

Article

Foreign Exchange Futures Trading and Spot Market Volatility in Thailand

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Abstract: This paper investigates how the introduction of foreign exchange futures has an impact on spot volatility and considers the contemporaneous and dynamic relationship between spot volatility and foreign exchange futures trading activity, including trading volume and open interest in the Thailand Futures Exchange context, with the examples of the EUR/USD futures and USD/JPY futures. The results of the EGARCH (1,1) model show that the introduction of foreign exchange futures decreases spot volatility. It also increases the rate at which new information is impounded into spot prices but decreases the persistency of volatility shocks. A positive effect of unexpected trading volume and a negative effect of unexpected open interest on contemporaneous spot volatility are in line with the VAR(1) model results of the dynamic relationship between spot volatility and foreign exchange futures trading activity. With the impact on spot volatility caused by unexpected open interest rate being stronger than by unexpected trading volume, foreign exchange futures trading stabilizes spot volatility.

Keywords: foreign exchange futures; spot volatility; GARCH family models; VAR



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1. Introduction

Since the 1997 Asian financial crisis, Thailand, South Korea, Indonesia, and the Philippines have all adopted a floating exchange rate regime, thereby increasing the importance of foreign exchange exposure management in East and Southeast Asia. The financial crisis originated in Thailand and caused the Thai government to float Thai baht on 2 July 1997. Facing volatile foreign exchange movements, exporters/importers, multinational companies, and overseas investment funds, have used financial derivatives for hedging exchange rate exposure. The value of foreign exchange (FX) derivatives activity has grown substantially over the last two decades. As illustrated in Figure 1, the FX derivatives volume traded in exchanges worldwide jumped from 46,947,055 contracts in 2000 to 990,925,534 contracts in 2009. After the 2007–2009 global financial crisis, trading of FX derivatives witnessed the biggest growth in volume in 2010, a 154.93 percent surge in yearly volume. This increase was driven mostly by Asian derivatives markets, which rose 239.84 percent and accounted for 75.81 percent of FX derivatives contracts traded on exchanges worldwide. Since the COVID-19 pandemic impacted global markets and volatility, the number of exchange-traded FX derivatives contracts has grown continuously to surpass the 4 billion mark in 2020. It reached the highest level in 2022, amounting to 7.73 billion contracts with 70.71 percent of them being traded in Asia. While trading of global FX derivatives decreased in volumes by 9.25 percent in 2023, the FX derivatives traded at Thailand Futures Exchange (TFEX) increased 12.19 percent compared to 2022, due to currency fluctuations and the popularity of FX trading. TFEX also launched new FX futures with EUR/USD and USD/JPY underlying on 31 October 2022. Although the most common hedging tools for Thai importers and exporters is a forward contract, Thai importers and exporters wishing to hedge their trade exposure may have limited access to forward contracts due to credit constraint or high transaction costs. They can use FX futures to better manage currency fluctuations.

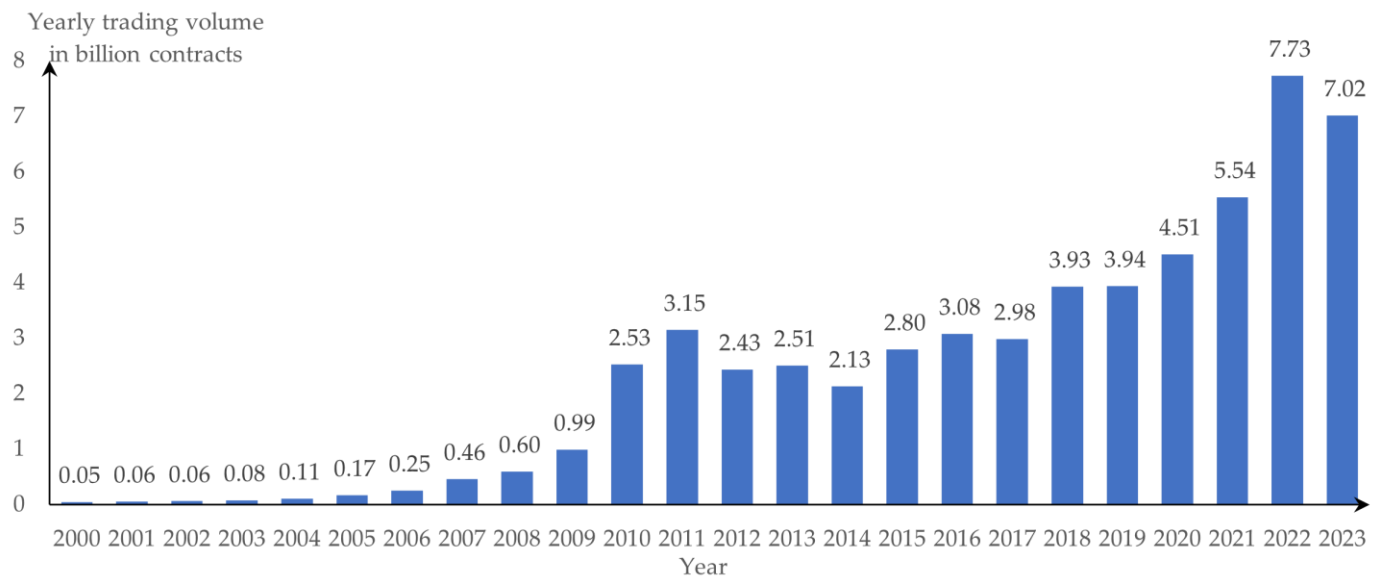


Figure 1. Volume of FX derivatives traded in exchanges worldwide from 2000 to 2023. Source: [Futures Industry Association \(2024\)](#).

Although the introduction of new FX futures provides traders with more options to match their investment goals and risk tolerance, it may cause an increase in the volatility of underlying exchange rates. The impact of FX futures trading on spot volatility has been widely investigated for major markets, but the empirical evidence is mixed. Some research, as detailed in the next section, shows that FX derivatives trading stabilizes the FX market by reducing its volatility. The FX derivatives market attracts additional traders to the underlying spot market, contributes to efficient price discovery, and leads to an increase in market depth. Other research, on the other hand, reveals that FX derivatives trading leads to an increase in spot volatility. This destabilizing impact on spot volatility is based on high leverage and speculative activities in the derivatives market. This study therefore aims to investigate the impact of FX derivatives trading on the volatility of the FX market in Thailand and to consider the contemporaneous and dynamic relationship between the volatility of the FX market and FX futures trading activity, with the examples of the EUR/USD futures and USD/JPY futures.

Using Generalized Autoregressive Conditional Heteroskedasticity (GARCH) family models augmented with dummy variable to investigate how the introduction of the EUR/USD futures and USD/JPY futures affects spot volatility, the empirical results show that the EGARCH (1,1) model is the best fitting model and highlight the evidence of the stabilizing effect of the introduction of FX futures on spot volatility. The launch of FX futures also increases the rate at which new information is incorporated into underlying spot prices and decreases the persistency of volatility shocks. In addition, the results show the destabilizing effect of unexpected trading volume and the stabilizing effect of unexpected open interest on contemporaneous spot volatility. These results are in line with the VAR(1) model results of the dynamic relationship between spot volatility and FX futures trading activity.

This study complements the literature about the stabilizing impact of FX derivatives trading on the volatility of the FX market in Thailand. It provides more insightful empirical evidence of how the introduction of FX futures changes the volatility structure of the underlying spot market and the relationship between spot volatility and the level of futures trading, including trading volume and open interest. Thus, the findings offer new insights for policy makers in relation to the economic usefulness of the derivatives market in emerging markets.

The remainder of this study is organized as follows. Section 2 provides a brief literature review on the impact of derivatives trading on spot volatility. Section 3 presents the data

and methodology used for the analysis. Section 4 discusses an empirical analysis of the impact of FX futures trading on the volatility of underlying exchange rates in Thailand, whilst the final section presents the conclusion.

2. Literature Review

Empirical studies on the impact of FX derivatives trading on spot volatility come with different methodologies. Much of the empirical research literature employs Generalized Autoregressive Conditional Heteroskedasticity (GARCH)-type models for modelling volatility of spot returns. For example, [Gokcan \(2000\)](#) and [Szczygielski and Chipeta \(2023\)](#) model the volatility of emerging stock market returns by employing GARCH family models. To analyze the impact of FX derivatives trading on spot volatility, the previous literature includes a dummy variable for the introduction of FX derivatives in the conditional variance equation. Some studies find the significance of the negative dummy coefficient, indicating the stabilizing effect of FX derivatives for these currency pairs CAD/USD, DEM/USD, JPY/USD, CHF/USD ([Shastri et al. 1996](#)), MXN/USD ([Jochum and Kodres 1998](#)), JPY/INR, and GBP/INR ([Sakthivel et al. 2017](#)). In addition, [Oduncu \(2011\)](#) shows a statistically significant negative relationship between the introduction of futures trading and the volatility of the Turkish currency market. The results also suggest that recent news plays a greater role, while old news plays a smaller role in determining the underlying spot market volatility as a consequence of the introduction of futures trading. Another group of research; however, finds that the introduction of FX derivatives destabilizes the FX market for EUR/INR ([Gupta 2017](#); [Sakthivel et al. 2017](#)). The results by [Shastri et al. \(1996\)](#) and [Sahu \(2012\)](#) indicate a positive but insignificant impact of FX derivatives trading on volatility in spot exchange rates for GBP/USD and EUR/INR, respectively.

