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Is the Renminbi a Safe-Haven Currency? Evidence from Conditional Coskewness and Cokurtosis*

By **Cheng Xin, Chen Hongyi and Zhou Yinggang***

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Abstract

We examine whether the renminbi (RMB) is a safe-haven currency in terms of its effectiveness in hedging financial stress for global equity investors. The coskewness of the RMB (the covariance between the RMB premium and equity volatility) is mostly negative, implying that the RMB is not a good hedge in times of market volatility. Moreover, the positive cokurtosis of the RMB (the covariance between the RMB premium and equity skewness) implies that the RMB is unable to hedge against stock market crashes. Neither the coskewness nor the cokurtosis of the RMB is priced, suggesting that equity investors with skewness and kurtosis preferences would not use the RMB to hedge against financial stress. Therefore, the RMB is not yet a safe-haven currency.

JEL Classification: G11,G12, G15

Keywords: currency hedging, conditional coskewness, conditional cokurtosis, idiosyncratic skewness, international asset pricing

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1. Introduction

A safe-haven asset tends to hold its value if stock markets experience extreme negative returns (Baur and McDermott, 2010). Safe-haven currencies are those that give hedging benefits in times of financial market volatility or financial distress (Habib and Stracca, 2012). Conventionally, the US dollar (USD), the Swiss franc (CHF), and the Japanese yen (JPY) have been safe-haven currencies.[1] Some market participants have argued that the renminbi (RMB), the Chinese currency, joined the group of safe-haven currencies after it was included in the Special Drawing Rights (SDR) basket as a global reserve currency in 2016, with the other components of the SDR being traditional safe-haven currencies (Aizenman et al., 2020). Although the RMB did indeed hold its value against the US dollar during the 2008 financial crisis, others dispute the RMB's status as a safe haven and assert that the RMB will not become a safe-haven currency until Chinese economic and broader institutional reforms are implemented because the RMB is not sufficiently liquid and not readily convertible. This paper investigates the role of the RMB as a safe-haven currency in the face of financial stress.

The most intuitive approach to evaluating the hedging benefits of currencies is based on the correlation (or covariance) between equity and currency markets (Dumas and Solnik, 1995; De Santis and Gerard, 1998). From this perspective, investors use foreign currencies to minimise the risk of a diversified portfolio and long those currencies that are more negatively correlated with international equity portfolio returns to minimise the overall portfolio volatility. Campbell et al. (2010) show that the US dollar, the euro, and the Swiss franc move against the international equity market. Thus, these currencies should be attractive to risk-minimising global equity investors despite their low average returns. However, there are two main limitations associated with the correlation approach. On the one hand, the correlation cannot capture the nonlinear response of a safe-haven currency to an extreme shock (Habib and Stracca, 2012; Fatum and Yamamoto, 2016; Fatum et al., 2017). On the other hand, the hedging benefits of the currency might not be fully captured by the correlation approach, as investors typically go beyond the mean-variance preference when they flee to safety (Chan et al., 2018).

By dealing with the above shortcomings, we attempt to contribute to the safe-haven currency literature as follows. First, we use a regime-switching approach, a nonlinear method, to derive currency coskewness and cokurtosis and measure the nonlinear response of safe-haven currencies to a global stock market shock. In the literature, Baur and McDermott (2010) provide an intuitive method to study whether gold is a safe haven with dummies measuring extreme downturns in the global stock market at different scales using a linear model. Following Baur and McDermott (2010), Ming et al. (2020) study whether gold is a safe haven against extreme downturns in the Chinese stock market, and Baur and Smales (2020) show that precious metals are ideal safe havens against uncertainty measured by geopolitical risk. Similarly, Habib and Stracca (2012) and Habib et al. (2020) investigate the drivers of safe-haven currency behaviour using a linear model and treat the VIX as the measure of market uncertainty.

Unlike the above linear models, Chan et al. (2018) measure a currency's hedging capacity with its coskewness with the global stock market (the covariance between the currency premium and equity volatility) using a multivariate regime-switching approach, which can better capture the joint distribution of asset returns empirically and theoretically (Ang and Bekaert, 2002;

[1] Conventional wisdom holds that "When foreign exchange investors felt panicky, they head to, or back to, old faithfuls: the Swiss franc, the US dollar and the Japanese yen." See "Dollar Stands Out as Safe Haven Currency", *Wall Street Journal*, December 9th, 2011.

Guidolin and Timmermann, 2008;Branch and Evans, 2010) and situate the time-varying beta method within the literature (Christiansen et al., 2011). We extend this approach to derive not only currency conditional coskewness but also cokurtosis, which refers to the stable performance of a currency (as measured by currency return) during times of financial stress (as measured by stock market volatility or skewness).Our time-varying coskewness and cokurtosis may contain more information in integrated global asset markets since they are driven by the joint distribution of currency and equity returns. Additionally, they are more intuitive than other measures based on extreme value theory and copulas as well as other (nonlinear) comovements used in the recent literature. Intuitively, a higher and positive currency coskewness means that when stock volatility increases, the currency risk premium also increases. Similarly, a lower and negative currency cokurtosis means that when the stock market has a higher possibility to crash, the currency risk premium tends to be higher. In contrast, Bekiros et al. (2017) study the nonlinear relationship between an asset and stock market using continuous wavelet approach and copula models, which are pure econometric models and less intuitive. Moreover, regime-switching-based estimates are typically determined with considerably more accuracy than estimates of the higher moments obtained directly from realised returns (Guidolin and Timmermann, 2008).

Second, currency conditional coskewness and cokurtosis have a strong economic foundation in the skewness and kurtosis preference of investors who consider the capacity of a currency to hedge volatility and crashesin the global stock market. The skewness and kurtosis preference are based on "prudence"[2](e.g., Kimball, 1990) and "temperance" (e.g., Denuit and Eeckhoudt, 2010), respectively, signifying that investors desire higher (positive) skewness and lower (negative) kurtosis (Rubinstein, 1973; Kraus and Litzenberger, 1983).An investor examines an asset's contribution to the skewness and kurtosis of a broadly diversified portfolio, referred to as coskewness and cokurtosis of that asset with the portfolio. The literature has provided supportive empirical evidence that coskewness and cokurtosis on stock, bond, and option markets are significant in determining expected returns (e.g., Harvey and Siddque, 2000; Dittmar, 2002; Vanden, 2006; Guidolin and Timmermann, 2008; Yang et al., 2010). In contrast, crash risk, captured by currency (idiosyncratic) skewness (Brunnermeier et al., 2008; Burnside et al., 2010) and the global foreign exchange volatility factor (Menkhoff et al., 2012),is not informative about the hedging properties of currencies from a broadly diversified portfolio point of view. Although the currency covariance with global equity volatility in Lustig et al. (2011) is conceptually similar to currency coskewness, we propose time-varying currency coskewness and cokurtosis, which are essentially risk factors. Chan et al. (2018) evaluate the hedging benefits of currency coskewness but not cokurtosis. In a recent paper, Opie and Riddiough (2020) find that currency returns are predictable, accounting for their hedge capacity against global factor returns from a broadly diversified portfolio point of view, but their research is conducted under a mean and variance framework.

Third, we evaluate the hedging capacity of onshore and offshore RMB using currency coskewness and cokurtosis and compare it with this capacity of the Japanese yen. On one hand, Japanese yen is found to be the safest currency (Fatum and Yamamoto, 2016) and possesses desirable hedging benefits in times of financial market volatility (Chan et al., 2018). On the other hand, though offshore RMB (CNH) is much less regulated and is de facto fully convertible

[2] Prudence suggests a precautionary saving motive, the propensity to prepare and safeguard oneself in the face of uncertainty. It is in contrast to risk aversion, which is how much one dislikes uncertainty and turns away from uncertainty if possible.

because it is freely traded outside of mainland China, Fatum et al. (2017) find no evidence to suggest that offshore RMB is a safe haven. Similarly, we find that onshore RMB (CNY) has positive coskewness with the global equity market in some periods, while offshore RMB (CNH) has positive coskewness with the emerging stock market. The patterns imply that the CNY can only hedge against global stock market volatility to some extent, while the CNH can only hedge against emerging stock market volatility. In contrast, the JPY has positive coskewness in all periods with a larger scale and is a better hedge in a volatile market, as it appreciates when equity volatility increases. Moreover, the cokurtosis of both onshore and offshore RMB with the equity market is positive, and thus neither can hedge against a stock market crash. In contrast, JPY cokurtosis is negative, suggesting even higher hedging effectiveness during a stock market crash.

Furthermore, we investigate whether the features of a currency as a safe haven are priced in its future excess return using predictive regressions. In general, we find that RMB coskewness with stock markets is not priced in the RMB’s future excess return. In contrast, the counterpart of the JPY is priced, suggesting that prudent equity investors use the JPY rather than the RMB to hedge against global stock market volatility. Moreover, the conditional cokurtosis of the RMB and JPY with the equity market does not command a statisticallyor economically significant ex ante risk premium with the expected positive sign. By implication, temperate investors use neither the RMB nor the JPY to hedge against global stock market crashes. On the whole, the RMB is not yet a safe-haven currency, while the JPY exhibits the safe-haven property to some degree. These results are robust after controlling for currency beta (Lustig et al., 2014； Verdelhan, 2018), volatility factors (Lustig et al., 2011; Menkhoff et al., 2012), and crash risk (Brunnermeier et al., 2008; Burnside et al., 2010). For a further robustness check, we use the more intuitive method of Baur and McDermott (2010) and find similar results.

The rest of the paper is organised as follows. Section 2 describes the data and gives a preliminary analysis. Section 3 discusses the regime-switching models and derives their conditional moments. Section 4 presents the empirical results, and Section 5 checks the robustness of the main results. Section 6 concludes and offers final remarks.

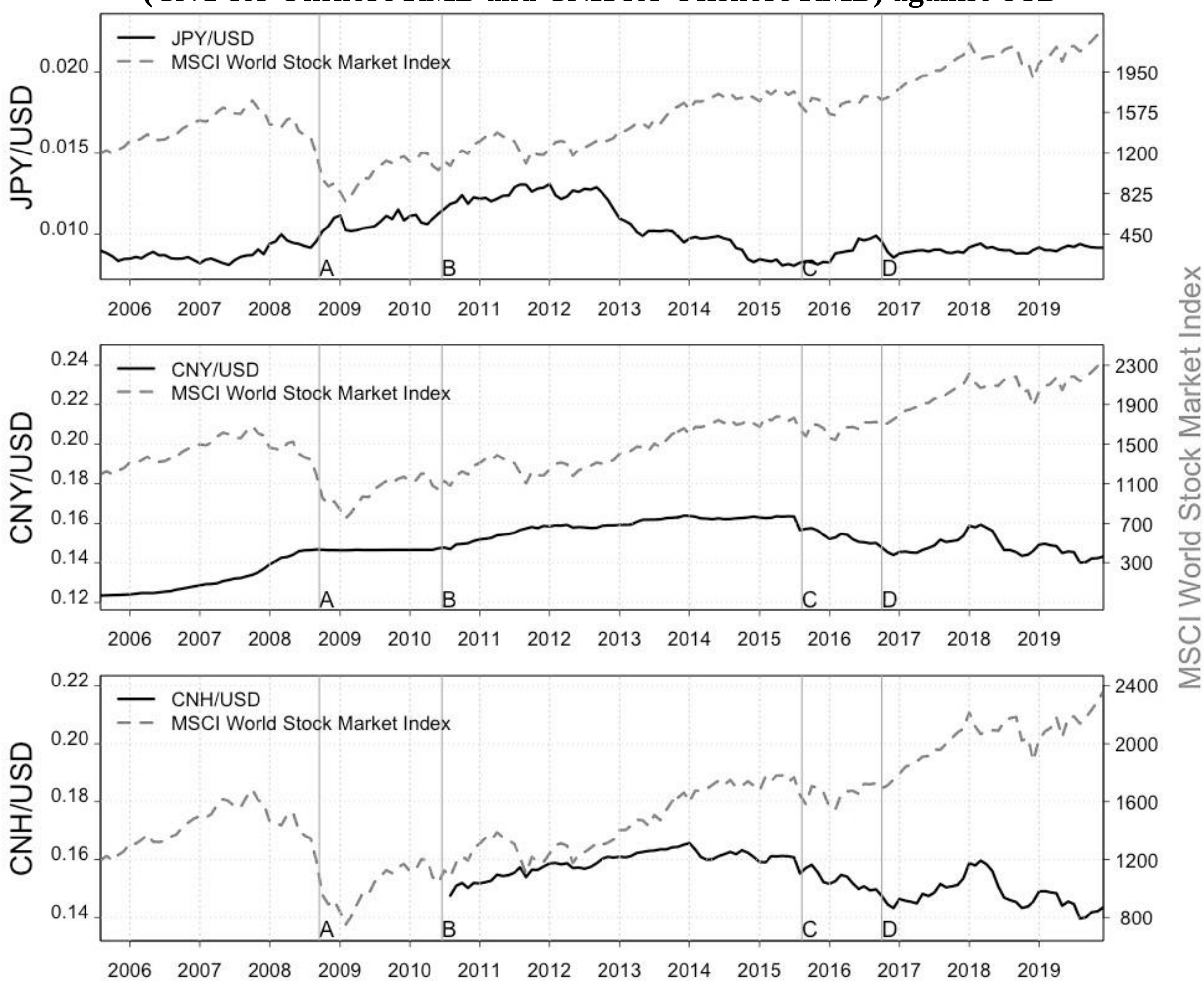
2. Data Description

Our analysis employs monthly data on exchange rates, the global stock market index, and interest rates. All data series, except for the time series of CNH exchange rates, cover the period from July 2005 to December 2019. Specifically, the CNY sample starts in July 2005, when the exchange rate of onshore RMB (CNY) started to float. To facilitate comparison, the JPY sample also starts in July 2005. The CNH sample starts in August 2010 when the CNH was launched. The monthly CNY and JPY exchange rates against the USD are obtained from the International Financial Statistics (IFS) database offered by the International Monetary Fund, while the monthly exchange rate of the CNH against the USD is from Bloomberg.

