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CARRY TRADES IN ASIA AND THE PACIFIC: EVIDENCE ON UNCONVENTIONAL MONETARY POLICIES OF ADVANCED ECONOMIES

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Abstract

Since the Global Financial Crisis (GFC) of 2008, the world economy has faced many challenges and changes, which led us to reassess the uncovered interest rate parity (UIP). We are particularly interested in whether and to what extent unconventional monetary policy (UMP) affects the UIP relationship for 11 currencies in Asia and the Pacific. When we run the Fama regression for the period of 2001 through 2016, we show that UIP does not hold, consistent with previous studies. We augment the original Fama regression with a set of variables that represent financial and macroeconomic conditions as well as unconventional monetary policies. We find that the unconventional monetary policies in advanced economies have a significant effect on the Fama beta. The QE in the US and QQE in Japan cause the Fama beta to be more negative, implying carry trade activities and "search for yield" behaviour. On the other hand, the negative interest rate policy (NIRP), especially in the Eurozone and Switzerland, seem to cause greater uncertainty and have a positive effect on the Fama beta.

JEL Classification: E43, E44, F31, G12

Contents

1. INTRODUCTION

The once unthinkable became a reality when the European Central Bank (ECB) changed its interest rate on excess bank reserves to −0.1% in June 2014: the first negative interest rate policy adopted by a major central bank.[1] Negative interest rates, like the rounds of quantitative easing (QE) implemented by many developed countries after the Global Financial Crisis (GFC), represent a drastic departure into the uncharted territory of unconventional monetary policies (UMP). These policies have forced economists to reassess the fundamental relationships within economics. One such relationship may include uncovered interest rate parity (UIP), a theory stating that the expected change in the exchange rate is equal to the interest rate differential between two countries.

The validity of UIP has consistently been questioned, with many studies finding empirical evidence against the theory.[2] Despite the theory's prediction of no scope for arbitrage when investing at different interest rates across currencies, world markets are in fact full of carry trade opportunities. A successful carry trade occurs when any gain from the interest differential between two currencies is not fully offset by a loss from the exchange rate. Strong capital flows out of the lower yielding funding currency and into the higher yielding investment currency cause the exchange rate to appreciate, violating the UIP equation.

Studies which examine the validity of UIP typically regress the change in the exchange rate on the interest rate differential (i.e., "Fama" regression) and test whether the coefficient (i.e., "Fama beta") is equal to the theoretical value of unity. Most studies reject the coefficient of unity, providing evidence that UIP is a poor predictor of future exchange rate movements. Froot and Thaler (1990) found an average estimate for beta of −0.88, and other studies have found similar estimates, which are negative and significantly different from unity (Chinn and Meredith 2004, 2005; Flood and Rose 2001).[3]

The rejection of UIP suggests that carry trade opportunities are abundant. This seems to have been particularly true since the mid-2000s. One prominent example is "Mrs. Watanabe" – the stereotypical Japanese housewife hailed in the media for her foreign exchange trading. Japan is a country where interest rates have been close to zero for a sustained period. Retail investors used their yen as the funding currency to invest in higher yielding currencies such as Australian dollars and New Zealand dollars. Such a tale reflected a period of global risk appetite, which abruptly came to a halt with the Global Financial Crisis (GFC) in 2008. Since then, many other advanced economies' central banks, including the United States (US) Federal Reserve, the ECB, and the Swiss National Bank, have lowered interest rates and implement UMP such as QE and negative interest rates (NIRP). The US dollar, the euro, and the

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1 As an exception, Denmark had lowered its benchmark rate to a negative figure in mid-2012. Another exception is Switzerland, which levied negative interest rates on Swiss franc deposits from non-residents in 1972 to curb rapid capital inflows. This policy lasted until 1978.

2 See Froot and Thaler (1990), Lewis (1995), Taylor (1995), Engel (1996), Sarno (2005), Isard (2006), Chinn (2006) and Alper et al. (2007) for surveys on the UIP literature.

3 The estimations with longer time horizon yield more supportive results with the correct sign for the β and closer to the theoretical value of unity than to zero (Alexius 2001; Lothian 2016; Chinn and Meredith 2004, 2005). In the longer horizon, interest rates are to be less influenced by changes to monetary policy, making the beta estimate freer from simultaneity bias (Chinn and Meredith 2004). Alper et al. (2007) argue that the empirical results unsupportive for UIP documented by the previous studies are more of statistical artifacts, especially when the estimations are done for developed countries.

Swiss franc have thus joined the club of funding currencies, creating further possibility for carry trades.

Carry trades have their own ebb and flow, which can be exacerbated by their self-fulfilling nature caused by herding behavior among investors. A carry trade strategy may be successful for some time before suddenly breaking and causing a significant loss, which can be compounded by investors all rushing to unwind their positions at once. It is this "crash risk" which explains the negative skew and excess kurtosis often associated with carry trades (Jordà and Taylor 2012).

Conceptually, unconventional monetary policies such as Negative Interest Rate Policy (NIRP) and Quantatitive Easing (QE) are supposed to reinforce the central banks' efforts to lower the cost of borrowing when its conventional interest rate-based monetary policy faces the zero bound. QE and NIRP may imply a sustained period of lax monetary policy, and in turn potential for greater risk taking and carry trades. That could lead to continuous appreciation pressure on the investment currencies, deviating further from the world of UIP. This replicates the low interest rate environment seen prior to the financial crisis when carry trades were particularly successful.

In reality, however, it is unclear what effect UMP has on risk appetite. Investors may take the implementation of UMP as a signal of uncertainty on future monetary or financial conditions. Both QE and negative interest rates had rarely been used before, so naturally they come with less visibility. In particular, NIRP has been unpopular in the eurozone, Japan, and Switzerland, possibly reflecting economic uncertainty. If investors interpret UMP as an indication of high uncertainty, this would in fact cause lower risk-taking, less carry trades, and movements of exchange and interest rates more consistent with UIP. Thus, when the positive effect of UMP outweighs the negative effect, we should find empirical evidence that QE or negative interest rates lead to a smaller or more negative Fama beta, i.e., more active carry trades. If the negative effect outweighs the positive one, we would expect a reduction in UIP deviations and a retrenchment from carry trades.

Against this background, we revisit the issue of UIP and focus on the impact of UMP on UIP behavior. More specifically, we augment the traditional Fama regression with variables which presumably reflect market conditions as well as implementations of UMP. The basis for this model modification is that the bias on the Fama beta might arise from correlations between the error term in the Fama regression and the information available, which affects the interest rate differential. With the augmented model, we examine whether controlling for market conditions as well as UMP helps us to find a Fama beta more consistent with theory.

For this exercise, we look at the UIP relationship among 11 currencies in Asia and the Pacific and four major funding currencies—the US dollar, the euro, the Japanese yen, and the Swiss franc—for the period 2001 through 2016. For the investment currency, we focus on countries in Asia and the Pacific due to their increased role in global foreign exchange markets. First, the region is home to a wide variety of economies in terms of growth performance and stages of development. Having a broad exposure to numerous currencies allows carry traders to diversify their risk and achieve a higher sharp ratio (Burnside et al. 2008). Second, studies have shown countries in Asia and the Pacific to be attractive targets for carry trades (Gyntelberg and Remolona 2007). The region is the key driver of global economic growth, and regional currency volumes have risen in recent years (Levich and Packer 2015). More liquid currencies are attractive to investors, given the nature of carry trades and the existence of crash risk. Given this increased relevance of currencies in Asia and the Pacific, our study hopes to expand on the relatively small body of existing literature relating to carry trades in the region.

In the following section, we first review the theoretical framework for the UIP regression and the sources of biased estimates before introducing an empirical model for the investigation. In Section 3, we show and discuss traditional UIP estimations. In Section 4, we augment the estimation model and discuss how the implementation of UMP affects deviations from, or convergence to, UIP. In Section 5, we make concluding remarks.

2. METHODOLOGY

2.1 Theory

The uncovered interest rate differential, $i_{t,k} - i^*_{t,k}$, can be decomposed into:

$$i_{t,k} - i^*_{t,k} = \left[\left(i_{t,k} - i^*_{t,k}\right) - \left(f_{t,t+k} - s_t\right)\right] + \left(f_{t,t+k} - s^e_{t,t+k}\right) + \Delta s^e_{t,t+k} \quad (1)$$

where $f_{t,t+k}$ is the k-period forward rate, the term in square brackets is the covered interest rate differential, and the term $\left(f_{t,t+k} - s^e_{t,t+k}\right)$ is the exchange risk premium. If covered interest rate parity (CIP) holds,

$$f_{t,t+k} - s_t = i_{t,k} - i^*_{t,k}\,. \quad (2)$$

This means that the forward discount equals the interest rate differential. With this equality, the ex-ante uncovered interest rate parity is driven by the existence of an exchange risk premium, η , that is defined as:

$$f_{t,t+k} - s^e_{t,t+k} = \eta_{t,t+k}\,. \quad (3)$$

Substituting (3) into (1) yields:

$$\Delta s^e_{t,t+k} = \left(i_{t,k} - i^*_{t,k}\right) - \eta_{t,t+k}\,. \quad (4)$$

That is, the expected exchange rate change equals the current interest rate differential when the risk premium is zero. In other words, UIP would hold if investors are risk-neutral, or the underlying bonds are perfect substitutes. However, equation (4) is not directly testable in the absence of observations on market expectations of future exchange rate movements. To make UIP testable, we need to assume rational expectations.

Using the rational expectations methodology, future realization of s_{t+k} equals the value expected at time *t* plus a white-noise error $\xi_{t,t+k}$ that is uncorrelated with all information known at time *t*, including the interest rate differential and the spot exchange rate. Equation (4) can then be changed to:

$$\Delta s_{t,t+k} = \left(i_{t,k} - i^*_{t,k}\right) - \eta_{t,t+k} + \xi_{t,t+k} \quad (5)$$

where the left-hand side of equation (5) is the realized change in the exchange rate from t to $t+k$. When CIP holds, there is no exchange rate risk and no forecasting error, so the realized change in the exchange rate from t to $t+k$ equals the current interest rate differential. Conversely, the most general form of UIP can be expressed as:

$$\Delta s_{t,t+k} = \left(i_{t,k} - i^*_{t,k}\right) + \nu_{t,t+k} - \eta_{t,t+k} + \xi_{t,t+k} \ , \quad (6)$$

where $\nu_{t,t+k}$ refers to political risk, default risk, or any other factor that prevents CIP from holding.

Thus, in order for UIP to hold, there must be no political risk, default risk, exchange rate risk, or forecasting errors. In other words, UIP holds when agents are both risk neutral and have rational expectations, and assets are perfectly substitutable. Deviations from UIP suggest these conditions are not satisfied.

Borio et al. (2016), focusing on how the CIP rule has been violated since the GFC of 2008 (GFC), argue that deviations can be explained by higher demand for foreign exchange hedging and tighter management of risks due to more stringent bank regulations. Chinn and Frankel (2016) show that biased expectations, i.e., the failure of the rational expectations assumption, contributes to the forward discount bias.

The above conceptual discussions indicate that when we run a typical Fama regression as:

$$\Delta s_{t,t+k} = \alpha + \beta\left(i_{t,k} - i^*_{t,k}\right) + \varepsilon_{t,t+k} \ , \quad (7)$$

the joint significance of $\alpha = 0$ and $\beta = 1$ is rejected. Just testing if $\beta = 1$ is often rejected and the estimated β takes (significantly) negative values.

The reason for the unsupportive β is that there are factors which do not allow $\varepsilon_{t,t+k}$ to be a white noise error, i.e., the existence of risks, and the $corr(i_{t,k} - i^*_{t,k}, \varepsilon_{t,t+k}) \neq 0$.

A number of studies have tried to explain how deviations from UIP when risk premia and $corr(i_{t,k} - i^*_{t,k}, \varepsilon_{t,t+k})$ are not properly treated. Frankel and Poonawala (2010) attribute UIP deviations to the levels of economic development and also find that more managed currency regimes result in more marked rejections of the unbiasedness hypothesis. Flood and Rose (1996, 2002) found crisis episodes marked periods where UIP worked quite well. Ito and Chinn (2007) find lower financial development and financial openness tend to increase UIP deviations while other factors such as inflation volatility, trade openness, legal development, and the nature of the exchange rate regimes can also affect the extent of deviations.

These factors can be considered as either affecting the UIP through risk premia or making the $corr(i_{t,k} - i^*_{t,k}, \varepsilon_{t,t+k})$ nonzero, both of which prevent the error term in equation (7) from being white noise leading to bias in the Fama beta.

As discussed earlier, unconventional monetary policies could also cause deviations from the typical Fama model by affecting risk premia or appetite. UMP may not be fully reflected as changes in the interest rate (of the funding currency), which implies that UMP may make the interest rate differential correlated with the error term when the Fama regression is applied to the post-GFC period. In any case, it may be necessary to properly control for the factors that affect risk premia or $corr(i_{t,k} - i^*_{t,k}, \varepsilon_{t,t+k})$ when the Fama regression is conducted. Controlling for these factors may yield the Fama beta that is more consistent with the theory.

2.2 The Augmented Fama Regression Model

Given these discussions, we augment the original Fama model by including variables that may affect risk premia and $corr(i_{t,k} - i^*_{t,k}, \varepsilon_{t,t+k})$ as follows:

$$\Delta s_{t,t+k} = \alpha + \beta\left(i_{t,k} - i^*_{t,k}\right) + X_t'\Gamma_1 + D_t'\Gamma_2 + u_{t,t+k} \quad . \tag{8}$$

Vector X includes factors which may affect the financial conditions both the funding and investment currencies face. We include the VIX index from the Chicago Board Options Exchange as a variable to control for the risk aversion of global investors. Stock markets indices are included for both the funding and investment currencies as measures of financial instability and conditions of the issuers of respective currencies. We also include the volatility of the exchange rate of concern, assuming that higher levels of volatility increase forecasting errors and risk.

Vector D includes the dummies to capture major macroeconomic policies including UMP. Here, we focus on policies adopted by the issuers of major funding currencies, such as QE policies by the US, the eurozone, and Japan and NIRP in the eurozone and Switzerland. We will explain the details of the estimation model in a later section.

2.3 Data

We use daily data from Bloomberg on exchange rates and 1-year interest rates, as well as on stock index prices and the VIX for our control variables. Data was collected for funding currencies from four developed economies (Europe, Japan, Switzerland, and the US) and 11 investment currencies from economies in Asia and the Pacific (Australia; the People's Republic of China; Hong Kong, China; India; Indonesia; Republic of Korea; Malaysia; New Zealand; the Philippines; Singapore; and Thailand). Precise details of our chosen securities are available in Appendix 1. Our data runs from 1 January 2001 to 26 October 2016. We chose 1-year securities due to their liquidity and prevalent use when testing UIP (Bekaert et al. 2007; Coudert and Mignon 2013). Using a relatively short maturity and timeframe allows us to properly analyze the effects of negative interest rates, which at most run for just 17 months in our data.

3. ESTIMATION RESULTS

3.1 Stylized Facts of UIP

Appendix Figures 1−4 plot 1-year interest rate differentials and currency depreciations for our investment currencies against each of the four funding currencies. For UIP to hold, any interest rate differential would have to be offset by a commensurate currency depreciation. That would require the two series for each graph to move together, something which appears to be seldom true. During the GFC, our funding currencies strengthened as investors moved money into safe havens. This is demonstrated by a spike in the red lines on each graph a year prior to the GFC. These moves were particularly pronounced for the US dollar, Japanese yen, and Swiss franc. However, directly after the GFC, there seems to have been an increase in risk-on trades with capital flows back to Asia and the appreciation of many Asian and Pacific currencies.

For example, for the Indonesian rupiah, one of our more risky focus currencies, the red line falls against all our funding currencies around the crisis. This is interpreted as an appreciation of the rupiah in the year after the crisis, and a return to risk. This result, as well as equivalent findings for our other investment currencies, is particularly interesting against the US dollar during this period given the implementation of QE1. In the year after the beginning of QE1, most of our investment currencies appreciated against the US dollar. In 2011, central bank interventions influenced currency movements, with the minimum exchange policy in Switzerland and interventions by Japan. The aim of these interventions was to depreciate the Swiss franc and Japanese yen against the euro and US dollar, respectively. Looking at the Indonesian rupiah again, we can see currency appreciations against the Swiss franc and Japanese yen after these interventions, but currency depreciations against the euro and US dollar. Later, in 2014, the ECB announced negative interest rates. This resulted in the euro appreciating against most of our investment currencies. This is an interesting result, as it opposes the result seen for QE1 in the US. Based on these simple findings at least, QE and NIRP seem to have had opposite effects.

3.2 Estimation with the Original Fama Regression

Appendix Table 3 Panels A−D reports the results of the traditional Fama regression. The tables include results for the whole observation period, as well as those split for before and after the GFC. The first column reports the estimated β's and their Newey−West standard errors.[4] We also test for the joint significance of the null hypothesis that α_i=0 and β_i=1 and report Wald statistics and p-values in the second column. The third column lists the t-test statistics and p-values for the null hypothesis that β_i=1.

The first thing to note is that $\hat{\beta}$ is very rarely equal to the theoretical value of unity at any level of significance. This is confirmed by the F tests and t tests conducted, which broadly confirm at a 1% significance level that $\hat{\beta}$ is statistically not equal to 1. This applies not only to the estimations for the whole sample but also to the pre-crisis and post-crisis subsample periods.

Table 1 helps us to understand an overview of the findings from this exercise. Panel A is based on Appendix Table 3 and presents only the signs of the betas estimated in each of the Fama regressions conducted for the 11 investment currencies from Asia and the Pacific against each of the four funding currencies. The cells shaded in light blue indicate that the estimated beta is found to be positive, and those in red for the negative estimated betas. “Negative” or “positive” in bold means the beta is significantly different from the value of unity with p-values lower than 10%.

In the panel, we see that when the estimation is conducted using the US dollar as the funding currency, the Fama beta is positive for all the investment currencies except for the Indonesian rupiah, but different from the value of unity for 9 out of 11 currencies. Considering that the investment currencies are all those of emerging markets except for the Australian dollar and the New Zealand dollar, the positive estimates are not surprising. Other studies such as Frankel and Poonawala (2010) and Ito and Chinn (2007) also found positive Fama betas for emerging market economies.

[4] The Newey–West standard errors are used to control for serial correlations that may arise because of overlapping data.