Some researchers divide full samples into two sub-periods, pre and post FX derivatives introduction periods, and use the GARCH volatility model to compare the underlying spot market volatility before and after the introduction of FX derivatives. For example, [Jin et al. \(2021\)](#) capture the effects of FX derivatives on the volatility of USD/INR, USD/RUB, and USD/ZAR by choosing a cutoff date to represent the beginning of a stable rise in FX futures trading and using the GARCH model for both pre and post cutoff periods. They have not found any strong evidence supporting the destabilizing effect of the FX derivatives market. However, in contrast with the study by [Jin et al. \(2021\)](#), [Rani et al. \(2022\)](#) and [Singh and Patra \(2022\)](#) show that the unconditional variance of the USD/INR exchange rate decreases in the post period. [Rani et al. \(2022\)](#) and [Singh and Patra \(2022\)](#) also investigated GBP, EUR, and JPY futures traded on the National Stock Exchange. They came to the same conclusion that the unconditional variance in the GBP/INR exchange rate decreases in the post period. For EUR and JPY, [Singh and Patra \(2022\)](#) found decreasing volatility in exchange rate returns in the post period, but [Rani et al. \(2022\)](#) witnessed opposite results.

The other way to investigate the impact of FX derivatives trading on spot volatility is by finding the relationship between spot volatility and FX derivatives trading variables, such as trading volume or open interest. Some researchers, such as [Chatrath et al. \(1996\)](#), found a positive relationship between spot volatility and FX futures trading volume. [Bhargava and Malhotra \(2007\)](#) used trading volume and open interest to separate hedgers from speculators and day traders. They suggest trading volume as a measure of speculating activities and open interest as a measure of hedging positions. Their main finding is that speculators and day traders destabilize the market for currency futures. [Guru \(2010\)](#), in contrast, found no causality either between trading volume and exchange rate volatility, or between open interest and exchange rate volatility in the case of USD/INR futures trading. In addition, [Jochum and Kodres \(1998\)](#) employed the Markov Switching Autoregressive Conditional Heteroscedasticity (SWARCH) model, augmented with futures trading volume as an additional explanatory variable in the conditional variance equation. Their findings show no statistically significant influence from futures trading volume on the underlying spot market volatility in the cases of HUF and BRL.

Another group of researchers used a ratio of futures trading volume to open interest as a proxy for futures trading activity. R  thig (2004) investigated the relationship between spot volatility and FX futures trading activity by employing a vector autoregressive (VAR) system. The GARCH (1,1) model was chosen for the estimation of spot volatility of the five currencies, including AUD, CHF, CAD, JPY, and KRW. The results show that futures trading activity granger causes spot volatility for all currencies except KRW. In addition, spot volatility reacts to a shock in futures trading activity for all currencies except KRW. Moreover, Sharma (2011) conducts a granger causality test to examine the relationship between spot volatility and USD/INR futures trading activity. The results indicate a bidirectional causal relationship between spot volatility and FX futures trading activity. Comparing spot volatility before and after the introduction of FX futures, spot volatility increases after the FX futures introduction. Sivarajadhanavel et al. (2016) also calculated futures trading activity by dividing trading volume by open interest and including it in the conditional variance equation. The results of the augmented GARCH (1,1) model show that FX futures trading activity increases USD/INR exchange rate volatility.

Numerous empirical studies have applied the approach of Bessembinder and Sequin (1992) by decomposing either trading volume or open interest into expected and unexpected components. The expected and unexpected components are commonly obtained by using an Autoregressive Integrated Moving Average (ARIMA) model and included in the conditional variance equation of GARCH family models. Their findings suggest that trading different types of derivatives influences spot volatility differently. Most of them reveal a significant positive coefficient with respect to unexpected trading volume (e.g., (Bessembinder and Sequin 1992) for the S&P 500 index; (Fleming and Ostdiek 1999) for crude oil; (Kumar 2009) for soybean, maize, castor seed, guar seed, gold, silver, aluminium, copper, zine, crude oil, and natural gas; (Malhotra and Sharma 2016) for soya bean oil and crude palm oil; (Yilgor and Mebounou 2016) for the BIST-30 index; (Zhang et al. 2021) for bitcoin). This implies that an increase in unexpected trading volume as more information shocks leads to an increase in spot volatility. Expected trading volume is negatively related to spot volatility in the cases of S&P 500 index (Bessembinder and Sequin 1992), European real estate securities (Lee et al. 2014), mustard seed (Malhotra and Sharma 2016), and bitcoin (Zhang et al. 2021; Conlon et al. 2024); however, it is positively related to the volatility in other markets (e.g., (Kumar 2009) for silver, aluminium, copper, zine, and crude oil; (Malhotra and Sharma 2016) for mentha oil and soya oil). Regarding expected open interest, it has a negative impact on spot volatility in the cases of crude oil (Fleming and Ostdiek 1999), European real estate securities (Lee et al. 2014), soya oil, and mustard seed (Malhotra and Sharma 2016). These findings suggest that the derivatives market improves market depth and reduces the volatility of the underlying spot market. Several studies such as Bessembinder and Sequin (1992) and Shenbagaraman (2003) show the insignificant coefficient of unexpected open interest in explaining spot volatility, contradicting the findings of Malhotra and Sharma (2016) that higher unexpected open interest in mentha oil futures leads to an increase in spot volatility, and those of Fleming and Ostdiek (1999) that higher unexpected open interest in crude oil futures leads to a decrease in spot volatility. Another study by Kumar (2009) uses a VAR model to explain the dynamic relationship between spot volatility and the unexpected component of futures trading activity in the context of the Indian commodity derivatives market. The results show the significant causality running from unexpected trading volume to the spot volatility of all commodities. Except for natural gas, unexpected trading volume causes an increase in the underlying spot market volatility. The effect of unexpected open interest is positive for soybean, crude oil, and copper, but negative for maize, gold, silver, and aluminium.

The impact of the introduction of FX derivatives trading has been different in different markets and in most of the cases, the analysis has been conducted in the context of leading organized exchanges. The literature in the context of organized exchanges in emerging markets like Thailand is scarce. Due to the developing country's vulnerability to speculative attacks and adverse financial market development, the investigation about the potential

role of FX futures trading in developing countries' exchange rate stability is significant. Therefore, this study empirically investigates the impact of FX futures trading on spot volatility in Thailand.

3. Data and Methodology

3.1. Data

To examine the impact of the introduction of FX futures on spot volatility, daily data used in this paper consists of the exchange rates of EUR/USD and USD/JPY for the period from 27 September 2021 to 12 January 2024, covering the period before and after the introduction of EUR/USD and USD/JPY futures on 31 October 2022. For trading FX futures, Thailand Futures Exchange (TFEX) announced the launch of a night trading session during 6:50 p.m.–11:55 p.m. on 27 September 2021 and extended night session trading hours until 3:00 a.m. on 15 January 2024. Since the previous literature such as [Jongadsayakul \(2024\)](#) shows the impact of night trading sessions on volatility, this specific time period is chosen to avoid any possible impact on volatility. In addition, to analyze the relationship between spot volatility and FX futures trading activity, the daily trading volume and open interest data of EUR/USD futures and USD/JPY futures covering the period from 31 October 2022 to 12 January 2024 are used.

Consistent with previous studies, this study calculates the daily exchange rate returns for the currency pairs EUR/USD and USD/JPY by finding the first difference in the natural logarithms of the daily exchange rates, as shown in Equation (1).

$$R_t = \ln S_t - \ln S_{t-1}, \quad (1)$$

where S represents the daily exchange rate and R is the daily exchange rate return.

The daily exchange rate return series consists of 558 observations (over the whole observation period), of which 263 observations belong to the pre introduction period (27 September 2021–28 October 2022), and the remaining 295 observations belong to the post introduction period (31 October 2022–12 January 2024). In the case of the post introduction period, daily trading volume and open interest data of EUR/USD futures and USD/JPY futures were obtained from SETSMART.

