

Wei, Wan; Pozo, Susan

Article

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Suggested Citation: Wei, Wan; Pozo, Susan (2021) : The effects of conventional and unconventional monetary policy on exchange rate volatility, Cogent Economics & Finance, ISSN 2332-2039, Taylor & Francis, Abingdon, Vol. 9, Iss. 1, pp. 1-19,
<https://doi.org/10.1080/23322039.2021.1997425>

This Version is available at:

<https://hdl.handle.net/10419/270174>

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To cite this article: Wan Wei & Susan Pozo | (2021) The effects of conventional and unconventional monetary policy on exchange rate volatility, Cogent Economics & Finance, 9:1, 1997425, DOI: [10.1080/23322039.2021.1997425](https://doi.org/10.1080/23322039.2021.1997425)

To link to this article: <https://doi.org/10.1080/23322039.2021.1997425>



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Received: 4 March 2021
Accepted: 22 October 2021

*Corresponding author: Wan Wei,
Department of Accounting, Finance,
and Economics, Arkansas Tech
University, Russellville, USA
E-mail: wwei@atu.edu

Reviewing editor:
Evan Lau, Department of
Economics, Universiti Malaysia
Sarawak, Kuching MALAYSIA

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

The effects of conventional and unconventional monetary policy on exchange rate volatility

Wan Wei^{1*} and Susan Pozo²

Abstract: This paper examines the impacts of U.S. conventional and unconventional monetary policy announcements on the volatility of six exchange rates, namely Australian dollar, British pound, Canadian dollar, Euro, Japanese yen, and Swiss franc against the U.S. dollar. Narrow windows around policy announcements and high frequency second-by-second intraday data are used in the analysis. Results show that the exchange rate volatility increases significantly in the narrow window before and after the announcements under conventional monetary policy regime. The increase in the volatility is even greater during the contemporaneous period under the unconventional regime. Dividing monetary policy announcements into expansionary and non-expansionary groups, we further find that exchange rate volatility responds stronger to the non-expansionary announcements compared to the expansionary ones under the unconventional monetary policy regime.

Subjects: Macroeconomics; Monetary Economics; International Economics

Keywords: Foreign exchange; Volatility; Unconventional Monetary Policy; Monetary policy announcements; High-frequency data

JEL classification: F31; G14

ABOUT THE AUTHORS

Wan Wei is an assistant professor of economics in the College of Business at Arkansas Tech University. Her research interests include exchange rate behavior, monetary policy, and housing market.

Susan Pozo is a professor of economics in the Department of Economics, and the director of Global and International Studies at Western Michigan University. Her areas of expertise include immigration policy, undocumented migration, returns to international human capital, determinants and economic impacts of worker's remittances, empirical distribution of foreign exchange rates and measures of exchange risk, underground financial and economic activity. This paper sheds light on the relationship between monetary policy and foreign exchange market and provides important implications for policymakers and market participants. This paper also provides other central banks with important information to proceed in their implementation of unconventional monetary policy.

PUBLIC INTEREST STATEMENT

Have you ever thrown a rock and/or a feather in water? When a monetary policy announcement is made, exchange rates may react to the announcement by moving up or down, resulting in possible increase in the volatility, just like the ripples as water molecules going up and down caused by a rock or a feather. Some announcements may be like rocks, making the exchange rate more volatile; some announcements may be like feathers, causing insignificant changes. The results show that both conventional and unconventional monetary policy announcements are "rocks", and unconventional monetary policy "rocks" are even bigger than the conventional ones. This paper contributes to the understanding of the stability of the foreign exchange market, the biggest financial market in the financial system, and also provides policymakers with insights into the impacts of different monetary policy.

1. Introduction

This paper studies the impact of unconventional and conventional monetary policy announcements on the volatility of the U.S. dollar with respect to six currencies. Narrow windows around policy announcements and high-frequency second-by-second intraday data are used in the analysis.

In response to the 2007 financial crisis and recession, the Fed used conventional monetary policy to help steer the economy onto a better trajectory. Under conventional monetary policy the Fed lowers the federal funds rate in order to stimulate the economy. However, the Fed ran into a problem in October 2008, since the federal funds interest rate reached zero in October 2008, in effect a lower bound for interest rates, therefore leaving the Fed with no more room to continue to stimulate the economy¹ using conventional monetary policy. In its effort to continue to counteract the recession, the Fed adopted a new and unproven method to conduct monetary policy. It began to implement a type of unconventional monetary policy, by making large-scale asset purchases (LSAPs) usually referred to as quantitative easing (QE). Under QE, the Fed tries to influence long-term interest rates instead, which at the time were well above zero.

The federal funds rate was raised above zero in December 2015, indicating a resumption of conventional monetary policy. However, it is still worthwhile to study the impacts of unconventional monetary policy in order to provide insights to US policymakers about the effects of unconventional monetary policy. In the event that the interest rate is stuck at the zero lower bound again, we would be armed with better knowledge about unconventional monetary policy than we were in late 2008.

This paper focuses on the impacts of the unconventional monetary policy on the foreign exchange market, because the latter “underpins all other financial markets” (Levinson 2005) and is the largest financial market in the world. The foreign exchange market can impact a country’s international trade activities, influence the flow of international investment and affect domestic interest and inflation rates. The stability of foreign exchange markets contributes to the overall stability of the financial markets as a whole, which may, in turn, affect the stability of the economy.

This paper investigates the following questions. First, do monetary policy announcements affect exchange rate volatility? Second, does the effect differ across conventional and unconventional monetary policy regimes? In our further analysis, we revisit monetary policy by identifying the stance of each announcement and examine how the volatility respond differently to expansionary monetary policy announcements compared with non-expansionary ones.

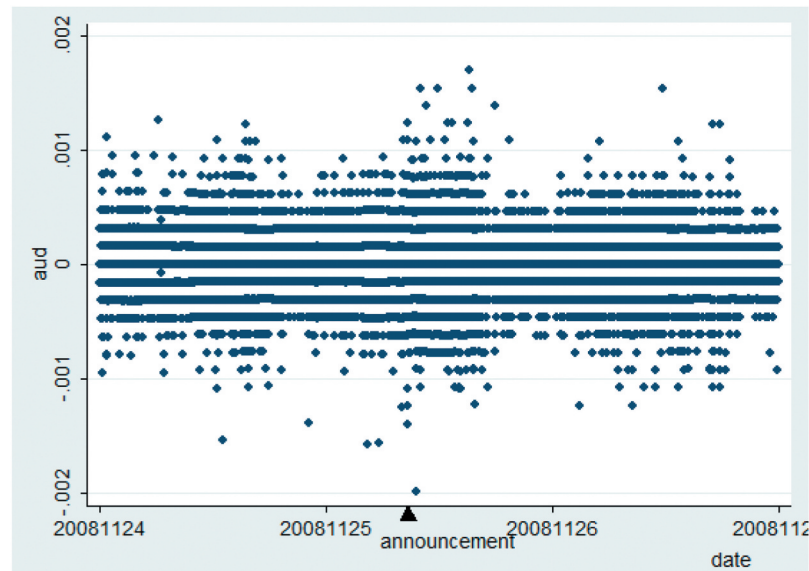
2. Literature review

Relevant empirical literature linking monetary policy to exchange rate can be divided into three categories. The first category covers the impact of monetary policy on exchange rate in the long run using daily, weekly or even lower frequency data. In an earlier paper, Pozo (1988) studied the volatility of five major exchange rates under different monetary operating procedure in the US. Her analysis indicate that exchange rate volatility was higher in the non-borrowed reserves target period. A similar result was obtained by Lastrapes (1989), R  th (2020), and Bj  rnland (2009) find that conventional monetary policy has significant impact on the level of exchange rate.

