

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

Arisa Chantaraboontha\*

August 8, 2024

## 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. The findings confirm heterogeneous responses of examined foreign exchange rates to unconventional shocks, varying by magnitude, direction, and duration depending on monetary conditions and shock type. Both shocks caused the appreciation of foreign exchange rates against the US dollar in all monetary conditions, except for the forward guidance shock during the normalization. The forward guidance shock had a greater impact magnitude on the examined foreign exchange rates than the LSAPs shocks. The effects of both unconventional shocks were more persistent during ZLB periods than during normalization. However, the impact of such shocks on foreign exchange rates diminishes within a couple of months, contrasting with some literature that finds more persistent effects. Lastly, variance decomposition shows that forward guidance shocks significantly influenced foreign exchange rate variation more than LSAPs shocks, emphasizing the importance of effective guidance communication to the markets.

**Keywords:** Federal Reserve, Unconventional monetary shocks, Large-scale asset purchases (LSAPs), Forward guidance (FWG), Euro, Japanese Yen, Thai baht, Malaysian Ringgit

---

\*Graduate School of Economics, Osaka University, 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 works by Rosa (2011), Bauer (2014), Gürkaynak et al. (2005, 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 engaging in unconventional operations, particularly under zero-lower-bound conditions, aligning with the findings of Stavrakeva and Tang (2015).

Despite these insights, several aspects regarding the spillover effects of the US's unconventional monetary tools on nominal exchange rates - particularly on some emerging market currencies - and the propagation of shocks over time remain poorly understood. Additionally, there is a need to further explore whether each particular unconventional monetary tool transmits symmetrically through advanced and emerging foreign exchange rates across varying global monetary conditions: ZLBs and normalization .

The persistence of the impact of the Federal Reserve'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 Forward guidance and LSAP 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 using Local Projections technique 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 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 QE tools across global monetary conditions.

Accordingly, the key questions to 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 the ZLB periods and the normalization period. 4) The persistence of the shock during different monetary circumstances. 5) observing which shock contributes significantly to the variation in foreign exchange. The key foreign exchanges examined in this paper will be the Japanese yen, the euro, the Thai baht and the Malaysian ringgit.

By employing Local Projections and extending the data from 2009 through the post-pandemic crisis in 2022, the study finds heterogeneity in foreign exchange responses to unconventional shocks, varying in magnitude, direction, and duration, depending on the monetary conditions and type of corresponding shock. Generally, LSAPs shocks led to the relative appreciation of local foreign exchange rates against the US dollar, with a greater absolute impact magnitude during ZLB periods. Forward guidance led to the appreciation of local foreign exchange rates against the US dollar but failed to do so during normalization periods, with a greater shock response magnitude during hiking time. This highlights the reduced effectiveness of the Fed's forward guidance in containing exchange rate volatility and its diminished role in easing pressure on the US dollar.

Additionally, the effects of US unconventional shocks were more persistent during ZLB periods compared to normalization periods. Next, forward guidance shocks significantly contributed to foreign exchange rate variation, as indicated by variance decomposition, aligning with the measurement of a greater absolute impact from forward guidance shocks compared to LSAPs shocks. Lastly, heterogeneous reactions to unconventional shocks were observed across currency pairs. During the ZLB period, a clear pattern emerged with no significant QE effects on key global exchange rates, but notable effects on emerging market currencies. These study results thus underscore the heterogeneous transmission of the Fed’s QE shocks across foreign exchanges and across global financial circumstances.

The remainder of the paper is structured as follows. *Section2* delves into the theory and methodologies employed in each part of the analysis. *Section3* provides the details of research data. *Section4* explains the process of constructing unconventional monetary policy shocks, specifically unexpected large-scale asset purchases (LSAPs) and unexpected forward guidance (FWG) shocks. Following this, *Section5* presents empirical results on foreign exchange rates’ reactions to the Federal Reserve’s unconventional surprises across monetary conditions. The paper concludes in the last section.

## 2 Theory and Methodology

In this section, overviews of the theories and methodologies referenced for each part of the study will be 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 country  $j$  to US dollar, we can express the factors underlying foreign exchange movements as follows.

$$1 + i_t^j = (1 + i_t^{us}) \frac{E_t S_{t+1}}{S_t}$$

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

$$\log S_t = E_t \sum_{k=0}^{\infty} (i_{t+k}^j - i_{t+k}^{us}) + \lim_{t \rightarrow \infty} E_t \log S_{t+1}$$

$$\log S_t - \log S_{t-1} = (E_t - E_{t-1}) \sum_{k=0}^{\infty} (i_{t+k}^j - i_{t+k}^{us}) + (i_{t-1}^j - i_{t-1}^{us})$$

As the Federal Reserve’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 our focus is solely on monetary shocks from the Federal Reserve, we 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. (2005) and empirically used in Swanson (2021) as follows.

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

$$[t \times n] \quad [t \times k] \quad [k \times n]$$

where  $X$  is a  $t \times n$  matrix,  $t$  represents key monetary policy announcement dates and public speech dates by key Federal Reserve officials and  $n$  is a corresponding asset prices' changes on such date.  $F$  represents latent factors in the form of  $t \times k$  matrix. Let denote that  $k$  is the unobserved factor with  $k$  less than  $n$ . In addition  $\Lambda$  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 analyzing the structure of the loading matrix and applying theoretical constraints to ensure the accurately represented characteristics of the monetary shocks.

Specifically, let's suppose here the orthogonal matrix  $\tilde{U}$  with  $3 \times 3$  dimension of determining factors and  $\tilde{\lambda}_{ij}$  is an element at row  $i$  and column  $j$  of the matrix  $\tilde{U}$ . Please note that row  $i = 1$  to  $3$  represents Federal fund rate shock, forward guidance shock and LSAPs shock respectively. Meantime the column  $j$  represents current, medium and long term tenor of a yield curve.

In a general concept, a surprise component of the change in federal funds rate would be associated with an impact on the current tenor of yield curve. However, forward guidance shock signals the change in future path of monetary policy, which should be therefore observed its impact in the medium-term tenor of yield curve and cause no effect on the current federal funds rate. This suggests the appropriate restriction of  $\tilde{\lambda}_{21} = 0$ . Concerning changes in LSAPs, 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 LSAPs tools have been mainly implemented during the ZLB period, so it is uncontroversial to impose a restriction  $\tilde{\lambda}_{31} = 0$ .