Table 1: Results of the "Fama" Regressions

Panel A: Sign of the Fama Beta

Funding Currency	Period	AUD	CNY	HKD	IDR	INR
USD	Full	positive	positive	positive	negative	positive
EUR	Full	negative	negative	positive	negative	negative
JPY	Full	positive	negative	positive	negative	negative
CHF	Full	negative	negative	positive	negative	negative
USD	Pre-crisis	positive	positive	positive	positive	positive
	Post-crisis	negative	positive	negative	negative	positive
EUR	Pre-crisis	positive	negative	positive	negative	negative
	Post-crisis	negative	negative	positive	negative	positive
JPY	Pre-crisis	positive	positive	negative	negative	positive
	Post-crisis	negative	negative	positive	negative	negative
CHF	Pre-crisis	negative	negative	positive	negative	negative
	Post-crisis	negative	negative	negative	negative	negative

Funding Currency	KRW	MYR	NZD	PHP	SGD	THB
USD	positive	positive	positive	positive	positive	positive
EUR	negative	positive	positive	positive	negative	negative
JPY	positive	positive	positive	positive	negative	negative
CHF	negative	positive	positive	negative	negative	negative
USD	positive	positive	positive	positive	positive	positive
	negative	positive	positive	negative	positive	positive
EUR	negative	negative	positive	negative	negative	negative
	positive	positive	positive	negative	positive	positive
JPY	positive	negative	positive	negative	negative	negative
	negative	positive	positive	positive	positive	negative
CHF	negative	negative	negative	negative	negative	negative
	positive	positive	positive	positive	negative	negative

Panel B: Adjusted R^2 of the Fama Regression

Funding Currency		AUD	CNY	HKD	IDR	INR
USD	Full	0.018	**0.333**	**0.013**	0.095	**0.256**
EUR	Full	0	0.053	0.006	0.106	0.011
JPY	Full	**0.026**	0.06	0.008	0.005	0.000
SF	Full	0.003	0.06	0.022	**0.11**	0.000
USD	Pre-crisis	0.082	0.005	0.013	0.055	**0.224**
EUR	Pre-crisis	0.003	**0.608**	**0.06**	0.028	0.012
JPY	Pre-crisis	**0.319**	0.438	0.048	**0.127**	0.033
SF	Pre-crisis	0.041	0.453	**0.06**	0.084	0.002
USD	Post-crisis	**0.077**	0.077	**0.192**	**0.388**	**0.315**
EUR	Post-crisis	0.008	0.02	0.024	0.251	0.032
JPY	Post-crisis	0.005	**0.169**	0.002	0.032	0.044
SF	Post-crisis	0	0.16	0.033	0.227	0.005

continued on next page

Table 1 *continued*

Funding Currency	KRW	MYR	NZD	PHP	SGD	THB
USD	0.000	**0.228**	0.069	0.012	0.071	0.167
EUR	**0.158**	0.016	**0.16**	**0.021**	**0.098**	0.081
JPY	0.04	0.013	0.061	0.007	0.001	0.114
SF	0.003	0.023	0.01	0.001	0.09	**0.15**
USD	0.004	**0.905**	0.093	**0.148**	0.119	0.049
EUR	0.07	0.006	0.083	0.009	0.099	0.304
JPY	0.035	0.278	**0.196**	0.098	**0.301**	0.146
SF	**0.076**	0.519	0.001	0.042	0.231	**0.385**
USD	0.000	**0.586**	0.202	**0.442**	0.088	0.179
EUR	0.005	0.434	0.239	0.002	0.134	0.122
JPY	**0.08**	0.06	**0.465**	0.133	**0.374**	**0.182**
SF	0.002	0.14	0.103	0.025	0	0.002

UD = Australian dollar; CNY = People's Republic of China yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; KRW = Korean won; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai baht; USD = United States dollar; EUR = euro; JPY = Japanese yen; CHF = Swiss franc.

When the funding currency is the euro, the Japanese yen, or the Swiss franc, however, the beta is typically found to be negative. The only exceptions are when the Hong Kong dollar, Malaysian ringgit, or New Zealand dollar is the investment currency.

Considering that the estimated beta would be negative when carry trades are existent and successful, the consistently negative beta for the Indonesian rupiah (Rp) across all funding currencies may suggest the currency is a commonly used investment currency. Another observation is the positive beta across different investment currencies when the US dollar is the funding currency. We do not necessarily interpret this to mean that the US dollar is not a popular funding currency for carry trades. In fact, when the whole sample period is divided into pre-crisis and post-crisis subsample periods, the Fama beta for the estimation with the US dollar as the investment currency turns negative among five investment currencies—Australian dollar, Hong Kong dollar, Indonesia rupiah, Korean won, and Philippine peso—once we enter the post-crisis subsample period. This is in stark contrast to the pre-crisis period when the Fama beta was not negative for any of the 11 investment currencies.[5] Such results suggest that the US dollar became a major funding currency after the GFC, which is consistent with evidence that the cost of borrowing in the dollar fell significantly in the aftermath of the GFC.

As for the other currencies, when the euro or the Swiss franc was the funding currency, there are more currencies in the pre-crisis period than in the post-crisis period for which the Fama beta is found to be negative—eight vs. four for the euro and ten vs. seven for the Swiss franc. This suggests that the two were more actively used as funding currencies in the period prior to the GFC. In case of the Japanese yen, the number of investment currencies for which the Fama beta is negative was constant at six in both pre- and post-GFC periods, but it is only the Indonesian rupiah for which the interest rate differential is negatively correlated in both pre- and post-GFC periods, with the compositions of the other five currencies different between the two periods.

[5] The pre-crisis period starts on 1 January 2001 and ends on 1 July 2008. The post-crisis period starts 1 January 2009.

Panel B tabulates the adjusted R-squared (R2) for each of the currency combinations for the full sample as well as the pre- and post-crisis periods. For each investment currency, the adjusted R2 values for the four funding currencies are compared for the full sample period and the two subsample periods, with the highest adjusted R2 shown in bold. Figures which are both bold and red indicate that the Fama beta for that particular currency combination was negative.

When we focus on the full sample estimations, the US dollar and the euro are each found to be the funding currencies that yield the highest adjusted R2 for four of our investment currencies. The Swiss franc has the highest adjusted R2 for two investment currencies and the Japanese yen has the highest adjusted R2 for just one currency. However, again, looking at the full sample period masks the changing dynamics in the periods before and after the GFC. When looking only at the pre-crisis period, the number of investment currencies for which having the US dollar as the funding currency yields the highest adjusted R2 goes down to three and none of them show a negative Fama beta. In the post-crisis period, six investment currencies yield the highest adjusted R2 when the US dollar is the funding currency, and four out of six currencies: the Australian dollar, Hong Kong dollar, Indonesian rupiah, and Philippine peso yield negative betas. Considering the sign of the beta and the goodness of fit, these findings suggest that the US dollar did become the major funding currency for carry trades in the post-GFC period.

As for other funding currencies, two estimations for investment currencies yield the highest adjusted R2 when the euro is the funding currency in the pre-crisis period, but there is no currency for which the estimation has the highest adjusted R2 in the post-crisis period. When the Swiss franc is the funding currency, the Hong Kong dollar, Korean won, and Thai baht have the highest adjusted R2 in the pre-crisis period, and for all these currencies the Fama beta is found to be negative. However, in the post-GFC period, no currency leads to the highest adjusted R2 when paired with the Swiss franc.

Two investment currencies yield the highest adjusted R2 and negative Fama betas when they are paired with the Japanese yen in the pre-crisis period, whereas three currencies have such properties in the post-crisis period. All these findings suggest that in the period prior to the GFC, the Japanese yen, the Swiss franc, and the euro were funding currencies for carry trades with Asian emerging markets' currencies, whereas in the post-crisis period, the US dollar and the Japanese yen became the main funding currencies for carry trades. This is particularly interesting, given that the US and Japan were the initial proponents of QE, whereas Switzerland and the eurozone were the first to use NIRP. Prior to this point, we had discussed UMP as a whole, without making a different between QE and NIRP. However, these findings would suggest that QE and NIRP may have different effects on investors.

3.3 Coefficient Stability

The empirical exercise in the previous subsection showed that 1) conducting the Fama regression over the period that encompassed the GFC can be misleading because it can mask the dynamics that took place before, during, and after the crisis; and that 2) it is necessary to incorporate the possibility for coefficient instability.

This is confirmed in Figure 1 Panels A−D. These panels show the time varying Fama beta values obtained from rolling regressions for each of our currency pairs. The estimation is run with a rolling window of 1,000 business days. The panels confirm coefficient instability for the Fama beta for most of the countries. Also, comparing the shapes of the rolling beta with key events (shown by the vertical lines) indicates that some of the movements of the rolling betas can be explained by changes in the economy and policy decisions.

In Panel A, which shows the time varying betas for the estimation with the US dollar as the funding currency, many countries experience a rise in the beta around the time the GFC occurred, presumably reflecting the flight to safety and resultant US dollar appreciation against our focus investment currencies.[6] Once QE1 is implemented, the beta falls rapidly for some countries, such as the Hong Kong dollar, Korean won, and Thai baht, and even enters the negative territory for the Indonesian rupiah. Around the time of the implementation of QE3, the beta reaches negative territory for currencies like the Australian dollar, Hong Kong dollar, Indonesian rupiah, Korean won, New Zealand dollar, and Philippine peso. However, the timing of when the beta turns negative and returns to positive territory again varies among countries.

The flight to safety movement is not observed in the time varying beta when the estimation is done with the euro as the funding currency. The beta tends to be negative after the GFC for the Indonesian rupiah, Indian rupee, Korean won, Malaysian ringgit, and Thai baht. Interestingly, the beta responds positively to NIRP for some currencies such as the Korean won, Malaysian ringgit, and Thai baht, which may suggest that for these currencies, the implementation of NIRP may have increased uncertainty and reduced risk appetite.

When the estimation is conducted with the Japanese yen as the funding currency, a flight to safety movement similar to that of the US dollar appears for the rolling beta in currencies such as the Australian dollar, Indian rupee, Korean won, and New Zealand dollar. In the estimations with the Swiss franc as the funding currency, for investment currencies like the Australian dollar, Indian rupee, Korean won, and New Zealand dollar, the rolling beta appears to plummet around the time of the outbreak of GFC, which can be viewed as puzzling. However, this is primarily because these investment currencies were exposed to both the Japanese yen and the Swiss franc, and these two currencies are negatively correlated with each other. Hence, when the investment currency depreciates against the Japanese yen, it appears as the investment currency appreciating against the Swiss franc.

For the yen estimations, the rolling beta often rises some time after the implementation of Japan's "Quantitative, Qualitative Easing" (QQE). The beta continues to rise toward the end of the sample for currencies and falls for some other currencies.

For the estimations with the Swiss franc as the funding currency, the beta tends to rise some time before the implementation of a minimum exchange rate in September 2011 for the Swiss franc against the euro. This result may instead be explained by the outbreak of the Greek and European debt crisis, which started around the same time. The debt crisis made investors more risk averse, which increased the demand for Swiss francs, causing the beta to become more positive.

Thus, the Fama beta appears to be affected by major economic events due to the impact on risk appetite for investors. That leads us to conclude that, as discussed in section 2.1, it is necessary to control for external factors that affect the risk premia to run the Fama regression.

[6] Because the estimation is done with a rolling regression and the rate of depreciation is calculated in forward-looking manner (i.e., as the rate of change between *t* and *t*+252), the time varying beta tends to represent shocks from actual events a little earlier than their dates.

Figure 1: Rolling Regression Results (Original Fama Model)