A second area of the empirical literature examines how exchange rate volatility is impacted by macroeconomic news and announcements using intraday exchange-rate data. This group of papers provides evidence that exchange rate volatility does respond to new information (Andersen and Bollerslev 1998; Bauwens et al., 2005; Evans & Speight, 2010; Omrane & Savaser, 2017). However, these studies do not take the change in the monetary policy regime into account.

A third set of empirical studies takes the unconventional monetary policy experiment into account (Fassas & Papadamou, 2018; A. Fassas et al., 2019; Papadamou et al., 2020; Kenourgios et al., 2020; Mehmet et al., 2020; Gokmenoglu & Haddood, 2020; Thomas et al., 2020), however, these studies do

Figure 1. Second-by-second data for AUD/USD from 24 November 2008 to 26 November 2008.



not shed light on the foreign exchange market. Glick and Leduc (2013), Neely (2015), Adler et al. (2019), Inoue and Rossi (2019), and Yang and Zhang (2021) find that exchange rates respond to unconventional monetary policy announcements. A. P. Fassas et al. (2021) find that the US unconventional monetary policy announcements decrease the market expectations about future realized volatility of exchange rates. This paper differs with the previous studies in several ways. First, we compare the different impacts of conventional and unconventional monetary policy announcements. Second, most of these studies are only concerned with the impact of the monetary policy announcements on the level of the exchange rate using intraday data. In contrast, there has been limited research considering unconventional monetary policy announcements' impacts on volatility, and in comparing the difference between the impacts of the two monetary policy regimes.

This paper contributes to the accumulating empirical literature and a deeper understanding of monetary policy and exchange rate volatility for the benefit of policymakers as well as market participants. It addresses and compares the impact of both unconventional and conventional monetary policy announcements on the volatility of the exchange rate. Therefore, it provides insights for US policymakers to evaluate the effects of unconventional monetary policy more comprehensively. Second, it helps market participants understand that monetary policy announcements play an important role in affecting the stability of the financial market. Third, the central banks of Europe and the UK also implemented of unconventional monetary policy². Therefore, analyzing the U.S.'s experience with unconventional monetary policy on exchange rate volatility will provide other central banks with knowledge to make monetary policy decisions in the future.

3. Data and model

3.1. Data

In this analysis, we use high-frequency exchange rate data. We employ second-by-second exchange rate data from *ForexTickData*.³ The use of high-frequency data allows us to better isolate the response of exchange rate movements to monetary announcements, and separate those from other possible shocks that take place several times a day. We have intraday spot exchange rate data on the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), Euro (EUR), Great British pound (GBP), all against the US dollar. The data used span from October 2001 to February 2014. To better visualize these data, Figure 1 through 6 display a sample subset of the

Figure 2. Second-by-second data for CAD/USD from 24 November 2008 to 26 November 2008.

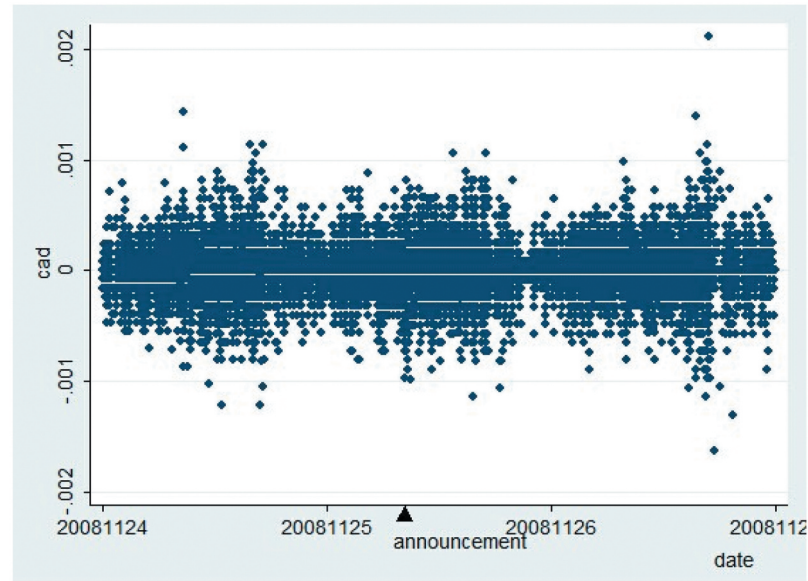
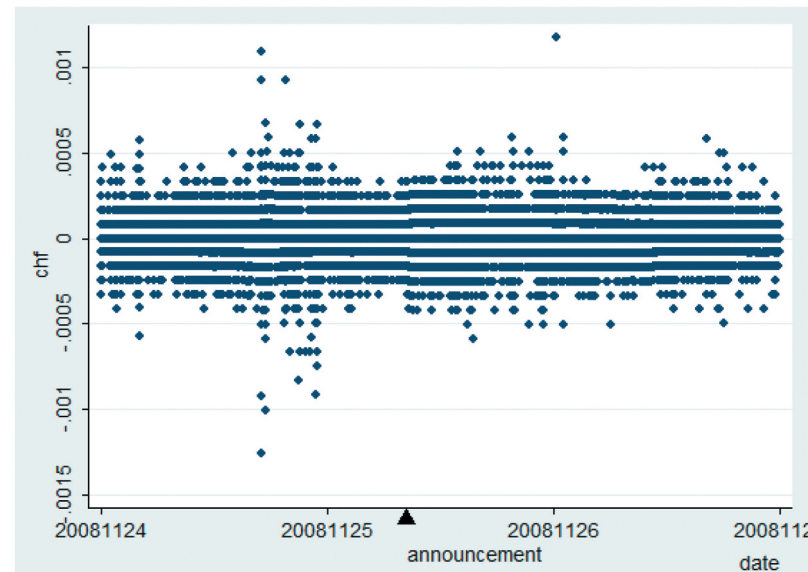


Figure 3. Second-by-second data for CHF/USD from 24 November 2008 to 26 November 2008.



returns for the second by second data for each of the currencies over a 3-day period, 24 November 2008 to 26 November 2008. These represent 259,200 observations. There was an announcement made on November 25 at 8:15 am. The arrow on the X-axis indicates the timing of the announcement. The exchange rate AUD/USD, displayed in Figure 1 and 2, appears to fluctuate by larger margins upon the announcement. The CHF/USD exchange rate in Figure 3 and 6, however, does not seem to display a different pattern at the time of the announcement. Figure 7 combines the plots for all the six exchange rates. Visually and in the aggregate, it seems that the returns fluctuate more around the announcement period.

Figure 4. Second-by-second data for EUR/USD from 24 November 2008 to 26 November 2008.

