International Analysis Note

May 2015

(ID-GSID, MA-MFAD and MPC unit)

How do changes in foreign monetary policy spill over to the UK?

Main message: *Foreign monetary policy is an important determinant of the UK outlook today. We think that QE in the euro area has raised growth and reduced inflation in the UK. Future US tightening might have the opposite effect, depending on the reaction of financial markets and other economies. Financial channels which are not normally captured in the forecast round do much of the work. Because shocks like these can send output and inflation in opposite directions, the right policy reaction is not obvious.*

Summary

The MPC is due to discuss the impact of foreign monetary policy on the UK at the Special Topics Meeting on Monday 18th May. Time seems ripe for such a discussion, following the recent experience with spillovers from the ECB's QE programme and with a US monetary policy tightening in prospect later in the year. This note sets out the channels through which foreign monetary policy actions such as these affect the UK. It serves as background reading for the Special Topics Meeting.

The world economy affects the UK through the demand and price of our tradable goods (trade channels), through UK asset prices (financial channels), and through confidence channels.

Central banks adjust policy rates to accommodate shocks that start outside the central bank – in the financial markets and the real economy. This accounts for most of the variation in policy interest rates, especially at low frequencies. But monetary policy surprises are important when they do happen, and we focus on their effects in this note.

We find that a surprise loosening of monetary policy in the US or EA tends to raise GDP and inflation there, and could also lower term and risk premia around the world. These effects would tend to raise UK GDP and inflation, while the concomitant rise in sterling would tend to push GDP and inflation the other way. The sign of the net effect is uncertain and contingent. But we present new evidence here which is broadly consistent with the staff treatment of euro-area QE (EAQE): the fall in long-term interest rates and rise in the exchange rate it has caused are such that EAQE is expected to raise UK GDP but reduce inflation over the forecast horizon.

The financial channels that seem most important for EAQE – its effects on term and risk premia – are not routinely captured in the Inflation Report forecast process. They are highly uncertain, and likely to vary in strength from case to case. For example, a tightening in US policy could trigger crises in emerging markets that amplify its initial effects, depending on the state of balance sheets in those countries.

Important considerations for the MPC are therefore:

- *Do the Committee find this a useful framework for thinking about the effect of EAQE and US monetary tightening on the UK?*
- *Which channels deserve the most attention from staff, now and in the future?*
- *How should the MPC respond to the impact of foreign monetary policy on UK output and inflation, especially when inflation is away from target?*

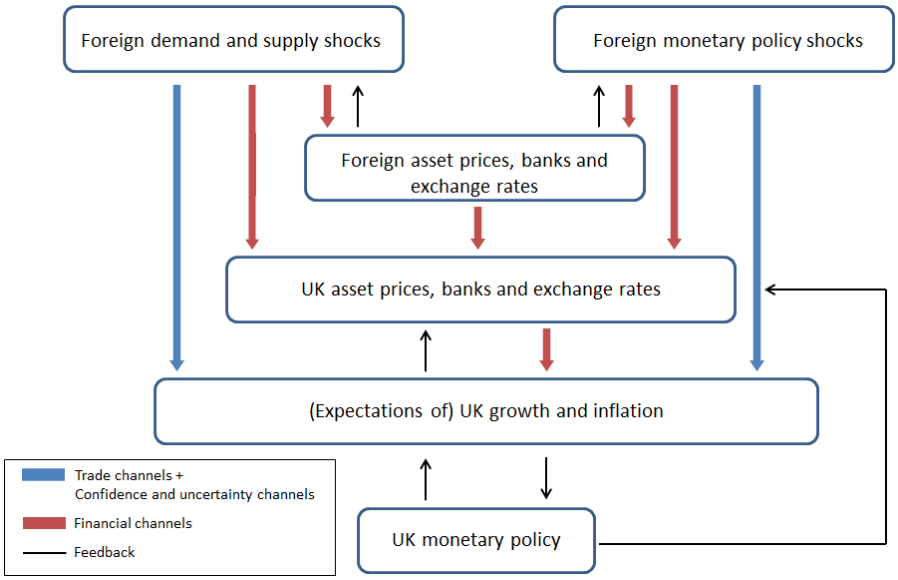
Introduction

Monetary and economic conditions abroad are a key input to the policy decision in the UK. This note analyses the question of how foreign monetary policy affects the UK, how this depends on what is driving policy abroad, and what if anything the MPC should do in response. We start with a framework in which to think about these effects, then describe the empirical evidence linking UK asset prices and macroeconomic variables to foreign monetary policy. We apply this to the current conjuncture – specifically the impact of EAQE on the UK - and end with some policy considerations.

International shocks and the UK economy

Foreign shocks spill over to the UK through several channels. Some of those we capture systematically in the forecast; others we try to capture on an ad hoc basis. **Chart 1** represents how we think of foreign demand, supply and monetary policy spilling over to the UK. The following section explains this chart.

Chart 1. International spillovers channels



(1) Trade channel

A rise in demand abroad caused, for example, by a rise in business confidence, will raise foreign spending. Some of this will go on UK goods, tending to boost UK net trade and GDP. Stronger demand or weaker supply abroad will tend to boost foreign inflation, which – for a given exchange rate– will raise UK competitiveness and directly raise UK import prices, as will a fall in the nominal exchange rate. This will tend to boost UK GDP and CPI. Our forecast takes account of these factors directly, via forecast for UK-weighted world import volumes and export prices.

Foreign demand, supply, and monetary policy shocks will affect foreign asset prices and banks – which in turn will feed back to foreign demand, supply and monetary policy. Our international forecast is conditioned on market paths for foreign short and long rates, bank funding costs and exchange rates, so our forecast for world trade volumes and prices systematically takes account of this feedback.

