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Do interest rates play a major role in monetary policy transmission in China? *†

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Abstract

We explore the role of interest rates in monetary policy transmission in China in the context of its multiple instrument setting. In doing so, we construct a new series of monetary policy surprises using information from high frequency Chinese financial market data around major monetary policy announcements. Our event analysis shows that monetary policy surprises have persistent effects on interest rates. We then use these surprise measures as external instruments to identify monetary policy shocks in an SVAR. We find that a contractionary monetary policy surprise increases interest rates and significantly reduces inflation and economic activity. Our findings provide further support to recent studies suggesting that monetary policy transmission in China has become increasingly similar to that in advanced economies.

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1 Introduction

Understanding how monetary policy works in China is important in the context of its growing weight in the global economy. In market economies this assessment crucially depends on the role interest rates play in resource allocation decisions and the transmission of monetary policy. In this paper we examine whether China's gradual transition to a market economy in the past decade has made any difference to the way monetary policy works. In particular, what role do interest rates play in transmitting monetary policy? How effective is monetary policy as a stabilisation tool?

There is already a significant literature (He and Wang, 2012, 2013; Fernald et al., 2014; Chen et al., 2017) suggesting that monetary policy transmission in China has started to resemble that of advanced economies. The actual conduct of monetary policy has also moved in this direction, as suggested by the recent removal of interest rate controls and the general reorientation of monetary policy away from the use of quantity targets to one where the People's Bank of China (PBC) manages a key short-term interest rate. For instance, the PBC has recently stated that it would improve its liquidity management strategies to release timely policy signals to guide market expectations of interest rates to achieve its monetary policy objectives (PBC, 2016)

Yet, ascertaining whether an interest rate channel of monetary transmission exists in China remains challenging for several reasons. First, the PBC uses multiple instruments, including reserve requirements and implicit credit quotas, to conduct monetary policy. Researchers using standard monetary policy transmission models are, therefore, confronted with the problem of accurately representing the stance of monetary policy using either a price or quantity variable. This potential "mis-specification" bias is significant in the context of conflicting evidence about the PBC's true policy response function. [1] Second, China's monetary policy framework is still evolving in the context of its transition to a flexible exchange rate regime. Not only is the exchange rate an important channel of monetary policy, but shifts in the exchange rate regime can have a significant impact on interest rates and credit conditions, more generally.

[1]For instance, while Fan et al. (2011) argue that money supply plays a more important role than official interest rates in setting the monetary policy stance in China, Sun (2015) shows that the PBC's policy rule can be represented by neither a money growth rule nor an interest rate rule, but by a mix of both. See also Burdekin and Siklos (2008) and Mehrotra and Sánchez-Fung (2010) who estimate McCallum-Taylor type monetary policy reaction functions for China.

Finally, any assessment of monetary policy must consider the fact that the PBC's policy instruments evolve endogenously with the state of the economy. The PBC may not only respond to incoming news about output and inflation by changing its policy stance, but shifts in its policy stance can also affect agents' expectations about the future evolution of the economy. Without isolating this systematic component of monetary policy, it is difficult to infer anything about the effectiveness of monetary policy (Bernanke and Blinder, 1992; Bernanke and Mihov, 1998; Christiano et al., 1999). As pointed out by Gertler and Karadi (2015), standard recursive identification strategies in VAR models, which use timing restrictions on the effects of monetary policy on other variables, are not very effective in removing this endogeneity bias in monetary policy.

In this paper, our goal is to explore the role of interest rates for monetary policy transmission in China taking account of its multiple instrument setting. In doing so, we exploit information from high-frequency Chinese financial market data to identify monetary policy shocks and assess their macroeconomic effects. In contrast to the approach followed in previous studies, our strategy does not require an assumption about the PBC's reaction function. Instead, we assume that while financial market participants do not have full information about the PBC's true reaction function, they can reasonably anticipate changes in its main policy instruments conditional on the state of the economy and price them in interest rates. The high-frequency financial market information then enables us to separate the "surprise" component of monetary policy from the "expected" component, which we use subsequently to identify monetary policy shocks. We show that, apart from being intuitively appealing, the so-called high-frequency identification strategy (Kuttner, 2001; Gürkaynak et al., 2005; Gertler and Karadi, 2015) is able to assess several interesting aspects of China's monetary policy in a more robust way than does the traditional VAR analysis. Moreover, such an analysis helps us to resolve some of the familiar puzzles concerning China's monetary policy, such as the counterintuitive response of macroeconomic variables to monetary policy shocks.

Our main contribution is to construct a time series of monetary policy surprises using daily changes in interest rates during short windows around policy decisions and communications by the PBC. Specifically, we focus on movements in one-year interest rate swap (IRS) contracts based on the interbank 7-day repo rate to measure market expectations of monetary policy. The 7-day repo rate is not only considered very informative with respect to the monetary policy stance of the PBC, but it is also the most liquid among all types of IRS contracts. To account for China's multiple-instrument setting, we compute daily changes in IRS contracts on days when lending rates and reserve requirements are changed, when quarterly monetary policy reports are published or when there are major changes in the exchange rate regime.

In the next stage, we use the policy surprises to study their macroeconomic effects. Our identification of monetary policy shocks exactly follows Gertler and Karadi (2015). First, we carry-out an event-study analysis to compute the response of the term structure of interest rates to monetary policy surprises. Second, following the proxy VAR approach, we identify monetary policy shocks using the monetary policy surprise series as external instruments and quantify their impact on output and inflation. Our monthly VAR model includes five endogenous variables (reserve requirement ratio, one-year benchmark lending rate, M2, industrial production and consumer prices excluding food) and three exogenous variables (the VIX index, one-year US government bond rate and commodity prices). Our sample covers the period 2004-2016.

Our analysis shows that the surprise component of monetary policy in China is sizeable: the largest policy surprises occurred around the 2008 global financial crisis, and again around the monetary policy easing in 2015. Surprises associated with changes in reserve requirements and the benchmark lending rate are larger than those associated with changes in the exchange rate regime and the publication of the monetary policy report. Further monetary policy tends to have persistent effects on long-term bond yields, corporate bond spreads and aggregate bank deposits and loans, pointing to the existence of an interest rate channel of monetary policy in China.

The analysis of impulse responses suggests that monetary transmission in China is remarkably similar to that typically found in advanced economies. For example, a contractionary monetary policy shock is associated with slower money growth and higher lending rates. Both industrial production and inflation fall persistently following the shock. Importantly the identification scheme using an external instrument approach does not seem to suffer from the "price puzzles" typically present in models using a recursive identification scheme.

Our paper complements several recent papers on China's monetary policy. Conceptually, it is closely related to Porter and Xu (2009), Chen et al. (2011) and He and Wang

(2012, 2013) which analyse Chinese monetary policy as a "dual track" interest rate system, with the regulated interest rates and the freely-determined market rates being linked through a set of arbitrage and profit maximising conditions. It is also related to Fernald et al. (2014) which studies the relative importance of money supply and short-term interest rates in Chinese monetary policy transmission by using a factor augmented VAR model, as well as Chen et al. (2017) which studies the same issue using a latent variable model. Our approach differs from others, however, not only regarding the identification of monetary policy shocks but also in terms of the assessment of the PBC's monetary policy stance using its multiple instrument framework.

The rest of the paper is structured as follows. Section 2 presents some preliminary analysis on the PBC's instruments and their predictive power for economic activity in China. Section 3 reports time series estimates of monetary policy surprises for China constructed using high-frequency data as well as responses of the term structure of interest rates to those surprises. Section 4 discusses the identification strategy and presents impulse responses from the proxy VAR model. Section 5 concludes.

2 Monetary policy instruments in China

In this section we start with a discussion of monetary policy instruments in China and examine their information content for the Chinese economy. China's multiple-instrument setting implies that it does not conform to the standard monetary policy description characterised by either a policy interest rate or the money supply. There is also a widespread perception that China's underdeveloped financial system and various interest rate controls impede transmission of monetary policy. Yet, over the past two decades, China has liberalised most segments of its money and bond markets (Porter and Xu, 2009; Porter and Cassola, 2011; Si, 2015). While the liberalisation of the interbank lending rate started in the 1990s, yields on treasury bonds and financial bonds (issued by the state-owned financial institutions) have been allowed to be fully market-determined since 1999. Most corporate bonds in China are typically linked to the interbank borrowing rate (SHIBOR). While China used to impose controls on bank lending rates (in terms of a floor) and deposit rates (in terms of a ceiling), those were removed in 2013 and 2015, respectively.

In order to influence market rates, the PBC has been developing an interest rate corridor system, with the interest rate on excess reserves of banks serving as the floor and the interest rate on standing lending facilities (SLF) as the ceiling. Since February 2016, it has introduced daily open-market operations to stabilise the money market rates (the 7-day pledged repo rate) and to give signals to financial markets about its monetary policy stance. These measures have been supplemented by the introduction of an averaging rule for the reserve assessment of commercial banks to reduce volatility of short-term rates around the reserve maintenance dates.

Figure 1 depicts the evolution of two main instruments of the PBC: one-year benchmark bank lending and deposit rates and reserve requirements on banks. Before the recent liberalisation of interest rates, the PBC typically used its benchmark rates as the main stabilisation tool. The fact that both benchmark deposit and lending rates were adjusted in the same direction and by similar magnitudes ensured that commercial banks retained a constant intermediation spread on their lending business. The PBC used its main policy rate symmetrically most of the time, with the number of tightening adjustments in the lending rate since 2000 being roughly equal to the number of loosening adjustments. At the same time, the PBC combined its main policy instrument with other quantitative controls, particularly reserve requirement ratios. Typically, the required reserve ratios were adjusted in fewer cycles and on a more persistent basis than the benchmark interest rates.

A key question is the extent to which these measures actually influenced monetary conditions in China. The right-hand side panel of Figure 1 shows movements in the 7-day interbank (pledged) repo rate and M2 as two major indicators of monetary conditions. The 7-day repo rate appears to have moved closely with the main policy rates of the PBC; specifically, it tracked most turning points of monetary policy fairly well. The correlation coefficient between the 7-day repo rate and the benchmark deposit rate was 0.56 during 2000-16, which strengthened to 0.63 during 2010-16. Excluding the 2008 crisis period from the sample does not alter the strength of the correlation. At the same time, the fact that the 7-day repo rate has been quite volatile in the post-crisis period suggests that other policy measures have also had significant effects on interbank interest rates. Indeed, the correlation coefficient between the reserve requirement ratio and 7-day repo rate has been consistently high over the past two decades (0.61 in 2000-16 and 0.75 in 2010-16.)

