“Does currency smirk predict foreign exchange return?”

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DOES CURRENCY SMIRK PREDICT FOREIGN EXCHANGE RETURN?

Abstract

This study examines the predictive power of implied volatility smirk to forecast foreign exchange (FX) return. The volatility smirk contains critical information, especially when the market experiences negative news. The Australian dollar, Canadian dollar, Swiss franc, Euro, and British pound options traded in the opening, midday and closing periods of the trading day are selected to estimate the currency smirk. Research results reveal that the currency smirk outperforms in forecasting FX returns. In addition, the steeper slope in the middle of the trading day suggests that the predictive power of currency smirk in the midday period is higher compared to the opening and closing periods. However, currency smirks' predictability lasts for a short period, as the FX market is highly adept at incorporating the vital information embedded in the currency smirk. These findings imply that the currency smirk is distinctive for forecasting very short-term FX fluctuations, and the day- or overnight FX traders can use its uniqueness to profit from quick price swings in the 24-hour global FX market.

Keywords implied volatility, skewness, information content, reverse skew

JEL Classification G01, G15, G17

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INTRODUCTION

The implied volatility (IV) smirk is the difference between the IV of out-of-the-money (OTM) put options and the IV of at-the-money (ATM) call options. It occurs when IV is higher on lower options strikes. The foreign exchange (FX) market spans the globe and is open 24 hours worldwide, with prices moving and currencies trading somewhere every hour of every business day. It is the largest and the most influential market for global and national economies. As the FX is the underlying asset of currency options, there is a high possibility of the mispricing of currency options in the severely volatile FX market. The speculators also believe this is an opportunity to make a profit by trading currency options. This leads to the fact that the currency options market becomes inefficient and makes currency options, an FX risk management tool, more expensive. Consequently, the currency options market participants, mainly multinational companies, are reluctant to use currency options for hedging, which reduces the variability of future FX return. Therefore, this study introduces the implied volatility smirk for currency to examine that currency smirk can hold information to forecast the FX return.

This study differs from previous research in this area along several dimensions. First, it estimates currency smirk based on currency options prices to examine its forecasting performance for the FX return. Therefore, the findings of reverse skew or smirk analysis for the FX options add a new dimension to the literature. Second, the efficient ATM call and OTM put options market prices are used to measure the currency smirk; otherwise, the currency smirk is biased, result-

ing from mispriced (underpriced or overpriced) options price. This fundamental critical issue has been overlooked in previous studies. Third, to obtain ATM call for currency smirk with higher accuracy, this research uses ten per cent narrower swing band than what Xian et al. (2010)[1] employed. It provides ATM call price, rather than call price at near-the-money. Fourth, the information content is not constant and changes during the trading day with a different magnitude. This study, therefore, analyzes the forecasting performance of currency smirk at different trading hours. The research findings indicate that the predictive power of currency smirk is not the same for the opening, midday, and closing trading periods. This intraday smirk analysis approach is also new in the literature.

1. LITERATURE REVIEW

This section reviews the literature on IV and a smirk containing the market information to provide negative market news. Gemmill (1996) conducted research on the changing shape of volatility smile and found that after the crash, traders buy more OTM put options to insure themselves. The finite moment log stable process (FMLS) model developed by Carr and Wu (2003) provided a parsimonious way to model how IVs vary in terms of moneyness and maturity.

Doran, Peterson, and Tarrant (2007) showed that the power of the crash prediction decreases with an increase in the time to option maturity. Pena, Rubio, and Serna (1999) showed that the shape of IV function correlated with options time to maturity, the uncertainty associated with the market and the relative market momentum. Duan and Wei (1999) found conditionally fat-tailed distributions and the volatility smile in options. Tanha and Dempsey (2015) showed that the pronounced volatility smile is related to the differential sensitivities of ITM and OTM options, which itself suggest an explanation for the characteristic smile shape. Lee, Wang, and Nguyen (2016) indicated that intraday data was more potent than daily data in analyzing the information content of the IV.

In the reverse skew literature, Foresi and Wu (2005) suggest that the smirk does not flatten out but steepens the risk-neutral distribution of equity index returns and becomes even more negatively skewed at longer horizons. Zhang and Xiang (2008) presented a formal, two-way representation of the link between the level, slope and curvature of the smirk and the risk-neutral standard deviation, skewness and excess kurtosis. They reveal a lot of information about investors' fair expectations regarding the index return distribution over different terms in the future. Christoffersen, Heston, and Jacobs (2009) found that the shape and term structure of the index option smirk and multifactor stochastic volatility models explain how the volatility smirk moves up and down in response to changes in risk. Bradshaw, Hutton, Marcus, and Tehranian (2010) suggested strong relations among three facets of that risk: two predictors of crashes, earnings opacity and the option smirk curve, and actual crash incidence. Research by Han, Liang, and Wu (2016) suggest that the price impact from critical economic determinants can help fill the gap between theoretical and practical IV skews.

Rubinstein (1994) and Dumas et al. (1998) examined the OTM put IV and ATM call IV for S&P 500 index options for the market crash period in 1987 and found that the OTM put IV was significantly higher than the ATM call IV. Intuitively, OTM put of volatility smirk conveys negative news in the market. The concerned investors hold the put to protect their financial losses from the possible market crashes, which makes OTM put more expensive. Bates (1991) showed that the OTM put options on S&P futures became unusually costly during the year preceding the crash of 1987. Further, Bates (2000) argued that the volatility smirk represents investors' intuition of future market crash. Pan (2002), based on index options, pointed out that the investor aversion to negative news is the driving force for the smirk in the options market. Bollen and Whaley (2004) and Gârleanu, Pedersen, and Poteshman (2009) documented that the volatility smirk appears in both index and individual stock due to high demand for OTM put options.

