Global Research Unit

Global Research Unit Working Paper #2016-022

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Abstract

Analyzing monetary policy in China is not straightforward because the People's Bank of China (PBoC) implements policy by using more than one instrument. In this paper we use a Qual VAR, a conventional VAR system augmented with binary policy announcements, to extract a latent indicator of tightening and easing pressure, respectively, for China. The model acknowledges that policy announcements are endogenous and summarizes policy by a single indicator. The Qual VAR allows us to study the impact of monetary policy in terms of unexpected changes in these latent variables, which we identify using sign restrictions. We show that the transmission of monetary policy impulses to the rest of the economy is remarkably similar to the transmission process in advanced economies in terms of both output growth and inflation despite a very different monetary policy framework. We find that bank loans are not sensitive to policy changes, which implies that window guidance is still a

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necessary policy tool. We also find that the impact of monetary policy shocks is asymmetric in terms of asset prices, that is, the asset price reactions differ in their sensitivity to tightening shocks and easing shocks, respectively. In particular, an easing of monetary conditions boosts stock prices while a tightening shock leaves stock prices unaffected. This shows that monetary policy is not a suitable tool to stabilize asset prices, which raises implications for financial stability and macroprudential policy.

Keywords: China, monetary policy, Qual VAR, transmission mechanism, asset prices, financial stability

JEL classification: E4, E5, C3

1. Introduction

Understanding Chinese monetary policy is more important than ever before. Growth and financial stability in China are increasingly important in driving other countries' financial and business cycles – in Asia and beyond. At the same time, however, interpreting monetary policy in China is difficult. This is because the People's Bank of China (PBoC) uses more than one instrument to implement monetary policy. In fact, the PBoC frequently uses a multitude of instruments ranging from required reserve ratios, benchmark lending rates to benchmark deposit rates to set policy. A characterization of the monetary policy stance that does not draw on the entire instrument set of the PBoC remains incomplete. Therefore, a conventional vector autoregression, which has been the workhorse model for monetary policy analysis in the U.S. and other advanced economies (Christiano, Eichenbaum and Evans, 1999), is not suitable for the Chinese case. Using these models researchers typically identify a monetary policy shock that is driving, among other variables, the single instrument of the central bank.

The aim of this paper is to propose an alternative framework for estimation, which encompasses the multitude of instruments used by the PBoC and, at the same time, remains as close as possible to the standard VAR framework used so widely. Here we propose Dueker's (2005) Qual VAR as a highly useful framework to model Chinese monetary policy. The approach combines a VAR model with a binary variable reflecting policy steps. The assumption is that the binary policy observations, e.g. a series of tightening or easing steps, are driven by a latent variable, which is also included in the VAR system. The latent variable is filtered out of the observables using Markov Chain Monte Carlo estimation based on the two observable inputs, the binary policy dates and the VAR dynamics. In our case, the latent variable can be interpreted as reflecting the PBoC's tightening or easing pressure.

This Qual VAR has several advantages in the context of Chinese monetary policy: First, it can deal with various policy instruments at the same time. As long as, e.g., tightening events are coded as "1" and all other events exhibit a "0", the latent variable summarizes the tightening pressure implemented by multiple policy instruments. In this sense we can account for the multitude of instruments used by the PBoC. Second, the model retains the important features of VAR models. Policy is interpreted in

terms of policy shocks through imposing suitable restrictions on the VAR model. In this paper we use sign restrictions (Uhlig, 2005) to identify a policy shock. A shock is interpreted as a surprise change in the latent policy stance that also affects inflation and output. Hence we do not estimate merely the response at selected policy dates, but locate a shock in periods in which the latent policy pressure moves unexpectedly. That also implies that policy is endogenous as the business cycle feeds back on policy through the VAR dynamics. This is an important advantage over other models using binary policy indicators as exogenous treatments.

In our application the binary data reflects calendar dates at which the PBoC changed its monetary policy. We construct two alternative binary indices, one for policy tightening against the alternative of no policy action and one for policy easing against the alternative of no policy action and estimate a tightening and an easing model separately. This allows us to shed light on the asymmetry involved in the policy transmission process.

It is important to note that the binary coding of policy steps does not imply that all policy steps are equally important. Although each policy tightening and easing is assigned a "1", irrespective of whether it is a weak or a strong policy action, the model endogenously differentiates the relevance of policy steps. Ultimately, it is a surprise change in the policy stance that serves as a monetary policy shock – and this can differ a lot across policy announcements.

