Discussion Paper No. 1276

ISSN (Print) 0473-453X
ISSN (Online) 2435-0982

MEASURING THE SPILLOVERS OF US UNCONVENTIONAL SURPRISES ACROSS MONETARY CONDITIONS WITH LOCAL PROJECTIONS

Arisa Chantaraboontha

March 2025

The Institute of Social and Economic Research
Osaka University
6-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan

Measuring the Spillovers of US Unconventional Surprises across Monetary Conditions with Local Projections

Arisa Chantaraboontha*

February 14, 2025

Abstract

This paper examines the responses of foreign exchange rates to the Federal Reserve's large-scale asset purchases (LSAPs) and forward guidance (FWG) from 2009 to 2022 using local projections. I confirm heterogeneous responses of examined foreign exchange rates to unconventional shocks, varying by magnitude, direction, and duration depending on monetary policy conditions and the type of shock. Both shocks caused the appreciation of foreign exchange rates against the US Dollar in all monetary policy cycles, except for the FWG shock during normalization periods of monetary policy. The FWG shock had a greater impact magnitude on the examined foreign exchange rates than the LSAPs shock. The effects of both unconventional shocks were more persistent during periods of zero lower bound (ZLB) on the policy interest rate than during normalization periods of monetary policy. However, the impact of such shocks on foreign exchange rates diminished within a couple of months, contrasting with the literature that finds more persistent effects. The implementation of variance decomposition reveals that the FWG shock had a significantly greater influence on foreign exchange rate variation than the LSAPs shock, emphasizing the importance of effective guidance communication to the markets.

Keywords: Federal Reserve, Unconventional monetary shocks, Large-scale asset purchases, Forward guidance, Euro, Japanese Yen, Thai Baht, Malaysian Ringgit

*Graduate School of Economics, Osaka University, Japan. Email: u444398i@ecs.osaka-u.ac.jp

1 Introduction

Since 2008, the Federal Reserve (Fed)'s large-scale asset purchases (LSAPs) and forward guidance (FWG) have served as pivotal tools to stabilize financial markets and stimulate US economic recovery by suppressing medium to long-term interest rates.

Numerous studies have demonstrated the effectiveness of unconventional monetary tools, including Rosa (2011), Bauer and Neely (2014), Gürkaynak et al. (2004, 2021), Gagnon et al. (2011), Glick and Leduc (2012), and Neely (2015). A recent study by Swanson (2021) highlighted that forward guidance (FWG) and large-scale asset purchases (LSAPs) had significant effects on bond and stock markets, as well as foreign exchange rates, showing a level of effectiveness comparable to standard monetary policy measures. Furthermore, Ferrari et al. (2021) identified a more pronounced impact of unconventional monetary policy on foreign exchange rates which engage in unconventional operations, particularly under zero-lower-bound conditions, aligning with the findings of Stavrakeva and Tang (2015).

Despite these insights, several aspects of the spillover effects of US unconventional monetary tools on nominal exchange rates—particularly for emerging market currencies, which often experience high exchange rate volatility due to global capital flows—and the way these shocks propagate over time remain poorly understood. Additionally, there is a need to further explore whether each particular unconventional monetary shock transmits symmetrically through advanced and emerging foreign exchange rates across global monetary policy conditions, including ZLB periods and normalization periods. Asymmetrical pass-through could lead to unexpected volatility in exchange rates, complicating policy formulation and risk management. A clearer understanding of these dynamics would help policymakers and financial institutions manage financial stability and associated risks more effectively across varying global financial conditions.

The persistence of the impact of the Fed's unconventional monetary tools also presents contradictory findings that warrant further exploration. While Swanson (2021) and Dedola et al. (2021) observed large and persistent impacts of FWG and LSAPs announcements with no tendency to diminish over the following months, Wright (2012) conversely discovered that the effects of these unconventional monetary policy announcements died out fairly quickly over the subsequent months.

To the best of my knowledge, the existing literature has barely employed impulse response analysis and variance decomposition to measure the magnitude, propagation and contributions of unconventional monetary shocks on foreign exchange rates. This study uniquely contributes to the field by analysing a more comprehensive dataset that spans from the 2009 financial crisis to the post-pandemic period, thereby covering the full cycle of two Zero Lower Bound (ZLB) periods and one non-ZLB period. This extensive temporal coverage allows for a more robust examination of the effects of the Fed's quantitative easing (QE) tools across global monetary policy conditions.

Accordingly, the key questions to further explore in this paper include: 1) whether exchange rates react differently in terms of direction and magnitude to each type of the Fed's unconventional monetary shock; 2) examining whether the shock impacts vary across currencies; 3) comparing the variation of foreign exchange responses to monetary shocks between ZLB periods and normalization periods; 4) exploring the persistence of the shock during different monetary policy circumstances and 5) observing which shock contributes significantly to the variation in foreign exchange. The key foreign exchange rates examined in this paper are the Japanese Yen and the Euro, selected as advanced currencies with QE operations. Additionally, the Thai Baht and the Malaysian Ringgit represent the currencies of emerging Southeast Asian Nations (ASEAN), which are closely aligned in the size of economy and monetary policy cycles, effectively reflecting the Fed's impact on ASEAN emerging economies.

Using data spanning from 2009 through the post-pandemic crisis in 2022, this study finds that the foreign exchange rate responses to the Fed's unconventional shocks vary quantitatively in magnitude, direction, and duration, depending on the prevailing monetary policy conditions and the type of shock. Generally, the LSAPs shock led to the relative appreciation of local foreign exchange rates against the US Dollar, with a greater absolute impact magnitude during ZLB periods. Meanwhile, the FWG shock led to the appreciation of local foreign exchange rates against the US Dollar but failed to do so during normalization periods, with a greater magnitude of shock response during hiking time. This highlights the reduced effectiveness of the Fed's FWG in containing exchange rate volatility and its diminished role in easing pressure on the US Dollar.

Furthermore, the effects of US unconventional shocks were more persistent during ZLB periods compared to normalization periods. Next, the FWG shock significantly contributed to foreign exchange rate variation, as indicated by variance decomposition, aligning with the measurement of a greater absolute impact from the FWG shock compared to the LSAPs shock. Lastly, heterogeneous reactions to unconventional shocks were observed across currency pairs. During ZLB periods, a clear pattern emerged, with notable QE effects on emerging market currencies but no significant impact on major global exchange rates.

The remainder of the paper is structured as follows. Section 2 delves into the theory and methodologies used in each part of the analysis. Section 3 provides the details of the research data. Section 4 explains the process of constructing unconventional monetary policy shocks, specifically unexpected large-scale asset purchases (LSAPs) and unexpected forward guidance (FWG). Following this, Section 5 presents empirical results on the reactions of foreign exchange rates to unconventional surprises from the Fed across monetary policy cycles. The paper concludes in the final section.

2 Theory and Methodology

In this section, overviews of the theories and methodologies referenced for each part of the study are provided.

2.1 Uncovered Interest Parity (UIP)

The movement of nominal exchange rates is theoretically grounded in the Uncovered Interest Parity Condition (UIP), where unexpected changes in interest rate path differentials between two economies play a crucial role.

With S_t denoting the foreign exchange rate of the country j to US Dollar, we can express the factors underlying the foreign exchange movements as follows.

$$\log S_t = (i_t^j - i_t^{us}) + \mathrm{E}_t \log S_{t+1}$$

$$\log S_t - \log S_{t-1} = (\mathrm{E}_t - \mathrm{E}_{t-1}) \sum_{k=0}^{\infty} (i_{t+k}^j - i_{t+k}^{us}) + (i_{t-1}^j - i_{t-1}^{us})$$

In reference to the above mathematical expressions, the foreign exchange rate at time t is influenced by interest rate differentials between two countries and the expected future trajectory of the exchange rate. The variation in the exchange rate between t and $t-1$ is consequently driven by changes in the expectations of future interest rate path differentials, as well as the realized interest rate differential from the preceding period.

As the Fed's potential monetary actions will already be expected by market participants, they will be reflected in the current market value of the foreign exchange rate. However, only the unexpected component of these Fed's actions will affect the revision of future interest rate expectations, thereby inducing foreign exchange movements. Since the focus is solely on monetary shocks from the Fed, I assume that shocks from counterpart central banks remain at the status quo. To conduct empirical analysis, the dataset of US bond yields and federal fund rate will be utilized to construct the Fed's unconventional monetary shocks used in this study.