1 Xian et al. (2010) used the ratio of the strike price to the stock price between 0.95 and 1.05 (i.e., 10 percent swing band [1.05–0.95]*100). In this study, the ratio of the strike price to the stock price is between 0.995 and 1.005 (i.e., 1 percent swing band [1.005–0.995]*100). Therefore, this study uses 10 percent narrower ([1 percent/10 percent]*100) swing band compared to Xian et al. (2010).

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Most of the previous research on stock and stock index options examined that the volatility smirk reflects the risk of future adverse news; all these research works mostly focus on the information contained in the options volatility smirk. On the other hand, Xing et al. (2010) analyzed the relationship between stock return and implied the volatility smirk for the individual stock option. They found that the equity volatility smirk has significant predictive power for future equity returns. The FX market and stock market are analogous, since both are used as financial assets for investment purposes and underlying assets of exchange-traded options. Therefore, the findings of Xing, Zhang, and Zhao (2010) leave a gap: to study the "currency options implied volatility smirk" (henceforth "currency smirk"). The objective of this study is to fill this research gap by examining the information contained and predictive power of the currency smirk to forecast FX returns.

2. DATA AND METHODOLOGY

The sample selection procedure is discussed first in this section, followed by the development of the methodology. This study employs the Nasdaq currency options. It includes the major World Currency Options (WCO)[2] on Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), Euro (EUR), and British pound (GBP). These currency options sample data are obtained from the Securities Industry Research Centre of Asia-Pacific (SIRCA) database. The intraday currency smirk is estimated for the opening period (9:30 am to 10:00 am), midday period (12:30 pm to 1:00 pm), and closing period (3:30 pm to 4:00 pm) of the trading day. These three trading periods are evenly set up within a trading day by maintaining two-and-a-half hour's time difference among opening, midday, and closing periods.

Norden and Xu (2010) indicate that the implied volatility smirk significantly depends on the relative liquidity between options series with different "moneyness." The sample selection period, therefore, is critical to minimize the data liquidity issue for the options traded in the newly developed WCO. Consequently, the intraday data from the SIRCA database are extracted for a four-year sample period from September 20, 2010 to September 19, 2014. Further, options with time to maturity between two and ninety days are included in the sample to confirm that the options have adequate liquidity.

This study considers the ATM call price, OTM put price and strike price of sample currency options. The spot price against the US dollar (USD) and the interest rates of the sample currency are also used to estimate the currency smirk. The strike price to stock price ratio between 0.995 and 1.005 provides the ATM call options. Similarly, the ratio of strike price to the stock price is lower than 0.995 [but higher than 0.80, as Xian et al. (2010) use in their study] for the OTM put options.

The following steps develop a methodology to conduct the empirical analysis in this study. First, the sample currency options' market efficiency is examined using the put-call-parity (PCP) regression model developed by Mittnik and Rieken (2000), as in equation (1):

$$Y_{t,i,j} = \beta_0 + \beta_1 X_{t,i,j} + \varepsilon_{t,i,j}, \qquad (1)$$

where

$\forall_i = AUD, CAD, CHF, EUR, GBP;$
$\forall_i = Opening\ hours,\ Midday\ hours,$
$Closing\ hours;$

$Y = (C - P);$ $X = \left(Se^{-R_d T} - Xe^{-R_f T}\right);$
C, P, S, X, R_d, R_f, and T represent ATM call, ATM put, spot rate, strike price, domestic currency interest rate, foreign currency interest rate, and options maturity, respectively. The strike price to stock price ratio between 0.995 and 1.005 provides the ATM call and ATM put options. The coefficients β_0 and β_1 in equation (1) should be 0 and 1, respectively, to hold the PCP condition under the null hypothesis.

Next, the efficient ATM call and OTM put options estimate the daily currency smirk (*DCS*), using equation (2); this shows the difference between

2 The World Currency Options is an entirely new class of currency options launched at the Philadelphia Stock Exchange (PHLX) on July 24, 2007. These options are designed for monthly maturity and have a smaller contract size than the existing currency option contract, which matures quarterly; this opens up the world of currency trading to those with smaller investment accounts.

the OTM put implied volatility (*OTMPIV*) and the ATM call implied volatility (*ATMCIV*):

$$DCS_{t,i,j} = OTMPIV_{t,i,j} - ATMCIV_{t,i,j}. \quad (2)$$

The log difference of two consecutive days' spot rate estimates the daily foreign exchange return (DFX). Finally, the regression analysis of Xian et al. (2010) follows, and the weekly currency smirk (WCS) and weekly foreign exchange return (WFX) are used as inputs of the regression equation (3) to assess the forecasting power of currency smirk to predict the FX return. The average of DCS over a week (Monday to Monday) and the average of DFX over a week (Tuesday to Tuesday) estimate *WCS* and *WFX*, respectively:

$$WFX_{t,i,j} = \alpha_0 + \alpha_1 WCS_{t,i,j} + \varepsilon_{t,i,j}. \quad (3)$$