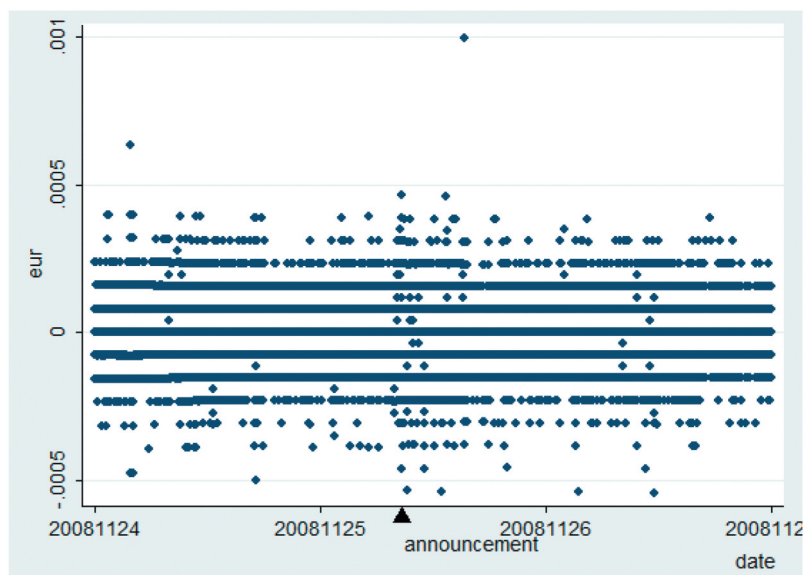


Figure 5. Second-by-second data for GBP/USD from 24 November 2008 to 26 November 2008.

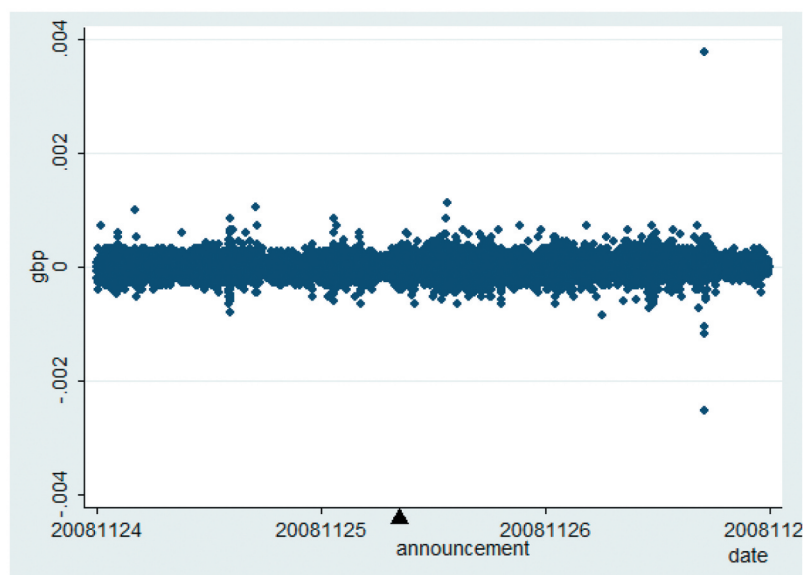


Table 1 and 2 displays the descriptive statistics for 5-minute returns of the six exchange rates over the sample period. Inspection of the data suggests that the 5-minute returns exhibit skewness and high kurtosis, features commonly observed in high-frequency data (Wang et al., 2001). Take the first exchange rate displayed, the USD/AUD. On average, the 5-minute return over the sample period indicates appreciation of the Australian dollar vis-a-vis the U.S. dollar. The distribution of return is positively skewed and shows considerable kurtosis.

The FOMC makes around eight announcements each year concerning monetary policy. The exact timing of each announcement is obtained from the official Federal Reserve website.⁴ The sample period for conventional monetary policy actions extends from October 2001 until October 2008 at which time the federal funds target rate reached its lower bound. The events in the conventional

Figure 6. Second-by-second data for JPY/USD from 24 November 2008 to 26 November 2008.

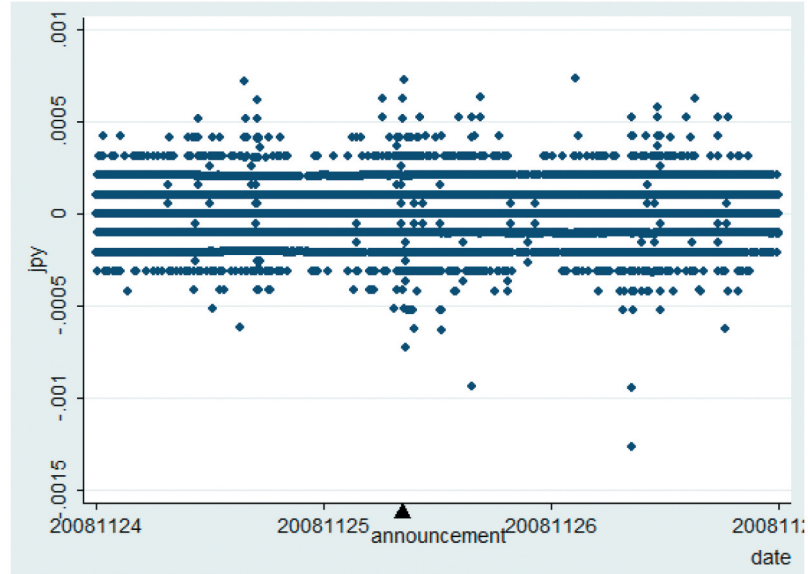
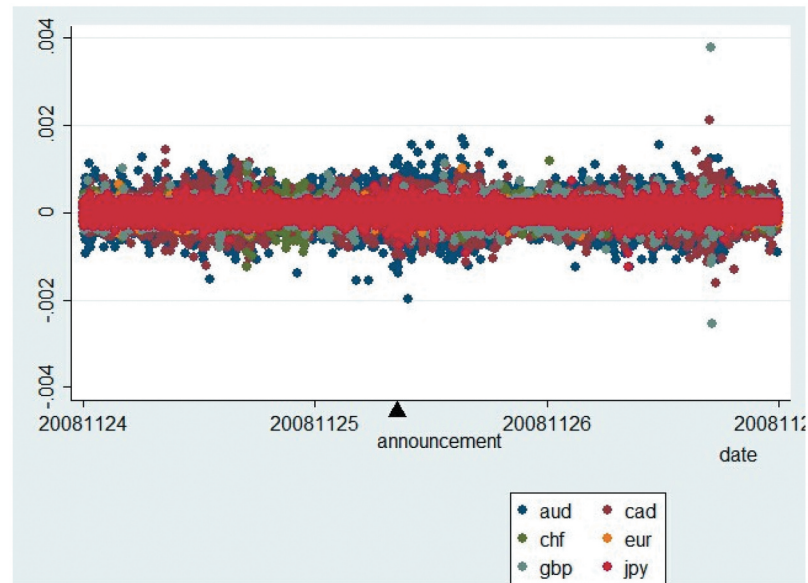


Figure 7. Second-by-second data for all the six exchange rates from 24 November 2008 to 26 November 2008.



policy period consist of 58 FOMC announcements. For the unconventional policy period, there were 50 FOMC announcements between November 2008 and February 2014. Table 3 displays the timing of FOMC announcements, in 2002, a period when conventional monetary policy was in effect and in 2009, when unconventional monetary policy was practiced.

