Identification of the Forward Guidance and QE Surprises in the UK*

Derin Aksit†

May 28, 2020

Abstract

Using intraday data, I separately identify the Bank of England's forward guidance and quantitative easing surprises during the effective lower bound period in the UK. Then, I estimate asset price responses to these unconventional monetary policies. I show that both surprises significantly move gilt yields and term premia on days of monetary policy announcements. However, their impact persists for only a few months. I further document that only forward guidance is effective in moving stock prices and their volatility. While both surprises influence the British pound, the impact of forward guidance persists for at least six months.

JEL Classification: E58, E52, E43

Keywords: Unconventional Monetary Policies, Bank of England, Forward Guidance, Quantitative Easing, High-Frequency Identification

*I would like to thank Jonathan Wright, Silvia Miranda-Agrippino, Ambrogio Cesa-Bianchi, Michael Joyce and seminar participants at the Bank of England for their insightful comments and suggestions.

†Department of Economics, Johns Hopkins University, Baltimore MD 21218; aksit@jhu.edu

1 Introduction

Following the global financial crisis, the Bank of England (BoE) has lowered its policy rate, the Bank rate, to its effective lower bound (ELB) in March 2009.[1] While the Bank rate remained at its ELB for almost a decade, the BoE employed unconventional monetary policies (UMPs) to further stimulate the economy. In particular, the BoE initiated its quantitative easing (QE) program[2] on the same day the Bank rate hit its ELB. While the communication about the future path of the policy rate, i.e. forward guidance (FG), was an important monetary policy tool before the global financial crisis, it gained more importance as the Bank rate was constrained by the ELB.

Following Kuttner (2001), the event-study literature identified the conventional monetary policy surprise as the change in the current month or one-month-ahead Fed funds futures rate. At the ELB, the variation in this monetary policy surprise is clearly zero. Gürkaynak et al. (2005) extend this methodology by identifying a second significant monetary policy factor, i.e. the future path of the policy rate, in other words, FG. They further show that these two factors almost fully explain the movement of the term structure around Federal Open Market Committee (FOMC) announcements.[3] After the initiation of the large-scale asset purchases (LSAPs) in the US, a new line of research that separates the surprise effects of different UMPs emerged. Swanson (2019) disentangles the effects of FG and LSAP surprises, extending the methodology in Gürkaynak et al. (2005) to the ELB period. Swanson (2019) shows that FG and LSAP surprises almost fully explain the movement of the term structure

[1] Although the Bank rate is lowered to 0.1% in 2020, 0.5% was communicated as the ELB after the global financial crisis of 2008.

[2] While the Federal Reserve refers this UMP as the large-scale asset purchases (LSAPs), the BoE calls it the QE policy.

[3] Note that this is also true in the UK.

around FOMC announcements during the ELB period.

Using high-frequency data, I separately identify the FG and QE surprises of the BoE during the ELB period in the UK, following the methodology of Swanson (2019). Then, I show the effects of these UMPs on asset prices in the UK and compare these effects with those in the US. I first document the response of gilt yields and term premia to these UMPs. Both surprises combined account for only a third of the daily variations in gilt yields and their term premia on the Monetary Policy Committee (MPC) announcement days during the ELB period. Besides, the impact of UMPs on gilt yeilds and term premia dies out within a few months. I also measure the responsiveness of stock prices, their volatility and the British pound to UMPs. While both UMP easings depreciate the pound, FG easings move stock prices up and their volatility down. Moreover, the impact of FG on the British pound persists for at least six months. Lastly, I illustrate that corporate bond spreads and equity risk premia increase in response to larger than expected asset purchases.

Over the past decade, a body of research that measures the effectiveness of newly implemented LSAP policies in lowering the yield curve at the ELB has emerged. While Gagnon et al. (2011), Vissing-Jorgensen and Krishnamurthy (2011) and D'Amico and King (2013) show that the LSAP policies of the Federal Reserve were effective in flattening the yield curve, Joyce et al. (2011) come to the same conclusion for the UK. Given the effectiveness of the QE policies in the UK, there is a subsequent line of literature that empirically measures the impact of the QE policies employed by the BoE on macroeconomic variables. Bridges and Thomas (2012), Kapetanios et al. (2012), Baumeister and Benati (2013) and Churm et al. (2015) use VAR analyses to measure the real impact of the QE policies and report that the policies were significant in avoiding deflation and output losses.

There is parallel line of literature that empirically assesses the effects of QE policies in the UK on asset prices. Rogers et al. (2014) employ identification through heteroskedasticity to show that a QE surprise in the UK lowers government and corporate bond yields at maturities higher than 2 years. Christensen and Rudebusch (2012) use an empirical dynamic term structure model to decompose the yield declines into changes in expectations about future monetary policy and changes in term premia. They show that the decline is sourced from the latter. Using an event-study approach, Joyce et al. (2011) report that the QE1 policy has lowered medium to long rates by about a percentage point and stress the importance of the portfolio balance channel in the effectiveness of QE1. Goodhart and Ashworth (2012) argue that the effectiveness of QE1 in loosening financial conditions was larger than that of QE2 in the UK.

Note that the literature which measures the real and financial effects of UMPs in the UK does not disentangle a QE surprise from an FG surprise and only Rogers et al. (2014) employ intraday changes in yields around every MPC announcement. For instance, in another event-study approach, Joyce et al. (2011) employ survey expectations to measure QE surprises. While the methodology of Swanson (2019) allows one to measure the separate impact of FG and QE surprises on asset prices, it also produces a time series of UMP surprises where every MPC announcement is a separate observation.

The rest of this paper is organized as follows: Section 2 describes the data and the identification methodology of the FG and QE surprises in the UK. Section 3 presents the analysis of important MPC announcements in the UK during the ELB period. Section 4 discusses the responses of asset prices to UMPs. Section 5 documents the persistence of the effects of FG and QE surprises on asset prices. Section 6 concludes.

2 Data and Methodology

The decomposition methodology employed to disentangle the effects of FG and QE on financial assets is an application of Swanson (2019). This approach provides a way to separate the relative importance of two distinct UMP tools. The Bank rate surprise, which is captured by the 30-minute change in the 1-month overnight interest swap rate (OIS1M) around each MPC meeting, is very small in absolute magnitude during the ELB period and has no significant impact on financial assets.

I follow the split sample identification in Swanson (2019). In the first step, I focus on the sample from July 1997 to February 2009, the pre-ELB period where there are two distinct monetary policy tools: the Bank rate surprise and the future path of the Bank rate communication, i.e. FG surprise. I extract the first two principal components from a matrix composed of 30-minute changes in six financial assets whose maturities range from 3 months to 10 years. Specifically, I use the 30-minute changes of the 1st, 2nd and 4th short sterling futures rates, and the 2-year, 5-year and 10-year gilt yields. The 30-minute window is between 11:50 and 12:20 on all MPC announcement days between July 1997 and February 2009. The illustration of this extraction can be represented by a factor model:

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

where X is the matrix of the high-frequency changes in financial assets, F is the matrix of principal components, Λ is the matrix of loadings and ε is a white noise residual. The dimensions of X is the number of announcements, $T = 140$, by the number of financial assets, $n = 6$. The dimensions of F is T by k, the number of principal components which is 2, and the dimensions of Λ is k by n.

As in Gürkaynak et al. (2005), I conduct the rank test of Cragg and Donald (1997) to identify the number of factors underlying the interest rate responses to the monetary policy announcements. I employ two principle components following this test. Table 1 shows that the rank test of Cragg and Donald (1997) rejects the null hypotheses that the rank of F is 0 (i.e. X is explained by a random walk) or 1 with relatively small p-values. A factor structure with two dimensions, however, sufficiently explains almost all of the variation in X matrix.

The first two principal components have no structural interpretation. However, they explain almost all of the variation in the term structure around MPC announcements. I rotate these two principal components such that the first vector moves one-to-one with the surprise change in the 1st short sterling futures rate, and the second vector captures all the variation orthogonal to the first vector by construction and corresponds to the moves in interest rate expectations over the subsequent horizons. Thus, the second factor has the structural interpretation of a future path of the policy rate, i.e. FG.