We use the Morgan Stanley Capital International (MSCI) global stock market index, including the MSCI world index, Asia index, and emerging markets index, to represent the world stock market, Asian stock market, and emerging stock market. The MSCI world index is a broad global equity index that represents large and mid-cap equity performance across 23 developed countries. Similarly, the components of the Asia stock index cover equities in developed market and emerging market countries in Asia, and the components of the emerging markets index cover equities in 26 emerging market countries. All the stock market indices mentioned above are US-dollar-denominated and represent the risk faced by a US dollar-based investor who is unhedged against exchange rate risk.

Figure 1 displays the evolution of the world stock market index and the JPY, CNY, and CNH exchange rates against the USD. When the 2008 financial crisis intensified with the collapse of Lehman Brothers, the Japanese yen appreciated and moved in the opposite direction to the world stock market index. In contrast, onshore RMB remained stable until the Chinese central bank restarted the market reform of the RMB exchange rate in June 2010. Having appreciated gradually for five years, the CNY devalued significantly after the Chinese central bank modified the RMB central parity quotation mechanism in August 2015. Following the inclusion of the RMB into the SDR basket in October 2016, the CNY appreciated for some time, which might be one of the reasons that some market participants argue that the RMB is a safe-haven currency. The last panel of Figure 1 displays the exchange rate trends of offshore RMB. Offshore RMB was initiated in 2010 and shared a similar pattern with onshore RMB.

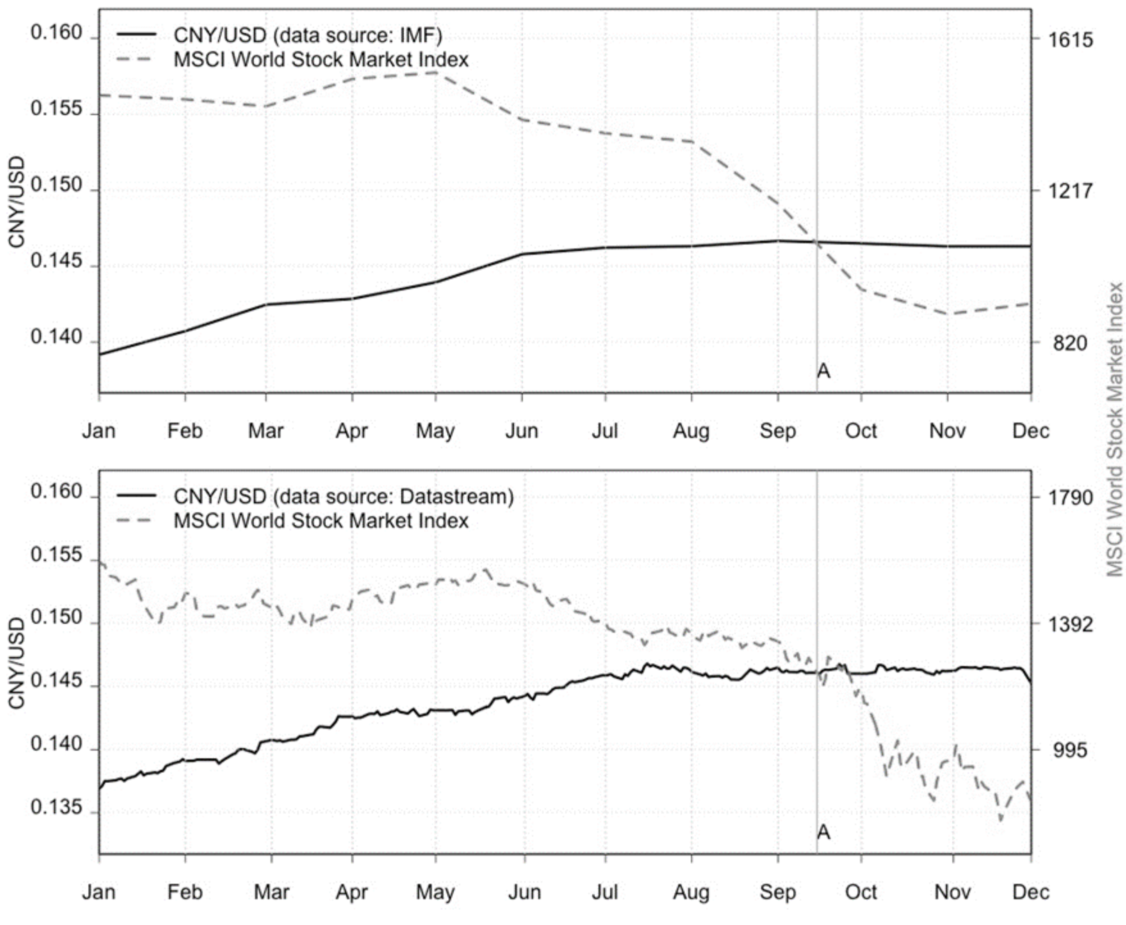
Figure 1 Evolution of the World Stock Market Index and JPY and RMB Exchange Rates (CNY for Onshore RMB and CNH for Offshore RMB) against USD



Note: The exchange rates are labelled on the left vertical axis, and the world stock market index is labelled on the right vertical axis. Several relative events are annotated with the tick marks and labelled accordingly. Label A represents the date when Lehman Brothers went into bankruptcy in September 2008. Label B represents the date when the Chinese central bank restarted the market reform of the RMB exchange rate in June 2010. Label C represents the date when the Chinese central bank modified the RMB central parity quotation mechanism in August 2015. Label D represents the date when the IMF included the RMB in the SDR basket in October 2016.

As shown in Figure 1 above, the CNY/USD time series is not monotonically decreasing. With monthly data from the IMF and daily data from Datastream, Figure 2 offers a closer look at the response of the CNY during the 2008 financial crisis. While the world stock market index dropped significantly in the crisis period, the CNY remained stable and even appreciated slightly, which could be another reason that some market participants argue that the RMB is a safe haven.

Figure 2 A Closer Look at the RMB Response during the 2008 Financial Crisis



Note: The exchange rates of onshore RMB (CNY) are labelled on the left vertical axis, and the world stock market index is labelled on the right vertical axis. In addition, label A represents the date when Lehman Brothers went bankrupt in September 2008.

Figure 3 further illustrates the time-varying correlation of the global stock market return with changes inthe JPY, CNY, and CNH exchange rate against the USD. The correlation of the JPY with the global stock market is almost negative, especially when the global stock market goes down. In contrast, the correlation of the CNY and CNH with the global stock market is often positive. One significant exception is that the CNY was negatively correlated with the global stock market in the period of the 2008 financial crisis.

Figure 3 Rolling Correlations of the World Stock Market with JPY and RMB Exchange Rates against USD (CNY for Onshore RMB and CNH for Offshore RMB)

Note: The figure presents the evolution of the correlation between the return of the world stock market index and the returns of JPY/USD, CNY/USD, and CNH/USD. The rolling correlation estimates are based on a window length of 24 monthly observations and illustrate that the correlation changes over time. The horizontal line marks the position of the zero axes. Several relative events are annotated on the tick marks and labelled accordingly. Label A represents the date when Lehman Brothers went into bankruptcy in September 2008. Label B represents the date when the Chinese central bank restarted the market reform of the RMB exchange rate in June 2010. Label C represents the date when the Chinese central bank modified the RMB central parity quotation mechanism in August 2015. Label D represents the date when the IMF included the RMB in the SDR basket in October 2016.

Furthermore, we use 3-month treasury bill rates to measure the potential losses and gains of an investor who converts holdings from the US dollar to another currency, such as onshore and offshore RMB or the Japanese yen. The 3-month treasury bill rates of the US and Japan are from Datastream, while the Chinese data are from WIND. Notably, we use the 3-month deposit rate of offshore RMB from Bloomberg to measure the gains of holding assets denominated in offshore

RMB because there is no active offshore RMB treasury market. Correspondingly, we measure the losses of a US dollar-based investor who converts the US dollar to offshore RMB using the 3-month deposit rate of the US dollar.

Since government bonds are always treated as safe assets (Habib et al., 2020) and the strength of the flight to safety is affected by the interest rate (Boucher and Tokpavi, 2019), we calculate the excess return (premium) for stock market indices and currencies following Habib and Stracca (2012) and Chan et al. (2018). The stock excess return is the log difference of MSCI stock market indices minus the US 3-month treasury bill rate, a proxy for the US and world risk-free rate. The currency excess return is the interest rate differential(the foreign interest rate minus the US interest rate)plus the rate of foreign currency appreciation against the US dollar, which measures the excess returns to a US investor from borrowing in US dollars to hold foreign currencies. All measures of excess return above are annualised.

Table 1 reports summary statistics for the premiums of stock market indices and currencies. The average stock premiums against the US interest rate for the world, Asian, and emerging stock markets are 4.679%, 3.594%, and 5.417%, respectively. All stock premiums exhibit negative skewness and positive excess kurtosis, suggesting a high probability of those markets experiencing financial crises. The premiums for onshore and offshore RMB are 2.203% and 1.301%, respectively, while the JPY premium is -1.400%. The striking difference can probably be attributed to the currencies' respective hedging properties, as will be demonstrated in the empirical study. The volatility of the currency premiums varies from 10.834% for the CNY and 14.357% for the CNH to 31.506% for the JPY. All the currency premiums exhibit negative skewness and positive excess kurtosis as well, suggesting a higher probability of those currencies having an extreme negative excess return. In addition, the left long and fat tails of the RMB are much more pronounced than their JPY counterparts, which indicates a less desirable hedging property of the RMB. Most notably, the premiums for all stock markets and currencies are stationary at 10% significance, which indicates a favourable property for modelling with a regime-switching model.

Table 1 Summary Statistics

	Mean	Std dev	Skewness	Kurtosis	ADF Test
World stock market premium	4.679%	51.619%	-0.834	5.359	-8.782*
Asian stock market premium	3.594%	57.156%	-0.653	4.710	-8.669*
Emerging market premium	5.417%	74.508%	-0.494	5.108	-7.936*
Premium of Japanese Yen	-1.400%	31.506%	-0.263	3.779	-7.959*
Premium of onshore RMB	2.203%	10.834%	-1.528	10.335	-7.580*
Premium of offshore RMB	1.301%	14.357%	-0.597	4.499	-7.020*

Note: The table reports summary statistics for the monthly stock market premiums and currency premiums. Stock premiums are the log differences of MSCI indices minus the US 3-month treasury bill rate, a proxy for the risk-free rate. Currency premiums are log interest rate differentials (foreign interest rate minus US interest rate) plus the rates of foreign currency appreciation against the US dollar. All measures are annualised.

3. Empirical Methodology

The empirical methodology in this study combines two models. The main analysis employs the regime-switching approach, from which we derive the conditional currency coskewness and cokurtosis as well as other conditional moments. Then, we conduct predictive regressions of the future currency premium on the conditional currency coskewness and cokurtosis, controlling for the conditional beta, idiosyncratic volatility, and skewness and correcting for the error-in-variables problem. We also check the robustness of the main results using a more intuitive method following Baur and McDermott (2010).

3.1. Regime-Switching Models

From an econometric perspective, regime-switching models belong to a general class of mixture distributions and can generate time-varying moments through the use of some simple distributions, such as the normal distributions in each regime. Following much of the literature (e.g., Gray, 1996; Ang and Bekaert, 2002; Connolly et al., 2005; Guidolin and Timmermann, 2008), we focus on the two-state regime-switching model, which has an intuitively appealing interpretation: a bear state has higher volatility due to economic recessions and/or market crashes, while a bull state has less volatile returns.

Moreover, we specify the conditional means in Eq. (1) as Chan et al. (2018) do,

$$\begin{pmatrix} r_t^s \\ r_t^c \end{pmatrix} = \begin{pmatrix} \mu_i^s \\ \mu_i^c \end{pmatrix} + \begin{pmatrix} \lambda_i^s & 0 \\ 0 & \lambda_i^c \end{pmatrix} \begin{pmatrix} RF_{t-1} \\ RD_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{it}^s \\ \varepsilon_{it}^c \end{pmatrix} \tag{1}$$

where μ_i^s and μ_i^c are the constant means ofstock and currency premiums given regime i, RF_{t-1} is the first lagged risk-free rate (the US interest rate), and RD_{t-1} is the first lagged interest differential (the foreign interest rate minus the US interest rate). λ_i^s and λ_i^c are the regression coefficients given regime i. The risk-free rate is closely attuned to discount rates and has significant predictive power for future stock returns. The interest rate differentials are well known to have significant predictive power for positive currency premiums from the carry trade. Lustig and Verdelhan (2007) and Campbell et al. (2010) both use interest rate differentials as the sole conditioning variable to study currency premiums. It would be interesting to see whether interest rate differentials can predict currency premiums differently in different regimes. In general, the conditional means might not linearly depend only on the first lag of the instrument, and there are other instruments. Thus, the specification adopted here represents a trade-off between flexibility and parsimony.

For the conditional variance-covariance matrices, we assume thatε_{it} follows an i.i.d. bivariate normal distribution. Then, the conditional distribution of $r_t$is a mixture of two i.i.d. bivariate normal distributions as follows.

$$\boldsymbol{r_t}|\boldsymbol{F_{t-1}} \sim \begin{cases} IIN(\boldsymbol{\mu_{it}}, \boldsymbol{H_{1t}}), & w.p. \;\; p_{1t}, \\ IIN(\boldsymbol{\mu_{2t}}, \boldsymbol{H_{2t}}), & w.p. \;\; p_{2t}. \end{cases} \tag{2}$$

Since mixtures of the normal distribution can approximate a broad set of density families, this assumption is not very restrictive. Moreover, the variances and correlation are assumed to be constant with each regime, and switches between regimes can generate conditional heteroskedasticity.

The parsimonious specification for the conditional variance-covariance matrices is as follows,

$$\boldsymbol{H_{it}} = \boldsymbol{D_{it}} \boldsymbol{R_{it}} \boldsymbol{D_{it}}, \boldsymbol{D_{it}} = \begin{bmatrix} \sqrt{h_i^s} & 0 \\ 0 & \sqrt{h_i^c} \end{bmatrix}, \boldsymbol{R_{it}} = \begin{bmatrix} 1 & 0 \\ \rho_i & 1 \end{bmatrix}, i \in \{1,2\} \tag{3}$$

where h_i^s and h_i^c are the constant conditional volatilities of stock and currency premiums given regime i. ρ_i is the constant conditional stock-currency correlation given regime i. Nevertheless, we also address below the possibility that the estimated correlations between stock and currency premiums may vary across two regimes.