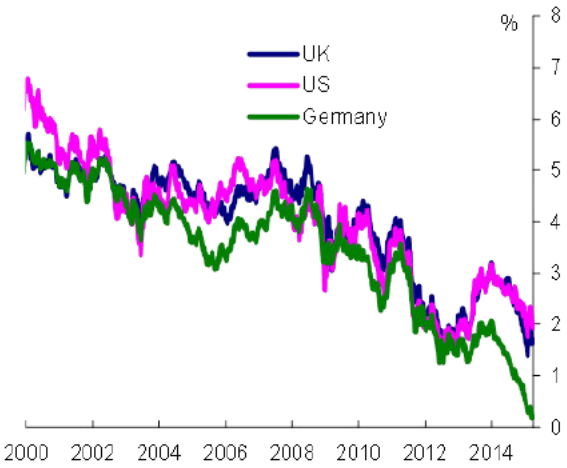
(2) Financial channels

Foreign demand, supply and monetary policy can affect UK asset prices (short rates, long rates, and risky asset prices), bank lending conditions, and the exchange rate – both directly, and via foreign asset prices – which affect UK growth and inflation.

UK asset prices are highly correlated with asset prices in other advanced economies. This is particularly evident in (but not limited to) bond markets, as shown in **Chart 2**. In an influential paper,

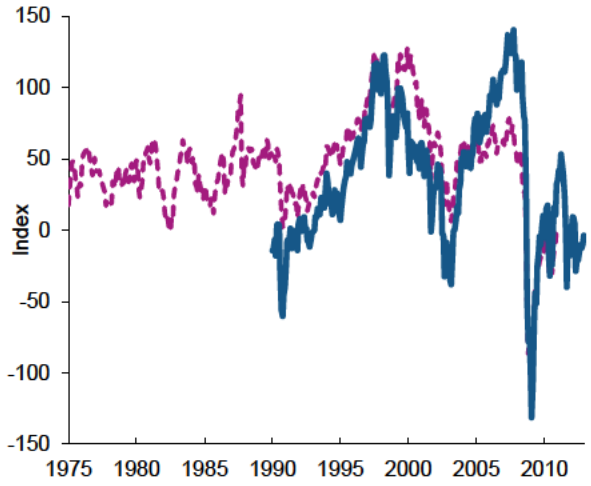
identify a 'global financial cycle' – a common factor (depicted in **Chart 3**) that explains around 60% of the variance of a broad array of global asset prices and credit flows.[1] While much of this comovement is correlated with monetary policy variables, it is for the most part likely to be driven by factors in the real economy and financial markets that central banks are responding to rather than independent changes in monetary policy.

Chart 2. 10-year spot yields



Note: *Bloomberg and Bank calculations.*

Chart 3. Global financial cycle - Common Factor



Note: *Estimates of the global factor (as in Miranda-Agrippino and Rey, 2015) obtained with two different samples. The dotted line uses data for the 1975:2010 sample and the solid line uses data for the shorter sample 1990:2010.*

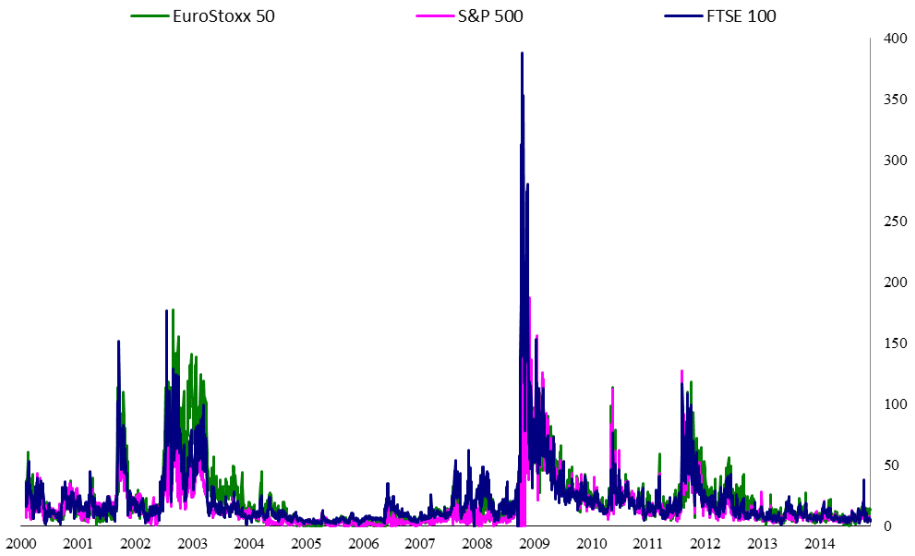
Monetary policy in inflation-targeting countries is normally set with a view to stabilising output and inflation in the domestic economy. The shocks that move these things around - demand, oil prices, animal spirits, and so on - will directly impact the UK. The foreign central bank response to these shocks is difficult to disentangle, both conceptually and empirically, from the shocks themselves. For example, when demand weakens in the euro area and the ECB responds with looser policy, which may also be associated with a rise in the UK exchange rate and perhaps a fall in UK long rates, the central bank can be thought of as transmitting rather than causing the demand shock. The way in which foreign monetary policy reacts to other shocks will affect how those shocks are transmitted to the UK.

From time to time, surprise changes in foreign monetary conditions occur, which cannot be predicted in terms of their standard determinants. These surprises may occur because the markets do not fully understand the central bank's view of the economy, or less commonly because of a change in the membership of, balance of power on, or legal constraints affecting a policy committee. For example, the partial resolution of legal uncertainty around OMTs may have made it easier for the ECB to launch QE. These so-called `policy surprises' will affect the UK through their impact on the foreign economy and global financial conditions.

If the marginal investor in UK bonds or equities also invests in foreign assets, she may view UK and foreign assets as close substitutes. This is consistent with the high correlation observed in proxies of risk premia across countries (see **Chart 4** and [illegible])). A monetary policy surprise that affects a global investor's net worth or funding costs will affect her financial constraints or perception of or aversion to risk and, consequently, the demand and price of UK and foreign assets in a similar fashion. Alternatively, the identity of the investors could be different but they may share similar attitudes towards risk, which may in turn be affected by monetary surprises.