A: Against USD

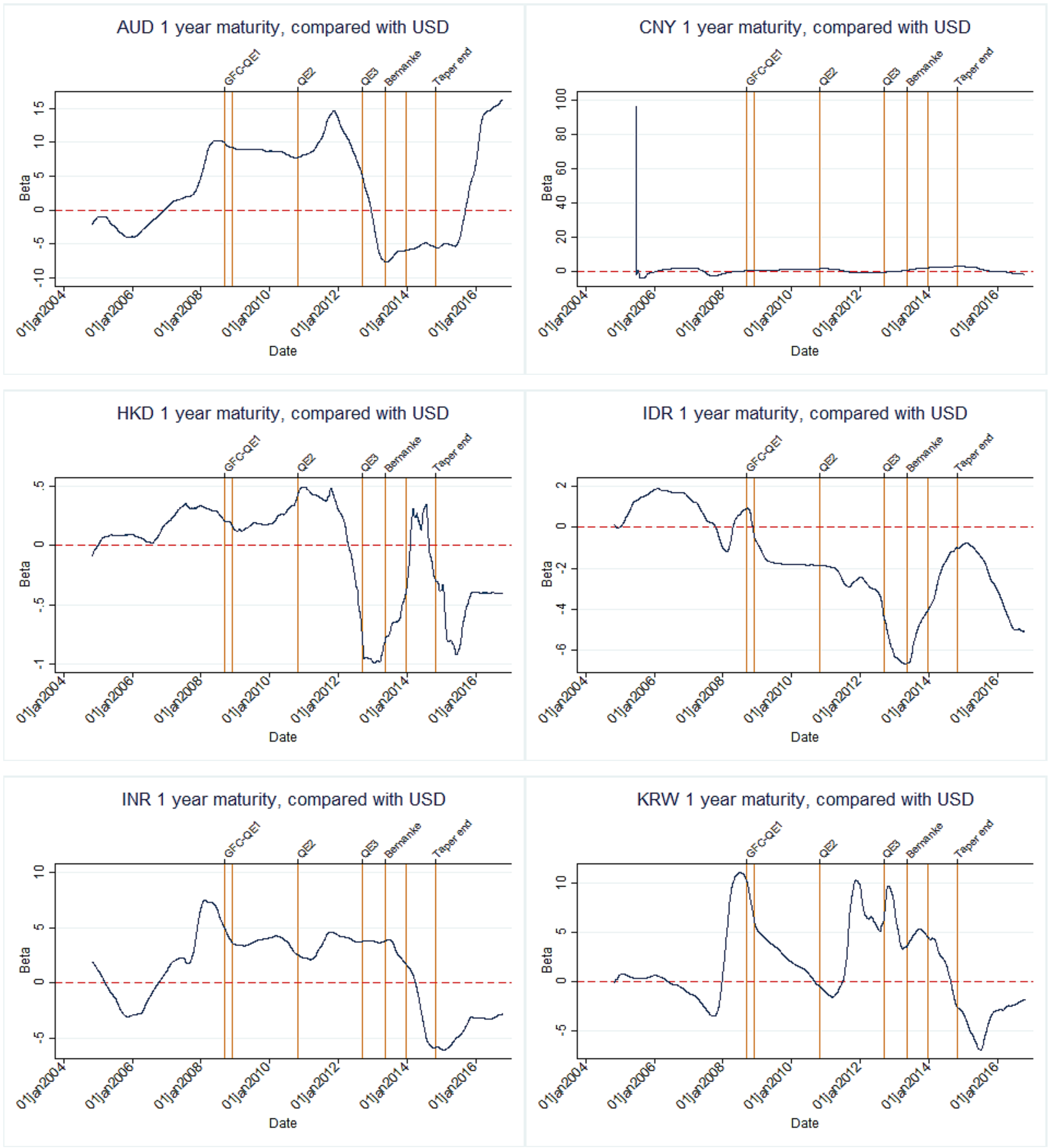

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Figure 1 *continued*

A: Against USD

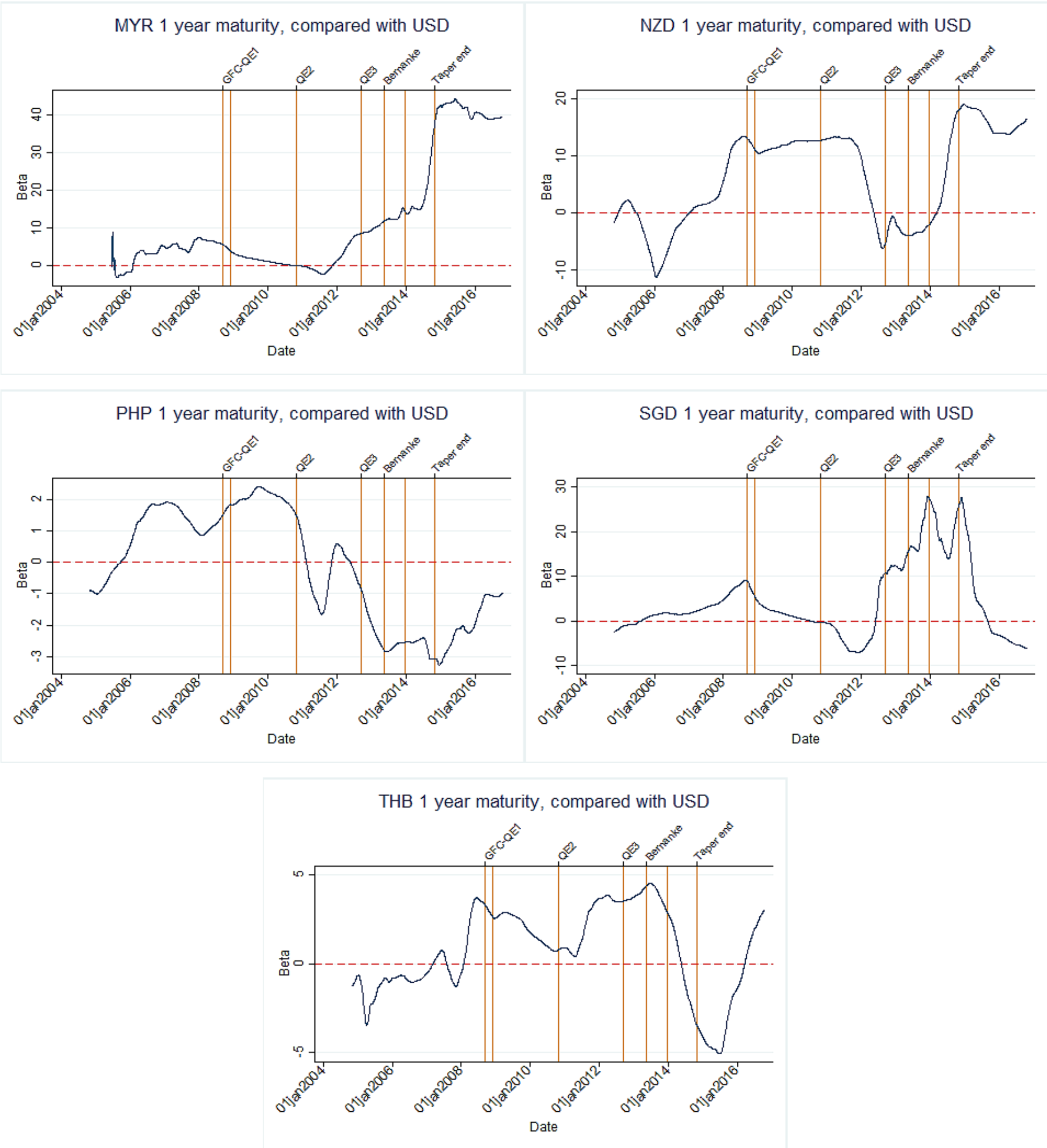

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Figure 1 *continued*

B: Against EUR

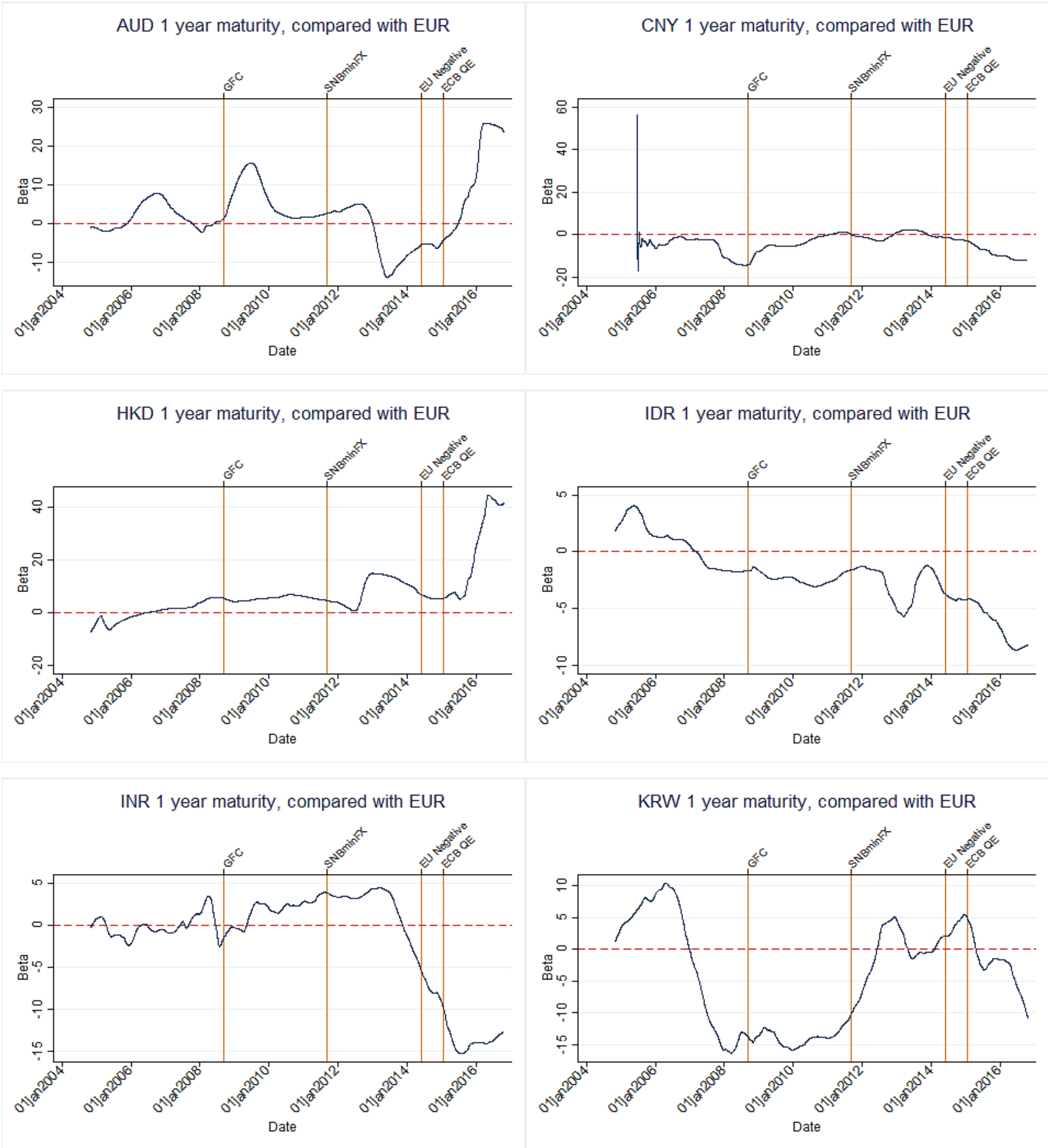

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Figure 1 *continued*

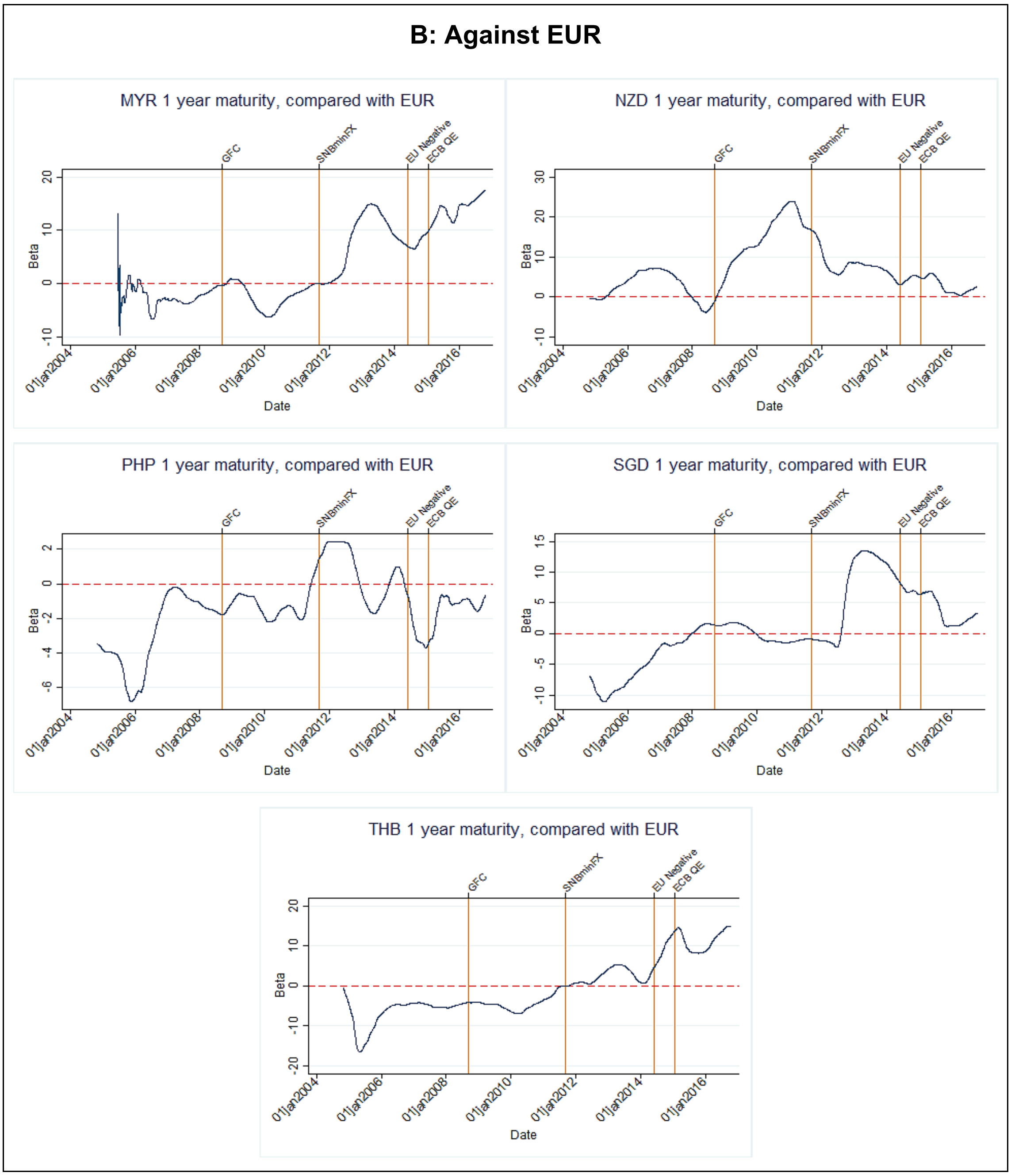

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Figure 1 *continued*

C: Against JPY

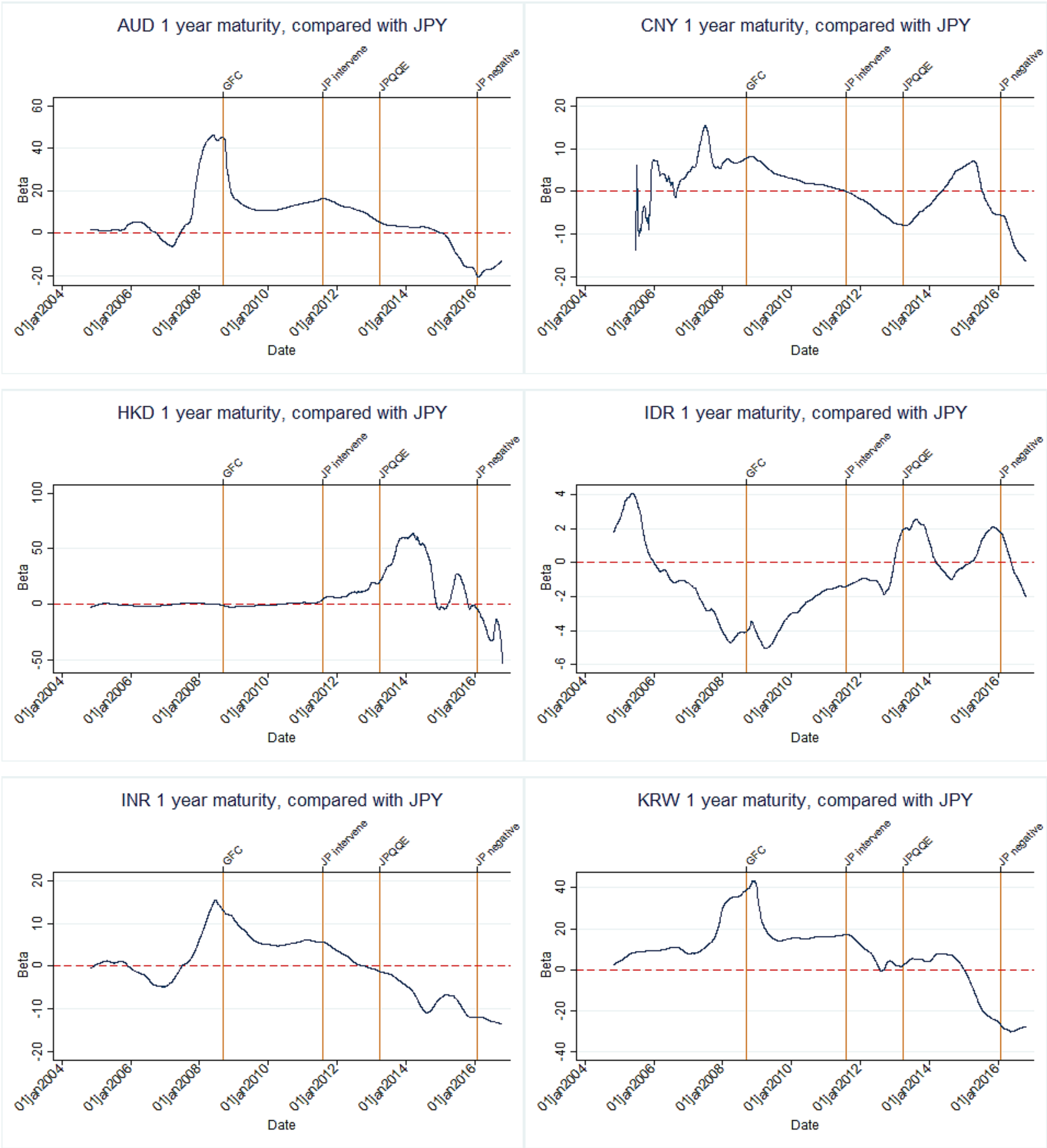

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Figure 1 *continued*

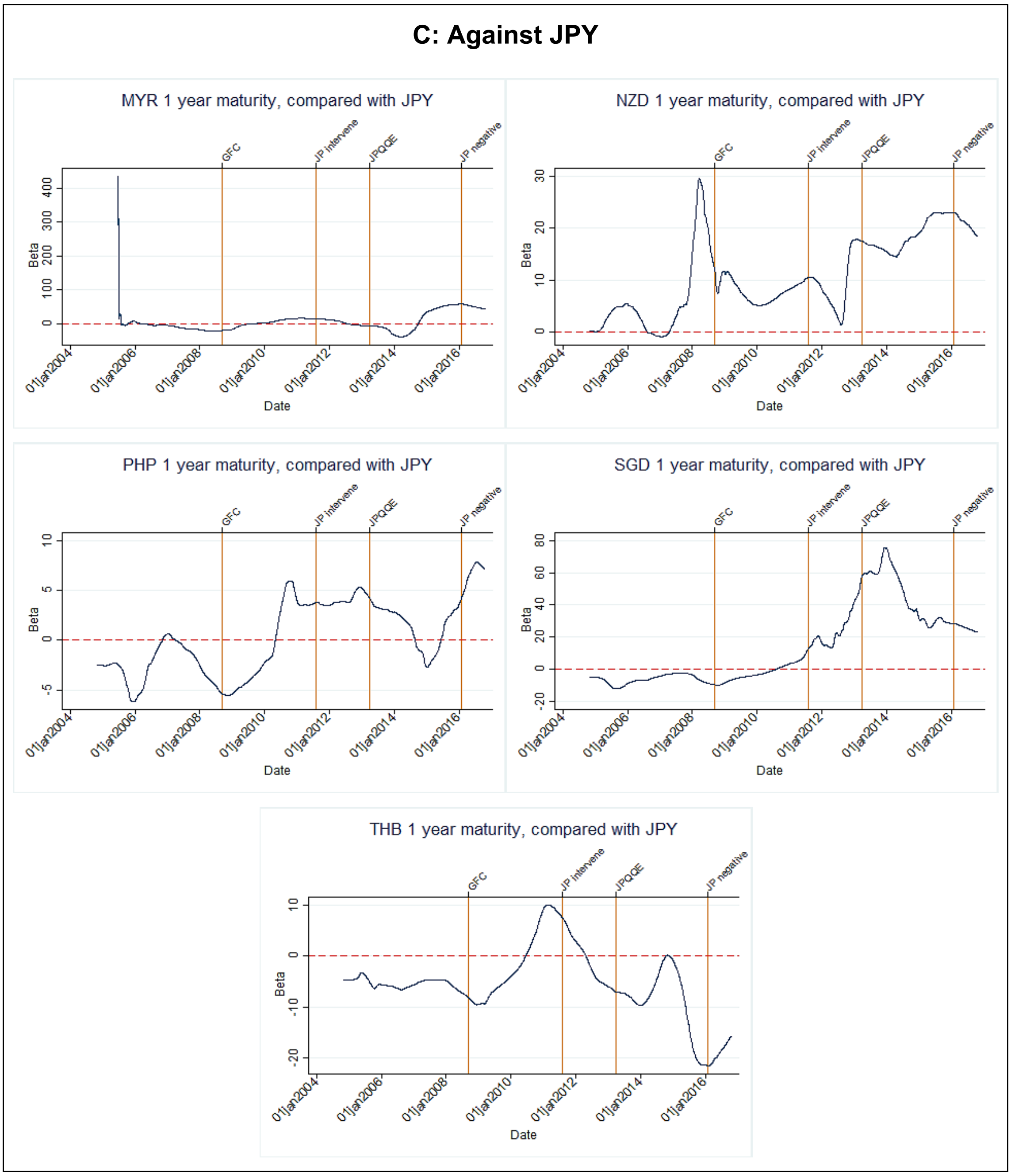

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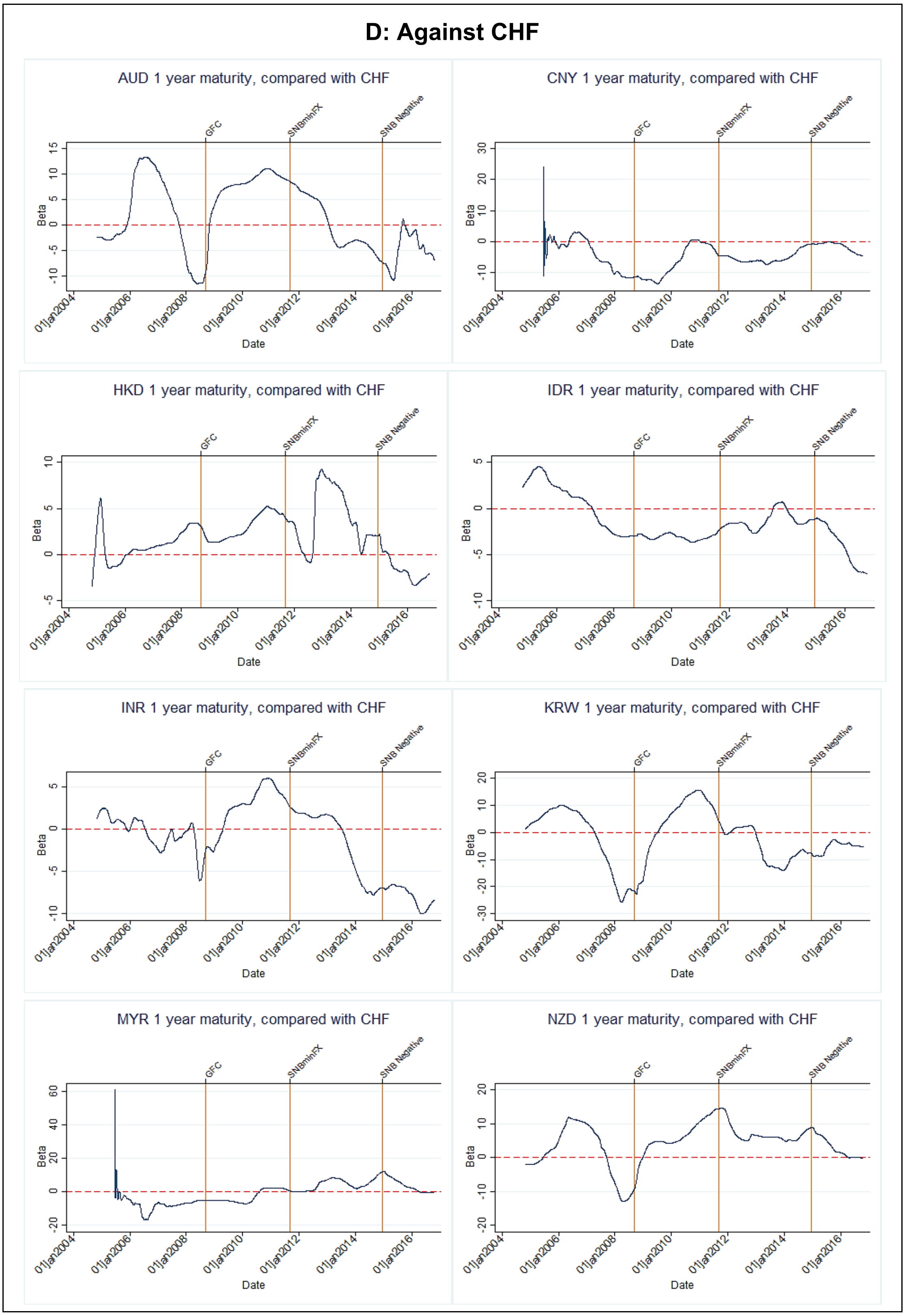
Figure 1 *continued*



USD = United States dollar; AUD Australian dollar; CNY = People's Republic of China RC yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai Baht; EUR = euro; JPY = Japanese yen; CHF = Swiss franc.