After imposing the restriction, we choose the adjusted elements of  $\tilde{U}$  that minimize the sum squares error in the model, ensuring they match the errors obtained using the loading

matrix  $\tilde{\Lambda}$ . In other words,  $F\tilde{U}$  represents an alternative model of  $F\tilde{\Lambda}$ . By confirming the characteristics of the loading matrix, we can identify the type of Federal Reserve monetary shocks encountered in the shock synthesis procedure and use these shocks further in the empirical section.

## 2.3 Impulse response by Local Projections

To illustrate the magnitude and direction of foreign exchange rate responses to unconventional monetary policy shocks, this paper will employ the technique of Local Projections introduced by Joda' (2005). This method involves estimating the direct response of the foreign exchange rates to unconventional monetary shocks at each forecast horizon of interest, rather than modelling the entire system of equations with a required lag length specification as in VAR model. Thus, this method is more straightforward and involves less computational burden than other methods.

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

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

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 fix effect. k is a forecast horizon. 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  $u_{j,t}$ .

Therefore, the impulse response (IR) 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:

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

## 2.4 Variance decomposition by Local Projections

Local projections can provide a simple and intuitive way to assess the contribution of identified shocks to foreign exchange rate variation at different horizons. For this study, a variance decomposition,  $D_{j,t+k}$ , illustrated in Gorodnichenko and Lee (2017) will be employed as follows:

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

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

Gorodnichenko and Lee (2017) state that such estimation does not matter in large samples, but possible biases may arise in small samples. If this is the case, a bootstrap should be used in the local projections' variation decompositions to correct estimation biases. However, due to the large sample size used in this paper, such biases can be avoided.

## 3 Data

### 3.1 Daily data of normal trading day

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.

In addition to using the federal funds rate to determine the monetary cycle, this study employs the Bai-Perron Global Breaks test to identify structural breaks within nominal foreign exchange rates, thereby reaffirming the timing of monetary cycle shifts. The time series is divided into two periods based on the respective global monetary cycles: 945 samples represent the normalization period (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). Please refer to [Table 1](#) for an illustration of the analytical timeframe

referred 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 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 currencies, such as the Thai baht and the Malaysian ringgit. The Thai baht and the Malaysian ringgit were chosen as representatives of key emerging ASEAN currencies due to their similar economic and monetary cycles, as well as relatively aligned policy actions. 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. Please refer to [Table 2](#) for descriptive statistics of the respective foreign exchange rates.

[ insert Table 2 ]

### **3.2 Intraday data for constructing Unconventional Monetary shocks**

Following the methodology used in Swanson (2021), I first accumulate 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 were collected from 15-minute windows both before and after 14:00, the time of key monetary announcements following FOMC meetings. This dataset comprises 116 event dates, including FOMC meetings from January 2009 to March 2022, as well as speeches by Federal Reserve officials as presented in [Table 3](#).

[ insert Table 3 ]

To reduce the dimensionality of the financial data, I utilize principal components analysis to extract latent factors from these financial data on event dates. These unobserved fac-

tors likely represent the underlying 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 impact characteristics on a yield curve. The federal funds rate shock primarily exerts a short-term impact on the yield curve, while the forward guidance shock tends to influence the medium-term tenors, specifically those with 2- to 5-year maturities. In contrast, the impact of large-scale asset purchases 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 do allow for only 2, out of the expected 3, key components of monetary policy factors whose eigenvalue are greater than 1, referring to Kaiser-Guttman criteria. The first component accounts for 51% of the data variation and the second one does account for 21% as shown in [Table 4](#). This is slightly greater than the PCA outcomes done by Kim, Laubach and Wei (2023) of 40% and 10% respectively.

[ insert Table 4 ]

In identifying the type of monetary shock of these synthesized factors, it's crucial to examine the shape of coefficients in the rotated loading matrix revealed by the PCA method. Prior to reaching the identification results, I also impose certain theoretical restrictions on loading factors and select the one that yields the least sum of squared errors, consistent with the non-imposed scenario. It's worth noting that based on my findings, even without theoretical imposition, my LSAPs factor has almost no impact on the federal funds rate. Nevertheless, I impose a "zero" value on both factors in the matrix to eliminate such impacts.

Drawing from 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. This aligns with the findings of Kim, Laubach, and Wei (2023). The second component corresponds to the nature of the Forward Guidance 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 second components as an LSAPs shock and a Forward Guidance shock, respectively.

[ insert Figure 1 ]

Before proceeding with the empirical analysis in the next section, I standardize the extracted unconventional shocks from the PCA method to have a unit of standard deviation. Additionally, I cross-check the impact of these synthesized shocks on 10-year US Treasury yields with other literature. The findings indicate that my LSAPs factor leads to a reduction in the 10-year US Treasury yield by 36 basis points, consistent with the finding in Kim et al. (2023) but much larger than Swanson (2021), who found a reduction of only 6.5 basis points. The positive impact of the forward guidance shock on the 10-year US Treasury yield is approximately 2.6 basis points, slightly smaller than the 3-4 basis points found in 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, I assume a linear path between event dates. Subsequently, I construct an equally weighted linear interpolation between two key event dates to obtain the daily series of unconventional shocks.

## 5 Empirical results

### 5.1 Impulse response of LSAPs shock

After constructing and identifying the large-scale asset purchases (LSAPs) shock and the forward guidance (FWG) shock, this section will measure the course of foreign exchange rate responses to these respective shocks using Local Projections.

[ insert Figure 2 ]

Figure 2 presents the impulse response with coefficient tables. This confirms that foreign exchange rates appreciated against US dollar, or that the dollar depreciated, as indicated by the negative sign of the gamma coefficient, in response to the one standard deviation of Federal Reserve's LSAPs shock during both the ZLB periods and the normalization era.

This finding aligns with intuition and the uncovered interest parity theory, which suggests that an unexpected decrease in US interest rate path leads to capital outflows from the United States, resulting in appreciation of foreign exchange rates against the US dollar or dollar depreciation. It is important to note that in my calculations, I assign a value of zero to the unconventional shock impact at the respective time horizons when such impact has completely vanished.

