Philippines and Thailand) to deal with large capital inflows on the foreign exchange market. Using the GARCH methodology, this paper models the changes in these economies' exchange rates against the US dollar with the eight CFMs from February 2010 to March 2011 as the focal explanatory variable. The empirical results show that four CFMs stabilised the exchange rates by reducing exchange rate volatility and one had an effect on the exchange rate level. However, their effects on the currency option market were mixed.

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1. Introduction

Since early 2009, emerging markets (EMs) have been experiencing large capital inflows due to both cyclical and structural reasons. On the cyclical side, in addition to extremely loose monetary policy adopted by advanced economies to alleviate the liquidity drain in the global financial crisis, the two-speed nature of the recovery from the crisis caused differentials in interest rates and growth between advanced economies and EMs. This has induced carry trades using low interest rate currencies (e.g. the US dollar) as the funding currency to invest in EM currencies. On the structural side, the subprime crisis in the US and the more recent sovereign debt crisis in the euro area have triggered institutional investors to purchase financial assets including bonds and equities in the EM.

While capital inflows could be beneficial to receiving economies, inflow surges also pose macroeconomic and financial risks, in particular exerting huge upward pressure on exchange rates leading to asset price inflation/bubbles. Inflows tend to be volatile and are typically concentrated in short-term maturity instruments. When risk sentiment changes, sharp reversals of capital flows could destabilise the exchange rates and asset markets.

Amid large capital inflows, EM policymakers use not only macro policies but also the capital flow management measures (CFMs) to alleviate the risks from large capital inflows. Habermeier at el. (2011) divide the CFMs into two categories: (i) residency-based CFMs refer to capital controls and (ii) other CFMs with prudential nature are designed to influence inflows. They study the effectiveness of the CFMs adopted by Brazil, Columbia, Korea and Thailand during the 2000s, and find that the CFMs had mixed success and the effectiveness decreased quickly over time.[1] Similarly, Pradhan et al. (2011) conclude that the effectiveness of CFMs introduced in Asian EMs was mixed.

This study uses a general autoregressive conditional heteroskedasticity (GARCH) model to assess the effectiveness of the eight CFMs adopted by five Asian economies including Indonesia, Korea, Malaysia, the Philippines and Thailand on the changes of exchange rate dynamics since early 2010. This approach to assessments is similar to those used in Clements and Kamil (2009), Edwards and Rigobon (2009) and Coelho and Gallagher (2010). Our model is simpler than their specifications as we only relate the exchange rate to its own dynamics without any external shocks in the mean equation. This is similar to the GARCH model specified by Hoshikawa (2008) in his study of the effect of official intervention on the Japanese yen.

In addition to assessing the effectiveness of the CFMs on actual exchange rate dynamics, we study how the CFMs affect the market expected exchange rate volatility from currency option prices. The information from the option-implied volatility could be utilised to compare with the realised volatility estimated from the GARCH model. Furthermore, we also use risk reversals to gauge risk aversion and market perceptions of uncertainty about the currencies due to the CFMs. Risk reversals measure

[1] Also see IMF Policy Paper February 2011 for wider discussions on CFMs.

the price difference between two equivalently out-of-the-money put and call options. A difference in these prices for a currency implies that market participants expect that a large movement of the currency in one direction is more likely than the other direction of the same size.

2. Data

As we investigate the effectiveness of CFMs on exchange rate dynamics, we collect the exchange rates series of the five selected Asian economies. They are daily closing prices of the Indonesian rupiah (IDR), Korean won (KRW), Malaysian ringgit (MYR), Philippine peso (PHP) and Thai baht (THB) against the US dollar from Bloomberg in the period from 9 January 2006 to 27 June 2011. Since daily data is very noisy, we convert the daily closing rate into a weekly average and calculate the return, i.e. the log difference of the weekly average rate. These returns are then used in the GARCH model to produce the realised volatility to reveal the effectiveness of CFMs.