This study begins with stationarity testing of all the return series (pre and post introduction periods and whole sample) as well as trading volume and open interest series via an Augmented Dickey–Fuller (ADF) test. The ADF test is performed to test the null hypothesis of a unit root ($H_0: b = 0$) against the alternative hypothesis of stationarity ($H_a: b < 0$). The Schwarz Information Criterion (SC) is used for the optimal lag selection. There are three cases, including a pure random walk, a random walk with intercept, and a random walk with intercept and linear time trend. The test equations of three cases are presented in Equations (2)–(4), respectively.

$$\Delta y_t = by_{t-1} + \sum_{j=2}^l \gamma_j \Delta y_{t-j+1} + u_t, \quad (2)$$

$$\Delta y_t = c + by_{t-1} + \sum_{j=2}^l \gamma_j \Delta y_{t-j+1} + u_t, \quad (3)$$

$$\Delta y_t = c + by_{t-1} + \sum_{j=2}^l \gamma_j \Delta y_{t-j+1} + dt + u_t, \quad (4)$$

The descriptive statistics of daily exchange rate returns, trading volume, and open interest are presented in Table 1. It also contains the results of the unit root test and selected ARIMA(p,d,q) models.

Table 1. Descriptive statistics and ARIMA models of daily returns, trading volume, and open interest.

Series	n	Mean	Maximum	Minimum	Standard Deviation	ADF in Level [in 1st Difference] ¹	ARIMA(p,d,q) Model ²
Panel A: EUR/USD							
Spot returns (whole sample)	558	−0.0114%	1.7211%	−1.8129%	0.5219%	−22.1842 ***	(0,0,0)
Spot returns (pre introduction)	263	−0.0605%	1.4397%	−1.8129%	0.5523%	−14.5942 ***	(0,0,0)
Spot returns (post introduction)	295	0.0323%	1.7211%	−1.4024%	0.4901%	−17.1121 ***	(0,0,0)
Futures volume	295	889.60	2897	54	580.11	−13.1272 ***	(1,0,1)
Open interest	295	1974.97	6197	75	1326.87	−2.4335 [21.5551 ***]	(0,1,1)
Panel B: USD/JPY							
Spot returns (whole sample)	558	0.0500%	2.5703%	−3.3618%	0.6406%	−18.7302 ***	(2,0,0)
Spot returns (pre introduction)	263	0.1095%	2.1451%	−3.3618%	0.5835%	−14.9389 ***	(0,0,0)
Spot returns (post introduction)	295	−0.0030%	2.5703%	−3.0036%	0.6842%	−14.3823 ***	(2,0,0)
Futures volume	295	3272.36	13,476	177	2133.69	−9.7128 ***	(2,0,1)
Open interest	295	7283.98	17,244	230	4676.60	−3.7239 **	(1,0,0)

Notes: Table 1 presents descriptive data statistics for EUR/USD (Panel A) and USD/JPY (Panel B). The whole samples for the EUR/USD and USD/JPY exchange rate returns range from 27 September 2021 to 12 January 2024, involving 558 observations. The whole samples are further classified into two sub-periods, pre introduction period (27 September 2021–28 October 2022) and post introduction period (31 October 2022–12 January 2024). The ADF test for stationarity is performed for spot returns, futures volume, and open interest. ** indicates significance at the 0.05 level, and *** indicates significance at the 0.01 level. All variables, except open interest in EUR/USD futures market, are stationary in levels. ¹ With the presence of unit root test in level, test for unit root in 1st difference is conducted for open interest in EUR/USD futures market. ² The correct ARIMA(p,d,q) model for the series depends on SC.

The results show that over the entire period from 27 September 2021 to 12 January 2024, the average daily exchange rate returns for the currency pairs EUR/USD and USD/JPY are −0.0114% and 0.05%, respectively. Throughout the entire period, the maximum (minimum) returns for the EUR/USD and USD/JPY exchange rates are 1.7211% (−1.8129%) and 2.5703% (−3.3618%), respectively. The standard deviations are 0.5219% for the EUR/USD exchange rate return and 0.6406% for the USD/JPY exchange rate return. A higher standard deviation indicates higher volatility in the FX market for the USD/JPY exchange rate compared to the EUR/USD exchange rate. The whole time period is divided into 2 sub-periods, pre introduction period (27 September 2021–28 October 2022) and post introduction period (31 October 2022–12 January 2024). The most volatile exchange rate is still USD/JPY during the pre and post introduction periods. The average daily returns of the EUR/USD exchange rate are negative during the pre introduction period and positive during the post introduction period, while those of the USD/JPY exchange rate witness the opposite results. Although both EUR/USD futures and USD/JPY futures were introduced on the same date, the USD/JPY futures contract is more actively traded than the EUR/USD futures contract in terms of trading volume and open interest. The mean USD/JPY futures trading volume is 3272 contracts, with an average open interest of 7284 contracts, while the mean EUR/USD futures trading volume is only 890 contracts, with an average open interest of 1975 contracts. In addition, at the 1% significance level, the ADF test for unit root in level rejects the presence of unit root in all the data series, except open interest. The EUR/USD futures open interest is non-stationary in level, but it is stationary after the 1st difference at

the 1% significance level. The USD/JPY futures open interest is stationary in level with a significance level of 5%. The ARIMA(p,d,q) models of all data series are discussed in Section 3.2.1.

3.2. Methodology

This study uses the following types of models for the analysis: (1) Autoregressive Integrated Moving Average (ARIMA) models, (2) Generalized Autoregressive Conditional Heteroskedasticity (GARCH) family models, and (3) Vector Autoregression (VAR) model.

3.2.1. ARIMA Models

In this section, ARIMA(p,d,q) models originally developed by [Box and Jenkins \(1976\)](#) are explored, where p denotes the number of autoregressive terms, d the number of times the series has to be differenced before it becomes stationary, and q the number of moving average terms. Therefore, an ARIMA(p,1,q) time series has to be differenced once (d = 1) before it becomes stationary, and the (first-differenced) stationary time series can be modelled as an ARMA(p,q) process. If d = 0, an ARIMA(p,0,q) process means ARMA(p,q), an ARIMA(p,0,0) process means a purely AR(p) stationary process, and an ARIMA(0,0,q) means a purely MA(q) stationary process. The equations for the ARMA(p,q) model, the AR(p) model, and the MA(q) model are stated in Equations (5)–(7), respectively.

$$\text{ARMA}(p, q) : y_t = C + \sum_{i=1}^p \lambda_i y_{t-i} + \sum_{i=1}^q \mu_i \varepsilon_{t-i}; \mu_0 = 1, |\lambda_i| < 1 \text{ (i = 1, \dots, p)} \text{ and } |\mu_i| < 1 \text{ (i = 1, \dots, q)}, \quad (5)$$

$$\text{AR}(p) : y_t = C + \sum_{i=1}^p \lambda_i y_{t-i} + \varepsilon_t; |\lambda_i| < 1 \text{ (i = 1, \dots, p)}, \quad (6)$$

$$\text{MA}(q) : y_t = C + \varepsilon_t + \sum_{i=1}^q \mu_i \varepsilon_{t-i}; |\mu_i| < 1 \text{ (i = 1, \dots, q)}, \quad (7)$$

The GARCH family models, as detailed in Section 3.2.2, are proposed to model the volatility of the underlying exchange rate. It is interesting to combine linear time series ARIMA with GARCH conditional variance. The ARIMA/GARCH model employs the ARIMA(p,d,q) model for the conditional mean and the GARCH family models for conditional variance. ARIMA captures the changes in the mean return, while GARCH presents the variance change in the residuals issued from the mean equation. As shown in Table 1, all exchange rate returns are stationary in levels. The condition mean equations are just constant mean equations for all EUR/USD returns series and for a series of USD/JPY returns during the pre introduction period. For the post introduction period and whole sample, the ARIMA(2,0,0) model was chosen for the USD/JPY returns series.

In addition, this research uses the ARIMA(p,d,q) models to decompose FX futures trading activity, including trading volume and open interest, into expected and unexpected components. The expected component is given by the model forecast, and the unexpected component is the difference between the actual and the fitted values. Table 1 shows the appropriate ARIMA models for trading volume and open interest in the FX futures market. For the EUR/USD futures, this study employs the ARIMA(1,0,1) model for trading volume and the ARIMA(0,1,1) model for open interest, while for the USD/JPY futures, this study chooses the ARIMA(2,0,1) model for trading volume and the ARIMA(1,0,0) model for open interest. The expected and unexpected components of FX futures trading activity are applied to the conditional variance of the selected GARCH model. It is interesting to include expected and unexpected components of FX futures trading activity as exogenous variables in volatility models and to examine the corresponding information. Only unexpected trading volume and unexpected open interest are included in the VAR model, as detailed in Section 3.2.3, to analyze the dynamic relationship between spot volatility and FX futures trading activity.

3.2.2. GARCH Family Models

This study adopts GARCH family models to examine spot volatility. Figures 2 and 3 are spot returns for the EUR/USD and USD/JPY exchange rates, respectively, which exhibit a volatility clustering property. The GARCH model proposed by Bollerslev (1986) was designed to capture the volatility clustering property in financial data (Jongadsayakul 2020, 2023). The GARCH (1,1) model is usually employed for modelling the volatility of a wide range of assets, as empirically demonstrated in previous studies (e.g., (Miaha and Rahmanb 2016) for stock; (Gokcan 2000) for stock; (Zhang et al. 2021) for bitcoin; (Jongadsayakul 2024) and for USD futures). However, the GARCH (1,1) model is a symmetric model with a non-negativity constraint on the parameters of the conditional variance. Since negative shocks are assumed to have a bigger impact on volatility than positive shocks in many financial markets, this study employs the asymmetric GARCH models, including the TARCH (1,1) model proposed by Zakoian (1990) and Glosten et al. (1993) and the EGARCH (1,1) model proposed by Nelson (1991). The EGARCH (1,1) model also ensures positive conditional variance without any restrictions on the parameters.