During the ZLB periods, the Japanese yen and the euro slightly appreciated against the US dollar just for a couple of days before returning to their steady states. Meanwhile, the Thai baht and the Malaysian ringgit initially appreciated steadily, with the rate of appreciation significantly accelerating 2 to 4 weeks after the LSAPs shock, before returning to their steady states by the third month.

The short-lived impact and smaller magnitude on the two key global currencies during ZLBs can be partly explained by the simultaneous massive QE implementations by the Bank of Japan and the ECB, which gradually mitigated the Federal Reserve's quantitative easing

impact. Another explanation for the delayed impact on emerging currencies, peaking at 4 to 5 weeks, is that foreign exchange management played a key role in mitigating local currency appreciation against the US dollar initially, amidst excessive global liquidity during the ZLB era. These results, however, confirm the greater impact of the US's massive asset purchase programs on representative Asian currencies compared to major global currencies in terms of both impact duration and magnitude.

Considering the LSAPs shock impact during the normalization period, all foreign exchange rates appreciated against the US dollar after the shock. Most representative foreign exchanges returned to their steady states within 1-2 weeks, except for the Malaysian ringgit, which took three weeks. The short-lived impacts of the Fed's massive asset purchases on other nations' foreign exchange rates during normalization period are intuitive. As global financial markets perceive that the Federal Reserve is preparing to taper its asset purchases and raise interest rates, liquidity is likely to return to the United States more quickly during the hiking period than during the search-for-yield era.

When comparing the LSAPs impact magnitude across monetary circumstances, it was found that the magnitude of the LSAPs shock on the representative foreign exchanges was also much less during normalization than during the ZLB 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) period of the 2008 financial crisis compared to the 1990s.

## 5.2 Impulse response of Forward Guidance shock

Figure 3 illustrates the impact of the Fed's unexpected future pace of monetary policy, or forward guidance shock, on the examined foreign exchange rates. In short, the direction of foreign exchange rate response to forward guidance (FWG) shocks is state-dependent.

During the ZLB periods, a 1 standard deviation forward guidance shock led to an

appreciation in foreign exchange rates against the US dollar, causing dollar depreciation. The peak response was observed approximately 30-45 days following the shock, with a return to the steady state occurring within 60-120 days. The Japanese yen was the only exception, experiencing the smallest impact from the forward guidance shock, which dissipated within the first 7 days.

[ insert Figure 3]

In striking contrast, a 1 standard deviation forward guidance shock during the normalization period resulted in a depreciation in foreign exchange rates against the US dollar, or a dollar appreciation. The strongest impact occurred 14-21 days after the shock for all currencies, with the only exception being the euro, which reached its peak response 45 days after the shock. The forward guidance shock during restrictive monetary conditions lasted around 30-90 days, slightly shorter than its impact during the ZLB periods. Notably, the euro responded sharply to the Fed's forward guidance shock in both monetary conditions, in contrast to its barely noticeable response to the LSAPs shock, as highlighted in the previous section.

Another point is that the absolute magnitudes of the forward guidance impact are relatively higher during the normalization period compared to the ZLB periods. Coupled with the inverse impact direction, this analysis suggests that guidance communication during the normalization period is less effective in containing foreign exchange volatility and fails to effectively induce a depreciation of the US dollar or an appreciation of other foreign exchange rates against US dollar.

The observed contrast in the direction of foreign exchange responses to forward guidance (FWG) shocks under different monetary conditions differs from the findings in Swanson (2021), who reported a consistent direction of foreign exchange rate responses to forward guidance shock both during and before the 2008 ZLB periods. However, given the Federal

Reserve’s forward guidance regarding asset purchases tapering and preparing to raise interest rates during the normalization era, it seems reasonable that capital reversals to the US should lead to an appreciation of the US dollar, rather than depreciation, in response to such a forward guidance shock.

When comparing the impact magnitudes of these two shocks - LSAPs and forward guidance - this paper finds that the response magnitude to the forward guidance shock is relatively greater than that to the LSAPs shock in both monetary circumstances. These findings are consistent with those quantitative results of Swanson (2021) and Ferrari (2021).

### 5.3 Robustness Check on Coefficients to Shocks

To ensure the robustness of the coefficients estimated in response to forward guidance (FWG) and large-scale asset purchase (LSAP) shocks, various checks were performed. [Table 5](#) presents the estimation of the impact of FWG and LSAP shocks on the 7-day moving average of exchange rates over the entire sample period from 2009 to 2022. This analysis aims to verify the direction of the coefficients of weekly exchange rate trends in response to these unconventional monetary shocks.

[ insert Table 5]

Initially, each exchange rate is regressed without control variables, followed by regression with the inclusion of its own lagged variables, 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 Federal Reserve’s forward guidance (FWG) and large-scale asset purchases (LSAPs) significantly led to appreciation of across weekly-trending foreign exchange rates against US dollar, expressed in negative shock coefficients, as similarly represented in daily-frequency Local Projections. Please note that 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 the normalization period, as shown in [Table 6](#), both forward guidance and large-scale asset purchases lead to appreciation across foreign exchange rates. The exception is the depreciation of local exchange rates against the US dollar in response to forward guidance shocks during the normalization period. This was similarly observed in daily-frequency Local Projections, although it is surprisingly statistically insignificant in this examination of weekly-moving exchange rate regressions.

To summarize, the robustness tests consistently confirm the initial findings that LSAPs shock led to significant appreciations of foreign exchange rates against the US dollar during both ZLB and normalization periods. In contrast, forward guidance shock caused exchange rate appreciation against the US dollar during ZLB periods but led to depreciation during normalization period, although this effect was statistically insignificant in the weekly-moving average regression.

## 5.4 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 forward guidance (FWG) shock has a significantly greater impact on foreign exchange fluctuations than the LSAPs (Large-Scale Asset Purchases) shock. The peak contribution of the forward guidance shock typically occurs 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 forward guidance 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 LSAPs on foreign exchange variability is notably less pronounced and diminishes relatively more quickly than the effects of forward guidance shocks 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 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 era, similar to what was once experienced in 2013.

