INTERNATIONAL MONETARY FUND

UNCONVENTIONAL MONETARY POLICIES—RECENT EXPERIENCE AND PROSPECTS—BACKGROUND PAPER*

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***Prepared by the Staff of the International Monetary Fund. Does not necessarily reflect the views of the IMF Executive Board.**

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Glossary

AE	Advanced Economy
APP	Asset Purchase Program
BOE	Bank of England
BOJ	Bank of Japan
CME	Comprehensive Monetary Easing
ECB	European Central Bank
EME	Emerging Market Economy
ETF	Exchange-Traded Funds
FAD	Financial Affairs Department
Fed	U.S. Federal Reserve
GFSR	Global Financial Stability Report
LSAP	Large Scale Asset Purchase
LTROs	Long Term Refinancing Operations
MBS	Mortgage-Backed Securities
MCM	Monetary and Capital Markets Department
NPV	Net Present Value
OIS	Overnight Index Swap
OMO	Open Market Operations
OMT	Outright Monetary Transactions
QEP	Quantitative Easing Policy
QQME	Quantitative and Qualitative Monetary Easing
REIT	Real Estate Investment Trusts
RES	Research Department
SPR	Strategy, Policy, and Review Department
UMP	Unconventional Monetary Policies
WEO	World Economic Outlook
ZLB	Zero Lower Bound

1. This paper provides background information to the main Board paper, "The Role and Limits of Unconventional Monetary Policy." This paper is divided in five distinct sections, each focused on a different topic covered in the main paper, though most relate to bond purchase programs. As a result, this paper centers on the experience of the United States Federal Reserve (Fed), the Bank of England (BOE) and the Bank of Japan (BOJ), mostly leaving the European Central Bank (ECB) aside given its focus on restoring the functioning of financial markets and intermediation. Section A explores whether bond purchase programs were effective at decreasing bond yields and, if so, through which channels. Section B goes one step further in evaluating whether bond purchase programs had—or can be expected to have—significant effects on real growth and inflation. Section C studies the spillover effects of bond purchases on both advanced and emerging market economies, using very similar methods as introduced in the first section. Section D breaks from the immediate focus on bond purchases to discuss how inflation might decrease the debt burden in advanced economies, in light of possible pressures that could fall (or be perceived to fall) on central banks. Finally, Section E discusses the possible risks of exiting given the very large central bank balance sheets.

A. Effectiveness and Channels of Bond Purchase Programs[1]

This section evaluates the effectiveness of bond purchases and the transmission channels through which they operate. Evidence suggests that bond purchases significantly decreased long-term bond yields. These effects, it seems, were most often transmitted through the signaling channel, though the duration and scarcity channels also played an important role. Evidence of diminishing returns is less clear cut.

2. The effectiveness of asset purchases is measured using event studies that control for surprises.[2] Doing so goes beyond simply measuring the change in asset prices on days of announcement. The focus shifts to the effectiveness of asset purchases: the bang (change in yield) for the buck (surprise). In addition, controlling for surprises allows for a more precise estimate of policy effectiveness. For instance, an increase in bond yields following an announcement is not necessarily a sign of policy failure.[3] On the contrary, it may be entirely consistent with effective policy to the extent that the announcement disappoints markets relative to more dovish expectations.

3. The one-year-ahead futures contract on the three-month Libor is used to measure the surprise component of announcements. This is in the spirit of Bernanke and Kuttner (2003) which laid the foundations for event studies in the analysis of monetary policy shocks. Yet, this paper

[1] Prepared by Tomas Mondino, in collaboration with Jiaqian Chen and Hideyuki Tanimoto (MCM).

[2] Krishnamurthy and Vissing-Jorgensen (2011) note that for the objective of analyzing transmission channels, omitting market-moving events increases noise in the sample, but does not lead to any biases. However, for the objective of estimating the overall effect of LSAPs, it could lead to an upward or downward bias depending on the market reaction on these omitted events.

[3] Refer to Table 1 in the main paper's appendix for a list of announcements and related programs (including dates, sizes and acronyms).

measures surprises by daily changes on the one-year ahead futures on Libor, instead of the current (next expiring) futures contract for three reasons. First, variance in one-year ahead futures remains relatively stable from the pre- to the post-crisis period, despite the zero lower bound (ZLB). Instead, the variance of the current futures drops dramatically at the ZLB, especially after the introduction of forward guidance, thereby complicating empirical analysis.[4] Second, Gurkaynak et al (2005) note that the one-year ahead futures contract accounts for both target and path surprises (respectively changes in the timing of rate hikes versus changes in the expected path of future monetary policy). The current futures is instead more closely correlated with the target factor. Yet, both factors are important to capture effects of monetary policy. Third, futures on Libor have good forecasting power.[5]

4. Evidence suggests that bond purchases have been effective at decreasing bond yields.

Table 1 displays coefficient estimates for regressions of various asset prices on the surprise factor. Regressions are estimated only over a sample of event days, thus there is no need to control for other factors affecting asset prices. As discussed in the main paper and drawing on the literature, the assumption is that policy announcements dominate any other impulse to asset prices on event days. The sample consists of all official and scheduled central bank announcement days. It is divided into two periods: pre-crisis (2000 to July 2007) and post-crisis (date of first bond purchase announcement, to January 2013). Results are robust to extending the pre-crisis period to the beginning of the first bond purchase program. For the United States (U.S.) and United Kingdom (U.K.), the pre-crisis period corresponds to a period of conventional monetary policy, in which the policy instrument was the short-term interest rate. For Japan, the pre-crisis period corresponds instead to the first period of unconventional easing—the Quantitative Easing Policy (QEP)—consisting of government bond purchases to satisfy a target for current account balances at the Bank of Japan (BOJ). To match the duration of the QEP program, the pre-crisis period in Japan is thus amended to go from 2001 to 2006. The surprise factor is used in both pre and post-crisis periods as a measure of the monetary policy surprise. Finally, the full-sample regression with a UMP dummy allows for a statistical comparison between the two periods.[6]

[4] Swanson and Williams (2012) note that one-year-ahead eurodollar futures' sensititvity to macroeconomic news remained near normal levels until late 2011, around the time of the announcement to keep rates near zero until "mid–2013."

[5] Gurkaynak et al (2007) compare forecasting performance of eurodollar futures with other market-based measures of policy expectations. They find that eurodollar futures perform as well as or better than any other measure at horizons of six months or more.

[6] The following regression was estimated over both the pre-crisis and post-crisis samples: $\Delta y\_t = a + b\ S\_t + e\_t$ with y being an asset price and S_t the surprise measured with the change in the one-year ahead futures on 3 month Libor; statistical difference between pre-crisis and post-crisis coefficients is determined with an F-test.

Table 1. Event Study Regression Results

Response to a Monetary Policy Easing (one basis point decrease in one-year-ahead futures on three-month Libor)

Country:	U.S.		U.K.		Japan	
Period:	Pre	Post	Pre	Post	Pre	Post
Fixed Income						
Gov Bond Yield 2yr	-0.70***	-0.53***	-0.75***	-0.63***	-0.46***	-0.25***
Gov Bond Yield 10yr	-0.52***	**-1.14*** **	-0.49***	-0.70***	-1.36***	-0.82***
MBS Yield 15yr	-0.72***	-0.88***				
Agency Yield 10 yr	-0.47***	-1.52***				
BBB-AAA Corp Spread	-0.03	**0.25*** **		0.04	1.52***	**-0.08**
Inflation and output						
Breakeven Inflation 5yr	-0.09*	0.05	-0.20***	-0.18**		0.08
Stock Returns	0.01	0.02	-0.05***	-0.05	-0.05	-0.34
NEER	0.00	-0.01*	0.00	-0.02	-0.31	0.08
Tail Risk						
VIX	-0.13*	0.00	0.11	0.24	-0.19	2.02
FX Risk Reversals 1/	-0.01	**-0.05*** **	-0.05**	-0.07*	-0.01	-0.23

Sources: Bloomberg, Datastream and IMF Staff estimates.

Note: One-day changes in asset prices in response to a monetary policy easing (negative surprise). ***, **, and * mean significantly different than zero at the 1 percent, 5 percent, and 10 percent level, respectively. Bold fonts indicate coefficients in the post-crisis period that are statistically different from those in the pre-crisis period. The pre-crisis period runs from January 3, 2000 to July 8, 2007 for the U.S. and U.K. and from 2001 to 2006 for Japan. The post-crisis period starts on the first announcement of bond purchases and runs to January 2013. The April 2013 QQME announcement was not included for Japan since a meaningful measure of surprise could not be extracted from the near-zero one year ahead futures on Libor. The sample consists of event days listed in Table 6 in the Main Paper and all official central bank announcement days in the period.

1/ "FX Risk Reversal" is the first principle component of FX risk reversals for the bilateral exchange rates of the country studied in the regression relative to foreign countries (the currencies are USD, GBP, EUR, and JPY). A 2-day window was used for the Risk Reversals to account for non-overlapping trading hours between countries, at the time of announcement. Option risk reversals are derived from highly liquid option contracts, and are available on a high frequency. Risk reversals are a measure of the skewness of the distribution of expectations of future spot rates. A distribution skewed towards a depreciation of the domestic currency suggests macro tail risks to the domestic economy (fat left-hand tails). The same measure of macro tail risk is used in Chapter 1 of the October 2012 GFSR.

5. Key results are as follows:

- **Government yields:** bond purchases, on average, decreased government bond yields. The effects appear similar in magnitude (for comparable surprises) to conventional rate cuts pre-crisis. In the U.S., the effect is even statistically larger in the post-crisis than in the pre-crisis period.

- **Inflation and output:** Effects on equity prices, five-year ahead breakeven inflation rates—a measure of inflation expectations stemming from relatively liquid markets, and nominal exchange rates are mostly insignificant. However, equities and expected inflation rates tend to increase significantly both pre- and post-crisis when the target factor (current futures) is used as a regressor. This result is consistent with Gurkaynak, et al (2005). A possible explanation is that changes to the path factor (one-year ahead futures—this paper's measure of surprise) also offer information on the state of the economy, perhaps confirming the market's negative outlook. The same explanation may hold for the apparent increase in corporate bond risk premia coming from bond purchase programs in the U.S.[7] The lack of strong results on equity prices, though, generally supports the main paper's findings that effects on output from asset purchases are not clear-cut.

- **Tail Risk:** While the effects on mean expectations of growth are unclear, asset purchases seem to have decreased tail risks of a severe economic crisis as shown by the effect on FX risk reversals for the U.S. and U.K. This is consistent with Chapter 3 of the April GFSR which finds that unconventional policies appear to have lessened banking sector vulnerabilities and contributed to financial stability, at least in the short-term. Monthly inflation surveys by Consensus Forecasts, corroborate these findings, suggesting that the left-skewness (risk of deflation) of the distribution of individual inflation forecasts decreased after each announcement of bond purchases.[8] In Japan, though, bond purchases do not seem to have affected tail risks, neither in the QEP program or the current program of Comprehensive Monetary Easing (CME). This is consistent with Japan not having faced the same prospects of economic and financial meltdown as in the U.S. and U.K. in 2008–09.

6. The transmission channels of bond purchases can be empirically disentangled using two broad approaches. The first is model-based and the second model-free. The first approach relies on decomposing the yield curve for bonds, using any one of the available dynamic term structure models. These models extract risk-neutral expectations of future short-term rates on the one hand, and term premia or the compensation for bearing risk (mostly interest rate risk), on the other hand. The two approximately sum to the observed bond yields. Changes in expected future short rates on days of announcements are associated with the signaling channel, whereas changes in term premia are associated with the duration and scarcity channels (the portfolio rebalancing channel more generally). See Bauer and Rudebusch (2012), Bauer and Neely (2012), and Christensen and Rudebusch (2012) which develop and apply this model-based approach to recent bond purchase programs mostly in the U.S. and U.K.

7. The model-free approach, followed in the literature and in this paper, instead relies on testable hypotheses to identify separate channels. Theory suggests that each channel will have a

[7] Krishnamurthy and Vissing-Jorgensen (2011) finds the same result which it attributes to flight to safety.

[8] Because these forecasts are monthly, they cannot be used in event studies. Yet, results are offered as generally supportive evidence. For other estimates of the impact on tail risks following a similar methodology, see Hattori and others (2013).

different effect on different asset prices.[9] Thus, a careful study of asset price reactions provides a rough picture of the channels relevant to each bond purchases program. The testable hypotheses are the following:

- **Signaling channel:** Although this channel affects all assets and maturities, Krishnamurthy and Vissing-Jorgensen (2010) note that signaling should have a larger impact on medium-term maturities relative to long-term maturities since a central bank cannot commit to a policy stance too far into the future. Following the announcement of bond purchase, the signaling channel suggests that yields on five-year bonds should decrease as much as, or more than, yields on 10-year bonds.
- **Duration channel:** This channel affects bonds of all maturities, as it decreases the price of risk. Yet, effects should be greater on longer maturities (which are more exposed to interest rate risk). Therefore, 10-year yields should react more than five-year yields (the opposite of the signaling channel), and in turn five-year yields should react more than two-year yields.
- **Scarcity channel:** Only the interest rate of the purchased assets should react, according to this channel. Thus, if 10-year bonds are purchased, 10-year yields should react more than any other yield. In addition, yields on a 10-year bond should decrease more than on a 10-year overnight indexed swap (OIS) contract, which is less liquid and not accepted as collateral for repo operations with the central bank (less has lower "use value" or a higher "preference premium" than 10-year government bonds in the "preferred habitat" models in support of the scarcity channel—see the main Board paper for references).

8. It remains to be said that channels are not mutually exclusive of one another. For instance, while 10-year mortgage-backed securities (MBS) rates might react most to purchases of 10-year MBS (emphasizing scarcity effects), five-year bonds might also react and indeed decrease by more than 10-year bonds (in accordance with some signaling effects).

9. Evidence mostly points to the signaling channel, though the scarcity and duration channels occasionally played important roles.[10] Staff estimates of changes in yields of key bonds are displayed in Figure 2 in Appendix I. Changes in bond yields for each announcement day are standardized by the announcement's surprise ($\Delta y_t/\Delta S_t$; where y_t is yields and S_t the surprise measured, namely one-year ahead futures on Libor), then added across the various announcements made in relation to a bond purchase program (surprises relative to each bond purchase program are illustrated in Figure 3. In the U.S. and Japan the signaling channel is prevalent in all programs except in Maturity Extension Program (MEP, commonly referred to as "Operation Twist").[11] This is evident in

[9] For more on the transmission channels, see "A Conceptual Framework" section of the main paper.

[10] Other papers that emphasize the role of the signaling channel are Krishnamurthy and Vissing-Jorgensen (2011), and Bauer and Rudebusch (2011).

