MONETARY POLICY IN THE CAPITALS OF CAPITAL

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Abstract
The importance of financial markets and international capital flows has increased greatly since the 1990s. How does this affect the effectiveness of monetary policy? We analyse the transmission of monetary policy in two important financial centres, the United States and the United Kingdom. Studying the responses of mortgage and corporate spreads, we find evidence in favour of an important financial channel in both countries. Our identification strategy allows us to study the effect of movements in the policy instruments and forward guidance, broadly defined. We also analyse international financial spillovers, which we find to be asymmetric. (JEL: E32, E43, E44, G01)

1. Introduction

How does monetary policy work in the "capitals of capital"[1]? Monetary policy affects the real economy via different channels. Do these channels depend on financial development and international financial linkages? On being a hegemon or not in the international monetary system? In a Keynesian or neo-Keynesian world featuring nominal stickiness, output is demand determined in the short run and monetary policy stimulates aggregate consumption and investment. There are no first-order responses of spreads or risk premia (see Woodford (2003) and Gali (2008) for classic

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1. Cassis and Collier (2010) in a book entitled "Capitals of Capital" provide a description of the rise and fall of international financial centres between 1780 and 2009.

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discussions). But when there are frictions in capital markets, they amplify shocks and affect monetary policy transmission. In such models, for example Gertler and Kiyotaki (2010), expansionary monetary policy leads to an increase in the net worth of borrowers, whether they be financial intermediaries or firms. This leads to an increase in lending and an increase in aggregate demand. This is the *credit channel* of monetary policy (Bernanke and Gertler 1995). Another stream of research has emphasized the *risk-taking channel* of monetary policy (Borio and Zhu 2012; Bruno and Shin 2015; Coimbra and Rey 2017) where financial intermediation plays a key role and a monetary policy loosening relaxes leverage constraints. These views of the transmission channel are complementary to one another.

In this paper, we start from the observation that the importance of financial markets and international capital flows has increased greatly since the 1990s (see Gourinchas and Rey 2014; Lane and Milesi-Ferretti 2007). We focus on the transmission channels of monetary policy that occur through financial intermediation and asset prices (*credit channel* or *risk-taking channel*) that we subsume in a broadly defined *financial channel* of monetary policy. We also note that the recent financial crisis underlines the importance of capital market frictions in macroeconomic modelling. We analyse the effectiveness of monetary policy in two important financial centres, the United States and the United Kingdom, the "capitals of capital". Our aim is not only to study the transmission of US and UK monetary policies via the *financial channel* domestically, but also to look at potential international spillovers of these monetary policies.[2]

The United States has been at the centre of the International Monetary System at least since Bretton Woods, playing major roles in goods and financial markets. The dollar is the main currency in banking and a large share of foreign exchange turnover is in dollars: according to the April 2016 BIS survey, 87.6% of the share of currency turnover (out of 200% because a transaction involves two currencies) was in dollars. Approximately 60% of disclosed official reserves are held in US dollars. The United Kingdom was the previous currency hegemon. The internationalization of the pound began early in the 1800s and continued for more than a century. The industrial revolution transformed Britain into the world's richest economy and leading trading nation. The years after the First World War saw the decline of Britain as an international power, but sterling kept a lot of its functions. Only after the Second World War did the decline of sterling accelerate, with a sharp rise in the use of the dollar as an international currency (see Rey 2001). Chiţu, Eichengreen, and Mehl (2014) find that the share of international reserves held in sterling went from about 80% in 1950 to less than 10% in 2013. London is still however a major financial centre receiving and sending large amounts of financial flows. Both countries are home to deep and sophisticated financial markets and have important international linkages. They are the "capitals of capital". Recent work has drawn attention to the importance of the US Federal Reserve in setting the tone in international financial markets worldwide with important effects on capital flows, risk taking of financial intermediaries, and on risky

2. See also Passari and Rey (2015) and Rey (2016).

asset prices. Comovements in those variables across the planet is what Rey (2013) called the *global financial cycle* (see also Bernanke 2016; Miranda-Agrippino and Rey 2015). But just how sensitive is a country like the United Kingdom to the global financial cycle? As the former centre country of the international monetary system how independent is its monetary policy from the current hegemon? And how potent is UK domestic monetary policy in the current environment of large capital mobility across borders?

The empirical analysis of monetary policy effectiveness has a long and distinguished tradition, making it one of the most studied empirical questions in macroeconomics (for a recent excellent survey see Ramey (2016)). We identify monetary policy shocks using high-frequency asset price movements around monetary policy events (such as Federal Open Market Committee (FOMC) announcements) following Bagliano and Favero (1999); Kuttner (2001); Gürkaynak, Sack, and Swanson (2005); Gertler and Karadi (2015); Nakamura and Steinsson (2013) and others. The idea behind the identification scheme is that only monetary policy or monetary policy announcements move asset prices in tight windows around monetary policy events. As in Gertler and Karadi (2015), we use these high-frequency price movements as external instruments in a proxy SVAR (see Stock and Watson 2008; Stock and Watson 2012; Mertens and Ravn 2013). Although this methodology has been used in the context of the United States, it has been very rarely used elsewhere, due to data availability and differences in monetary policy frameworks. More generally, there are surprisingly few papers focussing on the effect of UK monetary policy on the economy.[3] Cloyne and Hürtgen (2016) construct a new measure of monetary policy innovations for the United Kingdom based on the Romer and Romer (2004) methodology. They estimate peak responses of about −0.6% for industrial production for a 100-bp tightening of the Bank of England and an inflation rate decrease of about 100 bp, but they do not investigate the financial channels of monetary policy. Cesa-Bianchi, Thwaites, and Vicondoa (2016) is a contemporaneous paper to ours that uses local projection methods and high-frequency instruments (with a different methodology and different variables from ours) to study UK monetary policy. It finds in particular evidence that a tightening raises forward real rates and lowers break-even inflation.

One of our paper's contribution is to take seriously the importance of the different institutional setups of the United Kingdom and the United States in terms of monetary policy framework when performing the estimations. We show that the methodology used by Gertler and Karadi (2015) in the US context where they exploit surprises in specific Fed Funds Futures market cannot be straightforwardly applied to the United Kingdom. Instead, we use a set of high-frequency instruments (Short Sterling Futures (SS)) that, unlike Fed Funds Futures, do not aggregate only information about the policy rate. Thanks to different timings of monetary policy events in the United Kingdom, we allow for a separate identification of monetary policy rate shocks and forward guidance

3. For an early study using international data including the UK see Sims (1992). For a study of UK monetary policy using a VAR with sign restrictions see Mountford (2005). Ellis, Mumtaz, and Zabczyk (2014) estimate a FAVAR model.

shocks, broadly defined as shocks affecting the price of SS during tight windows around minutes and inflation reports. In our sample, most of the information about monetary policy in the United Kingdom is communicated around minutes and inflation reports, whereas policy rate announcements are largely void of information content once the zero lower bound is hit in March 2009. In the United States, monetary policy announcements about the policy rate are accompanied by a statement containing some information about future policy and the state of the economy. For the United States, we confirm the importance of a financial channel of monetary policy as described by Gertler and Karadi (2015). We also find evidence of important spillovers of US monetary policy on the United Kingdom, despite the flexible sterling exchange rate. Indeed, in terms of the financial variables we study, we find that Fed monetary policy is almost as potent in the United Kingdom as it is at home.

We also have new results on the domestic effects of UK monetary policy. We find evidence of a *financial channel*, measured by the responses of mortgage and corporate spreads to the Bank of England monetary policy shocks. The financial channel is roughly as important for the United Kingdom as it is in the United States. Furthermore, we cannot find any evidence of spillovers going from the United Kingdom to the United States, validating the view that the United States is the current hegemon of the International Monetary System.