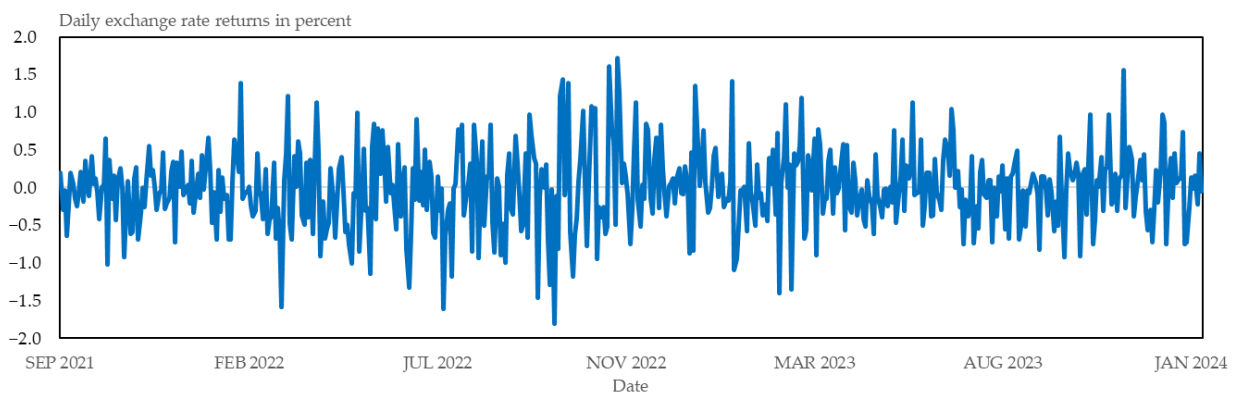


Figure 2. Daily spot returns of EUR/USD from 27 September 2021 to 12 January 2024.

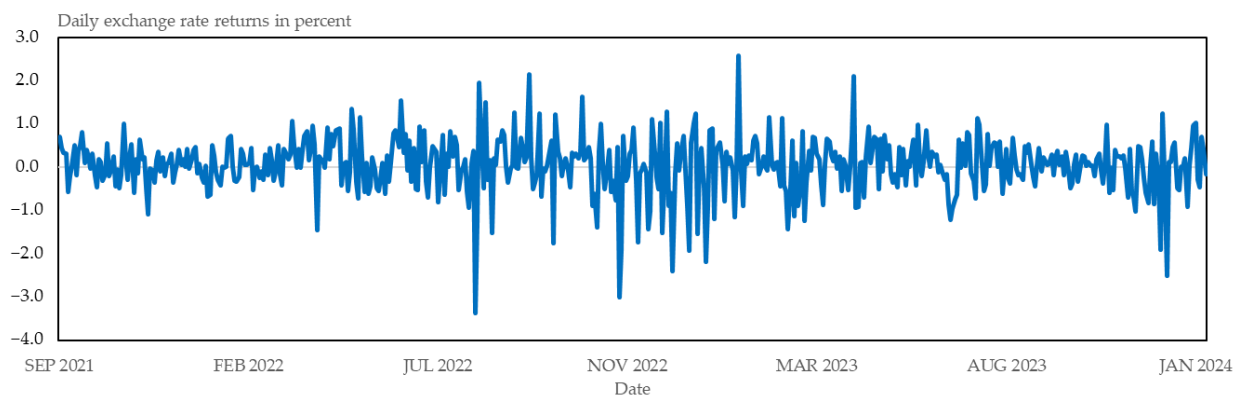


Figure 3. Daily spot returns of USD/JPY from 27 September 2021 to 12 January 2024.

To investigate the impact of the introduction of FX futures on spot volatility, this study adds a dummy variable (NEW), taking value 0 for the pre introduction period and 1 for the post introduction period, in the conditional variance equation. Thus, the conditional variance equations of the GARCH (1,1), TARCH (1,1), and EGARCH (1,1) models are shown in Equations (8)–(10), respectively.

$$\text{GARCH (1,1)} : h_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}^2 + a \text{NEW}_t; \alpha_i > 0, i = 0, 1 \text{ and } \beta_1 > 0, \quad (8)$$

$$\text{TARCH (1,1)} : h_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \gamma \varepsilon_{t-1}^2 d_{t-1} + \beta_1 h_{t-1}^2 + a \text{NEW}_t, \quad (9)$$

$$\text{EGARCH (1,1)} : \ln(h_t^2) = \alpha_0 + \alpha_1 \left| \frac{\varepsilon_{t-1}}{h_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{h_{t-1}} + \beta_1 \ln(h_{t-1}^2) + a \text{NEW}, \quad (10)$$

where h^2 is the conditional variance, ε^2 is square of residual, d_{t-1} takes a value of 0 if $\varepsilon_{t-1} \geq 0$ and a value of 1 if $\varepsilon_{t-1} < 0$, and $\frac{\varepsilon}{h}$ is standardized residual. For the existence of leverage effect, the sign of γ must be positive for Equation (9), such that the ARCH effect of $\alpha_1 + \gamma$ for bad news is larger than one of α_1 for good news. The negative sign of γ in Equation (10) indicates that the reaction to negative shocks ($\alpha_1 - \gamma$) is larger than the reaction to positive shocks ($\alpha_1 + \gamma$). To select the best volatility model of exchange rate returns for the whole sample, it is based on the lowest values of Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan Quinn (HQ).

In addition, the selected model without the dummy variable (NEW) in the conditional variance equation was estimated for the pre and post introduction periods. Comparing the ARCH and GARCH coefficients of the volatility model for the pre and post introduction periods provides more details about how FX futures trading has an impact on spot volatility and to what extent.

For the contemporaneous relationship between spot volatility and FX futures trading activity (trading volume and open interest), the expected and unexpected components of trading volume and those of open interest are included as explanatory variables in the conditional variance equation of the selected GARCH model for the post introduction period.

3.2.3. VAR Model

Using the VAR model as suggested by Kumar (2009), this research examines the dynamic interactions among spot volatility, the unexpected component of trading volume, and the unexpected component of open interest in the FX futures market for daily data between 31 October 2022 and 12 January 2024 (post introduction period). As discussed by Malhotra and Sharma (2016), information contained in the expected component of futures trading activity is already reflected in the spot prices. Therefore, only unexpected trading volume and unexpected open interest are used for the dynamic relationship analysis. The optimal lag order in the VAR model is then picked by considering the lowest values of AIC, SC, and HQ. The VAR(p) model can be written as follows:

$$h_t^2 = a_1 + \sum_{j=1}^p b_{1j} h_{t-j}^2 + \sum_{j=1}^p b_{2j} UV_{t-j} + \sum_{j=1}^p b_{3j} UO_{t-j} + e_{1t}, \quad (11)$$

$$UV_t = a_2 + \sum_{j=1}^p c_{1j} h_{t-j}^2 + \sum_{j=1}^p c_{2j} UV_{t-j} + \sum_{j=1}^p c_{3j} UO_{t-j} + e_{2t}, \quad (12)$$

$$UO_t = a_3 + \sum_{j=1}^p d_{1j} h_{t-j}^2 + \sum_{j=1}^p d_{2j} UV_{t-j} + \sum_{j=1}^p d_{3j} UO_{t-j} + e_{3t}, \quad (13)$$

where h^2 is the estimated conditional variance obtained from the selected GARCH model, UV is the unexpected component of FX futures trading volume obtained from the selected ARIMA model, and UO is the unexpected component of open interest obtained from the selected ARIMA model.

The Granger causality test, variance decomposition, and impulse response function are conducted while analyzing this dynamic relationship.

4. Results and Discussion

This section presents the results of the empirical analysis and provides some discussion.

4.1. Effect of FX Futures Introduction on Spot Volatility

Table 2 shows the estimation results of the GARCH family models, the GARCH (1,1), TAR(1,1), and EGARCH (1,1) models, augmented with the dummy variable (NEW) for the period from 27 September 2021 to 12 January 2024 (whole sample) for the currency pairs EUR/USD and USD/JPY. As mentioned earlier, this study adds the dummy variable (NEW) in the conditional variance equation to analyze the effect of the

introduction of new FX futures on spot volatility. All estimated models are first checked for appropriateness. The p -values from the Ljung–Box Q tests on the standardized residuals and squared residuals as well as the Lagrange Multiplier (LM) test for the remaining ARCH effects in the standardized residuals are greater than the 5% significance level. The insignificant Q statistics provide evidence for failing to reject the null hypothesis of no autocorrelation in the estimated GARCH family models' residuals. The insignificant LM test statistics show no sign of additional ARCH effects left in the standardized residuals. Thus, the use of GARCH (1,1), TARCH (1,1), and EGARCH (1,1) models for modelling the volatility of exchange rates for EUR/USD and USD/JPY is appropriate. In addition, as indicated in Table 1, the analysis applies the constant mean equation for EUR/USD returns and the AR(2) specification for the mean equation of USD/JPY returns. The AR terms are all significant at the 1% significance level for the GARCH (1,1) and EGARCH (1,1) models, and at the 5% significance level for the TARCH (1,1) model.