The rotation of these first two principal components is done by defining a 2x2 rotation matrix, U, and plugging it into the factor model given above.[4] Defining $\tilde{F} = FU$ and $\tilde{\Lambda} = U'\Lambda$, the same factor model can be rewritten as in Equation (2). This requires to make an additional (to the orthogonality assumptions implied by the rotation matrix) identifying assumption: equating the loading of the second factor that corresponds to the shortest maturity asset, the 1st sterling future, to 0. Therefore, the first column of $\tilde{F}$ has the

[4]Since the multiplication of a rotation matrix with its transpose is the identity matrix, the equality still holds with the same residuals.

structural interpretation of a Bank rate surprise while the second column has the future path of the policy rate interpretation.

$$X = \tilde{F}\tilde{\Lambda} + \varepsilon \tag{2}$$

This step follows from Gürkaynak et al. (2005). The second step is proposed by Swanson (2019). In this step, a similar exercise is conducted for the ELB period, from March 2009 to August 2018. Since the expectations of the short rates do not move much in the ELB period, I omit the 1st and 2nd short sterling futures from the asset matrix. Therefore, X has 4 financial assets whose maturities vary from a year to ten years.

I build the same factor model in Equation (1) for the ELB period. Table 2 shows the results of the Cragg and Donald (1997) rank test for the ELB period: the number of factors underlying the high-frequency response of the term structure around MPC announcements is 2 for this period as well.[5] The null hypotheses that the rank of the $\tilde{F}$ matrix is 0 or 1 are rejected by the Cragg and Donald (1997) rank test. Thus, I extract the first two principle components of the X matrix.

The identifying assumption in this step is to minimize the Euclidean distance between the loadings of the FG factor from the pre-ELB period and the loadings of the FG factor in the ELB period. This assumption implies that the effect of the FG surprise on the term structure during the pre-ELB and ELB periods are the same. Though questionable, Swanson (2019) shows that an alternative (full-sample) identification method implies a very similar FG factor. This is also true for the UK.

[5] I assume that the rank of $\tilde{F}$ matrix cannot exceed 2 since the Bank rate was effectively zero at the ELB.

3 Analysis of Important Announcements

The resulting factors are presented in Figure 1. A negative surprise is a monetary policy easing, which corresponds to a longer than expected ELB period (FG easing) or a larger than expected asset purchase (QE easing). The vertical axis shows the standard deviation changes in the surprise factors and the horizontal axis shows the MPC announcement dates.

The blue bars in Figure 1 display the FG surprises during the ELB period. March 2009, when the first QE policy was announced and the Bank rate was reduced to its ELB, is reflected as a large tightening FG surprise. The large tightening on this day could be due to ex-ante market expectations that the MPC would buy shorter maturity gilts. Moreover, after the Brexit referendum, the markets expected an additional monetary stimulus in the July 2016 meeting while the MPC did not announce any further easing (this is reflected as a tightening larger than a standard deviation). Other FG tightenings larger than a standard deviation are the more recent announcements of September 2017, February 2018 and June 2018, in which the Bank communicated that the QE unwinding could start when the Bank rate hits 1.5% instead of 2%.

As for FG easings, August 2009 announcement is the largest one. The term structure shifted downwards drastically as the MPC communicated a "lower path of Bank Rate than implied by market yields". Another large FG easing is the July 2013 announcement, when the MPC started to communicate the timing of the initial Bank rate hike explicitly. The third largest FG easing is the August 2016 announcement, which is the meeting after the MPC kept its policy stance following the Brexit referendum. In this meeting, the MPC cut the Bank rate by 25 basis points, signaling the extension of the ELB, along with further asset purchases. November 2017 "Dovish Hike" and May 2018 announcements are also reflected as recent FG easing surprises larger than a standard deviation.

The pink bars in Figure 1 illustrate the QE surprises. The largest QE surprise, which is a six standard deviation easing, is the initiation of the QE policy in March 2009. The May and August 2009 announcements, when QE was expanded, also imply large QE surprises. The QE2, which announced additional 75 billion pound asset purchases in October 2011, also corresponds to a large QE easing. Another QE easing, which is larger than 2 standard deviations, is the August 2016 announcement, when the MPC expanded the QE policy after the Brexit referendum. As for QE tightenings, the only surprise larger than 2 standard deviations is the July 2009 announcement, where the MPC did not expand the QE as expected.

4 The Responses of Asset Prices to UMP Surprises

The effect of FG and QE surprises on asset prices during the ELB period can be estimated by an event-study approach:

$$\Delta Y_t = \beta_0 + \beta_{FG} FG_t + \beta_{QE} QE_t + \varepsilon_t \quad (3)$$

where ΔY_t is the daily change in asset prices (e.g. gilt yields, term premia, stock prices, the exchange rate).[6]

[6] I use log changes for stock prices and the exchange rate.

4.1 Response of Gilt Yields

Table 3 shows the responses of gilt yields whose maturities range from 1 year to 10 years. Each coefficient estimate shows the basis point change in gilt yields in response to a one standard deviation tightening surprise. The effect of the FG surprise on gilt yields maturing from 2 years to 6 years is statistically significant at the 1% level. The estimated effect on daily gilt yield movements is between 1 to 2 basis points for all yields. As for the QE surprises, Table 3 shows that the impact of a QE surprise increases towards the long end of the term structure while it also significantly affects the medium term yields. Its effect on the 10-year gilt yield is close to 4 basis points. As expected, QE surprises affect longer term yields more while FG surprises have a larger impact on shorter term yields. FG and QE surprises, combined, explain only a third of the daily variation in medium to long-term rates.

The coefficient estimates reported in Table 3 are smaller in absolute magnitude than their US counterparts.[7] The difference in coefficient estimates could be explained by the relative importance of each monetary policy announcement in both countries. While there are 8 FOMC announcement in the US every year, there were 12 MPC announcements in the UK every year until 2018, practically the end of the sample period. Thus, while the estimated effect of a one standard deviation UMP surprise in the UK is smaller for each MPC announcement, the cumulative impact of UMP surprises is larger since there are more announcements in a given year.

[7] Swanson (2019) reports the 30-minute responses of Treasury yields to UMP surprises and finds larger coefficient estimates. Note that the daily government yield responses in both countries are slightly larger than their 30-minute responses since some announcements were followed by detailed press conferences that were outside the 30-minute intervals around monetary policy announcements. Besides, the financial markets could have taken some time to process the UMP descriptions and their economic implications.

The reported coefficients of determination in Table 3 are also much smaller than their US counterparts. While both UMP surprises explain up to three quarters of the daily variations of the Treasury yields on the days of FOMC announcements, they explain up to only a third of the daily variations of gilt yields in the UK. Note that both UMPs explain almost all of the variation in the government yields in a 30-minute window. Thus, this stark disparity at a daily horizon could be due to other information revealed throughout the day. In fact, some important macroeconomic news, such as the quarterly inflation report,[8] are announced simultaneously with the monetary policy announcements in the UK. The timing of the FOMC and MPC announcements are also consistent with this explanation. While the FOMC announcements are at 2:00 PM, the MPC announcements are at 12:00 PM. Therefore, there is more room for additional information to influence the daily variation of gilt yields in the UK. For instance, as a small open economy, one would expect gilt yields of the UK to be more sensitive to foreign macroeconomic news revealed throughout the day.

It is important to note that the reported gilt yield responses are the average daily responses during the ELB period in the UK. There is an alternative line of literature which reports very large effects of LSAPs on Treasury yields (e.g. Li and Wei (2013), Vissing-Jorgensen and Krishnamurthy (2011), Gagnon et al. (2011)). The difference is mainly due to the employed sample period.[9] These studies mostly analyze the impact of LSAP surprises in late 2008 and early 2009. Extending the sample space to the whole ELB period and disentangling the impact of LSAP surprises from FG surprises yield much smaller effects.[10]

[8]The quarterly inflation report is announced simultaneously with the monetary policy announcement since 2015.

[9]These papers also employ alternative identification methods which do not use high-frequency data. For instance, Li and Wei (2013) use private holdings of Treasury securities and agency mortgage-backed securities to identify LSAP surprises.

[10]For instance, Greenlaw et al. (2018) report that extending the sample of Gagnon et al. (2011) to all

Greenlaw et al. (2018) argue that the LSAP surprises had large effects on the Treasury yields at the beginning of the ELB due to severe market dislocation and illiquidity. As the markets improved, the impact of LSAP surprises on Treasury yields went down.[11] Therefore, using all monetary policy announcements implies a smaller estimated impact on government yields.

4.2 Response of Term Premia

I also analyze the impact of FG and QE surprises on the term premia components of gilt yields. Different term structure models employ various assumptions to estimate the term premia. I use the Bank of England's term premia estimation for the UK, which is the average of several term premia estimations implied by different term structure models. Table 4 shows that FG surprises affect the term premia component of gilt yields with maturities of 1 to 5 years. Less than half of the estimated impact of FG surprises on gilt yields at all maturities is due to the impact of FG on the term premia component of gilt yields.[12]

This result is consistent with economic theory. FG is a communication about the future path of the policy rates. Hence, it operates mostly through the expectations hypothesis of the term structure of interest rates. However, changes in expected future short rates could also affect term premia. For instance, Hanson and Stein (2015) suggest a mechanism due to investors that increase their demand for longer-term bonds following a cut in short rates. In this mechanism, the switch to riskier longer-term bonds is motivated by reaching for higher yields. Hence, the reported coefficient estimates of FG in Table 4 are statistically significant.