The remainder of the paper is structured as follows. In Section 2, we review briefly the theoretical literature on the credit and risk-taking channels of monetary policy. In Section 3, we describe the monetary policy frameworks of the US Federal Reserve and the Bank of England, pointing out the differences in the timing of the announcements and in their communication strategies. Section 4 presents our identification schemes for the United States and the United Kingdom, making use of different financial instruments, whereas Section 5 describes the empirical model used. Finally, Section 6 analyses our results in both countries as well as the international spillovers.

2. The Financial Channel of Monetary Policy

The literature has long ago recognized agency problems as an important source of business cycle amplification (Bernanke and Gertler 1989). When agency costs between borrowers and lenders are important, there is a wedge between the opportunity cost of internal finance and the cost of external finance: the external finance premium. The financial accelerator mechanism (Bernanke Gertler, and Gilchrist 1999) has been mostly studied in the context of non-financial corporations and households (Kiyotaki and Moore 1997).[4] Part of the recent literature has focused on the role of these frictions in affecting monetary policy transmission. In such models, expansionary monetary policy leads to an increase in the net worth of borrowers, whether they be financial

4. There is a rapidly growing literature modelling some type of balance sheet constraints: Christiano, Motto, and Rostagno (2010); Fostel and Geanakoplos (2012); Lorenzoni (2008).

intermediaries or firms. This mitigates adverse selection and moral hazard problems, decreasing the size of the external finance premium. Hence, there is an increase in lending. This is the *credit channel* of monetary policy.[5] Another stream of research has emphasized the *risk-taking channel* of monetary policy (Borio and Zhu 2012; Bruno and Shin 2015), of which Coimbra and Rey (2017) provide a general equilibrium model. Coimbra and Rey (2017) features heterogeneous intermediaries with limited liability. Monetary loosening induces more risk taking due to increased risk shifting by the less risk averse intermediaries, which end up dominating the market in good times. These intermediaries price assets marginally and compress risk premia during booms. Both the credit channel (or net worth channel) and the risk-taking channels are part of what we call the *financial channel* of monetary policy transmission. From an empirical point of view, both lead to a loosening of financial constraints and a decrease in risk premium when there is a monetary policy expansion. They are hard to disentangle using only macroeconomic data but analysing the dynamics of the cross-section of leverage of intermediaries helps. A distinctive feature of Coimbra and Rey (2017) is that a monetary expansion when the interest rate level is already low increases risk concentration and leads to skewness in the distribution of leverage across banks. Analysing thoroughly the *financial channel* of monetary policy will in general require studying the responses to monetary policy shocks of asset prices (credit spreads, risk premia, exchange rates) and, where possible, leverage of intermediaries or capital flows in conjunction with the responses of the standard variables of a monetary VAR (output, inflation).[6]

Most movements in the policy rates (whether the Fed Funds rate or the Bank rate in the United Kingdom) are due to the systematic component of monetary policy, which reacts endogenously to developments in the economy and to changes in expectations of the policy makers regarding future conditions. It is therefore famously difficult to estimate causal effects of monetary policy on macroeconomic variables. Estimating causal effects of monetary policy on financial variables may be even more of a challenge, given how quickly asset prices respond to monetary policy. In a standard Cholesky ordering,[7] it is assumed that no variables can respond to the policy rate within the period, which is hardly a tenable proposition for asset prices. It becomes therefore paramount to look for alternative identification schemes to analyse the *financial channel* of monetary policy transmission. One possibility is to use the Romer and Romer (2004) narrative approach, a road pursued by Miranda-Agrippino and Rey (2015) for the United States and Cloyne and Hürtgen (2016) for the United Kingdom

5. Recently, there has been a flurry of models featuring explicitly financial intermediaries (Adrian and Boyarchenko 2015; Brunnermeier and Sannikov 2014; Coimbra 2016; He and Krishnamurthy 2013). Some aim at analysing specifically monetary policy transmission, for example, Gertler and Kiyotaki (2010), Gertler and Karadi (2011), Cúrdia and Woodford (2010).

6. For empirical analyses of the risk taking channel using very granular balance sheet data see Jimenez et al. (2014) and Morais, Peydro, and Ruiz Ortega (2015). For a large Bayesian VAR analysis combining real economy and international financial variables including capital flows and credit aggregates see Miranda-Agrippino and Rey (2015).

7. See Christiano, Eichenbaum, and Evans (1999).

(though the latter paper does not investigate the financial channel of monetary policy). Another possibility, which we pursue in this paper is to use a high-frequency approach to identification[8]. The advantage of this method is that it will allow us to discuss not only the causal effect of movements in the policy rates on asset prices, but also the effect of *forward guidance*. This is where an intimate knowledge of monetary policy frameworks is required.

3. Monetary Policy Frameworks

3.1. Federal Reserve

The monetary policy framework of the United States is well known. The FOMC sets monetary policy. It consists of the members of the Board of Governors of the Federal Reserve System and five Reserve Bank presidents. The FOMC holds eight regularly scheduled meetings during the year, and other meetings as needed. After each meeting, the committee releases the statement that contains the decisions regarding monetary policy implementations (including the Fed Funds rate target) as well as a short summary of the current and prospective state of the economy. So for our purposes, this means that at the time of FOMC meetings we have not only a statement about the policy rate, but also a statement which we define broadly as *forward guidance* and which reveals information about future policy and future state of the economy as seen by the FOMC. The minutes of regularly scheduled meetings are released 3 weeks after the date of the policy decision.[9]

3.2. Bank of England

The Bank of England follows an inflation target since 1992. Since 1997, the Bank of England has had operational independence. Starting in January 2000, the UK Monetary Policy Committee meets monthly to decide on monetary policy. After every meeting, the decisions regarding the policy rate are announced by publishing a news release on the website of the Bank of England at 12:00 p.m. the first or the second Thursday of each month. From 5 March 2009, the Monetary Policy Committee in addition to setting the Bank rate also sets a target for the level of assets to be financed by central bank reserves. The Bank of England provides information about the current and expected state of the economy in separate news releases. The Bank of England Inflation report is published four times a year and becomes available at 10:30 a.m. on the second Wednesday of November, August, May, and February. Minutes of each Monetary Policy Committee meeting are published at 9:30 a.m. on Wednesday 2 weeks after the meeting has taken place. The important difference between the way the monetary policy is conducted in

8. Cesa-Bianchi et al. (2016) also use a high-frequency approach for part of their analyses.

9. www.federalreserve.gov/monetarypolicy/fomccalendars.htm

the United Kingdom compared to the United States is that the policy rate decision at the time of the announcement is not accompanied by any statement about the economy or about future policy. Information about the economy or future policy comes at distinct times when minutes and the inflation reports are released. Therefore, this setting allows us to disentangle two separate effects of monetary policy: the direct effect of the policy rate change from the effect of *forward guidance* defined broadly as news on the future path of interest rates or on the Bank view on the future state of the economy. For the United Kingdom, the announcement dates and times are those of releases of Monetary Policy Committee decisions, minutes, and inflation reports releases. The current data set contains 180 policy rates decisions, 179 min releases, and 60 inflation reports from January 2000 to January 2015 (between 1997 and 2000 announcement times were not scheduled and before 1999 min were released with a different timing).[10]

4. Identification of Monetary Policy Shocks

The definition of a monetary policy shock is not an easy one to formulate. Most movements in the policy rates are due to the systematic component of monetary policy rather than to deviations from it. We define a monetary policy shock as an unanticipated movement in monetary policy or a piece of news about future monetary policy, exogenous to other current and lagged endogenous variables in the model and uncorrelated with other exogenous shocks. This can be interpreted as a shift in central bank preferences, a change in the relative standing of people in the monetary committee, a change in the judgement about future policy or in the expectations about future economic developments.[11] This shock may be about the current policy stance or about forward guidance, broadly defined. Identifying shocks allows us to estimate the *causal* effect of monetary policy on macroeconomic and financial variables.