3.2. Empirical model

This paper aims to study the responsiveness of exchange rate volatility to FOMC announcements. To be more specific, we test to see whether exchange rate volatility differs immediately before, during and immediately following FOMC announcements, relative to no announcement periods.

Figure 8. An example of the time line around monetary policy announcements (an announcement was made at 10:00 am on 16 December 2008).

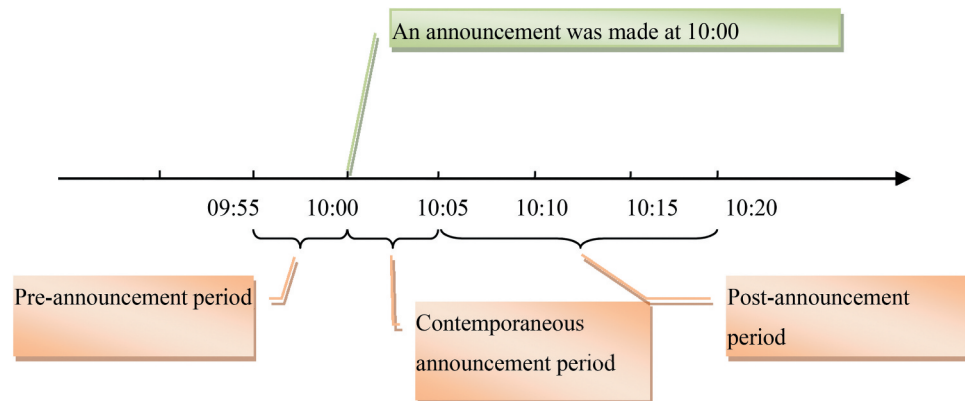


Table 1. Descriptive statistics for five-minute returns of the six exchange rates

	OBS	Mean	Std dev	Variance	Skewness	Kurtosis
USD/AUD	924772	1.54E-08	0.0000142	2.02E-10	724.1082	646,251.1
CAD/USD	924573	6.57E-10	2.79E-06	7.77E-12	38.50704	55,019.93
CHF/USD	923013	4.53E-09	5.05E-06	2.55E-11	166.81	75,949.66
USD/EUR	924750	-1.88E-09	4.53E-06	2.06E-11	-341.7688	235,849.5
USD/GBP	912281	6.68E-10	2.62E-06	6.84E-12	98.23094	69,821.45
JPY/USD	918229	-1.78E-09	5.70E-06	3.25E-11	-94.52381	96,092.77

Table 2. Descriptive statistics for the average of the volatility of the six exchange rate returns, measured by the standard deviation of the second by second exchange rate returns over a 5minute interval

Exchange rate	OBS	Volatility (avg)	Min	Max
USD/AUD	924710	0.0000303	0	0.2679638
CAD/USD	924502	0.0000204	0	0.0018159
CHF/USD	922945	0.0000249	0	0.0646486
USD/EUR	924684	0.0000227	0	0.0025362
USD/GBP	912220	0.0000186	0	0.0026952
JPY/USD	918153	0.0000259	0	0.0038201

Next, we test to see whether the impacts of FOMC announcements on exchange volatility are the same under conventional and unconventional monetary policy regimes.

The volatility of the exchange rate is measured by the standard deviation of exchange rate returns over each 5-minute interval. During each 5-minute time interval, we have second by second data (60×5) = 300 observations. We compute the second by second return providing us with a time series consisting of 299 observations. From this series, we obtain the standard deviation of returns for the 5-minute interval. Table 2 displays the descriptive statistics for the volatility of the six exchange rates. The third column of the table shows the average of the volatility of each exchange rate. According to the descriptive statistics, it appears that the Australian dollar is most volatile while the British pound is least volatile.

Table 3. Example of FOMC announcements under both monetary policy regimes

Conventional period		Unconventional period	
Date	Time	Date	Time
30 January 2002	14:15	28 January 2009	14:15
19 March 2002	14:15	18 March 2009	14:15
7 May 2002	14:15	29 April 2009	14:15
June 26,2002	14:15	24 June 2009	14:15
August 13,2002	14:15	12 August 2009	14:15
24 September 2002	14:15	23 September 2009	14:15
6 November 2002	14:15	4 November 2009	14:15
10 December 2002	14:15	16 December 2009	14:15

Table 4. Results of estimating Equation (1) for all the six exchange rates

	USD/AUD (*10 ⁻⁵)	CAD/USD (*10 ⁻⁵)	CHF/USD (*10 ⁻⁵)	USD/EUR (*10 ⁻⁵)	USD/GBP (*10 ⁻⁵)	JPY/USD (*10 ⁻⁵)
α	430.62***	64,313.64***	1922.29***	59,428.67***	56,785.03***	53,177.14***
t-stat	(4.14)	808.41	24.58	720.25	676.59	603.72
β	3.35	1.86***	3.54***	2.66***	2.0***	2.49***
t-stat	(0.93)	11.26	3.58	17.37	13.32	12.64
β'	-0.327	-3.46	-0.579	-0.546**	0.0873	0.799***
t-stat	-0.06	-0.25	-0.39	-2.36	0.39	2.65
γ	9.26**	3.46***	7.04***	4.55***	3.05 ***	4.62***
t-stat	2.56	20.94	7.12	29.62	20.35	23.44
γ'	-0.0368	2.0***	3.5**	3.52***	2.07***	4.47***
t-stat	-0.01	8.01	2.35	15.21	9.14	14.82
$\delta t - \text{stat}$	4.69**	0.512***	3.96***	0.789***	0.687***	1.02***
	2.25	5.36	6.94	8.90	7.92	8.94
$\delta' t - \text{stat}$	0.503	0.17	0.49	-0.0415	0.00186	-0.152
	0.16	1.18	0.57	-0.31	0.01	-0.88
θ	0.415***	0.223***	2.26***	0.0994***	0.175***	0.0687***
t-stat	7.07	81.49	14.03	39.68	71.00	21.29
constant	2.84***	0.631***	2.33***	0.874***	0.728***	1.18***
t-stat	73.26	279.26	216.97	361.33	337.43	385.44

Notes:

*indicates that the coefficient is significant at the 10% level.

**indicates that the coefficient is significant at the 5% level.

*** indicates that the coefficient is significant at the 1% level.

We use ordinary least squares (OLS) to model the impact of announcements on exchange rate volatility. To study how volatility changes around announcements, we divide the time around announcements into three periods; the pre-announcement period, the contemporaneous period and the post-announcement period. The observation windows are equal to 5 minutes before the announcement (pre-announcement period), 5 minutes just after the announcement (contemporaneous period), and 15 minutes after the contemporaneous period (post-announcement period,

Table 5. Average volatility of the six exchange rates during different periods, namely non-announcement period, pre-announcements period, contemporaneous-announcement period, and post-announcement period

	Average volatility ($\times 10^{-5}$)							
	Conventional				Unconventional			
	Non ann	Pre	Cont	Post	Non ann	Pre	Cont	Post
AUD	2.85	6.21	12.13	7.56	3.26	6.29	12.5	8.48
CAD	1.77	4.67	7.1	4.86	2.39	4.74	9.37	6.38
CHF	2.39	5.95	9.48	6.44	2.61	5.58	13.21	7.19
EUR	2.16	5.43	8.65	5.78	2.4	4.84	11.91	7.0
GBP	1.69	4.24	6.19	4.3	2.09	4.35	8.5	5.33
JPY	2.52	5.45	8.7	5.93	2.67	6.2	13.64	7.27

which is 20 minutes after the announcement). As an example, [Figure 8](#) demonstrates the time line around the monetary policy announcements made 16 December 2008.