[illegible]

Chart 4. Variance risk premium for UK, US and euro area



***Note**: Bloomberg, Oxford Man Realized Library and Bank calculations.*

Term premia are typically thought to be countercyclical, but it also seems likely that monetary policy has the ability to influence them. That may be particularly the case for QE (and possibly the unwind of QE). Conventional US monetary policy surprises have been found to affect the price of risk (as well as its quantity, or uncertainty).[2] By affecting global uncertainty and risk aversion, US monetary policy could have a direct impact on UK asset prices, as might EA policy, given the weight of the EA in the global financial system. The international co-movement of bonds' term premia[3] is also consistent with these dynamics (although has not explicitly been linked to monetary policy shocks in the literature yet).[4] Foreign monetary policy surprises would then affect UK asset prices via their risk premia, as well as through expected policy rates and their underlying cashflows.

The UK forecast is conditioned on the market curve for overnight UK interest rates out to three years. So the effects that foreign shocks have on the short end of the OIS curve are systematically captured in the forecast. Changes in long-term UK forward rates are not directly captured, but they may be reflected in other asset prices that the forecast does capture (e.g. house prices, the exchange rate, and – via the suite of models – household wealth and the cost of capital). In addition, to the extent that changes in term premia are correlated with changes in short rates, they may be captured in our empirical estimates of the effects of short rates. In the past, we have also made judgements to include additional effects from particular identifiable policy actions on long rates – as with EAQE this round. Two other examples where an effect has been incorporated in the forecast in the past are movements in long yields driven due to the Bank's own QE programme and to market concerns about the fiscal position.

Changes in foreign conditions can also affect bank lending conditions in the UK, as UK banks have foreign exposures and fund themselves in international markets, and foreign banks interact with the UK real economy. These effects are captured in the forecast via a model of credit spreads.

Finally, the future path of the exchange rate depends partially on interest-rate differentials, so moves in foreign yield curves will have an effect on the forecast through this channel too.

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[2] Bekaert et al. (2013) find that shocks to US monetary policy significantly affect both uncertainty and risk premia (as measured by a decomposition of the VIX), and explain around 20% of its variance in a medium-run horizon. and find that US monetary policy surprises explained up to 12% of the variance of the global financial cycle in Chart 3

[3] Documented in and

[4] However, some of the global factors in bond pricing have been linked to monetary policy uncertainty; see Abritti et al. (2013).

(3) Uncertainty and confidence

Foreign shocks can affect UK growth and inflation via large uncertainty and confidence effects. For example, the synchronicity of the worldwide fall in GDP in 2008 is difficult to explain with trade and financial linkages alone, suggesting that uncertainty and confidence played an important role. Similarly, pessimism over the euro-area crisis likely played an important role in depressing UK activity in 2010-12. And the ECB's announcement of OMTs in 2012 relieved crisis fears, playing a substantial role in the UK's recovery.

We do not capture confidence spillovers systematically in the forecast – but where we think they will be important, we can incorporate them via judgements on UK domestic demand.

Quantifying the impact of foreign monetary policy surprises

Surprise changes in foreign monetary policy – the focus of this note – will affect the UK through the channels described above. For concreteness, let us consider the case of a surprise loosening in euro-area monetary policy[5]

- Foreign demand and inflation
  Looser policy in the euro area will tend to boost demand and inflation abroad. Some of this extra spending will go on UK goods, while the rise in foreign inflation will raise UK competitiveness and directly raise UK import prices somewhat. This will tend to raise UK GDP and CPI.
- Exchange rate
  Lower interest rates abroad may raise the UK exchange rate. This will directly lower UK import prices and UK CPI. The relative price of UK goods will increase, switching UK and foreign expenditure away from the UK economy. This will push down on UK GDP and thus inflation.
- Domestic asset prices
  UK bond and other asset prices may rise in sterling terms. This will boost UK output and inflation.
- Confidence and uncertainty
  Lower expected interest rates may improve debt sustainability abroad, and thus reduce the risk of a grave crisis. That could improve the position of the capital position of the banking sector, easing credit conditions and raise business and consumer confidence in the UK over and above what would be justified by the other channels.

So the first, third and fourth effects will tend to boost output and inflation, while the second will tend to lower them. The net effect can in principle go either way, and will depend on factors that are uncertain, such as how sensitive spending and the term premium are to the policy rate, and how the exchange rate affects trade volumes and prices.

To illustrate this, **Chart 5** shows the effect of a surprise cut in foreign interest rates on UK inflation in a model similar to COMPASS. The effect will depend on how the MPC responds – these results mimic the case in which there is no change in UK policy rates.[6] The grey areas show results for all possible combinations of reasonable parameters.[7] The charts show that a negative interest-rate surprise in the rest of the world is likely to boost UK output in the very short run but after that the impact is ambiguous, as is the impact on inflation. For most plausible parameter combinations, however, lower foreign interest rates raise UK output and reduce UK inflation.

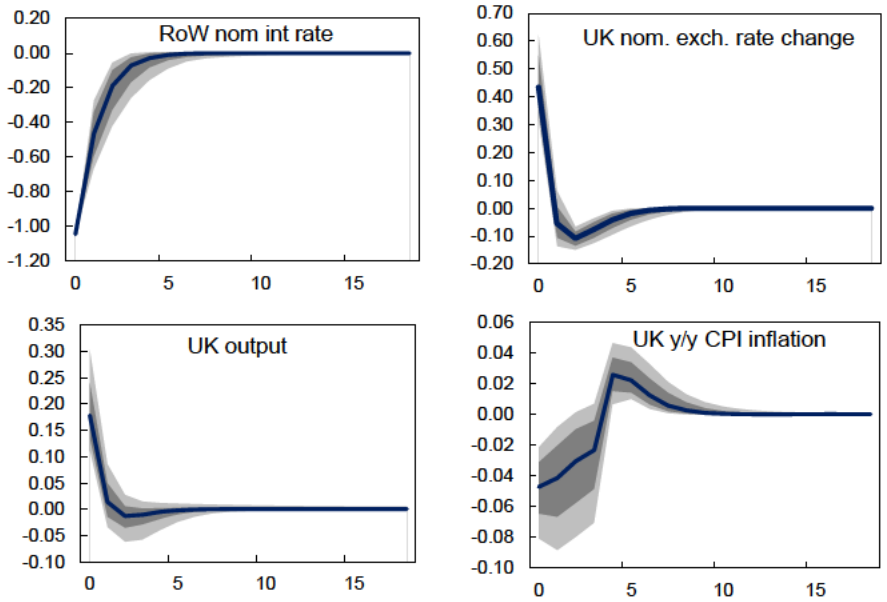
[5] For the case of policy tightenings we can, to a first approximation, reverse the sign of the above effects. Comparing the US to the EA, the EA has a larger trade weight than the US so the first two effects will be smaller but qualitatively similar. The dollarization of the international financial system means that the Fed may however have a larger impact on global financial conditions than the euro area.