FOMC announcements and controlling for the impact of FG surprises decrease the estimated impact of LSAPs on the 10-year yield from 117 basis points to 33 basis points.

[11] A parallel argument to this is the big shift in market expectations regarding the size of the announced asset purchases. For instance, QE2 is characterized as an LSAP tightening by Swanson (2019) as the size of the program did not exceed the market expectations.

[12] Note that the FG surprises in the US also have a limited impact on term premia.

The impact of QE surprises on the term premia component of gilt yields is substantial. As shown in Table 3, the effect grows with the maturity and almost two thirds of the impact on the 10-year rates are explained by the change in the term premia component of gilt yields. The mechanism through which QE surprises lower term premia is often called the portfolio balance channel. The asset purchases of the central bank reduce the bond supply in order to lower the term premia. Note that the estimated coefficients of QE surprises in Table 4 are statistically different than those in Table 3. Thus, it also moves the government yields through the signalling channel, i.e. the signalling effect of asset purchases that lowers the expected future short rates. In the US, LSAP surprises also mostly operate through the portfolio balance channel (see e.g. Gagnon et al. (2011)) while the signalling channel also exists (see e.g. Bauer and Rudebusch (2014)). Figures 2-3 summarize these findings visually, plotting the daily responses of gilt yields and their term premia at different maturities to FG and QE surprises with 95% confidence intervals.

4.3 Response of Stock Prices and the Exchange Rate

Table 5 shows that both the FTSE All Share (FTSE-AS) index, which captures around 600 companies traded in the London Stock Exchange, and the UK firms in the FTSE-AS index are responsive to FG surprises. A one standard deviation FG easing moves the stock prices up by 35 basis points and the volatility of the stock market down by more than a percentage point. These results are consistent with economic theory as lower interest rates would increase expected earnings and decrease the discount rate. Likewise, lower rates are expected to decrease the stock market volatility due to lower uncertainty and risk aversion as discussed in Bekaert et al. (2013).

A QE surprise does not significantly influence the stock prices and their volatility. This could be due to two opposing implications of QE surprises on macroeconomic expectations. Aksit (2020) shows that, similar to a FG easing, a QE easing could be interpreted as either "good news" due to looser financial conditions (Odyssean), or "bad news" due to the central bank's revealed perception of the state of the economy (Delphic). Hence, the opposing impact of these two possible interpretations on the stock prices could be cancelling each other. On the other hand, both UMP easings significantly depreciate the British pound (ERI). The direction of this relationship is as expected due to lower international demand for UK financial securities.[13]

These results are parallel to those in the US. Swanson (2019) shows that a one standard deviation FG easing increases the S&P500 index by 25 basis points during the ELB period while the impact of an LSAP surprise is insignificant. He further shows that both UMP easings depreciate the US dollar with similar magnitudes (a one standard deviation FG surprise depreciates the dollar by 36 basis points while a one standard deviation LSAP surprise depreciates the dollar by 19 basis points). Aksit (2020) reports that an FG easing in the US during the ELB period decreases the options implied volatility of the stock market. The volatility decreasing impact of an FG easing is consistent with the findings of Bekaert et al. (2013), who find that a lax conventional monetary policy decreases the VIX, the stock market option-based implied volatility.

[13]Note that both Delphic and Odyssean interpretations of an UMP easing would depreciate the local currency due to weaker demand for local financial securities.

4.4 Response of Corporate Spreads and Equity Risk Premia

I also analyze the impact of UMP surprises on investment grade (IGCORPS) and high yield (HYCORPS) corporate bond spreads.[14] A UMP easing is expected to decrease corporate bond yields less than government bond yields due to two complementary channels: central banks operating their asset purchases mostly in government bond markets and the risk associated with the corporate bonds going up, especially for riskier bonds. Table 6 reports that a QE easing increases the corporate bond spreads (i.e. lower gilt yields faster than the corporate yields) as one would expect. The last column of Table 6 further shows that a QE easing very significantly increases the equity risk premia of UK firms by almost 4 basis points.[15] This finding supports the existence of the latter channel. Note that LSAP easings in the US also widen the corporate spreads as shown by Swanson (2019).

On the other hand, the impact of an FG surprise is not significant on IGCORPS but is marginally significant with an inverse sign on HYCOPRS. However, the opposite sign of the FG surprise is not robust to omitting outliers. Computing the Cook's distance for each observation after running the OLS regression and dropping any observation with a Cook's distance statistic larger than 1 make the FG coefficient estimates insignificant as shown in the third and fourth columns of Table 6.[16] Dropping these outliers also makes the coefficients estimates of QE surprises significant at the 5% significance level in both regressions.

[14] Note that the average maturity of these corporate bonds is around 8 years and the maturity of the employed risk-free rate matches the average maturity of the corporate bonds.

[15] I report the responses of equity risk premia estimated for the FTSE-AS index and FTSE-UK index by the Bank of England.

[16] The identified outliers are March 2009 and August 2016 in the HYCORPS regression and March 2009 and May 2009 in the IGCORPS regression. These observations include three of the largest UMP surprises.

5 The Persistence of the Effects on Asset Prices

The persistence of the effect of FG and QE surprises on asset prices can be estimated by local projections as in Jordà (2005) with Newey and West (1987) standard errors:

$$\Delta Y_{t+h} = \beta_0 + \beta_{FG,h} FG_t + \beta_{QE,h} QE_t + \beta^h_{control} \Delta Y^m_{t-i} + \varepsilon^h_t \quad (4)$$

where ΔY_{t+h} is the change in asset prices at different monthly horizons, i.e. $Y_{t+h} - Y_{t-1}$ for $h \in \{0, 1, ..., 6\}$. FG_t and QE_t are UMP surprises. ΔY^m_{t-i}, $i \in \{1, 2, 3, 4\}$, which is the collection of preceding monthly changes of the dependent variable in the four months[17] before the announcement, is the set of control variables. The purpose of this control variable is to decrease the sampling variance of the estimator by decreasing the variance of the error term. The coefficient estimates are still consistent in the absence of these control variables since the UMP surprises, which are identified using high-frequency data, are assumed to be independent of the true past and future monetary policy shocks.

5.1 Persistence of the Responses of Gilt Yields and Term Premia

Figures 4-5 illustrate the persistence of the effects of FG and QE surprises on gilt yields with different maturities ranging from 1-year to 10-years. The impact of FG surprises on medium term yields (in particular, 1-year and 2-year yields) is significant for about three months using 95% confidence intervals. Similar to the results presented in Figure 4, Swanson (2019) reports that the impact of FG surprises on the 5-year Treasury yield persists less than a month at the 5% significance level in the US. On the other hand, Figure 5 shows that the

[17] Following Ramey (2016), and Stock and Watson (2018), I include four lags.

impact of QE surprises on long term yields persists for about two months. This result is also consistent with the estimated impact of LSAP surprises in the US. Wright (2012) shows that the impact of UMPs on the long term interest rates in the first half of the ELB period persists for around two to three months.

Note that the estimated impact of QE surprises on the government yields, as shown for the UK in this paper and for the US in Wright (2012) and Swanson (2019), is relatively short lived compared to the studies that report large LSAP effects on the 10-year rates in the US (e.g. Li and Wei (2013), Vissing-Jorgensen and Krishnamurthy (2011), Gagnon et al. (2011)). These studies find that the impact on asset prices persists for at least a year. The difference between these two set of results on the persistence of the effects of LSAPs is also mainly due to employing a limited sample period as discussed above. Estimating the persistence of the effects of LSAPs on government yields using all monetary policy announcements yields much shorter lived effects.

There is a recent body of research that discusses why the effects of LSAP surprises on asset prices might be short lived. Duffie (2010) argues that large capital movements might have a transitory impact on asset prices since capital could be slow-moving and cannot be reallocated instantly due to limits on capital market intermediation in response to asset price distortions. Consistent with this argument, Fleckenstein et al. (2014) provide empirical evidence of TIPS-Treasury mispricing during the global financial crisis while Greenlaw et al. (2018) and Woodford (2012) discuss how markets reassess their reactions in response to LSAPs on the subsequent days due to the large-scale of the announced asset purchases.