## 6 Conclusions

Using the Local Projections technique, this paper demonstrates the heterogeneous responses of foreign exchange rates to unconventional shocks from the Federal Reserve. Specifically, foreign exchange rates appreciated against the US dollar following Large Scale Asset Purchases (LSAPs) shocks under both monetary conditions. In contrast, Forward Guidance (FWG) shocks led to appreciation in local currencies against the US dollar during periods of the Zero Lower Bound (ZLB), but caused depreciation against US dollar during normalization, which diverges from existing literature.

Regarding the magnitude, the forward guidance shock produced a greater absolute magnitude of impact on the examined foreign exchange rates compared to LSAPs shocks, aligning with its larger contribution to foreign exchange variation in variance decomposition. When evaluating the impact magnitude of one particular shock across both monetary conditions, LSAPs shocks showed a more pronounced foreign exchange response during ZLB peri-

ods. In contrast, Forward Guidance shocks caused a larger absolute exchange rate response during normalization. Comparing across exchange rates, 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.

During ZLB periods, the effects of both unconventional shocks would typically persist longer compared to normalization periods. However, contrary to the findings of Swanson (2021) and Dedola et al. (2021), my paper found that both unconventional shocks faded away within a couple of 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 in stabilizing markets, particularly during tightening periods. This would yield significant policy implications. Additionally, 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—forward guidance effectively steers medium-term interest rates, while LSAPs shock influences long-term tenor—the transmission channels and the time lag before the impact takes effect on real variables warrant further examination.

## References

Bauer, Michael D. and Neely, Christopher J. (2014) International channels of the Fed's unconventional monetary policy. *Journal of International Money and Finance*, 44, 24-46.

Baumeister, C. and Benati, L. (2013) Unconventional Monetary Policy and the Great Recession: Estimating the Macroeconomic Effects of a Spread Compression at the Zero Lower Bound. *International Journal of Central Banking*, vol. 9(2), pp 165-212.

Cho, D. and Rhee, C. (2013) Effects of Quantitative Easing on Asia: Capital Flows and Financial Markets. *Economics Working Paper Series No. 350*. Asian Development Bank.

D'Amico, S. and Seida, T. (2023) Unexpected Supply Effects of Quantitative Easing and Tightening. *The Economic Journal*.

Dahlhaus, T., Hess, K. and Reza, A. (2014) International Transmission Channels of U.S. Quantitative Easing: Evidence from Canada. *Working Paper No. 2014-43*. Bank of Canada.

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

Engen, E., Laubach, T. and Reifschneider, D. (2015) The Macroeconomic Effects of the Federal Reserve's Unconventional Monetary Policies. *FEDS 2015-005*, January.

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*, vol 129.

Fratzcher, M., Duca, M. and Straub, R. (2013) On the International Spillovers of US Quantitative Easing. *Working Paper Series No. 1557*. European Central Bank.

Gagnon, J., Raskin, M., Remache, J. and Sack, B. (2011) The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases. *The international Journal of Central Banking*. Vol.7 No. 1

Gambacorta, L., Hofmann, B. and Peersman, G. (2012) The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis. *Working Paper No. 384*. Bank for International Settlements.

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, 2078–2101.

Gorodnichenko, Y. and Lee, B.(2017) A Note on Variance Decomposition with Local Projections. NBER working paper series, 23998.

Gürkaynak, Refet S. and Sack, Brian P. and Swanson, Eric T. (2005), Do Actions Speak Louder than Words? The Response of Asset Prices to Monetary Policy Actions and Statements. *International Journal of Central Banking*.

Gürkaynak, Refet S., Kara, A. Hakan and Kısacıkoglu B. and Lee S. (2021), Monetary policy surprises and exchange rate behavior. *Journal of International Economics*.

Han, F. and Westelius, Niklas J (2019) Anatomy of Sudden Yen Appreciations. IMF Working Paper No 19/136. International Monetary Fund.

Jordà, O. (2005) Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review*. Feb 2005, Vol. 95, No. 1: Pages 161-182.

Jordà, O. (2023) Local Projections for Applied Economics. Working Paper 2023-16. Federal Reserve Bank of San Francisco.

Kapetanios, G., Mumtaz, H., Stevens, I. and Theodoridis, K. (2012) Assessing the Economy-wide Effects of Quantitative Easing. *The Economic Journal*, vol. 122, issue 564.

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. Working Paper Series No. 1253. European Central Bank.

Muller, P., Tahbaz-Salehi, A. and Vedolin, A. (2017) Exchange Rates and Monetary Policy Uncertainty. *The Journal of Finance*, vol. LXXI, no.3.

Neely, Christopher J.(2015) Unconventional monetary policy had large international effects. *Journal of Banking Finance* 52 (2015) 101–111

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

Sekinea, A. and Tsuruga, T. (2018) Effects of commodity price shocks on inflation: a

cross-country analysis. *Oxford Economic Papers*, 70(4), 2018, 1108–1135.

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

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

Wright, Jonathan H. (2012) What does Monetary Policy do to Long-term Interest Rates at the Zero Lower Bound?. *The Economic Journal*, 122 (November), F447–F466.

## Table and Figure

Table 1: Regression timeframe with structural breaks in time series

	<b>Full sample</b>	<b>ZLBs</b>	<b>Normalization</b>
<b>Periods</b>	1/01/2009-3/16/2022	1/01/2009-12/16/2015 8/1/2019-3/16/2022	12/17/2015-7/31/2019
<b>Sample size</b>	3445	2500	945
<b>Number of Event</b>	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

	<b>Full Sample</b>	<b>ZLBs</b>	<b>Normalization</b>
<b>USDJPY</b>			
Mean	0.94	1.70	-1.08
Standard Deviation	0.57	0.58	0.55
<b>USDEUR</b>			
Mean	0.84	1.18	-0.05
Standard Deviation	0.56	0.59	0.45
<b>USDTHB</b>			
Mean	-0.08	0.52	-1.65
Standard Deviation	0.29	0.30	0.26
<b>USDMYR</b>			
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. 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