4.1. High-Frequency Identification

We use a high-frequency identification strategy for the United Kingdom and the United States. The general idea behind that identification strategy is that in the short window around monetary policy announcements (fifteen- or thirty-minute), it is very likely that the most important shock hitting the economy is the monetary policy shock. For such a strategy, we need to discuss in detail not only the timing of monetary policy announcements and what they reveal (pure policy rate decision versus news about forward guidance and the economy), but also which market instruments are

10. The schedule of communications changed in August 2015. More details can be found at www.bankofengland.co.uk/publications/Pages/news/2016/070.aspx

11. For a discussion on the informational content of high-frequency monetary surprises in the context of monetary policy shock identification see Miranda-Agrippino (2016). For an extensive and thorough discussion on identification and propagation of monetary policy shocks in the domestic context see Miranda-Agrippino and Ricco (2017).

used to measure surprises (futures of the policy rate or other market prices) and what information these instruments price.

4.1.1. Federal Funds Futures (FF). For the United States, several papers use a high-frequency identification of monetary policy shocks by analysing movements in Federal Funds Futures (FF) prices around FOMC announcements[12]. The FF contract gives an insight into market opinion of the average daily Fed Funds effective rate for a given calendar month. It is traded on the Chicago Board of Trade exchange and is quoted as 100 less the interest rate. On every trading day, the contract is available for the first 36 calendar months into the future. This instrument is used in the market to hedge against or speculate on changes in short-term interest rates given innovations to the monetary policy in the United States[13].

Gertler and Karadi (2015) combine this high-frequency identification method with a proxy SVAR to study the effect of monetary policy on financial variables. Specifically, they use the movement of the fourth Fed Funds futures contract (FF4) around the times when the FOMC press release is published to identify monetary policy shocks. This particular future contract measures how the market revises its expectations about the Fed Funds rate 3 months from the current date given the new information released by the FOMC. The movements of futures prices are not necessarily expected to be positively correlated with movements of the spot prices as they measure changes in the expectations of market participants. For example, markets might have been pricing in a larger move of the Fed Funds rate and might have to readjust the price of the future contract in a direction opposite to the actual move of the rate. Or, if the rate was not changed at the current meeting, market participants may increase the probability of the target rate being readjusted in the next meeting. The target rate change itself is an important component in anchoring market expectations, but it is not the only part of the press release that affects the market's views of the Fed Funds rate 3 months ahead. The short statement that FOMC releases together with the rate decision is a crucial new piece of information that becomes available to the market participants at the time of the announcement. As a result, market expectations about rates movements in the next quarter are being revised also according to the content of the statement. Hence, surprises in the Fed Funds futures do not reflect a pure shock of the policy rate but also a forward guidance shock, broadly defined as some information about future policy or judgement about the future of the economy. Gertler and Karadi (2015) uses the shocks in the FF4 to instrument the 1-year government bond rate as the policy rate in their VAR. Their justification for using the shocks to instrument the 1-year rate is precisely to capture the effect of forward guidance on financial and macroeconomic variables in the VAR. They find that a monetary policy tightening of 20 bp in the 1-year rate leads to an increase in mortgage rates of about 7 bp and of 15 bp in the corporate bond

12. See Bagliano and Favero (1999), Kuttner (2001), Gürkaynak et al. (2005), Gertler and Karadi (2015), Nakamura and Steinsson (2013).

13. Please refer to the CME group website for the full description of the contract.

rate. In each case, the increase is due to the excess premium, defined as the sum of the credit spread and the term premium.

In this paper, we follow the literature as far as the US data are concerned and use the change in the price of the Fed Funds Future contract (FF4) measured in a tight window around each policy announcement to instrument the US monetary policy shock. US data are special in the sense that the Fed Funds futures directly represent market opinion about the policy rate for a given month. No such instruments are traded in the United Kingdom. However, short-term interest rate futures are available and can potentially play a similar role as the Fed Funds future contract in identifying monetary policy shocks.

4.1.2. Short-Sterling Future (SS). For the United Kingdom, there is no equivalent to the Fed Funds Future contract *stricto sensu*. SS is a 3-month sterling future that is traded at ICE Futures Europe (part of the Intercontinental Exchange). The futures quotation is defined as 100 less an interest rate on 3-month deposit of £5,00,000 on the contract settlement date.[14] This contract is an analogue of the eurodollar future contract in the United States, and given that this is the only future contract on short-term interest rates available for the UK economy with long-enough time series, we use it in our analysis.

It is important to keep in mind that even though short-term interest rates are closely linked to the policy rate, there is not a one-to-one mapping. By measuring the difference in prices of SS around the announcements, we are capturing changes in expectations of the market regarding the costs of short-term credit.

Tick-by-tick data for trading activities on all SS contracts available on each date of monetary policy announcements were acquired from the Thompson Reuters Tick history data set. We apply the same methodology as Gürkaynak et al. (2005) to construct surprises. We measure the difference in the price of the future contract in a tight window before (10 min) and after (20 min) every monetary policy event.[15]

4.2. Differences Between the United States and the United Kingdom

Because of the differences in traded instruments that we highlighted and because of the different timing of announcements between the United States and the United Kingdom, we cannot replicate existing studies on the effect of US monetary policy on UK data. SS price movements around announcements are not capturing only the market surprises about current and future path of the policy instrument. What we can do however is to measure how the market expectations of the cost of short-term bank credit changes given innovations to monetary policy. Changes in the cost of short-term bank credit reflect a combination of expectations regarding the future path of policy rates, the risk

14. For more details regarding the ICE Futures Europe FSS contract specifications, please refer to www.theice.com/api/productguide/spec/37650330/pdf.

15. More details about construction of surprises are in Appendix B.

premium of the LIBOR—including possible counterparty risk—and demand for cash in the banking sector. Furthermore, we can study how this shock propagates through other interest rates to the economy.

Another important difference of our analysis compared to the existing literature on monetary policy VARs is that we can obtain a new "clean" measure of *forward guidance*, broadly defined. The reason is that, unlike the Fed, the Bank of England communicates pure policy rate decisions at a time that is distinct from the releases of minutes and of the inflation report. Minutes and reports provide a lot of information to market participants regarding the future monetary policy and the judgement of the Bank about the future state of the economy. This allows us to separate the market reactions to the policy rate announcements from the effect of the information about the state of the economy and on the course of future policy. In the case of the United States, these two effects are partially mixed together because the rate decision is accompanied by a short statement in the press release published by FOMC. In the United Kingdom, it is possible to measure the first effect by taking the difference of SS prices around the MPC decisions. Market reaction to Bank of England's *forward guidance* can be directly estimated by focussing on the movement of SS prices around releases of the minutes of MPC meetings and releases of the inflation reports.

5. Proxy SVAR

Like Gertler and Karadi (2015), we combine high-frequency identification of shocks, which we use as external instruments for the monetary policy variable and a VAR approach to analyse the dynamic responses of real and financial variables, building on Stock and Watson (2012) and Mertens and Ravn (2013).