Furthermore, we specify the transition probabilities as a function of the lagged interest rate differentialsRD_{t-1}, which strikes a good balance in defining regimes of both currency and equity markets. Recent literature, such as Lustig et al. (2011) and Menkhoff et al. (2012), use the interest rate differential or, equivalently, the forward discount to sort currencies into portfolios and then construct the risk factor based on the comparison between the portfolios of high versus low quintiles, where a_i and b_i are unknown parameters and Φ is the cumulative normal distribution function, which ensures that $0 < p_{ii,t} < 1$. This specification makes the transition probabilities monotonic in the instrument, thus facilitating interpretation of the parameters.

$$p_{ii,t} = p(S_t = i | S_{t-1} = i, \mathbf{F}_{t-1}) = \Phi(a_i + b_i RD_{t-1}), i \in \{1,2\} \quad (4)$$

With the above specification, we obtain quasi-maximum likelihood estimates (QMLEs) for model parameters and use the standardised likelihood ratio test proposed by Hansen (1992) to test for the existence of regimes[3]. In addition, diagnostic tests are conducted on the standardised residuals from the regime-switching model and the corresponding single-regime model.

We derive the general formula of the centred conditional moments as shown in Eq. (5).

$$E[(r_t^s - \mu_t^s)^k (r_t^c - \mu_t^c)^l | \boldsymbol{F}_{t-1}, \theta] \quad (5)$$

In particular, Eq. (6) calculates the conditional currency beta against the stock excess return, which is the conditional standardised covariance between the stock and currency excess returns. A negative conditional currency beta means that the currency and stock excess returns move in opposite directions and, in turn, that the currency has hedge capacity against the downturn of the stock market.

$$\beta_t = \frac{E[(r_t^s - \mu_t^s)(r_t^c - \mu_t^c) | \boldsymbol{F}_{t-1}, \boldsymbol{\theta}]}{E[(r_t^s - \mu_t^s)^2 | \boldsymbol{F}_{t-1}, \boldsymbol{\theta}]} \quad (6)$$

Eq. (7) calculates the conditional standard deviation of the currency excess returns.

$$std_t^c = \sqrt{E[(r_t^c - \mu_t^c)^2 | F_{t-1}, \boldsymbol{\theta}]} \quad (7)$$

Eq. (8) calculates the conditional currency coskewness, which is the conditional standardised covariance between the currency excess return and the volatility of the stock excess return. A positive conditional currency coskewness means that the currency excess return increases when the volatility of the stock excess return increases and, in turn, that the currency has hedge capacity against a volatile stock market.

$$cos_t^c = \frac{E[(r_t^c - \mu_t^c)^3 | \boldsymbol{F}_{t-1}, \boldsymbol{\theta}]}{(\sqrt{E[(r_t^c - \mu_t^c)^2 | \boldsymbol{F}_{t-1}, \boldsymbol{\theta}]})^3} \quad (8)$$

Eq. (9) calculates the conditional currency skewness as follows.

$$skew_t^c = \frac{E[(r_t^s - \mu_t^s)^2 (r_t^c - \mu_t^c) | \boldsymbol{F}_{t-1}, \boldsymbol{\theta}]}{E[(r_t^s - \mu_t^s)^2 | F_{t-1}, \theta] \{E[(r_t^c - \mu_t^c) | \boldsymbol{F}_{t-1}, \boldsymbol{\theta}]\}^{1/2}} \quad (9)$$

Eq. (10) calculates the conditional currency cokurtosis, which is the conditional standardised covariance between the currency excess return and the skewness of the stock excess return. A negative conditional currency cokurtosis means that the currency excess return increases when the stock excess return has a higher probability of crashing (smaller skewness) and, in turn, means that the currency has hedge capacity against a stock market crash.

$$cok_t^c = \frac{E[(r_t^s - \mu_t^s)^3 (r_t^c - \mu_t^c) | \boldsymbol{F}_{t-1}, \boldsymbol{\theta}]}{\{E[(r_t^s - \mu_t^s)^2 | F_{t-1}, \theta]\}^{3/2} \{E[(r_t^c - \mu_t^c) | \boldsymbol{F}_{t-1}, \boldsymbol{\theta}]\}^{1/2}} \quad (10)$$

Eq. (11) calculates the conditional currency kurtosis as follows.

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[3] Note that the likelihood ratio test does not have the standard X^2 distribution for Markov-switching models due to unidentified nuisance parameters. The standardised LR test proposed by Hansen (1992) can circumvent this problem and provides an upper bound of the p-value for general cases.

$$kurt_t^c = \frac{E[(r_t^c - \mu_t^c)^4 | \boldsymbol{F}_{t-1}, \boldsymbol{\theta}]}{(\sqrt{E[(r_t^c - \mu_t^c)^2 | \boldsymbol{F}_{t-1}, \boldsymbol{\theta}]})^4} \quad (11)$$

3.2. Currency Coskewness and Cokurtosis Pricing Effects

By extending Chan et al. (2018), we approximate the pricing kernel through a fourth-order Taylor expansion and examine whether currency coskewness and cokurtosis with the stock market are priced in currency premiums beyond the conventional beta factor as follows,

$$r_{t,t+m}^c = \lambda_0 + \lambda_1 \widehat{\beta_t} + \lambda_2 \widetilde{cos}_t^c + \lambda_3 \widetilde{cot}_k^c + \varepsilon_t^c \quad (12)$$

where $r_{t,t+m}^c$ is the currency excess return over the m-month horizon. The expected beta, $\hat{\beta}_t$, controls the traditional CAPM pricing effect. The second factor is the conditional currency coskewness. Instead of including $\widehat{cos}_t^c$ directly, we separate the additional effect of $\widehat{\beta_t}$ and use the orthogonal residual $\widetilde{cos}_t^c$. We further orthogonalise the conditional currency cokurtosis from $\hat{\beta}_t$ and $\widetilde{cos}_t^c$ to examine the additional pricing effect of the conditional currency cokurtosis.

If λ_1 is significantly positive, the conditional currency beta earns a positive risk premium, implying that the currency's hedge capacity against a stock market downturn is desirable to risk-averse investors. If λ_2 is significantly negative, the conditional currencycoskewness earns a negative risk premium, implying that investors with a skewness preference are willing to accept the negative risk premium to take advantage of the currency's hedge capacity against a volatile stock market. If λ_3 is significantly positive, the conditional currency cokurtosis earns a positive risk premium, implying that the currency's hedge capacity against stock market crashes is desirable to investors with a kurtosis preference.

Moreover, extending Menkhoff et al. (2012), we include other possible risk factors and orthogonalise them by order of moments to separate the additional effect of high-order moment factors from low-order moment factors as follows,

$$r_{t,t+m}^c = c_0 + c_1 \hat{\beta}_t + c_2 \widetilde{std}_t^c + c_3 \widetilde{cos}_t^c + c_4 \widetilde{skew}_t^c + c_5 \widetilde{cok}_t^c + c_6 \widetilde{kurt}_t^c + e_t^c \quad (13)$$

where $\hat{\beta}_t$ is the beta risk factor. $\widetilde{std}_t^c$ is the idiosyncratic currency volatility, proxied by the residual from the auxiliary regression of the conditional standard deviation orthogonal to $\hat{\beta}_t$. $\widetilde{cos}_t^c$ is the residual of the conditional currency coskewness orthogonal to $\hat{\beta}_t$ and $\widetilde{std}_t^c$. $\widetilde{skew}_t^c$ is the idiosyncratic currency skewness, which is the residual of the conditional currency skewness orthogonal to $\hat{\beta}_t$, $\widetilde{std}_t^c$, and $\widetilde{cos}_t^c$. $\widetilde{cok}_t^c$ is the conditional currency cokurtosis orthogonal to $\hat{\beta}_t$, $\widetilde{std}_t^c$, $\widetilde{cos}_t^c$, and $\widetilde{skew}_t^c$. The final factor $\widetilde{kurt}_t^c$ is the idiosyncratic currency kurtosis, which is the residual of the conditional currency kurtosis orthogonal to $\hat{\beta}_t$, $\widetilde{std}_t^c$, $\widetilde{cos}_t^c$, $\widetilde{skew}_t^c$, and $\widetilde{cok}_t^c$.

The regression produces an estimate of the risk exposure vector, $c = [c_1, c_2, c_3, c_4, c_5, c_6]'$. We want to see whether the "pure" effects of the conditional currency coskewness (cokurtosis) risk are negatively (positively) priced in currency returns beyond the traditional beta and volatility risks, i.e., $c_3 < 0$ and $c_5 > 0$.

With a significant and negative c_3, currency coskewness is negatively priced in the future currency excess return, indicating that investors with a skewness preference are willing to accept a lower future excess return for the currency because of its good hedging property against stock market volatility. In contrast, with a significant positive c_3 and negative currency coskewness, the currency has an undesirable coskewness property. The higher future excess return is to compensate for the coskewness risk, as investors will flee these currencies, which will depreciate during times of market volatility. In sum, the coskewness for a safe-haven currency should be negatively priced in its future excess return.

Similarly, currency cokurtosis is positively priced in the currency return with a significant and positive c_5, indicating that investors with a kurtosis preference are willing to accept a lower future excess return for the currency when the stock market has lower skewness because of its good hedging property against a stock market crash. In sum, the cokurtosis for a safe-haven currency should be positively priced in its future excess return.

As the regressions are conducted using estimates from the regime-switching model, the variables may be measured with noise. To deal with the errors-in-variables problem, the coefficient estimates are adjusted for a serial correlation of 24 lags and heteroskedasticity following Newey and West (1987).

3.3. An Alternative Method

As an alternative, we employ a relatively intuitive model following Baur and McDermott (2010), as shown below.

$$\begin{gathered} c_t = a + b_t s_t + e_t \\ b_t = c_0 + c_1 D(s_t q_{10}) + c_2 D(s_t q_5) + c_3 D(s_t q_1) \\ h_t = \pi + \alpha e_{t-1}^2 + \beta h_{t-1} \end{gathered} \tag{14}$$

c_t and s_t are the currency and world stock market index returns, respectively. The error term, e_t, follows a GARCH(1,1) process, as shown in Eq. (14). The dummy variables, denoted as $D(\cdots)$, capture extreme stock market movements and are equal to one if the stock market exceeds a certain threshold given by the 10%, 5%, and 1% quantiles of the return distribution. If one of the corresponding parameters of the dummy variables c_1, c_2, orc_3 is significantly different from zero, there is evidence of a nonlinear relationship between the currency and the stock market. If the parameters are nonpositive (including c_0), the currency acts as a weak safe-haven currency. If the parameters are negative and significantly different from zero, the currency under investigation functions as a strong safe haven.

4. Empirical Results

4.1. Results on Regime-Switching Model Estimation

The analysis proceeds with the estimation of the single-regime model as a benchmark and the two-state regime-switching model. Based on estimated likelihood functions and the resulting likelihood ratio tests (not reported here), the regime-switching model for each currency fits significantly better than the corresponding single-regime model. Table 2 shows the estimation results for the USD-denominated world stock market and currency premiums.

We first examine the parameters for the conditional volatilities as shown in Eq. (2). h_i^s and h_i^c are the constant conditional volatilities of stock and currency premiums given regime i, and the second regime is a bear state with higher volatility for the world stock and currency premiums. Taking the result for the JPY as an example, h_1^s and h_2^s are 0.061 and 0.456 in the bull and bear states, respectively, while h_1^c and h_2^c are 0.064 and 0.114 in the bull and bear states, respectively, implying that the volatilities for the JPY and the stock market are higher in the bear state than in the bull state.

Then, we check the fitness of the mean equation. As shown in Eq. (1), λ_i^s is the regression coefficient of the risk-free rate given regime i on the stock market excess return. The estimates of λ_2^s for the JPY and the CNY are significantly negative in the bear regime, indicating a negative association between the US interest rate and the world stock excess return in more volatile market conditions, in line with intuition. λ_i^c is the regression coefficient of interest rate differentials given regime$i$ on the currency excess return. The estimates of λ_1^c for the CNY and the CNH are significantly positive, proving that the interest rate spread has positive predictive power for the excess return of the RMB in the bull state, in turn suggesting profitable carry trades in the bull (or low-volatility) state. In contrast, neither λ_1^c nor λ_2^c for JPY is significant, indicating that the relatively lower JPY premium is not the result of the carry trade (Christiansen et al., 2011).

More importantly, we focus on the constant conditional stock-currency correlation ρ_i.We find that the correlation between the excess return of the JPY and the world stock market is significantly negative in the bear state with $\rho_2 = -0.169$, suggesting that the JPY tends to appreciate against the USD in a downturn volatile stock market. However, stock-currency correlations are significantly positive for the CNY and the CNH in the bear state, with $\rho_2 = 0.344$ for the CNY and $\rho_2 = 0.423$ for the CNH. The above results preliminarily imply that the Japanese yen may offer better diversification opportunities than onshore and offshore RMB do under undesirable stock market conditions.