Table 2. Estimation results of the GARCH family models for whole sample.

Exchange Rate	EUR/USD			USD/JPY		
Model	GARCH (1,1)	TARCH (1,1)	EGARCH (1,1)	GARCH (1,1)	TARCH (1,1)	EGARCH (1,1)
Panel A: Mean equation						
Constant (C)	−0.0002 (0.4104)	−0.0002 (0.4050)	−0.0002 (0.3258)	0.0006 (0.0139) **	0.0006 (0.0255) **	0.0004 (0.0967) *
AR(1) (λ_1)				0.1181 (0.0064) ***	0.1114 (0.0114) **	0.1204 (0.0048) ***
AR(2) (λ_2)				−0.1290 (0.0064) ***	−0.1183 (0.0121) **	−0.1188 (0.0091) ***
Panel B: Variance equation						
Constant (α_0)	2.36×10^{-7} (0.0099) ***	2.33×10^{-7} (0.0001) ***	−0.0527 (0.0010) ***	3.55×10^{-7} (0.0458) **	5.92×10^{-7} (0.0064) ***	−0.1239 (0.0047) ***
ARCH (α_1)	−0.0105 (0.1203)	−0.0096 (0.0670) *	0.0024 (0.8484)	0.0491 (0.0000) ***	0.0276 (0.1658)	0.0987 (0.0000) ***
Asym. (γ)		0.0020 (0.8589)	−0.0110 (0.5454)		0.0385 (0.0823) *	−0.0358 (0.0414) **
GARCH (β_1)	1.0066 (0.0000) ***	1.0048 (0.0000) ***	0.9947 (0.0000) ***	0.9482 (0.0000) ***	0.9446 (0.0000) ***	0.9940 (0.0000) ***
NEW (a)	-2.09×10^{-7} (0.0000) ***	-2.08×10^{-7} (0.0000) ***	−0.0081 (0.0617) *	-1.67×10^{-7} (0.2162)	-3.51×10^{-7} (0.0316) **	−0.0161 (0.0011) ***
Panel C: Residual diagnostics						
Q(36)	42.568 (0.209)	42.116 (0.223)	39.484 (0.317)	33.313 (0.501)	34.682 (0.435)	33.439 (0.495)
Q ² (36)	27.261 (0.852)	27.020 (0.860)	30.586 (0.724)	26.738 (0.869)	27.219 (0.854)	32.592 (0.631)
ARCH-LM (1)	2.1333 (0.1441)	1.8827 (0.1700)	0.6311 (0.4269)	0.2027 (0.6526)	0.1651 (0.6845)	0.7424 (0.3889)
Panel D: Model selection						
AIC	−7.7504	−7.7454	−7.7415	−7.3962	−7.3961	−7.4042
SC	−7.7117	−7.6989	−7.6950	−7.3418	−7.3340	−7.3420
HQ	−7.7353	−7.7272	−7.7234	−7.3749	−7.3718	−7.3799

Notes: Table 2 shows the estimation results of the GARCH family models augmented with the dummy variable (NEW) for the introduction of FX futures. p -values are in parentheses with the use of *, **, and *** to indicate significance levels at 0.10, 0.05, and 0.01, respectively. The dummy variable coefficient (a) is negative, indicating the stabilizing effect of the introduction of FX futures on spot volatility.

For the case of EUR/USD, although the GARCH (1,1) and TARCH (1,1) models have lower values of AIC, SC, and HQ than the EGARCH (1,1) model, their ARCH coefficients (α_1) are negative (though insignificant in the GARCH (1,1) model), violating the condition of non-negativity on the parameters of the conditional variance equation. Therefore, the EGARCH (1,1) without any restrictions on the parameters was chosen for modelling the volatility of EUR/USD returns. The estimation result of the EGARCH (1,1) model reveals the insignificant coefficient of ARCH term (α_1), meaning that recent news does not have an impact on changes in the EUR/USD exchange rate. However, the significant coefficient of GARCH term (β_1) confirms the effect of old news on the volatility of EUR/USD returns. In addition, the leverage effect does not exist in the FX market for EUR/USD due to the insignificance of the asymmetric coefficient (γ). The results further show that the introduction of EUR/USD futures reduces spot volatility since the coefficient of the dummy variable (NEW) is negative and statistically significant at the 10% level.

For the case of USD/JPY, the GARCH (1,1) and TARCH (1,1) models satisfy the condition of non-negativity on the parameters of the conditional variance equation. Both TARCH (1,1) and EGARCH (1,1) models show the existence of leverage effect in the FX market for USD/JPY due to the positive sign of γ in the TARCH (1,1) model and the negative sign of γ in the EGARCH (1,1) model. However, the EGARCH (1,1) model is best suited based on its lowest values of AIC, SC, and HQ. The estimation result of the EGARCH (1,1) model reveals the significant coefficients of the ARCH term (α_1) and the GARCH term (β_1), meaning that recent news and past news have an impact on spot volatility. In addition, the introduction of USD/JPY futures reduces spot volatility since the coefficient of the dummy variable (NEW) is negative and statistically significant at the 1% level.

Therefore, the estimated coefficient on the dummy variable (NEW) is negative and significant in the EGARCH (1,1) model of exchange rate returns for EUR/USD and USD/JPY, implying that the introduction of new FX futures by TFEX results in a decrease in spot volatility. This result is consistent with the existing literature (see for example, [Shastri et al. 1996](#); [Jochum and Kodres 1998](#); [Oduncu 2011](#); [Sakthivel et al. 2017](#)), which provides evidence of the stabilizing effect of the introduction of FX derivatives on spot volatility.

4.2. Pre and Post Introduction Comparison of Spot Volatility and Contemporaneous Relationship between Spot Volatility and FX Futures Trading

The whole sample was divided into two sub-periods, the pre introduction period (27 September 2021–28 October 2022), and the post introduction period (31 October 2022–12 January 2024). The EGARCH (1,1) model without the dummy variable (NEW) was chosen for modelling the volatility of EUR/USD and USD/JPY returns. To understand how and to what extent the introduction of FX futures affects spot volatility, the ARCH and GARCH coefficients for the pre introduction period were compared with those for the post introduction period. In addition, to investigate the contemporaneous relationship between spot volatility and FX futures trading activity (trading volume and open interest), the EGARCH (1,1) model was extended by adding FX futures trading activity in the condition variance equation for the post introduction period. Trading activity in the FX futures market, including trading volume and open interest, can be decomposed of expected and unexpected components using the ARIMA(p,d,q) model. Table 3 represents the outcomes of the EGARCH (1,1) model for pre and post introduction periods as well as the outcomes of the extended EGARCH (1,1) model with FX futures trading activity for post introduction period.

As shown in Table 3, the EGARCH (1,1) model and its extension are appropriate for modelling the volatility of the EUR/USD and USD/JPY returns based on diagnostic tests for serial correlation and remaining ARCH effect. All p -values from the Ljung–Box Q tests on the standardized residuals and squared residuals and the ARCH-LM test are greater than the 5% significance level, indicating no evidence of serial correlation and remaining ARCH effect. With the selected ARIMA(p,d,q) models shown in Table 1, the EGARCH (1,1) model of EUR/USD returns is estimated with the constant mean equation for both the pre

and post introduction periods. For USD/JPY returns, the analysis applies the EGARCH (1,1) model with the constant mean equation for the pre introduction period and that with the AR(2) for the post introduction period.

Table 3. Estimation results of the EGARCH (1,1) and extended EGARCH (1,1) models.