Our results are twofold. First, we find that the transmission of policy impulses to the rest of the economy is remarkably similar to the transmission process in advanced economies despite a very different monetary policy framework. After a policy tightening inflation and growth fall for a considerable period of time. In addition, consumption growth falls after a tightening. Following an easing of policy, we see these effects roughly in reverse. We also find an important difference with respect to the transmission mechanism in advanced economies: bank loans do not respond to monetary policy shocks in a way consistent with the VAR evidence on policy transmission in other countries. This is because in China the growth rate of bank loans is detached from conditions on the

interbank market set by the central bank (see Chen, Chen and Gerlach, 2011). Our second finding is related to the asymmetries of policy. We show that a policy easing boosts stock prices. A tightening shock, however, also raises stock prices. The exact opposite happens for housing prices. Both tightening and easing shocks reduce the growth of house prices. Hence, monetary policy has no leverage in containing asset price bubbles. This raises important financial stability concerns.

Our paper is particularly related to two major contributions to the literature: First, He and Pauwels (2008) address the fact that no tool studied in isolation is a good description of monetary policy by modeling the policy stance as a latent variable.[1] They code tightening and easing actions implemented by different instruments as a series of -1/ 0/ +1 and estimate a discrete choice model for China. They show that the reactions function of the PBoC is a function of the inflation gap and the money growth gap, but not the output gap. In this paper we extend this reasoning by letting the latent variable interact with the macroeconomy in order to see the dynamic effect of monetary policy on the economy.[2] Second, Fernald, Spiegel and Swanson (2014) estimate a Factor-augmented VAR model (FAVAR) following Bernanke, Boivin and Eliasz (2005) in order to obtain impulse response functions. They collect a large set of variables from which they extract factors, such that each factor should be less affected by measurement errors or noises. A shock to required reserves or policy-determined interest rates is shown to be transmitted to the economy in a way that is similar to advanced economies. We take away from this study that a VAR system, in our case with a latent variable instead of factors, is generally suitable to analyze the dynamic effects of China's monetary policy transmission. In contrast to their study, we identify monetary policy shocks not through a triangular Choleski decomposition but through sign restrictions.

The remainder of the paper is organized as follows: Section two briefly outlines the policymaking framework of the PBoC. Section three introduces the Qual VAR, the data set and the identification scheme. Section four discusses the main results of the estimation. The results are compared to those

[1] Other recent papers that aim at measuring the monetary policy stance are Shu and Ng (2010) and Sun (2015).

[2] Xiong (2012) extends the work of He and Pauwels (2008).

of a conventionally used shock in required reserves in section five and section six offers some further robustness analyses. Section seven concludes.

2. Some background on China's monetary policy

The objective of the PBoC's monetary policy is stipulated by law as maintaining the stability of the currency and thereby promoting economic growth. In terms of priority, the stability of the currency comes first. Recently, the PBoC added financial stability to its policy objectives, although this was not explicitly listed in the Central Bank Law.

In order to achieve these multiple objectives, the PBoC sets multiple variables such as M2 growth, new loans and outstanding loan growth, interbank interest rates and reserve money as its intermediate operational targets, although it has never strictly stuck to a particular combination of these variables.

The policy instruments that the PBoC uses to achieve its goals can be broadly classified into two categories: quantity based and price based instruments (Shu and Ng, 2010). For each of these categories, the instruments can be either market based or non-market based. The quantity-based instruments include required reserve ratios (RRR), differentiated, dynamic and target reserve requirements, central bank bills, the amount of repo or reverse repo. Until October 2015, the PBoC had maintained either retail deposit rate or retail lending rate controls. The price based policy instruments include benchmark lending and deposit rates, issuance rate of central bank bills, repo or reverse repo rates. After October 2015, the PBoC lifted both retail deposit and lending rate controls, although it continues to announce benchmark deposit and lending rates. Ever since, the PBoC has been trying to establish an interest rate corridor system similar to that of the ECB, with the interest rate on excess reserves at the central bank serving as a floor and the interest rate on the standing lending facility (SLF) serving as the upper limit on short term interest rates. Through the adjustment of short

term interest rates, the PBoC hopes to influence long-term rates and, as a consequence, inflation and real economic activity[3].

Besides the above standard instruments, since the global financial crisis, the PBoC has used macro-prudential policies to supplement monetary policy in maintaining financial stability. These policies are generally implemented together with the Chinese Banking Regulatory Commission (CBRC). Policy instruments such as loan to value ratios, debt to income ratios, capital requirements and dynamic provisioning are used to curb potential housing price bubbles.