Let our general structural form of the VAR be

$$AY_t = \sum_{k=1}^{m} C_k Y_{t-k} + \varepsilon_t.$$

The following reduced form representation can be obtained with the reduced form shock u_t expressed as a function of the structural shocks $u_t = P\varepsilon_t$ and where $D_k = A^{-1}C_k$ and $P = A^{-1}$,

$$Y_t = \sum_{k=1}^{m} D_k Y_{t-k} + u_t.$$

We define Σ as the variance−covariance matrix of the reduced form model. We have $\Sigma = E[u_t u_t^{'}] = E[PP']$. We assume $i_t^m \in Y_t$ to be the monetary policy indicator that in our case will be either the US 1-year government bond rate or the UK 5-year rate. The exogenous variation of the policy indicator stems from the policy shock ε_t^m. Finally, p stands for the column in P corresponding to the impact of the policy shock ε_t^m on each element of the vector of reduced form residuals u_t. For the impulse responses

of our economic and financial variables to a policy shock we run,

$$Y_t = \sum_{k=1}^{m} D_k Y_{t-k} + p\varepsilon_t^m.$$

Our instruments Z_t for the monetary policy variables are the surprises to the price of Fed Funds futures or SS in windows around monetary policy announcements. In order for the vector of instrumental variables Z_t to be a valid set of instruments for the monetary policy shock ε_t^m, we need $E[z_t \varepsilon_t^{m'} = \varphi]$ and $E[z_t \varepsilon_t^{d'} = 0]$, where ε_t^d stands for any structural shock but the monetary policy shock (which could be a rate or a forward guidance shock). We follow Mertens and Ravn (2013) to estimate the variation in the reduced form residual for the policy indicator due to the structural monetary policy shock. To compute the estimates of vector p, as a first step we compute the estimates of the reduced form residuals vector u_t from the least squares regression of the reduced form representation. We denote u_t^d the reduced form residual for variable d that is different from the policy indicator and u_t^m the reduced form residual for the policy indicator. Denoted by $p^d \in p$, the response of u_t^d to a unit increase of one standard deviation in the policy shock ε_t^m. A few simple steps allow to identify p^d.[16]

6. Results

6.1. United States: A Hegemonic Monetary Policy?

We run the US VAR on monthly data for the period July 1979 to June 2012, and we use Feds Funds Futures surprises (FF4) around FOMC announcements as instruments for the period January 1999 to June 2012. We report the *F*-stats for each of our VARs. Following the literature, *F*-stats above 10 validate the strength of our instruments. In all our monthly VARS, we use 12 lags as is customary. We are not the first ones to analyse the financial channel of monetary policy for the United States. We confirm the results of Gertler and Karadi (2015) in a VAR in which we added the dollar sterling exchange rate. Figure 1 shows that a 20-bp tightening in the US 1-year rate leads to increases in mortgage spreads (point estimate increase of about 5 bp). This is evidence that some form of capital market friction is playing a role in the transmission of monetary policy in the United States. The tightening leads to an appreciation of the US dollar-sterling

16. From the two-stage least-squares regression of u_t^d on u_t^m and using the vector of instrumental variables Z_t, we can compute an estimate of the ratio p^d/p^m. It is obtained by first regressing u_t^m on the vector of instruments yielding $\widehat{u_t^m}$. As the variation in $\widehat{u_t^m}$ is only due to ε_t^m, a second-stage regression of u_t^d on $\widehat{u_t^m}$ provides a consistent estimate of p^d/p^m. The estimated reduced from variance−covariance matrix is then used to obtain an estimate of p^m using the second-stage regression, allowing to identify p^d.

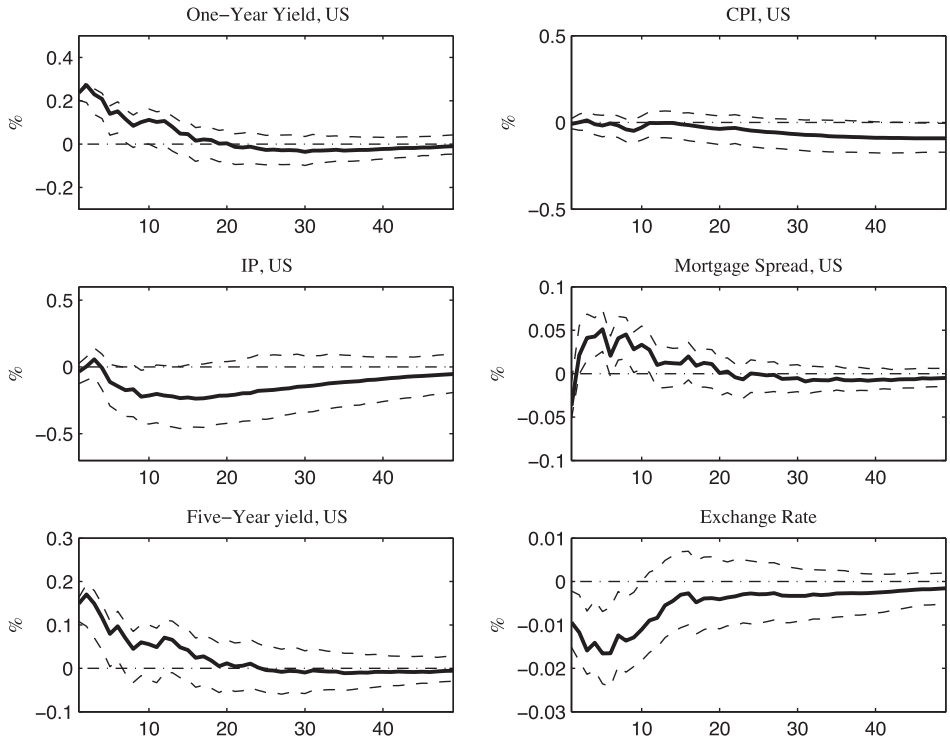

FIGURE 1. Responses of US variables to a 20-bp increase in the US 1-year rate. Instruments (FF4) from Gertler and Karadi (2015), 90% confidence intervals. *F*-stat: 30.

on impact (by about 1 bp on impact to 1.5 bp), an increase in the 5-year yield on impact, a delayed decrease in industrial production, and a delayed decrease in the CPI.[17]

We now turn to potential international spillover effects of US monetary policy. The traditional international transmission channels of monetary policy via aggregate demand and via the exchange rate may not be the only ones. Because of the increased importance of international financial flows, global intermediaries (banks, asset managers) may transmit liquidity conditions cross-borders (see for example Cetorelli and Goldberg 2012). Hence, it is plausible that the capital market frictions studied in the context of the credit channel (or net worth channel) or the risk-taking channel of monetary policy in a domestic context play also a role internationally. The literature on financial crises has emphasized for a long time the role of capital flows in fuelling domestic credit booms and the latter have been found to be one of the most reliable early warning indicators of crises (see for example Gourinchas and Obstfeld

17. We tried numerous specifications including replacing the 5-year yield with the VIX or with corporate spreads. In both cases, these variables increase on impact significantly. The results are robust. For further discussion of robustness of the Gertler and Karadi (2015) results see Miranda-Agrippino (2016) and Miranda-Agrippino and Ricco (2017).