Table 2

Regime-Switching Model Estimation for World Stock Market and Currency Premiums

	JPY		CNY		CNH	
Regime	$i = 1$	$i = 2$	$i = 1$	$i = 2$	$i = 1$	$i = 2$
μ_i^s	0.137***	0.042	0.057	0.198***	0.157***	0.028
	(4.464)	(0.549)	(1.099)	(3.478)	(3.075)	(0.570)
μ_i^c	-0.140***	0.072*	0.023***	-0.023	0.010	-0.044**
	(-4.691)	(1.778)	(7.005)	(-1.202)	(1.203)	(-2.527)
λ_i^s	0.022	-14.294**	-0.170	-13.155***	4.439	-0.081
	(0.018)	(-1.707)	(-0.043)	(-4.451)	(0.253)	(-0.019)
λ_i^c	-1.954	-3.904	0.702***	2.248	2.287***	2.008***
	(-1.352)	(-0.660)	(5.339)	(1.623)	(5.778)	(2.762)
h_i^s	0.061***	0.456***	0.298***	0.202***	0.077***	0.216***
	(4.912)	(6.377)	(11.389)	(5.829)	(3.311)	(6.968)
h_i^c	0.064***	0.114***	0.001***	0.028***	0.001***	0.028***
	(6.397)	(8.067)	(8.416)	(7.119)	(3.166)	(6.481)
ρ_i	-0.080	-0.169**	0.118	0.344***	-0.017	0.423***
	(-0.757)	(-1.991)	(1.304)	(3.978)	(-0.073)	(5.329)
a_i	1.542***	-1.810***	1.899***	-2.158***	-0.150	-0.418
	(7.041)	(-6.869)	(7.561)	(-7.873)	(-0.470)	(-1.483)
b_i	11.579	-64.481***	-0.406	33.645**	62.079***	-56.883***
	(1.154)	(-3.634)	(-0.028)	(2.356)	(3.419)	(-3.362)

Note: The table estimates the regime-switching model for the monthly world stock market and currency premiums using $\begin{pmatrix} r_t^s \\ r_t^c \end{pmatrix} = \begin{pmatrix} \mu_i^s \\ \mu_i^c \end{pmatrix} + \begin{pmatrix} \lambda_i^s & 0 \\ 0 & \lambda_i^c \end{pmatrix} \begin{pmatrix} RF_{t-1} \\ RD_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{it}^s \\ \varepsilon_{it}^c \end{pmatrix}$, where $\begin{pmatrix} \varepsilon_{it}^s \\ \varepsilon_{it}^c \end{pmatrix} \sim \text{IIN}(\mathbf{0}, \mathbf{H}_{\mathbf{it}})$, and $\boldsymbol{H_{it}} = \boldsymbol{D_{it}} \boldsymbol{R_{it}} \boldsymbol{D_{it}}, \boldsymbol{D_{it}} = \begin{bmatrix} \sqrt{h_i^s} & 0 \\ 0 & \sqrt{h_i^c} \end{bmatrix}, \boldsymbol{R_{it}} = \begin{bmatrix} 1 & 0 \\ \rho_i & 1 \end{bmatrix}, i \in \{1,2\}$, and transition probabilities $p_{ii,t} = p(S_t = i | S_{t-1} = i, \boldsymbol{F}_{t-1}) = \Phi(a_i + b_i RD_{t-1}), i \in \{1,2\}$, where RF_{t-1} is the first lagged US risk-free rate and RD_{t-1} is the first lagged interest rate difference (foreign interest rate minus US interest rate). S_t is the unobserved regime at time t. $\boldsymbol{F}_{t-1}$ is the past information set. Φ is the cumulative normal distribution function. The parameter estimates are the QMLE. The t-statistics are reported in parentheses. *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

4.2. Results on Conditional Currency Coskewness and Cokurtosis

We derive conditional currency coskewness and cokurtosis, as well as other moments, based on the model estimated in the previous process. Table 3 summarises the statistics of the conditional currency moments.

Panel A of Table 3 summarises the averages of the conditional moment estimates derived as in Eqs. (6)-(11) for the JPY, CNY, and CNH. On the whole, the conditional moment estimates of all currency premiums are very close to their unconditional counterparts, as shown in Table 1. The evidence hints at the adequacy of the regime-switching model specification in describing the data-generating process up to the second moment and the well-known challenge in modelling the expectation of the third and fourth moments (e.g., Harvey and Siddique, 1999; Yang et al., 2010).

Table 3

Summary Statistics of Conditional Moment Estimates Derived from Stock–Currency Regime-Switching Models and Orthogonal Regressors

Currency	JPY	CNY	CNH
Panel A: Average of Conditional Moments against the World Stock Market			
conditional currency beta	-0.125***	0.048***	0.126***
conditional currency standard deviation	0.308***	0.092***	0.136***
conditional currency co-skewness	0.292***	0.003	-0.140***
conditional currency skewness	0.187***	-0.474***	-0.432***
conditional currency co-kurtosis	-1.124***	0.576***	1.443***
conditional currency kurtosis	3.214***	12.919***	5.108***
Panel B: Standard Deviation of the Orthogonalised Conditional Moments			
conditional currency beta	0.040	0.047	0.031
orthogonalised currency standard deviation	0.022	0.008	0.005
orthogonalised currency co-skewness	0.041	0.031	0.012
orthogonalised currency skewness	0.030	0.362	0.017
orthogonalised currency co-kurtosis	0.035	0.013	0.039
orthogonalised currency kurtosis	0.026	0.550	0.047

Note: The table reports summary statistics of the conditional moment estimates for the currencies. *, **, and *** in Panel A are the significance levels of a T-test, indicating whether the conditional moment estimates are significantly unequal to zero at the 1%, 5%, and 10% levels.

The conditional beta of the JPY is significantly negative, while the counterparts for onshore and offshore RMB are significantly positive, suggesting that the JPY is more desirable than the

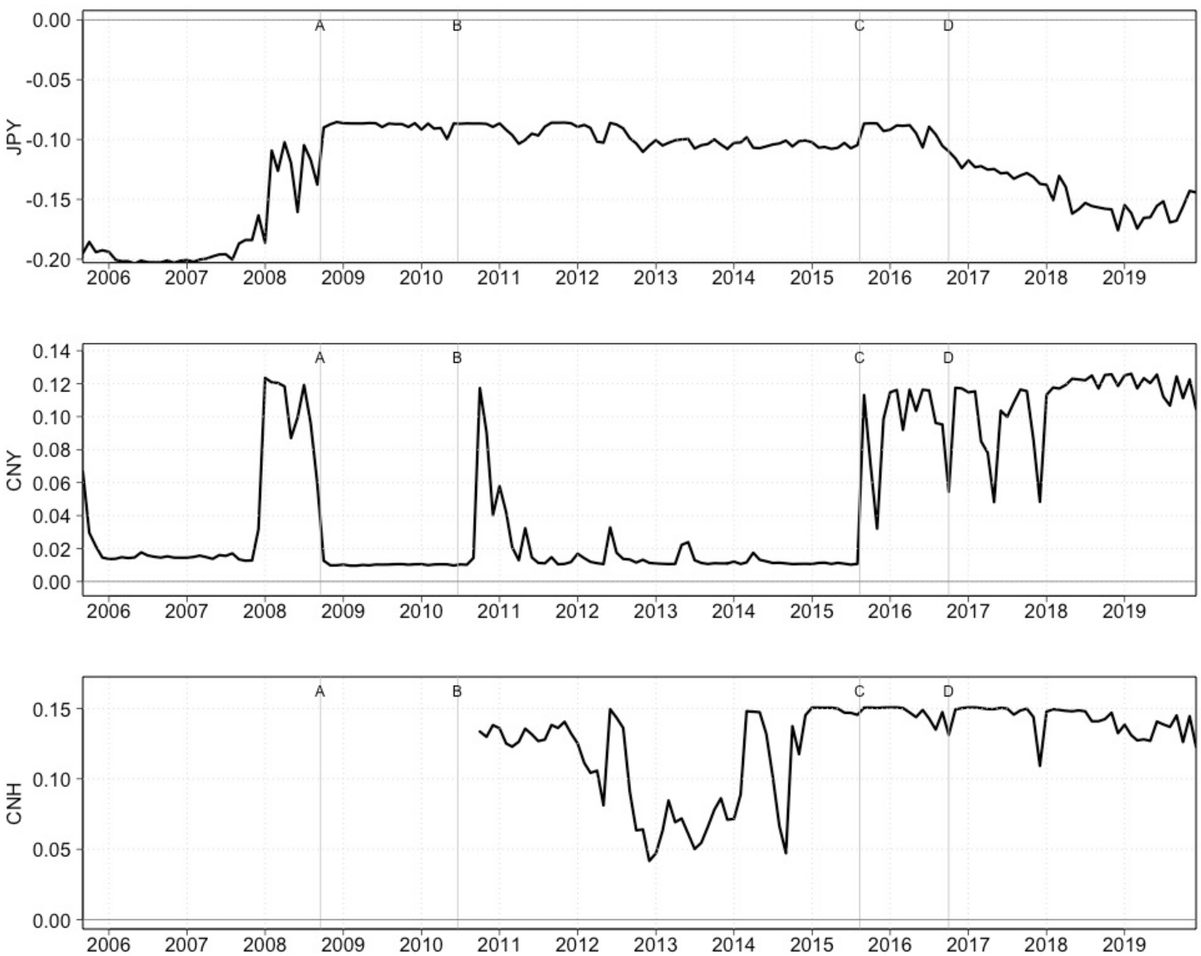
RMB in a downturn stock market with an increasing JPY premium. Similarly, the coskewness of the JPY is significantly positive, while the counterparts for onshore and offshore RMB are significantly negative, again indicating that the JPY is more favourable than the RMB in a volatile market with an increasing JPY premium. Moreover, the cokurtosis of the JPY is significantly negative, while the counterparts for onshore and offshore RMB are significantly positive, suggesting that the JPY is preferable to the RMB because the premium of the JPY increases when the stock market has a higher probability of crashing.

On the whole, the patterns imply that the JPY is a safe-haven currency not only because of its hedge capacity against world stock market downturns but also because of its hedge capacity against world stock volatility and crashes. In comparison, the RMB is not a safe-haven currency in the full sense.

Panel B of Table 3 summarises the standard deviation of the corresponding orthogonalised conditional moment estimates. We detect the economic significance of coskewness and cokurtosis using the standard deviation of the orthogonalised counterparts by investigating how much future currency premiums change if coskewness and cokurtosis increase by one standard deviation in the empirical study.

We also compare time-varying patterns of hedging benefits across currencies. Figure 4 plots the conditional betas of the currency premium against the world stock market premium. A negative conditional currency beta means that the currency and stock excess returns move in opposite directions and, in turn, that the currency has hedge capacity against a downturn in the stock market. The currency beta of the JPY is negative in the whole sample, while the currency betas of the CNY and the CNH are positive, indicating that the JPY can hedge against downturns in the world stock market, while the RMB cannot.

Figure 4 Conditional Currency Betas with the World Stock Market

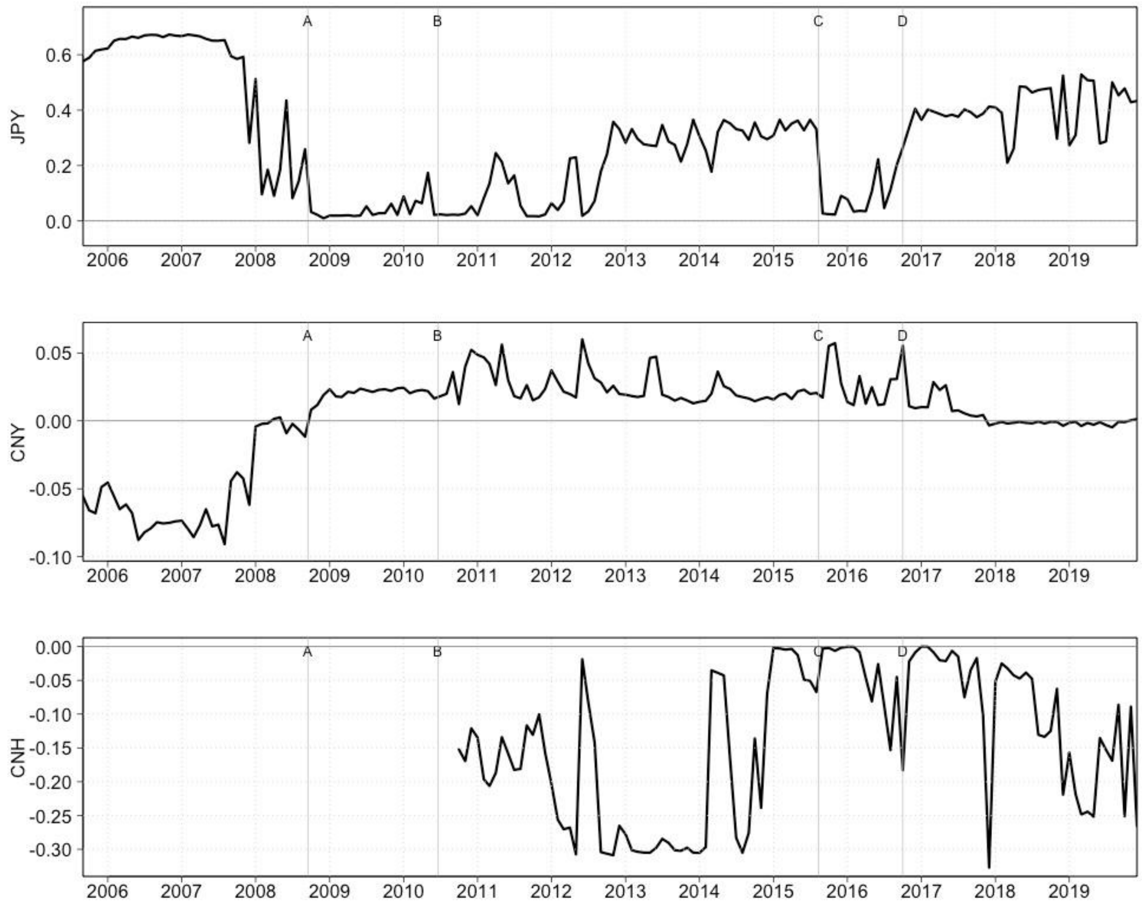


Note: The horizontal line marks the position of the zero axes. Several relative events are annotated on the tick marks and labelled accordingly. Label A represents the date when Lehman Brothers went into bankruptcy in September 2008. Label B represents the date when the Chinese central bank restarted the market reform of the RMB exchange rate in June 2010. Label C represents the date when the Chinese central bank modified the RMB central parity quotation mechanism in August 2015. Label D represents the date when the IMF included the RMB in the SDR basket in October 2016.