4. ESTIMATIONS WITH THE AUGMENTED FAMA REGRESSIONS

4.1 Model Setup

We now conduct the estimation using the Fama regression augmented with the variables that affect the risk premia which we specified in equation (8). However, given the above discussion that the Fama beta seems to be influenced by economic conditions and events, we modify the equation as follows:

$$\begin{aligned}\Delta s_{t,t+k} &= \alpha + \beta\left(i_{t,k} - i^{*}_{t,k}\right) + X_t{}'\Gamma_1 + D'\Gamma_2 + \left[Z_t{}'\left(i_{t,k} - i^{*}_{t,k}\right)\right]'\Theta_1 \\ &\quad + \left[D_t{}'\left(i_{t,k} - i^{*}_{t,k}\right)\right]'\Theta_2 + \varepsilon_{t,t+k}\end{aligned} \quad . \tag{9}$$

We include interaction terms: one between the interest rate differential and vector Z, a subset of vector X, and the other between the interest rate differential and the dummies for major economic events and policies. In this estimation exercise, we focus on the coefficients Θ_2 .

Vector X includes the factors for financial conditions which both the funding and investment currencies face. Namely, X includes the variables for stock market volatility of both the funding and investment currencies, volatility of exchange rate against the funding currency, and the VIX index (in log) from the Chicago Board Options Exchange. While the stock market volatility of the investment currency can be regarded as a measure of financial stability or the risk premium of the investment currency issuer, the stock market volatility of the funding currency can be regarded as reflecting the level of financial uncertainties emanated by the funding currency issuer.[7] The VIX index is a proxy of global investors' risk aversion. Volatility of exchange rate movements should affect the extent of forecasting errors.

Out of the four variables included in X, we interact the interest rate differential between the investment and funding currencies with stock market volatility and the VIX index. The interaction term with stock market volatility for our investment currencies reflect the impact of risk premium on the carry trade activity; the higher levels of financial instability can make investors become more risk averse. Therefore, we expect the coefficients for the interaction terms to be positive (i.e., $\theta_{11} > 0$), reflecting investors avoiding and exiting potentially risky carry trades and thereby implying a smaller extent of deviations from the UIP. Similarly, we expect the interaction term of the interest rate differential and the VIX index to take a positive estimated coefficient (i.e., $\theta_{12} > 0$), which makes the overall beta more consistent with the UIP. Higher risk aversion could cause unwinding of carry trade. The interaction term of the funding currency stock market volatility should have negative estimates (i.e., $\theta_{13} < 0$). Financial uncertainties of the funding currency would weaken its value and improve expected returns from carry trade, which result in more deviations from the UIP. For example, during the Greek debt crisis, stock market volatility in Europe was high and the euro depreciated as investors fled from the currency. This implies an expected negative coefficient on the

[7] The credit-default swap (CDS) data is not available in some Asian countries. The series is quite short. Due to this limitation, we use the stock market volatility instead. We do not include stock market volatility when the funding currency is the US dollar since the VIX index is highly correlated with the volatility of the US stock exchange.

interaction term (i.e., $\theta_{13} < 0$), with higher volatility leading to a reduction in the beta value.

Vector D includes the dummies to capture macroeconomic events and policies, the latter of which includes UMP. It is included in the estimation model both individually and interactively with the interest differential. The economic events and policies captured by the dummies are different depending on which major currency is the funding currency. In the estimation where the US dollar is the funding currency, dummies are assigned for QE1, QE2, and QE3. As for QE3, there are two dummies. The first one refers to the period from the implementation of QE3 to a day before the previous chairman of the US Federal Reserve, Ben Bernanke, made a comment about the possibility of tapering QE3, which was followed by market jitters across emerging markets. Hence, the second dummy is for the remaining period of QE3 and is therefore supposed to capture the impact of the "Taper Tantrum."

All these dummies are interacted with the interest differential, and it is the estimated coefficients that we focus on. The dummies for QE1, QE2, and the first half of QE3 should reflect the active injection of liquidity by the US Federal Reserve after the Federal Fund rate hit the zero bound. These policy efforts should have contributed to active risk taking by investors who sought higher yields in emerging markets. Hence, the estimated coefficients for the interaction terms between the interest rate differential and these dummies are expected to be negative (i.e., $\theta_{21}, \theta_{22}, \theta_{23} < 0$). In other words, while these policies are in place, investors would be more actively taking risk and getting engaged in carry trades by borrowing in dollars and investing in our sample investment currencies. When investors are more engaged in carry trades, the exchange rate movements would deviate from UIP. However, during the time of the "Taper Tantrum," investors retrenched from carry trades since they expected higher returns in dollar-denominated assets and a higher cost of funding. Hence, the interaction term between the interest differential and QE3_2 may capture the retrenchment, so its estimated coefficient may become positive.

For the estimation when the euro is the funding currency, we include the dummy for the negative interest rate policy that was announced on 5 June 2014. This dummy, EUR_neg takes the value of one until the ECB implemented QE on 22 January 2015, the latter of which is captured by another dummy, ECBQE. Both dummies are interacted with the interest rate differential, and one would expect that if the policies were effective that the estimated coefficients take a negative value. However, they could take positive terms if these policies are viewed as more lingering or uncertain future directions of the area's economies or financial markets. Especially, the NIRP's effect on risking taking can be ambiguous as we already discussed.

The estimation for the Japanese yen as the funding currency includes a dummy for the foreign exchange intervention by the Bank of Japan in 2011 as an attempt to depreciate the currency. Such an active injection of liquidity may have encouraged investors to borrow in yen and conduct carry trades, meaning its interaction with the interest rate differential would take a negative sign. The Bank of Japan also implemented QQE policy on 2 April 2013, which we capture by the dummy variable JPQQE. Its interaction term may also take a negative coefficient if that led to more yen-based carry trades.[8]

[8] We do not include a dummy for Japan's NIRP. The rate of depreciation is calculated in a forward-looking manner, that is, over the period t and t+252. Japan's NIRP was implemented in February 2016, but the sample period for this paper ends in October 2016. That means that in order for the time period

The Swiss National Bank implemented a minimum exchange rate policy on 6 September 2011, where the minimum exchange rate against the euro was set at 1.20 euro:franc. We assign a dummy to capture this policy and interact it with the interest differential. Since the Swiss franc value against the euro was given a ceiling, this policy aimed to depreciate the currency. Hence, we expect the interaction term with the interest differential to take a negative value. We also include a dummy for NIRP by the Swiss National Bank and again expect its interaction to take a negative coefficient.[9]

4.2 Estimation Results

Table 2 Panels A−D present the results from the estimations of equation (9). Table 3 reports the signs of the estimated coefficients of the variables of our focus and helps us to interpret the results reported in the panels of Table 2. Namely, the signs of the yield spread between the funding and investment currencies, the interaction term between stock market volatility and the yield spread, the interaction term between the VIX index and the yield spread, and other interaction terms between the yield spread and macroeconomic policies by the funding currency issuers.

Our focus interaction terms are supposed to reflect the impact of macroeconomic policies on the relationship between the yield spread and the exchange rate movements. The dummies for the interaction terms usually pertain to policies implemented after the GFC, and the interaction between the yield spread and the VIX should reflect the impact of global financial shocks on the slope of the yield spread. The estimated coefficients on the interest rate differentials, shown in the first row in each panel of Table 2, should represent the impact of the yield spread on the exchange rate movements before the GFC. Table 3 reports that when the estimation is conducted for the US dollar-funded investments, only the estimation for the PRC yuan has a negative coefficient for the yield spread. When we look at the signs of the estimated coefficient on the yield spread for other estimations with the three other major currencies as the funding currencies, the estimates are much more likely to take negative coefficients. These results are consistent with the findings from the previous section that before the GFC, dollar-funded carry trades were less common than carry trades funded with other major currencies, namely the euro, Japanese yen, and Swiss franc.

When we focus on Table 2 Panel A and the top section of Table 3, we can see that many of the estimates for the interaction terms between the yield spread and QE1, QE2, QE3_1, or QE3_2 are negative, indicating that QE policies made the effect of the interest differential less positive or more negative, implying greater carry trades. In Column (11) of Table 2 Panel A, we see that the level impact of the yield spread on the Thai baht is found to be 9.24 (while excluding the effect of VIX for simplicity). The magnitude of the coefficient falls to −7.58 (= 9.24 – 16.82) during the first half of the QE3 period. Except for the Korean won, liquidity injections through QE policies seem to have guided the US dollar to become a funding currency for the carry trades in Asia and the Pacific.

with NIRP in place to be included, the sample period at least needs to cover up to February 2017, which is outside our sample period.

[9] Details on the dates for the dummies are presented in Appendix Table 2.

Table 2: Individual Country Regression Results: Asian Investment Currencies against Major Funding Currencies

A. US Dollar as a Funding Currency

CCY/USD	(1) AUD b/se	(2) CNY b/se	(3) HKD b/se	(4) IDR b/se	(5) INR b/se	(6) KRW b/se
Yield spread, %pa.a	13.17***	–3.34***	0.54***	6.67***	3.19***	12.59***
	(3.39)	(0.64)	(0.18)	(0.98)	(1.18)	(2.72)
DomesStockVolat, %pa.a	–1.30***	–0.03**	0.00*	0.17*	0.12	–0.17
	(0.20)	(0.02)	(0.00)	(0.10)	(0.08)	(0.12)
CCYUSD volat, %pa.a	–0.15	0.00	0.00	–0.15***	–0.08***	–0.02
	(0.10)	(.)	(0.03)	(0.05)	(0.03)	(0.08)
log(VIX)	1.39	–4.55***	–0.41***	19.43***	–0.28	10.53***
	(3.02)	(0.57)	(0.04)	(2.88)	(2.42)	(3.08)
USQE1	–9.94**	8.73***	0.27***	2.49	–6.61**	–29.30***
	(3.96)	(0.72)	(0.03)	(3.72)	(2.92)	(6.62)
USQE2	26.68***	–3.25***	–0.19***	4.23	23.11***	–12.36***
	(2.85)	(0.75)	(0.03)	(2.64)	(7.26)	(4.72)
USQE3_1	–5.37	10.06	–0.11***	41.93***	–35.21***	–29.43***
	(12.62)	(7.43)	(0.02)	(6.21)	(11.28)	(7.94)
USQE3_2	–142.41***	–0.22	–0.18***	30.75***	28.95***	72.62***
	(16.03)	(1.56)	(0.03)	(5.09)	(6.35)	(10.20)
DomesStockVolat*YieldSpread	0.60***	0.03***	0.00	–0.02*	–0.02	0.00
	(0.08)	(0.01)	(0.00)	(0.01)	(0.01)	(0.04)
log(VIX)*YieldSpread	–6.13***	1.68***	–0.12*	–2.05***	–0.25	–4.23***
	(1.27)	(0.25)	(0.07)	(0.37)	(0.44)	(1.05)
USQE1*YieldSpread	–0.22	–8.45***	–0.47***	–2.44***	0.33	7.33***
	(1.17)	(0.43)	(0.13)	(0.55)	(0.63)	(2.41)
USQE2*YieldSpread	–7.03***	–0.93***	0.01	–0.85*	–2.74***	3.23**
	(0.87)	(0.31)	(0.37)	(0.46)	(0.99)	(1.61)
USQE3_1*YieldSpread	6.30	–5.55**	–1.00***	–5.94***	5.06***	9.22***
	(4.84)	(2.78)	(0.31)	(1.39)	(1.49)	(2.97)
USQE3_2*YieldSpread	63.98***	–0.83*	–0.33**	–3.53***	–4.41***	–29.48***
	(6.76)	(0.46)	(0.16)	(0.81)	(0.75)	(4.20)
Constant	4.49	11.31***	1.20***	–54.98***	–8.13	–25.36***
	(8.39)	(1.47)	(0.10)	(7.34)	(6.51)	(7.49)
Observations	3,876	2,709	3,876	3,253	3,876	3,876
Adjusted R^2	0.487	0.653	0.235	0.600	0.428	0.130

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Table 2 *continued*

CCY/USD	(7) MYR b/se	(8) NZD b/se	(9) PHP b/se	(10) SGD b/se	(11) THB b/se
Yield spread, %pa.a	11.92***	16.57***	4.45***	16.70***	9.24***
	(1.38)	(5.40)	(0.79)	(1.47)	(1.30)
DomesStockVolat, %pa.a	–0.04	–0.27	–0.30***	0.04*	0.04
	(0.05)	(0.53)	(0.05)	(0.02)	(0.04)
CCYUSD volat, %pa.a	–0.21***	–0.02	0.04	–0.07	0.11
	(0.04)	(0.14)	(0.09)	(0.09)	(0.10)
log(VIX)	3.58***	–1.99	15.10***	–2.72***	1.87**
	(1.09)	(6.58)	(1.55)	(0.59)	(0.73)
USQE1	–19.55***	20.14***	–5.42**	–6.23***	–10.09***
	(1.54)	(6.39)	(2.51)	(0.52)	(0.99)
USQE2	–14.49*	8.54	–10.06***	1.57*	0.41
	(7.62)	(5.29)	(2.06)	(0.88)	(2.77)
USQE3_1	–28.98	80.86**	14.33***	4.84***	45.53***
	(33.45)	(33.07)	(1.44)	(0.94)	(6.95)
USQE3_2	–177.51***	–39.68***	7.45***	–12.60***	11.14**
	(16.31)	(4.53)	(0.94)	(1.57)	(4.45)
DomesStockVolat*YieldSpread	0.04	0.21	0.03***	0.07**	–0.04*
	(0.03)	(0.18)	(0.01)	(0.03)	(0.02)
log(VIX)*YieldSpread	–3.17***	–4.13*	–1.66***	–5.72***	–2.08***
	(0.54)	(2.14)	(0.27)	(0.55)	(0.44)
USQE1*YieldSpread	2.93***	–7.62***	–0.67	1.05	2.32***
	(0.84)	(2.09)	(0.55)	(2.17)	(0.87)
USQE2*YieldSpread	2.28	–0.62	2.89***	–10.71*	–1.66
	(2.86)	(2.01)	(0.65)	(5.68)	(1.04)
USQE3_1*YieldSpread	8.35	–31.89**	–4.38***	–25.90***	–16.82***
	(11.74)	(14.17)	(1.37)	(7.30)	(2.53)
USQE3_2*YieldSpread	58.56***	16.37***	–1.35***	78.78***	–5.23***
	(5.52)	(1.53)	(0.48)	(7.10)	(1.90)
Constant	–7.58***	–15.96	–39.42***	7.25***	–8.78***
	(2.85)	(16.75)	(4.31)	(1.61)	(2.23)
Observations	2,710	3,876	3,876	3,876	3,876
Adjusted R^2	0.741	0.361	0.369	0.561	0.413

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Table 2 *continued*

B. Euro as a Funding Currency

CCY/EUR	(1) AUD b/se	(2) CNY b/se	(3) HKD b/se	(4) IDR b/se	(5) INR b/se	(6) KRW b/se
Yield spread, %pa.a	–13.28***	–9.23***	12.91***	–6.95***	–2.05	–15.55***
	(3.22)	(1.81)	(2.66)	(1.26)	(1.50)	(5.38)
CCYEUR volat, %pa.a	–0.08	1.00***	–0.19	0.47***	0.05	–0.31***
	(0.08)	(0.20)	(0.18)	(0.17)	(0.07)	(0.08)
DomesStockVolat %p.a.	–0.22*	–0.13***	–0.12*	–0.10	0.12	0.11
	(0.12)	(0.05)	(0.07)	(0.11)	(0.09)	(0.20)
EUStockVolat %p.a.	0.10	0.27***	0.15**	0.08	0.14	0.02
	(0.09)	(0.06)	(0.06)	(0.13)	(0.10)	(0.23)
log(VIX)	–18.85***	–2.30*	1.49	–20.90***	–3.08	–2.79
	(2.86)	(1.38)	(1.24)	(3.04)	(2.65)	(4.32)
SNBminFX	5.01***	9.69***	–6.98***	3.43***	1.07	0.30
	(0.96)	(1.26)	(0.91)	(1.11)	(1.39)	(1.04)
EUR_neg	–107.01***	–8.92	–20.60***	–146.29***	57.42*	–8.56
	(20.06)	(12.70)	(2.23)	(25.61)	(30.63)	(9.32)
ECBQE	–46.04*	7.47**	–16.77***	33.85***	–76.77***	–78.18***
	(26.01)	(3.05)	(4.59)	(5.00)	(12.68)	(11.46)
DomesStockVol*YieldSpread	0.15**	0.06***	0.14	0.02	–0.04***	–0.01
	(0.06)	(0.02)	(0.11)	(0.02)	(0.02)	(0.09)
EUStockVol*YieldSpread	–0.06	–0.15***	–0.13*	0.01	–0.01	0.05
	(0.04)	(0.03)	(0.07)	(0.02)	(0.02)	(0.10)
log(VIX)*YieldSpread	3.31***	2.76***	–3.41***	1.53***	0.99*	2.46
	(1.15)	(0.69)	(1.00)	(0.40)	(0.53)	(1.91)
EUR_neg*YieldSpread	42.78***	0.93	58.82***	19.89***	–8.16**	2.04
	(8.03)	(3.56)	(14.34)	(3.69)	(3.68)	(4.04)
ECBQE*YieldSpread	21.98*	3.66***	44.66***	–4.80***	10.17***	43.26***
	(12.36)	(1.21)	(16.89)	(0.68)	(1.67)	(6.16)
Constant	62.36***	–9.22**	1.17	70.51***	7.70	24.63**
	(7.93)	(3.65)	(3.59)	(9.22)	(7.17)	(12.02)
Observations	3,876	2,709	3,876	3,253	3,876	3,876
Adjusted R^2	0.278	0.305	0.266	0.240	0.095	0.198