3. RESULTS AND DISCUSSION

The put-call-parity (PCP) test using equation (1) is conducted to examine the sample currency options' market efficiency. Table 1 presents the findings of the PCP test for the opening, midday and closing periods of a trading day. The standard error (std. error) is reported in parentheses below the estimated coefficients. For the intercept of AUD opening period, *t*-statistic 1.3802 (–0.0824/0.0597) indicates that at any significance level, the null of H_0: $\beta_0 = 0$ cannot be rejected. This is also valid for other intercepts reported in Table 1. This means the intercept is not statistically different from 0 for all cases. However, the slope of each occasion is statistically greater than 0 for the opening, midday, and closing periods. Further, for the slope of the AUD opening period, *t*-statistic 1.76 = (1 – 0.9245)/0.0429 reveals that at the standard level of significance, the slope null hypothesis H_0: $\beta_1 = 1$ cannot be rejected. This is also true for other slope coefficients reported in Table 1. The overall findings strongly suggest that PCP holds for each regression analysis, resulting in the effectiveness of each sample of the currency options market.

Next, the OTM put implied volatility (OTMPIV) and the ATM call implied volatility (ATMCIV) are estimated using the efficient OTM put price and ATM call price, respectively, to measure the currency smirk as the difference between OTMPIV and ATMCIV. Before answering the question of whether currency smirk defines and predicts the FX return, the properties of OTMPIV, ATMCIV and currency smirk are analyzed graphically and statistically. OTMPIV (blue color), ATMCIV (red color) and the currency smirk (green color) are plotted for opening, midday and closing options price in Figures 1, 2 and 3, respectively. The acronym is used to distinguish the graph of each sample currency for the different trading period. In the acronym, the first three letters are used for currency options (AUD, CAD, CHF, EUR and GBP are the Australian dollar, Canadian dollar, Swiss franc, Euro and British pound, respectively); the next two letters represent the trading period (OP, MD and CL are opening, midday and closing, respectively); the last three letters, PIV, CIV and SMR, are the short form of the put implied volatility, call implied volatility and volatility smirk, respectively. For example, AUDOPPIV, AUDOPCIV and AUDOPSMR stand for Australian dollar opening period put

Table 1. Currency options market efficiency analysis

Options	Opening period			Midday period			Closing period		
	Intercept (std. error)	Slope (std. error)	Adj R^2	Intercept (std. error)	Slope (std. error)	Adj-R^2	Intercept (std. error)	Slope (std. error)	Adj-R^2
AUD	–0.0824	0.9245*	0.31	–0.0506	0.9326*	0.36	–0.0102	0.9451*	0.39
	(0.0597)	(0.0429)		(0.0390)	(0.0356)		0.0105	(0.0288)	
CAD	0.0079	1.0271*	0.39	0.0046	1.002*	0.51	–0.2558	0.9416*	0.64
	(0.0248)	(0.032)		0.0289	(0.0373)		0.1482	(0.0314)	
CHF	–0.0951	0.8856*	0.26	–0.0605	1.0341*	0.27	–0.0621	0.9063*	0.25
	(0.0489)	(0.0603)		(0.0372)	(0.0562)		(0.0355)	(0.0518)	
EUR	0.0156	1.0025*	0.32	0.1037	1.0475*	0.45	0.1008	1.0677*	0.55
	(0.0353)	(0.0756)		0.0551	(0.0665)		0.0635	(0.0553)	
GBP	–0.3773	0.9116*	0.39	–0.3099	0.9089*	0.41	–0.0348	0.9913*	0.38
	(0.2832)	(0.1139)		(0.2209)	(0.1042)		0.0177	(0.0410)	

Note: * denotes at least 5% level of statistical significance; Adj-R^2 = adjusted R-squared.

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price implied volatility, Australian dollar opening period call price implied volatility and Australian dollar opening period currency smirk, respectively. In Figures 1, 2 and 3, the ATMCIV lies below the OTMPIV, which indicates that the OTM put price is more than ATM call price. Further, the spikes of OTMPIV reveal that the OTM put is sold at a substantially higher price than the ATM call due to its greater demand. The currency smirk (green color) sits at the base of the graph by showing similar pattern across opening, midday and closing hours.

Following the graphical illustration, the descriptive analysis of currency smirk is conducted, and the descriptive statistics, mean and skewness are given in panel A and panel B of Table 2, respectively. Further, the ANOVA test is used to examine the equality of means for different trading periods, and the results are reported in panel A (Table 2). The *t*-statistic of ANOVA test results indicate that the sample means of the opening, midday and closing periods differ significantly from each other. It supports the validity to divide the whole trading day into three different periods in this study. In panel B, the highest and lowest skewness can be seen during the midday and closing periods, respectively. The skewness decreases substantially from midday to closing period, which ranges from