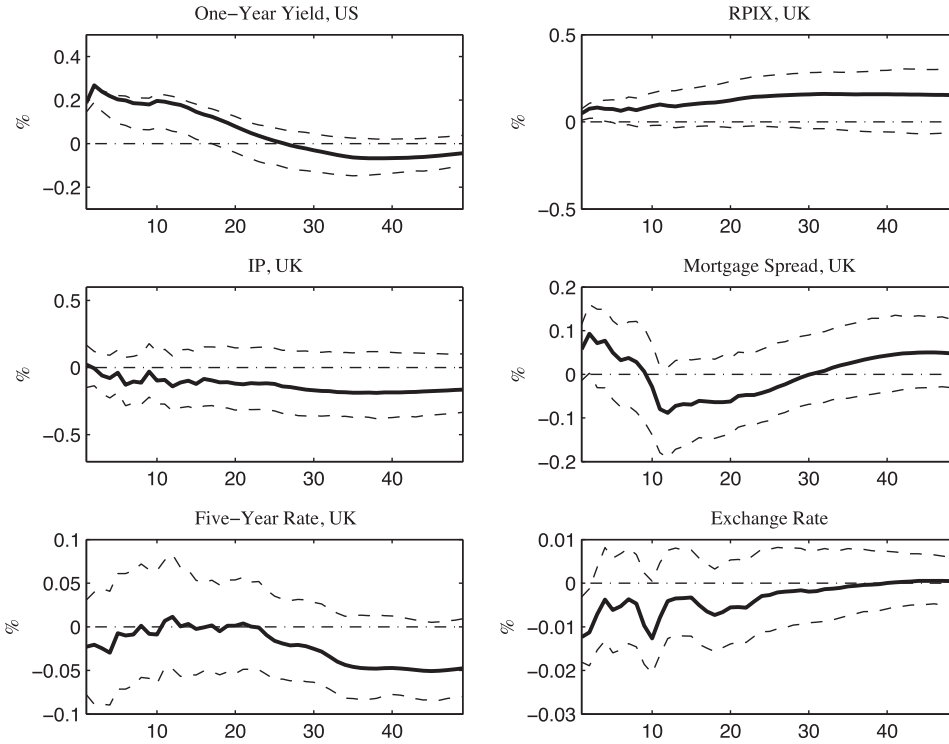

FIGURE 2. Responses of UK variables to a 20-bp increase in the US 1-year rate. Instruments (FF4) from Gertler and Karadi (2015), 90% confidence intervals. *F*-stat: 19.93.

2012). Miranda-Agrippino and Rey (2015) discuss the importance of the US Federal Reserve as a driver of the *global financial cycle* and analyses in a large Bayesian VAR the effect of a Fed loosening on the rest of the world using quarterly data. They find that a positive monetary policy shock increases the leverage of banks and cross-border capital flows and increases asset prices. Here, we estimate specifically the effect of international financial spillovers of the United States on the United Kingdom. We use the same instruments (FF4) as before and a similar specification of the VAR to estimate the effect of a US monetary policy shock on the economy but this time on UK variables. Figure 2 shows the effect of a 20-bp tightening in the 1-year US rate on the United Kingdom. We use the RPIX that is the retail price index excluding mortgage payments, industrial production, mortgage spread defined as UK mortgage rate minus 3-month bill, the dollar per sterling exchange rate and the UK 5-year rate as it is an important interest rate in the United Kingdom. A US monetary policy tightening leads to an increase on impact of about 8 bp in the mortgage spread and to an appreciation of sterling vis-a-vis the dollar of about 1.1 bp. This is of the same order as the one previously estimated when analysing the impulse responses of US variables, though less precisely estimated. We see no significant impact on UK Industrial Production or on the UK 5-year rate. We tend to find a slight increase on the UK RPIX index

in the short run. These results are robust to a number of specifications (inclusion of the VIX for example, which increases on impact) but estimates are less precise than the ones for the US VAR. The *F*-stats are lower, though they still indicate very strong instruments: they stand at about 20 compared to 30 for the US case. In Figure A.1 in the Appendix, we present another specification with UK corporate spreads and the 3-month UK T-Bill. Unlike the 5-year rate, the 3-month T-Bill tends to go up with a US tightening, indicating some effect of US policy rates at the short end of the yield curve in the United Kingdom. The UK corporate spread goes down with a Fed tightening. The only available data for UK corporate spreads correspond to very long maturity bonds (about 20 years). This is unlike the corporate spreads in the United States that are short maturity and go up as the Fed tightens. We conjecture that this asymmetry in reaction for corporate spreads is due to the short end of the yield curve in the United Kingdom reacting to a US tightening more than the long end. Therefore, we find some evidence that the monetary policy of the hegemon spills over into the United Kingdom via financial variables (mortgage spreads and corporate spreads). This happens despite the sterling dollar exchange rate being fully flexible.

6.2. United Kingdom: How does the Old Lady of Threadneedle Street fare?

We run the UK VAR on monthly data for the January 1982 to January 2015 period, using 12 lags. We first run a VAR using a recursive identification scheme (Cholesky). Our results, presented in Appendix in Figure A.2 confirm the inability of identifying responses of asset prices with such timing assumptions: the asset prices do not react significantly (not even the exchange rate) and we have a significant price puzzle. Hence, we switch to our proxy SVAR framework and use SS movements monetary policy events (rate decisions, minutes, inflation reports) as instruments for the period January 2000 to January 2015. As we discussed in previous sections, surprises based on movements of SS are not the direct analogue of the shocks measured by the Fed Funds futures. They reflect changes in the cost of short-term bank credit aggregating a combination of expectations regarding the future path of policy rates, the risk premium of the LIBOR—including possible counterparty risk—and demand for cash in the banking sector. Hence, movements in the LIBOR reflect both monetary policy conditions and market turmoil. For example, during the financial crisis of 2008 LIBOR spiked due to counter-party risk while Central Banks around the world were actively cutting their policy rates. Figure A.3 in the Appendix shows a clustering of points around the zero-rate change with a range of changes in the SS. It also shows some outliers in SS changes at the time of market stress due to the financial crisis coinciding with monetary policy rate announcements in 2008. During a large part of the relevant period, announcements of monetary policy rates are invariably the same (a typical statement would be that "the Bank of England maintains Bank Rate at 0.5% and the size of the Asset Purchase Programme at 375 billion"[18]), and there is no other

18. From www.bankofengland.co.uk/monetarypolicy/Pages/decisions.aspx.

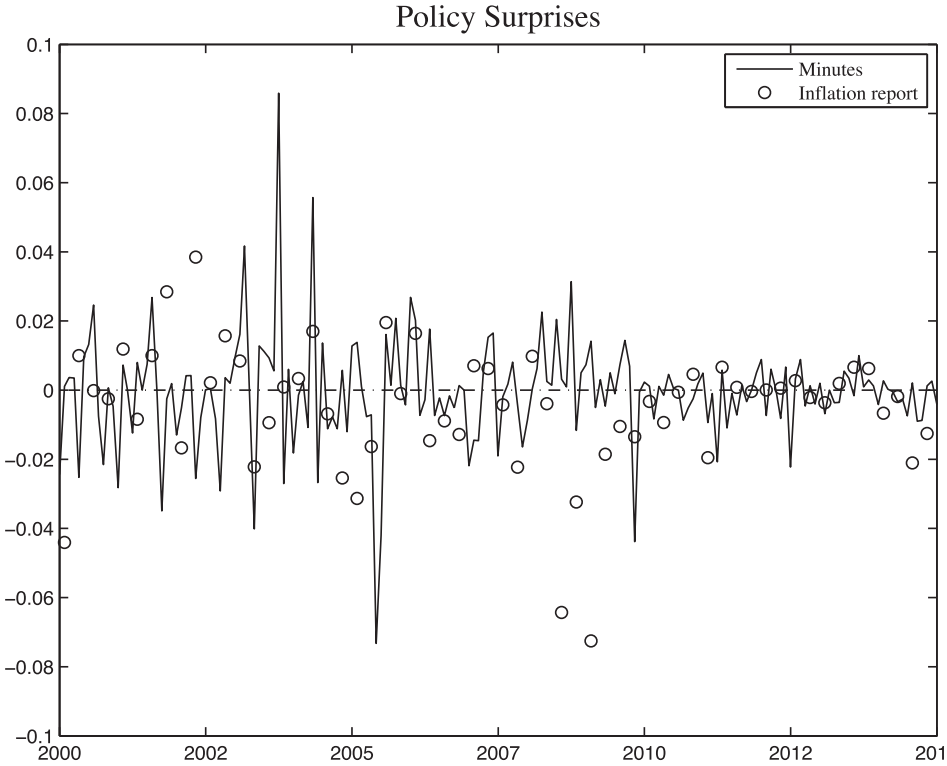

FIGURE 3. Monetary policy surprises, derived from SS data around inflation reports and minutes.