By contrast, growth in broad money does not seem to be associated with any of the policy instruments. While the correlation between growth in M2 and the benchmark lending and deposit rates has been close to zero, that between M2 growth and the reserve requirement ratio has been negative (-0.32 and -0.39 for 2000-16 and 2010-16, respectively). Indeed, during much of the post-crisis period, an acceleration in monetary growth has coincided with a persistent increase in reserve requirements, suggesting possibly the strong influence of other factors, particularly window guidance and direct credit controls, on credit growth. This could also represent indirect evidence for the growing role of interest rates in monetary conditions in China.

Several papers have highlighted the growing importance of the benchmark interest rates in the transmission of monetary policy in China (Porter and Xu, 2009; Porter and Cassola, 2011; Chen et al., 2011; He and Wang, 2012).[2] That said, existing empirical evidence is mixed about the impact of the PBC's policy rate on market interest rates. For instance, Porter and Xu (2009) show that a 100 basis points rise in the benchmark lending rate leads to an increase of 75 basis points in the 7-day repo rate, although the impact dies out quickly after three days. A similar rise in the deposit rate has the opposite effect of reducing the interbank rate, reflecting the positive supply response of the depositors.[3] He and Wang (2012) show that while higher regulated deposit rates and reserve requirements have positive effects on both money and bond market rates, monetary policy is more effective through the former rather than the latter instrument. In this paper we argue that the lack of clear-cut evidence on the interest rate channel in China does not necessarily reflect the weak impact of monetary policy, but rather the inaccurate identification of the shocks that may drive both the policy and market rates in the same direction.

Apart from how the central bank's instruments affect the market interest rate, as pointed out by Bernanke and Blinder (1992) a key exercise for assessing the role of monetary policy is to assess whether and how these instruments ultimately influence macroeconomic variables. In China's case this question is of crucial importance given the fact that the authorities also depend significantly on direct controls to influence bank credit and economic activity. Following Bernanke and Blinder (1992), we examine the predictive

[2] He and Wang (2012) show that the minimum lending rate regulation was never binding on banks because it was set significantly below the equilibrium level. Their estimates suggest that during 2004-10, only 16-32% of actual lending was done at or below the floor rate. In contrast, because the regulated deposit rate was set as the maximum permissible rate, it was binding on banks.

[3] In addition, the authors report that a rise in the reserve requirement ratio, conditional on the level of benchmark interest rates, has no effect on money and bond market rates.

power of the PBC's policy instruments for economic activity by running several Granger causality tests. Specifically, we consider annual growth in industrial production, retail sales, manufacturing PMI, fixed asset investment and a broad major of credit (the aggregate social financing) and regress them on their own lags as well as the lags of five major monetary policy variables: the annual growth of M2, the reserve requirement ratio, the 10-year government bond yield, the 7-day repo rate, and the one-year benchmark lending rate. The data are monthly (2005:09-2016:09) and, following the usual statistical criteria for optimal lag selection, we restrict the number of lags to four, uniformly for all variables.

Table 1 reports p-values of F-tests for predictability of all row variables after excluding all lags of a particular column variable from the regression. A significant test value is thus indicative of the fact that excluding a particular monetary policy indicator lowers the predictive power of all other indicators for future economic activity. As the top half of Table 1 shows, quantity aggregates such as M2 and reserve requirements dominated the information content for economic activity for the entire sample period 2005:09-2016:09. Among the interest rate variables, the 7-day repo rate seems to have some information content for aggregate social financing while the one-year lending rate appears to be more important for both industrial production and aggregate social financing.

However, as reported in the bottom half of Table 1, the picture changes substantially after 2010. In particular, with the exception of aggregate social financing, the predictive power of M2 has weakened for all variables. Reserve requirements still continue to be important for several macroeconomic variables. What is clear is that some of the interest rate variables, particularly the benchmark lending rate, have become more significant for economic activity since 2010. Besides being important for aggregate credit flows in the latter period, the 7-day repo rate also seems to play an important role for the future evolution PMI.

3 Constructing monetary policy surprises in China

Having obtained preliminary evidence about the working of the interest rate channel in China, in this section, we turn our attention to the construction of high frequency monetary policy surprises. Our strategy for constructing monetary policy surprises in China follows the extensive literature that uses changes in market expectations around monetary policy announcements (Kuttner, 2001; Gürkaynak et al., 2005). The idea underlying this approach is that any change in future prices in a tight window around a monetary policy announcement would be associated with the unanticipated change in the monetary policy stance.

However, the construction of monetary policy surprises for China using this strategy is challenging. As monetary policy is communicated and implemented through multiple tools, including price and quantity instruments, a direct measure of policy expectations is not available. Our strategy is to construct an indirect measure of monetary policy surprises using changes in the expected path of the 7-day interbank repo rate. As we have argued in the previous section, the 7-day interbank repo rate is closely tied to changes in the monetary policy stance. It has also become an important market interest rate reflecting market liquidity and the cost of funding for banks. Therefore, our strategy is to proxy the expectation of monetary policy by the expected path of the 7-day repo rate measured through IRS.

The IRS market has been operational in China since 2006 and is available for different reference rates in up to ten year tenors. Table 2 gives a snapshot of the IRS market in November 2016. It makes clear that interest rate swaps based on the 7-day repo dominate the market. In that month, both the turnover and the number of transactions for IRS based on 7-day repo were an order of magnitude larger than those for SHIBOR or one-year deposit and lending rates. Overall, the 7-day repo IRS accounts for 80% of the overall IRS turnover. Within the total 7-day repo interest rate swaps traded, those for one-year and five-year tenors are the most frequently used by a significant degree.

For the purpose of identifying the effect of monetary policy actions on IRS, the liquidity of the chosen instrument is an important aspect. As we consider the daily movements in IRS around policy announcements, it is important that the particular measure has enough activity and volume to be able to extract a meaningful market response within a daily window. Both the one-year and five-year IRSs are accordingly the natural candidates. Because a five-year time-frame would be outside the horizon of typical monetary policy effects, we take the one-year 7-day repo IRS as our baseline indicator to estimate policy surprises. When estimating the effects of monetary policy surprises in the next section, we check the sensitivity of our results to this choice by presenting results based on IRS of alternative tenors.

In order to assess the changes in the stance of monetary policy, we consider two conventional types of monetary announcements: changes in the reserve requirement ratio (RRR) and adjustment of benchmark lending and deposit rates. We also consider publication of the quarterly monetary policy report as part of the monetary policy announcements. The main motivation for including these publications is that, at many times, through these reports, the PBC communicates its intention for future policy actions as well as details of future changes in the monetary policy framework. Therefore, it is possible that the publication of the monetary policy report has a significant effect on the expectations of the future evolution of monetary policy. Indeed, as we show below, market interest rates react significantly to the publication of these reports. Another consideration for adding these is related to the fact that monetary policy announcements in China do not follow a pre-announced schedule. As a result, contrary to central banks following a pre-announced policy decisions schedule, for China we do not have in our sample any policy announcement day without a corresponding actual change in policy instruments. We thus see these announcements as a proxy for evaluating the effectiveness of communication in shaping markets' monetary policy expectations. Finally, under a quasi fixed exchange rate regime, adjustment in the exchange rate policy can be seen as part of the monetary policy toolkit. We therefore include any policy change relating to the exchange rate regime in China in our list of monetary policy announcements.

Table 3 lists all monetary policy announcement dates in our sample since June 2006. For the actual policy decision, Table 3 presents the size and the direction of changes in the RRR and the benchmark lending and deposit rates. Over our sample, the RRR is the most frequently used policy instrument (40 announcements), followed by deposit and lending rates (25 announcements). We include 41 announcements pertaining to the release of PBC's quarterly monetary policy report, as well as 12 announcements pertaining to changes to the exchange rate policy. For announcements relating to the exchange rate, we also include a brief description. Overall, taking into account the days on which multiple instruments have been adjusted, we have 107 announcements covering the period from June 2006 to August 2016.

3.1 The surprise component of monetary policy announcement

Our approach is based on correctly uncovering the movements in IRS contracts during a narrow window around monetary policy announcements. We then interpret these movements in IRS as the surprise component of the monetary policy announcement. The window over which we compute these changes is daily frequency. It is, however, important that we correctly take into account the exact timing of the policy announcement. This is relevant for China because several monetary policy announcements in our sample occur either over weekends or on weekdays after the market closes.

Therefore, in order to compute the daily change on the IRSs before and after a policy announcement, we also collect information on the exact timing of each announcement. We then construct monetary policy surprises according to the following rules. First, if a policy announcement is made when the market is open, during a weekday, our surprise measure is the difference between the announcement day's close value minus the previous working day's close value. Second, if a policy announcement is made on a weekday but after markets are closed, our measure is then the following day's close value minus the announcement day's close value. Finally, if an announcement is made during the weekend or over a holiday period, our surprise measure is the first working day following the announcement's close value minus the latest working day before the announcement's close value.

Figure 2 plots an example of our procedure and the resulting surprise measure. On 26 November 2008, the PBC lowered both lending and deposit rates by around 100 basis points and relaxed the RRR from 17% to 16% for large banks and from 16% to 14% for small banks. Figure 2 depicts the evolution of one-year 7-day repo IRS before and after the announcement. The IRS was stable at around 1.9% before the announcement but fell sharply to 1.35% the day after the announcement. Therefore our estimate for the monetary policy surprise for this announcement, which involved multiple policy instruments, is 55 basis points.

Applying the same methodology in all announcement days, Figures 3 to 6 plot the daily time series of monetary policy surprises for all policy announcements combined as well as for announcement days that correspond to changes in the RRR, in the lending rate and FX regime separately. In all these figures, we measure the surprise component using one-year IRS based on 7-day repo. It is apparent that the biggest monetary policy surprises in China happened around the global financial crisis when the PBC aggressively eased its monetary policy stance.