[11] The QQME announcement was not included in this particular analysis, as a meaningful measure of policy surprise could not be extracted from the near-zero futures on Libor.

the larger (or equal) changes in five-year bond yields relative to 10-year yields. Operation Twist in the U.S. and the second wave of the Asset Purchase Program (APP2) in the U.K. worked through the duration channel. In these cases longer-term maturities were affected the most. This is as expected for Operation Twist which involved a large swap of long for short-term bonds in the hands of market participants (removal of duration risk from investors' portfolios). The scarcity effect is rejected in both cases since the 10-year OIS and 10-year government yield decreased by the same amount. Yet, scarcity does appear in the first wave of the Fed's Large Scale Asset Purchase program (LSAP1A) and LSAP3 and in APP1 in the U.K. In these cases, the purchased assets—marked by an asterisk in the figure—decreased substantially more than other assets. In the U.S., these programs involved large scale purchases of MBS and Agency bonds, for which the market may indeed have been segmented. Results for the U.K. (both APP1 and APP2) generally point to greater market segmentation than in the U.S., as also suggested in Bauer and Neely (2012). Implications for the design of policy from the channels of transmission found to be most active are discussed in the main paper.

10. Relative to pre-crisis rate cuts, bond purchases extended the signaling channel, but also gave much greater prominence to the portfolio rebalancing channel. The relative importance of the signaling versus the portfolio rebalancing channels (duration and scarcity together) can be gauged using the Kim and Wright (2005) decomposition of the U.S. government bond yield curve.[12] Figure 4 in Appendix I shows the size of coefficients of a regression of monetary policy surprises (always measured by one-year ahead futures) on the two components of bond yields (expected future short rates versus term premia) at various maturities. Results suggest that:

- Prior to the crisis, the main channel of transmission was the signaling channel (predominance of the expectations of future short yields component—ST in the figure, even despite the method's tendency to under-estimate this component). This is as expected in well-functioning markets, and with a well understood central bank reaction function.

- Post-crisis, the portfolio rebalancing channels significantly grew in importance over all maturities relative to pre-crisis levels (judging by the higher coefficient on the term premium component).

- In addition, post-crisis, the signaling channel was considerably extended in time, having increasing marginal effects up to seven years ahead.

11. While not conclusive, evidence points towards some degree of diminishing returns to bond purchase programs. Figure 5 in Appendix I shows that bond purchase announcements had similar effects on long-term yields through time, when normalizing the effect by the surprise factor. In other words, the "bang for the buck" of announcements seems to have remained relatively

[12] As Bauer and Rudebusch (2012) and others point out, the Kim and Wright decomposition gives a predominant weight to term premia relative to expectations of future short-term yields. This is because of a high auto-regressive parameter on the equation of motion of the risk-free rate. While the decomposition may thus have limitations to determine the relative importance of the signaling versus portfolio rebalancing channels at any given time, it can nonetheless be used to illustrate the evolution of the relative importance of these channels over time. In addition, the Kim and Wright (2005) decomposition is readily available on the Fed's website.

constant. In addition, in the U.S. where sufficient data is available, the role played by the signaling versus the portfolio rebalancing channel seems to have been relatively constant over time. Yet, the surprise of subsequent announcements decreased notably over time. One interpretation is that surprises are greater when times are most uncertain (Section C emphasizes this point). Another interpretation is that most of the effects of bond purchases were felt early on, already in anticipation of later programs. Thus, scope for further easing through additional announcements relative to existing programs may be limited. Announcements of significantly different programs (in size and scope), or made in the context of worsening economic conditions, could instead have greater effects. These issues are discussed in the main paper.

B. Macroeconomic Effects of Bond Purchase Programs[13]

This section has two goals. The first is to quantify the macroeconomic impact of bond purchases on output growth and inflation using U.S. and U.K. data. Consistent with the literature, a reduction in the yield spread (long minus short-term rates) seems to increase GDP growth and inflation, though temporarily. However, these results—and those in the literature—should be interpreted with caution given the instability of coefficients. The second goal is to analyze the relative effects of the signaling versus portfolio rebalancing channels on growth and inflation. The analysis requires a new identification strategy applied to a structural VAR. Results suggest that lowering long-term rates through the signaling channel are much more effective at increasing growth and inflation than doing so through the portfolio rebalancing channels.

Macroeconomic effects of bond purchases on GDP growth and inflation

12. The same caveats as underlined in the main paper continue to apply. The effect of bond purchases on the macro-economy is gauged through the impact of lower long-term yields on GDP growth and inflation.[14] Yet, the relationship between these variables is subject to long and variable lags. Especially with the crisis, historical relationships are unlikely to hold. The credit channel, in particular, is likely to have been perturbed as banks faced pressures to deleverage. Finally, results cannot be easily generalized, as they focus on just the U.S. and U.K.

13. The analysis begins with a VAR model including four variables. The model is summarized below:

$$\begin{pmatrix} \pi_t \\ y_t \\ SR_t \\ SP_t \end{pmatrix} = c + \beta_1 \begin{pmatrix} \pi_{t-1} \\ y_{t-1} \\ SR_{t-1} \\ SP_{t-1} \end{pmatrix} + \beta_2 \begin{pmatrix} \pi_{t-2} \\ y_{t-2} \\ SR_{t-2} \\ SP_{t-2} \end{pmatrix} + e_t \qquad (1)$$

where π_t denotes inflation, y_t the annualized GDP growth rate, SR_t the short-term interest rate (three-month treasury yield), SP_t the term spread (difference between 10-year government bond and three-month treasury yields). Consistent with the literature, the lag length is set to two.

[13] Prepared by Jiaqian Chen and Tahsin Saadi Sedik (MCM), in collaboration with Andrea Pescatore (RES).

[14] Asset purchases affect the macro-economy through many different channels. However, in this section we focus only on the interest rate channel.

14. In this model, four structural shocks are identified: a supply shock, a demand shock, a monetary policy shock, and a shock to the term spread. This last shock is the shock of interest, as it represents the effects of bond purchase programs (that indeed were designed and found to flatten the yield curve).

15. These shocks are identified using a set of sign and exclusion restrictions. These follow Benati (2008), Benati and Goodhart (2010), Baumeister and Benati (2010), and Kapetanios and others (2012). The restrictions are presented in the table below:

Table 2. Identification Restrictions

Shock/Variables	π	y	SR	SP
Supply	**+**	**-**	?	?
Demand	**+**	**+**	+	?
Monetary policy (SR)	**-**	**-**	**+**	-
Spread (SP)	**-**	**-**	**0**	**+**

Source: IMF staff estimates.

16. The restrictions are justified as follows. A positive monetary policy shock, which increases the short-term rate, will lead to a compression in the yield spread, lower GDP growth, and lower inflation. A positive demand shock will lead to higher inflation, output and short-term interest rates, while a negative supply shock will lead to higher inflation, but lower output growth. On the other hand, a positive shock to the spread will lower inflation and output growth. However the spread shock is assumed to have zero contemporaneous impact on the short-term interest rate. This is key to identify a "pure" spread shock, namely a flattening of the yield curve without a cut in short-term rates, as at the ZLB and as discussed in Baumeister and Benati (2010).

17. The benchmark model is estimated using quarterly data. These run between 2001Q4 and 2012Q2 for the U.S. and 2001Q1 and 2012Q2 for U.K.[15] However, to investigate the instability of the relationship between term spreads and macroeconomic variables, the model is also estimated using a rolling sample with a fixed window. For each sample, a full set of impulse responses is computed. Since in the current environment the policy rate is expected to remain unchanged for an extended period of time, the short-term rate is restricted to move within a +/- 5bp band for four quarters after the initial shock.

[15] The benchmark sample is dictated by the availability of OIS data used as an instrument for ST, which start in 2001Q4 for U.S. and 2001Q1 for U.K.

18. Key results are as follows:

- The relationship between the term spread and both growth and inflation varies over time. This instability is illustrated in Figure 6 in Appendix II. Interestingly, the instability does not seem to materialize with the crisis, but existed already before. This was a recognized, though possibly under-appreciated, feature of the yield curve literature, as pointed out in Wheelock and Wohar (2009). The instability of coefficients could explain in part the relatively large range of results found in the literature, pointed out in the main paper.

- Results are broadly consistent with those in the literature. A reduction of the term spread increases GDP growth and inflation. While effects appear substantial, they also seem short lived, disappearing after a few quarters. These results are consistent with those found in Peseran and Smith (2012) and Kapetanios and others (2012).[16] On the whole, though, effects are more persistent for inflation than for GDP growth. Detailed results in the form of impulse response functions are presented in Appendix II in Figures 7 and 8.

Macroeconomic effects of bond purchases, which channel is strongest?

19. Does the impact on the real economy differ if bond purchases decrease long rates through the signaling or portfolio rebalancing channels? The question arises prominently in the current debate on the effects of bond purchase programs.[17] Some theory, only just burgeoning, does suggest that the signaling channel should be effective. This is because shocks to expected future short rates can be expected to be more permanent than shocks to term premia, and because lowering term premia beyond a certain point may induce firms to optimize the maturity structure of their liabilities, without necessarily engaging in productive investments. More details are given in the main paper.

20. To answer the question, the analysis attempts to estimate the effects of a shock to expected future short rates versus term premia. As discussed earlier, a shock to the risk neutral expectations of future short rates (ST) is associated with the signaling channel. Instead, a shock to term premia (TP) is symptomatic of the portfolio rebalancing channels (either duration or scarcity). Values for ST and TP are drawn from dynamic term structure models. The following analysis rests on the decompositions of Kim and Wright (2005) for the U.S. and Guiaraes (2012) for the U.K.

21. A natural starting point is to replace the term spread (SP) in equation (1) with the two components of long-bond yields (ST and TP). Short term interest rates, instead, are left in the equation to control for the current level of the policy rate. Doing so allows changes in ST to more clearly capture changes in signaling, over and above changes in short rates. However, ST and TP

[16] Peseran and Smith (2012) explicitly discuss the short-lived effect of QE on growth and inflation. While Kapetanios and others (2012) do not emphasize this aspect of their results, the time profiles of the effects of the QE provided show similar results, namely the effects of QE are rather short-lived (Chart 2 of their paper, page 35).

[17] See Stein (2012a and 2012b)

shocks cannot be identified in the resulting equation, since both affect inflation, output and short-term rates in the same manner.

22. A novel method is introduced to overcome this identification hurdle. The method introduces an instrument for ST: the OIS rate with a one-year maturity. The OIS rate is a valid instrument for ST because (i) it is highly correlated with ST since it too captures expectations of future short rates (the relevance condition); (ii) yet it is not correlated with TP, since it is of short maturity and thus contains little term premium (the validity condition; Woodford (2012) also points this out, for different purposes, though). On this basis, ST is first regressed on the OIS rate and a constant, and predicted values, $\widehat{ST}$—now exogenous to TP—are used in the VAR. The exercise is then to compare the effects of shocks to TP and $\widehat{ST}$.

23. In particular, the identification strategy is the following. The $\widehat{ST}$ shock is identified by assuming that a positive shock decreases output and inflation, however has no initial impact on the short-term rate, which is thought to remain at the ZLB. The TP shock is instead identified as having no contemporaneous impact on $\widehat{ST}$, following the instrumental variable logic above. The identification strategy is unchanged for supply, demand and short-term interest rate shocks.

24. Results suggest that a shock to expected future short rates has approximately a two times larger impact on GDP and inflation than a shock to the term premium. Results, in the form of impulse response functions, are presented in Appendix II (Figures 9 to 12). Otherwise, results are consistent with former findings: effects of lower long rates on inflation and GDP growth are substantial, but short-lived, though are more persistent for inflation than for GDP growth.

Table 3. Identification Restrictions

Shock/ Variables	π	y	SR	$\widehat{ST}$	TP
supply	+	-	?	?	?
demand	+	+	+	+	?
SR	-	-	+	+	?
$\widehat{ST}$	-	-	0	+	?
TP	-	-	0	0	+

Source: IMF staff estimates.

C. Spillover Effects on Asset Prices of Unconventional Monetary Policy Announcements[18]

Empirical evidence shows that early announcements of asset purchases in advanced economies buoyed asset prices globally—as they decreased the tail risk of a severe recession—but their effects diminished once markets normalized. This section is technical in nature and focuses exclusively on the immediate impact of UMP announcements on asset prices in emerging economies. The main paper instead also explores the longer-term patterns in capital flows, and policy implications for both emerging and advanced economies.

25. The focus of this study is on the impact on foreign asset prices of conventional and unconventional monetary policies in advanced economies.[19] Financial market spillovers from unconventional monetary policy are gauged using event studies. The impact of unconventional monetary policies is estimated on two-day returns over a 10-year period from January 1, 2003 to December 31, 2012. The study focuses on four asset markets (money, bond, equity, and foreign exchange market) in a wide range of countries—23 advanced economies (AEs), 11 emerging markets economies (EMEs).[20] Effects on asset prices are gauged following surprise policy moves, where the surprise is measured as earlier using one-year-ahead futures on Libor.[21] The pre-crisis and non-UMP post-crisis announcements provide context against which to examine how far responses to unconventional monetary policies were dissimilar to those of conventional cut rates during pre- and post-crisis periods, respectively.

26. The analysis is adapted to control for "typical" international and domestic financial linkages. High correlations in asset prices both across and within countries imply complex dynamics, even at daily frequencies. The direct impact of a monetary surprise on an asset price in a foreign country is often magnified by indirect spillovers via third countries, as well as the response of other domestic assets, for instance the money market. Analogously, the direct effect of early U.S. bond purchase announcements on bond yields in EMEs appears to have almost doubled by indirect spillovers through simultaneous asset price movements in other advanced, systemic economies.

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[18] Prepared by Silvia Sgherri (SPR).

[19] The impact of unconventional monetary policies on capital flows—and associated policy challenges in recipient countries—will be analyzed in a separate paper.

[20] The advanced markets included in the analysis are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, adopted Germany, Greece, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the U.K., and the U.S. The emerging markets are Brazil, China, India, Indonesia, Malaysia, Mexico, Poland, Russia, South Africa, Thailand, and Turkey. In the context of the event study, country-specific estimates have been pooled across selected subgroups of countries having similar characteristics by using Generalized Least Squares with robust standard errors for panel regressions with cross-sectional dependence. A two-day window is used to account for differing time zones in the sampled markets—in particular, Asian markets in any given day are closed before the same day session in the U.S. starts.

[21] For an illustration of measured surprises from announcements of bond purchase programs, see Figure 3.

27. A two-stage approach is used to control for this "typical" behavior. First, the transmission of shocks between bond yields, equity prices, exchange rates, and money market rates within and between the four systemic financial markets (Germany, Japan, the U.K., and the U.S.) is examined in a simultaneous manner. Specifically, a structural VAR is estimated by identifying the shocks through heteroscedasticity. [22] Next, the corresponding underlying shocks are used as inputs into a similar system for each small open economies of interest, with the goal of uncovering typical correlations among domestic assets. For example, the model for Brazil accounts for contemporaneous financial markets shocks from the four systemic AEs as well as interactions across Brazilian asset prices.