<b>Speeches of Fed Chairman</b>	
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 the National Association for Business Economics Virtual Annual Meeting
August 27, 2021	Chair Powell at Jackson Hole
<b>Speeches of Fed Governors</b>	
June 27, 2013	Governor Powell at the Bipartisan Policy Center, Washington, D.C.
October 11, 2013	Governor Powell at the 2013 Institute of International Finance Annual Membership Meeting, Washington, D.C.
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, Stanford, California
November 19, 2021	Governor Waller at the Center for Financial Stability, New York

Source: Federal Reserve Board

Table 4: The eigen values from principal components analysis (PCA) on financial data

<b>Eigenvalues: (Sum = 5, Agerage = 1)</b>					
<b>Number</b>	<b>Value</b>	<b>Difference</b>	<b>Proportion</b>	<b>Cummulative Value</b>	<b>Cummulative Proportion</b>
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

<b>ΔUSDJPY</b>	<b>Full sample (7-day moving average)</b>					<b>ΔUSDTHB</b>	<b>Full sample (7-day moving average)</b>			
C	0.62 *	0.34	0.36	0.93 ***	0.87 ***	C	-1.73 ***	-0.90 ***	-0.90 ***	-1.01 ***
	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>		<i>0.002</i>	<i>0.002</i>	<i>0.002</i>	<i>0.002</i>
FWG	-4.27 ***	-2.32 ***	0.50	-2.42 ***	-2.58 ***	FWG	-1.67 ***	-0.70 **	0.16	-0.60 **
	<i>0.009</i>	<i>0.008</i>	<i>0.017</i>	<i>0.007</i>	<i>0.007</i>		<i>0.004</i>	<i>0.003</i>	<i>0.010</i>	<i>0.003</i>
LSAPs	-7.40 ***	-3.95 ***	-5.76 ***	-4.23 ***	-4.32 ***	LSAPs	-3.60 ***	-1.72 ***	-1.62	-1.64 ***
	<i>0.009</i>	<i>0.008</i>	<i>0.016</i>	<i>0.008</i>	<i>0.008</i>		<i>0.006</i>	<i>0.005</i>	<i>0.010</i>	<i>0.005</i>
FWG (-1)			-2.96			FWG (-1)			-0.92	
			<i>0.019</i>						<i>0.010</i>	
LSAPs (-1)			1.95			LSAPs (-1)			-0.10	
			<i>0.018</i>						<i>0.011</i>	
ΔVIX				-1.90 ***	-1.90 ***	ΔVIX				0.56 ***
				<i>0.001</i>	<i>0.001</i>					<i>0.001</i>
BOJ-Fed BS					0.002 **					
					<i>0.000</i>					
ΔUSDJPY (-3)		54.09 ***	54.08 ***	51.37 ***	51.12 ***	ΔUSDTHB (-3)		56.72 ***	56.72 ***	56.34 ***
		<i>0.018</i>	<i>0.018</i>	<i>0.018</i>	<i>0.017</i>			<i>0.018</i>	<i>0.018</i>	<i>0.018</i>
.dj. R <sup>c</sup>	0.03	0.31	0.31	0.36	0.36	Adj. R <sup>c</sup>	0.02	0.33	0.33	0.35
<b>ΔUSDEUR</b>	<b>Full sample (7-day moving average)</b>					<b>ΔUSDMYR</b>	<b>Full sample (7-day moving average)</b>			
C	0.46	0.14	0.15	-0.05	-0.03	C	0.34	0.08	0.08	-0.28
	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>		<i>0.003</i>	<i>0.002</i>	<i>0.002</i>	<i>0.002</i>
FWG	-2.19 ***	-1.47 **	-1.90	-1.37 **	-1.29 *	FWG	-1.44 **	-1.02 **	-0.61	-0.95 **
	<i>0.008</i>	<i>0.007</i>	<i>0.017</i>	<i>0.007</i>	<i>0.007</i>		<i>0.006</i>	<i>0.005</i>	<i>0.014</i>	<i>0.005</i>
LSAPs	-2.63 ***	-0.85 *	-4.44 **	-0.65 *	-0.48 *	LSAPs	-4.77 ***	-2.69 ***	-2.28	-2.66 ***
	<i>0.009</i>	<i>0.008</i>	<i>0.021</i>	<i>0.008</i>	<i>0.008</i>		<i>0.008</i>	<i>0.007</i>	<i>0.019</i>	<i>0.006</i>
FWG (-1)			0.47			FWG (-1)			-0.43	
			<i>0.018</i>						<i>0.014</i>	
LSAPs (-1)			3.83 *			LSAPs (-1)			-0.45	
			<i>0.021</i>						<i>0.019</i>	
ΔVIX				0.63 ***	0.63 ***	ΔVIX				1.24 ***
				<i>0.001</i>	<i>0.001</i>					<i>0.001</i>
ECB-Fed BS					-0.002 ***					
					<i>0.000</i>					
ΔUSDEUR (-3)		55.22 ***	55.22 ***	54.86 ***	54.67 ***	ΔUSDMYR (-3)		58.92 ***	58.91 ***	56.34 ***
		<i>0.016</i>	<i>0.016</i>	<i>0.016</i>	<i>0.016</i>			<i>0.022</i>	<i>0.022</i>	<i>0.022</i>
.dj. R <sup>d</sup>	0.00	0.30	0.31	0.31	0.31	Adj. R <sup>d</sup>	0.01	0.36	0.36	0.39

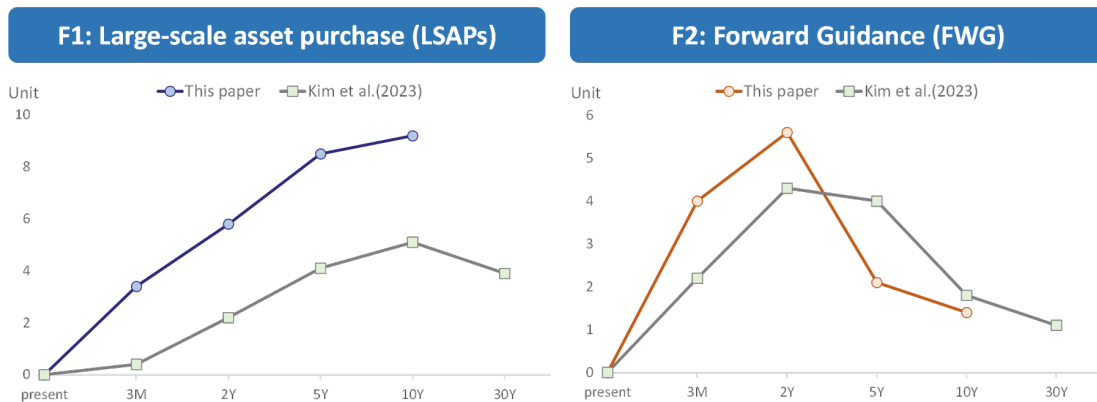
Note: 1) \*\*\*, \*\* and \* represent 1, 5, and 10 percentage of significant level respectively 2) Italic text represents a heteroskedasticity and autocorrelation consistent standard error (HAC). 3) The respective foreign exchange rate is represented as units per 1 US dollar 4) Coefficients are in a 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