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Table 2 *continued*

CCY/EUR	(7) MYR b/se	(8) NZD b/se	(9) PHP b/se	(10) SGD b/se	(11) THB b/se
Yield spread, %pa.a	–2.29	–19.46***	–9.34***	11.58***	–1.72
	(2.48)	(4.76)	(1.26)	(2.50)	(2.21)
CCYEUR volat, %pa.a	0.60***	–0.31**	–0.16	0.46***	0.53***
	(0.22)	(0.14)	(0.12)	(0.14)	(0.16)
DomesStockVolat %p.a.	0.03	0.13	0.01	–0.02	–0.04
	(0.08)	(0.29)	(0.09)	(0.06)	(0.05)
EUStockVolat %p.a.	0.27***	0.18	0.10	0.05	0.19***
	(0.07)	(0.18)	(0.10)	(0.05)	(0.04)
log(VIX)	–7.42***	–28.57***	–8.08***	–6.71***	–0.36
	(1.28)	(4.68)	(2.04)	(1.06)	(1.13)
SNBminFX	5.53***	–0.81	–1.93	1.80**	8.20***
	(1.28)	(0.71)	(1.22)	(0.86)	(1.38)
EUR_neg	–137.86***	–193.61***	–30.90***	–14.33***	–112.36***
	(22.18)	(21.11)	(4.30)	(2.29)	(38.65)
ECBQE	–64.19**	603.80***	–4.41*	9.05***	–31.76***
	(28.76)	(92.10)	(2.56)	(1.71)	(6.92)
DomesStockVol*YieldSpread	–0.20***	0.10	–0.02	0.12**	–0.02
	(0.07)	(0.13)	(0.02)	(0.05)	(0.03)
EUStockVol*YieldSpread	–0.07*	–0.09	0.02	–0.12***	–0.07**
	(0.04)	(0.07)	(0.02)	(0.04)	(0.03)
log(VIX)*YieldSpread	1.48*	8.16***	3.32***	–4.71***	0.03
	(0.85)	(1.74)	(0.46)	(0.92)	(0.80)
EUR_neg*YieldSpread	43.69***	55.78***	10.81***	22.26***	50.43***
	(6.68)	(6.00)	(1.79)	(4.04)	(18.41)
ECBQE*YieldSpread	22.91***	–164.10***	3.06***	–2.87**	23.25***
	(8.83)	(25.16)	(0.86)	(1.45)	(3.84)
Constant	9.24**	71.47***	22.67***	11.22***	–8.12**
	(3.81)	(13.22)	(5.64)	(2.72)	(3.39)
Observations	2,710	3,876	3,876	3,876	3,876
Adjusted R^2	0.223	0.262	0.184	0.225	0.197

continued on next page

Table 2 *continued*

C. Yen as a Funding Currency

CCY/JPY	**(1) AUD b/se**	**(2) CNY b/se**	**(3) HKD b/se**	**(4) IDR b/se**	**(5) INR b/se**	**(6) KRW b/se**
Yield spread, %pa.a	–23.55***	–28.83***	13.04***	4.02***	–3.68	6.12
	(2.78)	(4.16)	(1.92)	(1.42)	(2.37)	(4.45)
CCYJPY volat, %pa.a	0.12**	–0.01	–0.21	–0.28**	–0.14***	0.24**
	(0.06)	(0.12)	(0.13)	(0.13)	(0.04)	(0.12)
DomesStockVolat %p.a.	–0.61**	–0.02	0.08	1.00***	–0.33*	–0.25
	(0.28)	(0.10)	(0.06)	(0.27)	(0.17)	(0.25)
JPStockVolat %p.a.	0.24	–0.13	–0.11*	–0.01	–0.39	–0.12
	(0.29)	(0.13)	(0.06)	(0.19)	(0.26)	(0.23)
log(VIX)	–40.43***	–4.62**	15.10***	8.50*	1.92	5.41
	(3.96)	(2.08)	(1.58)	(4.79)	(4.86)	(5.06)
JPintervene	53.04***	–0.55	–12.43***	11.00**	295.68***	8.85
	(13.13)	(5.44)	(1.42)	(5.14)	(40.93)	(80.41)
JPQQE	70.66***	43.91***	10.61***	17.31***	116.45***	81.32***
	(6.37)	(4.00)	(3.57)	(5.01)	(12.55)	(4.13)
DomesStockVol*YieldSpread	0.28***	0.13***	0.11***	–0.10***	0.07**	0.01
	(0.07)	(0.04)	(0.04)	(0.03)	(0.03)	(0.06)
JPStockVol*YieldSpread	–0.13*	–0.01	–0.07*	0.02	0.04	–0.02
	(0.08)	(0.05)	(0.04)	(0.02)	(0.04)	(0.08)
log(VIX)*YieldSpread	9.69***	7.53***	–4.44***	–0.86	0.83	0.01
	(1.03)	(1.29)	(0.71)	(0.54)	(0.80)	(1.37)
JPintervene*YieldSpread	–13.18***	–2.26	27.85	–2.42***	–35.62***	–2.60
	(3.55)	(1.86)	(26.75)	(0.86)	(4.97)	(24.18)
JPQQE*YieldSpread	–23.75***	–10.49***	–85.29***	–2.40***	–14.44***	–32.20***
	(2.65)	(1.48)	(25.95)	(0.73)	(1.55)	(1.30)
Constant	90.86***	22.57***	–42.42***	–37.02***	8.32	–34.48**
	(11.22)	(7.10)	(4.76)	(13.91)	(14.52)	(16.78)
Observations	3,876	2,709	3,876	3,253	3,876	3,876
Adjusted R^2	0.422	0.413	0.184	0.040	0.175	0.185

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Table 2 *continued*

CCY/JPY	(7) MYR b/se	(8) NZD b/se	(9) PHP b/se	(10) SGD b/se	(11) THB b/se
Yield spread, %pa.a	–44.98***	–14.96***	–0.89	–4.27	–21.33***
	(6.30)	(3.45)	(1.21)	(2.89)	(2.70)
CCYJPY volat, %pa.a	–0.02	0.32***	0.04	–0.14*	0.86***
	(0.10)	(0.10)	(0.10)	(0.08)	(0.13)
DomesStockVolat %p.a.	–0.17	–1.30**	0.18*	0.21**	–0.13*
	(0.65)	(0.57)	(0.11)	(0.08)	(0.08)
JPStockVolat %p.a.	1.24***	–0.32	0.20	0.07	0.10
	(0.34)	(0.36)	(0.14)	(0.06)	(0.15)
log(VIX)	–43.82***	–25.89***	7.59***	3.75**	–11.39***
	(6.28)	(4.93)	(2.88)	(1.46)	(2.26)
JPintervene	251.24***	–64.52***	–8.82***	1.34	24.18
	(62.60)	(14.74)	(2.79)	(1.46)	(34.97)
JPQQE	–119.52***	–42.47***	–11.65***	–7.54***	31.67***
	(14.55)	(3.89)	(2.68)	(1.22)	(4.06)
DomesStockVol*YieldSpread	0.22	0.26*	–0.04***	0.02	0.03
	(0.24)	(0.14)	(0.01)	(0.07)	(0.02)
JPStockVol*YieldSpread	–0.47***	0.01	–0.05**	–0.17***	–0.08
	(0.12)	(0.09)	(0.02)	(0.06)	(0.06)
log(VIX)*YieldSpread	17.53***	5.26***	0.95**	2.83***	6.76***
	(2.29)	(1.12)	(0.44)	(1.09)	(1.06)
JPintervene*YieldSpread	–91.22***	28.13***	–0.57	–59.43***	–8.15
	(22.15)	(5.07)	(0.83)	(14.18)	(10.62)
JPQQE*YieldSpread	41.41***	16.22***	7.91***	21.35***	–14.89***
	(4.67)	(1.11)	(1.17)	(1.35)	(2.04)
Constant	108.27***	72.42***	–32.07***	–16.39***	30.13***
	(18.24)	(15.44)	(8.18)	(4.44)	(6.60)
Observations	2710	3876	3876	3876	3876
Adjusted R^2	0.239	0.220	0.195	0.221	0.246

continued on next page

Table 2 *continued*

D. Swiss Franc as a Funding Currency

CCY/CHF	(1) AUD b/se	(2) CNY b/se	(3) HKD b/se	(4) IDR b/se	(5) INR b/se	(6) KRW b/se
Yield spread, %pa.a	–27.60***	2.77*	3.86**	–4.16***	7.40***	–53.73***
	(2.96)	(1.49)	(1.52)	(1.16)	(1.64)	(4.81)
CCYCHF volat, %pa.a	0.04	–0.05	–0.53**	–0.12	–0.02	–0.16**
	(0.09)	(0.08)	(0.22)	(0.12)	(0.05)	(0.07)
DomesStockVolat %p.a.	–0.26*	–0.13***	–0.07*	0.09	–0.05	0.11
	(0.14)	(0.05)	(0.04)	(0.17)	(0.12)	(0.17)
SWStockVolat %p.a.	0.45***	–0.07	–0.07	0.14	0.04	0.54***
	(0.12)	(0.05)	(0.04)	(0.24)	(0.13)	(0.15)
log(VIX)	–37.18***	4.85***	7.78***	–14.12***	12.82***	–45.55***
	(3.36)	(0.83)	(1.14)	(3.47)	(3.34)	(4.57)
SNBminFX	–3.64	–2.63*	–3.47***	5.55*	70.51***	–5.83
	(6.21)	(1.40)	(0.81)	(3.36)	(7.49)	(5.65)
SNBNegRate	–22.63*	10.20***	3.12**	45.91***	17.94	–34.62***
	(13.45)	(3.67)	(1.32)	(9.82)	(12.83)	(9.81)
DomesStockVol*YieldSpread	0.19***	0.04**	0.01	–0.02	0.01	–0.05
	(0.06)	(0.02)	(0.04)	(0.02)	(0.02)	(0.05)
SWStockVol*YieldSpread	–0.22***	–0.04*	–0.03	0.00	–0.04	–0.20***
	(0.04)	(0.02)	(0.03)	(0.03)	(0.02)	(0.05)
log(VIX)*YieldSpread	8.89***	–2.24***	–0.46	1.05***	–1.59***	17.79***
	(1.03)	(0.56)	(0.56)	(0.40)	(0.59)	(1.59)
SNBminFX*YieldSpread	1.99	2.33***	1.10	–0.71	–9.86***	–1.34
	(2.54)	(0.59)	(0.98)	(0.56)	(0.98)	(2.15)
SNBNegRate*YieldSpread	6.09	–0.21	–12.26***	–6.73***	–3.43**	11.73***
	(4.82)	(1.16)	(1.98)	(1.22)	(1.53)	(3.78)
Constant	115.22***	–5.57**	–9.63**	53.36***	–42.40***	146.75***
	(9.84)	(2.28)	(4.46)	(10.23)	(9.39)	(14.10)
Observations	3,876	2,709	3,876	3,253	3,876	3,876
Adjusted R^2	0.318	0.173	0.191	0.195	0.143	0.195

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Table 2 *continued*

CCY/CHF	(7) MYR b/se	(8) NZD b/se	(9) PHP b/se	(10) SGD b/se	(11) THB b/se
Yield spread, %pa.a	–0.37	–13.80***	–15.27***	–7.62***	–9.44***
	(2.94)	(2.95)	(1.11)	(1.43)	(2.61)
CCYCHF volat, %pa.a	–0.04	0.05	–0.27	–0.41**	0.26*
	(0.07)	(0.12)	(0.18)	(0.16)	(0.14)
DomesStockVolat %p.a.	0.05	–0.91**	0.09	–0.12***	–0.04
	(0.07)	(0.38)	(0.10)	(0.04)	(0.06)
SWStockVolat %p.a.	0.07	0.36**	0.05	0.10***	0.13*
	(0.06)	(0.14)	(0.09)	(0.03)	(0.07)
log(VIX)	–0.48	–21.42***	–15.71***	1.01	–4.09**
	(1.76)	(3.32)	(1.84)	(0.90)	(1.77)
SNBminFX	–27.75***	–17.04***	2.63	–0.30	–21.92***
	(2.90)	(2.17)	(1.70)	(0.49)	(3.56)
SNBNegRate	–52.57***	–13.21	5.10	–2.61	–19.57***
	(8.53)	(22.89)	(3.47)	(1.91)	(5.64)
DomesStockVol*YieldSpread	–0.06	0.37***	–0.02	0.00	–0.01
	(0.07)	(0.13)	(0.02)	(0.04)	(0.03)
SWStockVol*YieldSpread	–0.08**	–0.16***	–0.03**	0.02	–0.11**
	(0.03)	(0.05)	(0.02)	(0.03)	(0.05)
log(VIX)*YieldSpread	0.07	4.33***	5.71***	1.65***	2.14**
	(1.16)	(1.04)	(0.40)	(0.51)	(1.00)
SNBminFX*YieldSpread	12.57***	7.21***	–2.85***	9.95***	12.04***
	(1.15)	(0.85)	(0.92)	(0.76)	(1.64)
SNBNegRate*YieldSpread	15.40***	2.52	–1.30	1.45	10.68***
	(2.34)	(5.43)	(1.00)	(1.22)	(2.48)
Constant	5.42	66.20***	46.69***	3.97	15.74***
	(4.80)	(9.49)	(5.97)	(3.18)	(5.15)
Observations	2,710	3,876	3,412	3,876	3,876
Adjusted R^2	0.214	0.171	0.282	0.194	0.254

CCY = People's Republic of China yuan; EUR = euro; AUD = Australian dollar; CNY = People's Republic of China yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; KRW = Korean won; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai baht; USD = United States dollar; EUR = euro; JPY = Japanese yen; CHF = Swiss franc.

Notes: Regression point estimates (Newey–West robust standard errors in brackets). *(**)[***] denoted significance at the 10%(5%)[1%].

Table 3: Summary of the Signs of the Estimates

USD	AUD	CNY	HKD	IDR	INR	KRW	MYR
Yield spread, %pa.a	positive	negative	positive	positive	positive	positive	positive
DomesStockVol*YieldSpread	positive	positive		negative			
log(VIX)*YieldSpread	negative	positive	negative	negative		negative	negative
USQE1*YieldSpread		negative	negative	negative		positive	positive
USQE2*YieldSpread	negative	negative		negative	negative	positive	
USQE3_1*YieldSpread		negative	negative	negative	positive	positive	
USQE3_2*YieldSpread	positive	negative	negative	negative	negative	negative	positive
EUR	**AUD**	**CNY**	**HKD**	**IDR**	**INR**	**KRW**	**MYR**
Yield spread, %pa.a	negative	negative	positive	negative		negative	
DomesStockVol*YieldSpread	positive	positive			negative		negative
EUStockVol*YieldSpread		negative	negative				negative
log(VIX)*YieldSpread	positive	positive	negative	positive	positive		positive
EUR_neg*YieldSpread	positive		positive	positive	negative		positive
ECBQE*YieldSpread	positive	positive	positive	negative	positive	positive	positive
JPY	**AUD**	**CNY**	**HKD**	**IDR**	**INR**	**KRW**	**MYR**
Yield spread, %pa.a	negative	negative	positive	positive			negative
DomesStockVol*YieldSpread	positive	positive	positive	negative	positive		
JPStockVol*YieldSpread	negative		negative				negative
log(VIX)*YieldSpread	positive	positive	negative				positive
JPintervene*YieldSpread	negative			negative	negative		negative
JPQQE*YieldSpread	negative	negative	negative	negative	negative	negative	positive
CHF	**AUD**	**CNY**	**HKD**	**IDR**	**INR**	**KRW**	**MYR**
Yield spread, %pa.a	negative	positive	positive	negative	positive	negative	
DomesStockVol*YieldSpread	positive	positive					
SWStockVol*YieldSpread	negative	negative				negative	negative
log(VIX)*YieldSpread	positive	negative		positive	negative	positive	
SNBminFX*YieldSpread		positive			negative		positive
SNBNegRate*YieldSpread			negative	negative	negative	positive	positive

USD	NZD	PHP	SGD	THB	Positive	Negative
Yield spread, %pa.a	positive	positive	positive	positive	**10**	1
DomesStockVol*YieldSpread		positive	positive	negative	**4**	2
log(VIX)*YieldSpread	negative	negative	negative	negative	1	**9**
USQE1*YieldSpread	negative			positive	3	**4**
USQE2*YieldSpread		positive	negative		2	**5**
USQE3_1*YieldSpread	negative	negative	negative	negative	2	**7**
USQE3_2*YieldSpread	positive	negative	positive	negative	4	**7**
EUR	**NZD**	**PHP**	**SGD**	**THB**	**Positive**	**Negative**
Yield spread, %pa.a	negative	negative	positive		2	**6**
DomesStockVol*YieldSpread			positive		**3**	2
EUStockVol*YieldSpread			negative	negative	0	**5**
log(VIX)*YieldSpread	positive	positive	negative		**7**	2
EUR_neg*YieldSpread	positive	positive	positive	positive	**8**	1
ECBQE*YieldSpread	negative	positive	negative	positive	**8**	3

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Table 3 *continued*

JPY	NZD	PHP	SGD	THB	Positive	Negative
Yield spread, %pa.a	negative			negative	2	**5**
DomesStockVol*YieldSpread	positive	negative			**5**	2
JPStockVol*YieldSpread		negative	negative		0	**5**
log(VIX)*YieldSpread	positive	positive	positive	positive	**7**	2
JPintervene*YieldSpread	positive		negative		1	**5**
JPQQE*YieldSpread	positive	positive	positive	negative	4	**7**
CHF	**NZD**	**PHP**	**SGD**	**THB**	**Positive**	**Negative**
Yield spread, %pa.a	negative	negative	negative	negative	3	**7**
DomesStockVol*YieldSpread	positive			negative	**3**	1
SWStockVol*YieldSpread	negative	negative		negative	0	**7**
log(VIX)*YieldSpread	positive	positive	positive	positive	**7**	2
SNBminFX*YieldSpread	positive	negative	positive	positive	**5**	2
SNBNegRate*YieldSpread				positive	3	3

AUD = Australian dollar; CNY = People's Republic of China yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; KRW = Korean won; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai baht; USD = United States dollar; EUR = euro; JPY = Japanese yen; CHF = Swiss franc.

In contrast, the yield spread variable mostly has negative coefficients among the euro, Japanese yen, and Swiss franc. That means, compared with the US dollar, these currencies were more likely to be funding currencies for carry trades before the GFC. Japan's foreign exchange intervention and QQE tend to make the Japanese yen more attractive as funding currency for many investment currencies. The estimate on the interaction term between the intervention dummy and the interest differential is negative among six currencies while it is positive only for the New Zealand dollar. The interaction term between QQE and the interest differential is negative among seven currencies and positive among four currencies. It appears to be safe to conclude that Japan's QQE led to increased activity using the Japanese yen as funding currency for carry trades invested in Asia and the Pacific.