If all the above instruments turn out to be inadequate, the PBoC can use window guidance, which is a purely administrative measure. In order for this measure to be effective, the PBoC can threaten serious punishment such as the removal of senior executives if its guidelines are not followed. The window guidance is used not just in the case of overheating, but also to encourage banks to lend, for example, to the sectors that PBoC consider important to the long-term growth of the economy, such as small and medium enterprises or the high-tech sector. In 2009, at the height of the global financial crisis, the PBoC tried to encourage banks to expand their balance sheets. However, with the development of shadow banking and direct financing through capital markets, the effectiveness of window guidance has been eroded (Chen, Chen and Gerlach, 2011).

Structural changes in the Chinese economy over the past three decades have increased the challenges faced by the PBoC in implementing monetary policy. One of the major challenges is distortions in the financial system, which prevents a smooth transmission process for monetary policy. Most of the time, the PBoC has to use several instruments simultaneously. This makes it difficult to represent the PBoC's policy stance with a single instrument. In the next section, we will explain in detail how we construct the tightening and easing index used in this paper based on the multitude of

[3] Here we assume the PBoC takes all the monetary policy decisions. In fact, the PBoC is part of the cabinet. Major policy decisions need to be endorsed by the State Council, although it is never clear which policy move needs to be approved.

instruments used by the PBoC. In doing so, we will try to identify the major policy moves and ignore moves that are mainly used to smooth the liquidity in the banking system.

3. A Qual VAR approach

Here we propose Dueker's (2005) Qual VAR as a highly useful approach to model Chinese monetary policy.[4] The gist of the model is simple: it combines a standard VAR model (Christiano, Eichenbaum and Evans, 1999) with binary information. The assumption is that the binary series is driven by some latent, i.e. unobservable, series, which is endogenous and included in the list of variables modeled by the VAR. Using these two pieces of information, the binary observations and the VAR interaction, the Gibbs sampler can be employed to filter out the latent variable. This model has several advantages for our purposes: (1) Monetary policy is modeled as an endogenous feedback to the economy. (2) We can study policy in terms of shocks derived from VAR dynamics. (3) We acknowledge that monetary policy steps could have been anticipated and study unexpected policy changes only. In our model, a policy shock in an unexpected change in the latent policy variable.

We observe a binary variable, $y_t \in (0,1)$, which in our application represents a policy step. The idea of the model rests on two main assumptions. The first assumption is that this variable is driven by a continuous latent variable y^*. Whether the signal takes the value of one is determined by whether the latent variables are larger than zero

$$y_t = \begin{cases} 0 \;\; if \; y_t^* \leq 0 \\ 1 \;\; if \; y_t^* > 0 \end{cases}.$$

The second main assumption is that the latent variables are endogenous, and so is the binary variable, and are determined by a VAR system together with other observable variables. Think of the binary variable as reflecting tightening steps of the PBoC. The latent variable can then be interpreted as the pressure to implement a tightening action. If this pressure crosses some threshold, the PBoC

[4] See also Tillman (2015) and Meinusch and Tillmann (2016) for Qual VAR applications to binary Quantitative Easing announcements of the Federal Reserve.

acts and implements the policy. The latent tightening pressure is endogenous and interacts with other macroeconomic variables in a VAR. Formally, a Qual VAR model with k endogenous variables and p lags can be written as

$$\Phi(L)Y_t = \mu + \varepsilon_t,$$

Where

$$Y_t = \begin{pmatrix} X_t \\ y_t^* \end{pmatrix}$$

consists of macroeconomic data, X_t, and the latent variable, y_t^*.

Markov Chain Monte Carlo (MCMC) estimation can be used to jointly estimate the VAR system and filter out the latent variable. It is the multivariate interaction in the VAR system that allows us to extract the endogenous latent variable together with the information contained in the binary information.

This procedure a priori puts equal weight to all policy announcements. However, in combination with the VAR interaction the Gibbs sampler extracts a latent variable whose level can differ vastly across the binary policy steps. That is, the model endogenously attaches a different level of importance to each policy step.

Based on the estimated VAR system and a suitable identification scheme presented below we derive impulse responses showing the response of each variable to a shock in the latent variable. In this sense the Qual VAR is used as a conventional monetary policy VAR. It is important to stress that we are not studying the response of the economy to a 1/0 tightening or easing dummy, respectively, but the response to the unobservable policy stance extracted by the model.