The regression that we estimate is as follows:

$$\text{vol}_t = \alpha \text{vol}_{t-1} + \beta \text{PRE}_t + \beta' (\text{UCMP}_t \times \text{PRE}_t) + \gamma \text{CONT}_t + \gamma' (\text{UCMP}_t \times \text{CONT}_t) + \delta \text{POST}_t + \delta' (\text{UCMP}_t \times \text{POST}_t) + \text{constant} + \theta \text{UCMP}_t + e_t \quad (1)$$

where vol is the standard deviation of exchange rate return per five-minute time interval. This is calculated from second-by-second spot exchange rate data. The dummy variable, PRE_t represents the pre-announcement period, hence $\text{PRE}_t = 1$ if t is 5 minutes before announcements and 0 otherwise. The variable denoted CONT_t is a dummy variable representing the contemporaneous period. This means $\text{CONT}_t = 1$ if t is 5 minutes after the announcement and 0 otherwise. The dummy variable, POST_t represents the post-announcement period, where $\text{POST}_t = 1$ if t is 20 minutes after the announcement and 0 otherwise. The dummy variable, UCMP_t , distinguishes the conventional from the unconventional monetary policy regime. Therefore $\text{UCMP} = 0$ before October 2008 and 1 after that.

The coefficients on PRE_t , CONT_t , and POST_t (β , γ , and δ) provide evidence on the impact of announcements on exchange rate volatility before the policy change. The coefficients on the interaction terms, $(\text{UCMP}_t \times \text{PRE}_t)$, $(\text{UCMP}_t \times \text{CONT}_t)$ and $(\text{UCMP}_t \times \text{POST}_t)$, β' , γ' , and δ' , capture the change in the impact of announcements on volatility before and after the policy change. Therefore, the significance level of β' , γ' , and δ' indicate whether the impacts of announcements on volatility are different under the two different policy regimes. Statistical significance implies that the impacts are different. Furthermore, $\beta + \beta'$, $\gamma + \gamma'$, and $\delta + \delta'$ capture the impact of announcements on exchange rate volatility after the policy change and can therefore help us discover whether the difference is of economic significance. The coefficient θ captures the structural shift, if any, of the overall volatility in the non-announcement periods.

4. Results and robustness check

The results of estimating equation (1) for the six exchange rates are presented in [Table 4](#). Turning first to the Australian dollar, the coefficient on PRE , β , is not statistically significantly different from zero, suggesting that relative to non-announcement periods (e.g., when referring to [Figure 8](#), the periods before 9:55 12/18/2008 and after 10:15 12/16/2008), volatility does not change substantially immediately before announcements in the case of the Australian dollar. The coefficients γ and δ , however, are positive and statistically significantly different from zero, which means the

Table 6. Robustness check results

	USD/AUD (*10 ⁻⁵)	CAD/USD (*10 ⁻⁵)	CHF/USD (*10 ⁻⁵)	USD/EUR (*10 ⁻⁵)	USD/GBP (*10 ⁻⁵)	JPY/USD (*10 ⁻⁵)
α	205.11*	60,790.71***	1539.42***	54,784.31***	49,259.09***	46,055.4***
P value	0.065	0.00	0.00	0.00	0.00	0.00
β	1.62	0.842***	2.47	2.11***	1.46***	1.4***
P value	0.701	0.00	0.108	0.00	0.00	0.00
β'	1.37	1.03***	0.488	0.00835	0.602***	2.09***
P value	0.828	0.00	0.832	0.742	0.01	0.00
γ	5.51	3.14***	6.09***	4.52***	3.11***	3.41***
P value	0.193	0.00	0.00	0.00	0.00	0.00
γ'	3.47	2.0***	2.99	3.14***	1.74***	5.03***
P value	0.584	0.00	0.196	0.00	0.00	0.00
δ	3.36	0.603***	3.45***	0.95***	0.858***	1.14***
P value	0.169	0.00	0.00	0.00	0.00	0.00
δ'	1.48	0.119	0.805	0.0262	-0.0225	-0.122
P value	0.687	0.405	0.546	0.858	0.87	0.948
θ	0.223***	0.228***	0.198***	0.0635***	0.153***	0.0691***
P value	0.001	0.00	0.00	0.00	0.00	0.00
constant	2.64***	0.628***	2.23***	0.943***	0.809***	1.27***
P value	0.00	0.00	0.00	0.00	0.00	0.00

Notes:

*indicates that the coefficient is significant at the 10% level.

**indicates that the coefficient is significant at the 5% level.

*** indicates that the coefficient is significant at the 1% level.

volatility of the Australian dollar increases in the contemporaneous period and post-announcement period. Focusing on the coefficients on the interaction terms (β' , γ' , and δ'), which indicate whether there is change in the impact of the announcements on the volatility under the different monetary policy regimes, the three coefficients are not statistically significantly different from zero. In other words, the FOMC announcements have the same impact on the USD/AUD exchange rate volatility under the different monetary policy regimes.

$$\begin{aligned} \text{vol}_t = & \alpha \text{vol}_{t-1} + \beta \text{PRE}_t + \beta' \text{UCMP}_t \times \text{PRE}_t + \gamma \text{CONT}_t + \gamma' \text{UCMP}_t \times \text{CONT}_t + \delta \text{POST}_t \\ & + \delta' \text{UCMP}_t \times \text{POST}_t + \theta \text{UCMP}_t + \text{constant} + e_t \end{aligned} \quad (3.1)$$

In the case of the Japanese yen, the coefficients β , γ and δ are positive and significantly different from zero, indicating that the volatility of the yen increases during the three periods around announcements. The coefficients β' and γ' are also positive and significantly different from zero, which implies the impact of announcements become greater under the unconventional policy regime compared to under the conventional policy regime.

Next, if we compare the results for all the six exchange rates together, five exchange rates present higher volatility during announcements, compared to non-announcement periods, under the conventional policy regime. The results are also different for the exchange rates when we take the policy shift into account. The effects of the announcements in the contemporaneous period under unconventional regime are greater than the effects under conventional regime, with γ' being positive and significantly different from zero, for all the exchange rates except the Australian dollar. The impacts are the same under different policy regimes in the post-announcement period for all six exchange

rates. Turning to the pre-announcement period, the influence of the announcements under conventional regime is smaller in the case of the Euro, the influence is greater in the case of the Japanese yen while the influence is of no difference in the case of the other four exchange rates. The coefficient on the lagged volatility variable, α , is positive and significantly different from zero for all six exchange rates, which implies the persistence of exchange rate volatility. The Australian dollar and the Swiss franc have greater persistence in the volatility compared to the other exchange rates. Besides, all the six exchange rates increase in volatility in the non-announcement periods under the unconventional regime as indicated by the positive sign and significance of coefficient θ .