Figure 5 plots the conditional coskewness of the currency premiums against the world stock market premium. A positive conditional currency coskewness means that the excess return of the currency increases when the volatility of the stock excess return increases and, in turn, that the currency has hedge capacity against a volatile stock market. The JPY coskewness is always positive. Interestingly, the JPY coskewness decreased sharply after the 2008 financial crisis. Conversely, the CNY coskewness jumped from negative to positive in 2008 and stayed positive from 2008 to 2017, suggesting that the CNY played a hedging role against the volatility of the world stock market during the 2008 financial crisis. However, we do not find a similar pattern for the CNH. The CNH coskewness remained mostly negative for the whole sample, implying that the CNY can only hedge against stock market volatility to some extent, while the CNH cannot hedge against volatility of the world stock market at all.

In sum, the JPY is a safe-haven currency from the perspective of its hedging property against volatility in the world stock market. Moreover, the CNY hedged against a volatile stock market only during a particular period of the 2008 financial crisis.

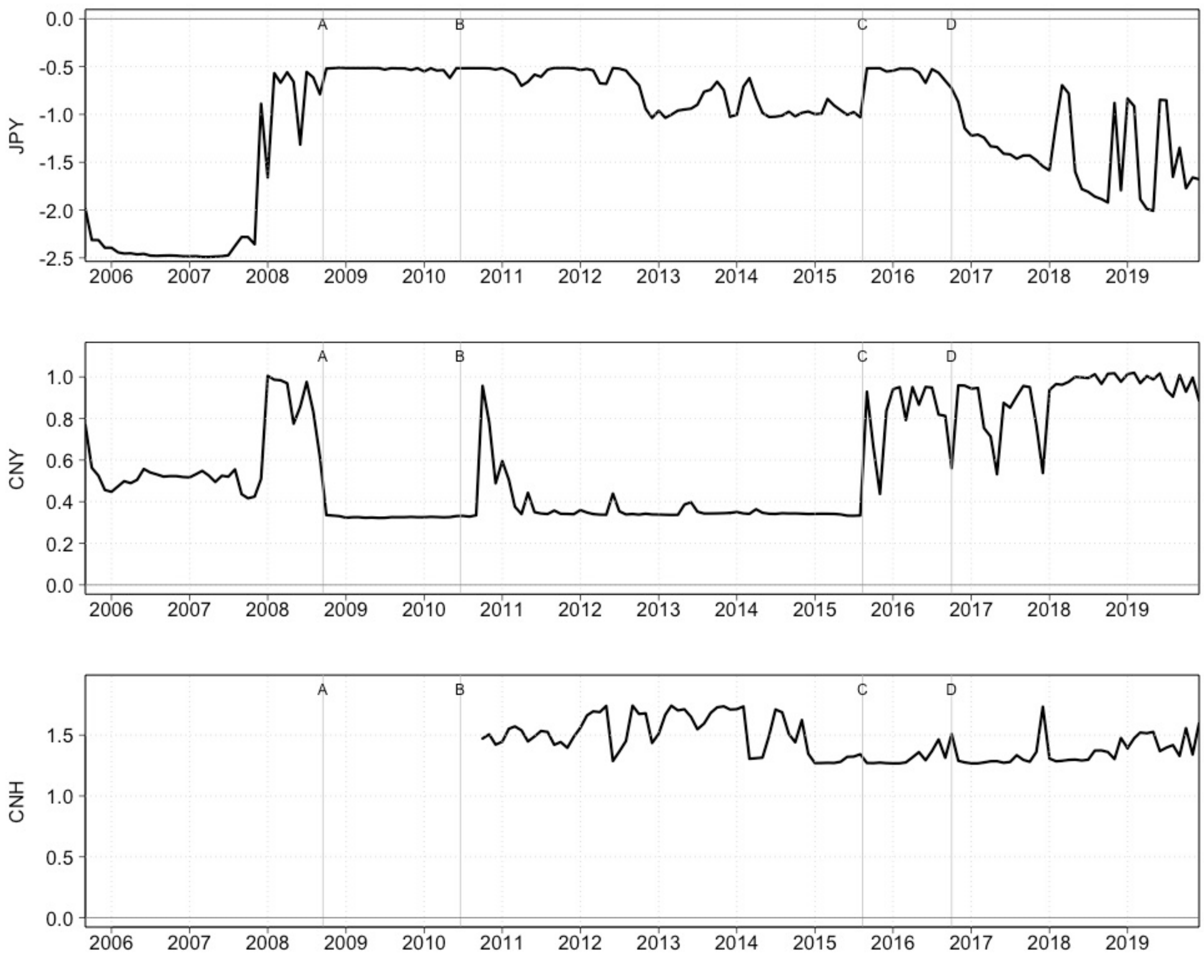
Figure 5 Conditional Currency Coskewness with the World Stock Market



Note: The horizontal line marks the position of the zero axes. Several relative events are annotated on the tick marks and labelled accordingly. Label A represents the date when Lehman Brothers went into bankruptcy in September 2008. Label B represents the date when the Chinese central bank restarted the market reform of the RMB exchange rate in June 2010. Label C represents the date when the Chinese central bank modified the RMB central parity quotation mechanism in August 2015. Label D represents the date when the IMF included the RMB in the SDR basket in October 2016.

Figure 6 plots the conditional cokurtosis of currency premiums with the world stock index premium. A negative conditional currency cokurtosis means that the excess return of the currency increases when the stock excess return has a higher probability of crashing(smaller skewness) and, in turn, that the currency has hedge capacity against a stock market crash. The JPY cokurtosis is always negative for the whole sample, which implies that the JPY can hedge against a world stock market crash. In contrast, cokurtosis for both the CNY and the CNH is always positive, which implies that neither onshore RMB nor offshore RMB is a safe-haven currency in the full sense, especially from the point of view of cokurtosis.

Figure 6 Conditional Currency Cokurtosis with the World Stock Market



Note: The horizontal line marks the position of the zero axes. Several relative events are annotated on the tick marks and labelled accordingly. Label A represents the date when Lehman Brothers went into bankruptcy in September 2008. Label B represents the date when the Chinese central bank restarted the market reform of the RMB exchange rate in June 2010. Label C represents the date when the Chinese central bank modified the RMB central parity quotation mechanism in August 2015. Label D represents the date when the IMF included the RMB in the SDR basket in October 2016.

4.3. Results on Pricing Effects of Conditional Currency Coskewness and Cokurtosis

To investigate how currency coskewness and cokurtosis are priced in future currency premiums beyond the conventional beta factor, we run a regression according to Eq. (12) and report the results in Table 4. The coskewness for a safe-haven currency should be negatively priced in its future excess return, and the cokurtosis for a safe-haven currency should be positively priced in its future excess return. However, almost none of the coefficients for the CNY and CNH is statistically significant at conventional significance levels with the expected sign, suggesting that the RMB is not acknowledged as a safe-haven currency among global investors with a skewness or kurtosis preference. Only the coefficients of JPY coskewness are statistically significant with the expected sign for 1-, 3-, and 6-month excess returns.

In addition to the statistical significance, we evaluate the economic significance of the pricing effect of coskewness on future currency excess returns, which is proxied by the products of the regression coefficients of coskewness in Table 4 and the corresponding standard deviations in Table 3. The pricing effect of coskewness for the JPY is economically large and decreases gradually as the forecast horizon increases. For example, a one-standard-deviation increase in the JPY coskewness induces a decrease of 7.0%, 4.7%, and 2.9% in the next future 1-, 3- and 6-month currency excess returns, respectively. Overall, JPY coskewness commands statistically and economically significant negative ex ante excess returns.

In contrast to the relatively robust pricing effects of JPY coskewness, the coefficients of cokurtosis for the JPY, which should be positive, are not significant with the expected sign, suggesting that global investors with a kurtosis preference do not seek to trade off the JPY's future excess return with its hedge capacity against a world stock market crash.

We further include other possible risk factors and run a regression according to Eq. (13). The results are shown in Table 5. Nevertheless, the coefficients of currency coskewness for the JPY are statistically significant with negative signs in the 1-, 3-, and 6-month excess returns. Similarly, the currency excess returns decrease by 5.1%, 3.4%, and 3.0% in the next 1, 3 and, 6 months, respectively, if the JPY coskewness increases by one standard deviation.

None of the coefficients for cokurtosis of the JPY, which should be positive, are significant with the expected sign. The results illustrate that investors with a skewness preference are willing to accept the JPY's negative future premium to take advantage of the JPY's hedge capacity against world stock market volatility. In contrast, none of the coefficients for coskewness and cokurtosis of the CNY and CNH are priced with the expected signs, signifying that the RMB's minor hedge capacity is not acknowledged by investors at all.

Table 4

Pricing Effects of Currency Coskewness and Cokurtosis with the World Stock Market

Currency	$\hat{\beta}_t$	$\widetilde{cos}_t^c$	$\widetilde{cok}_t^c$	R^2	Economic Impact $\widetilde{cos}_t^c$	Economic Impact $\widetilde{cok}_t^c$
Panel A: 1-Month Excess Returns						
JPY	0.281	-0.824***	-0.061	5.2%	-7.0%	0.0%
	(0.385)	(0.231)	(0.137)			
CNY	-0.296	-0.012	-1.588*	5.9%	0.0%	-2.2%
	(0.241)	(0.257)	(0.88)			
CNH	-0.391**	0.065	0.274	1.4%	0.0%	0.0%
	(0.199)	(0.191)	(0.212)			
Panel B: 3-Month Excess Returns						
JPY	-0.241	-0.549**	-0.082	2.5%	-4.7%	0.0%
	(0.481)	(0.237)	(0.124)			
CNY	-0.402**	0.055	-0.241	3.0%	0.0%	0.0%
	(0.173)	(0.253)	(0.592)			
CNH	-0.034	0.112	0.144	0.4%	0.0%	0.0%
	(0.233)	(0.205)	(0.195)			
Panel C: 6-Month Excess Returns						
JPY	-0.035	-0.337*	-0.123	1.3%	-2.9%	0.0%
	(0.486)	(0.189)	(0.082)			
CNY	-0.216	-0.191	0.525	1.6%	0.0%	0.0%
	(0.189)	(0.299)	(0.862)			
CNH	-0.343	0.274	0.227	1.9%	0.0%	0.0%
	(0.309)	(0.333)	(0.233)			
Panel D: 12-Month Excess Returns						
JPY	-0.913	0.032	-0.070	1.5%	0.0%	0.0%
	(0.608)	(0.382)	(0.150)			
CNY	-0.286	-0.371*	0.346	2.9%	-1.3%	0.0%
	(0.296)	(0.213)	(0.381)			
CNH	0.041	-0.313	-0.536	2.0%	0.0%	0.0%
	(0.314)	(0.202)	(0.341)			

Note: The table presents the results of the following regressions: $r_{t,t+m}^c = \lambda_0 + \lambda_1\widehat{\beta_t} + \lambda_2\widetilde{cos}_t^c + \lambda_3\widetilde{cot}_k^c + \varepsilon_t^c$, where $r_{t,t+m}^c$ is the currency excess return over the m-month horizon. $\widehat{\beta_t}$ is the traditional beta risk. $\widetilde{cos}_t^c$ is the residual of the conditional currency coskewness orthogonal to $\widehat{\beta_t}$. $\widetilde{cos}_t^c$ is the conditional currency coskewness orthogonal to $\widehat{\beta_t}$ and $\widetilde{cos}_t^c$

Table 5

Pricing Effects of Currency Coskewness and Cokurtosis with the World Stock Market

Currency	$\hat{\beta}_t$	$\widetilde{std}_t^c$	$\widetilde{cos}_t^c$	$\widetilde{skew}_t^c$	$\widetilde{cok}_t^c$	$\widetilde{kurt}_t^c$	R^2	Economic Impact	
								$\widetilde{cos}_t^c$	$\widetilde{cok}_t^c$
Panel A: 1-Month Excess Returns									
JPY	0.276	2.332***	-1.242***	0.023	-0.655*	-0.025	6.0%	-5.1%	-2.3%
	(0.410)	(0.776)	(0.434)	(0.685)	(0.337)	(0.74)			
CNY	-0.293	1.718	-0.238	0.062***	-1.465**	0.016	11.5%	0.0%	-1.9%
	(0.182)	(1.576)	(0.212)	(0.021)	(0.718)	(0.012)			
CNH	-0.396**	0.248	-0.311	-0.714	0.231	0.920***	9.9%	0.0%	0.0%
	(0.167)	(1.732)	(0.809)	(0.610)	(0.204)	(0.195)			
Panel B: 3-MonthExcess Returns									
JPY	-0.261	1.516**	-0.838*	-0.118	-1.064***	0.005	3.8%	-3.4%	-3.7%
	(0.497)	(0.650)	(0.443)	(0.638)	(0.297)	(0.760)			
CNY	-0.404***	2.176***	-0.213	0.014*	-0.428	-0.012	6.5%	0.0%	0.0%
	(0.144)	(0.835)	(0.231)	(0.008)	(0.407)	(0.012)			
CNH	-0.032	0.452	1.588**	-1.396***	-0.172	0.100	4.8%	1.9%	0.0%
	(0.200)	(1.575)	(0.675)	(0.524)	(0.200)	(0.232)			
Panel C: 6-Month Excess Returns									
JPY	-0.048	0.790	-0.717**	-0.649*	0.680	1.239**	3.2%	-3.0%	0.0%
	(0.473)	(0.780)	(0.299)	(0.386)	(0.498)	(0.569)			
CNY	-0.216	-0.514	-0.175	-0.015	0.477	-0.001	1.8%	0.0%	0.0%
	(0.193)	(0.953)	(0.362)	(0.022)	(0.905)	(0.008)			
CNH	-0.333	2.798	1.790***	1.235**	0.326	-0.421**	7.2%	2.2%	0.0%
	(0.311)	(2.733)	(0.570)	(0.570)	(0.286)	(0.210)			
Panel D: 12-Month Excess Returns									
JPY	-0.967	-0.894	-1.000	0.262	0.948	0.485	4.8%	0.0%	0.0%
	(0.615)	(0.969)	(0.639)	(0.712)	(0.639)	(0.567)			
CNY	-0.285	-1.081	-0.329	-0.035**	0.063	0.004	4.2%	0.0%	0.0%
	(0.290)	(1.143)	(0.226)	(0.017)	(0.471)	(0.008)			
CNH	-0.045	-2.405	1.488	0.170	-0.370*	0.694***	7.5%	0.0%	-1.5%
	(0.215)	(1.850)	(1.087)	(1.150)	(0.220)	(0.218)			

Note: The table presents the results of the following regressions: $r_{t,t+m}^c = c_0 + c_1\hat{\beta}_t + c_2\widetilde{std}_t^c + c_3\widetilde{cos}_t^c + c_4\widetilde{skew}_t^c + c_5\widetilde{cok}_t^c + c_6\widetilde{kurt}_t^c + e_t^c$, where $r_{t,t+m}^c$ is the currency excess return over the m-month horizon.$\widehat{\beta}_t$ is the traditional beta risk. $\widetilde{std}_t^c$ is the idiosyncratic currency volatility, proxied by the residual from the auxiliary regression of the conditional standard deviation orthogonal to $\widehat{\beta}_t$. $\widetilde{cos}_t^c$ is the residual of the conditional currency coskewness orthogonal to $\widehat{\beta}_t$ and $\widetilde{std}_t^c$.$\widetilde{skew}_t^c$ is the idiosyncratic currency skewness, which is the residual of the conditional currency skewness orthogonal to $\widehat{\beta}_t$, $\widetilde{std}_t^c$ and $\widetilde{cos}_t^c$.$\widetilde{cok}_t^c$ is the conditional currency coskewness orthogonal to $\widehat{\beta}_t$, $\widetilde{std}_t^c$, $\widetilde{cos}_t^c$ and $\widetilde{skew}_t^c$.$\widetilde{kurt}_t^c$ is the idiosyncratic currency kurtosis, which is the residual of the conditional currency kurtosis orthogonal to $\widehat{\beta}_t$, $\widetilde{std}_t^c$, $\widetilde{cos}_t^c$,$\widetilde{skew}_t^c$, and$\widetilde{cok}_t^c$.