In order to facilitate the MCMC estimation, we have to make a few distributional assumptions about the VAR coefficients, the variance-covariance matrix and the latent variable. For the VAR coefficients,

Φ, we assume a normal distribution, where the means and the variances are given by the OLS coefficients. The variance-covariance matrix, Σ, is Wishart-distributed. The latent variable**,** y^*, follows a truncated Normal distribution as the variable is bounded for $y_t = 1$. The MCMC estimation is run with 10,000 iterations, from which the first 2,000 are dropped to allow for convergence towards the posterior distribution.[5]

We estimate two different models, one in which we include the 0/1 series of tightening events (*tightening* model) and one in which we include the respective series reflecting binary easing events (*easing* model). Since the model can only handle binary data, we cannot include the overall policy stance, i.e. a -1/ 0/ +1 series of policy events. However, we think this is advantageous because it allows us to assess whether tightening and easing actions of the PBoC have asymmetric effects on the economy.

3.1 The data set

Our estimated Qual VAR system contains five endogenous variables: first, the latent policy stance filtered out of the VAR interaction and the binary policy steps to be outlined below; second, the year-on-year growth rate of industrial production as a measure real economic activity; third, the year-on-year changes of consumer prices. Note that consumer prices are not available in levels but only in year-on-year growth rates. This dictates our choice of year-on-year growth rates for the other variables. These three variables are included in each of our different specifications.

In addition to the three core variables, we include two other variables out of the following list: The year-on-year change in real consumption; the year-on-year change in the loans to the non-financial sector; the year-on-year change in stock prices or the year-on-year change in house prices in order to assess whether monetary policy affects asset prices. The model that includes consumption and stock prices besides the core variables is our baseline specification. To summarize, our vector of observables is

[5] For details we refer to Dueker's (2005) original contribution.

$X_t = (\Delta IP, \Delta CPI, \Delta CONS, \Delta STOCKP)'$,

where all series are detrended as mentioned before; Δ refers to year-on-year growth rates.

The data is taken from the CEIC database.[6] We are particularly interested in the sensitivity of asset prices to tightening and easing shocks, respectively, and how consumption growth interacts with real activity and asset prices.[7] The data is monthly and spans 1999:1 to 2015:07. Both the start and the end of the sample period are dictated by data availability. Before the late 1990s reliable macroeconomic data is not available for China.

A salient feature of Chinese macroeconomic data is the presence of a strong growth trend. In fact, most variables exhibit long and persistent swings in growth rates, which are unlikely to be related to monetary policy or other cyclical policies. These low-frequency movements in growth rates reflect factors such as China's exorbitant economic catch-up, its WTO access or the fiscal stimulus package of 2008/09. Most importantly, these factors are structural in nature, not cyclical. For this reason we extract a slowly moving trend from each growth rate, which we proxy by the average growth rate over the previous three years.[8] The series used in the estimation of the Qual VAR model are the deviations of the year-on-year growth rates from these long-run growth trends. Figure (1) depicts the data series.

The downside of removing a trend from the growth rates of our variables is the risk of overdifferencing (Hamilton, 1994). However, we believe that for our purposes the variables have to be detrended. In a fast growing and converging economy, the long-run growth trend is not determined by monetary policy. Furthermore, typical unit root or stationarity tests, respectively, which are designed under

[6] As an important characteristic of Chinese data, the Chinese New Year celebrations, which are at the end of January and beginning of February, are reflected in economic realizations for these two variables. For the macroeconomic raw data we replace the January and February entry with the average of December and March, thus leading to a yearly growth rate that is equal in January and February as in Fernald, Spiegel and Swanson (2014).

[7] See Koivu (2010) for the importance of a wealth channel of monetary transmission in China.

[8] For some variables lacking a sufficiently long pre-1999 series, the growth trend in 1999 and 2000 is approximated by the one-year or two-year average growth rate, respectively. After 2000, we can use the three-year average for each variable.

laboratory conditions, certainly do not apply to an economy that has experienced frequent structural changes.