information communicated to market participants at those times. Almost all policy decisions on rate and purchases are therefore perfectly anticipated by the market as shown by the Bloomberg Survey. Hence, we believe that using surprises in SS around rate announcement times tend to pick up market disturbances rather than monetary policy in our sample. We verify our conjecture by running a VAR using surprises around policy rate announcement times as instruments. As expected, this VAR shows signs of spurious identification with, in particular, a jump in UK Industrial Production on impact and a significant price puzzle.[19]

On the other hand, surprises around minutes and inflation reports are more meaningful as there is new information about the future policy stance that is generally communicated to market participants at those occasions. Figure 3 shows the surprises in SS around the inflation reports and minutes, which is the series of surprises we will be using as our instruments as they are informative about future monetary policy. Results are very different from the recursive VAR in Figure A.2 and are robust across specifications. We instrument the 5-year rate because of data availability and because it

19. Results available upon request.

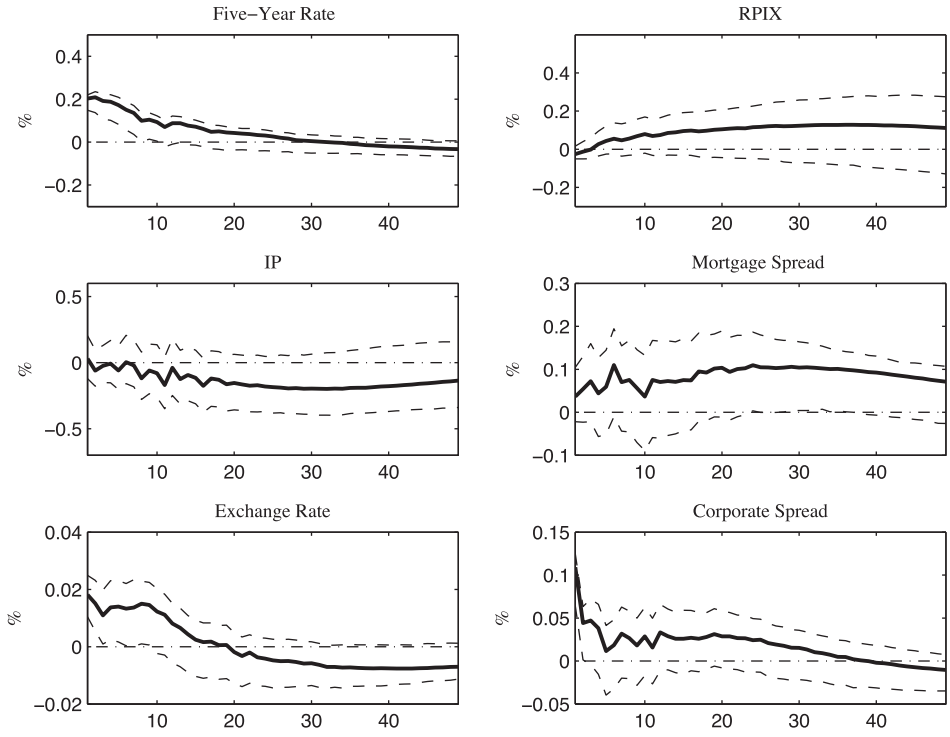

FIGURE 4. Responses of UK variables to a 20-bp increase in the UK 5-year rate. Instruments SS around inflation reports and minutes, 90% confidence intervals. *F*-stat: 15.22.

is an important rate for the United Kingdom. Furthermore, our instruments are strong with a *F*-stat of 15.22 and largely above 10 in all the specifications we ran for the 5-year rate. Sterling appreciates on impact against the dollar, the corporate spread (long maturities) goes up on impact and mortgage spreads tend go up on impact, Industrial Production does not move on impact but decreases with a delay in some specifications, RPIX is not significantly affected.

Results are similar when we include other asset prices such as the VIX as in Figure 5. The VIX goes up on impact as the sterling exchange rate appreciates and the corporate spread goes up on impact. IP declines with a delay and RPIX is not affected.[20]

In contrast, when we try to estimate the effect of UK monetary policy shocks on US variables, we do not find any significant responses. Hence, there is an asymmetry in international spillovers: US monetary policy as one of the factors driving the global financial cycle has spillovers on UK financial variables. But the reverse is not true:

20. In the Appendix (see Figure A.3), we present similar sets of results with the mortgage spread and when using the FTSE instead of the VIX (see Figure A.4). The FTSE goes down on impact.

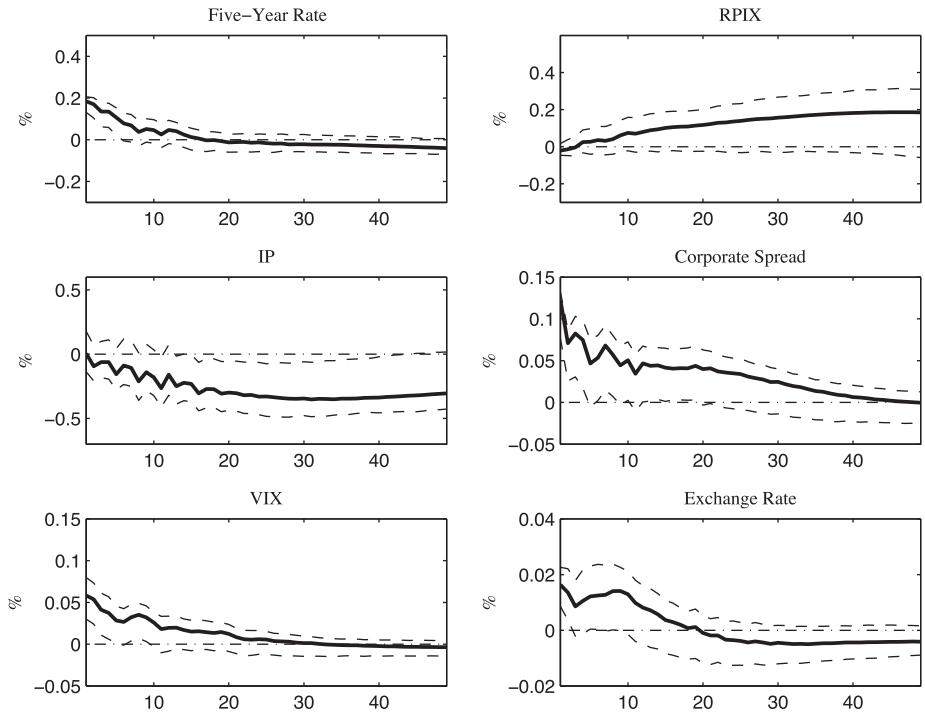

FIGURE 5. Responses of UK variables and VIX to a 20-bp increase in the UK 5-year rate. Instruments SS around inflation reports and minutes, 90% confidence intervals. *F*-stat: 15.01.

UK policy does not affect US financial variables. This asymmetry may reflect the very important role of the US dollar in international banking.