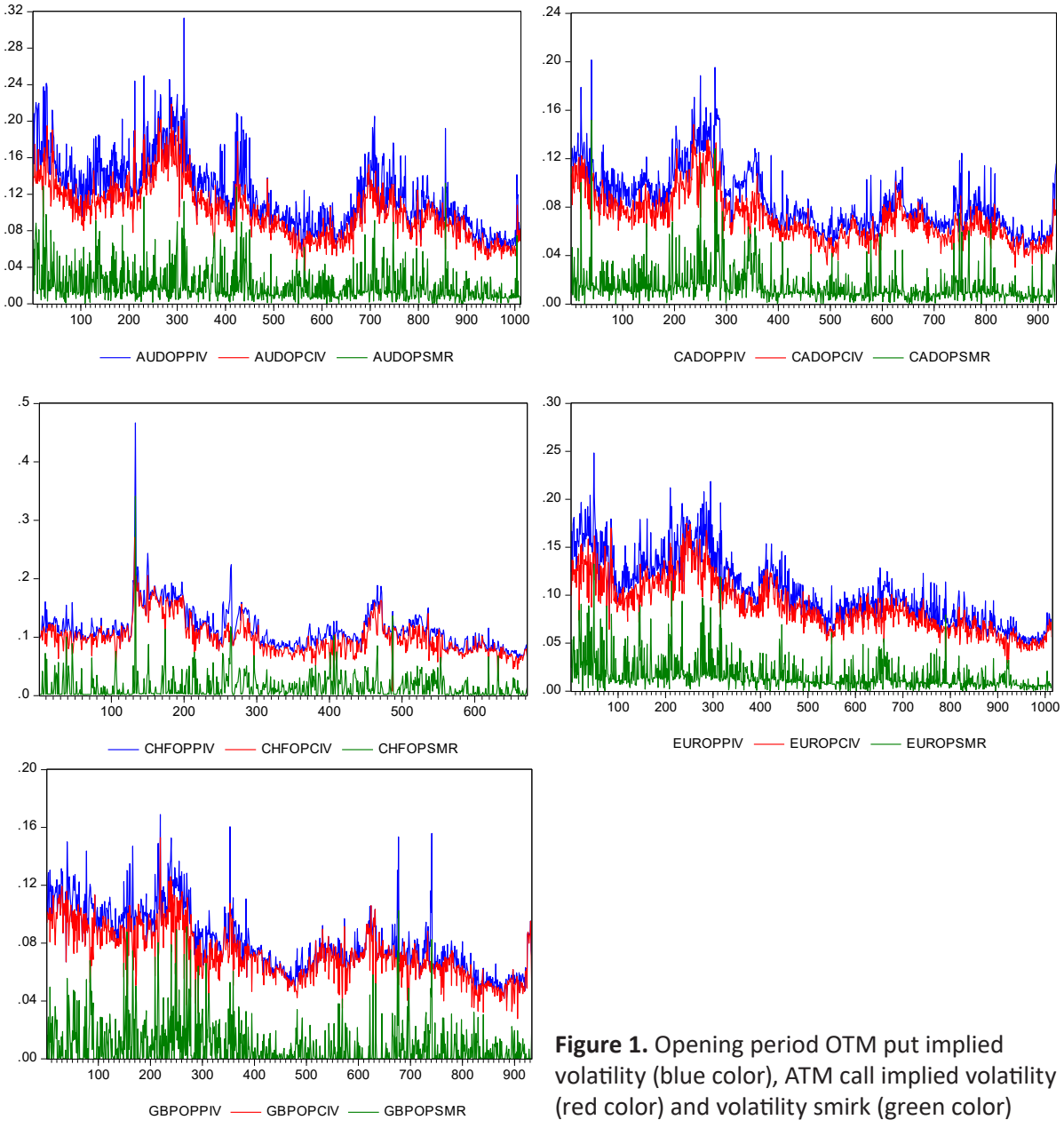

Figure 1. Opening period OTM put implied volatility (blue color), ATM call implied volatility (red color) and volatility smirk (green color)