$\Delta$ USDJPY	ZLBs			Normalization		
C	0.59 *	1.21 ***	1.17 ***	-0.16	0.26	0.30
	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>	<i>0.006</i>	<i>0.006</i>	<i>0.006</i>
FWG	-2.49 **	-2.68 **	-2.87 **	0.22	0.39	0.30
	<i>0.011</i>	<i>0.012</i>	<i>0.012</i>	<i>0.028</i>	<i>0.028</i>	<i>0.028</i>
LSAPs	-3.31 ***	-3.39 ***	-3.24 ***	-4.49 ***	-5.38 ***	-5.29 ***
	<i>0.010</i>	<i>0.010</i>	<i>0.010</i>	<i>0.016</i>	<i>0.017</i>	<i>0.017</i>
$\Delta$ VIX		-1.54 ***	-1.55 ***		-2.15 ***	-2.16 ***
		<i>0.002</i>	<i>0.002</i>		<i>0.002</i>	<i>0.002</i>
BOJ_Fed BS			0.005 ***			-0.001
			<i>0.000</i>			<i>0.000</i>
$\Delta$ USDJPY (-3)	52.64 ***	50.21 ***	49.46 ***	54.46 ***	51.01 ***	51.02 ***
	<i>0.021</i>	<i>0.022</i>	<i>0.021</i>	<i>0.034</i>	<i>0.033</i>	<i>0.033</i>
Adj R <sup>2</sup>	0.29	0.33	0.34	0.33	0.39	0.39
$\Delta$ USDEUR	ZLBs			Normalization		
C	0.23	-0.03	-0.06	0.08	-0.01	0.00
	<i>0.004</i>	<i>0.004</i>	<i>0.004</i>	<i>0.005</i>	<i>0.005</i>	<i>0.005</i>
FWG	-2.01 **	-1.94 **	-1.92 **	0.66	1.49	1.57
	<i>0.010</i>	<i>0.009</i>	<i>0.009</i>	<i>0.016</i>	<i>0.016</i>	<i>0.016</i>
LSAPs	-0.66 *	-0.57 *	-0.38 *	-1.28 *	-0.70 *	-0.63 *
	<i>0.010</i>	<i>0.010</i>	<i>0.010</i>	<i>0.013</i>	<i>0.014</i>	<i>0.014</i>
$\Delta$ VIX		1.10 ***	1.13 ***		-0.20	-0.21
		<i>0.002</i>	<i>0.002</i>		<i>0.002</i>	<i>0.002</i>
ECB_Fed BS			-0.006 ***			0.000
			<i>0.000</i>			<i>0.000</i>
$\Delta$ USDEUR (-3)	54.84 ***	54.24 ***	53.92 ***	51.52 ***	51.65 ***	51.55 ***
	<i>0.019</i>	<i>0.019</i>	<i>0.019</i>	<i>0.028</i>	<i>0.028</i>	<i>0.028</i>
Adj R <sup>2</sup>	0.31	0.32	0.32	0.27	0.27	0.27
$\Delta$ USDTHB	ZLBs			Normalization		
C	-0.83 ***	-0.94 ***		-1.20 ***	-1.35 ***	
	<i>0.002</i>	<i>0.002</i>		<i>0.003</i>	<i>0.002</i>	
FWG	-0.77 **	-0.94 ***		1.70	1.24 **	
	<i>0.003</i>	<i>0.003</i>		<i>0.009</i>	<i>0.006</i>	
LSAPs	-1.46 **	-1.66 ***		-1.45 **	-1.30 **	
	<i>0.006</i>	<i>0.006</i>		<i>0.008</i>	<i>0.006</i>	
$\Delta$ VIX		0.69 ***			0.10	
		<i>0.001</i>			<i>0.001</i>	
$\Delta$ USDTHB (-3)	57.55 ***	56.63 ***		52.80 ***	54.54 ***	
	<i>0.022</i>	<i>0.022</i>		<i>0.031</i>	<i>0.026</i>	
Adj R <sup>2</sup>	0.34	0.36		0.31	0.32	
$\Delta$ USDMYR	ZLBs			Normalization		
C	0.14 *	-0.32		0.03	-0.15	
	<i>0.003</i>	<i>0.003</i>		<i>0.003</i>	<i>0.003</i>	
FWG	-1.63 **	-1.62 ***		0.97	1.51	
	<i>0.007</i>	<i>0.006</i>		<i>0.013</i>	<i>0.012</i>	
LSAPs	-2.34 **	-2.58 ***		-3.21 ***	-2.56 ***	
	<i>0.009</i>	<i>0.009</i>		<i>0.009</i>	<i>0.009</i>	
$\Delta$ VIX		1.56 ***			0.68 ***	
		<i>0.001</i>			<i>0.002</i>	
$\Delta$ USDMYR (-3)	56.19 ***	51.61 ***		64.35 ***	64.45 ***	
	<i>0.026</i>	<i>0.027</i>		<i>0.036</i>	<i>0.036</i>	
Adj R <sup>2</sup>	0.33	0.38		0.46	0.48	

Note: 1) \*\*\*, \*\* and \* represent 1, 5, and 10 percentage of significant level respectively 2) Italic text 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.