In Figures 6-7, I plot the persistence of the effects of FG and QE surprises on the term premia component of gilt yields with different maturities ranging from 1-year to 10-years.

The persistence of the impact of both UMPs on the term premia component of gilt yields is roughly the same as the persistence of their impact on gilt yields. While this result is especially expected for QE surprises which are shown to be mostly operating through the portfolio balance channel in the UK (see e.g. Joyce et al. (2011)), it is also consistent with the "reaching for higher yields" argument of Hanson and Stein (2015).

5.2 Persistence of the Responses of Stock Prices and the Pound

Next, I analyze the persistence of the impact of FG and QE surprises on stock prices, their volatility and the British pound. Figure 8 shows that the impact of FG on the FTSE All Share index and its volatility dies out within a week, as in the US. This result is consistent with the "slow-moving capital" argument of Duffie (2010) and the "initial market overreaction" argument of Greenlaw et al. (2018).

On the other hand, the impact of FG on the British pound persists for at least six months at the 5% significance level and the size of its impact grows in absolute magnitude, up to a percentage point. Therefore, markets undervalue the induced depreciation in the British pound on the day of the MPC announcement and the pound continues to depreciate in response to the commitment of staying at the ELB for longer than expected. On the contrary, the impact of an FG surprise on the dollar is very transitory in the US.

Both the growing impact of FG on the British pound and the transitory impact of FG on the US dollar could be due to the time taken by markets to digest important news. Note that this readjustment could be in either direction. Hence, while an FG easing in the US temporarily depreciates the USD, an FG easing in the UK has a much more permanent impact on the pound. The relative overreaction of the US dollar on the day of the announcement could be explained by the relatively larger volume of transactions made in the US dollar.

The effect of QE surprises on the FTSE is insignificant at nearly all horizons. A QE easing is estimated with 95% confidence to increase the stock market index after five months. Interestingly, the impact of an LSAP surprise on stock prices in the US is also insignificant at nearly all horizons, except for a transitory impact with an expected sign after three months. These lagged responses could be explained by the resolved uncertainty about the macroeconomic implications of the undertaken QE policy. In particular, if the announced QE easing is associated with an improved subsequent macroeconomic outlook, the expected earnings in the financial sector could be increasing with a lag. Hence, a QE easing would be increasing stock prices with a lag of few months.[18] The response of stock market volatility over longer horizons is also consistent with this argument. A QE easing temporarily lowers stock market volatility after five months (while other policy surprises do instantaneously) due to the time it takes to process the macroeconomic implications of a QE surprise.

As in the US, the currency depreciating effect of a QE easing is very transitory. This finding is consistent with the arguments of limits on capital market intermediation and initial market overreaction as discussed above. Note that the sign of its impact on the domestic currency flips temporarily after five months. This flipped sign is also consistent with the transitory increase in stock prices after five months. If market participants observed stronger economic activity in response to QE policies, we would expect to see a lagged appreciation in the domestic currency due to higher demand for domestic financial securities.

[18] Note that this significant lagged impact is also transitory as the instantaneous effect of an FG surprise. Hence, the lagged transitory impact could also be a mispricing due to the limits on capital market intermediation as discussed by Duffie (2010).

6 Conclusion

Using high-frequency data, I empirically identify the FG and QE surprises employed by the BoE when its policy rate was constrained by the ELB. Then, I show that both policies were effective in moving the asset prices in the UK around MPC announcements. However, the UMP surprises account for up to only a third of the daily variations in gilt yields and term premia during the ELB period. Moreover, their impact on gilt yields and term premia do not persist for more than a few months as in the US.

I further document that both FG and QE surprises significantly influence the British pound. The impact of FG persists for at least six months while the effect of QE disappears very quickly. FG surprises are also effective in moving stock prices and their volatility. However, the response of stock prices to FG surprises do not persist more than a week. I further illustrate that corporate bond spreads and equity risk premia increase in response to QE easings.

7 Tables and Figures

Table 1: Testing the Number of Factors that Explain the Interest Rate Movements Around MPC Announcements in the Pre-ELB Period

No. of Factors under the Null	Degrees of Freedom	Wald Statistic	p-value
0	15	72.48	1×10^{-6}
1	9	22.62	0.07
2	4	2.49	0.65

The conducted test follows the Cragg and Donald (1997) test for the number of factors underlying the $T \times n$ matrix X of the 30-minute responses of the term structure in the UK to the MPC announcements from July 1997 to February 2009. $T = 140$ and $n = 6$. The test is for $H_0 : k = k_0$ versus $H_A : k > k_0$. Section 2 explains the methodology in detail.

Table 2: Testing the Number of Factors that Explain the Interest Rate Movements Around MPC Announcements in the ELB Period

No. of Factors under the Null	Degrees of Freedom	Wald Statistic	p-value
0	10	26.65	3×10^{-3}
1	5	9.02	0.10

The conducted test follows the Cragg and Donald (1997) test for the number of factors underlying the $T \times n$ matrix X of the 30-minute responses of the term structure in the UK to the MPC announcements from March 2009 to June 2018. $T = 105$ and $n = 4$. The test is for $H_0 : k = k_0$ versus $H_A : k > k_0$. Section 2 explains the methodology in detail.

Table 3: Response of Gilt Yields to FG and QE Surprises

	1YR	2YR	3YR	4YR	5YR	6YR	7YR	8YR	9YR	10YR
FG	0.69	1.28***	1.64***	1.70***	1.59***	1.40***	1.21**	1.04*	0.91	0.81
	(0.44)	(0.42)	(0.37)	(0.38)	(0.42)	(0.47)	(0.52)	(0.55)	(0.57)	(0.59)
QE	0.57**	1.15**	1.81***	2.42***	2.92***	3.28***	3.52***	3.68***	3.76***	3.82***
	(0.26)	(0.40)	(0.48)	(0.57)	(0.68)	(0.78)	(0.86)	(0.92)	(0.96)	(0.98)
R^2	0.15	0.22	0.28	0.32	0.34	0.34	0.35	0.35	0.35	0.35
N	105	105	105	105	105	105	105	105	105	105

Note: White standard errors are given in parentheses. ***, ** and * denote 1%, 5% and 10% level of significance respectively. The estimated coefficients are the basis point changes in the yields in response to a standard deviation UMP surprise. The regressions are run as in Equation (3). The sample period spans the ELB period, from March 2009 to June 2018.

Table 4: Response of the Term Premia to FG and QE Surprises

	1YTP	2YTP	3YTP	4YTP	5YTP	6YTP	7YTP	8YTP	9YTP	10YTP
FG	0.26**	0.50***	0.57***	0.52***	0.39*	0.23	0.06	-0.11	-0.26	-0.39
	(0.13)	(0.12)	(0.16)	(0.19)	(0.22)	(0.26)	(0.30)	(0.35)	(0.39)	(0.44)
QE	-0.33	0.13	0.58***	0.96***	1.28***	1.56***	1.80***	2.00***	2.16***	2.29***
	(0.21)	(0.16)	(0.21)	(0.29)	(0.37)	(0.45)	(0.52)	(0.59)	(0.65)	(0.70)
R^2	0.29	0.22	0.25	0.27	0.28	0.29	0.29	0.30	0.30	0.29
N	105	105	105	105	105	105	105	105	105	105

Note: White standard errors are given in parentheses. ***, ** and * denote 1%, 5% and 10% level of significance respectively. The estimated coefficients are the basis point changes in the yields in response to a standard deviation UMP surprise. The regressions are run as in Equation (3). The sample period spans the ELB period, from March 2009 to June 2018.