28. The limitations of the event study approach need to be recognized. Examining knock-on responses of financial markets to bond purchase announcements helps avoid concerns that responses are being contaminated by nonpolicy-related news. Also, spillover effects are expected to rapidly transmit between liquid and highly integrated financial markets through portfolio rebalancing and expectation channels. However, event studies only reveal the immediate market reaction to such policies. As views on the impact of unconventional policies evolve over time, these revisions will not be captured by these event studies. Also, interpreting market responses to UMP is difficult, as announcements reveal both a policy decision and an assessment of current economic conditions.

29. Results based on the above methodology suggest that spillovers from bond purchases are largest when domestic risks are most acute.[23] Early announcements of bonds purchases in the U.S. led to major global financial market rallies, involving widespread reductions in bond yields and money market rates (Figures 13 and 16), rises in equity prices (Figure 14), and appreciation of currencies vis-à-vis the U.S. dollar (Figure 15). Later announcements had either more muted effects on all foreign assets, or even negative effects on equities and bond yields. A similar basic pattern emerges following announcements in the U.K. The exchange rate effect, though, is similar to that of early U.S. announcements. Analysis shows a general appreciation of emerging-market currencies against the U.S. dollar and British pound, respectively (Figure 15). Later announcements, however, have had a more modest impact on exchange rates. In Japan, asset purchase announcements led to falling foreign equity prices, while triggering broad depreciation of foreign currencies vis-à-vis the Japanese yen, possibly reflecting market repricing of yen-denominated assets as the 2008–09 financial crisis mostly affected the rest of the world (on this point, see also Section A).[24]

[22] The approach is similar to that taken in Ehrmann, Fratzscher, and Rigobon (2011), although extended and modified to analyze spillovers between bond, equity, exchange rate, and money markets within and between the four systemic economies. Greater details of the methodology are provided in Sgherri (2013, forthcoming).

[23] Tables 6–9 summarize the sign of the significant impact from a monetary policy surprise from different types of monetary policy announcements on asset prices, while Figures 13–16 plot the estimated cumulative effect of the surprise for each type of announcement and each group of countries.

[24] The April 2013 announcement introducing Quantitative and Qualitative Monetary Easing (QQME) in Japan is not included in the sample. QQME extends government bond purchases to all maturities with the goal of doubling the average remaining maturity of outstanding bonds from 3 to 7 years. It also increases planned purchases of private

(continued)

30. More broadly, results suggest that financial market spillovers of bond purchases vary by market conditions. The spillover effects of early bond purchase programs appear to be the largest. This could be due to the market stabilizing impact of such programs, not only in domestic economies, but also globally, given the systemic importance of the economies initiating the purchases. Spillovers were smaller once markets normalized. However, the lower spillover effects from later programs may also come from the fact that the announcements associated with these programs surprised markets less (see Figure 3 in Appendix I for an illustration of surprises across programs).

31. The Outright Monetary Transactions (OMT) announcement by the European Central Bank (ECB) further highlights the importance of the market stability signal. The announcement raised bond yields in the core of the euro area and in much of the rest of the world, but significantly lowered bond yields in the euro area periphery. This reduction in tail risks in the euro area—a concern that was weighing heavily on financial markets—led to a generalized rally in global equity markets.

32. Pre-crisis easing and post-crisis policy announcements unrelated to unconventional policies appear to have had similar spillover effects. The sign and size of the bond market spillovers were generally similar (Table 6). Evidence from other asset markets is, however, far more mixed (Tables 7–9). Also, in the pre-crisis period, U.S. monetary policy appears to have had larger and more generalized financial market spillovers than policy surprises in other countries. An expansionary monetary policy shock in the U.S. tended to boost domestic financial conditions in the rest of the world. Bond yields generally fell while equity prices rose together with money market rates in AEs.

33. Results are echoed by other studies. These studies mostly find that early bond purchase announcements in AEs had the largest spillovers effects. These announcements buoyed asset prices globally by decreasing the tail risk of a severe recession, but their effects diminished once markets normalized.[25] Studies point to significant spillover effects on bond yields and currency in EMEs, with larger estimated effects from LSAP1 than from LSAP2.[26] Evidence of spillovers from U.S. bond

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assets, mainly exchange-traded funds (ETFs) and real estate investment trusts (REITs) to stimulate activity. On the whole, the program's goal is to add JPY 60 to JPY 70 trillion per year to the monetary base. On the day of announcement, global bond yields decreased by an average of 10 bps, foreign equity prices fell around 2 percent, and, most notably, the yen depreciated by around 3 percent.

[25] IMF (2012), for instance, suggests that in times of high uncertainty, market volatility and flight to safety effects interact with—and sometimes even offset—spillovers on bond yields and currencies in EMEs.

[26] There is relatively little research on the international spillovers of central bank balance sheet policies, especially the impact on emerging markets. Exceptions are Chen, Filardo, He and Zhu (2012), Glick and Leduc (2011), Neely (2012), Bauer and Neely (2012), Fratzscher, Lo Duca, and Straub (2012), Bayoumi and Bui (2011), IMF (2011). To give a sense of the order of magnitude, Neely (2012) finds that US quantitative easing lowered bond rates in the other AEs by 20–80 basis points and the value of U.S. dollar by 4–11 percentage points. Glick and Leduc (2011) showed that commodity prices fell on average on days of the Fed LSAP announcement, associated with declines in long-term interest rates and dollar depreciation.

purchases in non-U.S. AEs appears rather muted. Shocks to bond and equity markets in the U.K. and euro area generated mild spillovers to other AEs.[27]

D. Inflation and Debt Reduction in Advanced Economies[28]

While higher inflation could help reduce somewhat the public debt-to-GDP ratio in advanced economies, it could hardly solve the debt problem on its own and would raise significant challenges and risks. First of all, it may be difficult to create higher inflation, as evidenced by Japan's experience in the last decades. In addition, un-anchoring of inflation expectations could increase long-term real interest rates, distort resource allocation, reduce economic growth, and hurt the lower–income households.

34. Higher inflation could help reduce public debt through three main channels. First, governments can capture real resources by base money creation (seigniorage). Second, inflation can erode the real value of the debt. The impact of this channel will depend on the maturity structure and currency denomination of the debt, as well as on the interest rate response to higher inflation, with inflation having the largest impact on long-term, fixed rate, and local-currency-denominated debt: short-term debt and maturing long-term debt will need to be refinanced at higher interest rates, floating rate debt will adjust automatically to higher rates, and the local currency value of foreign-currency-denominated debt will rise due to the currency depreciation that will accompany higher inflation. Third, inflation can affect the primary balance, including if brackets are not indexed under a progressive income tax. Akitoby and others (2013) simulate the effect of the first two channels for G-7 countries.

35. Given the relatively low levels of base money in most advanced economies, seigniorage from higher inflation would play only a limited role in bringing down debt ratios. Simulations suggest that one additional point of inflation would raise seigniorage for the sample by about 0.12 percent of GDP annually. So, raising inflation from *World Economic Outlook* (WEO) baseline projections to 6 percent for five years would generate cumulative seigniorage revenue of about 2½ percentage points of GDP. Country-specific estimates vary from less than one percent (Canada) to about 5 percent (Japan).

36. The debt erosion channel could have a stronger impact. The same increase in inflation, while assuming a constant debt maturity structure, no impact of inflation on economic growth, and a one-for-one adjustment to inflation of nominal interest rates on newly-issued debt (full Fisher effect) would reduce the average net debt-to-GDP ratio by less than 10 percentage points by the

[27] Joyce and others (2011) show that QE announcements in the U.K. depreciated its currency by 4 percent. Event studies of large-scale asset purchases by Japan did not find significant impact on exchange rates, although Japan's QE in earlier 2000s appears to have a sizable impact on emerging Asian countries.

[28] This section is based on Akitoby and others (2013) and the authors' contributions to the Fiscal Monitor (2013).

end of the period for most countries (other than Japan and Italy, where the effect would be larger).[29] The erosion effect drops rapidly after five years, because an increasingly large share of securities will have been issued at higher interest rates, including replacing maturing debt that had been issued at lower rates. At this time, debt-to-GDP ratios could start increasing again, underscoring the temporary nature of the relief provided by inflation. Real interest rates on debt could rise, due to an inflation risk premium, and growth could be eroded from higher inflation, or uncertainty over inflation.

37. While higher inflation could have some effect on debt stocks, it could hardly solve the debt problem on its own and would raise significant challenges and risks. As a practical matter, it might be difficult to lift inflation to a meaningful level in the current economic environment, as evidenced by Japan's experience in the last decades; and, in any case, countries in a monetary union would not be able to use this tool on their own. More importantly, reliance on inflation to erode debt could lead to fiscal dominance,[30] with inflation rates drifting even higher as confidence in the future value of money is lost. As a result, inflation expectations could be un-anchored, thus undermining the credibility of the framework built over the past three decades to control inflation. Un-anchoring of inflation expectations might also have significant implications for the future structure of government debt portfolio, making it more crisis prone by raising liquidity, currency, and interest rate risk.

38. Un-anchoring of inflation expectations could increase long-term real interest rates, distort resource allocation, reduce economic growth, and hurt the lower–income households. This would likely make it difficult for government to finance their budgets and lead to even higher debt-to-GDP ratios. Introducing some form of financial repression could keep interest rates low, but such policies may be difficult to enforce in a complex financial environment and could cause additional collateral damage to the economy. Altogether, the output costs of restoring inflation to more moderate levels in the future would be substantial, based on the experience in the advanced economies in the 1980s (IMF 2012b). And inflation would have a highly regressive impact on incomes: while higher inflation would be a tax on bondholders, it would also disproportionately affect lower-income households, which tend to have more limited access to indexed assets.

[29] These debt reductions may be overestimated because of the underlying assumption that inflation does not affect output growth, debt structure or real interest rates. For instance, if maturity shortens in response to the inflation shock, the impact of inflation on the reduction would be somewhat smaller.

[30] Fiscal dominance can be defined as a situation where monetary policy is driven by the need to ensure fiscal sustainability when fiscal policy cannot adjust.

E. Risks of Exit from Bond Purchase Programs[31]

Central bank balance sheets have grown in size and maturity following recent bond purchase programs. This section investigates two implications. First, could central banks generate losses from tightening policy rates? And second, how will the transmission channel be affected by the excess liquidity?

Risk of central bank losses

39. As pointed out in the main paper, central banks might endure losses in the case of exit because of a maturity mismatch on their balance sheets. With large scale bond purchase programs, assets have become of increasingly long maturity. Liabilities, on the other hand, have shifted proportionally from currency to costly reserve balances. Upon exit, returns from assets would remain unchanged, while interest paid on liabilities would increase with the policy rate. This could generate negative cash flows, and thus losses, to the central bank. In net present value terms, these losses are very similar to selling long term assets outright, as the value of bonds reflects expectations of future interest-rate increases.[32] As mentioned in the main paper, though, losses are relevant mostly to the extent that they could put pressure on central bank independence. Losses per se should not constrain the effectiveness of monetary policy.

40. Pre-crisis, the AE central bank balance sheets consisted mostly of currency. There was substantial demand for currency and reserve balances (which commercial banks need for transactional reasons) and central banks were reasonably free to choose the counterpart assets.[33] As currency represented a substantial part of liabilities, central banks mostly generated positive cash flows: earnings on government bonds and credit to sound banks comfortably covered operational costs and any interest paid on non-currency liabilities. As a result, central banks normally remitted surplus income to the government.

41. Balance sheet expansion since 2008, particularly in the U.K. and U.S., means that reserve balances—on which interest is paid—now dominate liabilities (Tables 1 and 2).[34] For the moment, the central banks still run a profit, as the return on their asset portfolio—whether bonds, or in the case of the ECB credit to banks—is higher than the reserves remuneration rate (which currently is unusually low).

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[31] Prepared by Simon Gray and Nico Valckx (MCM).

[32] In order to gauge potential fiscal pressures arising from these potential central bank losses (e.g., through lower remittances), the net present value would need to be converted into flows over the years under consideration. This pre-supposes some knowledge of the allocation of bond purchases over time and across maturities and requires accounting for portfolio dynamics (including declining maturities and related changes to model-based bond prices, bonds' duration, etc.), which goes beyond the scope of this section.

[33] This would not be true for an exchange-rate targeting central bank, which may need to purchase foreign exchange in pursuit of its policy, generating reserve balances in excess of demand.

[34] The balance sheet expansion is a result QE (Japan, U.K., U.S.) and financial stability lending (ECB).

Table 4. Currency in Circulation, Bank Reserves Balances and Securities Portfolios
(As percent of balance sheet)

	Currency in Circulation		Reserve Balances		Securities Portfolio	
	Jan 2007	Jan 2013	Jan 2007	Jan 2013	Jan 2007	Jan 2013
Federal Reserve Bank	90	38	1	54	88	90
ECB	52	31	15	31	0	7 1/
Bank of Japan	68	53	7	28	71	72
Bank of England	48	14	23	67	8	96

Sources: Central bank websites and staff calculations.

1/ SMP portfolio.

Table 5. Central Bank Balance Sheet Size
(As percent of GDP)

	Balance Sheet Total		Currency in Circulation		Securities Portfolio	
	Jan 2007	Jan 2013	Jan 2007	Jan 2013	Jan 2007	Jan 2013
Federal Reserve Bank	6	19	6	7	6	17
ECB	14	32	7	10	0	2
Bank of Japan	22	33	15	18	16	24
Bank of England	6	26	3	4	1	25

Sources: Central bank data and IMF staff calculations.

42. A sharp increase in short-term rates might inflict losses on the central banks, as payments of interest on liabilities could exceed coupon payments on securities.[35] The Federal Reserve Bank (FRB) and Bank of England (BOE) are probably most at risk in this respect (although the BOE has a government indemnity against losses sustained on its QE portfolio). The Bank of

[35] The Net Present Value (NPV) of likely future losses could show up as revaluation losses, whether realized if bonds are sold to drain excess reserves, or unrealized, if the portfolio were marked to market. Not all central banks mark their portfolios to market—in some cases because historically such portfolios were not intended for sale. But the cash flow loss will be the same, whether or not the portfolio is marked to market.

Japan (BOJ) has a shorter maturity profile in its assets, and a lower proportion of bonds in its balance sheet total, and so faces less interest-rate risk.[36]

43. The ECB faces relatively little direct interest rate risk, as the bulk of its loan assets are linked to its short-term policy rate. However, it may be difficult for the ECB to shrink its balance sheet, as those commercial banks currently borrowing from the ECB may not easily be able to repay loans on maturity. The ECB could use other instruments to drain surplus liquidity, but could then face some loss of net income as the yield on liquidity-draining open market operations (OMOs) could exceed the rate earned on lending, assuming a positively-sloped yield curve, if draining operations were of a longer maturity.[37] The ECB's new bond portfolio (SMP purchases) is small relative to balance sheet size. As a result, the ECB is not considered in the estimation of losses discussed below.