[6] The model has a richer foreign block than COMPASS and so is better suited for considering some foreign shocks. Agents in the model expect the MPC to try to hit a CPI inflation target and are repeatedly surprised when they do not move interest rates. This policy rule and the departures from it are key determinants of the response of the UK economy. More detail on this model and the experiments we conduct can be found in the Appendix to this note and a forthcoming background note.

[7] The model could of course vary in other ways too - such as how financial markets are integrated across borders, and which currency import prices are set in.

If the UK term premium were also to fall – a channel omitted from this model[8] – we would expect a more positive net effect on output and inflation.

Chart 5. Impact of a foreign monetary policy shock when the UK interest rate is kept fixed



Note: *The figure depicts the impulse response functions to a 1pp surprise fall in the RoW interest rate. For all variables, percentage deviations from steady state are depicted, except for the nominal interest rate where the annual interest rate in percentage points deviations is depicted. The blue line corresponds to the median impulse response from 1000 simulations each using different parameter values randomly selected from a uniform distribution over a range of plausible parameter values, whereas the shaded areas depict the 68th and 90th percentiles of the impulse responses. The x-axis shows quarters after the monetary policy surprise.*

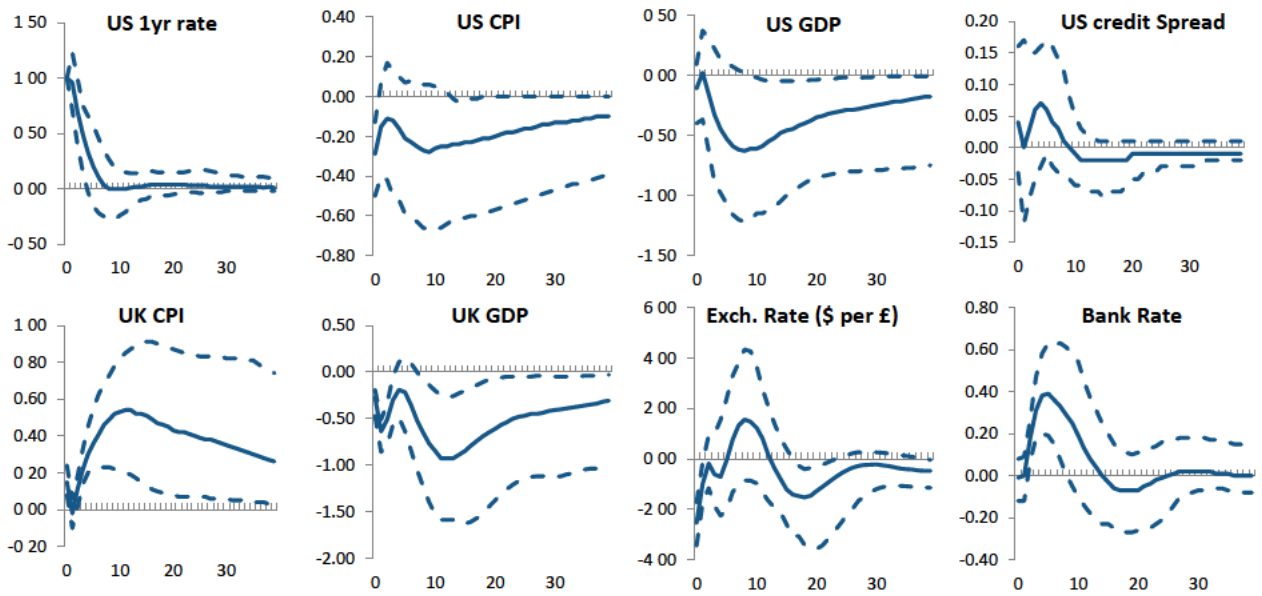
To say more about the balance and importance of these effects, we need to examine the empirical evidence. We can shed some light on the size of these effects by trying to identify the surprise component of foreign monetary policy in the data and relating it to subsequent changes in UK asset prices and macroeconomic variables. The appendix below considers a range of new and existing evidence and concludes that monetary policy surprises overseas of a given size have tended to move UK interest rates between one- and four-fifths as much in the same direction at varying points along the curve. UK risky asset prices and the exchange rate have tended to go in the opposite direction to foreign interest rates.

For example, we examine the effect of a surprise US foreign rate rise of 1pp in a new empirical model.[9] We find that UK GDP decreases by about 0.5% (**Chart 6**), suggesting that the demand and financial channels have outweighed the exchange rate channel on average in the past. And inflation increases, as the direct impact of higher import prices outweighs the drag from the output gap. So, flipping the sign, a surprise foreign policy loosening pushes inflation temporarily lower at any given level of GDP. Depending on where inflation and the output gap start, this may move them closer to or further from desired values.

[8] In the model, financial conditions are reflected in the expected path of short term interest rates, so there is no role for a term premium.

[9] The empirical model is a two-country VAR in which we identify the monetary policy surprise by looking for jumps in the short end of the US yield curve around the time of FOMC announcements.