Conversely, unconventional monetary policies by the ECB do not appear to have yielded the same effect as in Japan. First of all, NIRP is found to have a *positive* effect on the link between the yield spread and the exchange rate movements among eight currencies. That, along with negative estimates for the yield spread, means that its implementation led to the reduction of successful carry trades as can be seen in the cases of the Australian dollar, Indian rupee, New Zealand dollar, and Philippine peso. The impact of the ECB's QE on the Fama beta is also found to have been positive among eight currencies, and negative for the remaining three currencies. As previously discussed, unconventional monetary policies could signal future uncertainty. In the case of NIRP, uncertainty could arise from the potentially negative impacts of the policy on the financial system. QE could also be interpreted as the signs of prolonging stagnation that may help investors to lessen their risk taking behavior from using the euro as the funding currency.

The impact of NIRP taken by Switzerland is mixed. The interaction term between the NIRP dummy and the yield spread is significantly negative for three currencies: Hong Kong, China dollar; Indian rupee; and Indonesian rupiah while it is significantly positive for three other currencies: Korean won, Malaysian ringgit, and Thai baht. When neither the minimal exchange rate policy nor NIRP were in place, for investment currencies with the negative estimates for the yield spread variable, the interaction term between the NIRP dummy and the yield spread were found to be negative only for the Indian rupee and positive for the Koran won and Thai baht. In addition, the regressions for Hong Kong, China dollar and the Indonesian rupiah had the positive estimates for the yield spread variable before the NIRP and the minimum exchange rate were put in place, and the estimates became negative after the NIRP policy. The results suggest that the NIRP tended to further increase the franc carry trade activity using the Indian rupee; Hong Kong, China dollar; and Indonesian rupiah as investment currencies. In contrast, it reduced activities when the Korean won and Thai baht were investment currencies. The results for the remaining investment currencies are not clear.

Looking at the impact of the VIX, a measure of global financial risk, in the estimations for which the US dollar is the funding currency, the estimate on the interaction term between the VIX and the interest differential is found to be negative except for the PRC yuan and Indonesian rupiah, which is contrary to what we expected. One plausible explanation for this is the special role the dollar plays in international finance and also the way we calculate the rate of depreciation we have for the left-hand side of the estimation equation. It is the ex post rate of depreciation over the period t through t+252, which is a proxy for the expected rate of depreciation. When some global financial instability occurs (i.e., the VIX rises), the dollar usually appreciates in tandem with a rise in the VIX since investors try to flee to the currency as a safe haven. As the dollar rises against other currencies, that also raises dollar depreciation expectations (i.e., expected appreciation of the investment currency, that is, a fall in the left-hand side of the equation). Hence, a rise in the VIX tends to make the impact of the interest differential on the rate of depreciation more negative.

This is not observed among the other three currencies. A rise in the VIX seems to have caused *appreciation* expectations, especially when investors unwound carry trades and went back to funding currencies such as the euro, Japanese yen, and Swiss franc. That led to currency *depreciation* of the investment currencies vis-à-vis the three funding currencies. Therefore, the impact of the VIX is found to have a positive effect on the Fama beta for the estimations when these three major currencies are funding currencies. This suggests that a global scale financial shock makes the US dollar more attractive as a funding currency.

The estimated coefficient of the interaction term between the stock market volatility of the investment currency issuer and the yield spread show a significantly positive sign as expected for the majority of the currencies. When the dollar is the funding currency, the beta has a significant positive sign when the Australian dollar, PRC yuan, Philippine peso, and Singapore dollar are investment currencies. In case of the euro, the beta has a significantly positive sign for the Australian dollar, PRC yuan, and Singapore dollar. For the Japanese yen, the beta has a significantly positive sign in the case of the Australian dollar; PRC yuan; Hong Kong, China dollar; Indonesian rupiah; and New Zealand dollar. Lastly, when the Swiss franc is a funding currency, a significantly positive relationship is found in the case of the Australian dollar, PRC yuan, and New Zealand dollar.

Considering the impact of the funding currency issuer's stock market volatility on the UIP, the negative coefficient of the interaction term between the funding currency stock market volatility and the interest differential is as expected in all cases (namely, when the euro, Japanese yen, and Swiss franc are funding currency). There is no significant positive coefficient in the results. This implies that the financial uncertainty in the funding currencies tends to be associated with higher carry trade activities and subsequently a greater deviation from the UIP.

5. CONCLUSIONS AND POLICY IMPLICATIONS

Major advanced economies implemented unconventional monetary policies in response to the GFC and the following macroeconomic disturbances. These policies created a new chapter for the world of macroeconomics. While the effect may be easier access to funding, it is not clear whether this translates to higher risk appetite due to the potential problem of greater uncertainty. We addressed this issue in this paper, with a focus on uncovered interest parity.

In the baseline estimation, we have shown that UIP does not hold, consistent with previous studies. An in-depth analysis of unconventional monetary policies through a Fama regression shows they have a significant effect on the Fama beta. QE in the US and QQE in Japan cause the Fama beta to be more negative, implying carry trade activities and "search for yield" behaviour. The US and Japan were early-movers for QE policies, and this translated into higher risk appetite. The resulting capital flows into Asia and the Pacific, which offered higher yields, caused currency depreciation for the US dollar and Japanese yen and UIP deviations consistent with successful carry trades. NIRP, on the other hand, seem to cause greater uncertainty and have a positive effect on the Fama beta. Evidence from the eurozone and Switzerland showed how after the imposition of negative interest rates, the euro and Swiss franc tended to appreciate in value, consistent with a reduction in the execution and success of carry trades.

Given these findings, it is clear that quantitative easing and negative interest rate policies cannot be considered equals. Studies on unconventional monetary policies must recognize the different effects each policy has. QE appears to broadly have the desired effect that central banks would hope for, whereas the opposite is true for NIRP. As such, central banks are encouraged to be cautious when implementing NIRP, at least until more research has been done on how to optimize the policy.

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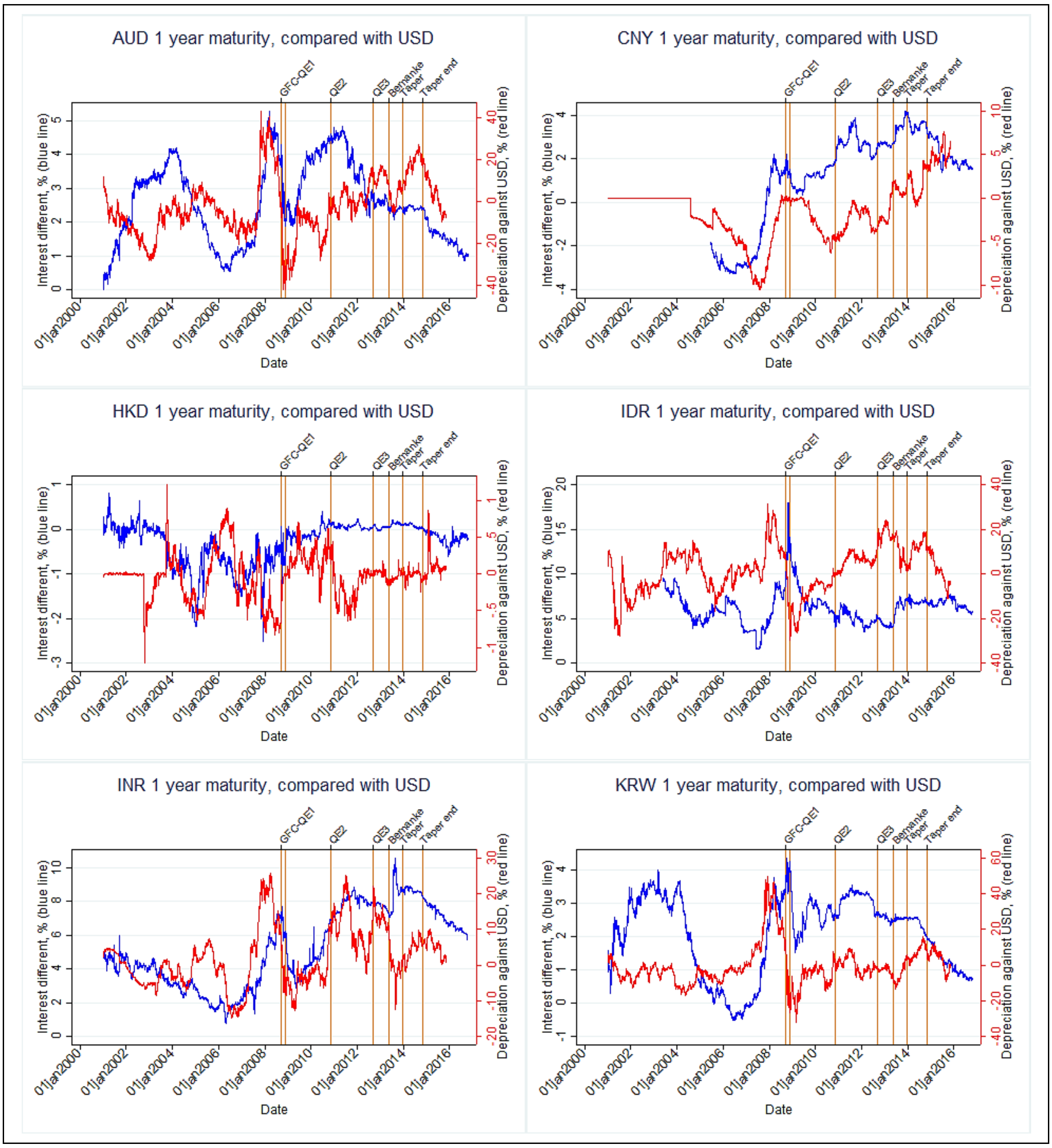
APPENDIX

Appendix Figure 1A−1K: Plots of 1 Year Interest Differential and Currency Depreciation, Against USD



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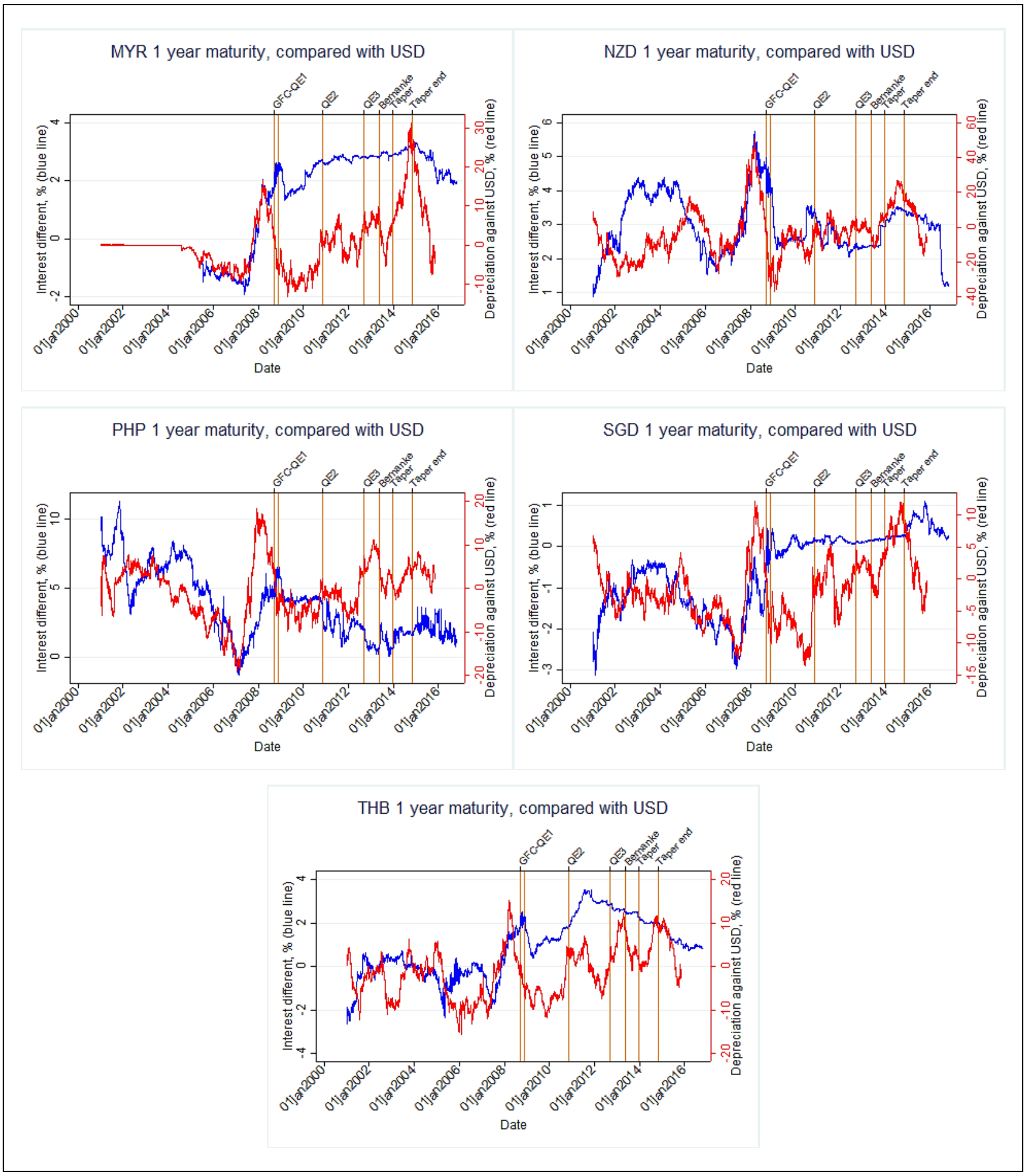
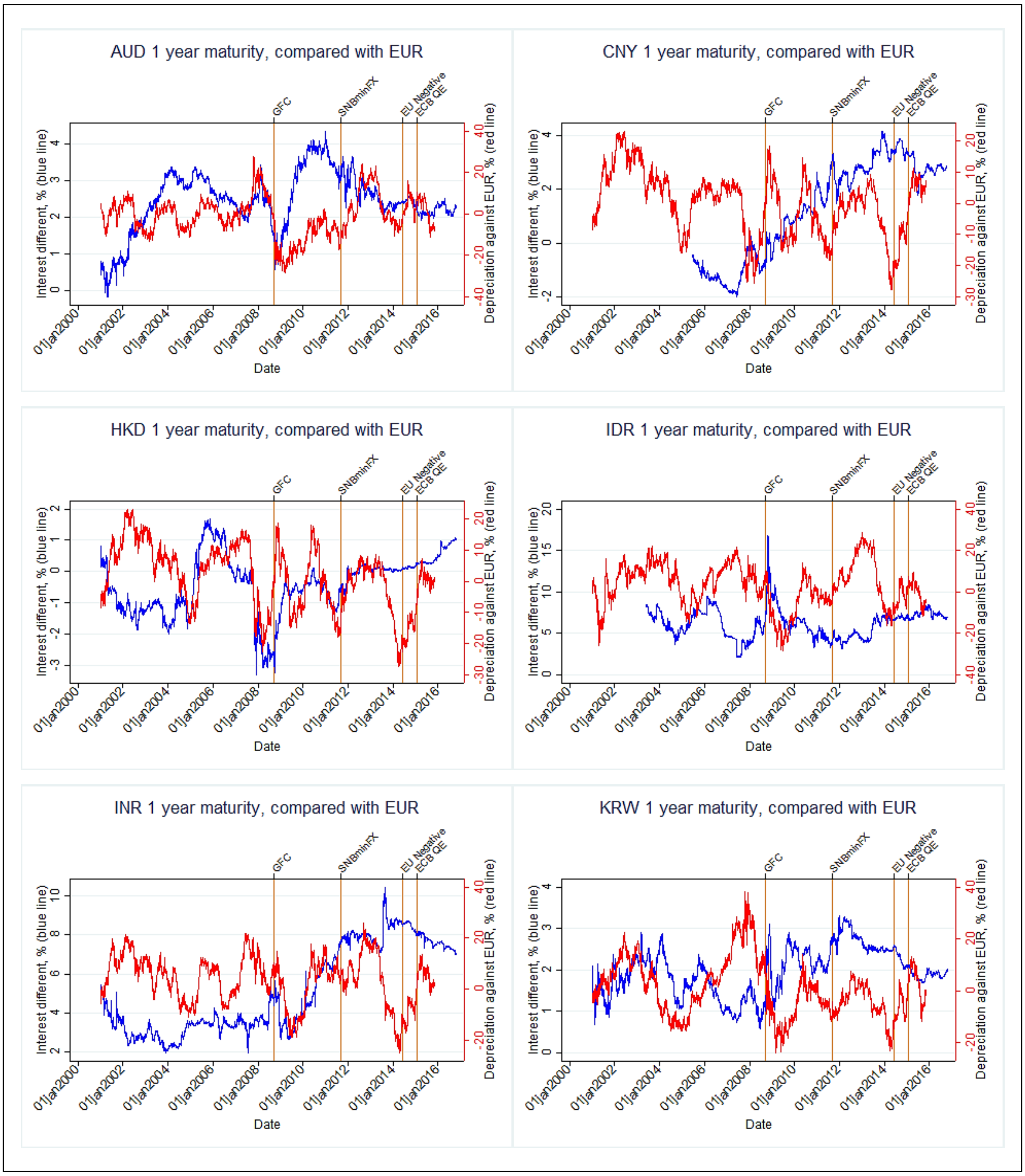
Appendix Figure 1A−1K *continued*



USD = United States dollar; AUD Australian dollar; CNY = People's Republic of China RC yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai Baht.