Table 5: Responses of Stock Prices and the British Pound to FG and QE

	FTSE-AS	FTSE-UK	VFTSE	ERI
FG	-0.35***	-0.34***	1.66**	0.27***
	(0.11)	(0.08)	(0.83)	(0.07)
QE	0.09	0.09	-1.02	0.17***
	(0.15)	(0.15)	(0.79)	(0.04)
R^2	0.09	0.08	0.05	0.31
N	105	105	105	105

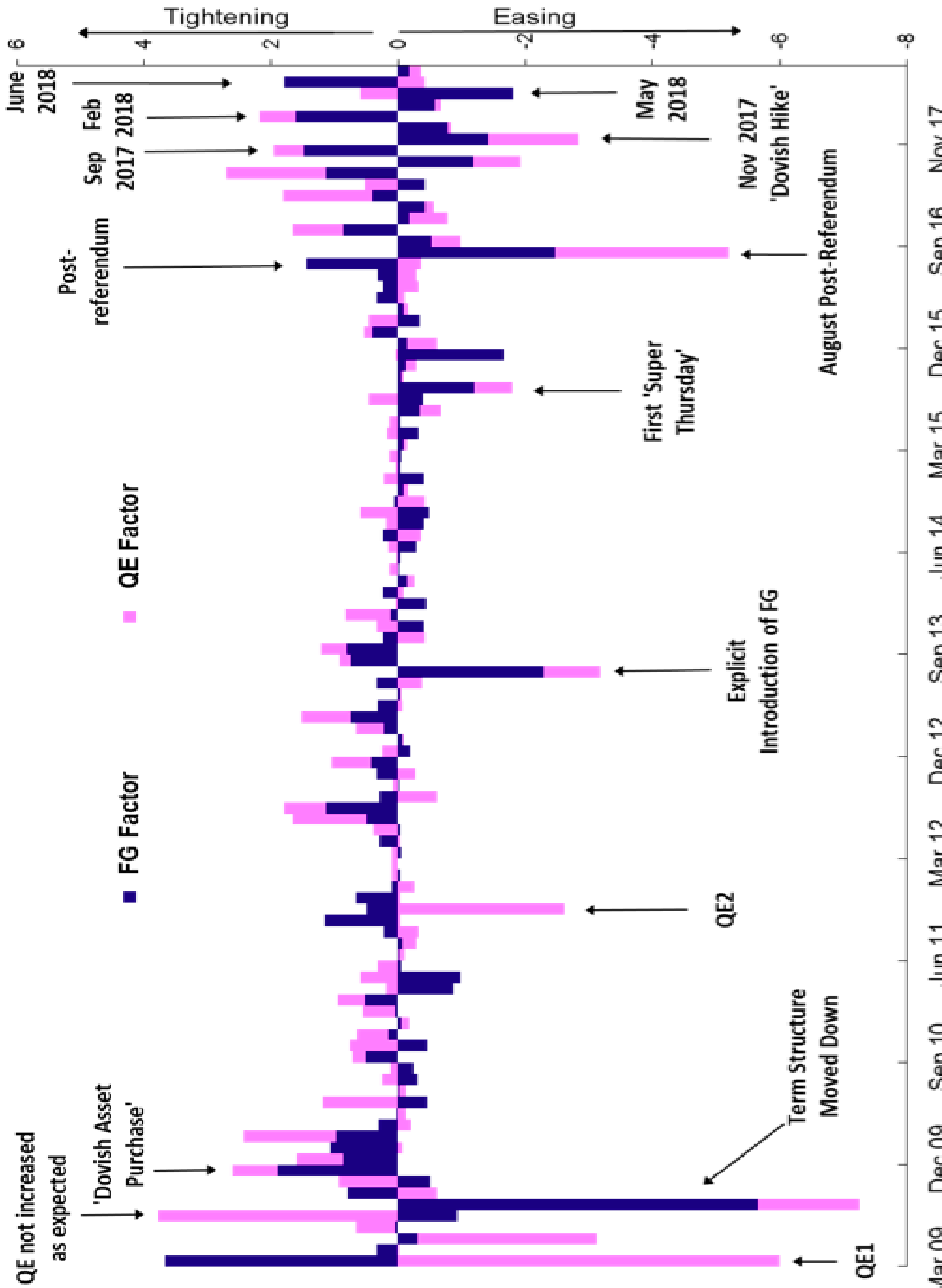
Note: White standard errors, are given in parentheses. ***, ** and * denote 1%, 5% and 10% level of significance respectively. The estimated coefficients are the percentage point changes in the asset prices to a standard deviation UMP surprise. The regressions are run as in Equation (3). The sample period spans the ELB period, from March 2009 to June 2018. FTSE-AS is the average stock price of all firms in the FTSE, FTSE-UK is the average stock price of all UK firms in the FTSE, VFTSE is the volatility index of the FTSE and ERI is the response of the British Pound index.

Table 6: Responses of Corporate Spreads and Equity Risk Premia to FG and QE

	IGCORPS	HYCORPS	IGCORPS	HYCORPS	ERP-AS	ERP-UK
FG	0.24	0.61*	-0.86	-0.10	0.66	0.83
	(0.12)	(0.35)	(0.63)	(0.17)	(1.16)	(0.61)
QE	-2.20	-0.94*	-1.58**	-0.39**	-2.25	-3.90***
	(1.83)	(0.48)	(0.79)	(0.20)	(1.49)	(0.95)
R^2	0.08	0.22	0.08	0.05	0.04	0.12
N	105	105	103	103	105	105

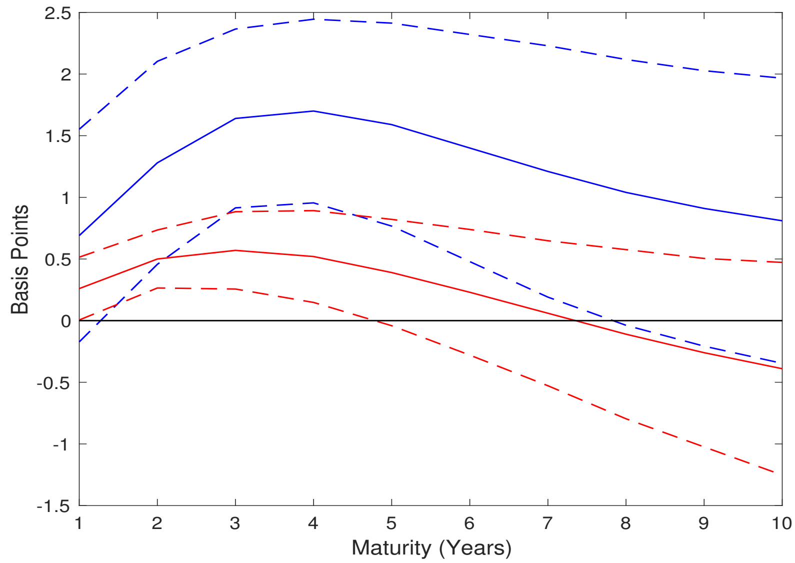
Note: White standard errors, are given in parentheses. ***, ** and * denote 1%, 5% and 10% level of significance respectively. The estimated coefficients are the basis point changes in the yields to a standard deviation UMP surprise. The regressions are run as in Equation (3). The sample period spans the ELB period, from March 2009 to June 2018. The robust regressions in the 3rd and 4th columns omit the outlier observations with Cook's distance statistic larger than 1. IGCORPS is the corporate spread of investment grade firms, HYCORPS is the corporate spread of high yield firms, ERP-AS is the equity risk premium of the FTSE-AS index and ERP-UK is the equity risk premium of the FTSE-UK index.

Figure 1: FG and QE Surprises in the UK



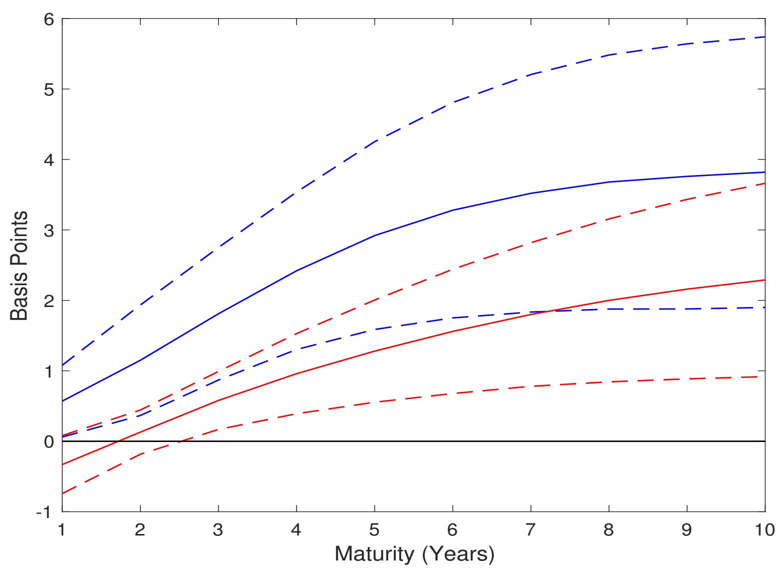
Notes: The blue bars show the FG surprise while the pink line depicts the QE surprise for each MPC announcement during the ELB period. The empirical identification methodology is as described in Section 2. Positive surprises are tightenings while negative surprises are easings. Units are in standard deviations.