Exchange Rate	EUR/USD			USD/JPY		
Period	Pre Intro.	Post Intro.	Post Intro.	Pre Intro.	Post Intro.	Post Intro.
Panel A: Mean equation						
Constant (C)	−0.0010 (0.0002) ***	0.0003 (0.3706)	0.0002 (0.4380)	0.0013 (0.0001) ***	0.0005 (0.1416)	0.0003 (0.3369)
AR(1) (λ_1)					0.0450 (0.3920)	0.0601 (0.2793)
AR(2) (λ_2)					−0.1622 (0.0051) ***	−0.1496 (0.0096) ***
Panel B: Variance equation						
Constant (α_0)	−0.0856 (0.0365) **	−9.9206 (0.0030) ***	−10.1623 (0.0000) ***	0.0085 (0.9208)	−1.1219 (0.0004) ***	−1.3627 (0.0013) ***
ARCH (α_1)	−0.0330 (0.4135)	0.2912 (0.0490) **	0.3467 (0.0247) **	−0.0109 (0.6891)	0.1883 (0.0210) **	−0.0824 (0.2746)
Asym. (γ)	−0.0375 (0.1423)	0.1629 (0.0815) *	0.1813 (0.0520) *	0.0570 (0.0092) ***	−0.2347 (0.0000) ***	−0.1854 (0.0042) ***
GARCH (β_1)	0.9885 (0.0000) ***	0.0921 (0.7664)	0.0819 (0.6503)	0.9993 (0.0000) ***	0.9049 (0.0000) ***	0.8468 (0.0000) ***
Expected vol.			−0.00001 (0.9853)			−0.000004 (0.8587)
Unexpected vol.			0.0008 (0.0001) ***			0.0002 (0.0000) ***
Expected OI			0.0006 (0.5241)			−0.00002 (0.0167) **
Unexpected OI			−0.0007 (0.0209) **			−0.0001 (0.0813) *
Panel C: Residual diagnostics						
Q(36)	25.673 (0.899)	44.747 (0.150)	39.639 (0.311)	42.384 (0.215)	28.985 (0.712)	32.009 (0.566)
Q ² (36)	31.286 (0.692)	27.917 (0.830)	34.992 (0.516)	35.418 (0.496)	26.783 (0.868)	24.268 (0.932)
ARCH-LM (1)	0.0632 (0.8015)	0.0790 (0.7786)	0.0001 (0.9910)	1.9487 (0.1627)	0.1552 (0.6936)	0.1847 (0.6674)

Notes: Table 3 shows the EGARCH (1,1) estimation results for pre and post introduction periods and the estimation results of the EGARCH (1,1) model augmented with futures trading activity for post introduction period. *p*-values are in parentheses with the use of *, **, and *** to indicate significance levels at 0.10, 0.05, and 0.01, respectively. The negative coefficient γ shows the existence of the leverage effect in the USD/JPY spot market after the introduction of USD/JPY futures. The coefficient of unexpected trading volume is positive and significant, indicating the destabilizing effect of unexpected trading volume on spot volatility. On the other hand, the coefficient of unexpected open interest is negative and significant, indicating the stabilizing effect of unexpected open interest on spot volatility.

For the case of EUR/USD, the results show an increase in the ARCH coefficient (α_1) for the post introduction period, suggesting a greater impact of recent news on changes in EUR/USD after the introduction of EUR/USD futures. On the other hand, there is a reduction in the GARCH coefficient (β_1), implying a decrease in the persistency of volatility shocks after the introduction of EUR/USD futures. In addition, the asymmetric coefficient (γ) becomes positive and is statistically significant at the 10% level after the introduction of EUR/USD futures, suggesting the presence of an asymmetric effect in the EUR/USD spot market after the introduction of EUR/USD futures. The EGARCH (1,1) model is also augmented with the expected and unexpected components of FX futures trading activity (trading volume and open interest). The extended EGARCH (1,1) model

confirms the presence of asymmetric effect in the EUR/USD spot market during the post introduction period due to the positive and significant coefficient γ at the 10% level. In addition, none of the coefficients on expected trading volume and expected open interest are statistically significant. Unlike the results from the expected component part, the coefficients of unexpected trading volume and unexpected open interest are significant. The positive coefficient of unexpected trading volume suggests an increase in spot volatility as a result of information shocks. Information shocks are expected to move prices and cause a sudden increase in volume in both underlying spot and futures markets. However, the negative coefficient of unexpected open interest suggests a decrease in the volatility of EUR/USD returns due to open interest shocks.

For the case of USD/JPY, recent news significantly influences changes in USD/JPY for the post introduction period, as the coefficient of ARCH term (α_1) is significant at the 5% level. An increase in the ARCH coefficient (α_1) for the post introduction period implies that recent news has a greater impact on changes in USD/JPY after the introduction of USD/JPY futures. In contrast, the GARCH coefficient (β_1) reflects the persistence of the effect of old news on volatility. The GARCH coefficient (β_1) is statistically significant at the 1% level for both the pre and post introduction periods. Its value falls after the introduction of USD/JPY futures, implying that old news has a lower impact on the current volatility of USD/JPY returns. In addition, the asymmetric coefficient (γ) is statistically significant at the 1% level for both the pre and post introduction periods. Its value becomes negative after the introduction of USD/JPY futures, suggesting the presence of a leverage effect in the USD/JPY spot market after the introduction of USD/JPY futures. Then, the expected and unexpected components of trading volume and those of open interest are included as additional explanatory variables in the EGARCH (1,1) model. The estimation result of the extended EGARCH (1,1) model confirms the existence of leverage effect in the USD/JPY spot market after the introduction of USD/JPY futures due to the negative and significant coefficient γ at the 1% level. In addition, only the coefficient of the expected trading volume is insignificant. The positive and significant coefficient of unexpected trading volume suggests that a sudden change in USD/JPY futures trading volume increases the volatility of USD/JPY returns. Furthermore, the negative and significant coefficients of the expected and unexpected components of open interest imply that lower volatility shocks are associated with a given volume in deeper markets, as suggested by [Smit and Louw \(1996\)](#). [Smit and Louw \(1996\)](#) discuss that the expected open interest component reflects open interest at the start of a trading day, while the unexpected open interest component reflects any change in open interest during a day. The negative coefficient of expected open interest suggests that the USD/JPY futures market improves market depth and stabilizes the USD/JPY spot market. The negative coefficient of unexpected open interest suggests the unanticipated daily change in open interest as a proxy for traders' willingness to risk capital mitigates volatility of the USD/JPY spot market.

The analyses for both EUR/USD and USD/JPY achieve the same results of a higher ARCH coefficient and a lower GARCH coefficient after the FX futures introduction. The introduction of FX futures increases the rate at which new information is incorporated into underlying spot prices and decreases the persistency of volatility shocks. This implies an improvement in efficiency in the underlying spot market as a result of the introduction of new FX futures by TFEX. This finding offers some empirical support for the presence of a stabilizing effect of futures trading on the underlying spot market. In addition, the results of the destabilizing effect of unexpected trading volume on volatility in spot exchange rates for EUR/USD and USD/JPY are in line with a large number of previous studies (e.g., [Bessembinder and Sequin 1992](#); [Fleming and Ostdiek 1999](#); [Kumar 2009](#); [Malhotra and Sharma 2016](#); [Yilgor and Mebounou 2016](#); [Zhang et al. 2021](#)). The insignificant coefficient of expected trading volume is evident in both EUR/USD and USD/JPY, indicating the minor role of this variable on spot volatility. Consistent with the research on the crude oil market by [Fleming and Ostdiek \(1999\)](#), there exists a negative contemporaneous relationship between spot volatility and unexpected open interest in the EUR/USD and USD/JPY futures

markets. While the expected open interest as a proxy for market depth has a stabilizing influence on the USD/JPY spot market, its insignificant coefficient in the EUR/USD case may be attributed to lower trading activity, as discussed by [Lee et al. \(2014\)](#) in the European real estate case.

4.3. Dynamic Relationship between Spot Volatility and FX Futures Trading Activity

This section investigates the dynamic relationship between spot volatility and trading activity in the EUR/USD and USD/JPY futures markets by adopting a Vector Autoregressive (VAR) model. The VAR(1) model is chosen for both cases (EUR/USD and USD/JPY) based on the optimal lag order that minimizes the AIC, SC, and HQ values. In the VAR(1) model, the estimated conditional variance (h^2) obtained from the EGARCH (1,1) model and the unexpected components of trading volume (UV) and open interest (UO) obtained from the ARIMA models are stationary at the 1% level of significance. The stability test of the VAR(1) model was conducted as shown in Figure 4. Since all the inverse roots of the model have roots with a modulus less than one and lie inside the unit circle, the VAR(1) model is variance and covariance stationary.