Figures 4 and 5, depict, for each RRR and lending rate announcements, the actual policy change and the associated surprise component. A first observation is that, for both RRR and lending rate announcements, changes of similar magnitudes in policy instruments may correspond to quantitatively very different surprise components. This suggests that markets have developed an understanding of the PBC's systematic monetary policy as expectations about policy are conditional on the state of the economy and they vary over time. Second, not only does the size of the surprise component vary over time, but the surprise component is found to have the opposite sign to the actual direction of the policy announcement in some instances. This implies that in the case of a tightening (loosening) move, market expectations of the policy decision were higher (lower) than what the PBC delivered, and that the perceived change in the monetary policy stance can be the opposite of the actual policy move. Assessing the impact of monetary policy using only actual changes in the monetary policy instruments can therefore be misleading in evaluating their effectiveness. As shown by Kuttner (2001), isolating the systematic component is key for evaluating monetary policy effectiveness as, if markets are efficient, the anticipated component of monetary policy would have no effect on market interest rates following policy announcements.

Another clear advantage of our approach is that it provides a measure of monetary policy surprises which is comparable across monetary policy instruments. It is not, otherwise, straightforward to compare the effects of an adjustment to a quantity-based policy measure, such as a change in RRR, with a change in a price-based measure, such as the lending rate. Our surprise estimate provides a quantitative proxy for the surprise component of these policy actions in terms of the changes in the expected future path of the 7-day repo. Therefore these estimates are in the same units and comparable independent of the policy instrument used, enabling us to draw inference on the effects of monetary policy as a whole as well as comparing the effectiveness of individual policy instruments.

To provide a quantitative assessment of our policy news across announcement days, Table 4 provides summary statistics for the surprise component by computing the volatility of the changes in IRS on policy announcement and non-announcement days. As IRSs move in response to various economic news, their standard deviation on a typical day without a policy announcement is 5 basis points. Policy announcements seem to generate a higher volatility in IRSs than non-announcement days, as on policy announcement days the standard deviation increases to 15 basis points. Table 4 also provides a decomposition of this volatility by type of policy announcements. The days that correspond to changes in the RRR or lending rates account for most of the volatility as those days are associated with 16 basis points volatility in IRSa, while the days on which the monetary policy reports are published are only associated with only 4 basis points volatility.

We conclude this section by checking the sensitivity of our surprise estimate to the choice of the IRS contract. In our baseline, we focused on movements in the one-year IRS. Figure 7 provides scatter plots and correlations of surprise estimates based on IRS of different tenors. In each subplot of Figure 7, the surprise estimate based on the one-year IRS is plotted against an alternative measure using an IRS of a different tenor. The correlation coefficient between each measure is also reported. In the scatter plots, most of the alternative measures are clustered around the 45 degree line and they are highly correlated with our baseline measure (from 0.69 for three-month IRS to 0.84 for five-year IRS). In the next section when we analyse the high-frequency effects of policy surprises on market interest rates, we show that our results are robust to using these alternative measures.

4 High-frequency effects of monetary policy surprises

This section provides evidence on the high-frequency response of a number of market interest rates to monetary policy surprises. We provide estimates for the impact of high frequency monetary policy surprises on the dynamics of sovereign yields as well as corporate and bank bond yields at various maturities. To do so we estimate the following regression:

$$\Delta y_{t+h,t-1} = \alpha_h + \beta_h S_t + \varepsilon_{h,t} \tag{1}$$

Where S_t is our measure of monetary policy surprises at date t and $\Delta y_{t+h,t-1}$ denotes the daily change in yield y, h days ahead. In estimating the high frequency effect of monetary policy surprises on various yields, we follow the same timing convention as in the previous section. The daily change in yields is computed taking into account the exact timing of the monetary policy announcement so that the surprise estimate and the daily change in the yield cover exactly the same day.

We first focus on the response of sovereign yields. Table 5 presents estimates of β_h for sovereign yields of maturity up to 10 years, for $h = 0$, that is the same-day impact of the monetary policy surprises. In Table 5, each estimate comes from a different regression using equation (1), where the dependent variable is a particular maturity sovereign yield. The columns present coefficient estimates using surprise estimates for each type of policy announcement.

The first column displays the estimated β pooling together all policy announcements. The coefficient estimates for all maturities are positive and significant. A contractionary monetary policy surprise moves the whole term structure of sovereign yields upwards. Looking across maturities, the point estimates are around 0.3, with the peak impact at the three-year yield. That is, a policy announcement that is accompanied by a 100 basis point increase in IRSs is associated with around 30 basis points increase in sovereign yields.

It is interesting to note that the response of the term structure changes when we disaggregate the impact of policy shocks according to the type of policy announcement. The second column of Table 5 presents coefficient estimates when only policy surprises from changes to lending rates are included in the regression. Again, all coefficient estimates are positive and statistically significant with a peak of 41 basis points on the three-year yield. However, if we consider only surprises associated with RRR adjustments (third column of Table 5), we find that the peak impact is 41 basis points on the short end of the curve but decreases to 27 basis points at the long end of the yield curve. In comparison, policy news on the monetary policy report (MPR) days (fourth column of Table 5) have a small and insignificant effect on the short maturities while the impact on longer maturities are significant and higher. Although there is no material change to any of the policy instruments on these days, our coefficient estimates suggest that the sovereign yield curve reacts significantly to surprises arising from the publication of the MPR, albeit somewhat smaller in magnitude compared to the effects of actual policy changes. We see this result to be consistent with the use of the MPR to signal future monetary policy intentions.

We now turn to evaluating the persistence of the effects of monetary policy surprises. For this exercise, the independent variables are the cumulative daily changes in sovereign yields over the seven working days following the monetary policy announcement. Figure 8 shows the path and the corresponding confidence intervals of the sovereign yields following a monetary policy surprise. For all maturities, the impact of monetary policy is estimated to be persistent and significant. The confidence bands become wider over time as other market developments probably account for a larger share of movements in yields. The point estimates are increasing slightly in most cases, suggesting that the effect of the monetary policy surprises are only sluggishly priced in over the week following the monetary policy announcement.

In order to check the robustness of our results to the choice of the one-year IRS to measure policy surprises, we also estimate the path of sovereign yields when the surprise measure is constructed using changes in alternative tenors of the IRS (Figure 8). The results suggest that using alternative IRS measures gives both quantitatively and qualitatively similar results. The point estimates for the reaction of the sovereign yields under alternative specifications mostly lie within the confidence intervals of our baseline estimates.

We extend our high-frequency analysis by documenting the impact of monetary policy surprises on other market interest rates. To do so, we estimate equation 1 using corporate and bank bond yields of maturities up to 10 years as dependent variables. In both corporate and bank bond yields, we solely focus on AAA bonds, although our results are qualitatively similar if we consider lower-rated bonds. Figure 9 plots the response of corporate and bank bond yields after a monetary policy surprise using all announcements. As in the case of sovereign yields, the responses are estimated to be positive and significant and the increase in the yields slowly builds up over time. Most of the yield responses stabilize after around three days. The impact response of the corporate and bank bond yields are somewhat larger than that of sovereign yields, as on impact both yields increase by around 50 basis points. There is also a clearer pattern in the response of the yield curve, with the response of longer maturities increasing less than that of short maturities.

Overall, the high-frequency analysis of the effects of monetary policy surprises in China suggests that monetary policy actions have a significant and persistent effect across a range of market interest rates. In the next section, we examine whether the effect of monetary policy surprises on financial markets in the high frequencies translates to a broader impact on macroeconomic variables.

5 Proxy VAR

In this section we provide evidence on the macroeconomic impact of monetary policy shocks in China using a structural VAR approach with external instruments. In our implementation, we closely follow Gertler and Karadi (2015) who identify dynamic effects of monetary policy shocks in the US using the external instruments approach.

The identification strategy is based on the idea of using high-frequency monetary policy surprises to isolate the variation in the reduced-form residuals in the VAR due to monetary policy shocks. The external instruments approach to identify monetary policy shocks has been useful in delivering a credible account of monetary policy shock transmission (Caldara and Herbst, 2018; Cesa-Bianchi et al., 2016). This approach does not require any timing assumptions, as in recursively identified VAR, and as such it does not produce counterintuitive results regarding the effects of monetary policy shocks. For example, the Cholesky identification would predict that inflation would increase after contractionary monetary policy shocks even when the identification is applied to artificial data generated from a model without any such effect (Carlstrom et al., 2009).

Further, this approach is well suited for China given its multiple instruments setting. In typical applications of the Cholesky identification to China (see for example Fernald et al., 2014), one needs to decide which policy instrument is taken as the main policy tool. This is necessary as the monetary policy shocks are identified as some orthogonolisation of these residuals. However, as we have argued, Chinese monetary policy is best characterised with the use of multiple tools, and aiming to identify the policy shocks using just one instrument might be misleading. Our high frequency instruments are constructed using multiple instruments. Therefore in instrumenting the residuals in the reduced-form VAR, these surprises would isolate a more accurate portion of residuals due to monetary policy surprises.

Following Gertler and Karadi (2015), we start the analysis by estimating the following reduced from VAR:

$$Y_t = c + \sum_{j=1}^{p} B_j Y_{t-j} + DX_t + A_0 \varepsilon_t \tag{2}$$

where Y_t is a vector of endogenous variables, including various policy instruments of the PBC and X_t a vector of international exogenous variables. The reduced-form VAR residuals u_t are linear combinations of structural shocks, $u_t = A_0 \varepsilon_t$, and therefore the variance-covariance matrix of the reduced-form residuals $E[u_t u_t']$ is $\Omega = A_0 A_0'$.

Given that we are only interested in the effects of monetary policy shocks, our objective is to identify the column of the A_0 corresponding to the contemporaneous effect of the monetary policy shock. Our approach requires our instrument to verify:

$$E(Z_t, \varepsilon_t^p) = \alpha \neq 0 \quad (3)$$

$$E(Z_t, \varepsilon_t^q) = 0 \quad (4)$$

where Z_t is our instrument. We denote ε_t^p as monetary policy shocks while ε_t^q as all other structural shocks in the VAR. These two conditions state that in order for the monetary policy surprises to be a valid instrument, they should be correlated with the monetary policy shocks and uncorrelated with all the other structural shocks in the VAR.

Our dataset is monthly and covers the period 2004M1-2016M6. Our baseline VAR includes the following variables: RRR, 1-year lending rate, M2, 7-day repo rate, and year-on-year changes in industrial production and consumer prices excluding food. In order to be able to control for external shocks, we also include additional exogenous variables in the VAR. These are the VIX, an index of commodity prices and the one year US treasury bond yield. [4]

Our external instruments are available starting from June 2006. The high-frequency policy surprises are transformed to monthly frequency by taking the sum of daily changes in 7-day repo IRS. [5] In order to gain some extra precision in the estimation of the parameters of the VAR, we choose to estimate the model over a longer sample, starting in 2004. Then only residuals from June 2006 are used for the first stage regression to identify the contemporaneous impact of the policy shocks. Once the contemporaneous effect is identified, the dynamic effects of monetary policy shocks are computed using the reduced-form VAR coefficients estimated over the full sample.