Figure 2: Responses of Gilt Yields and Term Premia to FG Surprises



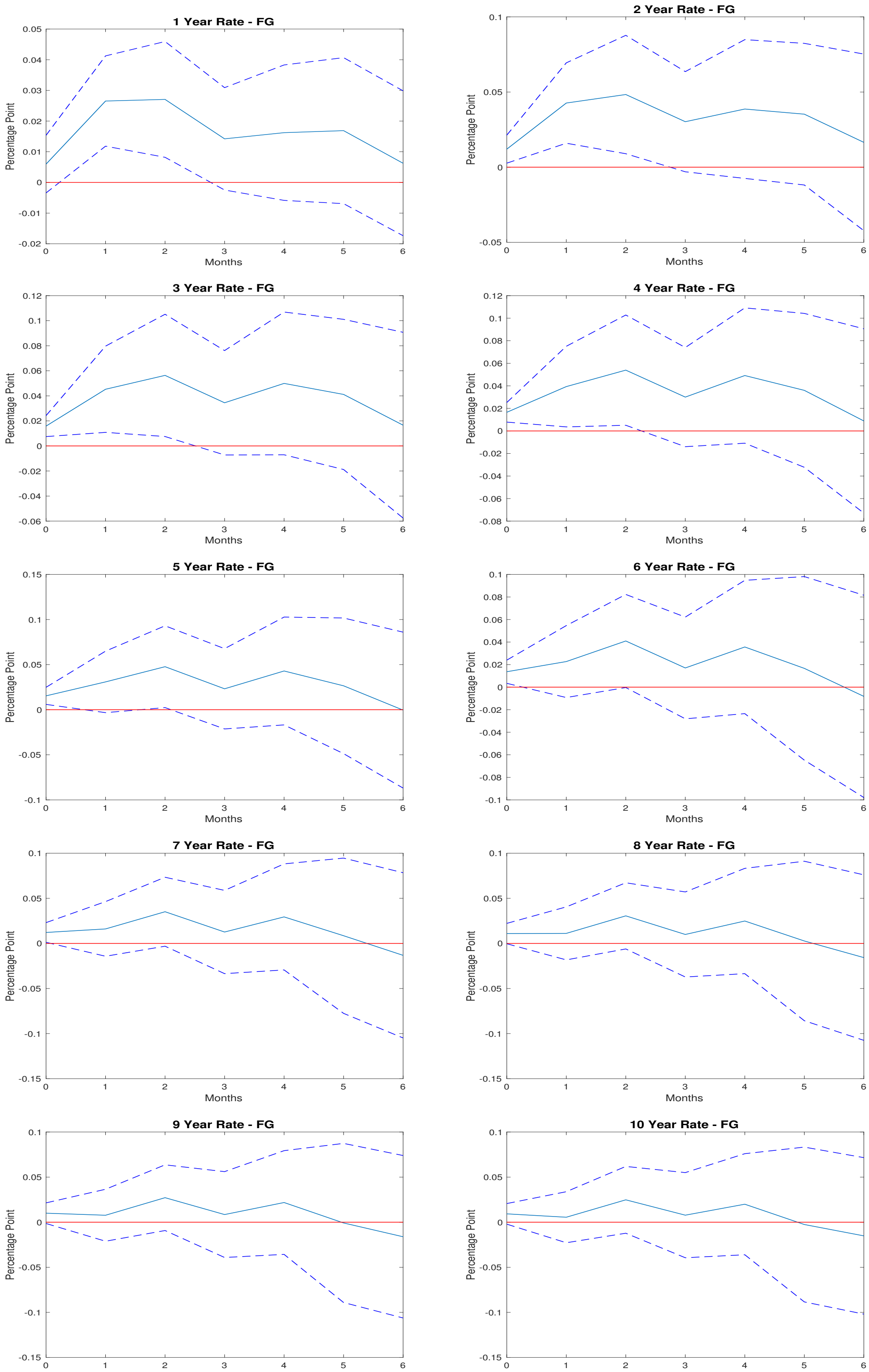
Notes: The blue solid line shows the estimated impact of FG surprises on gilt yields at different maturities while the red solid line shows the estimated impact of FG surprises on the term premia as reported in Tables 3 and 4. The dashed lines are 95% confidence bands, constructed using White standard errors.

Figure 3: Responses of Gilt Yields and Term Premia to QE Surprises



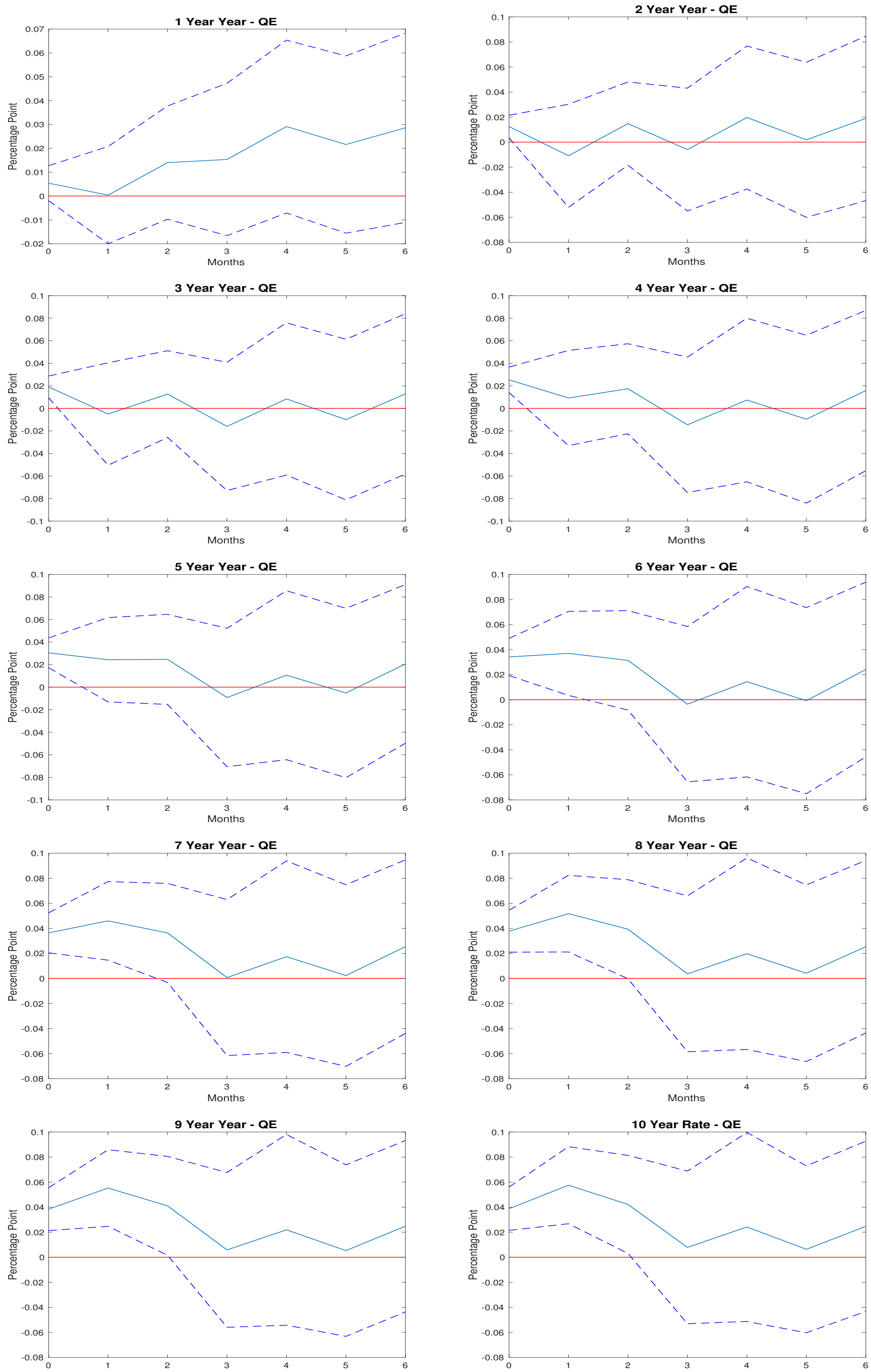
Notes: The blue solid line shows the estimated impact of QE surprises on gilt yields at different maturities while the red solid line shows the estimated impact of QE surprises on the term premia as reported in Tables 3 and 4. The dashed lines are 95% confidence bands, constructed using White standard errors.