44. Central banks' potential losses from bond holdings can be analyzed under various assumptions about interest rates and future bond purchase strategies.[38] These losses broadly depend on (i) the size of central banks' bond holdings and the extent of any additional purchases; (ii) the maturity of bonds purchased; and (iii) the severity of the interest rate scenario. Figure 1 below indicates that the net present value of losses, as a percent of GDP, could be substantial, even for modest interest rate increases.. Figure 1 also illustrates the yield curves attached to each of three exit scenarios. The first assumes a small, parallel shift in the yield curve; the second is similar to the yield curve change seen through 1994 (many market participants now refer to this); and the third reflects a more extreme inflation shock. No stance is taken relative to when the change may occur, nor over what period adjustment might take place, though the third scenario is clearly a tail risk. The second scenario is also very similar to the one used by Carpenter and others (2013), which projects the Fed's balance sheet and earnings under various asset purchase scenarios. Their base case arrives

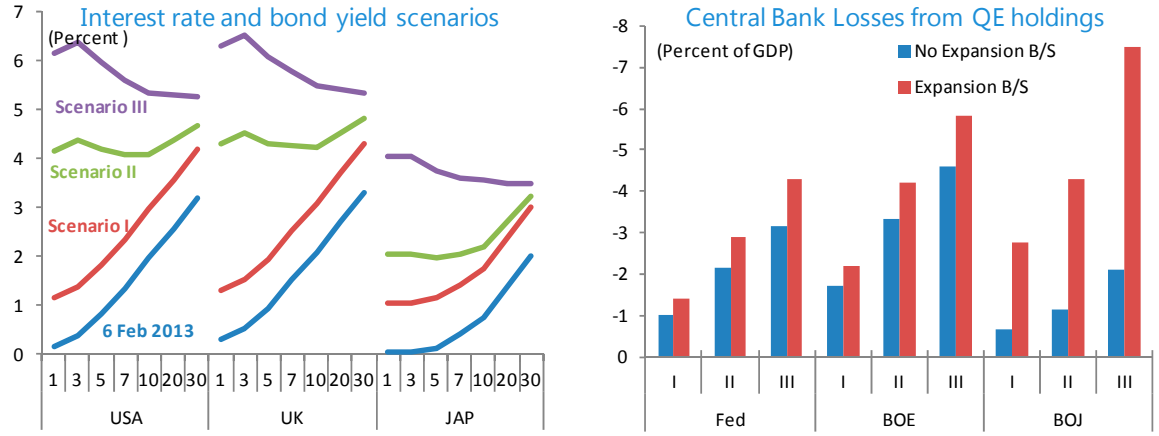
[36] In Japan, banknote demand prior to the early 1990s was stable at 6–7 percent of GDP, but rose to around 18 percent at present. Three important drivers for this have been: the very low level of deposit interest rates (so the opportunity cost of holding cash is low); some concern about the soundness of banks, following financial turmoil in 1997–98; and the removal of the blanket deposit guarantee in 2002. In a prolonged low interest-rate environment with concerns about banking sector strength, other countries could see a similar development. Indeed, since 2007 banknotes in circulation, as a percent of GDP, have risen in all of the cases considered here. By contrast, a future "normalization" might see cash demand in Japan drop back to previous levels, in which case the BOJ would lose substantial seigniorage revenue.

[37] Lending rates are linked to the short-term OMO rate, regardless of maturity, at the moment. Draining operations could be longer maturity—several months or even years—and therefore further out on the yield curve.

[38] Potential losses are projected using a bond price valuation formula $\Delta P/P = \frac{1}{2} C\Delta i^2 - D\Delta i$. The formula is a second-order Taylor approximation of the price impact of a change in yields (see Campbell, Lo and MacKinlay 1997) and relates relative bond price changes ($\Delta P/P$) to changes in yields (Δi); C denotes convexity and D modified duration. By using *effective* duration and convexity, obtained from a proper valuation model, it is possible to apply the formula to MBSs, whose cash flows also vary with interest rates (Fabozzi 2013). Projections are based on various interest rate scenarios, as well as current and future bond purchase strategies (see notes to Figure [E.1] for details).

at maximum (unrealized) losses of about 1.6 percent in 2017 (as a percent of 2012 GDP), assuming asset purchases continue into 2013.[39]

Figure 1. Possible Central Bank Losses in Different Scenarios



Sources: Federal Reserve Bank of New York System of Open Market Accounts; Bank of England; Bank of Japan; J.P. Morgan; U.S. Treasury; UK Debt Management Office; Japan's Ministry of Finance; and Staff computations

Notes: Central Bank losses from asset purchases are based on bond valuations as of February 6, 2013 using price sensitivity to interest rate changes, multiplied by the central banks' balance sheet exposure, and expressed as a percent of 2012 GDP. Price sensitivity is computed as $\frac{1}{2} C\Delta i^2 - D\Delta i$, where Δi denotes changes in yields, C convexity and D modified duration. Losses follow three scenarios: I. parallel shift +100 bps in yields, II. +400bps in short-term and up to +225bps in long term yields (Japan +200 and +125bps, respectively) and III. +600bps in short term and up to +375bps in long run yields (Japan +400bps and +167bps). 'No expansion B/S' assumes a static balance sheet (B/S). The Fed B/S expansion assumes purchases of UST and MBS until end-2013 of $85bn per month. The BOE B/S expansion assumes an addition of £75bn to its Asset Purchase Facility in the long range (+7 years) segment. The BOJ B/S expansion accounts for the April 4, 2013 announcement of qualitative and quantitative easing of ¥100 trillion JGB purchases in 2013-14 at a longer maturity (going from slightly below 3 years to about 7 years).

45. Thus far, credit risk on bond portfolios is contained by the relatively small proportion of non-government securities purchased by these central banks. But the ECB potentially faces credit risk on its lending to the banking system for financial stability purposes. In a "benign" scenario, where monetary tightening is a response to higher inflation resulting from economic growth, non-performing loans should fall and bank balance sheets should improve. But even then, some areas of the eurozone may lag in economic recovery. Banks in such areas could come under further pressure in a rising rate environment: weak banks may not be able to pass on to weak customers the rising costs of financing their balance sheets.

Transmission of policy

46. Apart from balance sheet risk, a future tightening of monetary policy is likely to be bumpy. Central banks will enter a phase of largely uncharted waters as they transition from operating policy with excess liquidity, where market rates are guided by the interest paid on excess

[39] Other approaches also exist. For instance, McLaren and Smith (2013) arrive at different estimates of losses for the Bank of England as they focus on losses net of capital gains and income from asset holdings.

reserves, to a higher level of policy rates and eventual resumption of OMOs to guide short-term market rates.

- There is reason to expect that, in the presence of substantial excess reserve balances, arbitrage will be less effective[40] in transmitting the policy rate to other market prices, so that market expectations and the impact on future inflation will be less smooth. This in itself suggests that central banks will want to drain excess reserves, at the appropriate time, rather than simply relying on interest on excess reserves. On balance, central banks should be able to move market rates in the right direction, but setting of policy rates will not be as finely tuned during the exit as pre-crisis, as the market response will be less predictable initially (possibly for several months or even years).

- A move to a tightening stance—which could be signaled either by starting to run down (or stop accumulating) securities portfolios or by raising short-term rates—could lead to sharp movements in the longer-term yield curve as investors try to anticipate the longer-term impact of the policy reversal. A likely consequence would be reduced market liquidity until expectations stabilize.[41] Higher rates might also induce an appreciation of the currency, further complicating policy and fueling uncertainty over future short rates.

47. There are ways to reduce the impact of exit on long rates. Clear forward guidance would help manage expectations of future short rates.[42] Also, liquidity draining operations could be focused on short-term instruments, such as three or six month repos, at least early in the tightening cycle. And when central banks resort to asset sales, these could be pre-announced to dampen movements in term premia. Finally, in the U.S., the Fed could operate with a wider range of counterparties than pre-crisis, so as to help overcome market segmentation. Yet, it may be less clear how transmission through a larger and more diverse group of counterparties will work. It remains that expectations, rather than central bank policy, will continue to drive longer-term yields.

[40] When all major market participants are cash rich, they will have little incentive in a low interest rate environment to compete for funding and, by competing across different markets, to arbitrage out rate variations.

[41] As an example, if the U.S. yield curve moves from its current level (three months–10bp; 10-years 2 percent; 30 years 3.2 percent) to a flat 4 percent, bonds in the 10–30 year range could lose 14 to 16 percent of their value.

[42] Syed and Yamaoka (2010) underscores the importance of clear communication in the BOJ's relatively smooth exit from very accommodative monetary policies and balance sheet expansion in March 2006. Yet, the BOJ's balance sheet at the time consisted mostly of open market operations of one year or less, while many of the assets purchased where also of very short maturity. The central bank's balance sheet thus quickly shrank without needing outright asset sales.

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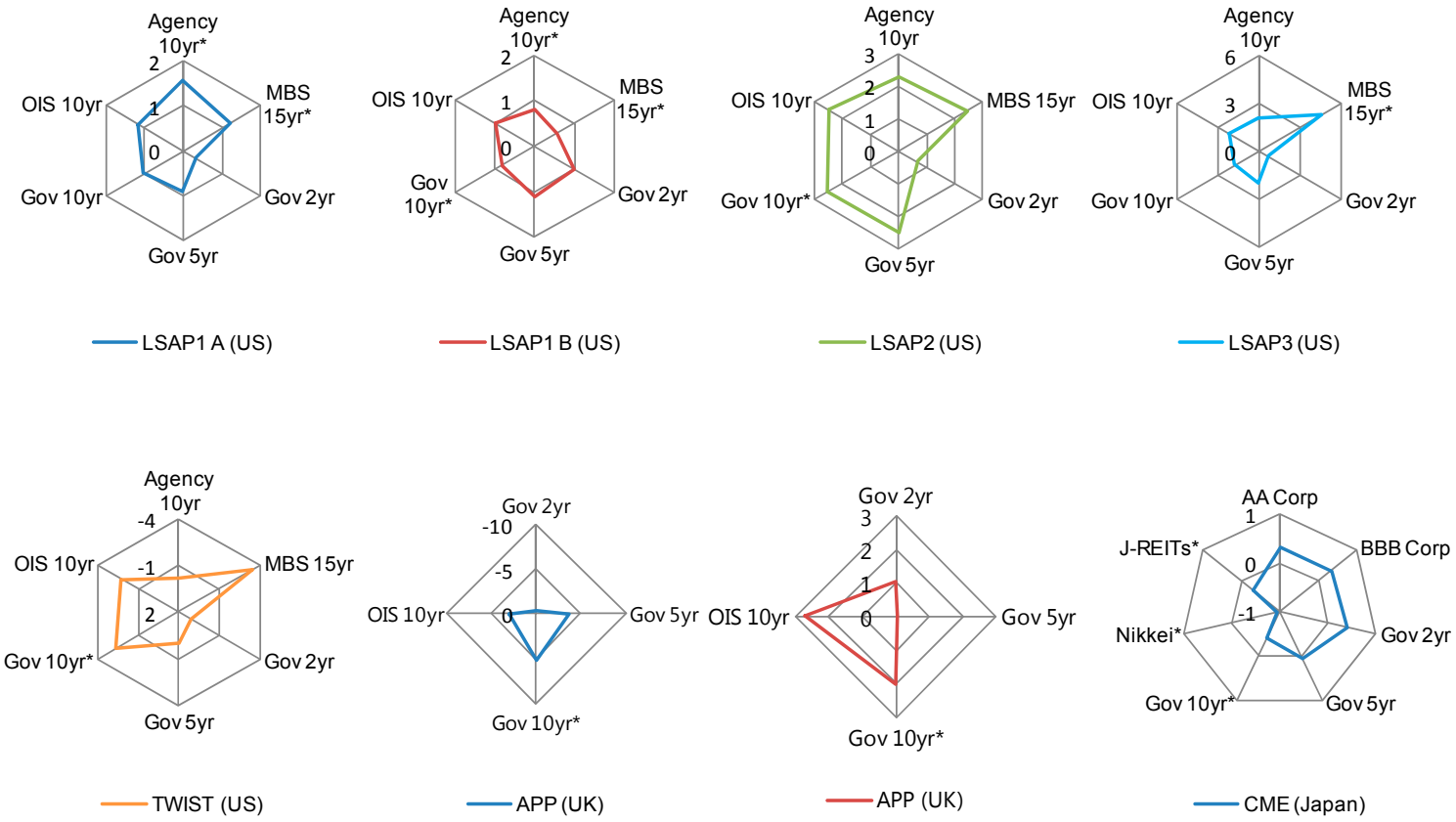
Appendix I. Supplementary Figures and Tables to Section A

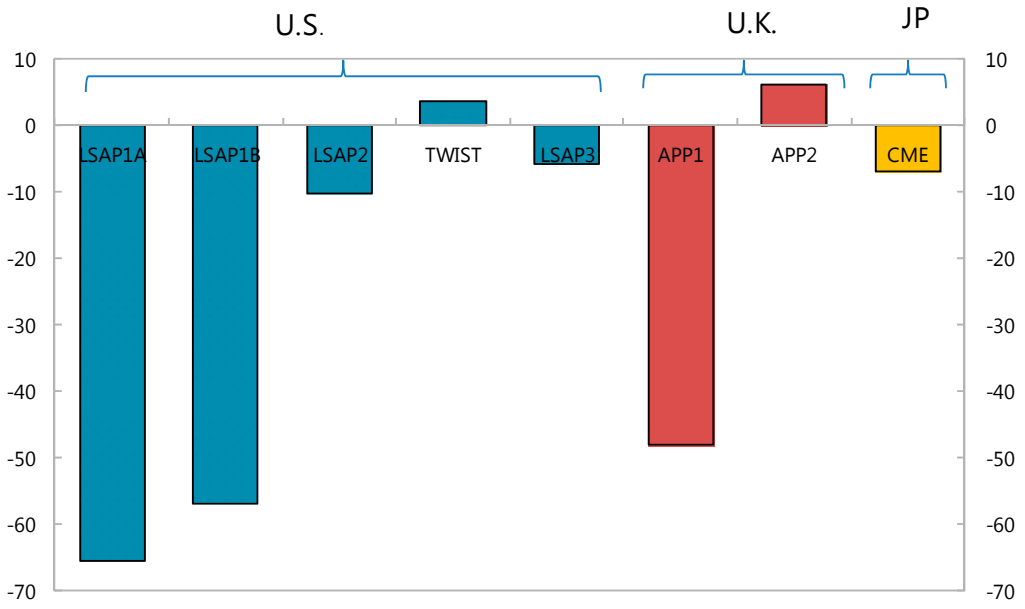
Figure 2. Asset Price Reactions to Bond Purchase Announcements—Gauging Transmission Channels



Sources: Bloomberg and IMF staff estimates.