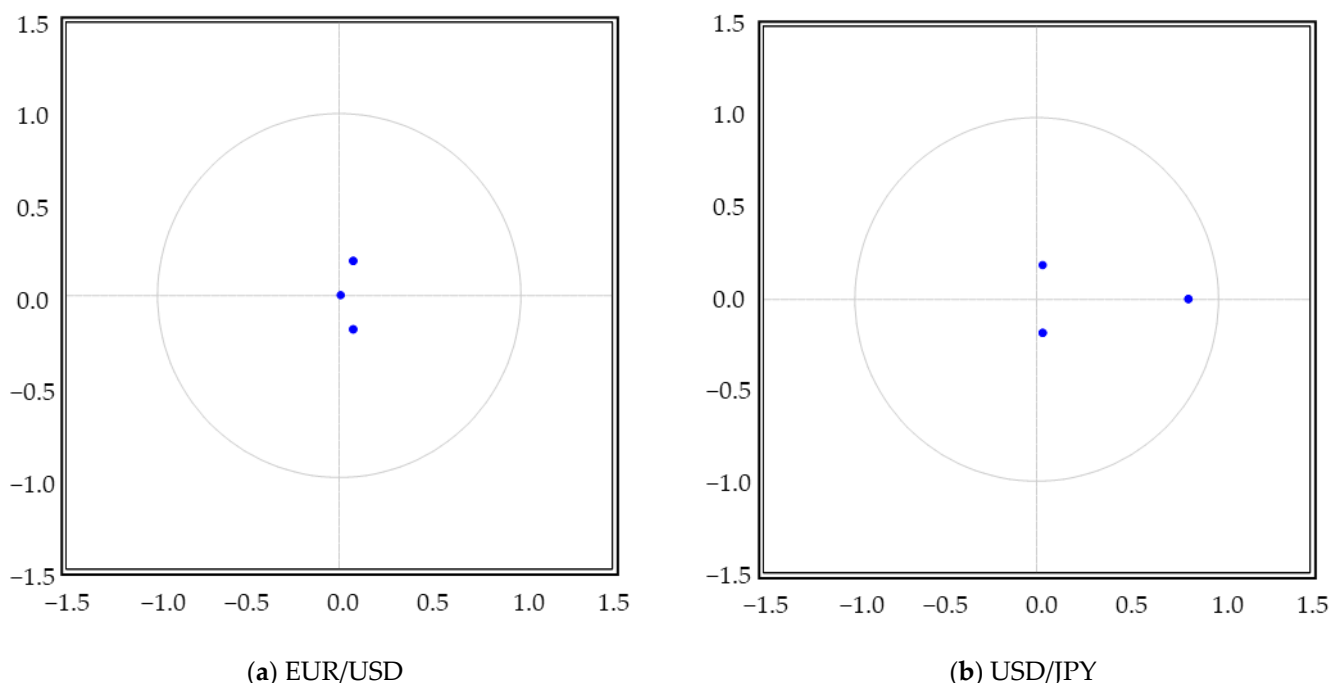


Figure 4. Inverse roots of AR characteristic polynomial. Notes: Figure 4 shows the inverse roots of the VAR(1) model for EUR/USD (a) and USD/JPY (b). The VAR(1) model for each case is stable since all roots have a modulus less than one and lie inside the unit circle.

Table 4 presents the estimated results of the VAR(1) model and the LM test results for autocorrelation. This study conducts an LM test of the null hypothesis of no autocorrelation for the first two lags of the residuals. All p -values associated with the LM test statistics are greater than 5%, meaning that there is no autocorrelation left in the residuals at lags 1 and 2. In addition, the estimation results of the VAR(1) model show that volatility of the EUR/USD and USD/JPY returns are positively affected by one day lag of unexpected trading volume (at the 1% significance level) and negatively affected by one day lag of unexpected open interest in the FX futures market for EUR/USD (at the 1% significance level) and USD/JPY (at the 5% significance level). The unexpected FX futures trading volume is found to be positively affected by one day lag of unexpected open interest in the FX futures market for EUR/USD (at the 10% significance level) and USD/JPY (at the 5% significance level). Regarding unexpected open interest in the FX futures market, it is positively affected by its lagged value at the significance level of 0.05 and negatively

affected by one day lag of unexpected trading volume at the significance level of 0.01. These results are confirmed through the Granger causality test (Table 5). The Granger causality test results show a significant causality running from unexpected trading volume to spot volatility or unexpected open interest to spot volatility. There exists a bi-directional relationship between unexpected trading volume and unexpected open interest in the FX futures market.

Table 4. Results of the estimated VAR(1) model and the LM test.

Exchange Rate	EUR/USD			USD/JPY		
Variables	h^2	UV	UO	h^2	UV	UO
Constant	0.00002 (0.0000) ***	58.3469 (0.4959)	10.8041 (0.8658)	0.000008 (0.0001) ***	73.6427 (0.6314)	118.2093 (0.2485)
$h^2(-1)$	0.0606 (0.2919)	−2,419,031 (0.4626)	−460,694 (0.8513)	0.8358 (0.0000) ***	−844,566 (0.7100)	−1,427,253 (0.3464)
$UV(-1)$	3.62×10^{-9} (0.0015) ***	−0.0200 (0.7586)	−0.2213 (0.0000) ***	2.38×10^{-9} (0.0094) ***	−0.0677 (0.2946)	−0.2333 (0.0000) ***
$UO(-1)$	$−4.29 \times 10^{-9}$ (0.0040) ***	0.1471 (0.0838) *	0.1283 (0.0433) **	$−2.66 \times 10^{-9}$ (0.0420) **	0.1971 (0.0334) **	0.1388 (0.0247) **
LM(1)		11.7995 (0.2249)			7.6433 (0.5705)	
LM(2)		13.2414 (0.1520)			10.8183 (0.2884)	

Notes: Table 4 shows the estimation results of the VAR model with the optimal lag order (1). p -values are in parentheses with the use of *, **, and *** to indicate significance levels at 0.10, 0.05, and 0.01, respectively. While one day lag of unexpected trading volume (UV) positively affects volatility of EUR/USD and USD/JPY returns, one day lag of unexpected open interest (UO) has a greater negative impact.

Table 5. Granger causality results.

Exchange Rate	EUR/USD		USD/JPY	
Null Hypothesis	Chi-Square Statistic	p -Value	Chi-Square Statistic	p -Value
UV does not Granger-cause h^2	10.1461	0.0014 ***	6.7722	0.0093 ***
UO does not Granger-cause h^2	8.3470	0.0039 ***	4.1494	0.0416 **
h^2 does not Granger-cause UV	0.5400	0.4624	0.1383	0.7099
UO does not Granger-cause UV	2.9974	0.0834 *	4.5409	0.0331 **
h^2 does not Granger-cause UO	0.0352	0.8512	0.8877	0.3461
UV does not Granger-cause UO	20.7472	0.0000 ***	29.2968	0.0000 ***

Note: Table 5 shows VAR Granger causality results. * indicates significance level at the 0.10 level, ** indicates significance level at the 0.05 level, and *** indicates significance level at the 0.01 level. There is evidence of bi-directional causality between unexpected trading volume (UV) and unexpected open interest (UO). Any changes in unexpected trading volume (UV) and unexpected open interest (UO) also affect volatility of EUR/USD and USD/JPY returns.

As discussed by Kumar (2009), the analysis on variance decomposition (Table 6) and impulse response function (Figure 5) exhibits information beyond the results of the VAR estimation and Granger causality tests. The percentage of variation in spot volatility explained by unexpected trading volume is about 2% for both the EUR/USD and USD/JPY cases. Unexpected open interest explains only 1% of the variation in the volatility of USD/JPY returns and about 2.55% of the variation in the volatility of EUR/USD returns. Contrarily, spot volatility explains less than 1% variation in the unexpected component of futures trading activity (trading volume and open interest) for both the EUR/USD and USD/JPY cases. These results are consistent with the Granger causality test results.

Table 6. Results of variance decomposition.

(%)	Variance Decomposition of h^2			Variance Decomposition of UV			Variance Decomposition of UO		
Period	h^2	UV	UO	h^2	UV	UO	h^2	UV	UO
Panel A: EUR/USD									
1	100.0	0.00	0.00	0.00	100.0	0.00	0.08	20.80	79.12
2	95.99	1.47	2.54	0.15	98.91	0.94	0.08	24.74	75.18
3	95.68	1.78	2.54	0.15	98.88	0.97	0.09	24.86	75.06
4	95.68	1.78	2.54	0.15	98.88	0.97	0.09	24.86	75.06
5	95.68	1.78	2.55	0.15	98.88	0.97	0.09	24.86	75.06
6	95.68	1.78	2.55	0.15	98.88	0.97	0.09	24.86	75.06
7	95.68	1.78	2.55	0.15	98.88	0.97	0.09	24.86	75.06
8	95.68	1.78	2.55	0.15	98.88	0.97	0.09	24.86	75.06
9	95.68	1.78	2.55	0.15	98.88	0.97	0.09	24.86	75.06
10	95.68	1.78	2.55	0.15	98.88	0.97	0.09	24.86	75.06
Panel B: USD/JPY									
1	100.0	0.00	0.00	0.13	99.87	0.00	0.51	18.86	80.63
2	98.49	0.76	0.75	0.13	98.49	1.37	0.47	24.77	74.77
3	97.70	1.35	0.95	0.14	98.48	1.38	0.53	24.85	74.62
4	97.37	1.61	1.02	0.15	98.46	1.38	0.56	24.84	74.59
5	97.20	1.75	1.06	0.16	98.46	1.38	0.59	24.84	74.58
6	97.09	1.83	1.08	0.17	98.45	1.38	0.61	24.83	74.56
7	97.02	1.88	1.09	0.17	98.45	1.38	0.62	24.83	74.55
8	96.98	1.92	1.10	0.17	98.44	1.38	0.63	24.83	74.55
9	96.95	1.94	1.11	0.18	98.44	1.38	0.63	24.83	74.54
10	96.93	1.95	1.11	0.18	98.44	1.38	0.64	24.82	74.54

Notes: Table 6 shows a forecast error variance decomposition analysis for both EUR/USD (Panel A) and USD/JPY (Panel B) cases. About 96 percent of the variation in spot volatility can be traced back to its own innovation, while the rest is explained by unexpected trading volume (UV) and unexpected open interest (UO).