Chart 6. Impact of a US monetary policy shock on the US and the UK



Note: *The charts report the impulse response functions to a monetary policy surprise that raises US 1-year government bond yield by 1pp. The y-axis shows percentage deviations from a long-run trend. Dotted lines represent 95% confidence bands. The x-axis shows quarters after the monetary policy surprise.*

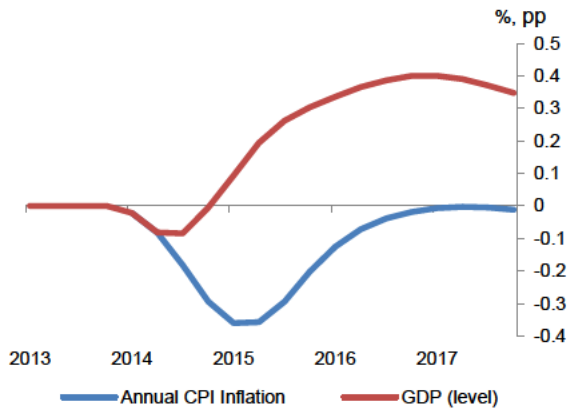
Table 1 and **Chart 7** show the staff assessment of the impact of ECB QE on UK output and inflation, expanding on what was presented at the May benchmark forecast. These findings are qualitatively consistent with the empirical evidence above: the loosening of policy in the EA raised GDP and, in the short run, reduced inflation.

Table 1. Impact of EA QE on the forecast

	News this round		Overall effect	
	Y3 GDP	Y3 Inflation	Y3 GDP	Y3 Inflation
Exchange rate	0.0	-0.1	-0.2	-0.3
Asset prices	0.1	0.1	0.4	0.3
External demand	0.0	0.0	0.1	0.0
Confidence	-	-	-	-
Total	**0.1**	**0.0**	**0.3**	**0.0**

Note: *Bank calculations.*

Chart 7. Impact of EA QE on the forecast



Note: *Bank calculations.*

Conversations with the foreign central banks indicate broad agreement on the framework and transmission channels outlined above. Contacts differed, however, on the sign of the net effect on GDP, it being the difference between a number of much larger gross impacts. For example, some at the Fed felt that the effect of EAQE on the US dollar outweighed its effect on US bond yields, calling for lower US policy rates than otherwise. Others there thought it called for higher US rates, and still others thought the effects would be broadly offsetting.

Risks and contingencies

The staff treatment of EAQE suggests that foreign monetary loosening warrants a lower yield curve in the UK, either in the form of lower policy rates or an 'automatic' fall in the UK term premium. In contrast, the 2014 IMF spillovers report suggested that policy rates would need to be cut outside the US if a renewed tightening of US policy led to another 'taper tantrum'. These results can be reconciled if we think that global risk and term premia will react more strongly to a US tightening than EA loosening. US tightening could also be more contractionary if it triggers vulnerabilities in non-US dollar borrowers, such as many emerging markets[10].

Another dimension to take into account is potential differences in spillovers resulting from conventional and unconventional monetary policy. Little has been done in the literature in terms of theoretical and empirical analysis of this issue. However, there are two factors that suggest spillovers from unconventional monetary policy might be bigger. First, unconventional policy targets the longer end of the yield curve, which also displays higher international co-movement, suggesting room for bigger spillovers. Additionally, portfolio rebalancing effects could also be bigger given the larger scale of unconventional asset purchase programmes compared to the conventional open market operations. The only empirical paper that tackles this issue (Gilchrist et al. (2014)) backs this hypothesis, as it finds that spillovers from US monetary policy to UK yields increased after November 2008 (see Appendix A for more details).

Conclusions and next steps

The balance of evidence is consistent with the prediction that ECB QE will temporarily boost output but reduce inflation in the UK. Flipping the sign, a surprise tightening in foreign monetary policy - say if EAQE were suddenly withdrawn or the Fed began to raise rates sooner than expected - would tend to reduce the level of GDP consistent with a given level of headline inflation. But there are risks on either side around the central case, particularly of a more pronounced reaction in long term rates from a prospective US policy tightening, and any ensuing damage done to vulnerable EMEs.

The size of these risks warrants further work by the staff on understanding the causes and policy implications of comovement in international financial conditions at home and abroad, whether caused by monetary policy surprises or otherwise. That said, monetary policy surprises on the scale we have seen in Europe over the past six months are not common events, and are the source of only part of the foreign shocks that hit the UK.

There is also an important question about whether and how the MPC should respond to shocks such as this. If the MPC prefers to `look through' changes in temporary inflation caused by foreign monetary policy, it may opt to focus on any effect on the output gap. In that case, depending on the size of the shock, the MPC might need to change the period over which it was seeking to return inflation to target. But to the extent that the Committee also places weight on the duration over which inflation is away from target, then the MPC will need to consider running the economy with a more positive output gap so as to return inflation to target more quickly.

The Committee may accordingly find it useful to discuss the following questions:

> *Do the Committee find this a useful framework for thinking about the effect of EAQE and US monetary tightening on the UK?*
>
> *Which channels deserve the most attention from staff, now and in the future?*
>
> *How should the MPC respond to the impact of foreign monetary policy on UK output and inflation, especially when inflation is away from target?*

APPENDICES

Appendix A – Empirical evidence on the impact of foreign monetary policy surprises on the UK

The first paper to quantify the impact of US monetary policy surprises on the UK is Ehrmann and Fratzscher (2009), who find that a 25 bps surprise increase in Fed funds rate pushes the FTSE down by 1%. Hausman and Wongswan (2011) extend this exercise to other asset classes and split the US monetary policy shocks into a "level" shock and a "path" shock. They find that UK equity markets respond to level surprises but not to path surprises, and that the magnitude is reassuringly similar to that found by Ehrmann and Fratzscher (2009): the FTSE falls by 1% after a 25 bps level shock to the Fed funds rate. In contrast, sterling is found to respond to path surprises but not to level surprises, falling by 0.3% after a 25bps upward revision to the future path of US monetary policy. But of course the reaction of exchange rates depends on relative interest rates paths, and hence on the reaction of UK interest rates to US monetary policy shocks, which the authors also quantify. They find that UK short term (3-month) interest rates respond significantly to both level and path shocks to US policy rates: UK rates go up by 4 bps and 3.5 bps in response to a 25 bps shock to the level and path of US rates, respectively. Long term (10-year) UK yields only react to news about the path of Fed funds rates, although more strongly: they go up by 6.5 bps in the face of a 25 bps path shock.

Our internal work goes further and includes the impact of foreign monetary policy on UK macroeconomic variables (a forthcoming background note will provide details). **Chart 6** (in the main text) shows econometric estimates of the impact on the US and UK of a monetary policy surprise that raises US 1-year risk free rate by 1pp. We identify the monetary policy surprise by looking for jumps in the short end of the US yield curve around the time of FOMC announcements, and we then trace their effects on the real economy in the UK and the US. In our estimates, a US policy tightening reduces output and inflation in the US in the standard fashion.