These results taken together tend to suggest that, as discussed in Ramey (2016), extreme care has to be taken regarding the identification strategy and the specification of the VAR. The robustness of the results has to be checked by adding enough lags in the VAR. Cholesky identification is inadequate for small VARs with asset prices. When using high-frequency instruments in proxy SVAR, it is very important to understand which information is aggregated in the price of the instrument and which type of information is being revealed at the time of the monetary policy announcements. In the US case, FF do aggregate information about future monetary policy. Around FOMC meetings, information revealed is about rate changes and forward guidance because of the statement released at the same time as the rate change. Instrumenting the 1-year rate allows to study the effect of monetary policy shocks on rates and forward guidance on the financial channel of monetary policy. In the United Kingdom, SS Futures are not futures of the policy rate. They aggregate information on future monetary policy but also on bank funding conditions including counterparty risk and liquidity conditions. Around rate announcement, information is revealed purely about rate changes or purchases of assets. Around minutes and inflation reports, information

is revealed about the future stance of monetary policy and about the judgement of the Bank about future state of the economy. In the recent period, pure rate announcements have brought in very little information on monetary policy. Surprises have reflected more market conditions; hence, using surprises around rate adjustments would not capture monetary policy shocks but rather market stress. In contrast, surprises around minutes and inflation report have brought in information about medium to long-term guidance prospects. Hence, instrumenting the 5-year UK rate by surprises of SS Futures around minutes and inflation reports make sense and provide information around the financial channel of monetary policy in the United Kingdom in the medium run.

7. Conclusion

The recent financial crisis has highlighted the need to model more fully the process of financial intermediation in the macroeconomy. Recent models show the importance of the financial channels of monetary policy that operate via different capital market imperfections due to moral hazard or risk shifting. The net worth channel of monetary policy (as in Bernanke and Gertler 1995) and the risk-taking channel of monetary policy (as in Coimbra and Rey 2017) both imply an increase in credit and a decline in spreads when monetary policy is loosened. In Coimbra and Rey (2017), fluctuations in funding costs have additional effects: lower costs of funds due to an expansionary monetary policy lead heterogeneous intermediaries to leverage differentially due to different abilities to shift risk. This leads to a concentration of risk in the largest players and to a sharper decline in risk premia when the interest rate is low as the most risk loving intermediaries are the ones who price risk at the margin. Empirical tests looking at these more specific predictions could help disentangle the risk-taking channel from the net worth channel. This is an important endeavour as policy implications differ.

Capital market imperfections play potentially an even bigger role in an environment of large capital flows. We investigate empirically these financial channels in the US and the UK economies as well as their international spillovers. Using an instrumental proxy VAR approach, we find evidence of monetary policy transmission via the financial channel measured by corporate spreads and mortgage spreads. For the United States, the methodology captures monetary policy shocks encompassing movements to the target rate and forward guidance and uses their effects on financial instruments reflecting market expectations about the future policy rate (Fed Funds futures). For the United Kingdom, the methodology captures monetary policy shocks distinguishing between movements to the target rate and forward guidance. It uses the effects of these different monetary policy shocks on financial instruments reflecting market expectations about the future policy rates but reflecting also the risk premium of the LIBOR and demand for cash in the banking sector (Short Sterling futures).

In both economies, a tightening of monetary policy leads to an increase in spreads. We also find that US monetary policy induces financial spillovers into the UK financial

markets, despite the flexible sterling dollar exchange rate whereas the reverse is not true. This supports further the view of a global financial cycle (Rey 2013) partly driven by the US Central Bank. Because of the very different institutional frameworks for monetary policy in the United States and the United Kingdom and the different financial instruments traded, our study is able to show separately the importance of policy rate moves in the United States and of forward guidance, broadly defined, in the United Kingdom. In this latter case, surprises in SS around minutes and inflation reports are shown to have significant effects on UK financial spreads.

Further robustness work is undoubtedly needed however, and our results suggest that, as discussed in Ramey (2016), extreme care has to be taken regarding the identification strategy and the specification of the VAR. In that respect, increasing the information set by including a larger number of variables as in Miranda-Agrippino and Rey (2015) while using Bayesian estimation is an important robustness check.

Appendix A

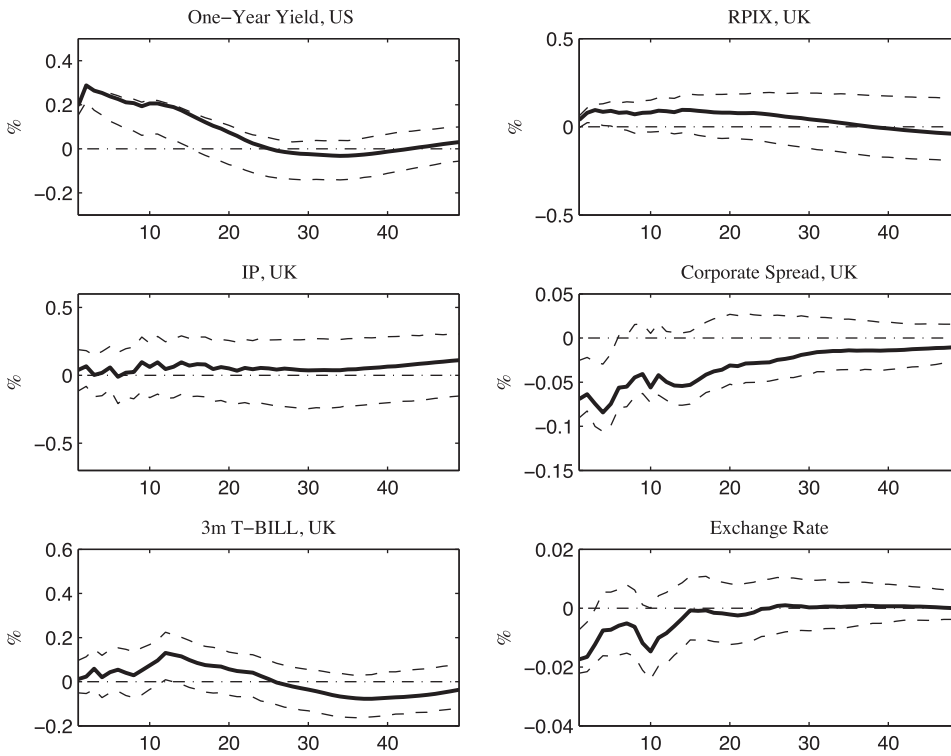

FIGURE A.1. Responses of UK variables to a 20-bp increase in the US 1-year rate. Instruments (FF4) from Gertler and Karadi (2015), 90% confidence intervals. *F*-stat: 18.31.

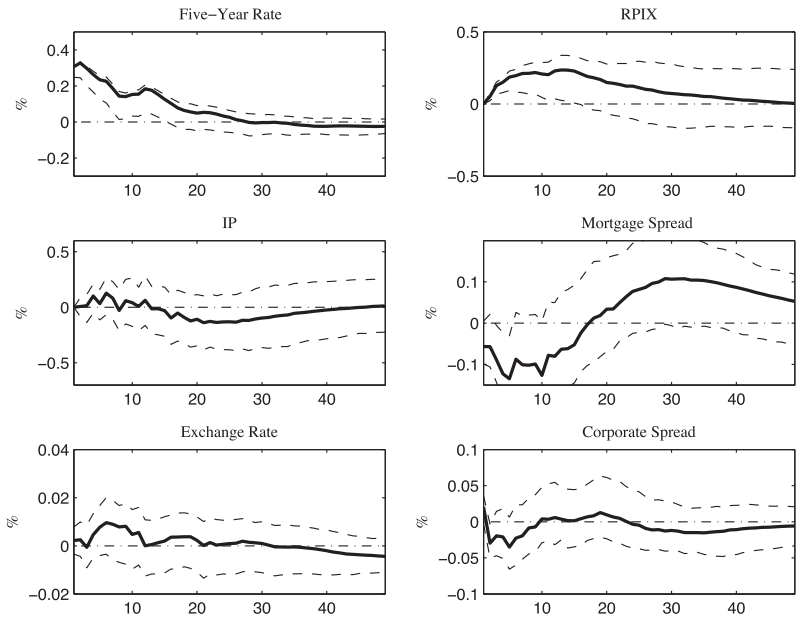

FIGURE A.2. Responses of UK variables to a 20-bp increase in the UK 5-year rate. Recursive identification, 90% confidence intervals.