We take the RRR ratio as the main policy indicator. Therefore we use the reduced-form residual from this equation to isolate the variations due to structural monetary policy shocks. The first stage regression has an F-statistic of 16.5, which suggests that we can rule out any potential weak instrument problem.[6]

[4] We adjust the industrial production data to cancel out the impact of the Chinese new year following Fernald et al. (2014), who note that new year holidays introduce significant seasonality on industrial production and follow the lunar calendar, falling in January or February. In order to correct this excessive volatility, we allocate the total growth in industrial production from December to March equally on January and February growth rates.

[5] Given delays in the implementation of actual policy changes after the announcement, if an announcement has been made in the second half of the month, we include it in the following month's estimates.

[6] F-statistics for instrumenting residuals from lending rate and 7-day interbank rate equations are 8.5 and 5.2, respectively. The impulse responses using these to identify monetary policy shocks are presented in Figure 11 and show that the results are almost identical.

5.1 Baseline results

Figure 10 displays the impulse responses to a monetary policy shock where the size of the shock is scaled to produce a 1% increase in the RRR. The impulse responses suggest that monetary policy transmission in China is surprisingly similar to that in advanced economies. A contractionary monetary policy shock is associated with lower money growth and higher lending rates. At the same time, a contractionary monetary policy shock has large and statistically significant effects on real activity and prices as both industrial production and inflation persistently fall. The response of output is muted in the first months, with the peak effect occurring after about a year. The maximum effect of a 1% surprise increase in the RRR on industrial production is around 1.5%. The response of inflation is somewhat more front loaded as the largest fall in inflation happens within the year after the shock. Inflation stays, however, below the pre-shock level for around two and a half years.

Contrary to some earlier studies analysing the monetary transmission mechanism in China using VAR models, our findings suggest that monetary policy shocks have significant and persistent macroeconomic effects. In order to contrast our results with alternative identification schemes, we present results for the transmission of monetary policy shocks based on the Cholesky identification. In such a recursive identification scheme, one needs to choose which policy instrument is the policy indicator. Therefore, Figure 11 presents the impulse responses of industrial production and inflation to monetary policy shocks using four different policy instruments. In each case, we estimate the same VAR with the same observables but we identify monetary policy shocks by changing the ordering of the variables in the VAR. In each of these alternative cases, the monetary policy indicator is ordered last as is usual in the literature, implying that the contemporaneous response of all the other variables to monetary policy shocks is zero.

The first observation from Figure 11 is that the estimated impact of monetary policy shock on industrial production and inflation varies substantially across policy instruments. Second, none of the impulse responses using a recursive identification scheme imply a joint drop in industrial production and inflation following a contractionary monetary policy shock (red lines and shaded areas in Figure 11). In most cases, inflation and output move in opposite directions. For example, except for the lending rate, all impulse responses for inflation points to the existence of the so-called price puzzle: that is, inflation increases after a contractionary monetary policy shock. And in the case of the lending rate, although inflation drops persistently, we find that industrial production increases after about six months.

This comparison shows that using a recursive identification scheme for China would not produce a plausible estimate of the monetary policy transmission mechanism. Overall the comparison suggests that the external instrument approach to identify monetary policy shocks delivers a more credible account of monetary policy transmission in China. Notably, the identification using an external instrument approach does not seem to suffer from the usual puzzles when a recursive identification scheme is used.

In order to complete our analysis of macroeconomic transmission of monetary policy shocks, we also analyse the responses of various interest rates to the VAR identified monetary policy shocks. Figure 12 shows the impulse responses of sovereign and corporate yields. Each impulse response is obtained adding one interest rate variable at a time to the benchmark VAR. The first observation comes from comparing these impulse responses to the findings from the high-frequency analysis. The impact response we obtain for each impulse response is very similar to the impact we estimated in the high-frequency analysis combining all the announcements. The impulse responses provide further evidence on the persistence of the effects of monetary policy surprises of interest rates and economic activity, as the increase in all yields last for up to a year after the policy shock.

5.2 Extensions

To gain further insights into monetary transmission channels in China, we extend our baseline model in two directions. First, we explore if the effects of monetary policy are different allowing for the fact that a significant share of Chinese firms may be credit-constrained. In a second extension, we examine the argument often made in the context of China that the presence of directed credit measures reduces the power of the conventional interest rate channel in exerting a meaningful impact on aggregate bank lending.

As eloquently shown in Gertler and Karadi (2015), models of monetary transmission without any financial frictions would imply that a monetary policy shock would result in a proportional increase in government bond rates and the rates on any private security of the same maturity. In the presence of financial frictions, however, monetary policy could operate via a "credit channel", implying fluctuations on the spread between yields on private securities and government bonds. For example, Gertler and Karadi (2015) find that, in the US, the credit channel amplifies the effects of monetary policy, as a contractionary monetary policy shock leads to a tightening of financial constraints and an increase in the external finance premium. In China, this amplification mechanism is likely to be strengthened by the fact that a large share of firms are either excluded from domestic bond markets or have only limited access to such finance. In addition, a significant share of the Chinese firms are exposed to currency and maturity mismatches on their balance sheet, which can further constrain their ability to access external finance in the midst of a tightening monetary policy cycle.

How strong is the credit channel in China? The bottom panel of Figure 12 displays the responses of corporate bond spreads to monetary policy shocks. For all maturities, we find that corporate spreads indeed increase following a contractionary monetary policy shock. The increase in the spreads, although relatively short-lived, is substantial and ranges from 15 to 20 basis points. While the impact on the 3-month credit spread is immediate and sizeable, that on the longer term spreads peaks with a lag. Overall, these estimates are stronger than the immediate impact of 10 basis points and a long-term impact of 7 basis points on the excess bond premium reported by the Gertler and Karadi (2015) for the United States. While Gertler and Karadi (2015) use the excess bond premium series of Gilchrist and Zakrajsek (2012), which eliminates the default premium, we use bond spreads of highly rated Chinese firms, which do not explicitly exclude such effects.

As a final piece of evidence on the macroeconomic transmission of monetary policy shocks, we extend the baseline model to include loan and deposit growth. The consensus in China is that monetary policy changes have limited effects on loans and that the primary tool to control loan growth is so called "window guidance", *i.e.* administrative controls. For instance, as argued by He and Wang (2013), one channel through which window guidance can reduce the power of the interest rate channel is by lowering the sensitivity of state-owned firms' borrowing behaviour to changes in the PBC's policies. Since most administrative credit controls are typically carried out by changing lending quotas for state-owned firms, the size of loans and hence lending volume can become insensitive to changes in interest rates. Chen et al. (2017) discuss another reason for suspecting a weak interest rate channel in China. This is linked to the pro-growth monetary policy strategies followed by Chinese authorities, which relies on varying loan supply to heavy industries to achieve the annual GDP growth target. In this framework, both interest rate and money supply become ineffective in influencing credit, with the latter passively adjusting to commercial banks' demand for reserves.

Figure 13 shows the impact of a monetary policy shock on bank deposits and loans. The key finding is that tighter monetary conditions are associated with a fall in both deposit and loan growth. The negative response of loans to a tighter monetary policy is both economically and statistically significant, although somewhat less than that of deposits. This suggest that a monetary policy shock is likely to work through two channels. First, a contractionary shock reduces deposits and loans, leading to a reduction in the aggregate lending growth. As pointed out by Bernanke and Blinder (1992), this does not necessarily mean that loan supply directly responds to interest rates; this could as well be the result of loans passively adjusting to economic activity following a tighter monetary policy. At the same time, our evidence also suggests the existence of a direct credit channel, which operates through bond spreads, implying that monetary policy does seem to have an effect on aggregate loan volumes and hence economic activity more directly.

Overall, the impulse responses from the structural VAR with external instruments complement our findings from the high-frequency analysis. While our event study analysis has shown that monetary policy surprises have a significant effect on sovereign, corporate and bank yields on a daily frequency, the VAR based impulse responses provide evidence that monetary policy shocks have also large and persistent macroeconomic effects.

6 Conclusion

Understanding how monetary policy works in China is challenging in the context of its gradual transition to a flexible exchange rate regime and the multiple instruments through which monetary policy is conducted. This severely limits the usefulness of standard identification strategies in VAR models for the analysis of monetary policy in China, which use timing restrictions and simplified assumptions about the PBC's policy reaction function to study the effects of monetary policy. An important consequence of such representation is that it downplays the role of financial markets and interest rates in the transmission of monetary policy. In this paper, we try to overcome these limitations by focusing on the financial market response to the PBC's policy announcements, including those relating to the exchange rate regime and the release of official reports. We use daily interest rate swap contracts to construct a time series of monetary policy surprises. We then use these surprises to evaluate the impact of monetary policy on the term structure of interest rates and economic activity.

Our analysis shows that monetary policy in China tends to have persistent effects on long-term bond yields and corporate spreads, pointing to the existence of an interest rate channel of monetary policy. A contractionary monetary policy shock is followed by lower growth in industrial production and lower inflation. Notably, the proxy VAR using monetary policy surprises as an external instrument to identify monetary policy shocks does not suffer from the price puzzles typically present in models that use a recursive identification scheme to study the effects of monetary policy. Additionally, our results suggest that the use of window guidance and implicit credit quotas by the Chinese authorities to directly control bank credit does not imply that bank credit is insensitive to interest rates. We find that monetary policy does have an independent effect on lending growth through changes in credit spreads following monetary tightening. In other words, monetary policy in China also operates through a "credit channel", as evident in economies with limited access of firms to external finance.