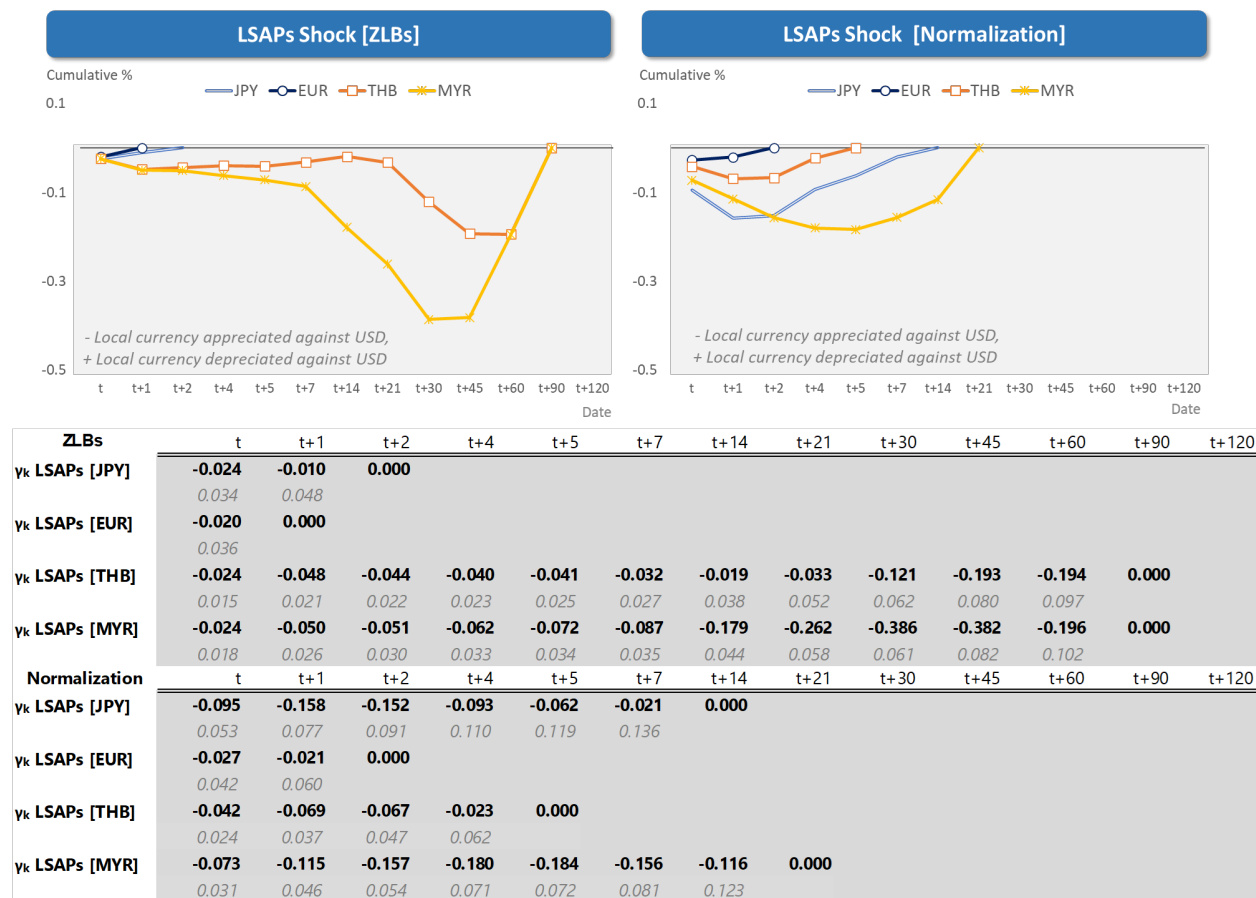
Figure 1: A comparison of Federal Reserve’s synthesized Unconventional Monetary Policy factors



Note: These two graphs illustrate the characteristics of the Fed’s unconventional shocks. While the 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

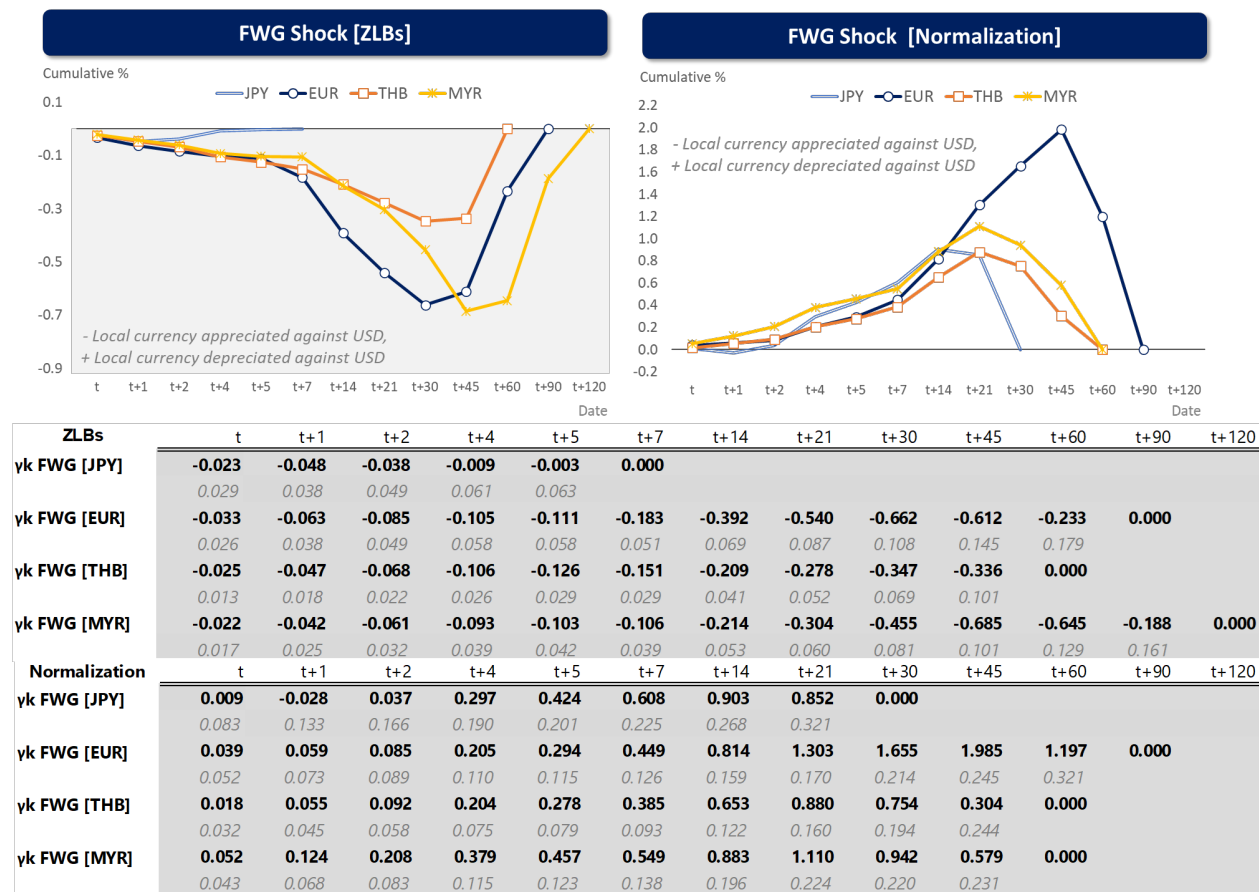
Figure 2: Impulse response of daily foreign exchange rates to large-scale asset purchases (LSAPs) shock during the Post-ZLB period or Normalization with Local Projections