5. Robustness Check

In this section, we conduct a similar analysis of the JPY, CNY, and CNH in the Asian and emerging stock markets and provide further evidence on the pricing effects of currency coskewness and cokurtosis.

Table 6: Regime-Switching Model Estimation for the Asian and Emerging Stock Markets and Currency Premiums

	JPY		CNY		CNH	
Regime	$i=1$	$i=2$	$i=1$	$i=2$	$i=1$	$i=2$
Panel A: Regime-Switching Model Estimation for the Currency and Asian Stock Markets Premiums						
μ_i^s	0.175***	-0.002	0.037	0.246***	0.079	0.006
	(4.983)	(-0.037)	(0.652)	(4.130)	(1.325)	(0.116)
μ_i^c	0.012	-0.023	0.023***	-0.026	0.051***	-0.056***
	(0.559)	(-0.703)	(7.084)	(-1.431)	(6.651)	(-3.138)
λ_i^s	-0.891	-1.569	1.387	-19.289***	8.988	-2.239
	(-0.630)	(-0.395)	(0.399)	(-6.087)	(0.338)	(-0.471)
λ_i^c	3.956***	-2.991	0.701***	2.470*	-0.144	2.223***
	(4.833)	(-0.990)	(5.375)	(1.812)	(-0.387)	(3.069)
h_i^s	0.046***	0.436***	0.359***	0.251***	0.192***	0.218***
	(3.399)	(8.357)	(10.796)	(5.810)	(4.990)	(7.115)
h_i^c	0.017***	0.130***	0.001***	0.028***	0.003***	0.027***
	(3.267)	(7.698)	(8.625)	(7.336)	(4.811)	(6.307)
ρ_i	0.338**	-0.140*	0.095	0.467***	0.566***	0.497***
	(1.968)	(-1.728)	(1.111)	(6.156)	(5.846)	(6.896)
a_i	0.573**	-1.381***	1.901***	-2.235***	-0.055	0.222
	(2.451)	(-6.667)	(7.531)	(-8.374)	(-0.140)	(0.610)
b_i	0.000	-20.692**	-0.794	38.174***	96.72***	-137.174***
	(0.000)	(-1.997)	(-0.053)	(2.758)	(3.675)	(-4.611)
Panel B: Regime-Switching Model Estimation for the Currency and Emerging Stock Market Premiums						
μ_i^s	0.028	0.101	0.016	0.318***	-0.063	0.184***
	(0.574)	(0.897)	(0.209)	(4.754)	(-0.819)	(3.241)
μ_i^c	-0.121***	0.072	0.024***	-0.028	0.040***	-0.081***
	(-4.487)	(1.600)	(7.043)	(-1.593)	(4.181)	(-4.540)
λ_i^s	7.023***	-29.289**	4.691	-23.759***	13.596	-12.519***
	(3.617)	(-1.823)	(1.112)	(-6.891)	(0.383)	(-2.897)
λ_i^c	-2.021	-4.085	0.698***	2.572*	0.022	3.243***
	(-1.544)	(-0.603)	(5.301)	(1.926)	(0.037)	(4.512)
h_i^s	0.226***	0.872***	0.645***	0.362***	0.397***	0.262***
	(6.287)	(6.588)	(10.956)	(5.951)	(5.488)	(5.496)
h_i^c	0.066***	0.123***	0.001***	0.028***	0.006***	0.030***
	(6.768)	(7.052)	(8.679)	(7.791)	(7.479)	(5.722)
ρ_i	0.181*	-0.193	0.071	0.530***	0.581***	0.668***
	(1.897)	(-1.597)	(0.786)	(9.064)	(8.598)	(10.355)
a_i	1.822***	-1.930***	1.920***	-2.175***	3.598***	-1.895***
	(6.988)	(-5.715)	(7.611)	(-7.502)	(10.922)	(-5.671)
b_i	14.446	-78.463***	-0.395	33.351**	-96.991***	20.977*
	(1.569)	(-2.775)	(-0.026)	(2.183)	(-6.872)	(1.825)

Note: The table estimates the regime-switching model for the monthly Asian or emerging stock market and currency premiums using $\begin{pmatrix} r_t^s \\ r_t^c \end{pmatrix} = \begin{pmatrix} \mu_i^s \\ \mu_i^c \end{pmatrix} + \begin{pmatrix} \lambda_i^s & 0 \\ 0 & \lambda_i^c \end{pmatrix} \begin{pmatrix} RF_{t-1} \\ RD_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{it}^s \\ \varepsilon_{it}^c \end{pmatrix}$, where $\begin{pmatrix} \varepsilon_{it}^s \\ \varepsilon_{it}^c \end{pmatrix} \sim IIN(\mathbf{0}, \boldsymbol{H_{it}})$ and $\boldsymbol{H_{it}} = \boldsymbol{D_{it}} \boldsymbol{R_{it}} \boldsymbol{D_{it}}, \boldsymbol{D_{it}} = \begin{bmatrix} \sqrt{h_i^s} & 0 \\ 0 & \sqrt{h_i^c} \end{bmatrix}, \boldsymbol{R_{it}} = \begin{bmatrix} 1 & 0 \\ \rho_i & 1 \end{bmatrix}, i \in \{1,2\}$, and transition probabilities $p_{ii,t} = p(S_t = i | S_{t-1} = i, \mathbf{F}_{t-1}) = \Phi(a_i + b_i RD_{t-1}), i \in \{1,2\}$, where RF_{t-1} is the first lagged US risk-free rate and RD_{t-1} is the first lagged interest rate difference (foreign interest rateminusUS interest rate). S_t is the unobserved regime at time t. F_{t-1} is the past information set.Φ is the cumulative normal distribution function. The parameter estimates are the QMLE. The t-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels.

Table 6 presents the results of the estimation of the regime-switching model for the JPY, CNY, and CNH in the Asian stock market, as shown in Panel A and Panel B. The estimation results for the regime-switching model are generally in line with the main results in Table 2.

The correlation between the excess return for the JPY and the Asian stock market is significantly negative in the bear state with a smaller scale in absolute value, with $\rho_2 = -0.14$. In addition, ρ_2 is not significantly negative for the JPY in the emerging stock market. The results suggest that the JPY's hedge capacity in the Asian and emerging stock markets is limited.

We further present the summary statistics of the conditional moments of currencies against the Asian and emerging stock markets in Table 7. The main results are consistent with previous results, as shown in Table 3. The average coskewness of the JPY against the Asian stock market is significantly positive, while that of the CNY and CNH is negative, again indicating that the JPY is a better hedge against volatility in the Asian stock market. Similarly, the average coskewness of the JPY against the emerging stock market is significantly positive, while that of the CNY is negative. Surprisingly, the average CNH coskewness against the emerging stock market is significantly positive with a smaller value than that of the JPY, indicating that the CNH has hedge potential against volatility in the emerging stock market. In addition, the average cokurtosis of the JPY is significantly positive, while that of the CNY and CNH is significantly negative against both markets, implying again that the JPY is a better hedge against stock market crashes. Overall, neither the CNY nor the CNHis an ideal hedge against volatility and crashesin the global stock market.

Table 7
Summary Statistics of Conditional Moment Estimates Derived from the Asian or Emerging Stock–Currency Regime-Switching Models

Currency	JPY	CNY	CNH
Panel A: Average of Conditional Currency Moments Estimates with the Asian Stock Market			
conditional currency beta	-0.068***	0.056***	0.141***
conditional currency standard deviation	0.311***	0.091***	0.131***
conditional currency coskewness	0.100***	-0.003	-0.036***
conditional currency skewness	0.161***	-0.467***	-0.402***
conditional currency cokurtosis	-0.598***	0.727***	1.509***
conditional currency kurtosis	3.958***	13.153***	4.613***
Panel B: Average of Conditional Currency Moments Estimates with the Emerging Stock Market			
conditional currency beta	-0.026***	0.051***	0.143***
conditional currency standard deviation	0.306***	0.091***	0.135***
conditional currency coskewness	0.221***	0.001	0.039***
conditional currency skewness	0.168***	-0.465***	-0.233***
conditional currency cokurtosis	-0.716***	0.725***	1.678***
conditional currency kurtosis	3.247***	13.116***	4.041***

Note: The table reports summary statistics of the conditional moment estimates for the currencies. *, **, and *** are the significance levels for a T-test, indicating whether the conditional moment estimates are significantly unequal to zero at the 1%, 5%, and 10% levels.

We plot the conditional beta, coskewness, and cokurtosis for each currency against the Asian and emerging stock markets as well as the world stock market for reference in Figure A, Figure B, and Figure C in the Appendix. The dynamics of conditional beta, coskewness, and cokurtosis for each currency against the Asian and emerging stock markets are quite close to those of the world stock market except CNH coskewness against the emerging stock market. CNH coskewness against the emerging stock market is mostly positive, suggesting that the CNH has hedge potential against volatility inthe emerging stock market.

Tables 8 and 9 summarise the estimation results of the pricing effects for the Asian stock market and the emerging stock market, respectively.

JPY coskewness is not priced as expected in the Asian stock market, suggesting that the JPY's hedge capacity against the Asian stock market is not well acknowledged by investors. It might be that because the MSCI Asia index includes the Japanese stock market as a component, investors may not be willing to hedge against financial stress in the Asian stock market using the JPY. However, JPY coskewness is significantly priced with a negative premium in the 1-month and 12-month currency excess return in the emerging stock market with an economic significance of -4.6% and -3.9%, suggesting that investors in the emerging stock market are willing to trade off the future excess return of the JPY for its hedge capacity against volatility in the emerging stock market.

Surprisingly, in the emerging stock market, CNH coskewness is also priced like a safe-haven currency in the 1-month and 12-month currency excess return with an economic significance of -2.4% and -2.8%, as shown in Table 9. Considering the positive coskewness of the CNH against the emerging stock market, we conclude that the CNH has a certain degree of hedge capacity against volatility in the emerging stock market. The results illustrate that investors with a skewness preference are willing to accept the CNH's negative future premium to take advantage of the CNH's hedge capacity against volatility in the emerging stock market.

Table 8 Pricing Effects of Currency Coskewness and Cokurtosis with the Asian Stock Market

Currency	$\hat{\beta}_t$	$\widetilde{std}_t^c$	$\widetilde{cos}_t^c$	$\widetilde{skew}_t^c$	$\widetilde{cok}_t^c$	$\widetilde{kurt}_t^c$	R^2	Economic Impact	
								$\widetilde{cos}_t^c$	$\widetilde{cok}_t^c$
Panel A: 1-Month Excess Returns									
JPY	-1.132	0.754*	1.683***	1.507***	0.183	-0.01	5.6%	5.2%	0.0%
	(0.707)	(0.385)	(0.374)	(0.532)	(0.998)	(0.741)			
CNY	-0.237*	1.993	-0.109	0.054***	-0.347	0.014	9.8%	0.0%	0.0%
	(0.139)	(1.682)	(0.109)	(0.020)	(0.229)	(0.014)			
CNH	-0.127	4.762***	0.498***	0.053	0.420	-0.020	3.7%	2.0%	0.0%
	(0.226)	(0.958)	(0.149)	(0.055)	(0.790)	(0.021)			
Panel B: 3-MonthExcess Returns									
JPY	-2.475**	0.327	-0.157	1.754**	-2.174***	-0.346	5.4%	0.0%	-2.6%
	(1.215)	(0.388)	(0.559)	(0.714)	(0.772)	(0.644)			
CNY	-0.311**	2.023**	-0.093	0.013*	-0.066	-0.025**	6.7%	0.0%	0.0%
	(0.121)	(0.926)	(0.092)	(0.007)	(0.146)	(0.010)			
CNH	-0.148	3.945*	0.390*	0.149**	-2.264***	-0.064***	8.5%	1.6%	-2.4%
	(0.240)	(2.076)	(0.200)	(0.067)	(0.645)	(0.015)			
Panel C: 6-Month Excess Returns									
JPY	-2.075***	0.653	1.689***	0.898**	0.495	0.150	5.3%	5.2%	0.0%
	(0.671)	(0.575)	(0.566)	(0.439)	(1.390)	(0.494)			
CNY	-0.159	-0.689	-0.079	-0.011	0.170	-0.015	2.1%	0.0%	0.0%
	(0.169)	(0.923)	(0.148)	(0.018)	(0.249)	(0.011)			
CNH	-0.416*	4.312**	0.047	-0.017	-2.955***	-0.067***	8.9%	0.0%	-3.1%
	(0.237)	(1.794)	(0.255)	(0.053)	(0.575)	(0.019)			
Panel D: 12-Month Excess Returns									
JPY	-1.997**	-0.232	-0.045	0.426	-0.326	2.905***	5.6%	0.0%	0.0%
	(0.828)	(0.499)	(0.692)	(0.583)	(1.058)	(1.022)			
CNY	-0.223	-1.056	-0.163	-0.028*	0.023	0.002	4.0%	0.0%	0.0%
	(0.245)	(1.202)	(0.103)	(0.016)	(0.160)	(0.013)			
CNH	-0.125	1.680	-0.413	0.047	3.278	0.020	3.6%	0.0%	0.0%
	(0.242)	(11.373)	(1.672)	(0.096)	(4.189)	(0.111)			