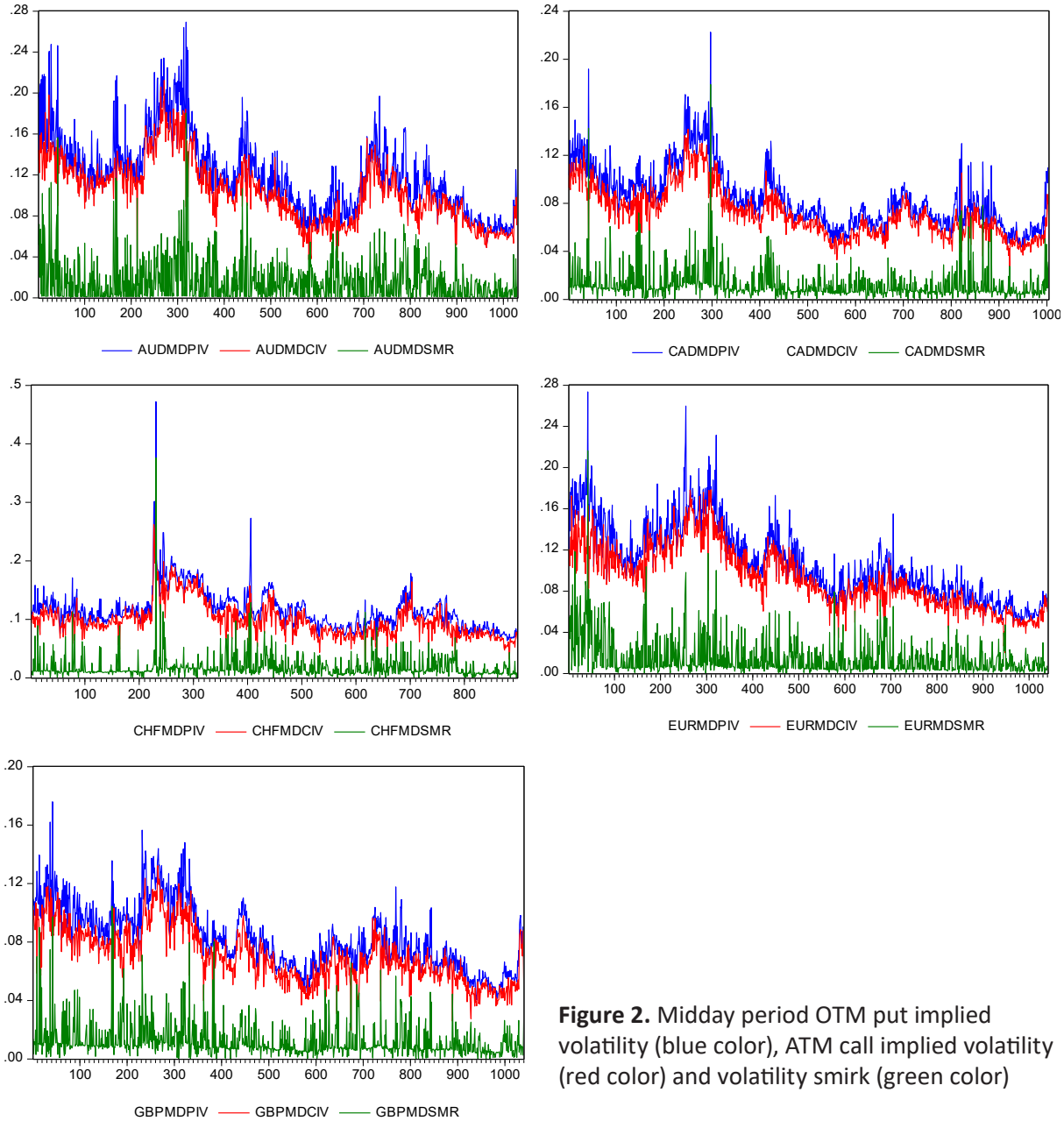

Figure 2. Midday period OTM put implied volatility (blue color), ATM call implied volatility (red color) and volatility smirk (green color)

21.6% (for EUR) to 95.5% (for GBP). This leads to the fact that the currency smirk of the midday period holds more asymmetry information, which deceases with the closing of the trading day.

Since the skewness is a measure of distributional asymmetry, the kernel density is estimated to compare the different period volatility smirks' skewness graphically (see Figure 4). The midday

Table 2. Descriptive analysis of the currency smirk

Options	Panel A: Means equality analysis				Panel B: Skewness analysis		
	Opening mean	Midday mean	Closing mean	ANOVA test *t*-statistic	Opening	Midday	Closing
AUD	0.020687	0.016909	0.041692	16.46	2.062101	2.476876	1.828611
CAD	0.015135	0.012582	0.009383	6.64	3.266146	4.471062	2.480774
CHF	0.015584	0.018380	0.013224	3.70	5.430057	6.988326	3.652388
EUR	0.016817	0.015503	0.011099	5.66	2.677309	3.090530	2.547239
GBP	0.009747	0.012420	0.016688	7.32	2.429584	3.018400	1.542098

Note: The ANOVA test provides F-statistic. However, *t*-statistic is used, which is the square root of *F*-statistic, for simplicity.

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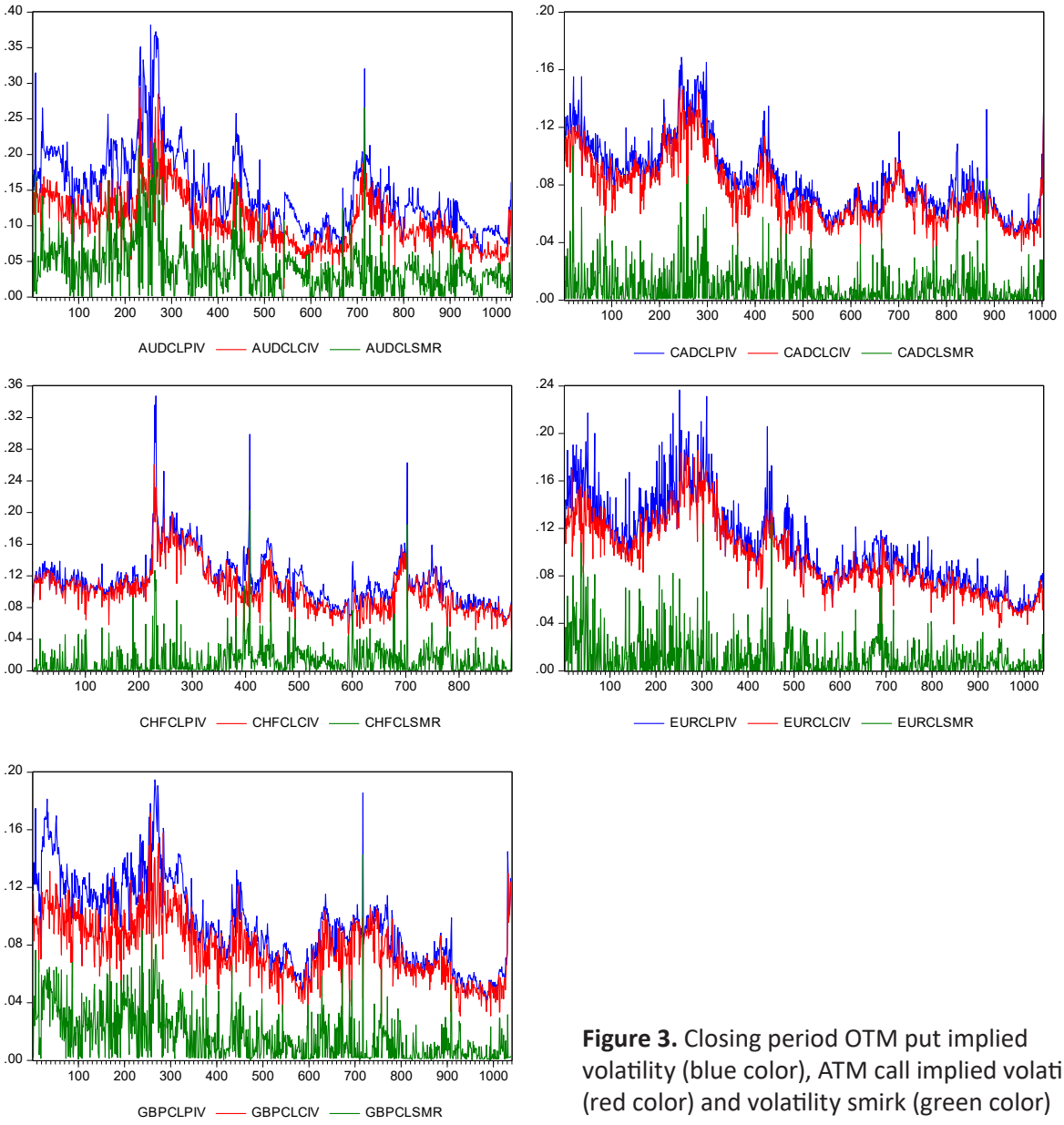