The rise in volatility in the announcement periods is substantial compared to the non-announcement periods, as reported in Table 4. Take the contemporaneous period under conventional monetary policy, for example. The volatility of the Australian dollar (AUD) increases by $9.26 (\times 10^{-5})$, the volatility of the Canadian dollar (CAD) increases by $3.4 (\times 10^{-5})$, and the volatility of the Swiss franc (CHF) increases by $7.04 (\times 10^{-5})$. To have a simple and clear understanding concerning the sizes of those increases, Table 5 displays the average volatility during the non-announcement periods and the three periods around monetary announcements. Take AUD as an example, the average volatility during the contemporaneous period is $12.13 (\times 10^{-5})$, which is more than four times the average volatility with no such announcements, $2.85 (\times 10^{-5})$. In short, monetary announcements are associated with significant and sizeable responses in volatility for five of the six exchange rates in the pre-announcement period, and for all six exchange rates in the contemporaneous and post-announcement periods. This indicates that announcements cause immediate pronounced increases in volatility.⁵

According to the results, the FOMC announcements lead to larger exchange rates fluctuations around announcements under both policy regimes. The greatest change in the impact of announcements on exchange volatility over the two regimes is in the contemporaneous period. Under unconventional monetary policy regime, the monetary announcements cause even greater responses in volatility for five out of the six exchange rates relative to the contemporaneous period. It causes greater responses for one out of the six exchange rates in the pre-announcement period and during the post-announcement period.

One question that may be worth asking is whether the different impact of announcements on the volatility is due to monetary policy shift or to the recession. We conduct a robustness check of the results taking this into account. The sample period includes the 2007–2009 recession, which lasted 18 months.⁶ To make sure that the change in the impact of announcement on the volatility is not due to the recession, we drop the observations for the recession period, and estimate the same model.

The regression results are displayed in Table 6. The results are consistent with the main results in the previous section. The only difference is that the volatility of the Australian dollar does not respond to announcements under both policy regimes. Hence, the overall finding of a difference in the impact of announcements under the different monetary policy regimes does not appear to be due to the Great Recession.

5. Discussion: monetary policy revisited

Some argue that the effects of expansionary monetary policy announcements and contractionary announcements are asymmetric with respect to their impacts on the financial markets. In this section, we test for this asymmetry. In order to do so, we distinguish expansionary announcements from others. We use different methodologies to determine whether announcements are expansionary or contractionary (i.e. the type of announcements) under conventional monetary regime versus under unconventional regime, because the Fed used different approaches for implementing monetary policy over the two regime periods.

Under conventional monetary policy, we use the change in the federal funds rate to identify the type of announcements. If the change in the federal funds rate was negative, that is, the Fed was

Table 7. Monetary policy announcements under unconventional regime and the criteria					
Announcement date	Whether expansionary	Which criteria satisfied	Announcement date	Whether expansionary	Which criteria satisfied
16 December 2008	yes	I II	9 August 2011	yes	I III IV
28 January 2009	yes	I II	21 September 2011	yes	I III IV
18 March 2009	yes	I II IV	2 November 2011	yes	I III IV
29 April 2009	yes	I II IV	13 December 2011	yes	I III IV
24 June 2009	yes	I IV	25 January 2012	yes	I III IV
12 August 2009	no	I III IV	13 March 2012	yes	I III IV
23 September 2009	no	I III IV	25 April 2012	yes	I III IV
4 November 2009	no	I III IV	20 June 2012	yes	I III IV
16 December 2009	no	I III IV	1 August 2012	yes	I III IV
27 January 2010	no	I III IV	13 September 2012	yes	I III IV
16 March 2010	no	I II IV	24 October 2012	yes	I III IV
28 April 2010	no	I II IV	12 December 2012	yes	I III IV
9 May 2010	no	I II IV	30 January 2013	yes	I III IV
23 June 2010	no	II IV	Mar. 202,013	yes	I III IV
10 August 2010	no	I II IV	1 May 2013	yes	I III IV
21 September 2010	no	I II IV	19 June 2013	yes	I III IV
3 November 2010	yes	I III IV	31 July 2013	yes	I III IV
14 December 2010	yes	I IV	18 September 2013	yes	I III IV
26 January 2011	yes	I III IV	30 October 2013	yes	I III IV
15 March 2011	yes	I III IV	18 December 2013	yes	I III IV
27 April 2011	yes	I III IV	29 January 2014	yes	I III IV
22 June 2011	yes	I III IV			

Table 8. Results of estimating Equation (2) for all the six exchange rates

			AUD(*10 ⁻⁵)	CAD(*10 ⁻⁵)	CHF(*10 ⁻⁵)	EUR(*10 ⁻⁵)	GBP(*10 ⁻⁵)	JPY(*10 ⁻⁵)	
CONVENTIONAL	EXP	PRE	$\beta_{1,1}$	6.79	4.34***	6.59**	3.03***	2.46***	4.37***
		CONT	$\beta_{1,2}$	22.52***	5.47***	12.14***	6.47***	4.09***	10.21***
		POST	$\beta_{1,3}$	9.47**	0.63***	5.93***	0.752***	0.784***	0.811***
	NON-EXP	PRE	$\beta_{2,1}$	2.25	1.11***	2.6*	2.53***	1.8***	1.89***
		CONT	$\beta_{2,2}$	5.23	2.85***	5.47***	3.87***	2.75***	2.8***
		POST	$\beta_{2,3}$	3.23	0.477***	3.35***	0.673***	0.628***	0.888***
UNCONVENTIONAL	EXP	PRE	$\gamma_{1,1}$	-4.09	-2.76***	-3.84	-1.09***	-0.5	-1.56***
		CONT	$\gamma_{1,2}$	-13.5	-0.198	-1.05	1.61***	1.09***	-1.65***
		POST	$\gamma_{1,3}$	-4.16	0.00451	-1.35	-0.0619	-0.0978	-0.192
	NON-EXP	PRE	$\gamma_{2,1}$	1.29	1.5***	1.15	0.227	0.753*	3.01***
		CONT	$\gamma_{2,2}$	4.75	3.3***	3.06	3.91***	2.17***	7.61***
		POST	$\gamma_{2,3}$	1.5	0.231	0.624	-0.341	-0.125	-1.11***
	UCMP	δ	0.415***	0.223***	0.214***	0.095***	0.173***	0.0646***	
		ϵ	2.84***	0.631***	2.34***	0.829***	0.721***	1.1***	

Notes:

*indicates that the coefficient is significant at the 10% level.

**indicates that the coefficient is significant at the 5% level.

*** indicates that the coefficient is significant at the 1% level.

lowering the rate, the announcement is considered as expansionary under the conventional monetary policy regime. On the other hand, if the change in the federal funds rate was zero or positive, it is counted as “non-expansionary.” Among the 59 FOMC announcements under conventional policy regime in the sample, there are 13 announcements pointing to a negative change in the federal funds rate, hence the policy stance is identified as expansionary. The remaining 46 announcements are defined as non-expansionary.