Note: 1) the bold numbers in the table express the unconventional shock coefficients,  $\gamma$ , from Local Projections, 2) Minus sign indicates local currency appreciated against US dollar or a dollar depreciation / Plus sign indicates local currency depreciated against US dollar or a dollar appreciation, 3) The italic numbers are heteroskedasticity-and-autocorrelation consistence standard errors.

Source: Author's calculations

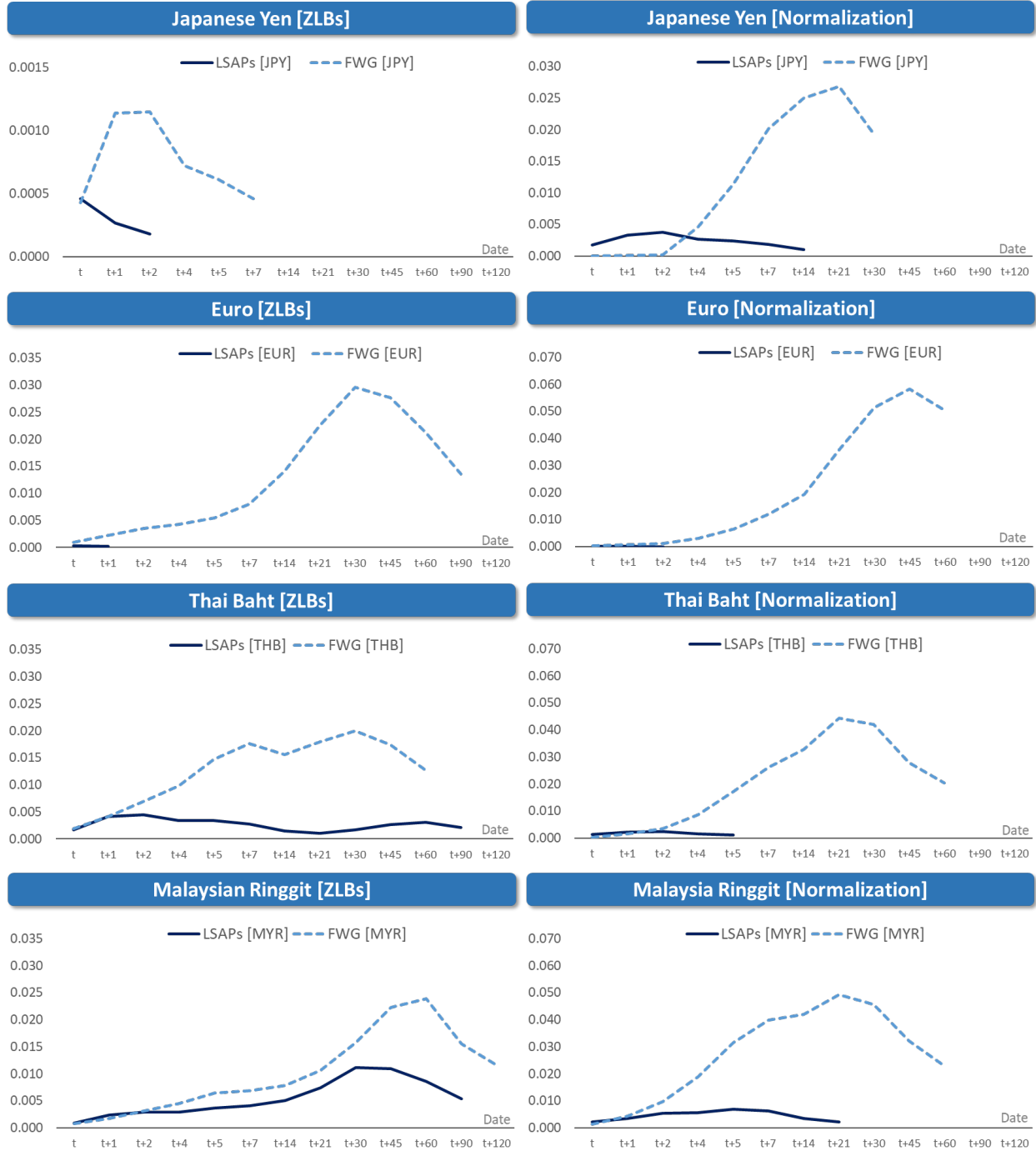
Figure 3: Impulse response of daily foreign exchange rates to Forward guidance shock (FWG) during the Zero lower bound (ZLB) periods with Local Projections



Note: 1) the bold numbers in the table express the unconventional shock coefficients,  $\gamma$ , from Local Projections, 2) Minus sign indicates local currency appreciated against US dollar or a dollar depreciation / Plus sign indicates local currency depreciated against US dollar or a dollar appreciation, 3) The italic numbers are heteroskedasticity-and-autocorrelation consistence standard errors.

Source: Author's calculations

Figure 4: Variance decomposition with Local Projections



Source: Author's calculations