2.2 Methodology for Unconventional Shock Identifications

There are numerous ways to construct unconventional monetary shocks. For instance, Ferrari et al. (2021) assumes that changes in the 3-month interest rate represent a target surprise, the difference between the 2-year and 3-month rates as a path surprise, and the gap between 10-year and 2-year bond yields as a long-term surprise. However, this paper will employ the technique introduced by Gürkaynak et al. (2004) and empirically used in Swanson (2021) as follows.

$$X = F\mathit{\Lambda} + \epsilon \tag{1}$$

where X is a $t \times n$ matrix, t represents key monetary policy announcement dates and public speech dates by key Federal Reserve officials, n is the number of corresponding asset prices' changes on such date and F represents latent factors in the form of $t \times k$ matrix. Let denote that k is the number of unobserved factors with k less than n. In addition $\mathit{\Lambda}$ is $k \times n$ loading matrix or an orthogonal matrix.

To estimate the unobserved factors in the matrix F, the first three principal components will be extracted from the data matrix X. Identifying the type of monetary shocks will be associated with analysing the structure of the loading matrix and applying theoretical constraints to ensure the accurately represented characteristics of the specific monetary shocks.

To illustrate more clearly, suppose here that the orthogonal matrix $\widetilde{U}$ with 3×3 dimension of determining factors and $\widetilde{\omega}_{ij}$ is an element at row i and column j of the matrix $\widetilde{U}$. It is important to note that row $i = 1$ to 3 represents the federal fund rate shock, the FWG shock, and the LSAPs shock, respectively. Meantime column j represents current, medium and long-term tenor of a yield curve.

In a general concept of the characteristics of monetary shocks, a surprise component of the change in federal funds rate would be associated with its impact on the current tenor of the yield curve. However, the FWG shock signals the unexpected change in future path of monetary policy. Consequently, its impact should be observed in the medium-term tenor of yield curve, while having no effect on the current tenor or the federal funds rate. This suggests the appropriate restriction of $\widetilde{\omega}_{21} = 0$. Concerning the LSAPs shock, it would also pose no impact on the current tenor of interest rate since it is intended to suppress yields at the long-term tenor. Together with the fact that the LSAPs tools have been mainly implemented during ZLB periods, it is uncontroversial to also impose a restriction $\widetilde{\omega}_{31} = 0$.

After imposing the restrictions in key elements of $\widetilde{U}$ as stated above, we then choose $\widetilde{U}$ which minimizes the sum squared errors in the model, ensuring they match the same errors as obtained when using the unrestricted loading matrix from (1) or $\widetilde{\Lambda}$. With equivalent errors in the model using the loading matrices $\widetilde{U}$ and $\widetilde{\Lambda}$, we can state that $F\widetilde{U}$ is an alternative model of $F\widetilde{\Lambda}$. Alternatively, it can be stated that utilizing the restricted loading matrix in the model represents an identical model to that using the unrestricted loading matrix.

By confirming the calibrated loading matrix with restrictions in line with the concept of monetary shock characteristics, we can therefore identify the type of the Fed's monetary shocks received from the shock synthesis procedure and subsequently use these shocks further in the empirical section.

2.3 Impulse response by Local Projections

To illustrate the magnitude and the direction of foreign exchange rate responses to unconventional monetary policy shocks, this paper will employ the technique of Local Projections introduced by Jordà (2005).

The application of this method involves directly estimating a univariate model of foreign exchange rate responses to each unconventional monetary shock at each forecast horizon of interest for each regression, rather than estimating through the entire dynamic system with the required lag specifications as in a VAR model. This approach enables estimation using simple regression techniques, thereby reducing computational burden. Moreover, it is less sensitive to model misspecification which may arise from incorrect lag length specifications.

Additionally, local projections do not require linearity or time-invariance in the relationships between variables. This makes them better suited for handling nonlinear relationships and offers greater flexibility for additional model specifications compared to the VAR approach.

To elaborate further, the following regression expression used in this paper is adapted from Sekine and Tsuruga (2018).

$$S_{j,t+k} - S_{j,t-1} = a_{j,k} + \textstyle\sum_{i=1}^{q} \beta_{i,k}(S_{j,t-i} - S_{j,t-i-1}) + \gamma_{j,k} X_{ump,t} + u_{j,t+k}^{k}$$

where $S_{j,t}$ is a nominal exchange rate of country j per US Dollar at time t and $a_{j,k}$ is a country fixed effect, k is a forecast horizon, and the variable $X_{ump,t}$ represents the unconventional monetary policy shock at time t, which includes large-scale asset purchases (LSAPs) and forward guidance (FWG) respectively. We assume $X_{ump,t}$ is orthogonal to $u^k_{j,t}$, and $u^k_{j,t}$ implicitly follows the MA(k) process.

Therefore, the impulse response (IRF) of foreign exchange rate of country j at the k-th forecast horizon when facing an unconventional shock at time t can be represented as follows:

$$IRF(k,j) = \gamma_{j,k} \text{ for } k = 0,1,..K$$

2.4 Variance decomposition by Local Projections

Local projections can provide a simple and intuitive way to assess the contribution of identified shocks to the variation of foreign exchange rates at different horizons. For this study, a variance decomposition, $D_{j,t+k}$, illustrated in Gorodnichenko and Lee (2020) will be used as follows:

$$D_{j,t+k} = \frac{(\sum_{k=0}^{K} \hat{\gamma}^2_{j,k})\ \hat{\sigma}^2_{X_{ump}}}{Var(\hat{\gamma}_{j,k}\ X_{ump,t} + u^k_{j,t+k})}$$

where j denotes country, k is forecast horizon, and $Var(X_{ump,t}) \equiv \hat{\sigma}^2_{X_{ump}}$

Gorodnichenko and Lee (2020) state that such estimation does not matter in large samples, but possible biases may arise in small-sample cases. If this is the case, a bootstrap should be used in the local projections' variance decompositions to correct estimation biases.[1] However, due to the sufficiently large sample size used in this paper, the results are less subject to small-sample biases.

[1]As a general guideline, a minimum of 1,000 simulations is commonly used in bootstrap estimation. Higher numbers of replications, such as 5,000 to 10,000, can further enhance the stability of the estimates. Gorodnichenko and Lee (2020) employed a VAR-based bootstrap technique by simulating 2,000 artificial time series to compute the true distribution of the forecast error variance for the dependent variable and to correct small-sample bias.

3 Data

3.1 Daily data of normal trading days

Since most of the previous literature was conducted using datasets predating 2019, this paper includes a longer dataset covering January 2009 to March 2022, comprising 3,445 normal trading days, excluding weekends.

Rather than only using the federal funds rate, this study employs the Bai-Perron Global Breaks test to identify structural breaks in nominal exchange rates, reaffirming the timing of monetary policy cycle shifts. The time series is divided into two periods based on the respective global monetary policy cycles: 945 samples represent normalization periods (December 2015 to July 2019), while 2,500 samples account for the two periods of zero lower bound (January 2009 to mid-December 2015, August 2019 to March 2022). Table 1 provides an illustration of the analytical timeframe mentioned in this paper. The entire time series will be used for measuring the course of foreign exchange responses to unconventional monetary policy shocks on regular trading day with the Local Projections technique.

[insert Table 1]

The foreign exchange rates will be divided into two groups: major global currencies, including the Japanese Yen and the Euro, and emerging ASEAN (Southeast Asian Nations) currencies, such as the Thai Baht and the Malaysian Ringgit. The Thai Baht and the Malaysian Ringgit were selected as representatives of key emerging ASEAN currencies due to their economic significance as the second- and third-largest economies in the ASEAN community respectively [2], as well as their relatively similar monetary policy cycles, reflected in the movement of policy rates. This categorization allows the study to examine potential differences in the response of these two foreign exchange rate groups to the Federal Reserve's unconventional surprises. Table 2 provides descriptive statistics of the respective exchange rates.

[insert Table 2]

[2] Although Indonesia is the largest economy in ASEAN, it is highly reliant on commodities for more than 50 percent of its total merchandise exports. Consequently, its economy, export performance as well as the value of Indonesian Rupiah are significantly influenced by fluctuations in global commodity prices, which could potentially lead to bias in measuring the influence of the United States' QE program.