In addition, this paper uses the impulse response function to analyze the response of spot volatility to a one standard deviation shock in unexpected trading volume and unexpected open interest for both the EUR/USD and USD/JPY cases. As shown in Figure 5, the response of spot volatility to its own shock is positive and high. It diminishes quickly in the case of EUR/USD and reaches equilibrium within 3 observation days, while in the case of USD/JPY, it exponentially decreases and reaches equilibrium within 21 observation days. For both the EUR/USD and USD/JPY cases, the response of spot volatility to shock in unexpected trading volume is positive, while spot volatility adjustment to shock in unexpected open interest is negative. It takes a few days (3–4 days) to die out in the case of EUR/USD, while it takes longer time (12–15 days) to die out in the case of USD/JPY. Therefore, these results are consistent with the Granger causality test results and are convincing proof of the sign results of the VAR(1) model.

Therefore, the analysis of the dynamic relationship between spot volatility and trading activity (unexpected component of trading activity) in the FX futures market for EUR/USD and USD/JPY provides evidence of the destabilizing impact of trading volume and the stabilizing impact of open interest on spot volatility. As discussed by [Malhotra and Sharma \(2016\)](#), futures market and spot market are linked by arbitrage. If there is an increase in unexpected futures trading volume driven by uninformed speculators, then spot volatility will increase. On the other hand, open interest is a measure of the positions of hedgers or actively informed traders who bring fundamental information to the futures market. The increase in hedging positions increases the market depth and consequently reduces spot volatility. Since unexpected open interest has a stronger influence on spot volatility than unexpected trading volume, FX futures trading stabilizes volatility in spot exchange rates for EUR/USD and USD/JPY.

Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E. Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

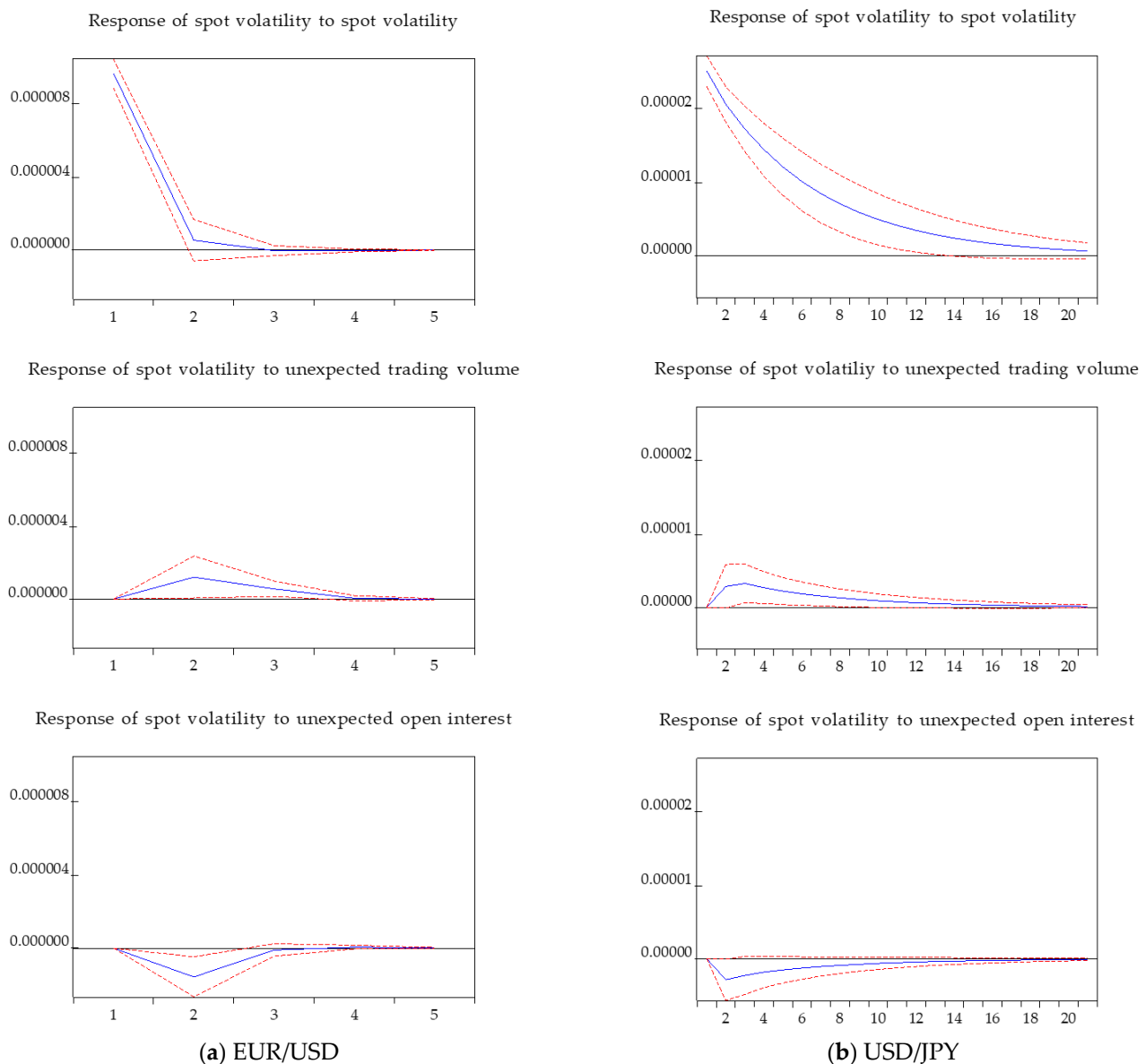


Figure 5. Results of impulse response function. Notes: Figure 5 shows the results on the response of volatility in spot exchange rates for EUR/USD (a) and USD/JPY (b) to a one standard deviation shock in unexpected trading volume and unexpected open interest. The response of spot volatility to its own shock is positive and high. It diminishes quickly in the case of EUR/USD, while it takes longer time to die out in the case of USD/JPY.

5. Conclusions

Trading of FX futures in Thailand began in 2012, with only one futures contract available for trading, USD futures. Since 31 October 2022 onwards, Thailand Futures Exchange (TFEX) has added two new FX futures, EUR/USD futures and USD/JPY futures. As concerns about whether FX futures trading has a stabilizing or destabilizing effect on spot volatility, this paper investigates how and to what extent the introduction of FX futures (EUR/USD and USD/JPY futures) has an impact on spot volatility in the context of Thailand and considers the contemporaneous and dynamic relationship between spot volatility and FX futures trading activity, including trading volume and open interest.

The GARCH family models augmented with the dummy variable for the impact of the introduction of FX futures are applied for modelling spot volatility over the sample

period from 27 September 2021 to 12 January 2024. The EGARCH (1,1) model is found to be the best fitted model for both EUR/USD and USD/JPY returns. The results suggest that the introduction of EUR/USD futures and USD/JPY futures by TFEX decreases spot volatility. By dividing the whole sample into two sub-periods (pre and post introduction periods) and applying the EGARCH (1,1) model for the pre and post introduction periods, the results suggest that the introduction of FX futures by TFEX increases the rate at which new information is incorporated into underlying spot prices and decreases the persistency of volatility shocks. This implies an improvement in spot market efficiency as a result of the introduction of FX futures by TFEX. Over the post introduction period from 31 October 2022 to 12 January 2024, trading volume and open interest in EUR/USD and USD/JPY futures are decomposed of expected and unexpected components using the ARIMA model. They are added into a conditional variance equation of the EGARCH (1,1) model for analysis of the contemporaneous relationship between spot volatility and FX futures trading activity. The results show a positive effect of unexpected trading volume and a negative effect of unexpected open interest on contemporaneous spot volatility. These results are in line with the VAR(1) model results of the dynamic relationship between spot volatility and FX futures trading activity. The Granger causality test results also show a significant causality running from unexpected trading volume to spot volatility or unexpected open interest to spot volatility. The results of the impulse response function provide convincing proof of the sign results of the VAR(1) model, which indicate that unexpected trading volume has a destabilizing impact, while unexpected open interest has a stabilizing impact on spot volatility. However, with the impact on spot volatility caused by unexpected open interest being stronger than that by unexpected trading volume, FX futures trading stabilizes spot volatility.

Since the introduction of FX futures can improve spot market efficiency and lower spot market volatility, TFEX should add new FX futures so that investors can select a mix of FX futures that align with their investment objectives and risk tolerance. In addition, it is important to encourage hedgers or informed traders into the FX futures market to ensure a stabilizing impact of FX futures trading on spot volatility. Supporting traders through education/training will enhance their confidence in the use of FX futures. Although this study focuses on the impact of FX futures trading on spot volatility, an interesting extension would be to assess the linkage between the futures market volatility and spot market volatility. In addition, a longer time series would be needed to conduct an analysis.

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