The CFMs may also affect market expected volatility which is implied from currency option prices. Option-implied volatility series of the three-month at-the-money options of the five currencies are collected in the same sample period as the exchange rates.[2] The series are then converted into weekly averages for comparison with the realised volatility of spot exchange rates. In order to explore whether the introduction of the CFMs alters investors' perceived risk of the five currencies, we compute the three-month 10-delta risk reversals by subtracting the implied volatility of call options from that of put options of the five currencies for analysis.[3]

3. GARCH Model

To gauge the effectiveness of the CFMs on capital flows, we investigate whether they have any effects on the level or volatility of the exchange rates of the five selected Asian economies. Using a method similar to Clements and Kamil (2009),[4] we estimate GARCH models of the returns of weekly average exchange rates. GARCH models are widely used in modelling time-varying volatility in financial asset returns, which generalise the seminal autoregressive conditional heteroskedasticity (ARCH) model developed by Engle (1982).[5]

Specifically, we use a GARCH(1,1) to capture the effect of the CFMs on the level and volatility of exchange rates as follows:

[2] The option data are from JPMorgan Chase.

[3] The risk-neutral probability of the underlying ending in-the-money is roughly equal to the delta of the option. For example, a 10-delta put option has approximately a 10% probability of in-the-money at maturity. This approximation holds well for a short time to maturity.

[4] Clements and Kamil (2009) study whether capital controls were effective for Colombia.

[5] See Engle (2001).

$$R_t = c + \sum_{i=1}^{p} \gamma_i R_{t-i} + \delta CFM + \varepsilon_t \quad (1)$$

$$\varepsilon_t \sim N(0, h_t^2)$$

$$h_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1}^2 + \delta CFM \quad (2)$$

$$\omega \succ 0; \alpha \geq 0; \beta \geq 0; \alpha + \beta \prec 1$$

where R_t is the return in the nominal weekly average exchange rate; h_t^2 is the conditional variance which allows for the possibility of time-varying conditional volatility; ε_t is the residual in Eq. (1) (i.e. the mean equation) and assumed to be uncorrelated normally distributed. As a proxy for the CFMs, we use a dummy variable CFM that takes a value of 1 in the week and the following few weeks when the CFM is imposed and zero otherwise. If the CFM is effective, the dummy variable will be significant in either Eq. (1) or Eq. (2) (i.e. the variance equation).

For simplicity, the specification of Eq. (1) is a pure autoregressive model which allows us to analyse the effect of the CFM on the level of exchange rates and also produce serially uncorrected residuals for the estimation of Eq. (2). As the focus of this study is not to explain the determinants of the dynamics of the exchange rate but only the effectiveness of the CFMs, this simple specification is considered as adequate. While some economies changed their policy rates some time (usually a few months) after the introduction of the CFMs, these changes do not affect the estimations as the effect of the CFMs was rather short-lived and lasted only for a few weeks as shown in the results in the next section. Therefore, the impact of the changes in policy rates should be immaterial.

In GARCH(1,1), Eq. (2) relates the current period variance with the weighted average of the long-term variance, the variance and squared residual of the previous period. The parameters ω, α, β must be estimated and updated by the model every period using the maximum likelihood method. However, if $\alpha + \beta$ is very close to unity, the impact of past squared shocks on the squared residual will be highly persistent. In this case, we will restrict the sum to be unity and drop ω in order to obtain the integrated GARCH (IGARCH) model. The strong persistence might be caused by occasional level shifts in volatility that could be the characteristics in some of our selected exchange rates because of the severe turmoil in currency markets during the global financial crisis in late 2008.

4. GARCH Model Empirical Results

Using the information of policy responses to capital flows in the five Asian economies reported in Pradhan et al. (2011), we apply the GARCH models to evaluate the effectiveness of the CFMs introduced by the authorities. These CFMs are prudential in nature to influence inflows. For clarity reasons, we only report the results with statistically significant CFM dummy variables in Table 1. The

details of the CFMs are in the Appendix. As there is no announcement of the end of the CFMs, they are considered to be effective throughout the estimation period.