Figure 3. Surprises Relative to Bond Purchase Program Announcements

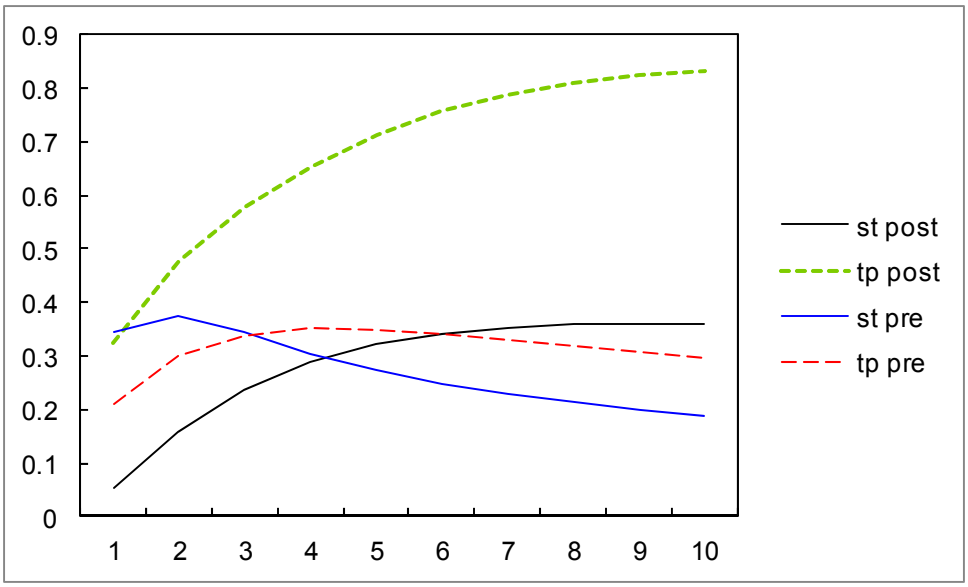
(Changes in one-year futures on 3m Libor, bps, cumulated over each asset purchase program.)



Sources: Datastream, Bloomberg, and staff calculations.

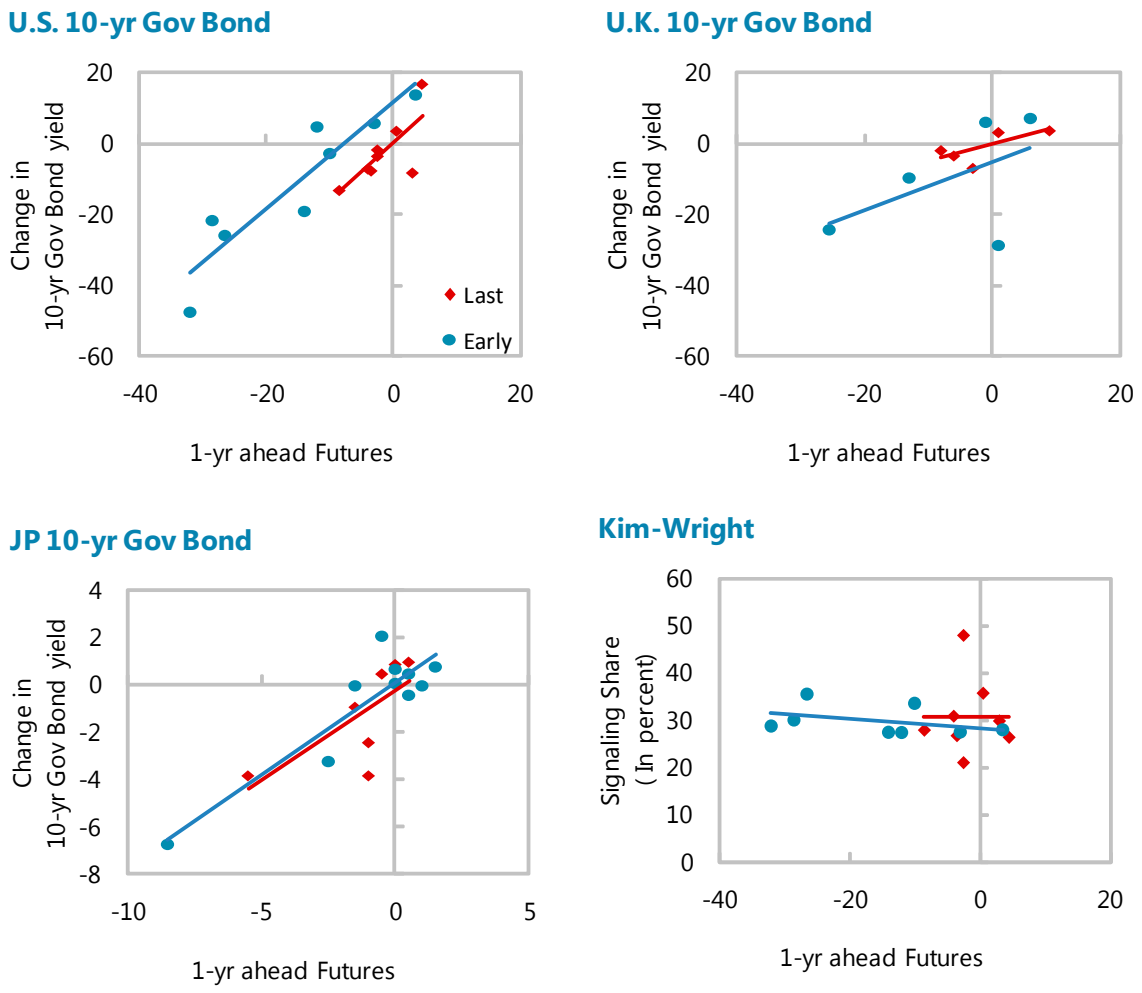
Figure 4. Correlation Coefficients

(One-year ahead Futures on Libor regressed on risk neutral expectations of future short-term rates (ST) and term premia (TP) of government bonds of various horizons)



Source: IMF staff estimates.

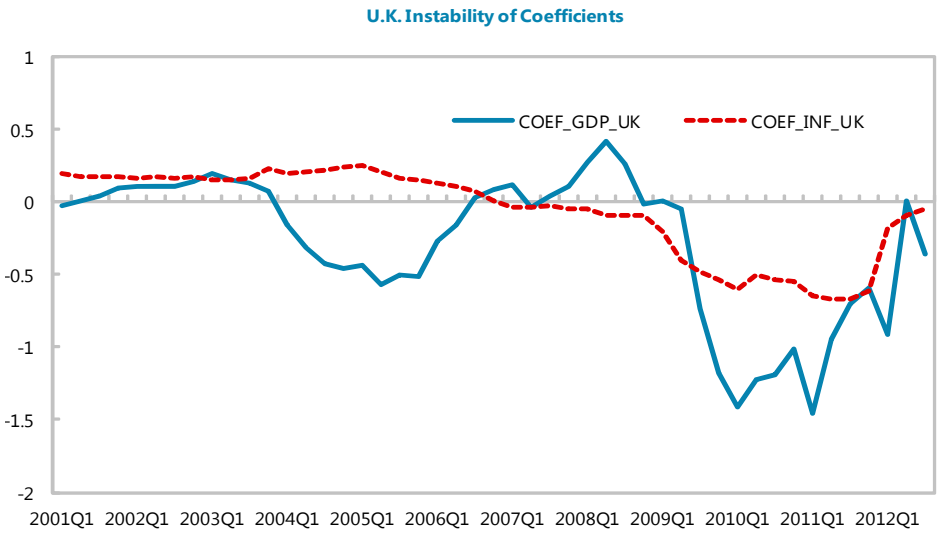
Figure 5. Announcement Surprise and Effects on 10-Year Government Bond Yields

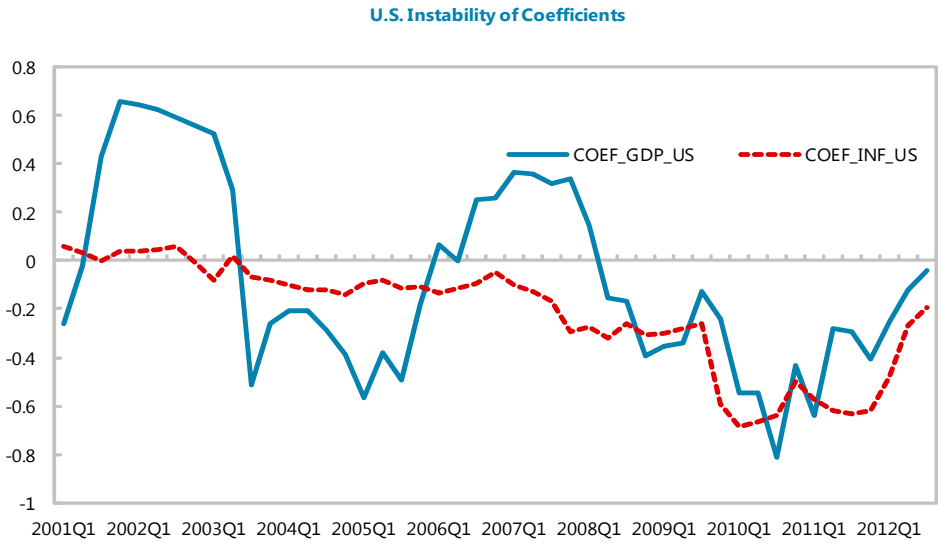


Sources: Bloomberg, Kim-Wright (2005), IMF staff estimates.

Appendix II. Supplementary Figures and Tables to Section B

Figure 6. Instability of Coefficients

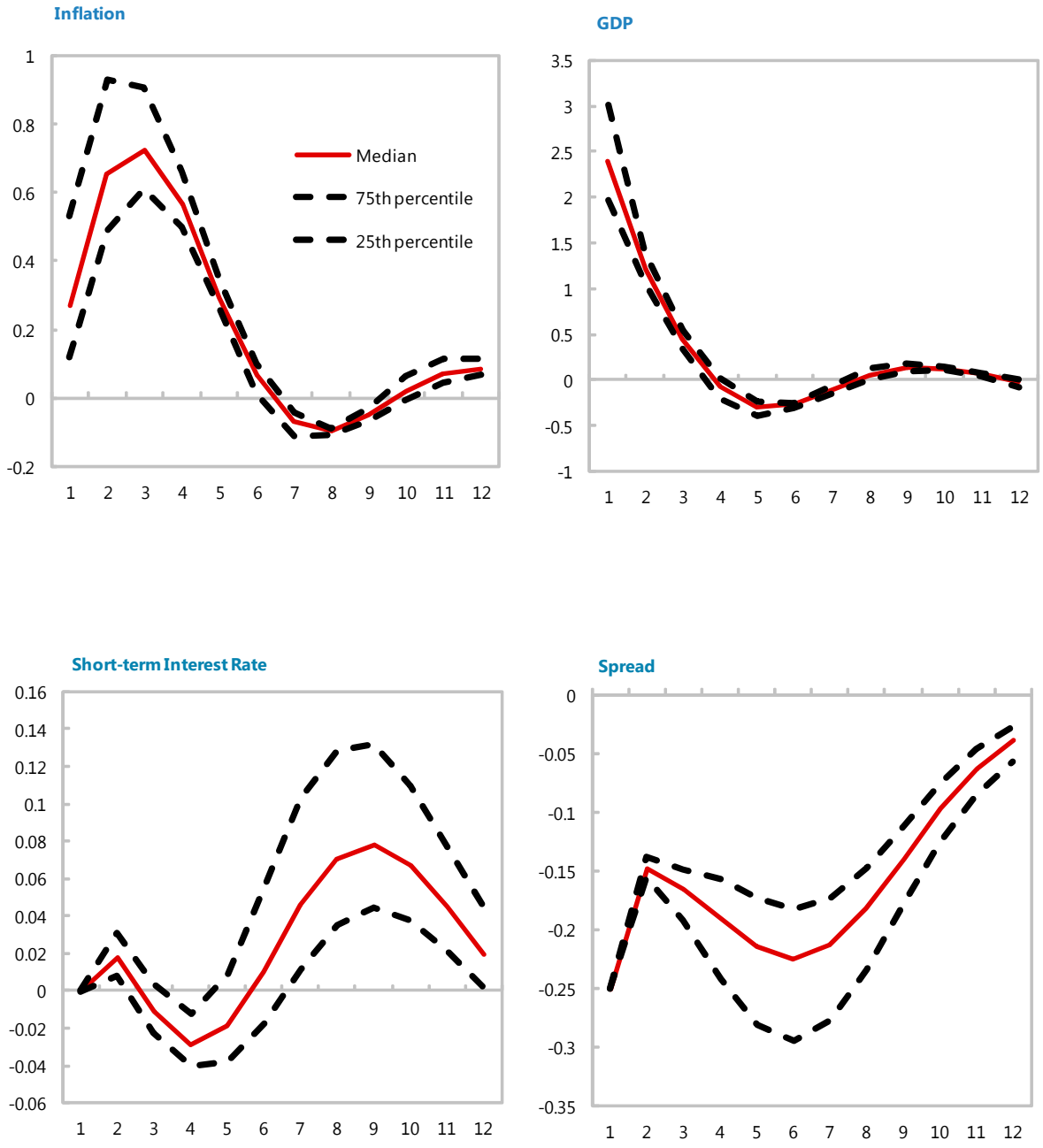




Source: IMF staff estimates.

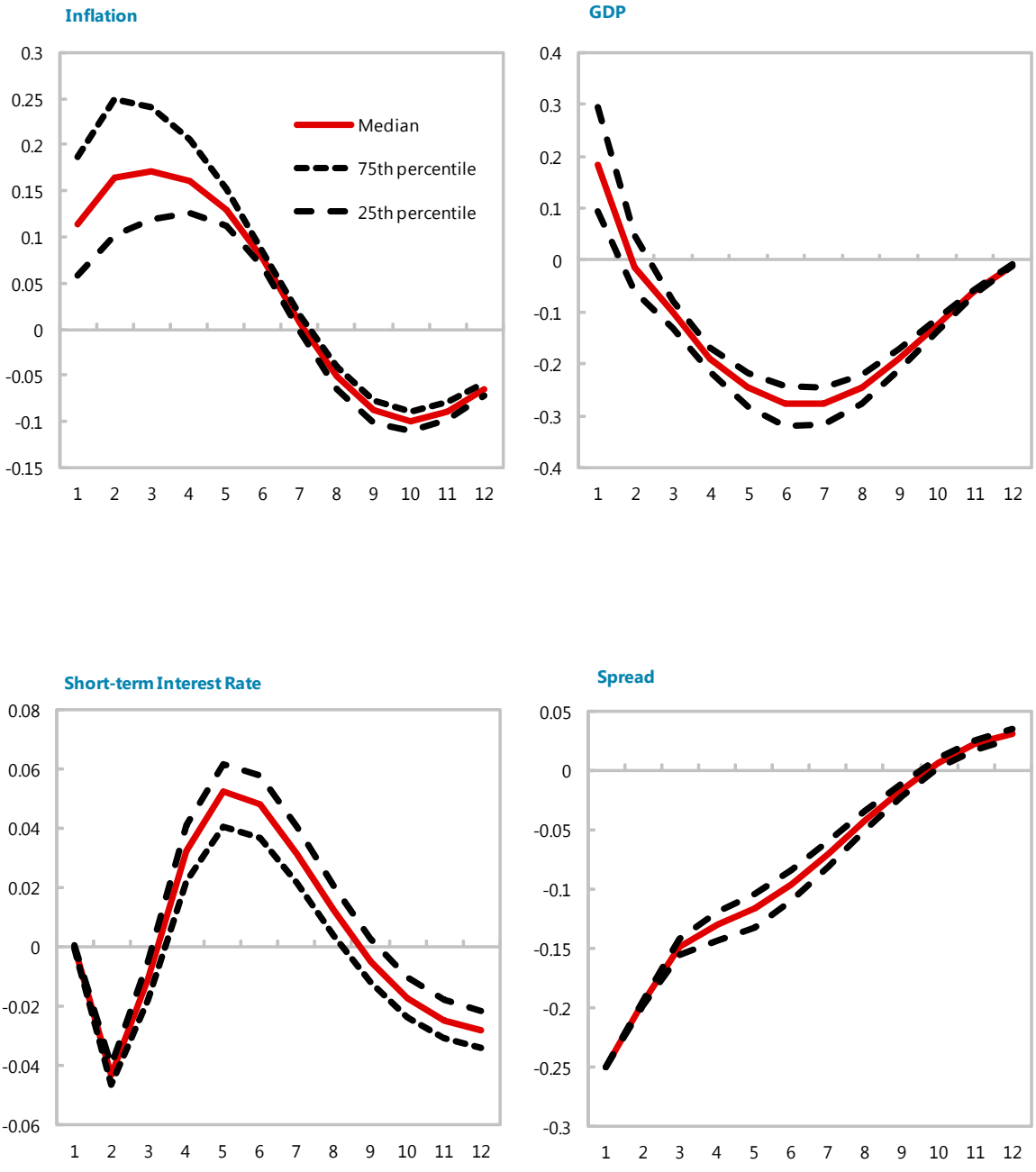
Note: Each point represents the sum of the first and second lag coefficients of the spread form the reduced form VAR. The coefficients are obtained using a roling sample with a fixed window. For example, 2012Q2 represents the sample 2001Q4-2012Q2 for US and 2000Q4-2012Q1 for UK.