3.2 Intraday data for constructing Unconventional Monetary shocks

Following the high-frequency data methodology used in Swanson (2021) and Nakamura and Steinsson (2018), I first accumulated intraday data for five financial market variables to replicate the shape of the yield curve. These variables include the federal funds rate, the 3-month Eurodollar rate and US Treasury yields with maturities of 2 years, 5 years, and 10 years. The data was collected from 15-minute windows from both before and after 14:00, the time of the US's key monetary announcements following its FOMC meetings. This narrow timeframe is intended to ensure that the variable response reflects only FOMC actions, minimizing the influence of other factors. The complete dataset comprises a total of 116 event dates, including FOMC meetings from January 2009 to March 2022, as well as speeches from Federal Reserve officials, which are expected to significantly influence market expectations regarding the Fed's upcoming unconventional monetary policy, [3] as shown in Table 3.

[insert Table 3]

To extract key latent factors from these financial dataset on event dates, principal components analysis is utilized. These unobserved factors should likely represent the significant underlying monetary components driving foreign exchange movements during key announcement dates, including shocks related to the federal funds rate (FFR), forward guidance (FWG), and large-scale asset purchases (LSAPs).

To accurately identify the type of monetary shocks of these synthesized factors, it is essential to analyze their impacts on a yield curve. The FFR shock primarily exerts a short-term impact on the yield curve, while the FWG shock tends to influence the medium-term tenors, specifically those with 2- to 5-year maturities. In contrast, the impact of the LSAPs shock is most pronounced in the long-term tenors of the curve, such as those with 10-year maturities.

4 Identifying Unconventional Monetary Policy shocks

Based on the calculations in this study, the corresponding outcomes from the principal component analysis allow for only two out of the expected three key components of monetary

[3] The selection criterion is that the senior official's speech must include explicit guidance from FOMC speeches or personal views that provide the potential direction of the Fed's upcoming large-scale asset purchases.

policy factors whose eigenvalues are greater than 1, referring to Kaiser-Guttman criteria.[4] The first component accounts for 51 percent of the data variation and the second one accounts for 21 percent, as shown in Table 4. This is slightly greater than the PCA outcomes from Kim et al. (2023) of 40 percent and 10 percent, respectively.

[insert Table 4]

In identifying the type of monetary shock of these synthesized factors, it is crucial to examine the shape of coefficients in the rotated loading matrix revealed by the PCA method. In doing so, I imposed the previously mentioned theoretical restrictions on the loading factors and selected the one that yields the least sum of squared errors, consistent with the non-imposed scenario.

Drawing from the previous section, the first principal components identified in the loading matrix exhibits characteristics consistent with the LSAPs factor, displaying a monotonically rising impact up to a 10-year maturity. [5] This aligns with the findings of Kim et al. (2023). The second component corresponds to the nature of the FWG factor, demonstrating a hump-shaped effect peaking around a 2-year maturity. For a comparative reference between the respective factors identified in this paper and the literature, please see Figure 1. Based on this PCA method, it is appropriate to designate the first and the second components as the LSAPs shock and the FWG shock, respectively.

[insert Figure 1]

Before proceeding with the empirical analysis in the next section, the extracted unconventional shocks from the PCA method were standardized to have a unit of standard deviation. Additionally, the impact of these synthesized shocks on 10-year US Treasury yields were cross-checked with other literature. The findings indicate that the LSAPs factor led to a reduction in the 10-year US Treasury yield by 36 basis points, consistent with the findings of Kim et al. (2023) but much larger than Swanson (2021), which found a reduction of only 6.5 basis points. The positive impact of the FWG shock on the 10-year US Treasury yield was approximately 2.6 basis points, slightly smaller than the 3-4 basis points found in

[4] This paper primarily refers to the Kaiser-Guttman criterion (Guttman, 1954), which considers factors with eigenvalues greater than 1, as it is more straightforward to apply in cases where the analysed dataset is not highly dimensional, as in this study. Meanwhile, the BN criterion (Bai and Ng, 2002), which determines the number of factors by minimizing information criteria, is more complicated and better suited for large and high-dimensional datasets.

[5] It is worth noting that, based on factor analysis in this study, the extracted LSAPs factor prior to theoretical imposition, has almost no impact on the federal funds rate or the current tenor of the yield curve. Accordingly, this reaffirms the alignment of the extracted factor with the characteristics of the LSAPs.

Swanson (2021) during the post-2008 crisis period.

To convert the unconventional shocks from an event frequency to a daily frequency compatible with the database used in this analysis, a linear path between event dates was assumed. Subsequently, an equally weighted linear interpolation was constructed between two key event dates to obtain the daily series of unconventional shocks.

5 Empirical results

After constructing and identifying the large-scale asset purchases (LSAPs) shock and the forward guidance (FWG) shock, this section measures and analyses the impulse responses of the exchange rates to each shock using Local Projections. The key aspects of analysis focus on exchange rates' response direction and magnitude, along with the duration of the shock impacts across different monetary cycles.

5.1 Analyzing Impulse Response to the LSAPs shock

Figure 2 presents the impulse response with coefficient tables. During both ZLB periods and normalization periods, foreign exchange rates appreciated against US Dollar, as indicated by the negative sign of γ, in response to the one standard deviation of the Fed's LSAPs shock.

[insert Figure 2]

This finding aligns well with intuition and the uncovered interest parity (UIP) theory, which suggests that an unexpected decrease in the US interest rate path or yield curve can reduce the attractiveness of the US Dollar. This often leads to capital outflows from the United States and consequently an appreciation of foreign exchange rates against the US Dollar or Dollar depreciation.

When comparing the LSAPs impact magnitude across different monetary cycles, it was found that the magnitude of the LSAPs shock on the representative foreign exchanges was greater during ZLB periods than during normalization periods. This is consistent with literature such as Stavrakeva and Tang (2015), which found that exchange rate reactions were more pronounced during the zero lower bound (ZLB) periods of the 2008 financial crisis compared to the 1990s.

Regarding impact persistence, this paper observes that the impact of LSAPs shock during ZLB periods tended to last longer, on average, across currencies compared to during normalization periods.

To gain a more precise understanding, the analysis of the impact magnitude and shock duration will be conducted separately for Asian and key global currencies, as well as across different monetary cycles, as follows. As shown in the left pane of Figure 2, during ZLB periods, the Euro and the Japanese Yen appreciated only slightly against the US Dollar. While the Euro experienced an appreciation solely on the shock date, the Japanese Yen appreciated for just one day after the shock, before quickly returning to its steady state. Meanwhile, the Thai Baht and the Malaysian Ringgit initially appreciated steadily, with a significantly greater rate of appreciation, reaching their peak around 1-2 months after the LSAPs shock, before returning to their steady states by the third month.

The smaller magnitude and short-lived impact of the shock on the two key global currencies during ZLB periods could possibly be explained by the concurrent implementations of massive QE programs by Bank of Japan and ECB, alongside the Fed. These unconventional operations reduce the relative short-term money market rate differentials (Dedola et al., 2021) compared to that of the Fed, as well as the relative differences in market expectations of medium- to long-term interest rate paths. Altogether, these factors seem to have mitigated the influence of the Fed's quantitative easing on these advanced currencies.

Another possible explanation for the delayed shock impact on emerging currencies, which peaked at 4 to 8 weeks, could be the role of foreign exchange management of such emerging countries. This may have helped moderate local currency appreciation against the US Dollar amidst the abundance of global liquidity during ZLB periods. However, these results help confirm the more pronounced impact of the US's massive asset purchase programs on representative Asian currencies compared to major global currencies in terms of both impact magnitude and duration.

During normalization periods, as shown in the right pane of Figure 2, all exchange rates appreciated against the US Dollar by a relatively comparable degree after the LSAPs shock. Most representative foreign exchanges returned to their steady states within 1-2 weeks after the shock, except for the Malaysian Ringgit, which took 3 weeks.

The short-lived impacts of the Fed's massive asset purchases on other nations' foreign exchange rates during normalization periods, compared to ZLB periods, are fairly intuitive. As global financial markets perceive the Fed's shift towards tapering its asset purchases and raising interest rates, liquidity is likely to return to the United States more quickly during normalization periods than during ZLBs periods.