Indonesia imposed two CFMs in response to large capital inflows. The first measure (CFM1) of a minimum holding period for central bank bills was implemented in June 2010 to limit the volatility of inflows as ample liquidity went into short-term central bank debt securities. In March 2011, the authorities adopted the second measure (CFM2) to limit bank vulnerabilities to inflow volatility. We first obtain a reasonable autoregression fit to Eq. (1) (the mean equation) as the residuals in the models with CFM1 and CFM2 (i.e. IDR(I) and IDR(II) models) are uncorrelated and pass the serial correlation test. Our results indicate that the two CFMs do not affect the level of the exchange rate, which are insignificant in the mean equation. Similarly, the autoregression fit to the mean equation in the estimated GARCH models of the other four selected economies all produce serially uncorrelated residuals. On the other hand, the estimates of Eq. (2) (the variance equation) of IDR(I) and IDR(II) models show that the measures reduced the volatility of the exchange rate as the measure dummy variable is significant at the one percent level with a negative sign. The effect, however, was rather short-lived and lasted only for a few weeks after the measure was introduced.

Announced in June and implemented in July 2010, the Korean authorities introduced CFM1 to limit the private sector's direct and indirect foreign exchange exposure. In January 2011, the authorities re-imposed the 14-percent withholding tax on foreign holdings of government bonds and central bank securities (CFM2) as a measure to restrict capital inflows through the government bond market. Our empirical results show that only the first measure was effective whereas the second measure was not. The CFM1 dummy variable is significant at the one percent level with a negative sign in the variance equation for the month of July 2010, indicating a reduction in the exchange rate volatility.

Malaysia raised the overseas investment limit of the Employment Provident Fund from seven percent to 20 percent in October 2010 to encourage outbound investment by residents in order to counteract large capital inflows. The GARCH regression shows that the measure was effective as it decreased the exchange rate volatility. The coefficient of the CFM dummy variable in the variance equation is significant at the 1 percent level with a negative sign.

The Philippines increased ceilings on residents' purchase of foreign currencies and assets from authorised agent banks in November 2010. This CFM is shown to have an effect on reducing the percentage appreciation of the exchange rate, with the CFM dummy variable significant at the one percent level in the mean equation of the GARCH model.

Lastly, Thailand implemented two CFMs in 2010. The first one (CFM1) was meant to raise the ceilings on residents' outward direct investment, lending abroad, and foreign currency holdings in February and September of 2010. The second measure (CFM2) re-imposed the 15-percent withholding tax on state bonds held by foreign investors in October 2010. Our estimates indicate that only the CFM2 dummy variable is significant in the mean equation, but with a positive sign (i.e. an increase in the appreciation of the THB) that is not consistent with the intention of the measure.

5. Option-Implied Volatility And Risk Reversals

In the previous section, the effectiveness of the CFMs are investigated based on the realised exchange rate volatility using the GARCH models. In this section we study whether the CFMs have any effect on the market expected volatility implied from the corresponding at-the-money options.

Figure 2 depicts the estimated GARCH volatility, the option implied volatility, and the CFM periods of the three selected economies—Indonesia, Korea and Malaysia—in which their CFMs reduce the realised volatility. From visual inspection, in the two panels on the left, the GARCH volatility and option-implied volatility were reduced simultaneously during the CFM effective periods. The correlations of their movements during the period are 0.14 for Indonesia(I) and 0.84 for Korea. In the other two panels, the movements of the GARCH volatility and option-implied volatility in the effective period diverge, with correlation of -0.54 for Indonesia(II) and -0.04 for Malaysia.

The reductions in option-implied volatility under the CFM1 of Indonesia and CFM1 of Korea demonstrate that the measures were effective in both the cash and option markets in terms of volatility reduction. However, such effect was not observed for the CFM2 of Indonesia and the CFM of Malaysia. This may imply that the currency option market is disconnected from the cash market in these two economies such that the effect of the CFMs on the two markets is different.

Low interest rates adopted by central banks in developed economies have increased carry trades to invest in EM currencies. Under the carry-trade strategy, investors tend to hold on to their long positions in EM currencies that are prevented from depreciating by capital inflows. Holding on to these positions appears profitable to each individual investor, since he does not know when others unwind their positions. As a consequence, the necessary price correction is delayed until a crash occurs when investors suddenly unwind their positions and fund flows reverse. More sophisticated investors (e.g. institutional investors) are aware of such crash risk in carry trades and would buy protection using out-of-the-money put options on the EM currencies to limit the possible losses associated with a crash. The greater the demand for put contracts, the greater will be their option-implied volatility (i.e. prices) than that of similar call contracts. Figure 1 illustrates the relationship between the three-month 10-delta risk reversals (which is the put-implied volatility minus the call-implied volatility) and the interest rate differentials (which is the simple average interest rate of the five Asian economies minus the US interest rate) before and after March 2009. It demonstrates that the risk reversals increased with the interest rate differentials after March 2009 across different EM currencies.