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A Tables

Table 1: Monetary indicators and economic activity in China

Dependent variable:	M2 (year-on-year)	Reserve requirements	10-year government bond	Repo 7-day fixing	1-year lending rate
Sample period 2005:09 – 2016:09					
Industrial production (year-on-year)	0.0041***	0.0844*	0.2424	0.0869*	0.0058***
Retail sales (year-on-year)	0.0585*	0.0889**	0.2924	0.2523	0.8171
Manufacturing PMI	0.0216**	0.0123**	0.3853	0.2917	0.1045
Social financing (year-on-year)	0.0365**	0.1079	0.2853	0.0112**	0.0036***
Fixed asset investment (year-on-year)	0.1968	0.2931	0.3702	0.1578	0.2076
Sample period 2010:04 – 2016:09					
Industrial production (year-on-year)	0.1838	0.1559	0.4563	0.8531	0.0270**
Retail sales (year-on-year)	0.1074	0.0334**	0.9458	0.9360	0.0242**
Manufacturing PMI	0.1425	0.0000***	0.4510	0.0986*	0.0000***
Social financing (year-on-year)	0.0379**	0.0297**	0.0490**	0.0203**	0.4525
Fixed asset investment (year-on-year)	0.5941	0.3002	0.6901	0.4536	0.2720

F-test for omitting the three-lags is reported for each monetary variable. CPI is included in the model, but the estimates are not reported.

The symbols *, **, and *** represent significance levels of 10%, 5%, and 1% respectively.

Table 2: Liquidity in the IRS market as of November 2016

Reference rate	Tenor	Nom. Principal (100M)	Number of Deals
7-day repo	1 month	98	9
	3 months	386.79	95
	6 months	1559.47	322
	9 months	525.31	177
	1 year	3994.62	3109
	2 years	200.45	266
	3 years	99.37	103
	4 years	31.05	47
	5 years	1970.1	6053
3M-SHIBOR	6 months	379.5	104
	9 months	566.83	145
	1 year	441.2	248
	2 years	28.5	21
	3 years	9.67	16
	4 years	1.5	3
	5 years	113	299
O/N SHIBOR	7 days	300	46
	3 years	4	2
LPY1Y	1 year	4	2
	2 year	6	2
1-year deposit rate	2 years	1.7	1
1-year lending rate	1 year	0.6	1

Table 3: Announcement dates and events

Announcement date	RRR	LR	$FX^\wedge$	MPR	Announcement date	RRR	LR	FX1	MPR
16.Jun.06	0.5				14.Jan.11	0.5			
21.Jul.06	0.5				30.Jan.11				*
10.Aug.06				*	08.Feb.11		0.25		
18.Aug.06		0.27			18.Feb.11	0.5			
03.Nov.06	0.5				18.Mar.11	0.5			
14.Nov.06				*	05.Apr.11		0.25		
05.Jan.07	0.5				17.Apr.11	0.5			
09.Feb.07				*	03.May.11				*
17.Mar.07		0.27			12.May.11	0.5			
05.Apr.07	0.5				14.Jun.11	0.5			
29.Apr.07	0.5				06.Jul.11		0.25		
10.May.07				*	12.Aug.11				*
18.May.07	0.5	0.18	a		16.Nov.11				*
20.Jul.07		0.27			30.Nov.11	-0.5			
30.Jul.07	0.5				15.Feb.12				*
08.Aug.07				*	18.Feb.12	-0.5			
21.Aug.07		0.18			14.Apr.12			c	
06.Sep.07	0.5				10.May.12				*
14.Sep.07		0.27			12.May.12	-0.5			
13.Oct.07	0.5				07.Jun.12		-0.25		
08.Nov.07				*	05.Jul.12		-0.31		
10.Nov.07	0.5				02.Aug.12				*
08.Dec.07	1				02.Nov.12				*
20.Dec.07		0.18			06.Feb.13				*
16.Jan.08	0.5				09.May.13				*
22.Feb.08				*	02.Aug.13				*
18.Mar.08	0.5				05.Nov.13				*
16.Apr.08	0.5				08.Feb.14				*
14.May.08				*	15.Mar.14			d	
07.Jun.08	1				06.May.14				*
15.Aug.08				*	01.Aug.14				*
15.Sep.08	-1	-0.27			06.Nov.14				*
08.Oct.08	-0.5	-0.27			21.Nov.14		-0.4		
29.Oct.08		-0.27			04.Feb.15	-0.5			
17.Nov.08				*	10.Feb.15				*
26.Nov.08	-1	-1.08			28.Feb.15		-0.25		
22.Dec.08	-0.5	-0.27			19.Apr.15	-1			
23.Feb.09				*	08.May.15				*
06.May.09				*	10.May.15		-0.25		
05.Aug.09				*	27.Jun.15		-0.25		
11.Nov.09				*	07.Aug.15				*
12.Jan.10	0.5				11.Aug.15			e	
11.Feb.10				*	25.Aug.15	-0.5	-0.25		
12.Feb.10	0.5				23.Oct.15	-0.5	-0.25		
02.May.10	0.5				06.Nov.15			f	*
10.May.10				*	11.Dec.15			g	
19.Jun.10			b		07.Jan.16			h	
05.Aug.10				*	11.Jan.16			i	
19.Oct.10		0.25			06.Feb.16				*
02.Nov.10				*	29.Feb.16	-0.5			
10.Nov.10	0.5				03.Mar.16			j	
19.Nov.10	0.5				06.May.16			k	*
10.Dec.10	0.5				05.Aug.16			l	*
25.Dec.10		0.25							

^ See next table for details on announcements related to exchange rate regime

	Announcement date	Details
a	18.May.07	Trading band of RMB/USD widened to +/-0.5% Time stamp of Bloomberg news
b	19.Jun.10	The PBOC decided to proceed with further reform of the RMB exchange rate regime and to enhance RMB exchange rate flexibility
c	14.Apr.12	Trading band of RMB/USD widened to +/-1% Limits for bid-ask spread of RMB/USD widened to 2% of mid-price Bloomberg news time stamp
d	15.Mar.14	Daily trading band of USD/CNY in the interbank market widened to +/-2% Limits for bid-ask spread of USD/CNY widened to 3% of mid-price
e	11.Aug.15	Announcement on improving quotation of the central parity of RMB against USD; market makers…should refer to the **closing rate** of the inter-bank foreign exchange market on the **previous day**, in conjunction with **demand and supply condition** in the foreign exchange market and exchange rate **movement of the major currencies** PBOC Spokesman Q&A on improving quotation
f	06.Nov.15	Release of 2015Q3 Monetary Policy Report, with a box explaining the policy change on 11 Aug 2015. Also stated that there is no basis for the RMB to devalue continuously.
g	11.Dec.15	Launch of **CFETS, BIS and SDR basket indices;** more desirable to refer to **both the bilateral RMB-USD exchange rate and exchange rate based on a basket of currencies** help guide market participants **to shift their focus** from the bilateral RMB/USD exchange rate **to the effective exchange rate**...based on a basket of currencies
h	07.Jan.16	it is **not** necessary for China to stimulate export through a competitive devaluation of the RMB there is not a basis for the RMB to devalue continuously. It will remain strong among reserve currencies

i	11.Jan.16	Jun MA interview the fixings are based on the previous day's closing price and changes to the basket of currencies against which the yuan is valued some of the market participants recently tried to determine the PBOC's intentions by looking at the change in the fixing rate versus the previous day. This is misunderstanding. **The fixing is determined by factors including the closing price of the previous day and the changes of the currency basket.** Market participants **should look at the differences between fixing and the closing prices, and the changes of the currency basket**
j	03.Mar.16	Explicitly mentioned the **reference to the baskets of CFETS, BIS and SDR:**market makers had taken into consideration not only the CFETS basket but also the BIS and SDR basket when submitting their daily central parity quotes First used the term**previous close + movements of a basket of currencies**:The RMB/USD central parity will keep reflecting the characteristics of previous close + movement of a basket of currencies in the future
k	06.May.16	Release of 2016Q1 Monetary Policy Report, with a box explaining the RMB/USD fixing in details. **Reiterated and explained in details** theprevious close + movements of a basket of currencies
l	05.Aug.16	Release of 2016Q2 Monetary Policy Report, with a box on RMB exchange rate fixing mechanism. Reviewed the operation of previous close + movements of a basket of currencies. Would continue to improve the RMB exchange rate fixing mechanism.

Table 4: Standard deviation of changes in IRS on policy announcement dates

	Standard deviation in basis points
All policy announcements	11
RRR announcements	15
Lending rate announcements	16
Monetary policy report	4
Non-announcement days	5

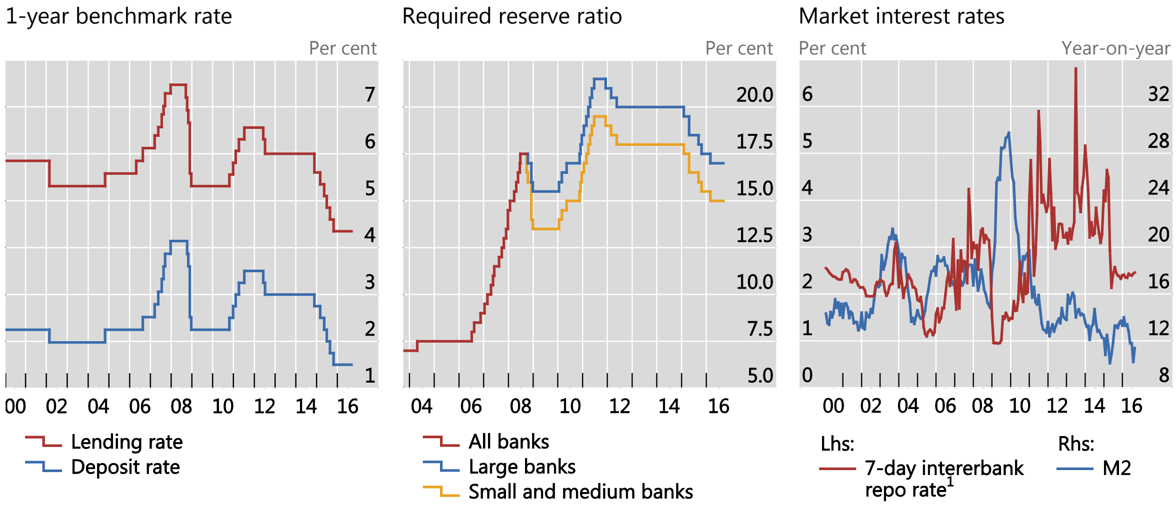
Table 5: Estimation Results

Sovereign yield	All announcements	LR surprise	RRR surprise	MPR surprise
3m	0.31	0.32	0.41	0.19
	(0.06)	(0.1)	(0.08)	(0.14)
6m	0.32	0.31	0.38	0.15
	(0.05)	(0.09)	(0.09)	(0.12)
1y	0.35	0.33	0.37	0.16
	(0.05)	(0.1)	(0.08)	(0.11)
3y	0.36	0.41	0.35	0.27
	(0.04)	(0.1)	(0.06)	(0.08)
5y	0.31	0.27	0.25	0.42
	(0.05)	(0.13)	(0.08)	(0.12)
10y	0.3	0.32	0.27	0.33
	(0.04)	(0.1)	(0.05)	(0.1)

Note: The table presents the impact of monetary policy surprises on Sovereign yields at various maturities as specified in equation 1. The first column denotes the maturity of sovereign yields. The second column corresponds to point estimates (standard errors in brackets) of the impact when all monetary policy announcements are included in the regression. The last three columns presents the results for various subsets of policy announcements: lending rate adjustments, change in reserve requirement ratio and the publication of the quarterly monetary policy report, respectively.