5.2 Analyzing Impulse Response to the FWG shock

Figure 3 illustrates the impact of the Fed's unexpected future pace of monetary policy, or the FWG shock, on the examined foreign exchange rates.

[insert Figure 3]

The impact of the foreign exchange rate response to the FWG shock is found to be state-dependent. During ZLB periods, a 1 standard deviation forward guidance shock led to an appreciation in foreign exchange rates against the US Dollar, while they caused a depreciation across currencies during normalization periods.

The observed contrast in the direction of foreign exchange responses to the FWG shock under different monetary conditions differs from the findings in Swanson (2021), which reported a consistent direction of foreign exchange rate responses to the FWG shock both during and before the 2008 ZLB periods. However, given the Fed's guidance on tapering asset purchases and preparing to raise interest rates during periods of normalization, the US Dollar becomes more relatively attractive, often leading to capital reversals to the U.S. and, consequently, triggering an appreciation of the US Dollar in response to such a forward guidance shock.

When comparing the FWG impact magnitude between monetary cycles, the absolute degree of the FWG impact is found to be stronger in normalization periods than in ZLB periods.

Given the higher absolute magnitudes of the FWG impact during normalization periods compared to ZLB periods, coupled with the previously mentioned inverse impact direction, this finding reveals that guidance communication during normalization periods may be less effective in containing foreign exchange volatility and could be less likely to effectively induce a depreciation of the US Dollar against the other currencies.

Regarding impact persistence, the FWG shock during ZLB periods lasted on average around 60-90 days across currencies, slightly longer than its impact during normalization periods, which lasted 30-60 days.

To explore the magnitude and duration of the impact in more detail, the following analysis was conducted across currencies as well as across monetary cycles. During ZLB periods, the response magnitudes of the Euro, Thai Baht, and Malaysian Ringgit were relatively comparable, with the peak observed approximately 30-45 days after the FWG shock and a return to the steady state occurring within 60-120 days. The Japanese Yen was the only exception, experiencing the smallest degree of impact from the FWG shock, which dissipated within the first 7 days.

During normalization periods, the impact degree is relatively comparable across the Japanese Yen, Thai Baht, and Malaysian Ringgit, with the strongest impact occurring around 14-21 days after the FWG shock. The only exception was the Euro, whose peak response was observed 45 days after the shock, with the strongest impact compared to the others.

5.3 Comparative Analysis and Implications

Based on the impulse response analysis of both the LSAPs shock and the FWG shock, the findings can be interpreted to address some key research questions as follows.

First, the direction in which exchange rates react to each type of the Fed's shocks is heterogeneous. Following the LSAPs shock, foreign exchange rates appreciated against the US dollar under both monetary conditions. In contrast, the FWG shock led to appreciation in local currencies against the US Dollar only during periods of the Zero Lower Bound (ZLB), but caused depreciation during periods of normalization, diverging from the existing literature.

In addition, an unequal response magnitude in foreign exchange rates to these two shocks, LSAPs and FWG, was observed. This paper finds that the response magnitude of exchange rates to the FWG shock was relatively greater than that to the LSAPs shock in both monetary circumstances. These findings are consistent with the quantitative results of Swanson (2021) and Ferrari et al. (2021).

Delving into the impact degree analysis across exchange rates, it is evident that both emerging and major global currencies were affected by each shock to a quite similar degree. Only the LSAPs shock during ZLB periods showed a clear pattern of having a greater impact on emerging market currencies than on key global currencies.

Next, a discrepancy was found when evaluating the responses of foreign exchanges across monetary cycles. The LSAPs shock showed a more pronounced foreign exchange response during ZLB periods. In contrast, the FWG shock caused a larger absolute exchange rate response during periods of normalization, which also coincided with the distinction mentioned above but in the reverse response direction.

Lastly, the variation was observed regarding the impact persistence of both shocks across different monetary cycles. During ZLB periods, the effects of both unconventional shocks, LSAPs and FWG, would typically persist longer than during normalization periods.

5.4 Robustness Check on Combined Influence of the Shocks

In real financial market conditions, two unconventional monetary shocks, the LSAPs shock and the FWG shock, would normally occur and exert their impacts concurrently. Therefore, the test in this section is designed to ensure that the impact of one synthesized shock on foreign exchange rates remains statistically significant, even when another shock occurs simultaneously. This can be achieved by assigning both shocks to be regressed together in a single equation. Additionally, the test aims to provide insights into the direction in which these two shocks jointly influence foreign exchange movements under different financial conditions.

It is important to note that, in line with the objectives of the robustness test, shifting the analysis from capturing the daily dynamic response of foreign exchange rates to focusing solely on the static response represented by a single regression would be preferable. Furthermore, employing 7-day moving average exchange rate data, which help mitigate daily fluctuations for the single regression analysis, is deemed more suitable. Another point is that these two unconventional monetary shocks, derived from Principal Component Analysis, are orthogonal, making it possible to include them together in a cross-check regression without significant statistical bias.

To ensure the robustness of the estimated impact of the FWG shock and the LSAPs shock under the aforementioned circumstances, the test is performed accordingly.

[insert Table 5]

Table 5 presents the estimation of the impact of both the FWG shock and the LSAPs shock on the 7-day moving average of exchange rates over the entire sample period from 2009 to 2022. Initially, each exchange rate is regressed without control variables, followed by regression with the inclusion of its own lagged variables, both of the lagged unconventional shocks, the VIX index, and finally the relative outright asset purchases on central bank's balance sheets of those QE-implementing nations.

The results indicate that both the FWG shock and the LSAPs shock significantly led to an appreciation of across weekly-trending foreign exchange rates against the US Dollar, expressed in negative shock coefficients, as similarly represented in daily-frequency impulse response by Local Projections. The coefficients for the lagged shocks are insignificant and caused mismeasurement in the regression; therefore, excluding lagged shocks is more appropriate for measuring shock impact.

[insert Table 6]

When splitting the data into ZLB periods and normalization periods, as shown in Table 6, both the FWG shock and the LSAPs shock led to an appreciation across foreign exchange rates. The exception is the depreciation of local exchange rates against the US Dollar in response to the FWG shock during normalization periods. This was similarly observed in daily-frequency Local Projections, although it is surprisingly statistically insignificant in this examination of weekly-moving exchange rate regressions.

It is noteworthy that comparing the magnitude of the shock impacts on exchange rates in this single regression test with those impulse responses by the Local Projections is not applicable. This is because the coefficient in a single regression represents the static, time-invariant relationships between predictors and the dependent variable. Meanwhile, a coefficient of impulse response captures the dynamic, time-varying effects of the dependent variable in response to a shock. Despite its limitations, the primary objectives of the robustness test - reaffirming the impact direction and statistical significance of both shocks in alignment with those obtained from the Local Projections - are effectively achieved.

To summarize, the robustness tests of these shocks' impacts consistently confirm the initial findings from Local Projections that the LSAPs shock led to significant appreciations of foreign exchange rates against the US Dollar during both ZLB periods and normalization periods. In contrast, the FWG shock significantly caused exchange rate appreciation against the US Dollar during ZLB periods, but led to depreciation during normalization periods, although this effect was statistically insignificant in the weekly moving average regression.

5.5 Variance Decomposition with Local Projections

This section focuses on employing variance decomposition through Local Projections, aiming to explain the relative importance of each unconventional shock over foreign exchange rate variations and to understand how the significance of these shocks propagates over time.

[insert Figure 4]

Figure 4 clearly illustrates that the FWG shock had a significantly greater impact on foreign exchange fluctuations than the LSAPs shock. The peak contribution of the FWG shock would typically occur approximately 21 to 60 days after the shock across foreign exchange rates. The Japanese Yen is an exception, with the impact of the Fed's FWG surprise reaching its peak 1 to 2 days following the shock, faster than other currencies, but with the least magnitude. In contrast, the influence of the LSAPs shock on foreign exchange variability was notably less pronounced and diminished relatively more quickly than the effects of the FWG shock across monetary conditions.

These results have significant policy implications. The study highlights the importance of communication regarding the future path of interest rates. With its greater role and more prolonged impact on exchange rate variations compared to another shock, effective guidance tools can help shape market expectations and manage foreign exchange fluctuations more effectively. This is especially important during periods of normalization, where forward guidance contributes more to exchange rate variation than it does during ZLB periods. Without successful implementation of forward guidance, financial market turbulence can be expected in normalization eras, similar to what was once experienced in 2013.