The shock also temporarily weakens the UK exchange rate, which falls on impact by 3pp. UK GDP falls, reaching a peak of -0.5pp (in annual terms) and suggesting that the impact of lower foreign demand dominates over the expenditure switching effect. Differently CPI inflation rises, peaking at 0.4pp (in annual terms) and suggesting a high degree of pass-through from import prices (which rose because of sterling depreciation) to consumer prices. Finally, in the data, Bank rate typically rose with a lag of 6 months, by a maximum of about 1/3 the size of the peak rise in US policy rates. So, over the past, the Bank seems to have followed positive US interest rate surprises with increases of its own.

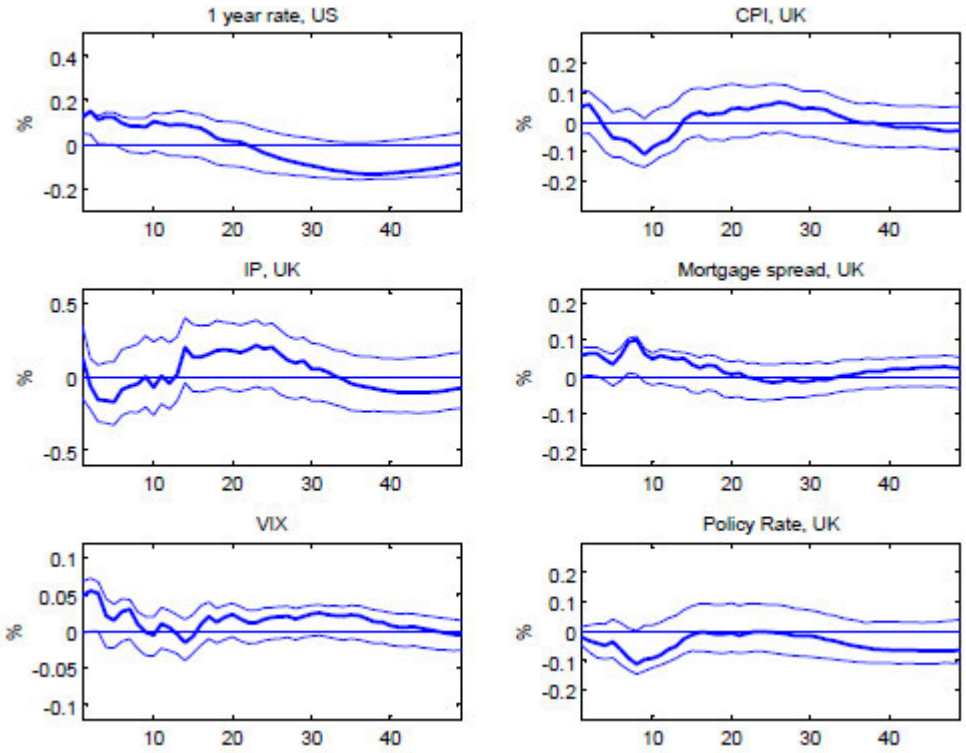
In her 2014 Mundell-Fleming Lecture, Helene Rey (in joint work with Passari[11]) performs a similar exercise and estimates the effects of US monetary policy on small open economies with flexible exchange rates. The results for the UK (reported in **Chart A1**) show that the response of UK GDP and inflation to a US monetary policy shock are not statistically significant. We believe this is due to the fact that Rey and Passari's SVAR falls short on an important aspect. While they simply add US interest rates to a closed-economy VAR for the UK, we allow US monetary shocks to affect the UK both directly and through their effect on US activity, prices, interest rates and credit premia to affect the UK both.

We also used a GVAR to check the robustness of the results obtained with the 2-country SVAR. Given the complexity of the model we could not use the same identification technique, so we identified the monetary policy shock with a standard short-run zero restriction. **Chart A2** reports the impulse response function to an unexpected US monetary policy shock that raises the US short rate by 1pp. In the US GDP falls by about 0.6pp (as in **Chart 6** in the main text), while inflation is positive on impact and then turns negative – a manifestation of the "price puzzle" that affects VAR models identified with similar timing restrictions.

The transmission of the US shock to the UK is in line with the estimates obtained from the 2-country SVAR. Specifically, UK GDP also falls by about 0.6pp and the sterling tends to depreciate (even though the impulse response is statistically significant only for the first few quarters).