Figure 7. United States Responses to 25 bps Spread Shock



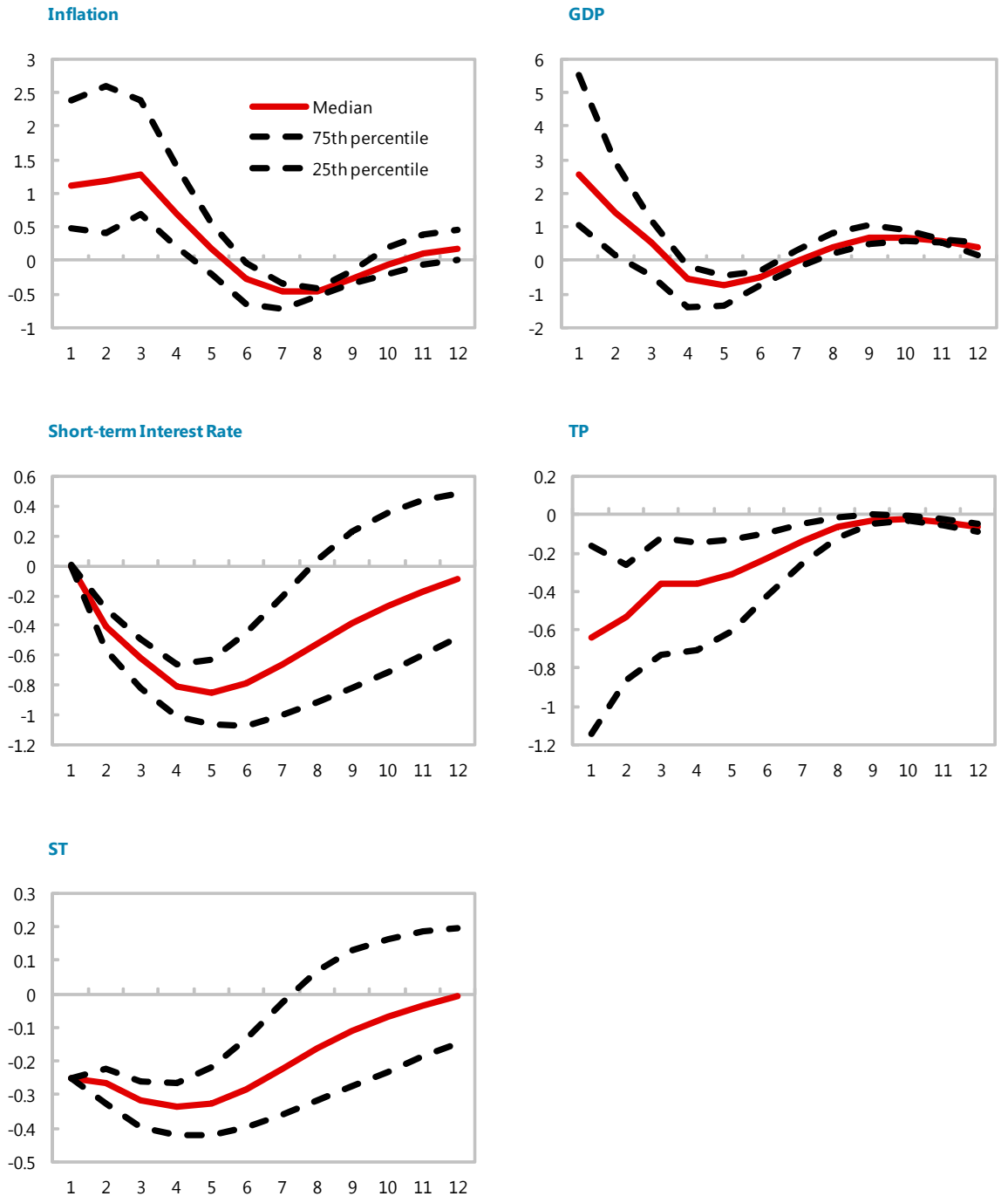
Source: IMF staff estimates.

Figure 8. United Kingdom Responses to 25 bps Shock Spread



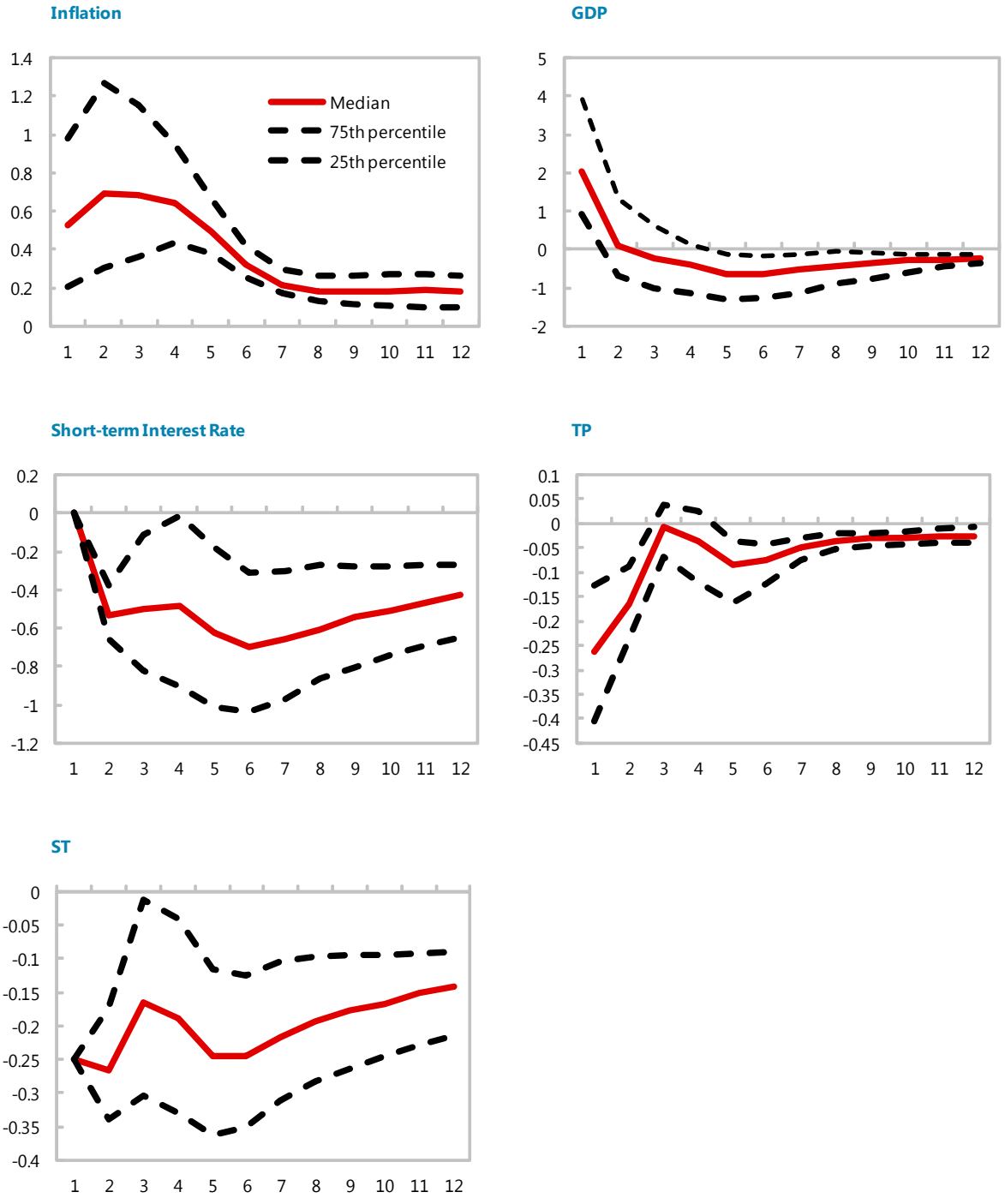
Source: IMF staff estimates.

Figure 9. United States Responses to 25 bps ST Shock



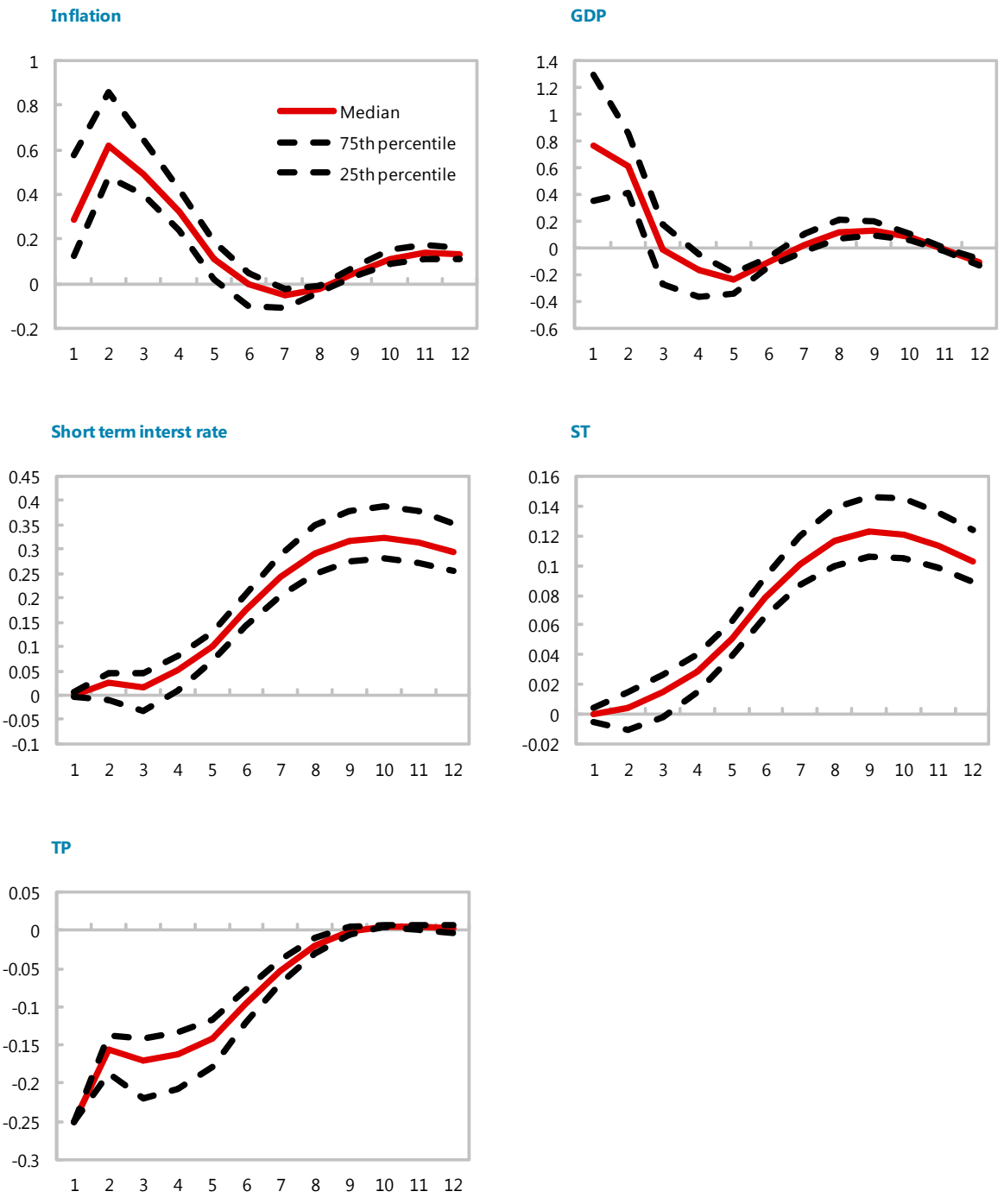
Source: IMF staff estimates.