B Figures

Figure 1: Monetary conditions in China



[1] Calculated as monthly average over daily data.

Sources: CEIC; Wind; BIS calculations.

Figure 2: Movements in IRS on 26 Nov 2008

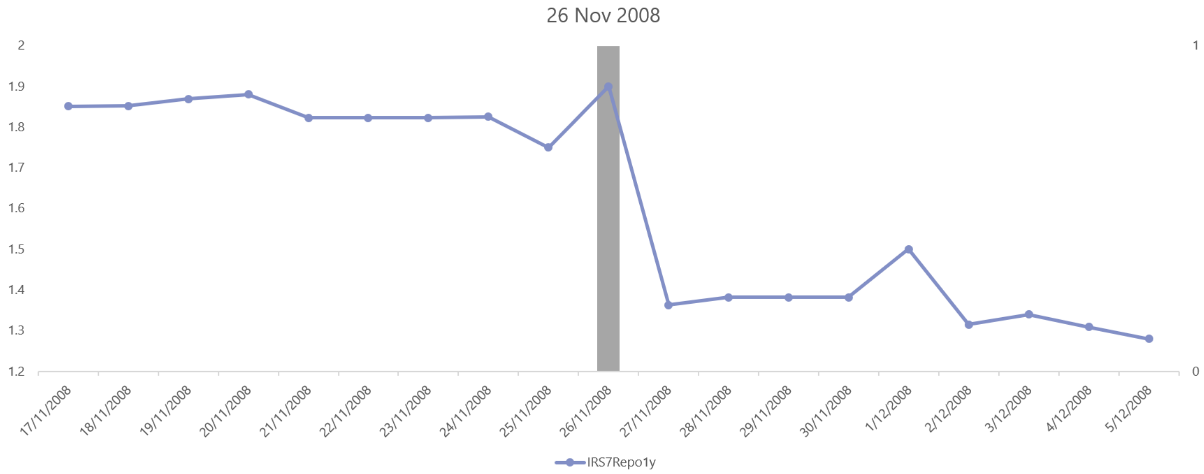
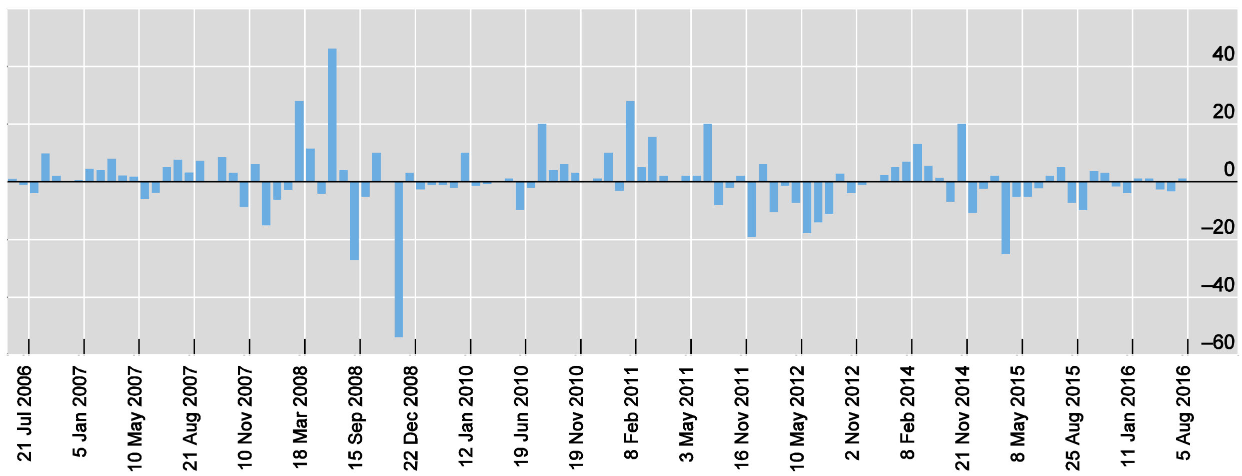
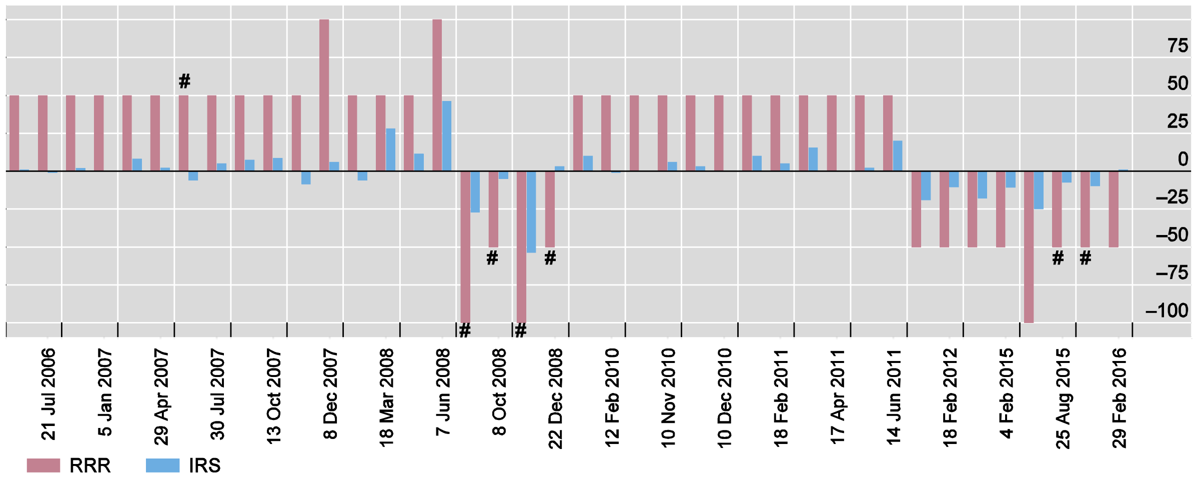


Figure 3: Daily surprises



Note: The figure presents daily monetary policy surprises, defined as the change in interest rate swaps based on 7-day repo, using all monetary policy announcements.

Figure 4: RRR surprises

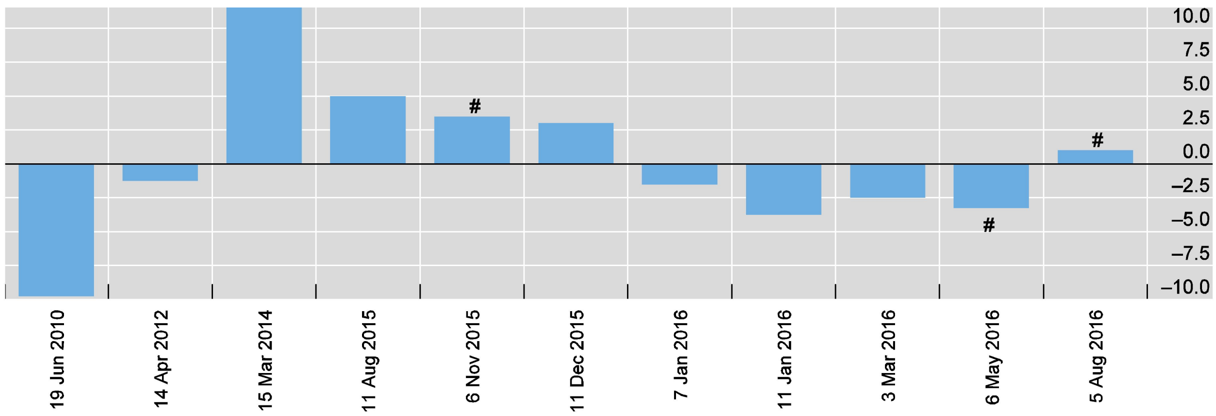


Note: The figure presents daily monetary policy surprises, defined as the change in interest rate swaps based on 7-day repo, using only announcement days on which reserve requirement ratio is changed (blue bars denoted IRS). Red bars plot the actual change in the RRR. A # denotes policy announcement days where a policy instrument, other than reserve requirement ratio, is also changed.

Figure 5: Lending rate surprises

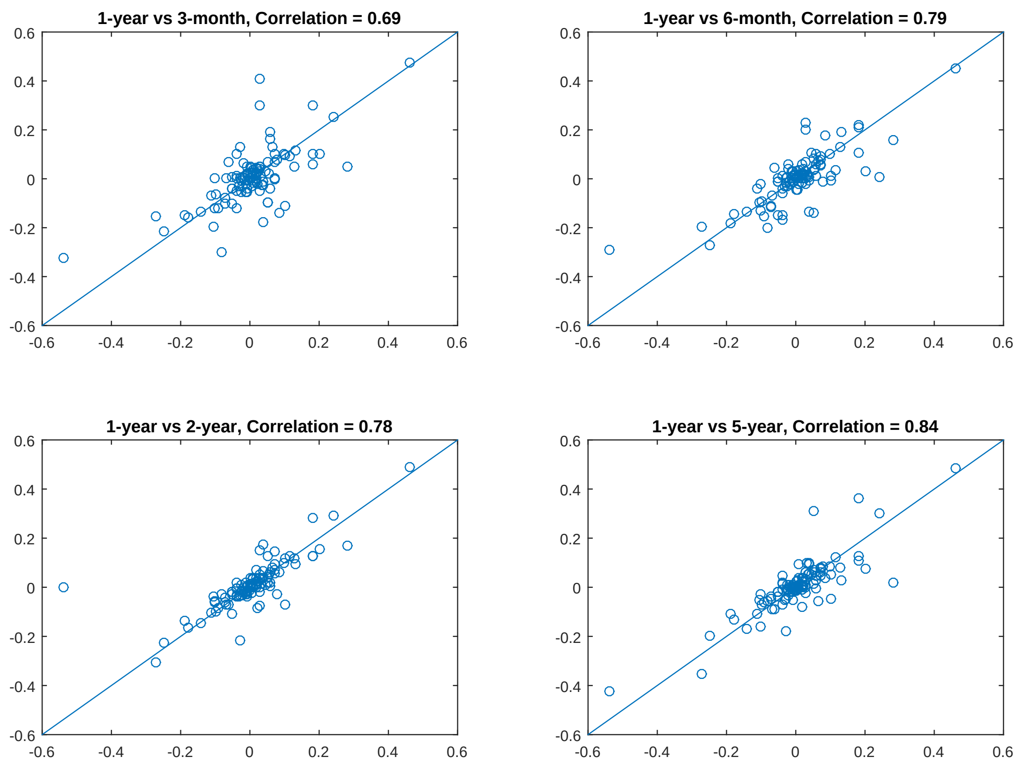
Note: The figure presents daily monetary policy surprises, defined as the change in interest rate swaps based on 7-day repo, using only announcement days on which 1-year benchmark lending rate is changed (blue bars denoted IRS). Red bars plot the actual change in the the 1-year benchmark lending rate. A # denotes policy announcement days where a policy instrument, other than 1-year benchmark lending rate, is also changed.