The results of the effect of the CFMs on the risk reversals are similar to those on option-implied volatility. Figure 3 shows that in the two panels on the left the GARCH volatility and risk reversals are reduced simultaneously during the CFM effective periods, where the correlations of their movements during the period are 0.98 for Indonesia(I) and 0.86 for Korea(I). In the two panels on the right, the

movements of the GARCH volatility and risk reversals in the CFM effective period diverge, with correlations stand at -0.52 for Indonesia(II) and -0.76 for Malaysia.

6. Conclusion

The aim of this paper is to clarify the effect of the eight CFMs introduced by the five Asian economies (Indonesia, Korea, Malaysia, the Philippines and Thailand) to deal with large capital inflows on the foreign exchange market. The effect of the CFMs on exchange rate volatility and the changes in exchange rates as a result of the CFMs from February 2010 to March 2011 are discussed. Empirical results suggest that four CFMs (introduced by Indonesia, Korea, Malaysia) stabilised the exchange rates by reducing volatility. The CFM introduced by the Philippines had an effect on the exchange rate level. However, by comparing the realised exchange rate volatility with the currency option-implied volatility and risk reversals, their effects on the currency option market were mixed.

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Table 1. Impacts of CFMs on the Exchange Rates of Indonesia, Korea, Malaysia, the Philippines and Thailand

Domestic Currency/USD – GARCH Regression Results

	IDR(I)		IDR (II)		KRW(I)		MYR		PHP		THB(I)
Mean Eqn.											
γ_{t-1}	0.23(0.05)***	γ_{t-1}	0.38(0.05)***	γ_{t-1}	0.24(0.06)***	γ_{t-1}	0.24(0.05)***	γ_{t-1}	0.17(0.06)***	γ_{t-1}	0.32(0.04)***
γ_{t-6}	-0.07(0.04)*	γ_{t-3}	0.13(0.04)***	γ_{t-4}	-0.09(0.04)**	γ_{t-13}	0.13(0.05)**	γ_{t-3}	0.11(0.04)**	γ_{t-8}	0.11(0.05)**
γ_{t-10}	-0.20(0.05)***	γ_{t-11}	0.14(0.06)**	γ_{t-8}	0.04(0.03)			γ_{t-9}	0.12(0.05)**		
γ_{t-14}	0.09(0.05)	γ_{t-14}	0.12(0.02)***	γ_{t-10}	-0.19(0.04)***						
δ									-6.7E-3(2.1E-3)***		3.5E-3(7.1E-4)***
Variance Eqn.											
ω			5.9E-5(3E-6)***		1.0e-5(3.7E-6)***						
α	0.14(0.01)***		0.71(0.08)***		0.34(0.07)***		0.03(0.01)***		0.09(0.02)***		0.16(0.02)***
β	0.86(0.01)***				0.64(0.07)***		0.97(0.01)***		0.91(0.02)***		0.84(0.02)***
δ	-1.7E-5(2.3E-6)***		-4.4E-5(1E-5)***		-1.2E-4(2E-5)***		-6.9E-6(3E-6)***				
CFM effective period	June 2010		March 2011 and June 2011		July 2010		October 2010		November 2010		February and September 2010
No. of Observation	271		271		275		272		276		277
Adj. R^2	0.12		0.14		0.08		0.06		0.06		0.001

Note: Asterisks denote significance of coefficients, with ***, ** and * indicating significance at the 1%, 5%, 10% level, respectively.