6 Conclusions

Using the Local Projections technique, this paper finds the heterogeneous responses of foreign exchange rates to the unconventional shocks from the Federal Reserve in several dimensions. First, a difference in the response direction of exchange rates to the two unconventional shocks was observed. The magnitude of the response was also different, with the FWG shock having a greater absolute impact on the examined foreign exchange rates compared to the LSAPs shock, aligning with its larger contribution to foreign exchange variation in the variance decomposition.

Regarding the measured impact across currencies, both emerging and major global currencies were affected in a quite similar manner. The only exception was the LSAPs shock during ZLB periods, which caused a greater impact on emerging market currencies than on key global currencies. Under different monetary cycles, the varying impact of shocks on currencies was also confirmed.

This paper also finds a variation in the persistence of both shocks' impacts on exchange rates, with effects lasting longer during ZLB periods than during normalization periods.

However, contrary to the findings of Swanson (2021) and Dedola et al. (2021), the present study finds that both unconventional shocks dissipated relatively quickly, typically within a few days to a few months after the shocks. This result is more in line with Wright (2012).

A key area for further exploration is identifying the determinants of the effectiveness of forward guidance communication in stabilizing markets, particularly during tightening periods. This would yield significant policy implications. In addition, comparing the impact of each unconventional shock on real economic variables such as employment and investment is crucial. Given the differences in impact horizon on yield curves - where the FWG shock effectively steers medium-term interest rates, while the LSAPs shock influences long-term tenor - the transmission channels and the time lag before the impact takes effect on real variables warrant further examination.

Acknowledgements

I would like to express my gratitude for the supports from Professor Takayuki Tsuruga, Osaka University, Japan, and the discussants at Vietnam Symposium in Banking and Finance 2024 for their thoughtful and constructive feedback on the previous drafts. Additionally, I gratefully acknowledge the financial support from Grants-in-aid for Scientific Research (JP21H00700). The views expressed in this paper are solely those of the author.

References

Bauer, M.D. and Neely, C.J., 2014. International channels of the Fed's unconventional monetary policy. Journal of International Money and Finance, 44, pp.24-46.

Baumeister, C. and Benati, L., 2012. Unconventional monetary policy and the great recession: Estimating the macroeconomic effects of a spread compression at the zero lower bound (No. 2012-21). Bank of Canada.

Cho, D. and Rhee, C., 2013. Effects of quantitative easing on asia: capital flows and financial markets. Asian Development Bank Economics Working Paper Series, (350).

D'Amico, S. and Seida, T., 2024. Unexpected supply effects of quantitative easing and tightening. The Economic Journal, 134(658), pp.579-613.

Dahlhaus, T., Hess, K. and Reza, A., 2014. International transmission channels of US quantitative easing: Evidence from Canada (No. 2014-43). Bank of Canada working paper.

Dedola, L., Georgiadis, G., Gräb, J. and Mehl, A., 2021. Does a big bazooka matter? Quantitative easing policies and exchange rates. Journal of Monetary Economics, 117, pp.489-506.

Engen, E.M., Laubach, T. and Reifschneider, D., 2015. The macroeconomic effects of the Federal Reserve's unconventional monetary policies. Washington, DC: Federal Reserve Board.

Ferrari, M., Kearns, J. and Schrimpf, A., 2021. Monetary policy's rising FX impact in the era of ultra-low rates. Journal of Banking and Finance, 129, p.106142.

Fratzscher, M., Lo Duca, M. and Straub, R., 2018. On the international spillovers of US quantitative easing. The Economic Journal, 128(608), pp.330-377.

Gagnon, J., Raskin, M., Remache, J. and Sack, B., 2011. The financial market effects of the Federal Reserve's large-scale asset purchases. International Journal of Central Banking, 7(1), pp.45-52.

Gambacorta, L., Hofmann, B. and Peersman, G., 2014. The effectiveness of unconventional monetary policy at the zero lower bound: A cross-country analysis. Journal of Money, Credit and Banking, 46(4), pp.615-642.

Glick, R. and Leduc, S., 2012. Central bank announcements of asset purchases and the impact on global financial and commodity markets. Journal of International Money and Finance, 31(8), pp.2078-2101.

Gorodnichenko, Y. and Lee, B., 2020. Forecast error variance decompositions with local projections. Journal of Business and Economic Statistics, 38(4), pp.921-933.

Gürkaynak, R.S., Sack, B.P. and Swanson, E.T., 2004. Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. The Response of Asset Prices to Monetary Policy Actions and Statements (November 2004).

Gürkaynak, R.S., Kara, A.H., Kısacıkoğlu, B. and Lee, S.S., 2021. Monetary policy surprises and exchange rate behavior. Journal of International Economics, 130, p.103443.

Han, M.F. and Westelius, M.N.J., 2019. Anatomy of sudden yen appreciations. International Monetary Fund.

Jordà, Ò., 2005. Estimation and inference of impulse responses by local projections. American economic review, 95(1), pp.161-182.

Jordà, Ò., 2023. Local projections for applied economics. Annual Review of Economics, 15(1), pp.607-631.

Kapetanios, G., Mumtaz, H., Stevens, I. and Theodoridis, K., 2012. Assessing the economy-wide effects of quantitative easing. The Economic Journal, 122(564), pp.F316-F347.

Kim, K., Laubach, T. and Wei, M., 2023. Macroeconomic Effects of Large-Scale Asset Purchases: New Evidence. Finance and Economics Discussion Series 2020-047r1. Washington: Board of Governors of the Federal Reserve System.

Lenza, M., Pill, H. and Reichlin, L., 2010. Monetary policy in exceptional times. Economic Policy, 25(62), pp.295-339.

Mueller, P., Tahbaz-Salehi, A. and Vedolin, A., 2017. Exchange rates and monetary policy uncertainty. The Journal of Finance, 72(3), pp.1213-1252.

Nakamura, E. and Steinsson, J., 2018. High-frequency identification of monetary non-neutrality: the information effect. The Quarterly Journal of Economics, 133(3), pp.1283-1330.

Neely, C.J., 2015. Unconventional monetary policy had large international effects. Journal of Banking and Finance, 52, pp.101-111.

Rosa, C., 2011. The high-frequency response of exchange rates to monetary policy actions and statements. Journal of Banking and Finance, 35(2), pp.478-489.

Sekine, A. and Tsuruga, T., 2018. Effects of commodity price shocks on inflation: A cross-country analysis. Oxford Economic Papers, 70(4), pp.1108-1135.

Stavrakeva, V. and Tang, J., 2015. Exchange Rates and Monetary Policy. Working Papers 15-16, Federal Reserve Bank of Boston.

Swanson, E.T., 2021. Measuring the effects of federal reserve forward guidance and asset purchases on financial markets. Journal of Monetary Economics, 118, pp.32-53.

Wright, J.H., 2012. What does monetary policy do to long-term interest rates at the zero lower bound?. The Economic Journal, 122(564), pp.F447-F466.

Tables and Figures

Table 1: Regression timeframe for varying monetary policy periods

	Full Sample	ZLBs	Normalization
Periods	01/01/2009 -03/16/2022	01/01/2009 -12/16/2015, 08/01/2019 -03/16/2022	12/17/2015, -07/31/2019
Sample Size	3445	2500	945
Number of Event	116	81	35

Note: This table illustrates the duration of periods concerning global financial conditions: ZLB periods, and a normalization phase. The Bai-Perron Global L Breaks test is utilized to detect structural breaks in foreign exchange time series, alongside the information on the federal funds rate.

Table 2: Descriptive statistics

	Full Sample	ZLBs	Normalization
USDJPY			
Mean	0.94	1.70	-1.08
Standard deviation	0.57	0.58	0.55
USDEUR			
Mean	0.84	1.18	-0.05
Standard deviation	0.56	0.59	0.45
USDTHB			
Mean	-0.08	0.52	-1.65
Standard deviation	0.29	0.30	0.26
USDMYR			
Mean	0.64	1.04	-0.42
Standard deviation	0.40	0.42	0.33

Note: 1) Means are represented as basis points of percentage change of respective currency per one US Dollar. 2) ZLB denotes the zero-lower-bound periods, while Normalization refers to the period during which the Fed begins tapering and preparing to raise interest rates.