Figure 6: FX announcement surprises



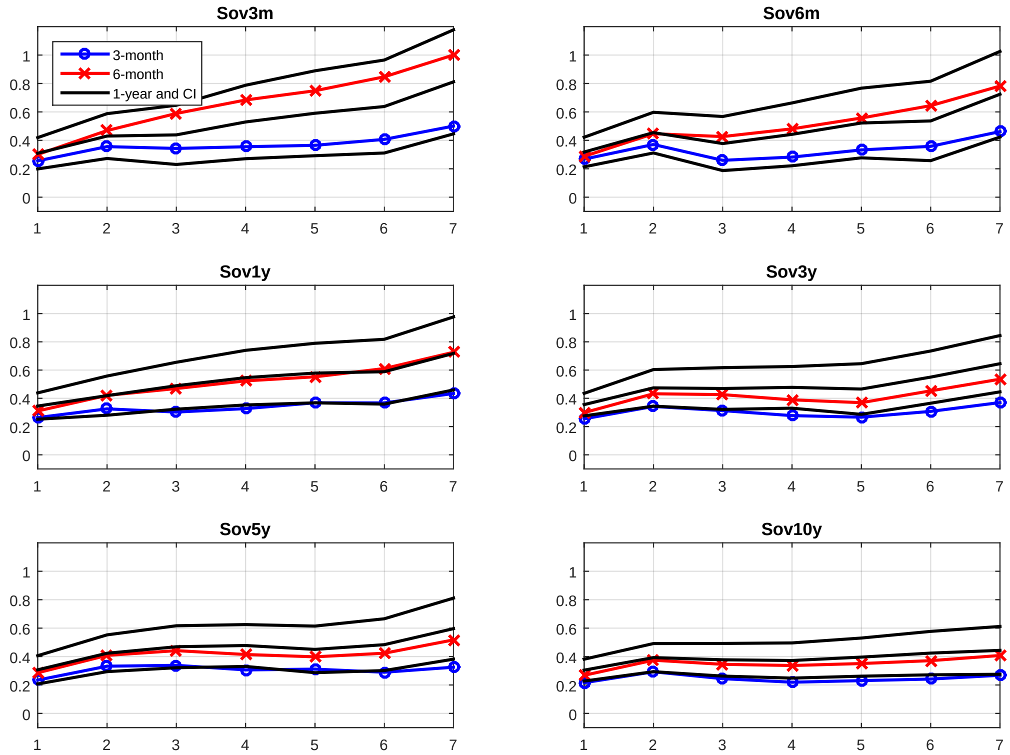
Note: The figure presents daily monetary policy surprises, defined as the change in interest rate swaps based on 7-day repo, using only announcement days on which there is an announcement related to the exchange rate regime. A # denotes policy announcement days where another policy instrument is also changed.

Figure 7: Correlation between surprise measures



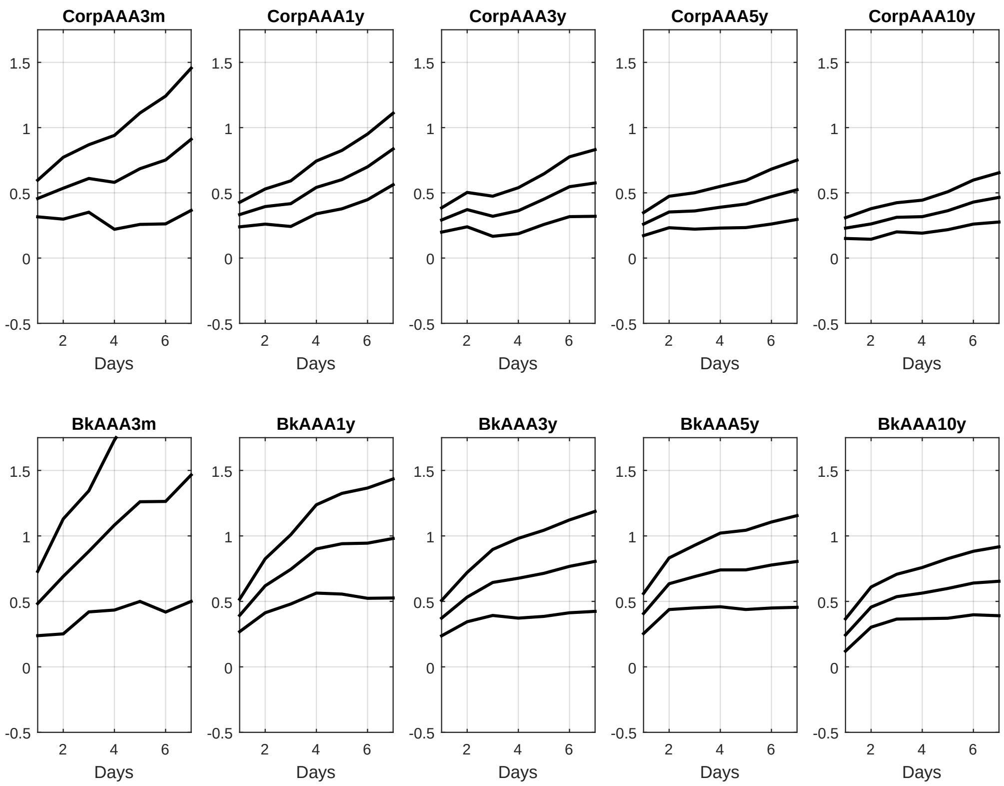
Note: Each panel presents a scatter-plot of monetary policy surprises calculated using a different tenor of IRS to our benchmark measure that uses 1-year IRS. The title also reports the correlation coefficient of each measure against our benchmark. Surprise measures are obtained using all policy announcements.

Figure 8: HF effect of policy surprises: Sovereign yields



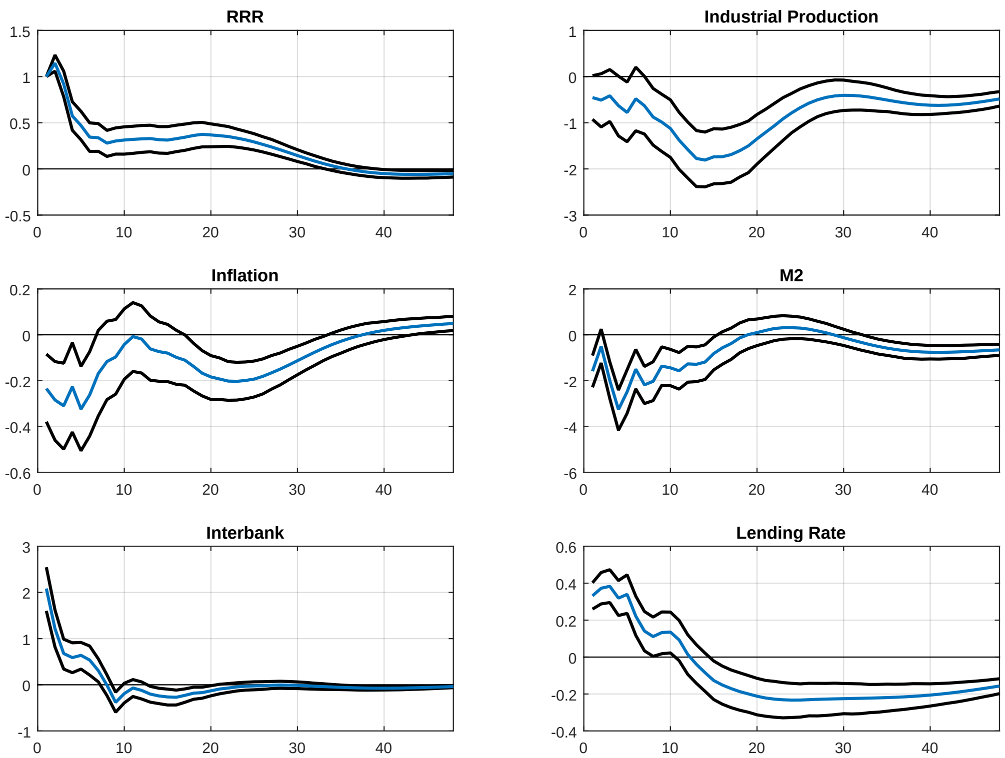
Note: The figure presents the impact of monetary policy surprises on Sovereign yields at various maturities and at different horizons as specified in equation 1. Each panel depicts the response of a particular yield over the following 7 days. The black lines plots the coefficient estimates (middle line) and confidence intervals for the benchmark measure of monetary policy surprises using 1-year IRS based on 7-day repo rate. The lines with circular and star marks plot coefficient estimates when the surprise measure is obtained using 3 and 6 month tenors, respectively.