Figure 10. United Kingdom Responses to 25 bps ST Shock



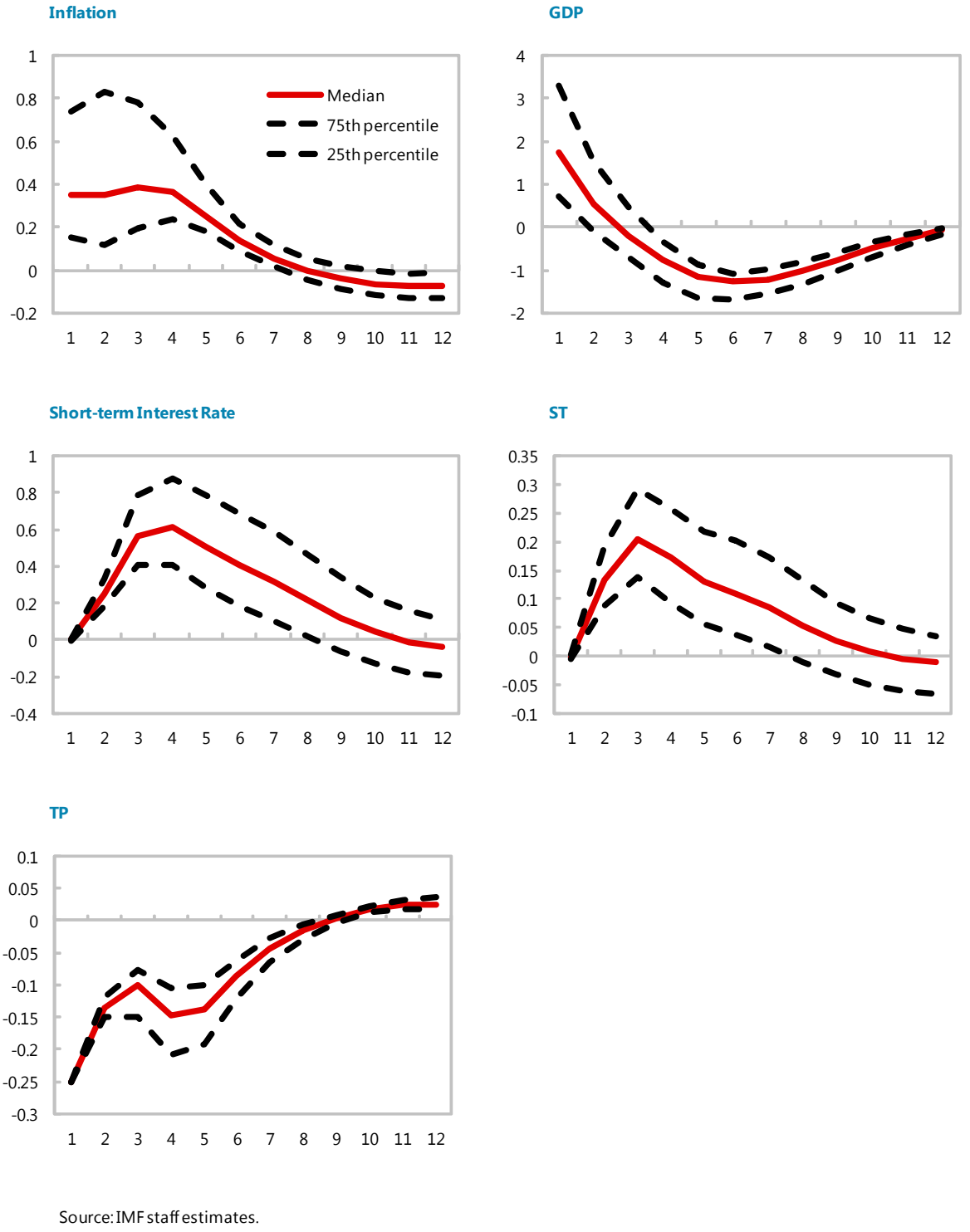
Source: IMF staff estimates.

Figure 11. United States Responses to 25 bps Shock



Source: IMF staff estimates.

Figure 12. United Kingdom Responses to 25 bps TP Shock



Source: IMF staff estimates.

Appendix III. Supplementary Figures and Tables to Section C

Table 6. Two-Day Change in 10-Year Bond Rates

Monetary Policy Announcement	Advanced Economies Responses								
	Systemic 4				Core EA 1/	Periphery EA 2/	European Safe Havens 3/	Inflation Targeters 4/	
	U.S.	U.K.	DE	JP					
United States									
Pre-UMP		↓	↓		↓	↓	↓	↓	
Post-UMP		↓	↓	↑	↓	↑	↓	↓	
LSAP1A		↓	↓	↓	↓	↓		↓	
LSAP1B			↓		↓		↓	↓	
LSAP2		↓	↓	↓	↓		↓		
TWIST					↑	↑		↓	
LSAP3		↑	↑			↓			
United Kingdom									
Pre-UMP			↓	↓	↓	↓	↓	↓	
Post-UMP	↑				↑	↑		↑	
APP1	↓		↓		↓				
APP2	↑		↑		↑		↑	↑	
FLS			↓		↓		↓		
Euro Area									
Pre-UMP	↓	↓			↓	↓	↓	↓	
Post-UMP	↓	↓		↓		↑	↓	↓	
OMT	↑	↓			↑	↓	↑	↑	
Japan									
Pre-UMP	↓	↓	↓		↓	↓	↓	↓	
Post-UMP		↑						↑	
CME	↓	↓	↓		↓	↓		↓	
…									

Monetary Policy Announcement	Emerging Economies Responses					
	All Emerging	Latin America 5/	Asia 6/	China & India	Europe 7/	Other EMs 8/
United States						
Pre-UMP	↓	↓	↓	↑	↓	↓
Post-UMP		↓	↓			
LSAP1A	↓	↓	↓		↓	↓
LSAP1B		↓	↓	↑	↑	
LSAP2	↓	↓				↓
TWIST	↑	↑	↑	↑	↑	
LSAP3						
United Kingdom						
Pre-UMP				↓	↓	↑
Post-UMP	↑	↑		↑	↑	↑
APP1	↑	↑	↑	↑	↑	↑
APP2	↓		↓			↓
FLS	↓		↓		↓	
Euro Area						
Pre-UMP	↓	↓			↓	↓
Post-UMP			↓			
OMT	↑				↑	
Japan						
Pre-UMP	↓	↓	↓	↓	↓	
Post-UMP	↓	↓		↓	↓	↓
CME	↓		↓		↓	
…						

Sources: Datastream, Bloomberg, and staff calculations.

Table 7. Two-Day Change in the Rate of Return of the Stock Market

Monetary Policy Announcement	Advanced Economies Responses								
	Systemic 4				Core EA 1/	Periphery EA 2/	European Safe Havens 3/	Inflation Targeters 4/	
	U.S.	U.K.	DE	JP					
United States									
Pre-UMP				↑	↑		↑	↑	
Post-UMP		↓	↓		↓	↓	↓		
LSAP1A		↑	↑		↑	↑	↑	↑	
LSAP1B						↑		↑	
LSAP2		↓	↓	↓	↓	↓	↓	↓	
TWIST						↑	↑		
LSAP3						↑		↑	
United Kingdom									
Pre-UMP	↓		↓	↓	↓		↓	↓	
Post-UMP	↓			↓	↓	↓	↓		
APP1	↓		↓		↓	↓	↓	↓	
APP2			↑	↑	↑	↑	↑	↑	
FLS	↑		↑		↑				
Euro Area									
Pre-UMP	↓	↓			↓	↓	↓	↓	
Post-UMP	↓	↓		↓	↓	↓	↓	↓	
OMT	↑	↑		↑	↑	↑	↑	↑	
Japan									
Pre-UMP	↑					↑			
Post-UMP									
CME	↓	↓	↓		↓	↓	↓	↓	
…									

Monetary Policy Announcement	Emerging Economies Responses					
	All Emerging	Latin America 5/	Asia 6/	China & India	Europe 7/	Other EMs 8/
United States						
Pre-UMP	↑	↑	↑	↑	↑	↑
Post-UMP			↓	↑		↓
LSAP1A	↑	↑				↑
LSAP1B	↑		↑		↑	↑
LSAP2	↓	↓				↓
TWIST		↓		↓	↓	↑
LSAP3	↑	↑				
United Kingdom						
Pre-UMP	↓	↓	↓		↓	↓
Post-UMP						↓
APP1	↓	↓		↓	↓	↓
APP2			↑		↑	
FLS		↑				
Euro Area						
Pre-UMP	↓	↓	↓	↓	↓	↓
Post-UMP	↓	↓	↓	↓	↓	↓
OMT		↑		↑	↑	
Japan						
Pre-UMP	↓		↓	↓	↓	↓
Post-UMP						
CME		↓			↓	
…						

Sources: Datastream, Bloomberg, and staff calculations.

Table 8. Two-Day Change in the Rate of Return of Cross Bilateral Foreign Exchange

Monetary Policy Announcement	Advanced Economies Responses								
	Systemic 4				Core EA 1/	Periphery EA 2/	European Safe Havens 3/	Inflation Targeters 4/	
	U.S.	U.K.	DE	JP					
United States									
Pre-UMP				↓					
Post-UMP		↓	↓	↓	↓	↓	↓	↑	
LSAP1A			↓	↓	↓	↓	↓	↓	
LSAP1B		↓	↓	↓	↓	↓	↓	↓	
LSAP2			↓	↓	↓	↓	↓		
TWIST			↓		↓	↓		↑	
LSAP3			↓		↓	↓			
United Kingdom									
Pre-UMP	↓		↓	↓	↓	↓	↓		
Post-UMP							↑		
APP1	↓		↓	↓	↓	↓	↓		
APP2				↓				↑	
FLS	↓			↓					
Euro Area									
Pre-UMP				↓			↓	↓	
Post-UMP	↑	↓					↓	↑	
OMT								↑	
Japan									
Pre-UMP			↑		↑	↑			
Post-UMP							↓		
CME								↑	
…									

Monetary Policy Announcement	Emerging Economies Responses					
	All Emerging	Latin America 5/	Asia 6/	China & India	Europe 7/	Other EMs 8/
United States						
Pre-UMP				↓		
Post-UMP	↑			↓		↑
LSAP1A	↓	↓	↓	↓	↓	↓
LSAP1B	↓		↓	↓	↓	↓
LSAP2					↓	↑
TWIST	↑	↑	↑	↑	↑	↑
LSAP3	↓	↓		↓		↓
United Kingdom						
Pre-UMP	↑	↑	↑			
Post-UMP		↑		↓	↑	
APP1	↓	↓	↓	↓	↑	↓
APP2		↓	↑	↑		
FLS						
Euro Area						
Pre-UMP	↓	↓	↓	↓	↑	↓
Post-UMP	↓		↓	↓		
OMT	↑	↑	↑	↑		
Japan						
Pre-UMP		↓			↑	↑
Post-UMP						↓
CME	↑	↑	↑	↑	↑	↑
…						

Sources: Datastream, Bloomberg, and staff calculations.

Table 9. Two-Day Change in Money Market Rates

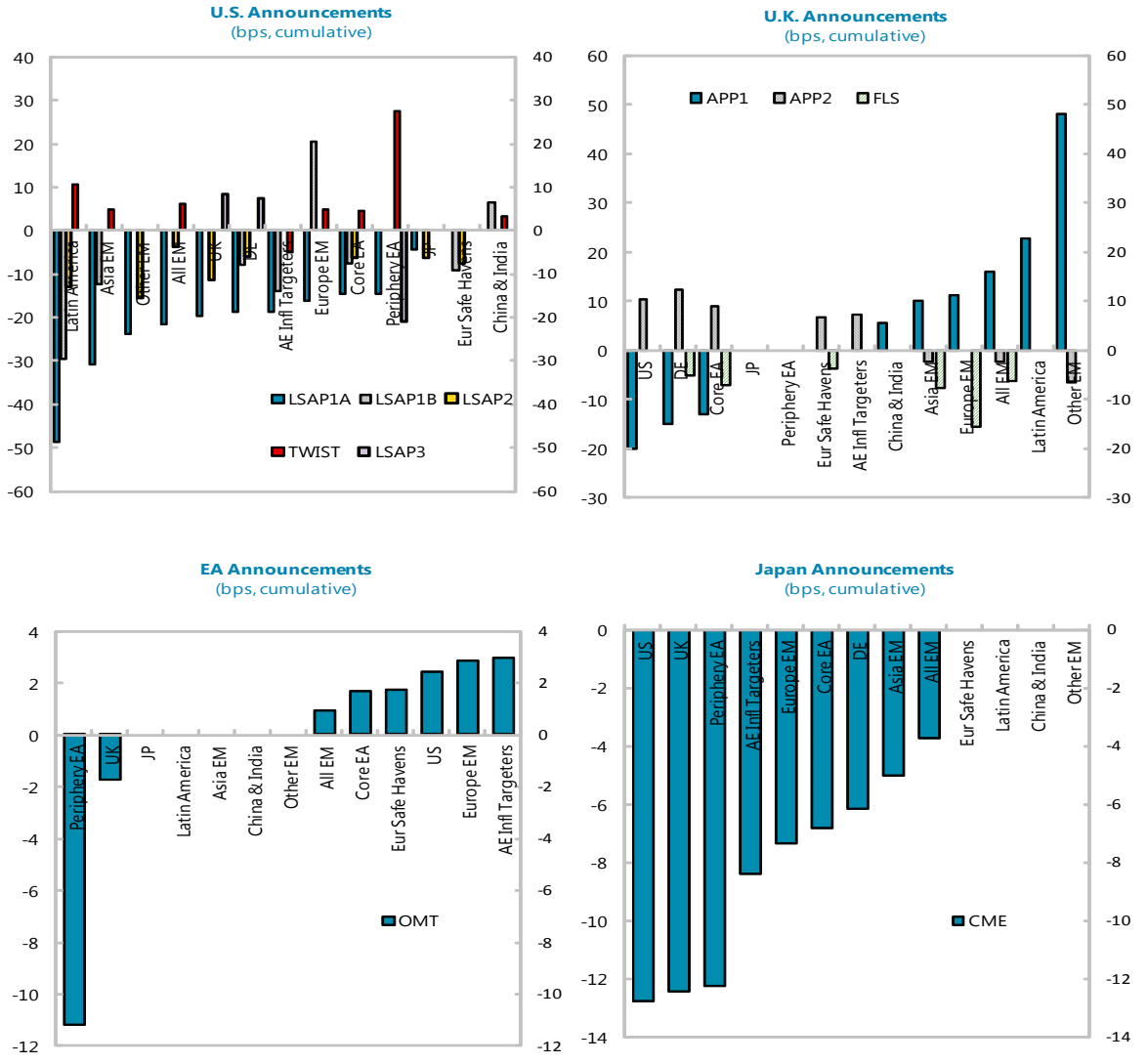
Monetary Policy Announcement	Advanced Economies Responses								
	Systemic 4				Core EA 1/	Periphery EA 2/	European Safe Havens 3/	Inflation Targeters 4/	
	US	UK	DE	JP					
United States									
Pre-UMP			↑	↑	↑	↑	↑	↑	
Post-UMP							↓		
LSAP1A			↓		↓	↓		↓	
LSAP1B							↑		
LSAP2									
TWIST									
LSAP3									
United Kingdom									
Pre-UMP			↓	↑	↓	↓		↓	
Post-UMP									
APP1								↓	
APP2									
FLS									
Euro Area									
Pre-UMP		↑					↑	↑	
Post-UMP							↓		
OMT								↓	
Japan									
Pre-UMP	↓	↓	↓		↓	↓	↓		
Post-UMP									
CME									
...									

Monetary Policy Announcement	Emerging Economies Responses					
	All Emerging	Latin America 5/	Asia 6/	China & India	Europe 7/	Other EMs 8/
United States						
Pre-UMP	↓	↑		↓	↓	
Post-UMP	↓		↓	↓		↓
LSAP1A	↓		↓	↓	↓	↓
LSAP1B	↓				↓	↓
LSAP2		↓		↑		
TWIST		↓				
LSAP3		↑				
United Kingdom						
Pre-UMP	↓	↓			↓	
Post-UMP						
APP1			↑			
APP2				↓	↑	
FLS	↓	↓	↓	↑		
Euro Area						
Pre-UMP	↑	↓	↑		↑	
Post-UMP	↓	↓	↓	↓		
OMT	↑	↑	↑	↑		
Japan						
Pre-UMP	↓			↓		↓
Post-UMP				↑	↑	
CME		↓	↑			
...						