Figure 1. Put-Call Volatility Differentials (Risk Reversals) and Interest Rate Differentials

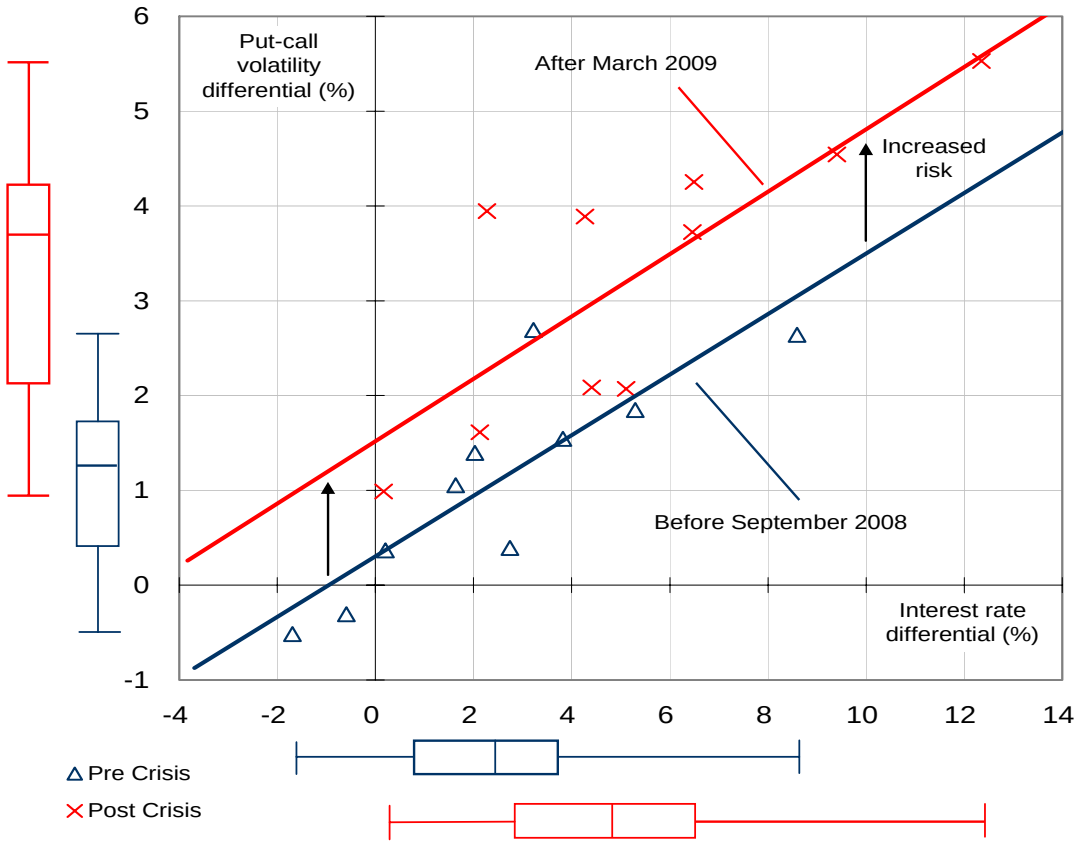


Figure 2. Realised Volatility from GARCH Models, Option Implied Volatility and Implemented CFMs