While it is straight forward to categorize announcements as expansionary or not under conventional monetary policy (since we need only consider in which direction, if any, the federal funds rate is posed to move), under the unconventional monetary policy regime, it is less obvious whether announcements are expansionary or not, given that the federal funds rate remained at the zero lower bound during the whole unconventional policy regime period. To define the announcements as expansionary or non-expansionary, we need to first analyze how the monetary policy is describe by the FOMC using the information in the statement for each FOMC meeting released by the Board of Governors of the Federal Reserve System website.⁷ Then, we are able to identify whether an announcement is expansionary or not.

By consulting the statements for each FOMC meeting, we categorize the monetary policy according to four different criteria that are described. These four criteria revolve around I) securities, II) the credit environment, III) policy intentions and IV) interest rates.

The first criterion is with respect to securities. The statements indicate the amount of securities the Federal Reserve will purchase or roll over if the securities are maturing. Securities include agency mortgage-backed securities, agency debt, and long-term treasury securities.

The second criterion concerns the credit environment. For example, in the statement released on 18 March 2009, the FOMC announced that “the Federal Reserve has launched the Term Asset-Backed Securities Loan Facility to facilitate the extension of credit to households and small businesses and anticipates that the range of eligible collateral for this facility is likely to be expanded to include other financial assets.”⁸ On the other hand, the Fed has made statement such as “the Federal Reserve has been closing the special liquidity facilities that it created to support markets during the crisis.”⁹ A statement of this sort would be classified as non-expansionary.

The third criterion is about the intention of the policy; Announcements (statements) point out whether actions are intended to stimulate the economy or to cool down the economy. For example, “to support a stronger economic recovery” or “to promote a stronger pace of economic recovery,” is used in the statement to describe the expansionary intention of the policy. On the other hand, an announcement made that include the following type of statement, “in order to promote a smooth transition in markets, the Committee will gradually slow the pace of its purchases of both agency debt and agency mortgage-backed securities,”¹⁰ suggests non-expansionary policy. Such an announcement was made on 27 January 2010, for example.

The fourth criterion refers to the federal funds rate or long-term interest rates. Statements might suggest that the FOMC anticipate the length of the federal funds rate staying at the lower bound, the FOMC expects lower levels for the federal funds rate for an extended period, or expects the policy “should put downward pressure on long-term interest rates and help make broader financial conditions more accommodative.”¹¹ An example of this is the announcement made on 21 September 2011.

The first criterion is mentioned in all the FOMC statements under unconventional policy in the sample period which is not surprising because the Fed is implementing unconventional monetary policy by making large-scale asset purchases. In the context of the federal funds rate being set to the zero-lower bound, the fourth criteria is mentioned in almost all the FOMC statement. Therefore, we define the type of monetary policy based on criteria II and III. When refereeing to criterion II, the

Table 9. Results for T-test

	AUD (*10 ⁻⁵)	CAD(*10 ⁻⁵)	CHF(*10 ⁻⁵)	EUR(*10 ⁻⁵)	GBP(*10 ⁻⁵)	JPY(*10 ⁻⁵)
$\beta_{1,1} + \gamma_{1,1}$	2.89 (0.53)	1.58 (0.000***)	2.75(0.100)	1.93 (0.000***)	1.96 (0.000***)	2.81 (0.000***)
$\beta_{1,2} + \gamma_{1,2}$	9.02(0.050*)	5.28 (0.000***)	11.09 (0.000***)	8.08 (0.000***)	5.17 (0.000***)	8.55 (0.000***)
$\beta_{1,3} + \gamma_{1,3}$	5.31(0.045**)	0.675 (0.000***)	4.58 (0.000***)	0.69 (0.000***)	0.686 (0.000***)	0.619 (0.000***)
$\beta_{2,1} + \gamma_{2,1}$	3.55(0.689)	2.61 (0.000***)	3.74(0.245)	2.75 (0.000***)	2.55 (0.000***)	4.9(0.000***)
$\beta_{2,2} + \gamma_{2,2}$	9.98(0.259)	6.16 (0.000***)	8.53 (0.008***)	7.78 (0.000***)	4.92 (0.000***)	10.44 (0.000***)
$\beta_{2,3} + \gamma_{2,3}$	4.74(0.354)	0.708 (0.002***)	3.97(0.033**)	0.332(0.113)	0.503 (0.015**)	-0.218 (0.402)

Notes:

*indicates that the coefficient is significant at the 10% level.

**indicates that the coefficient is significant at the 5% level.

*** indicates that the coefficient is significant at the 1% level.

policy announcement is considered as expansion, if the FOMC is launching to loosen the credit environment, while it is non-expansionary if the FOMC is closing “the special liquidity facilities that is created to support markets during the crises.” Regarding criterion III, the announcement is considered as expansionary if the intention of the policy is to “support a stronger economic recovery,” while it is non-expansionary if the policy is to promote a smooth transition in the markets.

Under unconventional monetary policy regime, the Federal Reserve had 43 FOMC announcements from November 2008 to February 2014. Among the 43 announcements, 32 are identified as expansionary policy announcements, and the remaining 11 non-expansionary announcements using the criteria described above. (See Table 7 for the categorization.) The regression distinguishing expansionary and non-expansionary announcements is as follows:

$$\text{vol}_t = \alpha \text{vol}_{t-1} + \sum_{j=1}^2 \sum_{\tau=1}^3 \beta_{j,\tau} d_{j,\tau,t} + \sum_{j=1}^2 \sum_{\tau=1}^3 \gamma_{j,\tau} (\text{UCMP}_t * d_{j,\tau,t}) + \delta \text{UCMP}_t + c + \epsilon_t \quad (2)$$

The variable denoted $d_{j,\tau,t}$ is a dummy variable representing an announcement of category j during the period τ . The dummy variable is equal to 1 if there is a FOMC announcement during the time interval t and is 0 otherwise. The index τ implies a time window around each announcement: a pre-announcement period ($\tau = 1$), a contemporaneous period ($\tau = 2$), and a post-announcement period ($\tau = 3$). The index j indicates the category of the announcement: an expansionary announcement ($j = 1$), and a non-expansionary announcement ($j = 2$). The dummy variable UCMP distinguishes the different monetary policy regimes. It is equal to 0 before October 2008 and equal to 1 after that. The interaction term $\text{UCMP}_t * d_{j,\tau,t}$ captures the change in the impact of announcements on exchange rate volatility under different regimes.

There were 58 announcements over the time period of analysis under the conventional regime. Thirteen are considered as expansionary because of the decrease in the federal funds rate target. There were 43 announcements under the unconventional regime, of which 32 are considered as expansionary according to evaluation of the four criteria described earlier.