Figure 4: Persistence of the Effect of FG on Gilt Yields



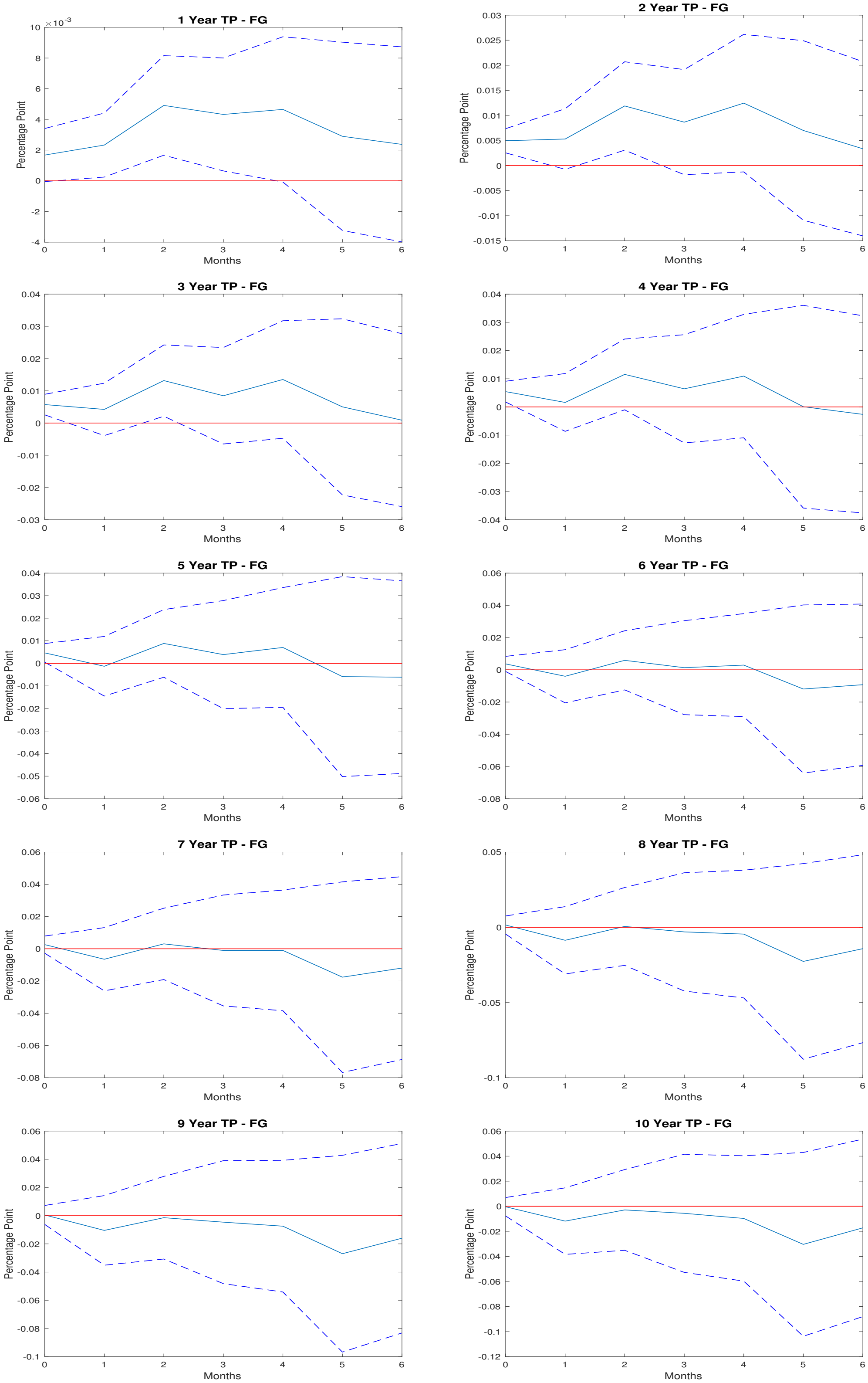
Notes: The blue solid line shows the estimated impact of an FG surprise on gilt yields with different maturities at different monthly horizons. The dashed lines are 95% confidence bands, constructed using Newey-West standard errors. The local projections are conducted as described in Section 5.

Figure 5: Persistence of the Effect of QE on Gilt Yields



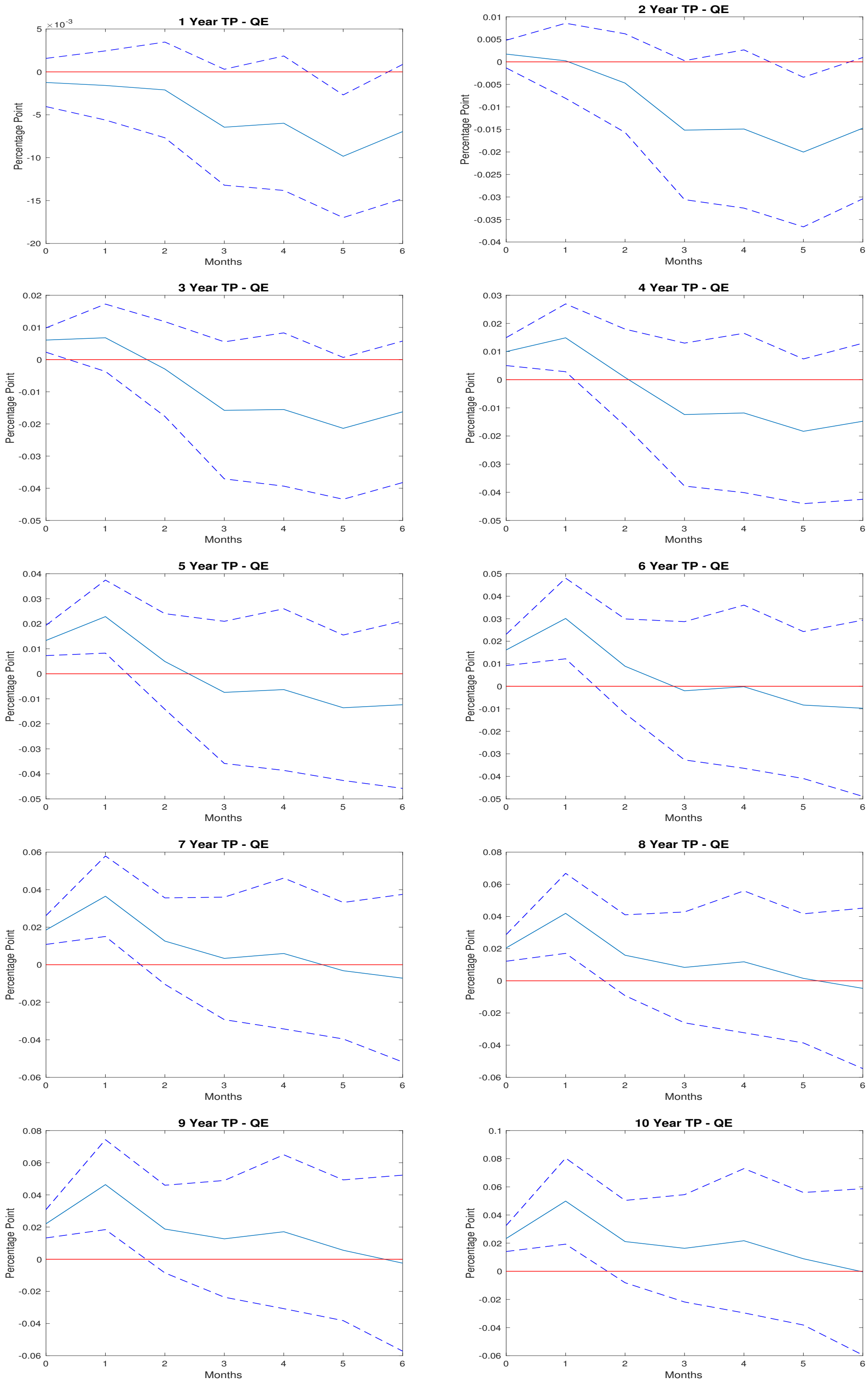
Notes: The blue solid line shows the estimated impact of a QE surprise on gilt yields with different maturities at different monthly horizons. The dashed lines are 95% confidence bands, constructed using Newey-West standard errors. The local projections are conducted as described in Section 5.