Table 3: Dates with Speeches by Federal Reserve officials

	Speeches of Fed Chairman
August 27, 2010	Chair Bernanke at Jackson Hole
August 26, 2011	Chair Bernanke at Jackson Hole
May 22, 2013	Chair Bernanke at JEC Testimony
October 6, 2020	Chair Powell at NABE Virtual Annual Meeting
August 27, 2021	Chair Powell at Jackson Hole
	Speeches of Fed Governors
June 27, 2013	Governor Powell at the Bipartisan Policy Center
October 11, 2013	Governor Powell at the 2013 Institute of International Finance Annual Membership Meeting
October 13, 2021	Governor Bowman at South Dakota State University
October 19, 2021	Governor Waller at the Stanford Institute for Economic Policy Research Associates Meeting
November 19, 2021	Governor Waller at the Center for Financial Stability

Note: In addition to regular FOMC announcement dates, dates with public speeches by high-ranking Federal Reserve officials are included in the high-frequency identification of unconventional monetary shocks, as shown above.
Source: Federal Reserve Board

Table 4: The Eigen values from principal components analysis (PCA) on financial data
Eigenvalues: (Sum = 5, Average = 1)

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	2.56	1.492	0.512	2.562	0.512
2	1.07	0.262	0.214	3.632	0.726
3	0.81	0.285	0.162	4.441	0.881

Source: Author's calculations

Table 5: The daily estimation of the 7-day moving average of exchange rates in response to forward guidance (FWG) and large-scale asset purchases (LSAPs) on daily trading day from 2009 to 2022

D(USDJPY)	Full sample (7-day moving average)				
C	0.62*	0.34	0.36	0.93***	0.87***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
FWG	-4.27***	-2.32***	0.50	-2.42***	-2.58***
	(0.009)	(0.008)	(0.017)	(0.007)	(0.007)
LSAPs	-7.40***	-3.95***	-5.76***	-4.23***	-4.32***
	(0.009)	(0.008)	(0.016)	(0.008)	(0.008)
FWG(-1)			-2.96		
			(0.019)		
LSAPs(-1)			1.95		
			(0.018)		
D(VIX)				-1.90***	-1.90***
				(0.001)	(0.001)
BOJ-FedBS					0.002**
					(0.000)
D(USDJPY(-3))		54.09***	54.08***	51.37***	51.12***
		(0.018)	(0.018)	(0.018)	(0.017)
Adjusted R^2	0.03	0.31	0.31	0.36	0.36
D(USDEUR)	Full sample (7-day moving average)				
C	0.46	0.14	0.15	-0.05	-0.03
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
FWG	-2.19***	-1.47**	-1.90	-1.37**	-1.29*
	(0.008)	(0.007)	(0.017)	(0.007)	(0.007)
LSAPs	-2.63***	-0.85*	-4.44**	-0.65*	-0.48*
	(0.009)	(0.008)	(0.021)	(0.008)	(0.008)
FWG(-1)			0.47		
			(0.018)		
LSAPs(-1)			3.83*		
			(0.021)		
D(VIX)				0.63***	0.63***
				(0.001)	(0.001)
ECB-FedBS					-0.002**
					(0.000)
D(USDEUR(-3))		55.22***	55.22***	54.86***	54.67***
		(0.016)	(0.016)	(0.016)	(0.016)
Adjusted R^2	0.00	0.30	0.31	0.31	0.31

D(USDTHB)	Full sample (7-day moving average)			
C	-1.73***	-0.90***	-0.90***	-1.01***
	(0.002)	(0.002)	(0.002)	(0.002)
FWG	-1.67***	-0.70**	0.16	-0.60**
	(0.004)	(0.003)	(0.010)	(0.003)
LSAPs	-3.60***	-1.72***	-1.62	-1.64***
	(0.006)	(0.005)	(0.010)	(0.005)
FWG(-1)			-0.92	
			(0.010)	
LSAPs(-1)			-0.10	
			(0.011)	
D(VIX)				0.56***
				(0.001)
D(USDTHB(-3))		56.72***	56.72***	56.34***
		(0.018)	(0.018)	(0.018)
Adjusted R^2	0.02	0.33	0.33	0.35
D(USDMYR)	Full sample (7-day moving average)			
C	0.34	0.08	0.08	-0.28
	(0.003)	(0.002)	(0.002)	(0.002)
FWG	-1.44**	-1.02**	-0.61	-0.95**
	(0.006)	(0.005)	(0.014)	(0.005)
LSAPs	-4.77***	-2.69***	-2.28	-2.66***
	(0.008)	(0.007)	(0.019)	(0.006)
FWG(-1)			-0.43	
			(0.014)	
LSAPs(-1)			-0.45	
			(0.019)	
D(VIX)				1.24***
				(0.001)
D(USDMYR(-3))		58.92***	58.91***	56.34***
		(0.022)	(0.022)	(0.022)
Adjusted R^2	0.01	0.36	0.36	0.39

Note: 1) ***, ** and * represent 1, 5, and 10 percentage of significant level respectively 2) Text in parenthesis represents a heteroskedasticity and autocorrelation consistent standard error (HAC). 3) The respective foreign exchange rate is represented as units per 1 US Dollar 4) Coefficients are in a unit of basis point of a percentage change from a previous period. A Positive number indicates a depreciation of foreign exchange to US Dollar and a negative means an appreciation.

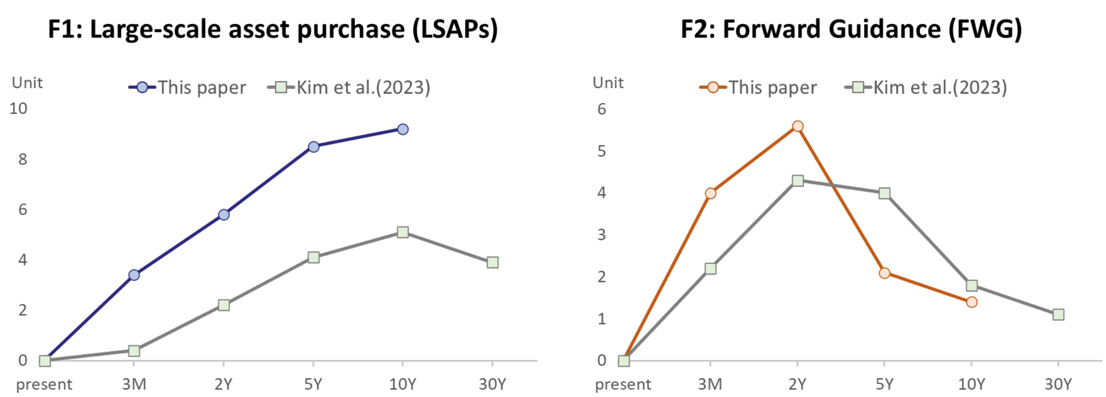
Table 6: The daily estimation of the 7-day moving average of exchange rates in response to forward guidance (FWG) and large-scale asset purchases (LSAPs) on daily trading day from 2009 to 2022, across monetary circumstances

D(USDJPY)	ZLBs			Normalization		
C	0.59*	1.21***	1.17***	-0.16	0.26	0.30
	(0.003)	(0.003)	(0.003)	(0.006)	(0.006)	(0.006)
FWG	-2.49**	-2.68**	-2.87**	0.22	0.39	0.30
	(0.011)	(0.012)	(0.012)	(0.028)	(0.028)	(0.028)
LSAPs	-3.31***	-3.39***	-3.24***	-4.49***	-5.38***	-5.29***
	(0.010)	(0.010)	(0.010)	(0.016)	(0.017)	(0.017)
D(VIX)		-1.54***	-1.55***		-2.15***	-2.16***
		(0.002)	(0.002)		(0.002)	(0.002)
BOJ-FedBS			0.005***			-0.001
			(0.000)			(0.000)
D(USDTHB(-3))	52.64***	50.21***	49.46***	54.46***	51.01***	51.02***
	(0.021)	(0.022)	(0.021)	(0.034)	(0.033)	(0.033)
Adjusted R^2	0.29	0.33	0.34	0.33	0.39	0.39
D(USDEUR)	ZLBs			Normalization		
C	0.23	-0.03	-0.06	0.08	-0.01	0.00
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
FWG	-2.01**	-1.94**	-1.92**	0.66	1.49	1.57
	(0.010)	(0.009)	(0.009)	(0.016)	(0.016)	(0.016)
LSAPs	-0.66*	-0.57*	-0.38*	-1.28*	-0.70*	-0.63*
	(0.010)	(0.010)	(0.010)	(0.013)	(0.014)	(0.014)
D(VIX)		1.10***	1.13***		-0.20	-0.21
		(0.002)	(0.002)		(0.002)	(0.002)
ECB-FedBS			-0.006***			0.000
			(0.000)			(0.000)
D(USDEUR(-3))	54.84***	54.24***	53.92***	51.52***	51.65***	51.55***
	(0.019)	(0.019)	(0.019)	(0.028)	(0.028)	(0.028)
Adjusted R^2	0.31	0.32	0.32	0.27	0.27	0.27