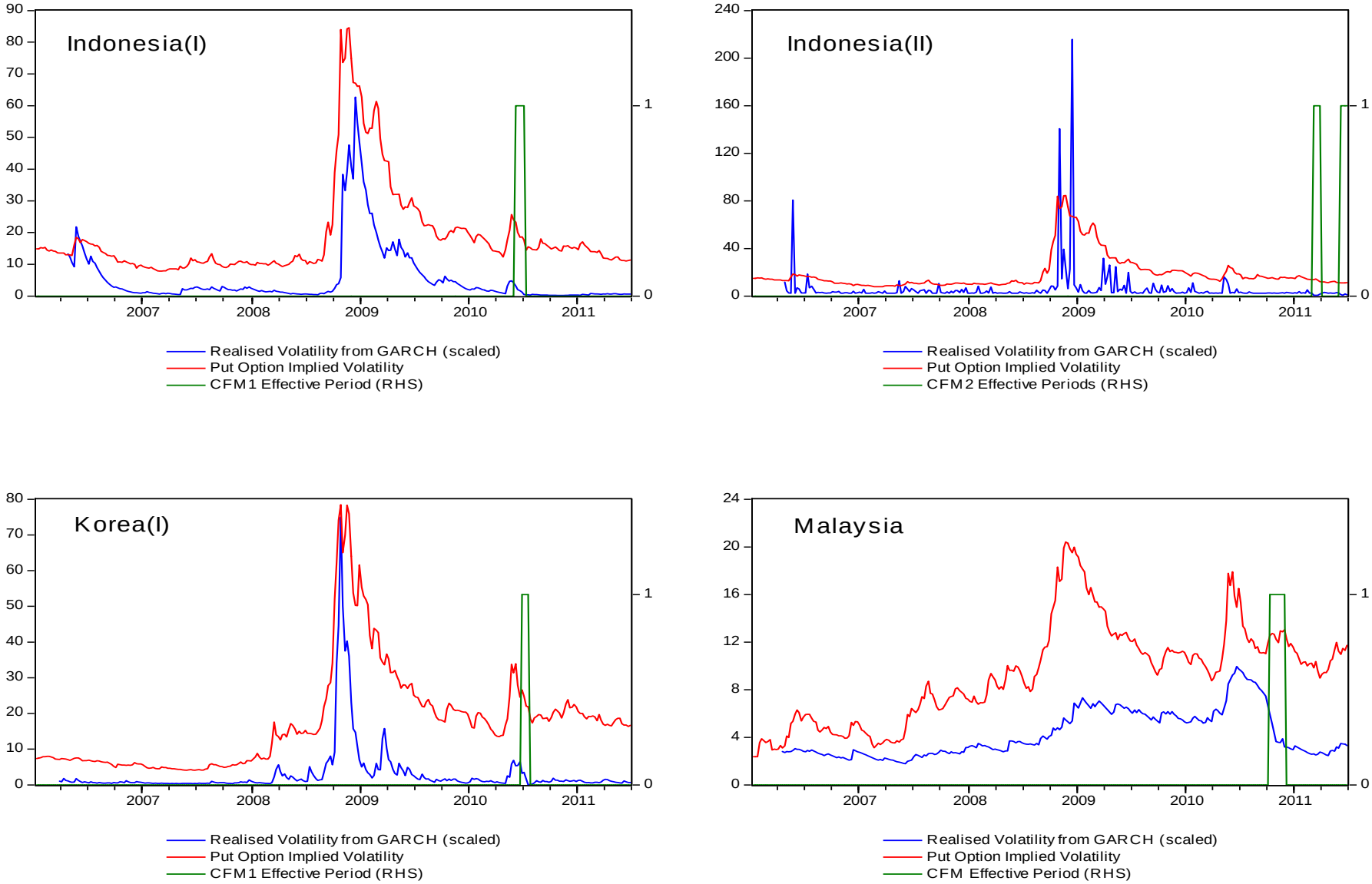
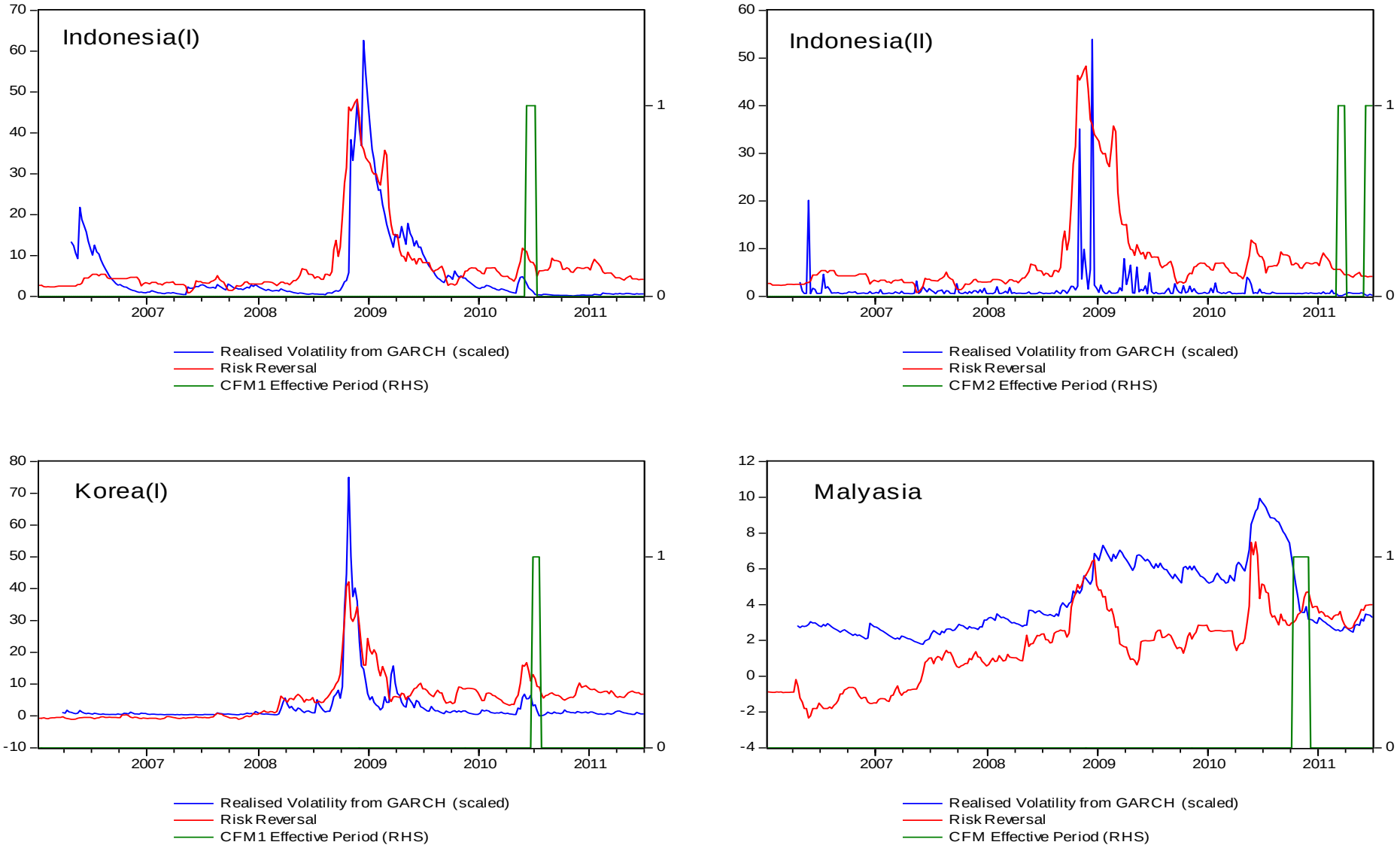