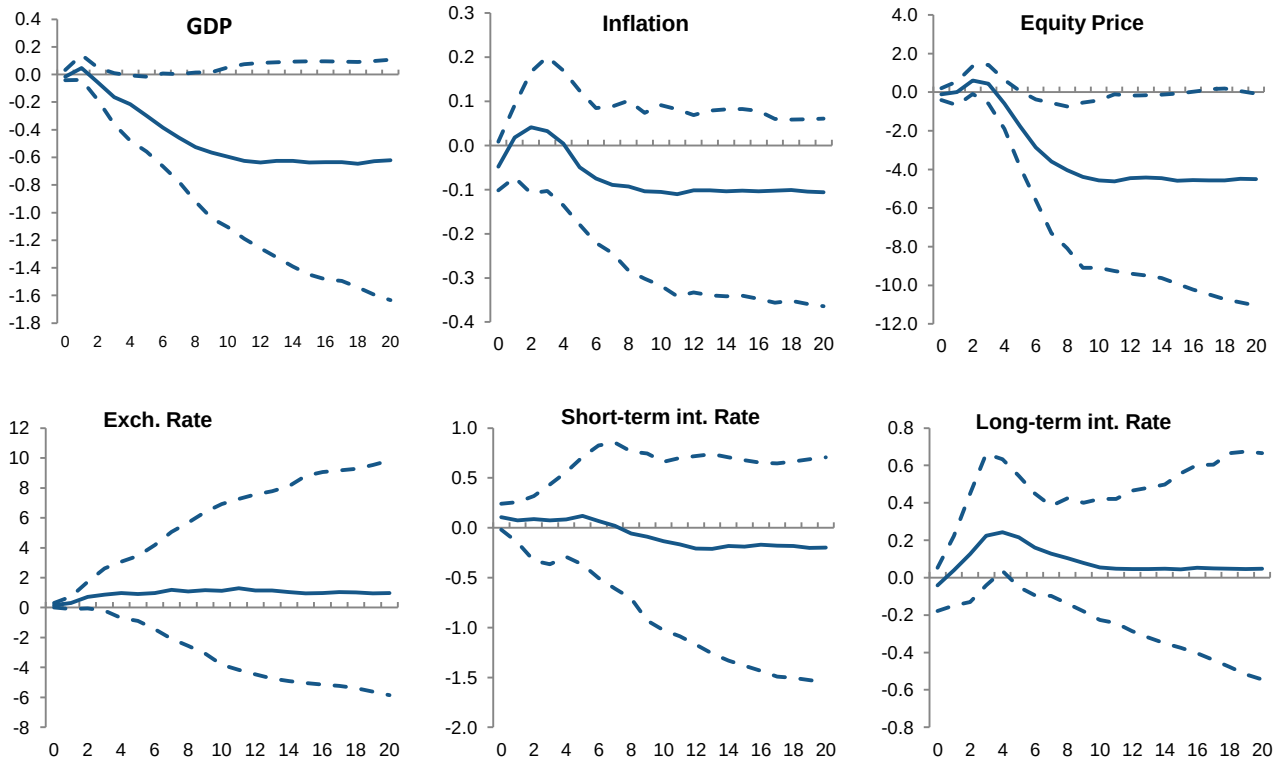
[11] See Passari and Rey (2014)

Chart A1: Response of the UK (% points) to a 20bp increase in the US one year rate (using high frequency instruments as in Gertler and Karadi, 2015)



***Note**: Chart from Rey and Passari (2014).*

Chart A2: GVAR estimates of the impact of an unexpected US monetary policy shock on the UK



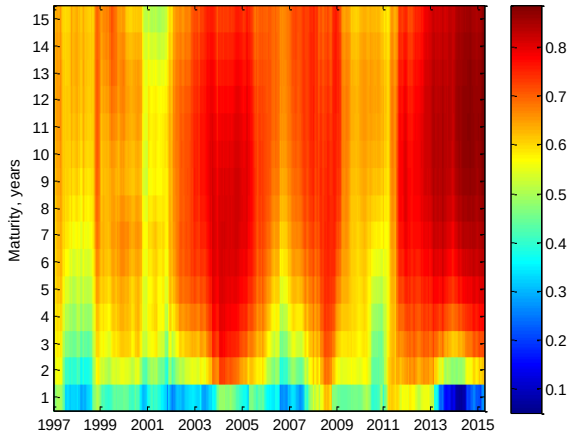
***Note**: The charts report the impulse response functions to a monetary policy shock that raises US short-term interest rates by 1pp. The y-axis shows percentage deviations from a long-run trend. Dotted lines represent 95% confidence bands. The x-axis shows quarters after the monetary policy surprise.*

This evidence comes with a number of caveats. First, we focus on movements in the yield curve around FOMC announcements as the best available measure of unanticipated changes in interest rates. But while these shocks may be unanticipated, they may still be related to economic conditions – something the Fed knows about the economy that the markets do not – rather than just news about how the Fed will go about its job. Second, these shocks relate to conventional monetary policy and treat all such changes, large or small, positive or negative, the same way. In the real world, there is some evidence that policy tightenings are more powerful than loosenings,.[12]

Third, this relates to the effect of US policy shocks. Policy shocks emanating in the Euro-area could have a different effect. It is a more important trading partner than the US, such that the exchange-rate and demand effects will be larger. But the dollarization of the world financial system makes the US punch above its trade weight when changing interest rates. Given that global banks fund themselves largely in US dollars, this may imply that US monetary policy may have larger spillovers globally than policies from other CBs, including the ECB. Rogers et al (2014) find a significant impact of US shocks on all foreign yields (including UK gilts, EA and JP bonds), while ECB shocks are found to affect only EA and gilts. Also, surprises to ECB policy have an opposite impact than Fed surprises: the former increase UK gilt yields whereas the latter decrease them. This opposite effect is likely due to the different channel via which the two CB's policies operated. While the impact of the Fed polices most likely operated via portfolio balance channels, pushing investors to hold foreign assets and in turn compressing their yields, most of the ECB policies during the crisis may have operated via a confidence channel, removing tail risk (see e.g. OMT), boosting confidence in the euro-area and therefore reducing the spreads of euro-area peripheral countries and increasing yields of safe-haven countries like the UK. This asymmetric impact is also reflected in the ECB policy surprises appreciating the domestic currency, as opposed to depreciating like in the Fed's case.

Spillovers from unconventional polices could be different from those arising from conventional ones. For example, the two types of polices target different segments of the yield curve (although of course both policies may have effects throughout the curve): unconventional policy targets the longer-end of the yield curve, while conventional policy targets the shorter end. To the extent that longer maturities are more correlated internationally than short ones (**Chart A3**), then unconventional policies could have bigger spillovers. Also, spillovers via the portfolio rebalance channel may be expected to be bigger given the larger scale of asset purchases under unconventional policy measures compared to those undertaken during conventional open market operations.

Chart A3: Correlation of UK and US spot yields at different maturities



[12] See Tenreyro, S. and G. Thwaites 'Pushing on a string'

Only a few papers that compare the spillovers of conventional and unconventional monetary policy shocks. Gilchrist et al. (2014) focus on the spillover of US actions on international interest rates using a sample ending in 2014. Acknowledging the existence of level and path components in the shocks as pointed out by Gurkaynak et al. (2005), the authors follow Gertler and Karadi (2015) and assume that both these aspects are captured by looking at high frequency changes in 2-year US Treasuries. Additionally, they split the sample in two using November 2008 as a turning point, and the sub-periods are labelled as corresponding to conventional (pre November 2008) and unconventional (post November 2008) policy frameworks.[13] Estimates are reported separately for each period. Gilchrist and co-authors find that, during the conventional period, a US monetary policy shock that pushes 2-year US treasuries up by 25bps significantly increases UK 2-year yields by 13 bps and 10-year yields by 10 bps.[14] Interestingly, the spillovers seem to be higher during the unconventional period, as 2-year UK yields are pushed up by 19 bps and 10-year yields by 22 bps after a US monetary policy shock that increases 2-year US Treasuries by 25 bps. Another paper that looks at the different spillovers of conventional and unconventional policies is Glick and Leduc (2013): they find that comparable conventional and unconventional MP surprises had the same proportionate effect on the USD (and on the US dollar-sterling exchange rate in particular).