Figure 9: HF effect of policy surprises: Corporate and Bank bond yields



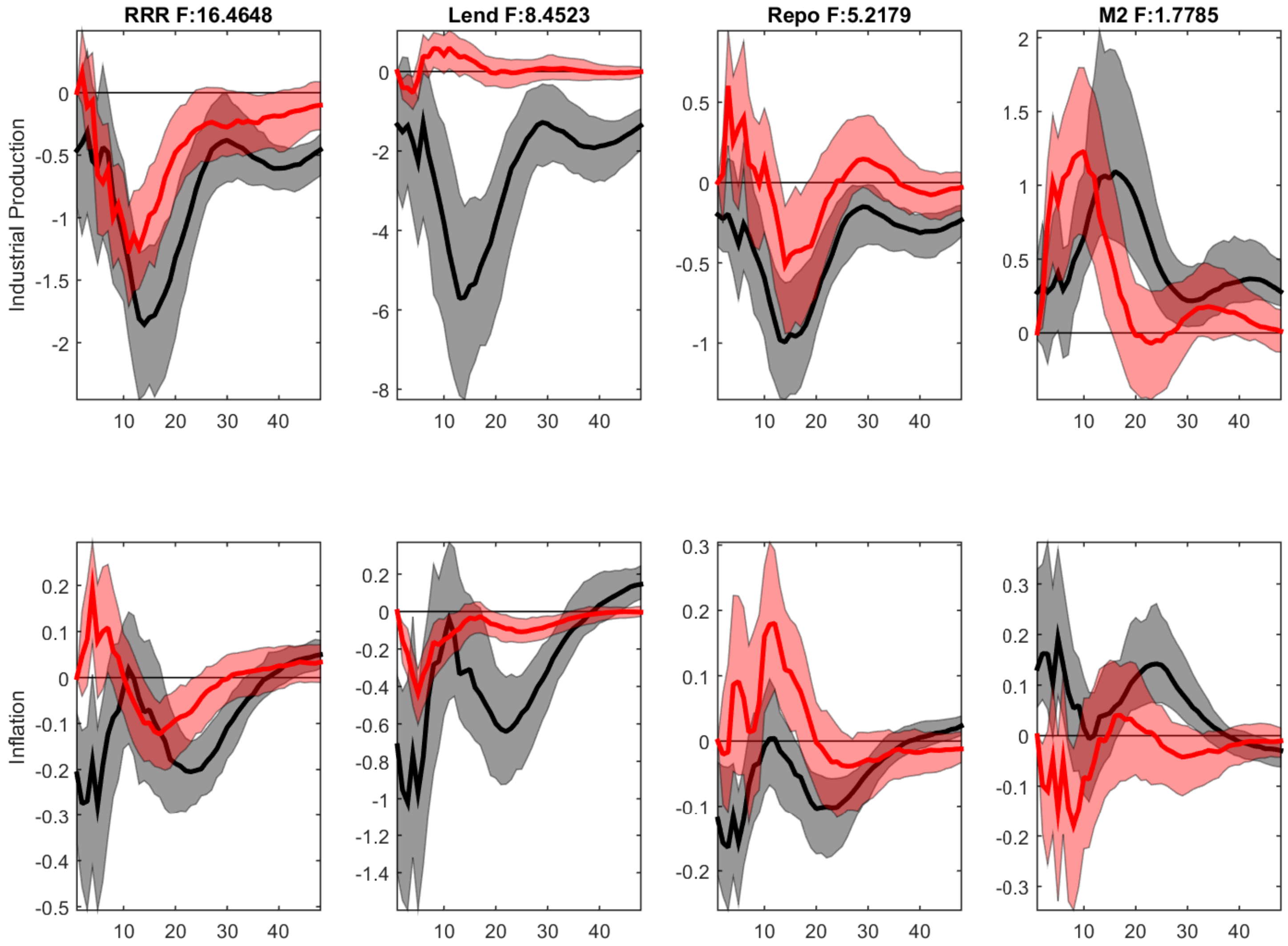
Note: The figure presents the impact of monetary policy surprises on corporate (first row) and bank bond (second row) yields at various maturities and at different horizons as specified in equation 1 . Each panel depicts the response of a particular yield over the following 7 days. The black lines plots the coefficient estimates (middle line) and confidence intervals for the benchmark measure of monetary policy surprises using 1-year IRS based on 7-day repo rate.

Figure 10: Proxy VAR: RRR as policy indicator



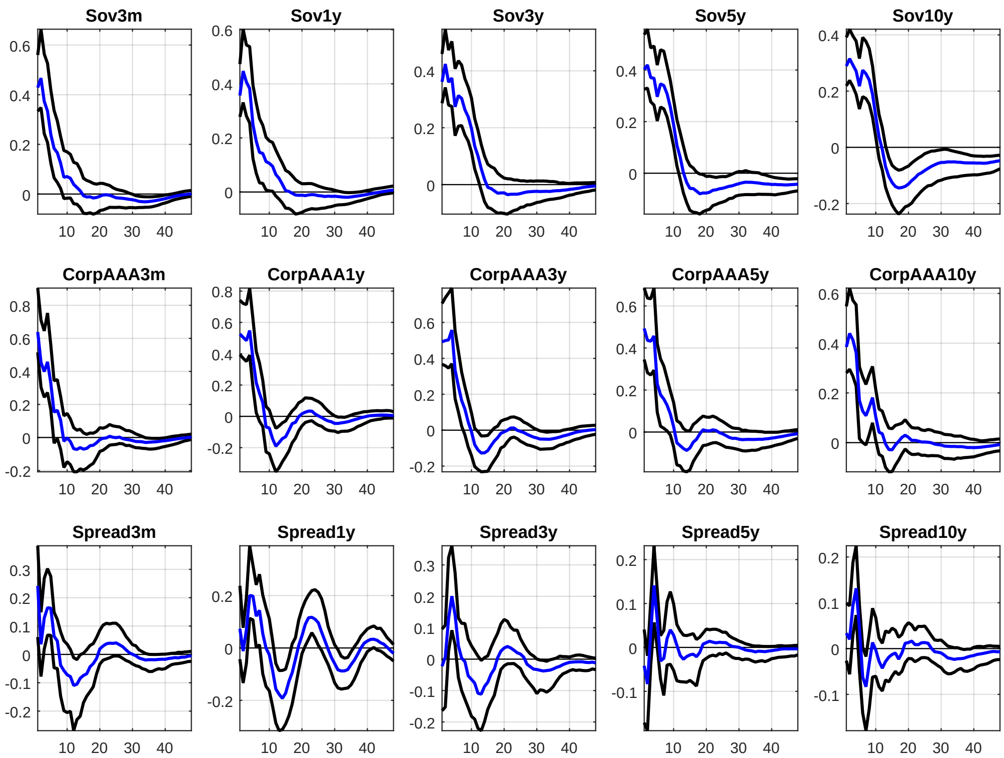
Note: The figure presents the impulse responses to a monetary policy shock that raises the RRR by 1%, obtained from the proxy VAR. The external instrument is monetary policy surprises using 1-year IRS based on 7-day repo rate. Black lines represent 68% confidence intervals.

Figure 11: Proxy VAR vs Cholesky for different policy indicators



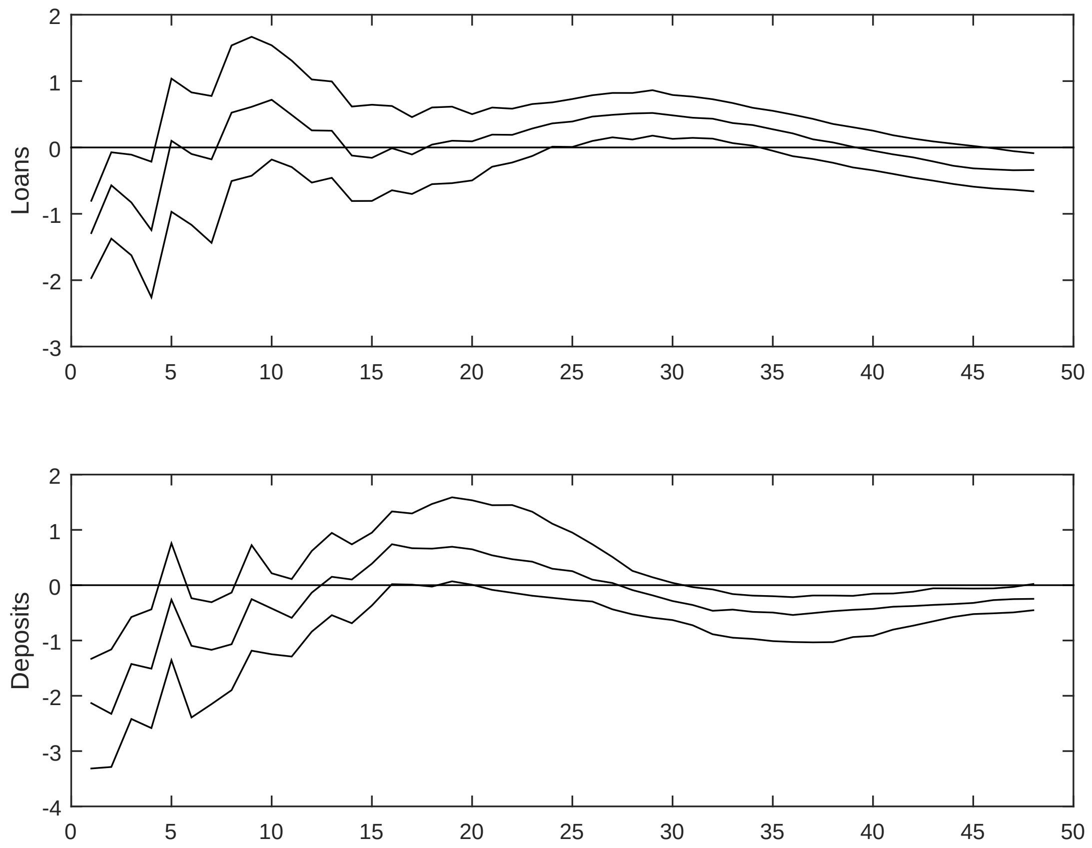
Note: The figure compares impulse responses to a monetary policy shock from Proxy VARs and structural VARs with Cholesky identification. Each column represents a VAR where residuals from a different policy indicator is used to identify monetary policy shocks. The first column reports our basline results using RRR, the second column uses 1-year benchmark lending rate, the third one the 7-day repo rate and the last one the growth rate of M2. The first row displays impulse responses of industrial production and second row those of inflation rates. Black lines and grey shaded areas correspond to impulse responses from the proxy VAR while red lines and shaded areas are from Cholesky identification. Shaded areas represent 68% confidence intervals.

Figure 12: Proxy VAR: Sovereign yields, Corporate yields and spreads



Note: The figure reports impulse responses to a monetary policy shock of sovereign yields (first row), corporate yields (second row) and spread between corporate and sovereign yields (last row) from Proxy VARs. Black lines represent 68% confidence intervals.

Figure 13: Proxy VAR: IRF of loans and deposits to a monetary policy shock



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