Sources: Datastream, Bloomberg, and staff calculations.

Notes: 1/ Core EA comprises: Austria, Belgium, Finland, France, and Netherlands; 2/ Periphery EA comprises: Greece, Ireland, Italy, Spain, and Portugal; 3/ European Safe Havens comprise Denmark and Switzerland; 4/ Inflation Targeters comprises Australia, Canada, New Zealand, Norway, and Sweden; 5/ Latin America comprises Brazil and Mexico; 6/ Asia comprises Indonesia, Malaysia, South Korea, and Thailand; 7/ Europe comprises Czech Republic and Poland; 8/ Other EMs include Russia, South Africa, and Turkey. A downward (an upward) arrow indicates a fall (an increase) in the money market rates, bond yields, stock returns, or an appreciation (a depreciation) of the foreign currency vis-à-vis the relevant bilateral FX rate (e.g., USD, GBP, EUR or JPY).

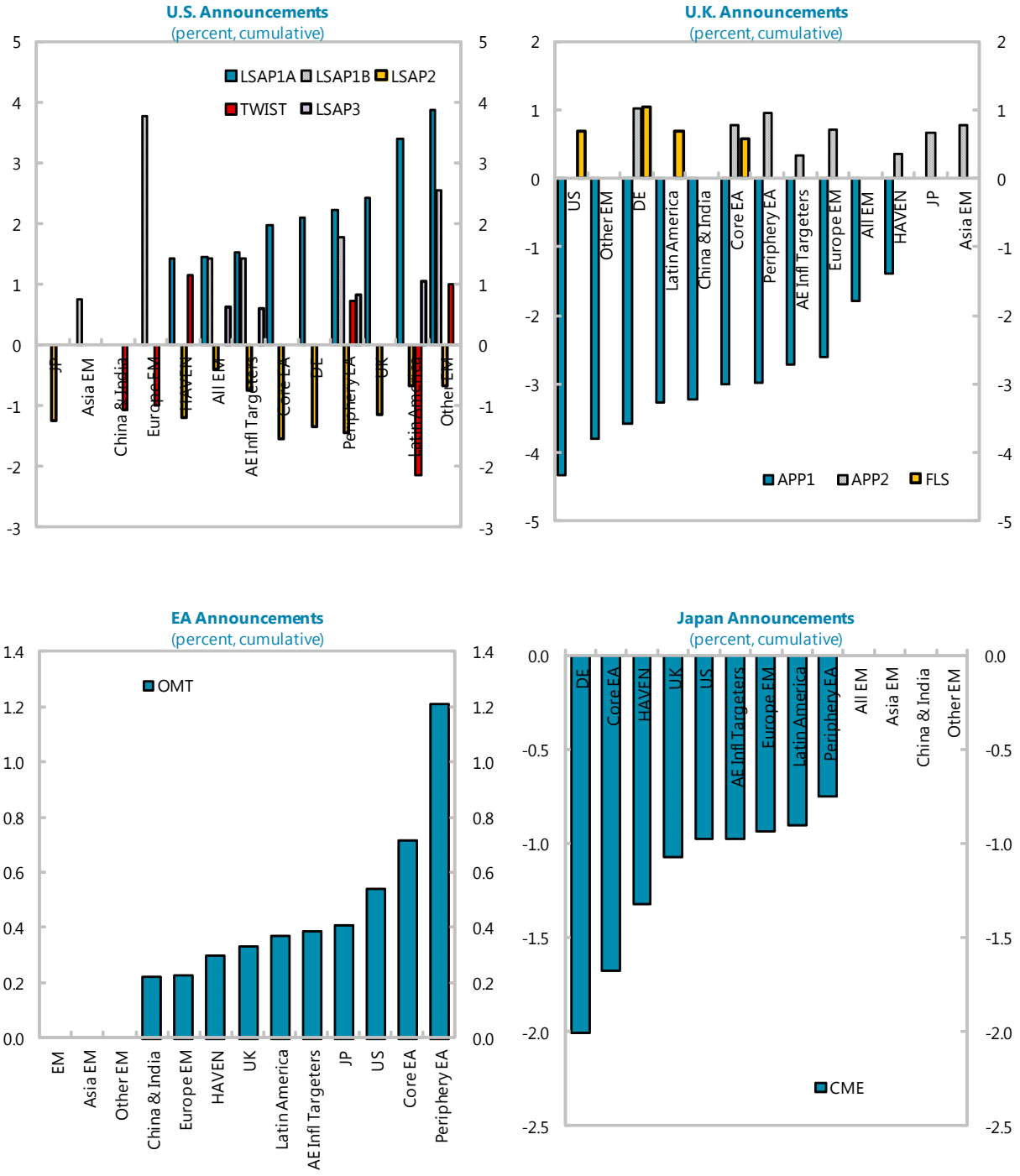
Figure 13. Foreign Bond Yields Responses



Sources: Datastream, Bloomberg, and staff calculations.

Notes: Core EA comprises: Austria, Belgium, Finland, France, and Netherlands; Periphery EA comprises: Greece, Ireland, Italy, Spain, and Portugal; European Safe Havens comprise Denmark and Switzerland; Inflation Targeters comprise Australia, Canada, New Zealand, Norway, and Sweden; Latin America comprises Brazil and Mexico; Asia comprises Indonesia, Malaysia, South Korea, and Thailand; Europe comprises Czech Republic and Poland; Other EMs comprise Russia, South Africa, and Turkey.

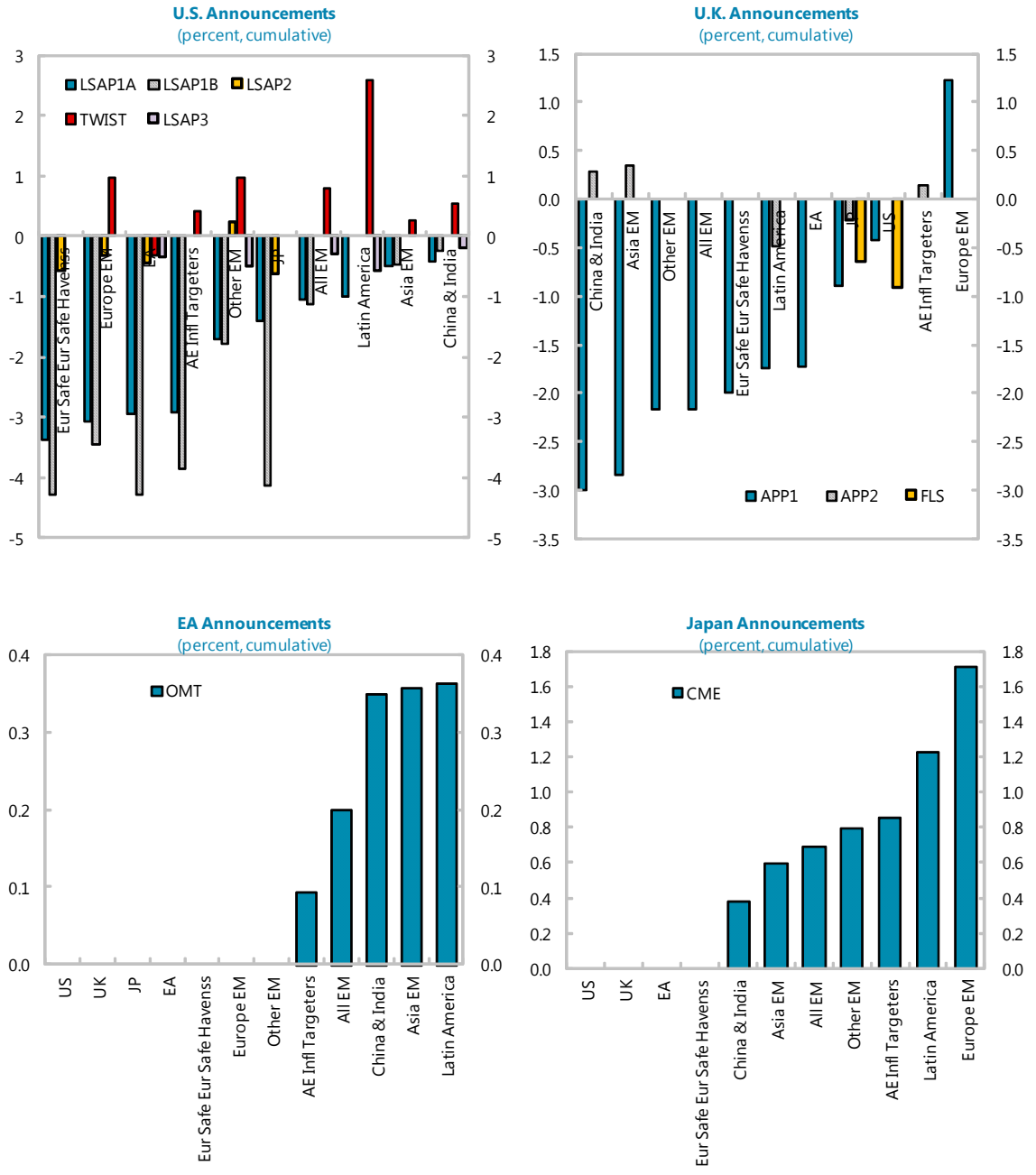
Figure 14. Foreign Equity Prices Response



Sources: Datastream, Bloomberg, and staff calculations.

Notes: Core EA comprises: Austria, Belgium, Finland, France, and Netherlands; Periphery EA comprises: Greece, Ireland, Italy, Spain, and Portugal; European Safe Havens comprise Denmark and Switzerland; Inflation Targeters comprise Australia, Canada, New Zealand, Norway, and Sweden; Latin America comprises Brazil and Mexico; Asia comprises Indonesia, Malaysia, South Korea, and Thailand; Europe comprises Czech Republic and Poland; Other EMs comprise Russia, South Africa, and Turkey.

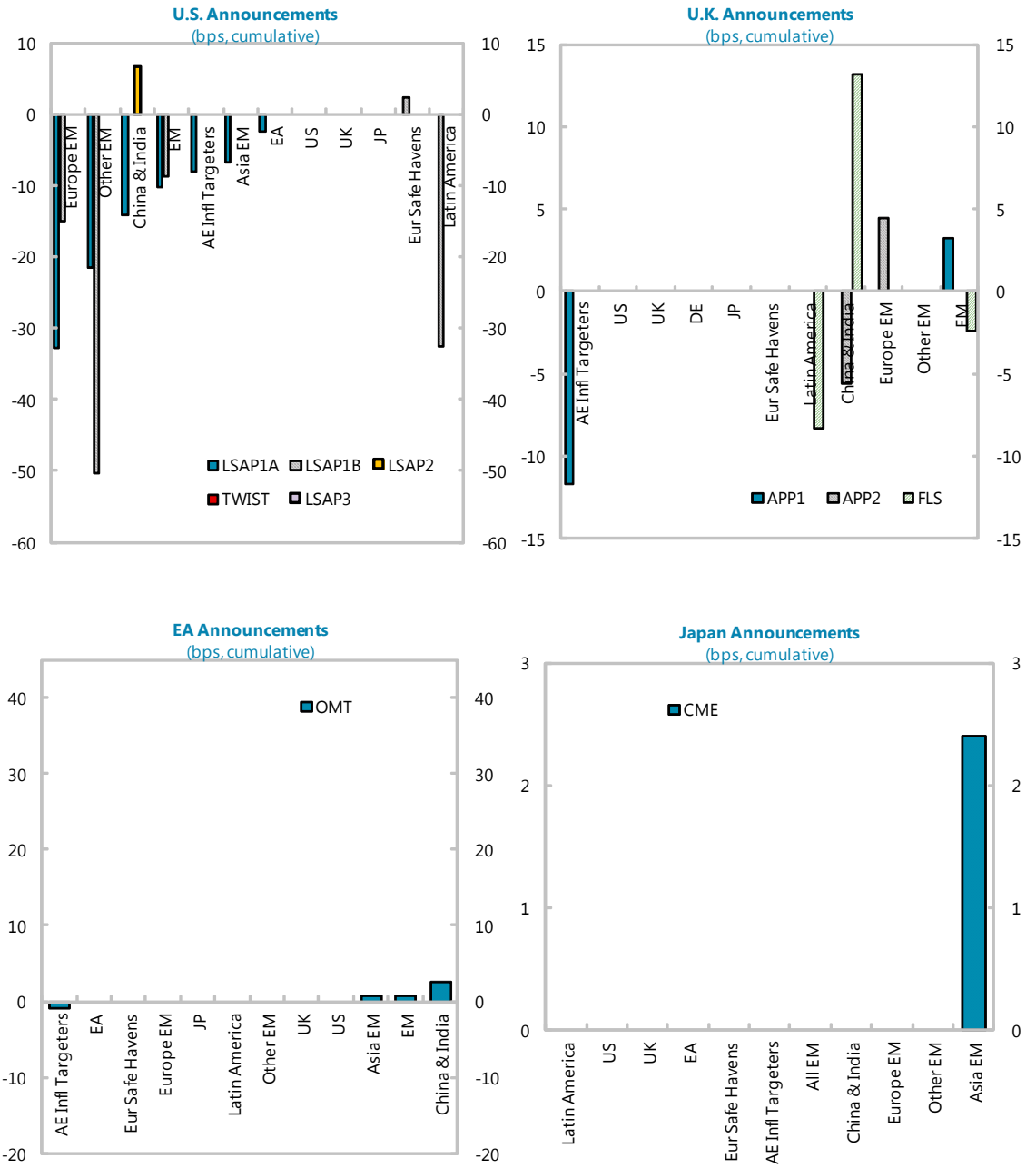
Figure 15. Relevant Cross Foreign Exchange Rates Response



Sources: Datastream, Bloomberg, and staff calculations.

Notes: EA comprises: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Spain, and Portugal; European Safe Havens comprise Denmark and Switzerland; Inflation Targeters comprise Australia, Canada, New Zealand, Norway, and Sweden; Latin America comprises Brazil and Mexico; Asia comprises Indonesia, Malaysia, South Korea, and Thailand; Europe comprises Czech Republic and Poland; Other EMs comprise Russia, South Africa, and Turkey. A rise (fall) in the cumulative 2-day window rate of return of the cross FX indicates a depreciation (appreciation) of the foreign currency vis-à-vis the relevant bilateral FX rate (e.g., USD, GBP, EUR, or JPY).

Figure 16. Foreign Money Market Rates Responses



Sources: Datastream, Bloomberg, and staff calculations.

Notes: EA comprises: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Spain, and Portugal; European Safe Havens comprise Denmark and Switzerland; Inflation Targeters comprise Australia, Canada, New Zealand, Norway, and Sweden; Latin America comprises Brazil and Mexico; Asia comprises Indonesia, Malaysia, South Korea, and Thailand; Europe comprises Czech Republic and Poland; Other EMs comprise Russia, South Africa, and Turkey.