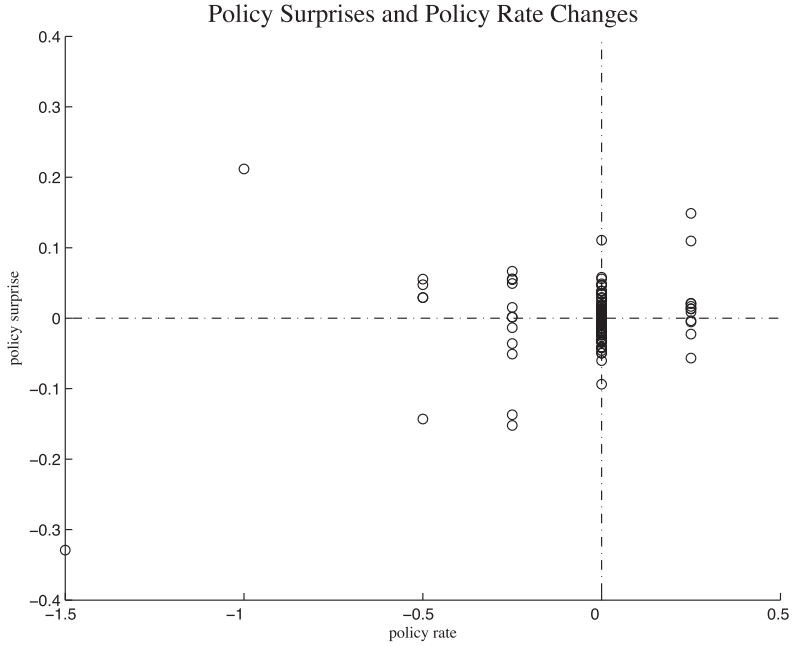

FIGURE A.3. Policy rate changes and monetary policy surprises, derived from SS data around rate changes.

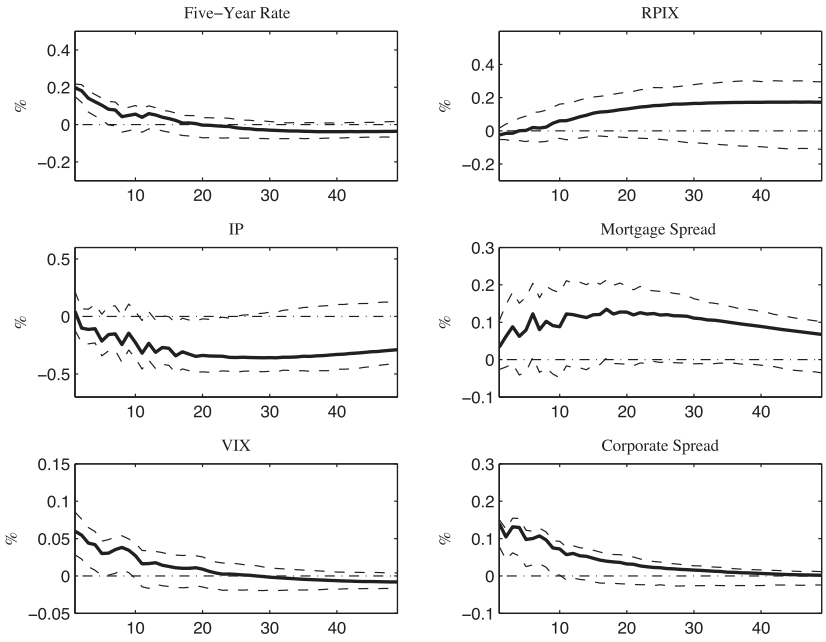

FIGURE A.4. Responses of UK variables and VIX to a 20-bp increase in the UK 5-year rate. Instruments SS around inflation reports and minutes, 90% confidence intervals. *F*-stat: 12.8.

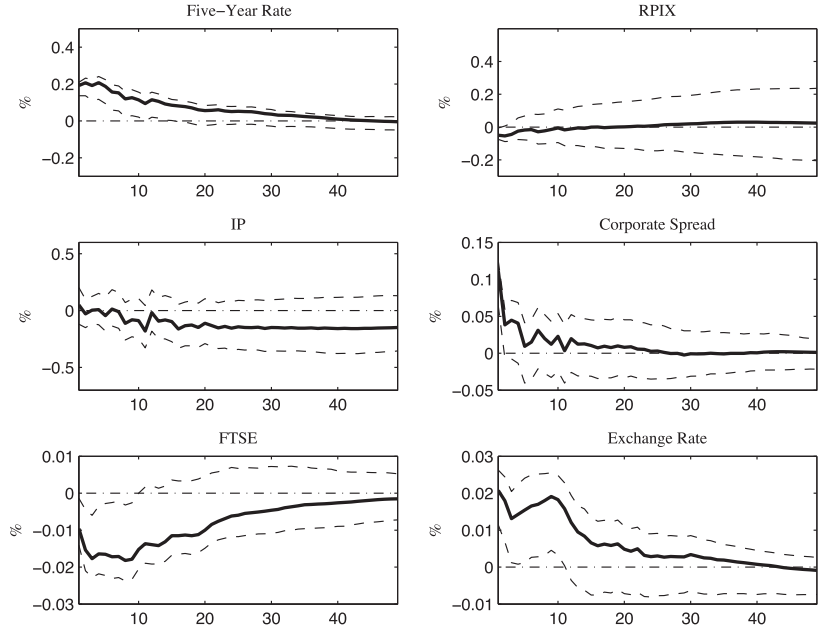

FIGURE A.5. Responses of UK variables including FTSE to a 20-bp increase in the UK 5-year rate. Instruments SS around inflation reports and minutes, 90% confidence intervals. *F*-stat: 15.5.

TABLE B.1. Data sources.

Variable	Description	Source
RPIX	Retail price index excluding mortgage interest payments, extended back using retail prices index (SA)	ONS
IP	Index of production (SA)	ONS
5-year rate	End month level of yield from British Government Securities, 5-year Nominal Zero Coupon	Bank of England
10-year rate	End month level of yield from British Government Securities, 10-year Nominal Zero Coupon	Bank of England
Exchange rate	US Dollars to one British pound, spot, end month level	Bank of England
Mortgage rate	Interest rate (fixed rate type) on loans for house purchasing, over 1 and up to 5 years maturity	Global Financial Database
Treasury bills (3 month)	End month level of discount rate, 3-month Treasury bills, sterling	Bank of England
Corporate bond yields	Monthly Corporate bond yields	Three centuries of macroeconomic data, Bank of England
20-year rate	Redemption yields on British government securities, 20 years	Three centuries of macroeconomic data, Bank of England
United States data and policy surprises[21]	Gertler and Karadi (2015) data set	

Appendix B

UK Spreads. Mortgage spread is the difference between Mortgage rate and the 3 months T-Bill rate. Corporate spread is the difference between Corporate Bond Yields and 20-year rate before January 1992 and 10-year rate after January 1992.

US Spreads. The Mortgage spread is the 30-year conventional mortgage rate minus the 10-year constant maturity treasury rate. The commercial paper spread is the 3-month AA nonfinancial rate minus the 3-month treasury rate.

Construction of Policy Surprises for the UK. The surprises were constructed using Short Sterling future prices from Thomson Reuters Tick history database. For each policy event, we are using a future contract with the closest available delivery month, given that a reasonable amount of trading was happening in this instrument around the time of the announcement. Following the literature, we are measuring the surprises in a tight window around each policy event. To measure a policy surprise, we take a difference of the implied average LIBOR rate 10 min before and 20 min after each

announcement. To convert the surprises to monthly variable, we sum all the surprises within the same month.

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21. We drop the assumption that each policy surprise persists for 30 days.

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