Figure 3. Closing period OTM put implied volatility (blue color), ATM call implied volatility (red color) and volatility smirk (green color)

period currency smirk (red color) with a long right tail (i.e., about 0.20, 0.18, 0.38, 0.22 and 0.07 for AUD, CAD, CHF, EUR and GBP, respectively) indicates that it is positively skewed and holds greater asymmetry information than that of opening and closing period currency smirk.

Next, the in-sample test is conducted for the individual sample and the whole sample to examine how well the asymmetry information of currency smirk fits-in with the FX return. For the individual sample, the currency smirk is regressed on the FX return using equation (3) for the opening, midday and closing hours. Table 3 shows the results with *t*-statistic (*t*-stat) in parentheses below the estimated coefficient. The significant slope coefficient ensures the relationship between each sample currency smirk and its FX return, which justifies this study. The slope coefficient and Adj-R^2 value indicate that the currency smirk has a strong capacity to define the FX return. The negative slope coefficient suggests that the anticipation depreciation of future foreign currency value against the US dollar increases the demand of OTM put. For an overwhelmingly pessimistic perception of the FX market, the investors who hold currency tend to buy put to protect their FX value against future currency price drops (for hedging purposes). Further, the negative slope coefficient

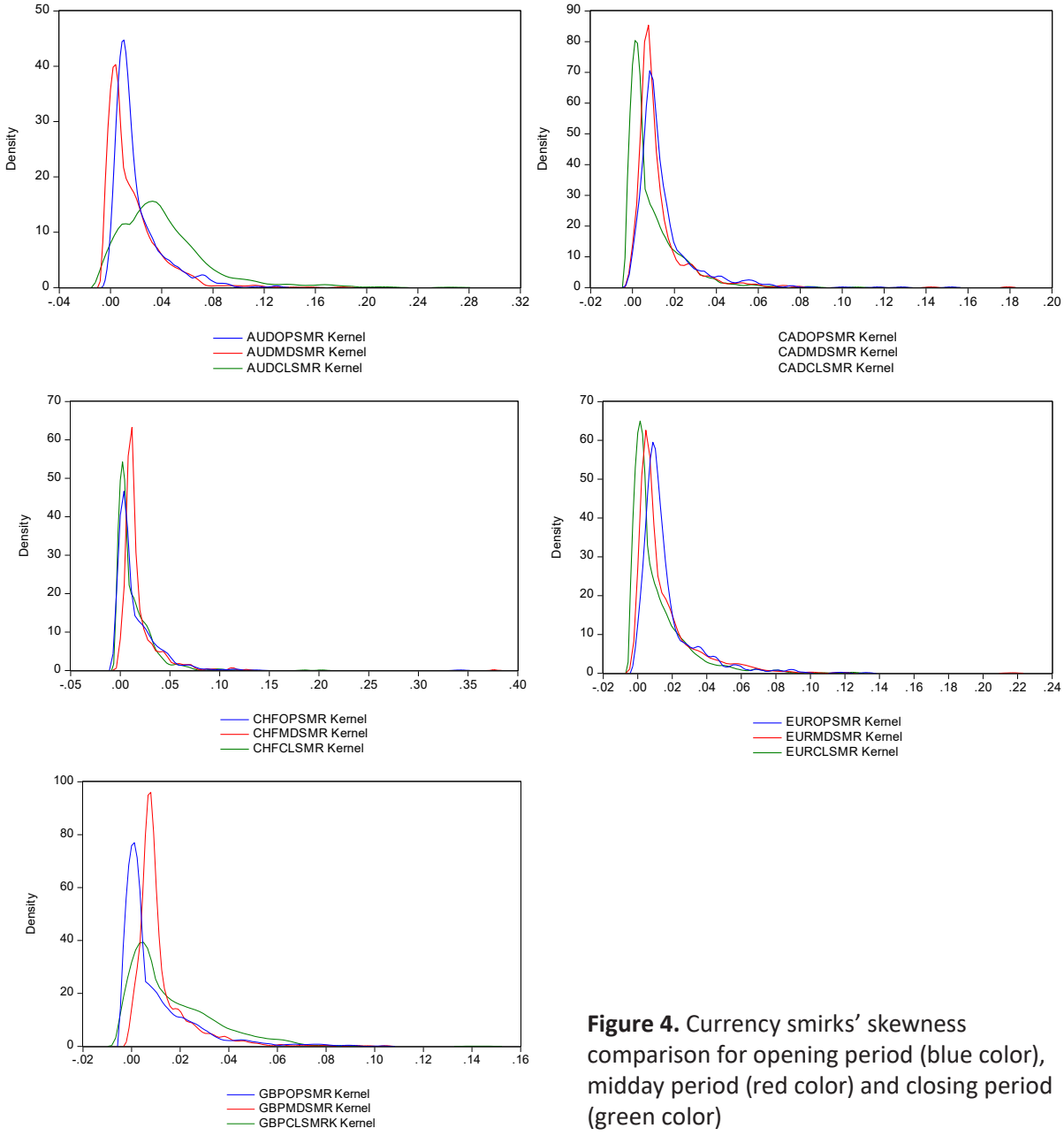

Figure 4. Currency smirks' skewness comparison for opening period (blue color), midday period (red color) and closing period (green color)

is higher in the midday period than that of the opening and closing period for each sample currency.

For the whole sample, the Prais-Winsten panel regression analysis is conducted, and the results are given in Table 3. The slope coefficient of all periods is statistically nonzero at any standard level of significance. Further, the slope coefficient of the midday hour is spotted higher than that of the opening and closing hour. It is consistent with the findings from the above individual sample regression analysis. The higher slope coefficient suggests that the midday currency smirk performs relatively better than opening and closing period currency smirks in describing FX return accurately. It reveals that the midday currency smirk is superior to hold asymmetry information, which supports the results of skewness analysis using kernel density estimation in the previous section. The steepness of the slope measures the intensity of put option demand, and the steeper slope of the midday hour suggests significant buying pressure on the OTM put in the middle of the trading day. This occurs because risk-averse investors are interested to hold OTM put during the midday period

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Table 3. Currency smirks' information content analysis

Options	Opening hour			Midday hour			Closing hour		
	Intercept (*t*-stat)	Slope (*t*-stat)	Adj-R^2	Intercept (*t*-stat)	Slope (*t*-stat)	Adj-R^2	Intercept (*t*-stat)	Slope (*t*-stat)	Adj-R^2