Appendix Figure 2A−2K: Plots of 1 Year Interest Differential and Currency Depreciation, Against EUR



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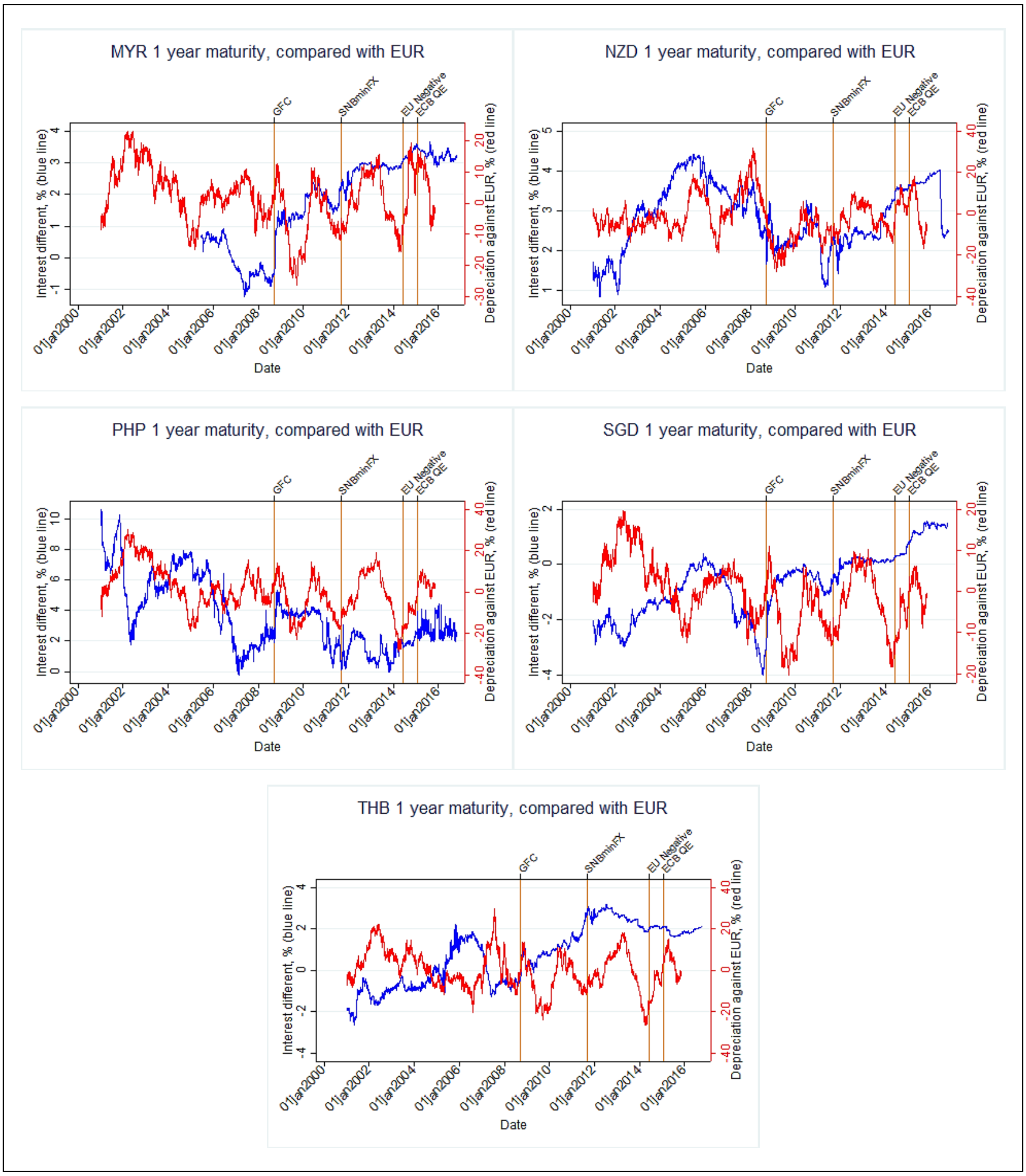
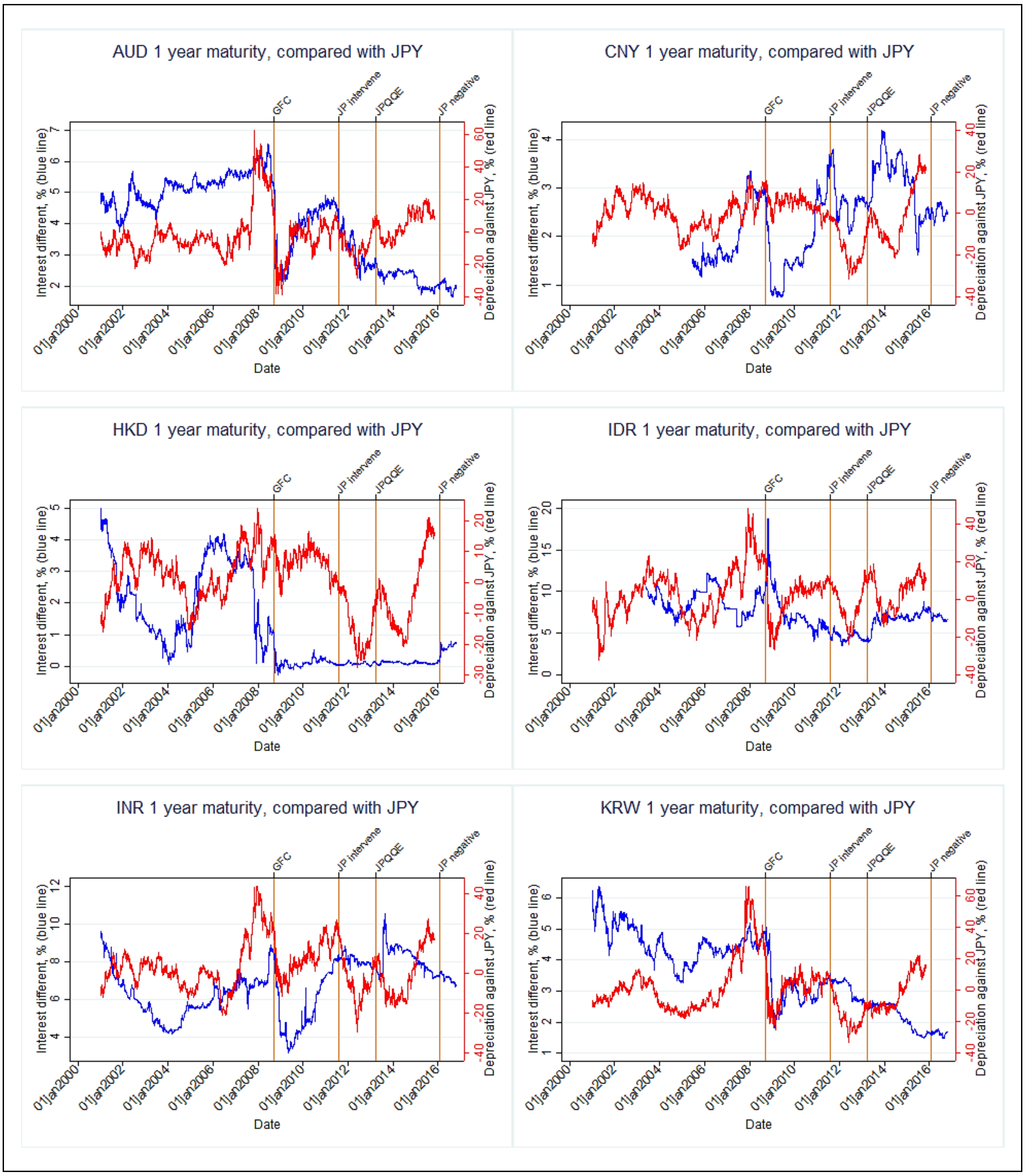
Appendix Figure 2A−2K *continued*



EUR = euro; AUD Australian dollar; CNY = People's Republic of China RC yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai Baht.

Appendix Figure 3A−3K: Plots of 1 Year Interest Differential and Currency Depreciation, Against JPY



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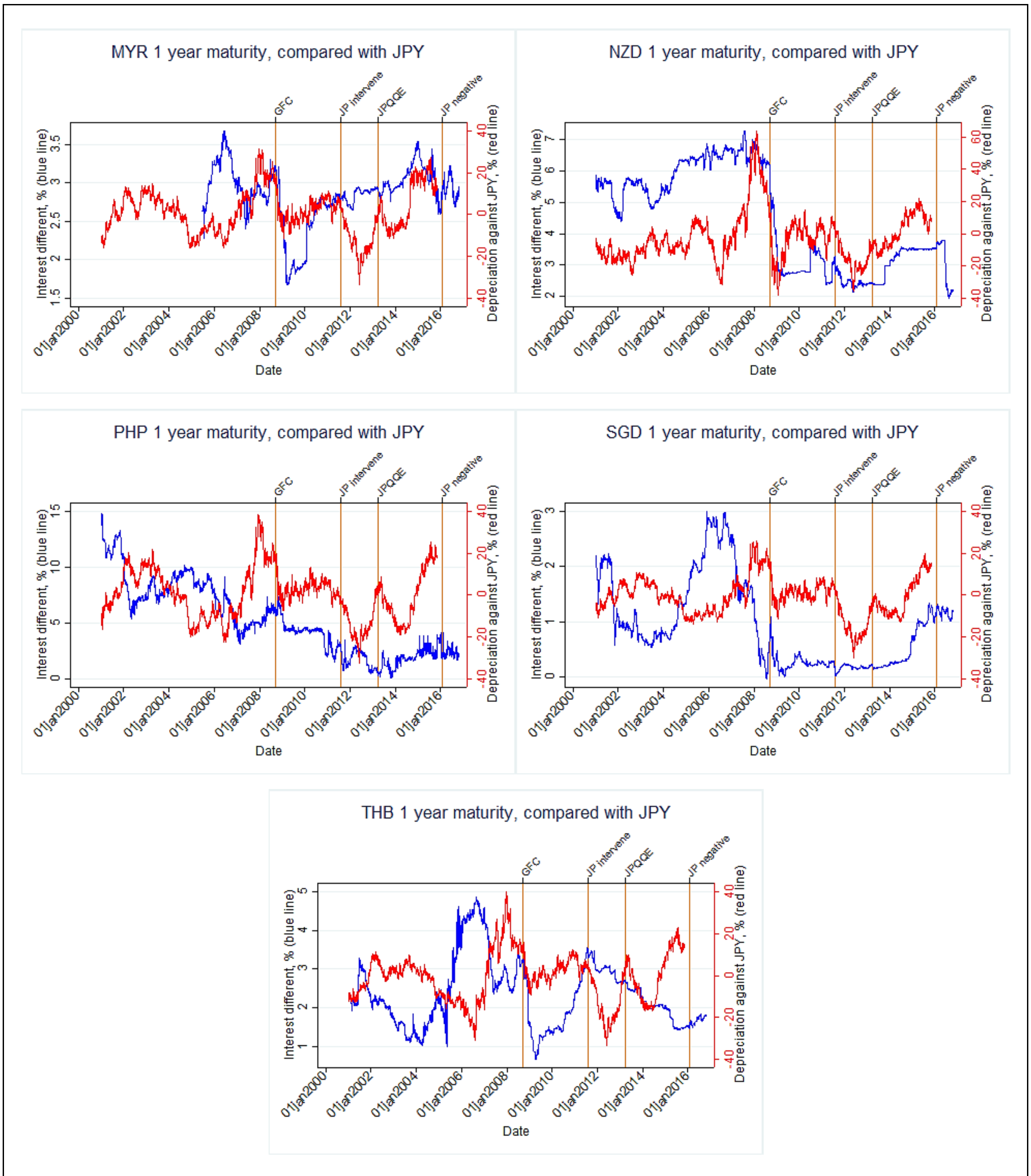
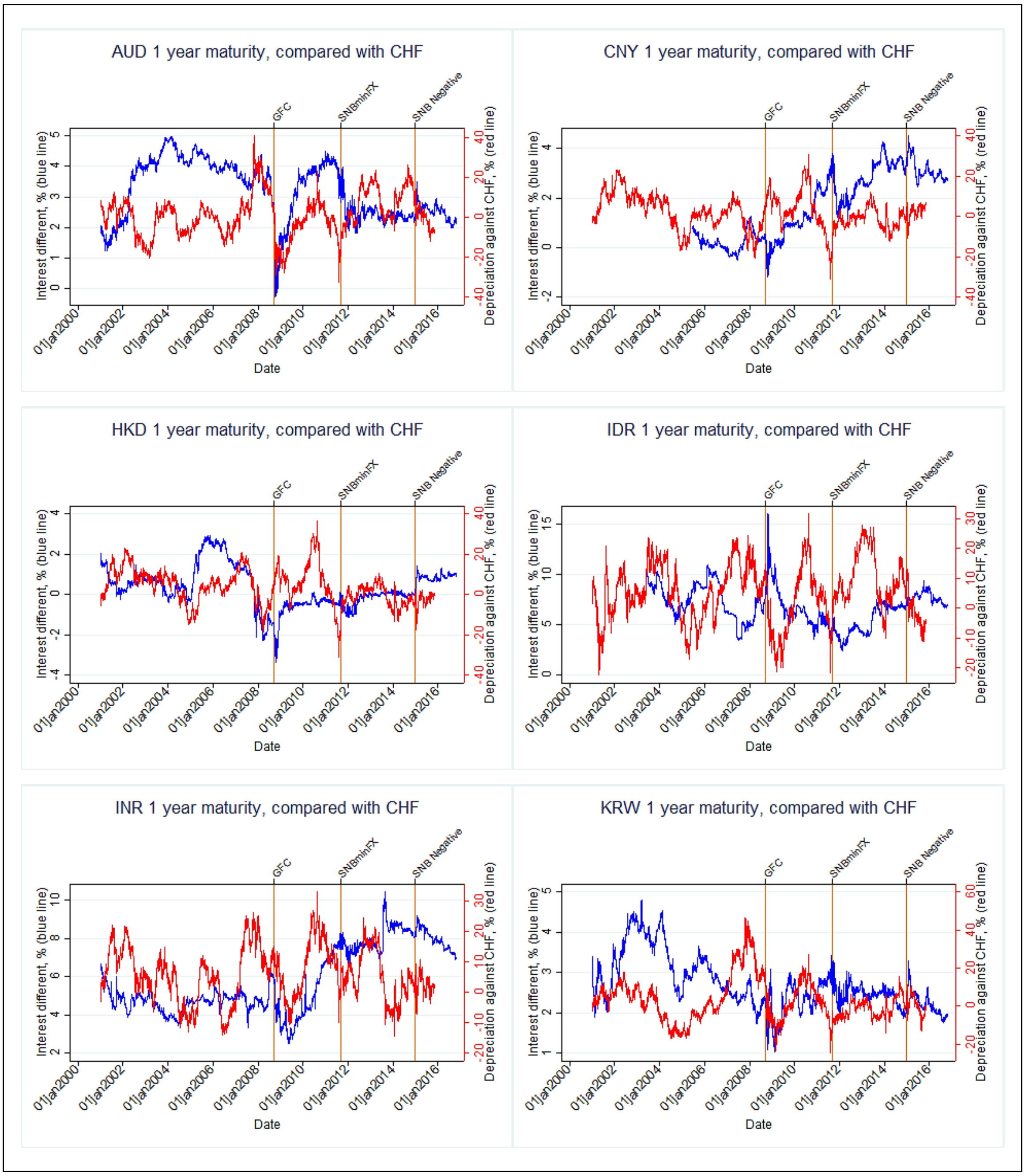
Appendix Figure 3A−3K *continued*



JPY = Japan yen; AUD Australian dollar; CNY = People's Republic of China RC yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai Baht.

Appendix Figure 4A−4K: Plots of 1 Year Interest Differential and Currency Depreciation, against CHF



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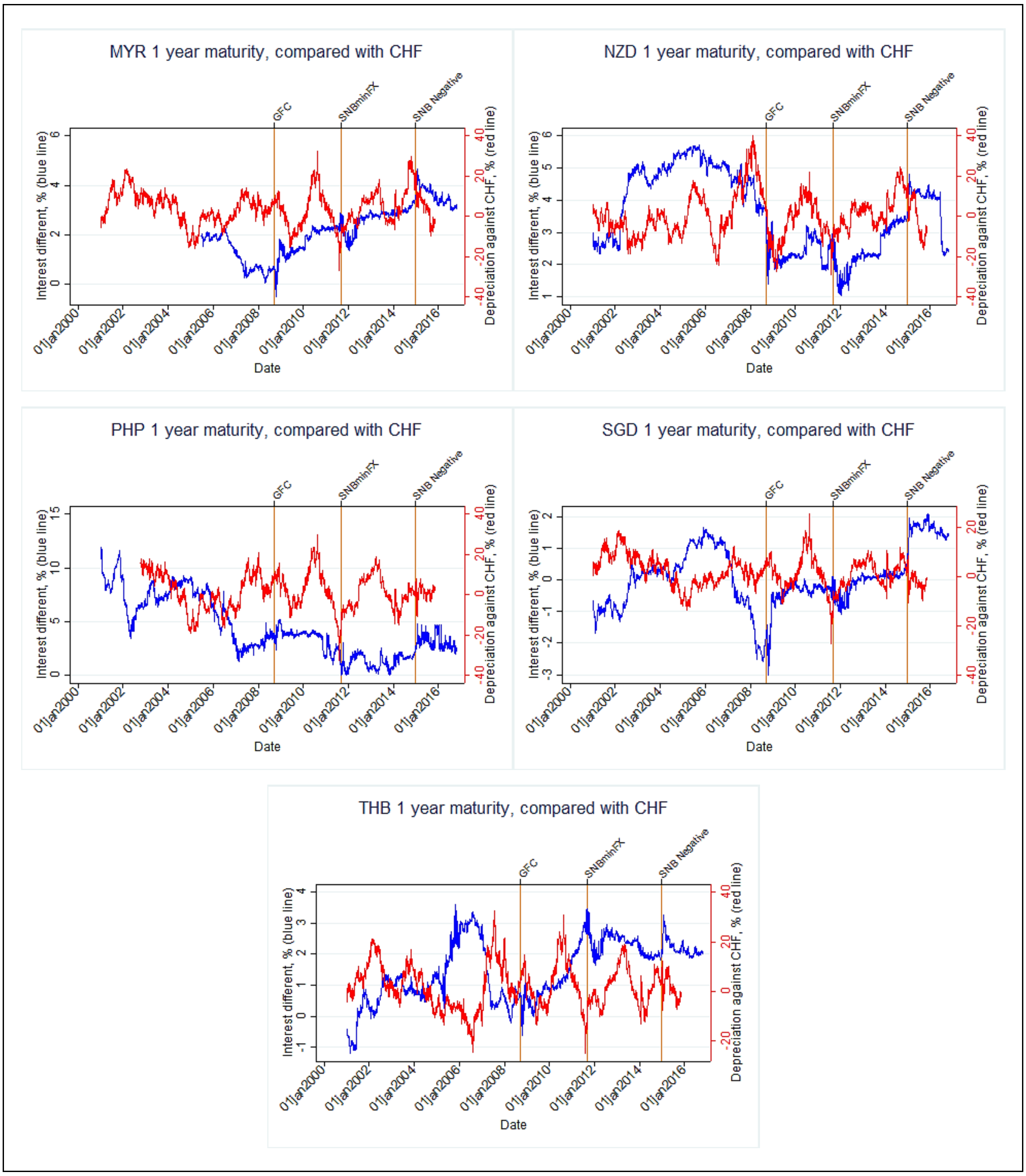
Appendix Figure 4A−4K *continued*



CHF = Swiss franc; AUD Australian dollar; CNY = People's Republic of China RC yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; MYR = Malaysian ringitt; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai Baht.