Figure 6: Persistence of the Effect of FG on the Term Premia



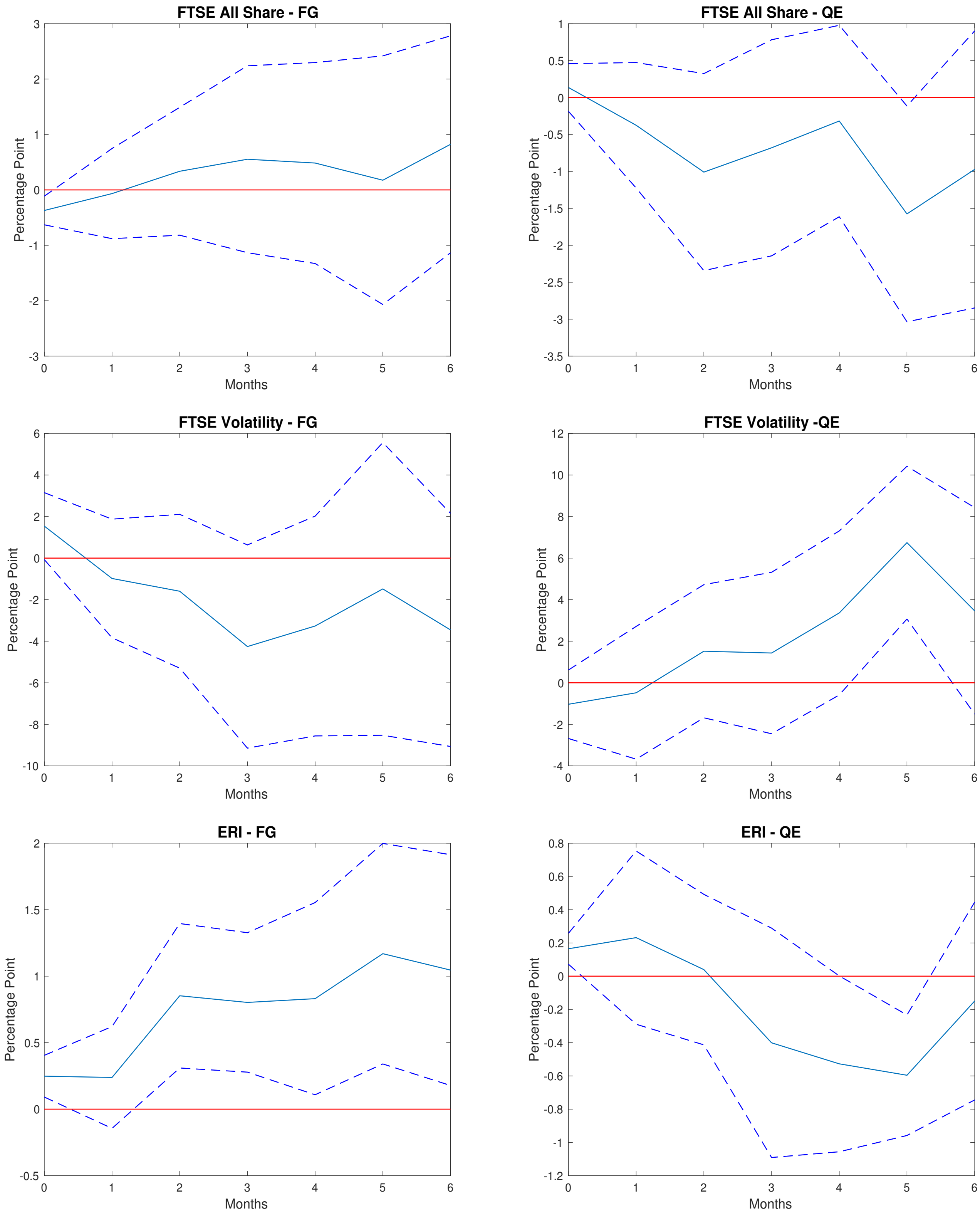
Notes: The blue solid line shows the estimated impact of an FG surprise on the term premia at different monthly horizons. The dashed lines are 95% confidence bands, constructed using Newey-West standard errors. The local projections are conducted as described in Section 5.

Figure 7: Persistence of the Effect of QE on the Term Premia



Notes: The blue solid line shows the estimated impact of a QE surprise on the term premia at different monthly horizons. The dashed lines are 95% confidence bands, constructed using Newey-West standard errors. The local projections are conducted as described in Section 5.

Figure 8: The Effect of FG and QE on Stock Prices, Market Volatility and the British Pound



Notes: The blue solid line shows the estimated impact of FG and QE on stock prices, their volatility and the British Pound index (ERI) at different maturities. The dashed lines are 95% confidence bands, constructed using Newey-West standard errors. The local projections are conducted as described in Section 5.

References

Aksit, D. (2020). Unconventional Monetary Policy Surprises: Delphic or Odyssean? *Working Paper*.

Bauer, M. D. and Rudebusch, G. D. (2014). The Signaling Channel for Federal Reserve Bond Purchases. *International Journal of Central Banking*, 10(3):233–289.

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*, 9(2):165–212.

Bekaert, G., Hoerova, M., and Duca, M. L. (2013). Risk, Uncertainty and Monetary Policy. *Journal of Monetary Economics*, 60(7):771–788.

Bridges, J. and Thomas, R. (2012). The Impact of QE on the UK Economy — Some Supportive Monetarist Arithmetic. *Bank of England Working Paper*, (442).

Christensen, J. H. and Rudebusch, G. D. (2012). The Response of Interest Rates to U.S. and U.K. Quantitative Easing. *Federal Reserve Bank of San Francisco Working Papers*, (6).

Churm, R., Joyce, M., Kapetanios, G., and Theodoridis, K. (2015). Unconventional monetary Policies and the Macroeconomy: The Impact of the United Kingdom's QE2 and Funding for Lending Scheme. *Bank of England Working Paper*, (542).

Cragg, J. G. and Donald, S. G. (1997). Inferring the Rank of a Matrix. *Journal of Econometrics*, 76(January-February).

D'Amico, S. and King, T. (2013). Flow and Stock Effects of Large-Scale Treasury Purchases: Evidence on the Importance of Local Supply. *Journal of Financial Economics*, 108(2):425–448.

Duffie, D. (2010). Presidential address: Asset price dynamics with slow-moving capital. *Journal of Finance*, 65(4):1237–1267.

Fleckenstein, M., Longstaff, F. A., and Lustig, H. (2014). The tips-treasury bond puzzle. *Journal of Finance*, 69(5):2151–2197.

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*.

Goodhart, C. A. E. and Ashworth, J. P. (2012). QE: A Successful Start May Be Running into Diminishing Returns. *Oxford Review of Economic Policy*, 28(4):640–670.

Greenlaw, D., Hamilton, J. D., Harris, E. S., and West, K. D. (2018). A skeptical view of the impact of the fed's balance sheet. *U.S. Monetary Policy Forum*.

Gürkaynak, R. S., Sack, B., and Swanson, E. T. (2005). Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements. *International Journal of Central Banking*, 1(1).

Hanson, S. G. and Stein, J. C. (2015). Monetary policy and long-term real rates. *Journal of Financial Economics*, 115:429–448.

Jordà, Ò. (2005). Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review*, 95(1):161–182.

Joyce, M. A. S., Lasaosa, A., Stevens, I., and Tong, M. (2011). The Financial Market Impact of Quantitative Easing in the United Kingdom. *International Journal of Central Banking*, 7(3).

Kapetanios, G., Mumtaz, H., Stevens, I., and Theodoridis, K. (2012). Assessing the Economy-Wide Effects of Quantitative Easing. *Bank of England Working Paper*, (443).

Kuttner, K. (2001). Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market. *Journal of Monetary Economics*, 47 (3):523–544.

Li, C. and Wei, M. (2013). Term structure modeling with supply factors and the federal reserve's large-scale asset purchase programs. *International Journal of Central Banking*, 9(1):1–37.

Newey, W. and West, K. (1987). A Simple, Positive Semi-Definite, Heteroskedasiticity and Autocorrelations Consistent Covariance Matrix. *Econometrica*, 55(3):703–708.

Ramey, V. A. (2016). Macroeconomic Shocks and Their Propagation. *Handbook of Macroeconomics*, Chapter 2.

Rogers, J. H., Scotti, C., and Wright, J. H. (2014). Evaluating Asset-Market Effects of Unconventional Monetary Policy: A Cross-Country Comparison. *Board of Governors of the Federal Reserve System International Finance Discussion Papers*, (1101).

Stock, J. H. and Watson, M. W. (2018). Identification and Estimation of Dynamic Causal Effects in Macroeconomics Using External Instruments. *The Economic Journal*, 128(May).

Swanson, E. T. (2019). Measuring the Effects of Federal Reserve Forward Guidance and Asset Purchases on Financial Markets. *Working Paper*.

Vissing-Jorgensen, A. and Krishnamurthy, A. (2011). The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy. *Brookings Papers on Economic Activity*, (2).

Woodford, M. (2012). Methods of policy accommodation at the interest-rate lower bound. *Proceedings - Economic Policy Symposium - Jackson Hole*.

Wright, J. H. (2012). What Does Monetary Policy Do to Long-Term Interest Rates at the Zero Lower Bound? *The Economic Journal*, 122(564):F447–F466.