AUD	0.0010*	–1.147*	0.647	0.0013*	–1.338*	0.680	0.0012*	–0.489	0.679
	(3.646)	(–6.932)		(6.441)	(–9.221)		(4.940)	(–6.283)	
CAD	0.0013*	–1.489*	0.641	0.0016*	–2.118*	0.662	0.0008*	–1.565*	0.662
	(7.207)	(–9.568)		(10.355)	(–13.961)		(5.960)	(–8.987)	
CHF	0.0015*	–1.427*	0.754	0.0021	–1.719*	0.855	0.0013*	–1.545*	0.749
	(3.774)	(–6.214)		(8.069)	(–12.322)		(4.466)	(–7.822)	
EUR	0.0016*	–1.632	0.688	0.0013*	–1.711*	0.698	0.0006*	–1.082*	0.832
	(8.815)	(–11.462)		(9.043)	(–12.432)		(3.371)	(–6.508)	
GBP	0.0007*	–1.153*	0.839	0.0013*	–1.789*	0.844	0.0010*	–1.178*	0.822
	(4.096)	(–7.550)		(7.279)	(–10.287)		(5.796)	(–9.057)	
Whole sample	0.0015*	–1.568*	0.077	0.0017*	–1.822*	0.118	0.0011*	–0.948*	0.052
	(11.110)	(–18.000)		(14.190)	(–24.050)		(8.930)	(–15.02)	

Note: * denotes at least 5% level of statistical significance; Adj-R^2 = adjusted *R*-squared. For the whole sample, the Prais-Winsten panel regression analysis is conducted.

instead of the opening and closing periods, since they consider the OTM put option is priced more efficiently when the market is less volatile at the middle of the trading day.

Finally, the predictive power of currency smirk is analyzed using the out-of-sample test for the individual sample as well as the whole sample. For the individual sample, the currency smirk is regressed on the FX return over the next one and two days to evaluate its FX return forecasting power over the one-day and two-day horizon, respectively. The regression results for the one-day forecast horizon are given in Table 4. Statistically, the slope coefficient is different from zero for each currency sample across the opening, midday, and closing hours. Statistically, two-day regression results are not significant, and thus the results are reported them here; however, the results are available upon request. The overall results suggest that the currency smirk has a strong capability of forecasting the FX returns of the next trading day. The temporary predictability of currency smirk occurs because the FX market is very efficient in incorporating new information from the options market. It is, therefore, argued that the *currency smirk holds information for future short-term FX price fluctuations*. Further, the slope coefficient of midday is higher than that of the opening and closing period for all cases. It indicates that the currency smirk of midday hours outperforms the currency smirk of opening and closing period.

The predictability of currency smirk for the whole sample is examined using the Prais-Winsten's proposed panel regression analysis. The results are summarized in Table 4. The slopes for different trading periods are statistically greater than zero at least 5 per cent level of significance. However, the higher slope coefficient is noticed in the middle of the day, which is consistent with the results reported for the individual sample. It signifies the midday currency smirks' superiority against the opening and closing hours' currency smirk in forecasting FX return. This happens because the midday hour currency smirk holds adequate information due to using efficient options prices in the less volatile middle of the trading day.