Tightening and easing surprises could have different spillover effects. It is difficult to analyse this issue in the context of unconventional monetary policy because most (but not all) surprises have been easings. Nonetheless, Rogers et al (2014) investigate this issue and find no evidence of asymmetric impact of easing and tightening surprises by G4 central banks on the GBP and other exchange rates.

However, the data also shows that large policy surprises are rare. For example, Miranda-Agrippino and Rey (2014) find that US monetary policy shocks can only explain around% of the variance in their global factor. This is consistent with central banks usually responding to shocks originating elsewhere rather than generating shocks themselves.

Appendix B - impact of US QE on Canada

The Fed's post-crisis asset purchases resulted in substantial spillovers to Canada. We spoke to Bank of Canada staff about their assessment of the spillovers.

The impact on Canadian GDP (0.3%), relative to the US (0.6%), is a little more powerful than the impact in our forecast for ECB QE on the UK (0.3%), relative to the euro area (1%). At least in part, that difference may be because the UK would not benefit from a QE-induced increase in the oil price, whereas Canada would.

[13] Note that the monetary policy shocks in the unconventional period do not only comprise news regarding asset purchase programmes but all FOMC announcements.

[14] Note that these estimates are not directly comparable to the figures in Hausman and Wongswan (2011) as the identification and normalisation of the shocks is different.

Appendix C – Impact of EA QE on the UK forecast

In the forecast, we have taken account of the ECB's asset purchase programme and its impact on the UK through trade, asset prices, credit spreads and exchange rate channels (**Table C1**).

Table C1: Estimated impact of the ECB's asset purchase programme on GDP

Channel	Euro area	World GDP (UK-weighted)	UK GDP*
Impact after three years, %			
Exchange rate	0.6		-0.2
Asset prices and credit spreads	0.4		0.4
External trade	0.0		0.1
Confidence	-	-	-
Total	**1.0**	**0.4**	**0.3**

Exchange rate: We estimated that 10pp of the appreciation of Sterling vs the euro since July 2014 can be attributed to ECB QE. That translates to a 5% appreciation of £ERI, which reduces UK GDP by 0.2%.

Asset prices: We model this by (i) estimating how much news in asset prices can be attributed to ECB QE; (ii) working out what level of UK QE we would have expected to cause that much asset price news; and (iii) applying the UK QE multiplier to that number, to produce an estimate of the impact on GDP.

We have two estimates of what ECB QE has done to risky asset prices:

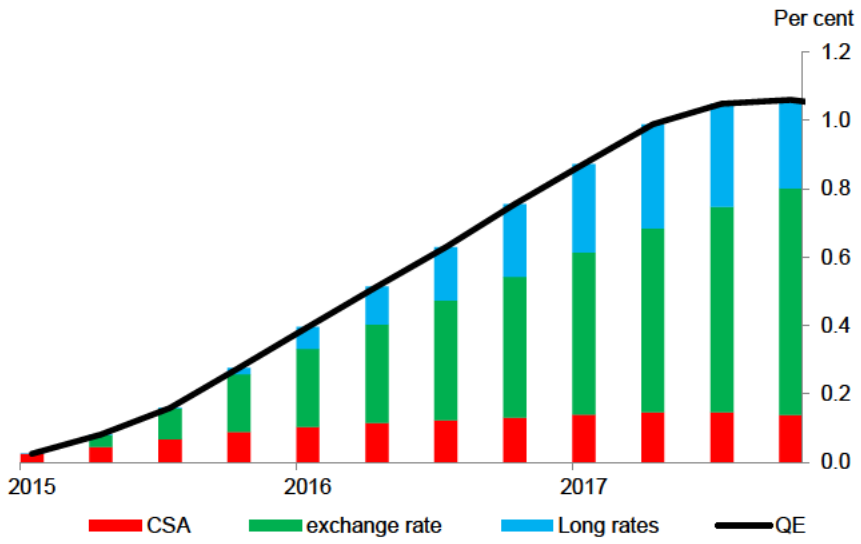
- Taking the total observed news in asset prices since July implies a total impact equivalent to what we'd assume from £50bn of UK QE.
- Using data on the frequency of Bloomberg news articles that mention ECB QE to attribute daily market movements to QE implies a total impact equivalent to what we'd expect from £80bn of UK QE.

We put equal weight on both methods, so assume a total effect equivalent to £65bn UK QE – which would add 0.4% to GDP after three years.

Credit spreads: This is captured via an explicit judgement in the credit spread adjustment. The size of this judgement is very small and its impact on the forecast is negligible.

External trade: We estimate that ECB QE will boost euro area GDP by 1.0% after three years, via the exchange rate, lower long rates (by 100bp) and lower credit spreads (**Chart C1**). The impact on other economies is likely to be positive but small. In the US, the fall in longer-term US Treasury rates since last summer (of around 90bps) is estimated to add around 0.4% to US GDP. It is difficult to say how much of this fall is related to ECB QE, but this channel has offset much of the impact of the move in the euro/dollar bilateral. We expect QE to add 0.4% to UK-weighted world GDP after three years, boosting UK exports, and thus raising GDP by around 0.1%.

Chart C1: Estimated impact of ECB QE on euro-area GDP, by channel



Note: *Provisional estimates*

Confidence: the ECB's QE programme was more aggressive than anticipated: the ECB turned out to be less constrained than many had expected. QE therefore provided new information about the ECB's policy capability and reaction function. Nonetheless, the forecast does not currently include an additional confidence channel to account for this, point towards a potential upside risk to the central projection.