D(USDTHB)	ZLBs		Normalization	
C	-0.83***	-0.94***	-1.20***	-1.35***
	(0.002)	(0.002)	(0.003)	(0.002)
FWG	-0.77**	-0.94***	1.70	1.24**
	(0.003)	(0.003)	(0.009)	(0.006)
LSAPs	-1.46**	-1.66***	-1.45**	-1.30**
	(0.006)	(0.006)	(0.008)	(0.006)
D(VIX)		0.69***		0.10
		(0.001)		(0.001)
D(USDTHB(-3))	57.55***	56.63***	52.80***	54.54***
	(0.022)	(0.022)	(0.031)	(0.026)
Adjusted R^2	0.34	0.36	0.31	0.32
D(USDMYR)	ZLBs		Normalization	
C	0.14*	-0.32	0.03	-0.15
	(0.003)	(0.003)	(0.003)	(0.003)
FWG	-1.63**	-1.62***	0.97	1.51
	(0.007)	(0.006)	(0.013)	(0.012)
LSAPs	-2.34**	-2.58***	-3.21***	-2.56***
	(0.009)	(0.009)	(0.009)	(0.009)
D(VIX)		1,56***		0.68***
		(0.001)		(0.002)
D(USDTHB(-3))	56.19***	51.61***	64.35***	64.45***
	(0.026)	(0.027)	(0.036)	(0.036)
Adjusted R^2	0.33	0.38	0.46	0.48

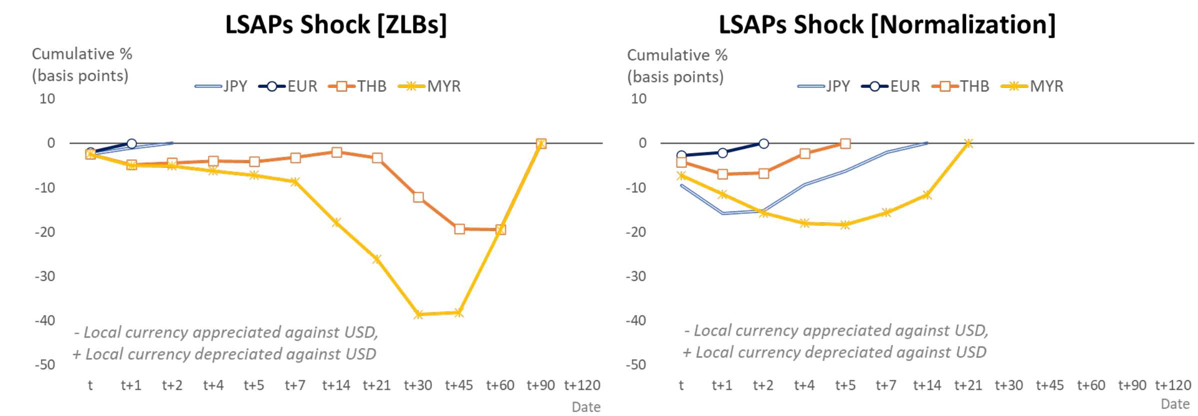
Note: 1) ***, ** and * represent 1, 5, and 10 percentage of significant level respectively 2) Text in parenthesis represents a heteroskedasticity and autocorrelation consistent standard error (HAC). 3) The respective foreign exchange rate is represented as units per 1 US Dollar 4) Coefficients are in a unit of basis point of a percentage change from a previous period. A Positive number indicates a depreciation of foreign exchange to US Dollar and a negative means an appreciation.

Figure 1: A comparison of Federal Reserve's synthesized Unconventional Monetary Policy factors



Note: These two graphs illustrate the characteristics of the Fed's unconventional shocks. While the Large-scale asset purchase (LSAPs) shock affects the yield curve at long maturities, the forward guidance (FWG) shock impacts the yield curve at medium maturity of 2-5 years.
Source: Kim, Laubach and Wei (2023) and Author's calculations

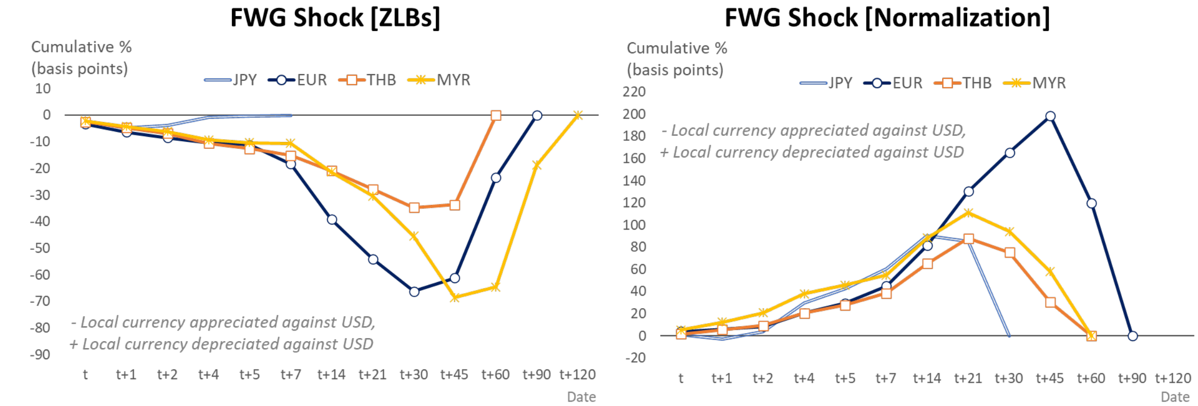
Figure 2: Impulse response of daily foreign exchange rates to large-scale asset purchases (LSAPs) shock both during ZLBs periods and normalization periods with Local Projections



ZLBs	**t**	**t+1**	**t+2**	**t+4**	**t+5**	**t+7**	**t+14**	**t+21**	**t+30**	**t+45**	**t+60**	**t+90**	**t+120**
γ_k LSAPs [JPY]	**-2.41**	**-0.99**	**0.000**										
	0.034	*0.048*											
γ_k LSAPs [EUR]	**-2.05**	**0.000**											
	0.036												
γ_k LSAPs [THB]	**-2.35**	**-4.78**	**-4.45**	**-3.96**	**-4.07**	**-3.19**	**-1.89**	**-3.31**	**-12.07**	**-19.34**	**-19.42**	**0.00**	
	0.015	*0.021*	*0.022*	*0.023*	*0.025*	*0.027*	*0.038*	*0.052*	*0.062*	*0.080*	*0.097*		
γ_k LSAPs [MYR]	**-2.39**	**-4.95**	**-5.14**	**-6.22**	**-7.17**	**-8.66**	**-17.86**	**-26.18**	**-38.63**	**-38.20**	**-19.62**	**0.00**	
	0.018	*0.026*	*0.030*	*0.033*	*0.034*	*0.035*	*0.044*	*0.058*	*0.061*	*0.082*	*0.102*		
Normalization	**t**	**t+1**	**t+2**	**t+4**	**t+5**	**t+7**	**t+14**	**t+21**	**t+30**	**t+45**	**t+60**	**t+90**	**t+120**
γ_k LSAPs [JPY]	**-9.45**	**-15.76**	**-15.22**	**-9.33**	**-6.23**	**-2.07**	**0.00**						
	0.053	*0.077*	*0.091*	*0.110*	*0.119*	*0.136*							
γ_k LSAPs [EUR]	**-2.71**	**-2.10**	**0.00**										
	0.042	*0.060*											
γ_k LSAPs [THB]	**-4.17**	**-6.85**	**-6.69**	**-2.25**	**0.00**								
	0.024	*0.037*	*0.047*	*0.062*									
γ_k LSAPs [MYR]	**-7.30**	**-11.54**	**-15.74**	**-18.01**	**-18.41**	**-15.64**	**-11.62**	**0.00**					
	0.031	*0.046*	*0.054*	*0.071*	*0.072*	*0.081*	*0.123*						