Note: The table presents the results of the following regressions: $r_{t,t+m}^c = c_0 + c_1\hat{\beta}_t + c_2\widetilde{std}_t^c + c_3\widetilde{cos}_t^c + c_4\widetilde{skew}_t^c + c_5\widetilde{cok}_t^c + c_6\widetilde{kurt}_t^c + e_t^c$, where $r_{t,t+m}^c$ is the currency excess return over the m-month horizon. $\widehat{\beta}_t$ is the traditional beta risk. $\widetilde{std}_t^c$ is the idiosyncratic currency volatility, proxied by the residual from the auxiliary regression of the conditional standard deviation orthogonal to $\widehat{\beta}_t$. $\widetilde{cos}_t^c$ is the residual of the conditional currency coskewness orthogonal to $\widehat{\beta}_t$ and $\widetilde{std}_t^c$. $\widetilde{skew}_t^c$ is the idiosyncratic currency skewness, which is the residual of the conditional currency skewness orthogonal to $\widehat{\beta}_t$, $\widetilde{std}_t^c$ and $\widetilde{cos}_t^c$. $\widetilde{cok}_t^c$ is the conditional currency coskewness orthogonal to $\widehat{\beta}_t$, $\widetilde{std}_t^c$, $\widetilde{cos}_t^c$ and $\widetilde{skew}_t^c$. $\widetilde{kurt}_t^c$ is the idiosyncratic currency kurtosis, which is the residual of the conditional currency kurtosis orthogonal to $\widehat{\beta}_t$, $\widetilde{std}_t^c$, $\widetilde{cos}_t^c$, $\widetilde{skew}_t^c$, and $\widetilde{cok}_t^c$.

Table 9

Pricing Effects of Currency Coskewness and Cokurtosis with the Emerging Stock Market

Currency	$\hat{\beta}_t$	$\widetilde{std}_t^c$	$\widetilde{cos}_t^c$	$\widetilde{skew}_t^c$	$\widetilde{cok}_t^c$	$\widetilde{kurt}_t^c$	R^2	Economic Impact $\widetilde{cos}_t^c$	Economic Impact $\widetilde{cok}_t^c$
Panel A: 1-Month Excess Returns									
JPY	-1.013***	0.791	-1.586**	0.123	-0.101	-0.452	5.3%	-4.6%	0.0%
	(0.293)	(0.693)	(0.798)	(0.436)	(0.281)	(0.485)			
CNY	-0.252*	1.638	-0.087	0.050***	-0.384	0.012	9.8%	0.0%	0.0%
	(0.141)	(1.461)	(0.110)	(0.018)	(0.237)	(0.010)			
CNH	-0.160	-0.239	-1.346*	0.025	-1.315***	-0.007	7.2%	-2.4%	-2.8%
	(0.227)	(1.417)	(0.694)	(0.047)	(0.326)	(0.015)			
Panel B: 3-Month Excess Returns									
JPY	-0.722*	-0.088	-0.764	0.114	0.043	-1.835***	5.3%	0.0%	0.0%
	(0.404)	(0.844)	(0.713)	(0.442)	(0.322)	(0.689)			
CNY	-0.323***	1.871**	-0.066	0.010	-0.048	-0.016*	6.2%	0.0%	0.0%
	(0.124)	(0.813)	(0.094)	(0.007)	(0.140)	(0.008)			
CNH	-0.266*	1.017**	0.318	0.079**	-0.825***	-0.022**	4.2%	0.0%	-1.8%
	(0.154)	(0.494)	(0.509)	(0.035)	(0.272)	(0.010)			
Panel C: 6-Month Excess Returns									
JPY	-0.537	-0.205	-0.496	0.189	0.036	1.489**	3.2%	0.0%	0.0%
	(0.429)	(0.986)	(0.654)	(0.380)	(0.259)	(0.653)			
CNY	-0.183	-0.643	-0.060	-0.014	0.203	-0.014*	2.7%	0.0%	0.0%
	(0.179)	(0.808)	(0.140)	(0.017)	(0.245)	(0.008)			
CNH	-0.119	-1.403	0.361	-0.008	-0.282	-0.004	1.3%	0.0%	0.0%
	(0.205)	(1.885)	(0.746)	(0.049)	(0.677)	(0.023)			
Panel D: 12-Month Excess Returns									
JPY	0.095	-1.741	-1.360*	-0.157	0.652*	0.091	4.3%	-3.9%	3.7%
	(0.468)	(1.163)	(0.774)	(0.435)	(0.377)	(0.759)			
CNY	-0.254	-0.740	-0.162*	-0.027*	0.035	0.000	4.1%	-1.2%	0.0%
	(0.249)	(1.077)	(0.098)	(0.015)	(0.168)	(0.010)			
CNH	-0.400**	1.633*	-1.559**	0.178***	-1.049	-0.047	9.8%	-2.8%	0.0%
	(0.180)	(0.963)	(0.614)	(0.050)	(1.082)	(0.031)			

Note: The table presents the results of the following regressions: $r_{t,t+m}^c = c_0 + c_1\hat{\beta}_t + c_2\widetilde{std}_t^c + c_3\widetilde{cos}_t^c + c_4\widetilde{skew}_t^c + c_5\widetilde{cok}_t^c + c_6\widetilde{kurt}_t^c + e_t^c$, where $r_{t,t+m}^c$ is the currency excess return over the m-month horizon. $\widehat{\beta}_t$ is the traditional beta risk. $\widetilde{std}_t^c$ is the idiosyncratic currency volatility, proxied by the residual from the auxiliary regression of the conditional standard deviation orthogonal to $\widehat{\beta}_t$. $\widetilde{cos}_t^c$ is the residual of the conditional currency coskewness orthogonal to $\widehat{\beta}_t$ and $\widetilde{std}_t^c$. $\widetilde{skew}_t^c$ is the idiosyncratic currency skewness, which is the residual of the conditional currency skewness orthogonal to $\widehat{\beta}_t$, $\widetilde{std}_t^c$ and $\widetilde{cos}_t^c$. $\widetilde{cok}_t^c$ is the conditional currency coskewness orthogonal to $\widehat{\beta}_t$, $\widetilde{std}_t^c$, $\widetilde{cos}_t^c$ and $\widetilde{skew}_t^c$. $\widetilde{kurt}_t^c$ is the idiosyncratic currency kurtosis, which is the residual of the conditional currency kurtosis orthogonal to $\widehat{\beta}_t$, $\widetilde{std}_t^c$, $\widetilde{cos}_t^c$, $\widetilde{skew}_t^c$, and $\widetilde{cok}_t^c$.

Finally, we check the robustness of the main results using an intuitive method following Baur and McDermott (2010). We estimate the model in Eq. (14) jointly using the maximum likelihood method for the return of the JPY, CNY, and CNH, as shown in Table 10. c_1, c_2, and c_3 are coefficients of dummy variables associated with extreme shocks in the stock market. If c_1, c_2, or c_3 is significantly different from zero, there is evidence of a nonlinear relationship between the currency and the stock market. If the parameters are non-positive (including c_0), the currency acts as a weak safehaven. If the parameters are negative and significantly different from zero, the currency under investigation functions as a strong safe haven.

The results in Table 10 show that in some cases, c_1, c_2, or c_3 is significant for the JPY, CNY, or CNH, suggesting that there is a nonlinear relationship between currency return and world stock market index return, which gives us another reason to measure the relationship of the currency and stock market premiums using the regime-switching model. Specifically, c_0 for the JPY is not significant, suggesting that the JPY is at least a weak hedge against an extreme shock in the world stock market. Though c_2 for the JPY is significantly positive, c_1 and c_3 for the JPY are significantly negative, and the sum of c_1, c_2, and c_3 is jointly below zero, suggesting that the JPY is a good hedge against an extreme shock in the world stock market. In contrast, neither the CNY nor the CNH is an ideal safe haven because c_0 and c_1 are significantly positive for the CNY and the CNH. However, the RMB has a minor hedge capacity against an extreme shock in the world stock market because c_2 for the CNY and CNH is significantly negative. The implications of the results estimated using the intuitive model are consistent with those of the main results obtained using the regime-switching approach..

Table 10

Nonlinear Response of Currencies to Shocksin the World Stock Market

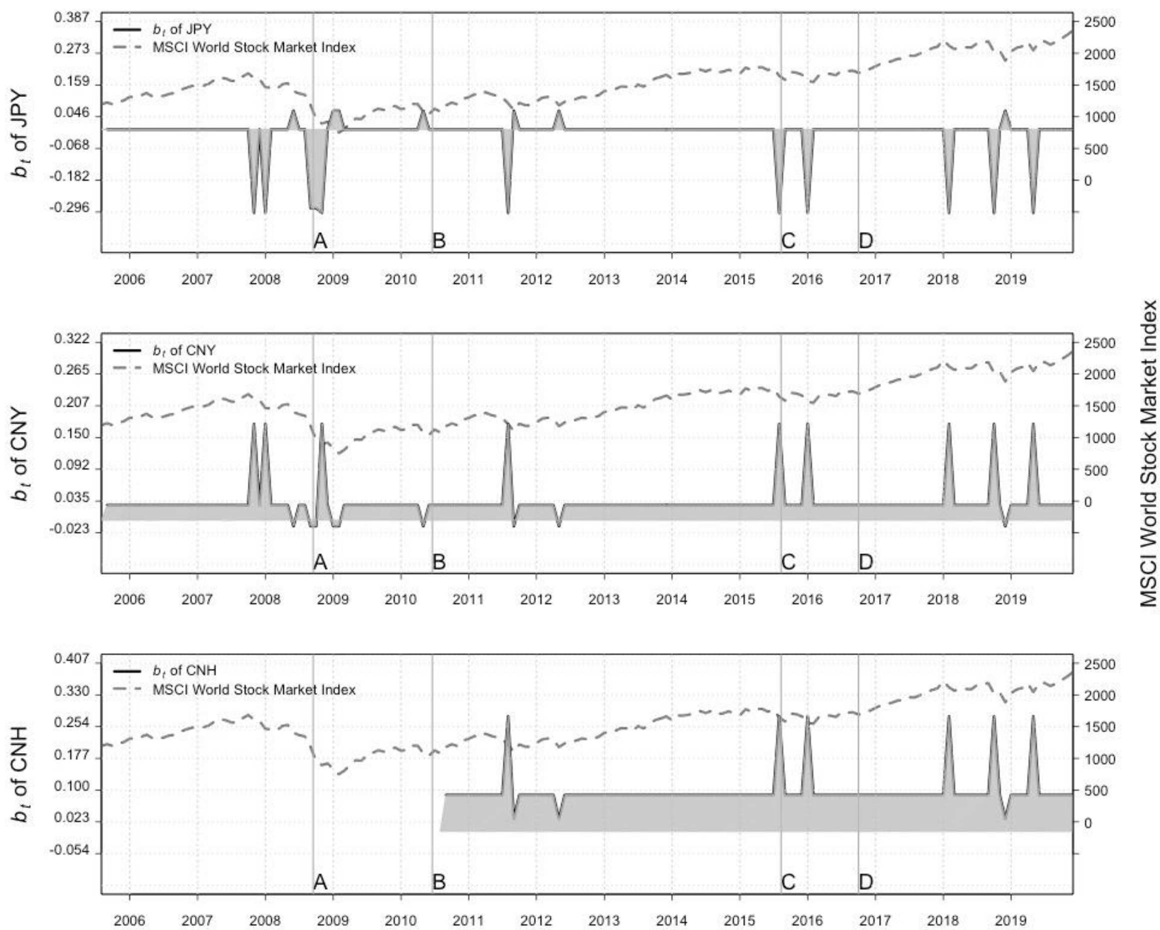
Currency	a	c_0	c_1	c_2	c_3
JPY	-0.043	-0.059	-0.299*	0.366**	-0.349**
	(-0.179)	(-0.887)	(-1.764)	(2.008)	(-2.248)
CNY	0.030***	0.027***	0.147***	-0.185***	0.003
	(51.968)	(49.794)	(3.489)	(-3.787)	(0.073)
CNH	0.116	0.088**	0.190**	-0.247***	0.097
	(1.111)	(2.179)	(2.372)	(-3.497)	(1.368)

Note: The table presents the results of the following regressions: $c_t = a + b_t s_t + e_t$, $b_t = c_0 + c_1 D(s_t q_{10}) + c_2 D(s_t q_5) + c_3 D(s_t q_1)$, and $h_t = \pi + \alpha e_{t-1}^2 + \beta h_{t-1}$, where c_t and s_t are the currency return and stock return, respectively. The dummy variables denoted as $D(\cdots)$ capture extreme stock market movements and are equal to one if the stock market exceeds a certain threshold given by the 10%, 5%, and 1% quantiles of the return distribution. b_t captures the nonlinear response of the currency return to the return of the world stock market index.

We further calculate and display the overall nonlinear response for each currency to the world stock market index according to Eq. (14) using the parameters estimated above, as shown in Figure 7. b_t for the JPY is below zero during the 2008 financial crisis, indicating that the JPY is an ideal and robust hedge against extreme shocks.

In contrast, b_t for the CNY and CNH is mainly above zero, which indicates that the RMB is not a hedge against an extreme shock. Although b_t for the CNY becomes slightly negative in some periods, the magnitudes are quite small and much lower than those for the JPY. The above results estimated using the intuitive model are consistent with the main results.