Appendix Table 1: Bloomberg Tickers

	Country Variables		
	1 Year Government Bond	Stock Market Indices	
	Ticker	Ticker	Description
Australia	GACGB1 Index	AS51 Index	ASX 200
PRC	GCNY1YR Index	SHCOMP Index	Shanghai Composite
Hong Kong, China	HKGG1Y Index	HIS Index	Hang Seng
India	IYTB1Y Index	NIFTY Index	NIFTY50
Indonesia		JCI Index	Jakarta Stock Exchange
Republic of Korea	GVSK1YR Index	KOSPI Index	KOSPI
Malaysia	MGIY1Y Index	FBMKLCI Index	FTSE Bursa Malaysia
New Zealand	GNZGB1 Index	NZSE50FG Index	S&P NZ 50
Philippines	PDSR1YR Index	PCOMP Index	PSEi Index
Singapore	MASB12M Index	STI Index	Strait Times Index
Thailand	GVTL1YR Index	SET Index	Stock Exchange of Thailand
United States	USGG12M Index	SPX Index	S&P 500
Japan	GJGB1 Index	NKY Index	Nikkei 225
Europe	GECU1YR Index	SX5E Index	Eurostoxx 50
Switzerland	SFDR1 CMPN	SMI Index	Swiss Market
	Non-country Variables		
	Ticker		
VIX	VIX Index		
Dollar index	DXY Index		

PRC = People's Republic of China.

Appendix Table 2: Variable Description

Variables	Description
CCY/USD depreciation	Local currency appreciation against USD, calculated from log return of currency at time t+252 days and currency at time t. Unit is percent per annum
CCY/EUR depreciation	Local currency appreciation against EUR, calculated from log return of currency at time t+252 days and currency at time t. Unit is percent per annum
CCY/JPY depreciation	Local currency appreciation against JPY, calculated from log return of currency at time t+252 days and currency at time t. Unit is percent per annum
CCY/CHF depreciation	Local currency appreciation against CHF calculated from log return of currency at time t+252 days and currency at time t. Unit is percent per annum
Yield spread, % p.a	Yield spread of local against major countries, maturity is 1 year. For instance, in the US regression, the yield spread is calculated as the yield of local country government bond minus yield of US treasury bill. Unit is percent per annum
Stock volat, % pa.a	Volatility of individual country's stock market index, calculated from GARCH(1,1) model. Unit is percent per annum
CCYUSD volat, % p.a	Volatility of individual country's currency against major currencies, calculated from GARCH(1,1) model. Unit is percent per annum
log(VIX)	Log of VIX index
USQE1	Dummy variable for QE1 (25 Nov 2008 − 2nov2010)
USQE2	Dummy variable for QE2 (03 Nov 2010 − 12 Sep 2012)
USQE3_1	Dummy variable for QE3 (13 Sep 2012) until before taper tantrum (21 May 2013)
USQE3_2	Dummy variable for the period covering taper tantrum (22 May 2013), QE taper (18 Dec 2013) until the end of QE tapering (29 Oct 2014)
EUR_neg	Dummy variable for announcement of negative interest rates in the euroarea (5 Jun2014) until before QE in Europe (21 Jan 2015).
ECBQE	Dummy variable for ECB's QE (22 Jan 2015 to present)
JPintervene	Dummy variable for BOJ intervention to weaken Yen (Aug. 4, 2011 − Oct 31, 2011) before the BOJ embarked on a massive monetary expansion
JPQQE	Dummy variable for BOJ's QQE (4 Apr 2013 to present)
SNBminFX	Dummy variable for SNB's minimum exchange rate (6 Sep 2011 − 15 Jan 2015)
SNBNegRate	Dummy variable for SNB's negative rate from (18 Dec 2014 – present)

CCY = People's Republic of China yuan; USD = United States dollar; EUR = euro; JPY = Japanese yen; CHF = Swiss franc; US = United States; QE = Quantitative Easing; QQE = Quantitative and Qualitative Easing; ECB = European Central Bank; BOJ = Bank of Japan; SNB = Swiss National Bank.

Appendix Table 3: Results of the "Fama" Regressions

Panel A: Local Currency Against US Dollar

(Full Sample, Jan 2001−Oct 2016)

vs USD	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	1.577	[0.413]***	55.124	0.001***	1.398	0.163	3,876	0.018
CNY	0.947	[0.057]***	243.511	0.001***	0.943	0.346	2,709	0.333
HKD	0.073	[0.026]***	678.914	0.001***	36.303	0.001***	3,876	0.013
IDR	−1.630	[0.256]***	60.018	0.001***	10.304	0.001***	3,253	0.095
INR	1.785	[0.119]***	78.019	0.001***	6.642	0.001***	3,876	0.256
KRW	0.212	[0.292]	22.567	0.001***	2.700	0.007***	3,876	0.000
MYR	2.463	[0.153]***	102.102	0.001***	9.592	0.001***	2,710	0.228
NZD	4.408	[0.849]***	141.684	0.001***	4.016	0.001***	3,876	0.069
PHP	0.291	[0.098]***	307.079	0.001***	7.259	0.001***	3,876	0.012
SGD	1.499	[0.226]***	20.080	0.001***	2.211	0.028**	3,876	0.071
THB	1.757	[0.145]***	76.698	0.001***	5.242	0.001***	3,876	0.167

(Pre-crisis, Jan 2001−Jul 2008)

vs USD	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	3.051	[0.675]***	126.113	0.001***	3.039	0.003***	1,957	0.082
CNY	0.131	[0.119]	128.291	0.001***	7.353	0.001***	790	0.005
HKD	0.074	[0.028]***	649.431	0.001***	33.256	0.001***	1,957	0.013
IDR	1.077	[0.194]***	4.176	0.016**	0.398	0.691	1,334	0.055
INR	3.422	[0.403]***	61.064	0.001***	6.016	0.001***	1,957	0.224
KRW	0.653	[0.431]	4.093	0.017**	0.806	0.421	1,957	0.004
MYR	6.280	[0.167]***	607.561	0.001***	31.714	0.001***	791	0.905
NZD	4.712	[1.041]***	92.495	0.001***	3.566	0.001***	1,957	0.093
PHP	1.085	[0.14]***	163.212	0.001***	0.608	0.544	1,957	0.148
SGD	2.340	[0.455]***	16.013	0.001***	2.947	0.004***	1,957	0.119
THB	1.582	[0.482]***	54.337	0.001***	1.207	0.228	1,957	0.049

(Post-crisis, Jan 2009−Oct 2016)

vs USD	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	−3.748	[0.685]***	47.980	0.001***	6.936	0.001***	1,788	0.077
CNY	0.916	[0.141]***	160.636	0.001***	0.600	0.549	1,788	0.077
HKD	−0.748	[0.084]***	251.836	0.001***	20.889	0.001***	1,788	0.192
IDR	−4.706	[0.328]***	153.712	0.001***	17.431	0.001***	1,788	0.388
INR	2.440	[0.194]***	112.604	0.001***	7.438	0.001***	1,788	0.315
KRW	−0.184	[0.761]	67.328	0.001***	1.558	0.12	1,788	0.000
MYR	15.056	[0.790]***	209.984	0.001***	17.803	0.001***	1,788	0.586
NZD	11.973	[1.553]***	89.482	0.001***	7.070	0.001***	1,788	0.202
PHP	−2.517	[0.148]***	533.812	0.001***	23.908	0.001***	1,788	0.442
SGD	7.181	[1.293]***	17.626	0.001***	4.784	0.001***	1,788	0.088
THB	3.304	[0.369]***	32.549	0.001***	6.258	0.001***	1,788	0.179

USD = United States dollar; AUD = Australian dollar; CNY = People's Republic of China yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; KRW = Korean won; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai baht.

Appendix Table 3 *continued*

Panel B: Local Currency Against Euro

(Full Sample, Jan 2001−Oct 2016)

vs EUR	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	−0.197	[0.390]	47.008	0.001***	3.076	0.003***	3,876	0.000
CNY	−1.178	[0.213]***	88.249	0.001***	10.262	0.001***	2,709	0.053
HKD	0.854	[0.444]*	10.967	0.001***	0.328	0.743	3,876	0.006
IDR	−2.075	[0.246]***	94.279	0.001***	12.524	0.001***	3,253	0.106
INR	−0.460	[0.187]**	33.151	0.001***	7.847	0.001***	3,876	0.011
KRW	−7.302	[0.652]***	121.894	0.001***	12.733	0.001***	3,876	0.158
MYR	0.808	[0.255]***	7.568	0.001***	0.753	0.452	2,710	0.016
NZD	4.658	[0.399]***	185.006	0.001***	9.187	0.001***	3,876	0.160
PHP	0.695	[0.165]***	24.300	0.001***	1.857	0.064*	3,876	0.021
SGD	−2.234	[0.298]***	59.205	0.001***	10.878	0.001***	3,876	0.098
THB	−1.890	[0.261]***	62.930	0.001***	11.112	0.001***	3,876	0.081

(Pre-crisis, Jan 2001−Jul 2008)

vs EUR	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	0.511	[0.364]	6.275	0.002***	1.346	0.179	1,957	0.003
CNY	−14.084	[0.957]***	191.481	0.001***	15.776	0.001***	790	0.608
HKD	2.179	[0.516]***	113.806	0.001***	2.288	0.023**	1,957	0.060
IDR	−0.808	[0.258]***	27.360	0.001***	7.015	0.001***	1,334	0.028
INR	−1.428	[0.578]**	21.924	0.001***	4.206	0.001***	1,957	0.012
KRW	−6.225	[1.099]***	32.148	0.001***	6.575	0.001***	1,957	0.070
MYR	−0.572	[0.601]	17.575	0.001***	2.620	0.009***	791	0.006
NZD	2.971	[0.399]***	60.425	0.001***	4.942	0.001***	1,957	0.083
PHP	−0.418	[0.208]**	23.969	0.001***	6.843	0.001***	1,957	0.009
SGD	−2.409	[0.465]***	69.673	0.001***	7.342	0.001***	1,957	0.099
THB	−4.572	[0.411]***	94.678	0.001***	13.567	0.001***	1,957	0.304

(Post-crisis, Jan 2009−Oct 2016)

vs EUR	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	−1.528	[0.953]	55.585	0.001***	2.655	0.008***	1,788	0.008
CNY	−1.138	[0.464]**	77.346	0.001***	4.610	0.001***	1,788	0.020
HKD	3.470	[1.065]***	22.852	0.001***	2.320	0.021**	1,788	0.024
IDR	−4.207	[0.359]***	195.338	0.001***	14.532	0.001***	1,788	0.251
INR	1.047	[0.340]***	41.812	0.001***	0.137	0.892	1,788	0.032
KRW	1.264	[0.987]	143.016	0.001***	0.268	0.789	1,788	0.005
MYR	9.043	[0.610]***	120.481	0.001***	13.205	0.001***	1,788	0.434
NZD	6.753	[0.702]***	170.096	0.001***	8.203	0.001***	1,788	0.239
PHP	−0.411	[0.511]	55.049	0.001***	2.766	0.006***	1,788	0.002
SGD	4.644	[0.490]***	80.412	0.001***	7.449	0.001***	1,788	0.134
THB	4.374	[0.615]***	49.691	0.001***	5.489	0.001***	1,788	0.122

EUR = euro; AUD = Australian dollar; CNY = People's Republic of China yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; KRW = Korean won; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai baht.

Appendix Table 3 *continued*

Panel C: Local Currency Against Japanese Yen

(Full Sample, Jan 2001−Oct 2016)

vs JPY	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	1.706	[0.548]***	73.708	0.001***	1.291	0.197	3,876	0.026
CNY	−3.226	[0.414]***	65.780	0.001***	10.220	0.001***	2,709	0.060
HKD	0.655	[0.265]**	2.887	0.056*	1.303	0.193	3,876	0.008
IDR	−0.433	[0.251]*	36.606	0.001***	5.713	0.001***	3,253	0.005
INR	−0.015	[0.263]	30.722	0.001***	3.862	0.001***	3,876	0.000
KRW	2.901	[0.574]***	31.066	0.001***	3.313	0.001***	3,876	0.040
MYR	3.485	[1.033]***	15.235	0.001***	2.407	0.017**	2,710	0.013
NZD	2.335	[0.398]***	129.038	0.001***	3.356	0.001***	3,876	0.061
PHP	0.331	[0.129]**	80.801	0.001***	5.187	0.001***	3,876	0.007
SGD	−0.379	[0.380]	29.266	0.001***	3.638	0.001***	3,876	0.001
THB	−4.481	[0.401]***	97.710	0.001***	13.692	0.001***	3,876	0.114

(Pre-crisis, Jan 2001−Jul 2008)

vs JPY	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	16.183	[1.886]***	174.141	0.001***	8.055	0.001***	1,957	0.319
CNY	6.877	[0.609]***	61.204	0.001***	9.662	0.001***	790	0.438
HKD	−1.354	[0.325]***	26.428	0.001***	7.257	0.001***	1,957	0.048
IDR	−3.252	[0.481]***	50.402	0.001***	8.848	0.001***	1,334	0.127
INR	2.020	[0.551]***	30.570	0.001***	1.854	0.064*	1,957	0.033
KRW	5.497	[1.259]***	10.985	0.001***	3.574	0.001***	1,957	0.035
MYR	−22.504	[2.502]***	64.900	0.001***	9.396	0.001***	791	0.278
NZD	11.913	[1.337]***	263.875	0.001***	8.168	0.001***	1,957	0.196
PHP	−1.717	[0.263]***	165.881	0.001***	10.332	0.001***	1,957	0.098
SGD	−6.051	[0.395]***	182.115	0.001***	17.856	0.001***	1,957	0.301
THB	−4.577	[0.449]***	78.080	0.001***	12.433	0.001***	1,957	0.146

(Post-crisis, Jan 2009−Oct 2016)

vs JPY	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	−0.866	[0.603]	63.005	0.001***	3.098	0.002***	1,788	0.005
CNY	−5.833	[0.414]***	170.833	0.001***	16.527	0.001***	1,788	0.169
HKD	7.796	[8.128]	6.146	0.003***	0.836	0.404	1,788	0.002
IDR	−1.196	[0.500]**	52.373	0.001***	4.392	0.001***	1,788	0.032
INR	−1.504	[0.313]***	43.849	0.001***	8.016	0.001***	1,788	0.044
KRW	−6.702	[1.324]***	54.856	0.001***	5.820	0.001***	1,788	0.080
MYR	6.632	[1.208]***	49.562	0.001***	4.666	0.001***	1,788	0.060
NZD	18.087	[1.056]***	225.793	0.001***	16.185	0.001***	1,788	0.465
PHP	3.077	[0.274]***	47.411	0.001***	7.589	0.001***	1,788	0.133
SGD	21.681	[1.125]***	170.491	0.001***	18.400	0.001***	1,788	0.374
THB	−7.178	[0.929]***	49.953	0.001***	8.811	0.001***	1,788	0.182

JPY = Japanese yen; AUD = Australian dollar; CNY = People's Republic of China yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; KRW = Korean won; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai baht.

Appendix Table 3 *continued*

Panel D: Local Currency Against Swiss Franc

(Full sample, Jan 2001−Oct 2016)

vs CHF	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	−0.590	[0.467]	24.373	0.001***	3.408	0.001***	3876	0.003
CNY	−1.385	[0.219]***	66.990	0.001***	10.920	0.001***	2709	0.060
HKD	1.240	[0.295]***	51.377	0.001***	0.816	0.415	3876	0.022
IDR	−1.781	[0.222]***	80.344	0.001***	12.578	0.001***	3253	0.110
INR	−0.134	[0.192]	18.046	0.001***	5.935	0.001***	3876	0.000
KRW	−0.880	[0.556]	6.338	0.002***	3.387	0.001***	3876	0.003
MYR	1.274	[0.351]***	6.343	0.002***	0.782	0.435	2710	0.023
NZD	0.852	[0.303]***	33.409	0.001***	0.489	0.625	3876	0.010
PHP	−0.146	[0.155]	44.415	0.001***	7.406	0.001***	3412	0.001
SGD	−2.119	[0.219]***	104.892	0.001***	14.283	0.001***	3876	0.090
THB	−3.483	[0.345]***	85.177	0.001***	13.009	0.001***	3876	0.150

(Pre-crisis, Jan 2001−Jul 2008)

vs CHF	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	−2.235	[0.361]***	45.453	0.001***	8.965	0.001***	1957	0.041
CNY	−11.710	[1.107]***	72.066	0.001***	11.491	0.001***	790	0.453
HKD	1.839	[0.417]***	61.316	0.001***	2.012	0.045**	1957	0.060
IDR	−1.542	[0.287]***	40.555	0.001***	8.886	0.001***	1334	0.084
INR	−0.886	[0.814]	3.143	0.044**	2.319	0.021**	1957	0.002
KRW	−5.170	[0.872]***	25.579	0.001***	7.083	0.001***	1957	0.076
MYR	−5.211	[0.477]***	88.708	0.001***	13.037	0.001***	791	0.519
NZD	−0.511	[0.459]	19.557	0.001***	3.298	0.001***	1957	0.001
PHP	−0.821	[0.228]***	54.196	0.001***	7.996	0.001***	1493	0.042
SGD	−3.220	[0.388]***	70.956	0.001***	10.878	0.001***	1957	0.231
THB	−5.721	[0.422]***	149.291	0.001***	15.947	0.001***	1957	0.385

(Post-crisis, Jan 2009−Oct 2016)

vs CHF	$\widehat{\beta_i}$	Robust Standard Errors	F test for H_0: α_i=0 and β_i=1	Prob. > F	t test for H_0: β_i=1	Prob. > t	# of Obs.	Adj R^2
AUD	−0.464	[0.859]	4.159	0.016**	1.705	0.089*	1788	0.000
CNY	−2.830	[0.348]***	74.988	0.001***	11.016	0.001***	1788	0.160
HKD	−3.468	[0.723]***	19.238	0.001***	6.186	0.001***	1788	0.033
IDR	−3.262	[0.337]***	95.428	0.001***	12.655	0.001***	1788	0.227
INR	−0.338	[0.297]	15.360	0.001***	4.514	0.001***	1788	0.005
KRW	1.115	[1.538]	16.482	0.001***	0.075	0.941	1788	0.002
MYR	4.485	[0.550]***	20.818	0.001***	6.338	0.001***	1788	0.140
NZD	3.914	[0.711]***	30.795	0.001***	4.100	0.001***	1788	0.103
PHP	1.119	[0.424]***	2.422	0.089*	0.282	0.779	1788	0.025
SGD	−0.265	[0.386]	5.392	0.005***	3.282	0.002***	1788	0.000
THB	−0.597	[0.681]	2.870	0.057*	2.349	0.019**	1788	0.002

CHF = Swiss franc; AUD = Australian dollar; CNY = People's Republic of China yuan; HKD = Hong Kong, China dollar; IDR = Indian rupee; INR = Indonesian rupiah; KRW = Korean won; MYR = Malaysian ringgit; NZD = New Zealand dollar; PHP = Philippine peso; SGD = Singapore dollar; THB = Thai baht.

Notes: Regression point estimates [Newey−West robust standard errors in brackets]. *(**)[***] denoted significance at the 10%(5%)[1%]. Constant terms in the regression are not reported. The joint significance for the null hypothesis that for α_i=0 and β_i=1 is tested and its Wald statistics and p-values are shown. The t test statistics for the null hypothesis that β_i=1 is also tested and its statistics and p-values are reported.