Note: 1) The bold numbers in the table express the magnitude of the local currencies' response per US Dollar to such an unconventional shock as expressed in basis points (γ), from Local Projections. While a minus sign indicates that the local currency appreciated against the US Dollar, signifying a Dollar depreciation, a plus sign indicates the opposite. 2) The italic numbers are heteroskedasticity-and-autucorrelation consistence standard errors (HAC).
Source: Author's calculations

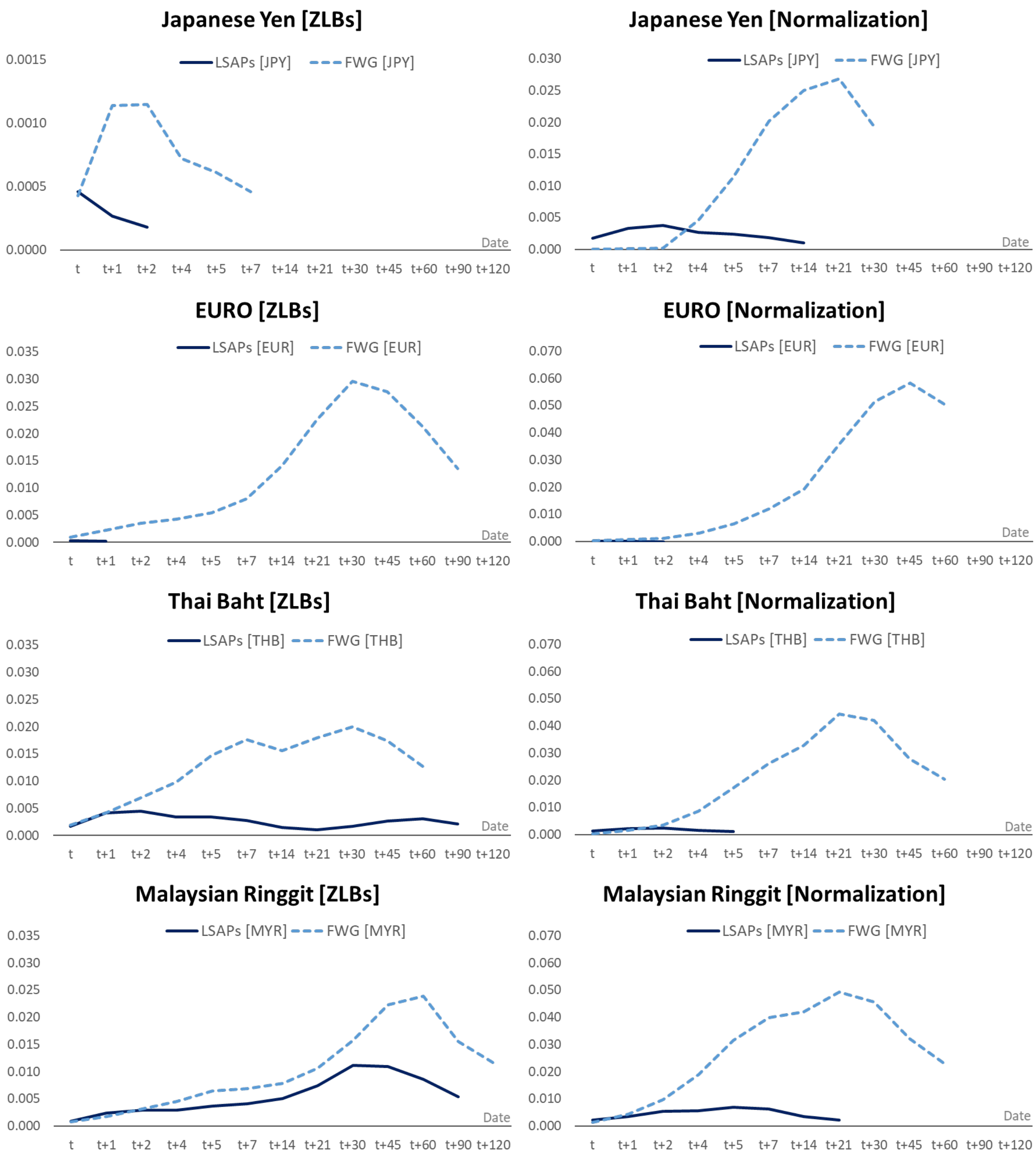
Figure 3: Impulse response of daily foreign exchange rates to forward guidance (FWG) shock both during ZLBs periods and normalization periods with Local Projections



ZLBs	t	t+1	t+2	t+4	t+5	t+7	t+14	t+21	t+30	t+45	t+60	t+90	t+120
γk FWG [JPY]	**-2.32**	**-4.79**	**-3.76**	**-0.88**	**-0.30**	**0.00**							
	0.029	*0.038*	*0.049*	*0.061*	*0.063*								
γk FWG [EUR]	**-3.29**	**-6.28**	**-8.51**	**-10.52**	**-11.10**	**-18.30**	**-39.23**	**-53.98**	**-66.18**	**-61.21**	**-23.25**	**0.00**	
	0.026	*0.038*	*0.049*	*0.058*	*0.058*	*0.051*	*0.069*	*0.087*	*0.108*	*0.145*	*0.179*		
γk FWG [THB]	**-2.49**	**-4.72**	**-6.76**	**-10.59**	**-12.61**	**-15.09**	**-20.94**	**-27.80**	**-34.72**	**-33.63**	**0.00**		
	0.013	*0.018*	*0.022*	*0.026*	*0.029*	*0.029*	*0.041*	*0.052*	*0.069*	*0.101*			
γk FWG [MYR]	**-2.16**	**-4.21**	**-6.14**	**-9.31**	**-10.32**	**-10.60**	**-21.42**	**-30.44**	**-45.53**	**-68.54**	**-64.54**	**-18.76**	**0.00**
	0.017	*0.025*	*0.032*	*0.039*	*0.042*	*0.039*	*0.053*	*0.060*	*0.081*	*0.101*	*0.129*	*0.161*	
Normalization	**t**	**t+1**	**t+2**	**t+4**	**t+5**	**t+7**	**t+14**	**t+21**	**t+30**	**t+45**	**t+60**	**t+90**	**t+120**
γk FWG [JPY]	**0.89**	**-2.77**	**3.70**	**29.74**	**42.36**	**60.82**	**90.25**	**85.22**	**0.00**				
	0.083	*0.133*	*0.166*	*0.190*	*0.201*	*0.225*	*0.268*	*0.321*					
γk FWG [EUR]	**3.86**	**5.93**	**8.50**	**20.46**	**29.38**	**44.88**	**81.37**	**130.29**	**165.55**	**198.51**	**119.72**	**0.00**	
	0.052	*0.073*	*0.089*	*0.110*	*0.115*	*0.126*	*0.159*	*0.170*	*0.214*	*0.245*	*0.321*		
γk FWG [THB]	**1.84**	**5.54**	**9.16**	**20.36**	**27.76**	**38.52**	**65.30**	**87.98**	**75.36**	**30.44**	**0.00**		
	0.032	*0.045*	*0.058*	*0.075*	*0.079*	*0.093*	*0.122*	*0.160*	*0.194*	*0.244*			
γk FWG [MYR]	**5.23**	**12.41**	**20.78**	**37.90**	**45.69**	**54.90**	**88.33**	**111.03**	**94.21**	**57.93**	**0.00**		
	0.043	*0.068*	*0.083*	*0.115*	*0.123*	*0.138*	*0.196*	*0.224*	*0.220*	*0.231*			

Note: 1) The bold numbers in the table express the magnitude of the local currencies' response per US Dollar to such an unconventional shock as expressed in basis points (γ),from Local Projections. While a minus sign indicates that the local currency appreciated against the US Dollar, signifying a Dollar depreciation, a plus sign indicates the opposite. 2) The italic numbers are heteroskedasticity-and-autucorrelation consistence standard errors (HAC).
Source: Author's calculations

Figure 4: Variance decomposition with Local Projections



Source: Author's calculations