Other than the new research idea of the currency smirk, the following three major methodological developments are introduced in this study to measure currency smirk with higher degrees of accuracy. First, the efficient OTM put price and ATM call price are employed to estimate the OTM put implied volatility (OTMPIV) and the ATM call implied volatility (ATMCIV), respectively, to measure the currency smirk as the difference of OTMPIV and ATMCIV. The efficient OTM put price and ATM call price prevent currency smirks from containing inappropriate information due to mispriced (i.e., underpriced or overpriced) options prices. Second, a 1 per cent swing band (the ratio of the strike price to the stock price between 0.995 and 1.005) is designed to obtain the ATM call, which increases the accuracy of the ATM

Table 4. Currency smirks' predictive power analysis

Options	Opening hour			Midday hour			Closing hour		
	Intercept (*t*-stat)	Slope (*t*-stat)	Adj-R^2	Intercept (*t*-stat)	Slope (*t*-stat)	Adj-R^2	Intercept (*t*-stat)	Slope (*t*-stat)	Adj-R^2
AUD	0.0012*	–0.998*	0.027	0.0014*	–1.387*	0.071	0.0017*	–0.701*	0.0511
	(3.820)	(–5.439)		(5.434)	(–8.973)		(5.608)	(–7.521)	
CAD	0.0015*	–1.723*	0.099	0.0017*	–2.227*	0.145	0.0009*	–1.768*	0.087
	(7.003)	(–10.174)		(8.720)	(–13.112)		(5.564)	(–9.871)	
CHF	0.0015*	–1.361*	0.100	0.0018*	–1.559*	0.082	0.0013*	–1.541*	0.059
	(3.790)	(–7.23)		(6.192)	(–9.014)		(4.653)	(–7.608)	
EUR	0.0014*	–1.785*	0.114	0.0014*	–1.910*	0.121	0.0007*	–1.068*	0.037
	(6.999)	(–10.267)		(7.884)	(–13.603)		(3.530)	(–6.420)	
GBP	0.0007*	–1.123*	0.054	0.0013*	–1.759*	0.092	0.0011*	–1.081*	0.061
	(4.2465)	(–7.364)		(7.126)	(–9.603)		(6.029)	(–8.339)	
Whole sample	0.0014*	–1.491*	0.072	0.0015	–1.605	0.093	0.0008*	–0.757*	0.039
	(12.140)	(–17.680)		(14.75)	(–21.27)		(8.680)	(–13.23)	

Note: * denotes at least 5% level of statistical significance; Adj-R^2 = adjusted R-squared. For whole sample, the Prais-Winsten panel regression analysis is conducted.

implied volatility. In previous studies, the wider swing band (e.g., Xian et al. [2010] use 10 per cent swing band) biased the ATM call price implied volatility estimation by including undesirable near-the-money call observations, which distorts smirks' information. Third, the information does not remain the same throughout the trading day. Therefore, the analysis of the currency smirk is conducted at the intra-day level for a greater picture of its predictive power for FX returns. The distinct findings for the opening, midday, and closing hours substantiate the validity of the authors' intra-day approach. Further, for the sample periods used, previous researchers have occasionally studied the opening period, hardly studied the midday period, and have widely considered the closing period. This study shows that the middle of the trading day's information that has been ignored by previous studies has a major impact on the findings of currency smirks' analysis.

CONCLUSION

Although the analysis that equity smirks' information contains the capability to forecast future stock returns is not new in the literature, this study is the first to examine the currency smirks' predictive power for the FX return. This study is justified based on the consideration that the stock market and the FX market are analogous in the context of financial assets for investment purposes, and exchange-traded stock and currency options have the same maturity (i.e., monthly maturity). The currency smirks' information content and predictive power analysis are summarized as follows. Under the in-sample test, the significant slope coefficient for the individual and the whole sample in Table 3 indicates that there is a relationship between currency smirk and FX return, which supports the justification of this study. It also confirms that the currency smirk contains relevant information to explain FX movements at different trading hours. The negative slope coefficient reveals that the expected decrease in future foreign currency value against the US dollar increases the demand for OTM put. This is consistent with the findings of Xing et al. (2010) for the equity options market. The in-sample test results also consist of a comparison of opening, midday and closing period currency smirks' ability to define FX returns. The midday currency smirk is superior to the opening and closing period currency smirk to hold information in describing the FX return.

Finally, the out-of-sample test results suggest that the currency smirk has a strong predictive power in forecasting FX returns. However, this forecast horizon is limited to the next trading day. Further, the currency smirk of midday is not only better to contain information; it also outperforms the cur-

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rency smirk of the opening and closing period to predict FX return. The temporary predictability of currency smirk is reasonable because the FX market is very efficient in incorporating new information from the options market. Furthermore, the *currency smirk holds the information that is appropriate to forecast short-term FX price fluctuations. Therefore, the use of currency smirk to predict FX returns is a unique approach for* FX traders, especially short-term, day-, and overnight traders who rely on the volatility to profit from the fast price swings in the 24-hour global FX market. During the global financial crisis (GFC), the movement of the FX market was unusual due to increased uncertainty about the market value of global financial assets and the impact of financial stress on economic performance (Melvin & Taylor, 2009). Therefore, the currency smirk can be examined for the GFC period as a future research.

AUTHOR CONTRIBUTIONS

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