Figure 3. Realised Volatility from GARCH Models, Risk Reversals and Implemented CFMs



Appendix

Country	Policy Tool	Measure	Objective	Time
Indonesia	Minimum holding period on central bank bills	**CFM1**: One month holding period on central bank bills instated for both domestic and foreign investors	To limit volatility of inflows	June 2010
	Reserve requirements on foreign currency and non-resident accounts	**CFM2**: Raised reserve requirement on foreign currency accounts from 1 to 5 percent	To limit bank vulnerabilities to inflow volatility.	March 2011
Korea	Limits to direct and indirect FX exposure	**CFM1**: Capped FX forward positions of banks relative to their equity capital. Reduce corporate FX hedging limit from 125% to 100% of export receipt	By limiting derivatives positions, the measure indirectly targets a reduction in external borrowing by the private sector, particularly the banking sector.	June 2010
	Withholding tax on foreign holdings of government bonds	**CFM2**: Reintroduced 14 percent withholding tax on foreign holdings of government bonds and central bank securities	To slow inflows into government bond markets	January 2011
Malaysia	Measures to encourage outbound investment by residents	**CFM**: Announced that overseas investment limit of the Employee Provident Fund would be raised from 7 percent to 20 percent	To counteract inflows	October 2010
Philippines	Measures to encourage outbound investment by residents	**CFM**: Increased ceilings on residents' purchase of FX and foreign assets from authorised agent banks	To counteract inflows	November 2010
Thailand	Measures to encourage outbound investment by residents	**CFM1:** Raised ceilings on residents' outward direct investment, lending abroad, and foreign currency holdings	To counteract inflows	February and September 2010
Thailand	Withholding tax on foreign holdings of government bonds	**CFM2**: Re-imposed 15 percent withholding tax for state bonds on foreign investors	To slow inflows into government bond markets	October 2010