Figure 7 Time-Varying Nonlinear Response of JPY, CNY, and CNH to Extreme World Stock Market Shocks



Note: The figure displays the evolution of b_t, which is estimated using Eq. (14), as well as the world stock market index for reference. The world stock market index is labelled on the right vertical axis, and b_t is labelled on the left vertical axis. b_t captures the nonlinear response of the currency return to the return of the world stock market index. The horizontal line marks the position of the zero axes. The shadow between the dashed line and the horizontal line clarifies whether b_t is above or below zero. Several relative events are annotated on the tick marks and labelled accordingly. Label A represents the date when Lehman Brothers went into bankruptcy in September 2008. Label B represents the date when the Chinese central bank restarted the market reform of the RMB exchange rate in June 2010. Label C represents the date when the Chinese central bank modified the RMB central parity quotation mechanism in August 2015. Label D represents the date when the IMF included the RMB in the SDR basket in October 2016.

6. Concluding Remarks

This study examines whether the RMB is a safe-haven currency in terms of currency coskewness and cokurtosis with the global stock market. Currency coskewness and cokurtosis directly address the essential characteristic of a safe-haven currency since they refer to the performance of a currency (as measured by currency excess return) during times of financial stress (as measured by global equity volatility and skewness).

We find that onshore RMB (CNY) has positive coskewness with the global stock market in some periods, while offshore RMB (CNH) has positive coskewness with the emerging stock market. The patterns imply that the CNY can only hedge against stock market volatility to some extent, while the CNH can hedge against volatility in the emerging stock market. In contrast, the JPY has positive coskewness in all periods and is a better hedge in a volatile market, as it appreciates when equity volatility increases. Moreover, both onshore and offshore RMB cokurtosis with the equity market are positive and thus cannot hedge against a stock market crash. In contrast, JPY cokurtosis is negative, suggesting even higher hedging effectiveness during extreme stock market downturns.

We also document that RMB coskewness with stock markets is not priced in the RMB future excess return, while the JPY counterpart is priced, which suggests that prudent equity investors use the JPY rather than the RMB to hedge against global stock market volatility. Moreover, cokurtosis for neither the JPY nor the RMB is priced, implying that temperate investors use neither the RMB nor the JPY to hedge against global stock market crashes. Although the RMB has some characteristics as a safe-haven currency, it is not yet a safe-haven currency in the full sense.

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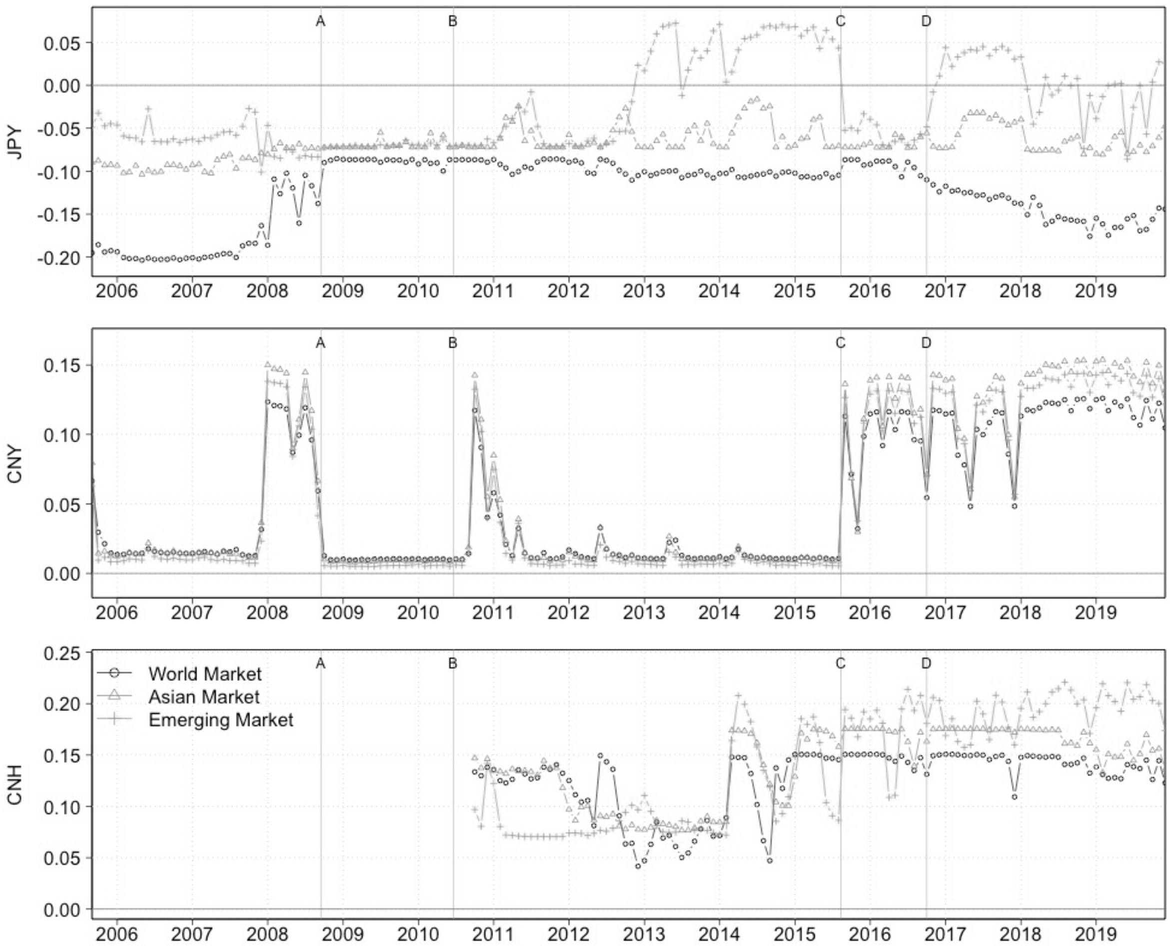
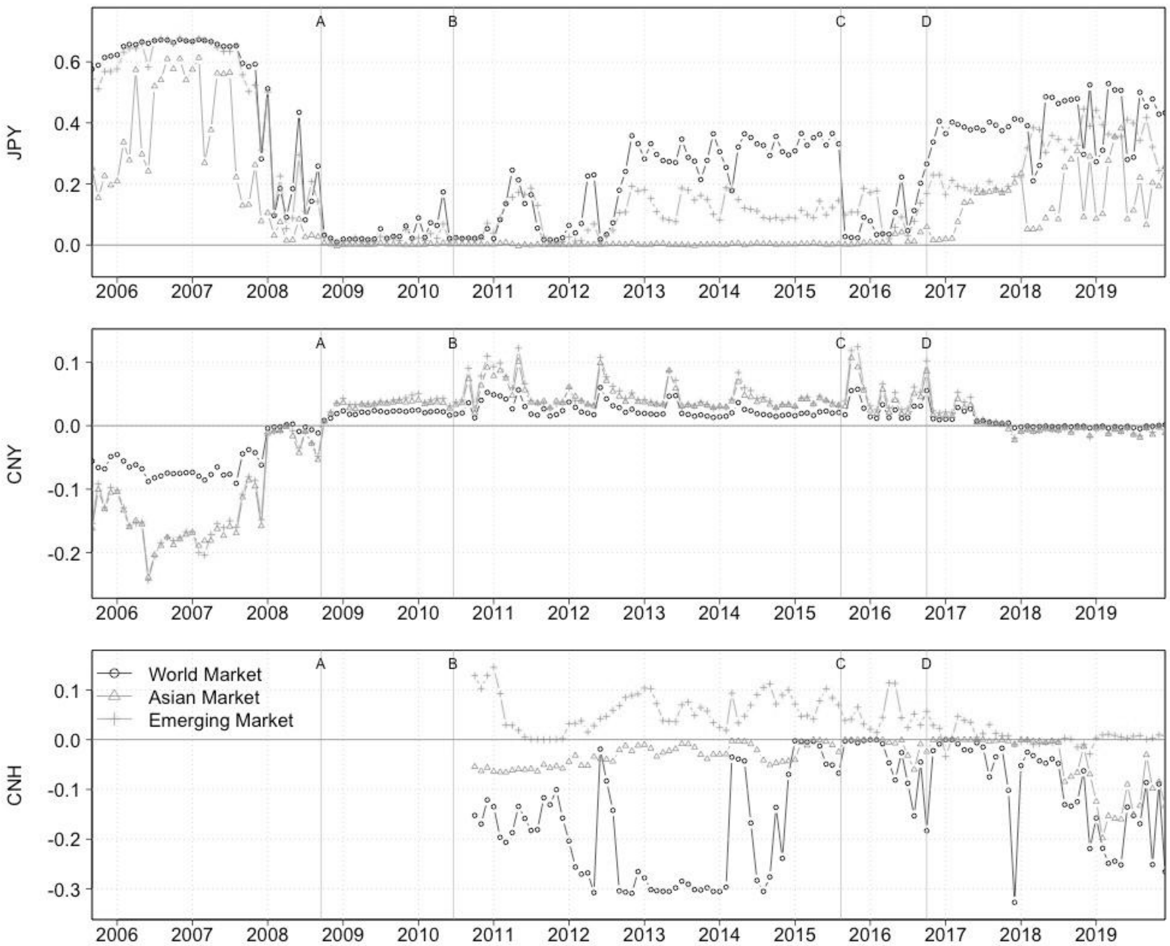
Appendix

Figure A Conditional Currency Betas with Stock Markets



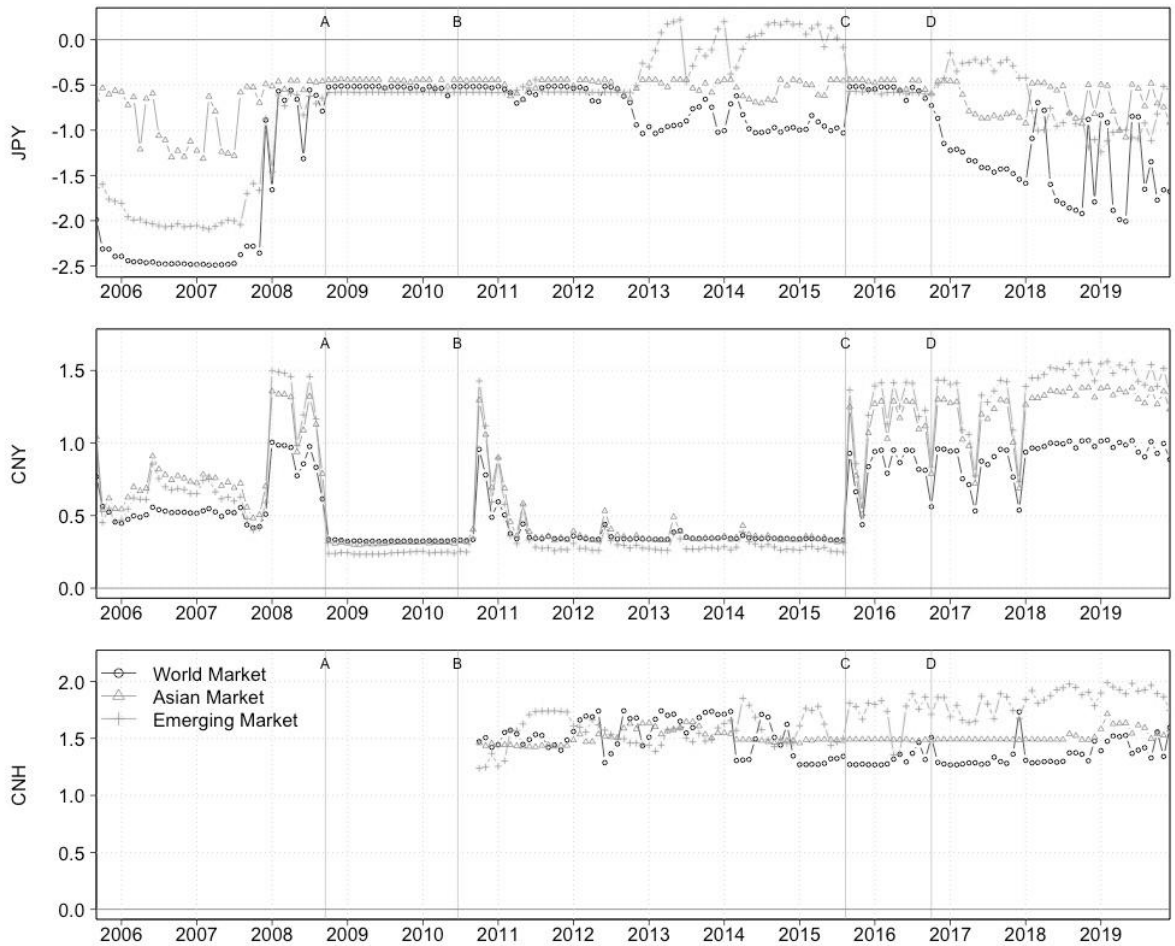
Note: The horizontal line marks the position of the zero axes. Several relative events are annotated on the tick marks and labelled accordingly. Label A represents the date when Lehman Brothers went into bankruptcy in September 2008. Label B represents the date when the Chinese central bank restarted the market reform of the RMB exchange rate in June 2010. Label C represents the date when the Chinese central bank modified the RMB central parity quotation mechanism in August 2015. Label D represents the date when the IMF included the RMB in the SDR basket in October 2016.

Figure B Conditional Currency Coskewness with Stock Markets



Note: The horizontal line marks the position of the zero axes. Several relative events are annotated on the tick marks and labelled accordingly. Label A represents the date when Lehman Brothers went into bankruptcy in September 2008. Label B represents the date when the Chinese central bank restarted the market reform of the RMB exchange rate in June 2010. Label C represents the date when the Chinese central bank modified the RMB central parity quotation mechanism in August 2015. Label D represents the date when the IMF included the RMB in the SDR basket in October 2016.

Figure C Conditional Currency Cokurtosis with Stock Markets



Note: The horizontal line marks the position of the zero axes. Several relative events are annotated on the tick marks and labelled accordingly. Label A represents the date when Lehman Brothers went into bankruptcy in September 2008. Label B represents the date when the Chinese central bank restarted the market reform of the RMB exchange rate in June 2010. Label C represents the date when the Chinese central bank modified the RMB central parity quotation mechanism in August 2015. Label D represents the date when the IMF included the RMB in the SDR basket in October 2016.