Results of equation (2) are reported in Table 8. The β coefficient show whether volatility increases significantly around announcements under the conventional monetary policy regime. Based on the results, the volatility of all the exchange rates increase significantly, responding to expansionary announcements under conventional policy regime, while five out of the six increases responding to non-expansionary announcements. The coefficient γ reveals whether the impacts of announcements on volatility are significantly different under the different regimes. Results show that in the pre-announcement periods, the impact of expansionary announcements under the unconventional regime is smaller than that under the conventional regime for three out of the six exchange rates. However, results are mixed for contemporaneous periods. Regarding the non-expansionary announcements, however, the impacts of these announcements are greater under unconventional regime for the pre-announcement and contemporaneous announcements for three exchange rates. There is no significant difference in the post-announcement period for the case of the Japanese yen (JPY). According to these results, in general, it appears that the impacts of non-expansionary monetary policy announcements on exchange rate volatility are the same or greater under unconventional monetary policy relative to conventional monetary policy during the pre-announcement and contemporaneous periods; while the impacts of expansionary announcements are the same or less under unconventional monetary policy relative to conventional monetary policy with the exception of the Euro and the British pound during the contemporaneous period.

$$\text{vol}_t = \alpha \text{vol}_{t-1} + \sum_{j=1}^2 \sum_{\tau=1}^{r-1} \beta_{j,\tau} d_{j,\tau,t} + \sum_{j=1}^2 \sum_{\tau=1}^{r-1} \gamma_{j,\tau} (\text{UCMP}_t * d_{j,0,\tau,t}) + \delta \text{UCMP}_t + c + \epsilon_t \quad (3.2)$$

While the estimated value for β indicate the impact of announcements on volatility under the conventional policy regime and the estimated γ indicate the change in this impact, they do not tell us whether the impacts of announcements on volatility are significant under the unconventional monetary policy regime. The impact of announcements under the unconventional regime is captured by $\beta_{j,\tau} + \gamma_{j,\tau}$. Therefore, we conducted a t-test to examine whether the volatility is impacted significantly around announcements under the unconventional regime.

$$H0: \beta_{j,\tau} + \gamma_{j,\tau} = 0$$

$$H1: \beta_{j,\tau} + \gamma_{j,\tau} \neq 0$$

If we fail to reject the null, it means that the impacts of announcements on the volatility are not statistically different when compared with the unconventional regime. If we reject the null, it implies that the volatility changes significantly around announcement under unconventional regime.

Table 9 shows results and p-values of T tests (in parentheses) of the linear combination of β and γ . Compared to β , which show the impact of announcements on volatility under conventional regime, four out of the six exchange rates become more volatile in the pre-announcement periods after October 2008, while five out the six are more volatile before October 2008 conditioning on the fact that the announcement is expansionary. The volatility of four exchange rates respond significantly to non-expansionary announcements in the pre-announcement period under unconventional regime compared to five under conventional regime. Three exchange rates become more volatile in the post-announcement period under unconventional regime compared to five under conventional regime if the announcement is non-expansionary.

Hence, in addition to the results that the impacts of announcement on volatility are different before and after the policy change, fewer exchange rates respond significantly to announcements under unconventional monetary policy regime with respect to volatility. Besides, none of the exchange rates decreases in volatility around announcements.

6. Conclusion

This paper examines six exchange rates, the Australian dollar, the Canadian dollar, the Swiss franc, the Euro, the British pound, and the Japanese yen all against the U.S. dollar, to determine if there is substantial impact on the volatility of these exchange rates around monetary policy announcements. This paper also investigates whether there is a difference in impacts conditioned on the monetary policy regime in place—conventional versus unconventional monetary policy. Two conclusions follow from the results reported here. First, exchange rate volatility increases significantly around announcements compared to non-announcement period. Second, there is evidence that the increases in the volatility around announcement are different under the two monetary policy regimes and those differences depend on the type of announcement, whether expansionary or not. While exchange rate volatility is higher when expansionary or non-expansionary policy announcements are made during the unconventional monetary policy regime, the increase in volatility is greater when non-expansionary announcements are made relative to expansionary announcements. In other words, exchange rate volatility responds stronger to the non-expansionary announcements compared to the expansionary ones under the unconventional monetary policy regime.

These findings have important implications. First, they indicate that US monetary policy announcements significantly affect the volatility of exchange rates around announcements. Hence, US monetary policy announcements may be a crucial source of systematic risk. Second, unconventional monetary policy seems to lead to greater volatility of exchange rates in announcement periods. This is to say that market participants respond more strongly to announcements under unconventional monetary policy regime. Hence, the results suggest that implementation of QE may contribute to an increase in the volatility of the exchange rate during announcement periods.

Therefore, this research helps policymakers assess the effects of conventional and unconventional monetary policy on exchange rate volatility and the stability of the foreign exchange market. In addition, it demonstrates that monetary policy announcements could be a crucial source of systematic risk which investors and institutions should pay attention to. Third, this dissertation also provides other central banks with important information to proceed in their implementation of unconventional monetary policy.

The limitation in this study that could be addressed in future research. The sample period does not include the whole unconventional monetary policy regime due to data availability. Future research can expand the sample size by including the data between March 2014 and December 2015. Researchers can also consider including data after December 2015, when the Fed started raising the federal funds rate above zero, a signal that the conventional monetary policy is back in effect, and compare the reaction of exchange rate volatility to monetary policy announcements with the unconventional regime. Since 15 March 2020, the federal funds rate has been at the zero lower bound again, indicating the implementation of a new round of unconventional monetary. Future studies can compare impacts under the two different unconventional monetary policy regimes as well.

Acknowledgements

The data used in this paper was funded by a research grant from the Western Michigan University Graduate School.

Author details

Wan Wei¹
E-mail: wwei@atu.edu
Susan Pozo²

¹ Department of Accounting, Finance, and Economics, Arkansas Tech University, Russellville, USA.

² Department of Economics, Western Michigan University, Kalamazoo, USA.

Citation information

Cite this article as: The effects of conventional and unconventional monetary policy on exchange rate

volatility, Wan Wei & Susan Pozo, *Cogent Economics & Finance* (2021), 9: 1997425.

Notes

1. In all fairness, nominal interest rates can go below zero as was the case of a different policy experiment undertaken by the European Central Bank (ECB) “Lowering the rate on overnight bank deposits at the ECB into negative territory—effectively forcing banks to pay to deposit excess funds—would put the ECB into uncharted territory as the first major central bank to experiment with such a policy. A negative rate could encourage banks to lend money to each other but could also have adverse effects on bank profits.” (Blackstone, Brian and Lawton, Christopher, “ECB’s Sabine Lautenschläger: Open to Negative

- Rates, Asset Purchases," *The Wall Street Journal*, 10 March 2014). For more on this type of policy, see Bech and Malkhozov 2016 and Heider et al 2019.
 2. Bank of England started Quantitative Easing in November 2009 and the last round of QE was in August 2016. <https://www.bankofengland.co.uk/monetary-policy/quantitative-easing>. The European Central Bank conducted QE from March 2015 to December 2018. <https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html>
 3. <http://www.forextickdata.com/>
 4. http://www.federalreserve.gov/monetarypolicy/fomc_historical.htm
 5. Table 5 displays the average volatility during different periods pre and post November 2008 to provide a simple and clear comparison of the volatilities.
 6. The recession begun in December 2007 and officially ended in June 2009, according to the Business Cycle Dating Committee of the National Bureau of Economic Research, the official arbiter of such dates. <http://www.nber.org/cycles/sept2010.html>
 7. <http://www.federalreserve.gov/monetarypolicy/fomccalendars.htm>
 8. <http://www.federalreserve.gov/newsevents/press/monetary/20090318a.htm>
 9. <http://www.federalreserve.gov/newsevents/press/monetary/20100316a.htm>
 10. <http://www.federalreserve.gov/newsevents/press/monetary/20100127a.htm>
 11. <http://www.federalreserve.gov/newsevents/press/monetary/20110921a.htm>
- Disclosure statement**
No potential conflict of interest was reported by the authors.
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