An important input for the Qual VAR and the Gibbs sampler used to extract the latent policy stance is the binary policy information. As mentioned before, we use two separate, binary policy measures – one for each model we estimate. The first reflects tightening measures of the PBoC. We use this to estimate the *tightening model*

$$y_t^{tight} = \begin{cases} 0 \;\; if \; y_t^{*,tight} \leq 0 \\ 1 \;\; if \; y_t^{*,tight} > 0 \end{cases}.$$

The second model, the *easing model*, is based in a binary series of easing steps

$$y_t^{ease} = \begin{cases} 0 \;\; if \; y_t^{*,ease} \leq 0 \\ 1 \;\; if \; y_t^{*,ease} > 0 \end{cases}.$$

Tables (2) and (3) list the most important tightening and easing steps within our sample, which are used to code y_t^{tight} and y_t^{ease}. It can be seen that over the past 15 years, the PBoC regularly used three instruments to implement major policy moves, the required reserve ratio, the benchmark lending rate and the deposit rate. The PBoC regularly conducts open market operations such as 7-day repo and reverse repo operations, issuing of central bank bills. Most of these operations are aimed at influencing interbank liquidity to smooth the shocks from liquidity demand, such as injecting liquidity before big IPOs, holidays such as Chinese New Year or month end interest rate smoothing. When compiling the binary policy index used in this paper, we ignore these fine tuning operations, so that our index only reflects the major policy moves. It has been argued in the literature that to have a correct measure of the monetary policy stance, it is important to focus on the policy moves that the central bank deliberately initiates and ignore minor moves that are mainly used to accommodate liquidity shocks in financial markets (Romer and Romer, 1989; Bernanke and Blinder, 1992; Bernanke and Mihov, 1998).

The months in Tables (2) and (3) are months in which policy becomes effective. It is an important advantage of the Qual VAR that it can summarize the policy stance in a single variable, which is then used to study the transmission mechanism. The tightening and easing dates are coded as +1 in the respective binary series. For all other dates the value of the binary series is zero.

Since we estimate two different models, one for tightening actions and one for easing actions, we obtain two latent measures of policy pressure. We interpret each series as reflecting policy pressure relative to a neutral policy stance. This allows us to work with tightening and easing shocks separately.

Finally, we have to specify a lag order *p* for the VAR model. Throughout the paper we choose to include *p* = 3 lags.

3.2 Identification

A monetary policy shock is identified using state-of-the-art sign restrictions following Uhlig (2005). A restrictive monetary policy shock is assumed to raise the latent tightening variable, reduce industrial production and reduce the change in the CPI. An expansionary shock is assumed to raise the latent easing variable, raise industrial production and raise the CPI. Table (1) summarizes the constraints.

Table 1: Identification restrictions

	latent variable	ΔIP	ΔCPI	$\Delta Credit$ or $\Delta Consumption$	$\Delta AssetPrices$
tightening model	+	-	-	unrestricted	
easing model	+	+	+	unrestricted	

Notes: The two models are estimated separately. The restrictions are imposed for *t = 1,2,3*,4.

The restrictions are imposed for four consecutive months starting from the moment the shock impacts, *t = 0*. We believe that this set of constraints, which is often used to identify monetary policy shocks in

advanced economies, is well suited to characterize Chinese monetary policy. The policy of the PBoC is ultimately also directed towards real activity and inflation, so constraining these responses should identify a Chinese monetary policy shock. Note that we only restrict the sign of the response, but not its magnitude, its significance or its persistence. We expect that a tightening action of the PBoC reduces credit growth, private consumption and asset prices.

4. Results

The results consist of the estimated latent policy variable for the tightening and the easing model, respectively, and the impulse response functions depicting the response of the endogenous variables to a one-time surprise increase in the latent variable one standard deviation in size. While we report the median of all draws as our standard measure of an impulse response, we also report the Fry-Pagan median-target impulse response (Fry and Pagan, 2011). The latter reflects the draw that delivers the impulse response closest to the median. Taking the median of all draws does not always guarantee that the resulting impulse response is one that could potentially have been observed in reality.

Figure (2) presents the estimated latent tightening pressure for the baseline model. We see how pressure to tighten gradually builds up before 2007 and than falls drastically in the aftermath of the global financial crisis. Although all binary dates are treated equally a priori, the estimation process attaches very different levels of the latent variable to each policy date. The figure shows that changes in the monetary policy stance are cyclical. Once the PBoC enters a tightening/easing cycle, it will keep its tightening/easing stance for a while until it more or less achieves its policy objectives. The exeception is during the global financial crisis, when the PBoC was forced to ease monetary policy because of global shocks.

Figure (4) shows how a shock to the latent tightening pressure, i.e. an unexpected change in the policy stance, affects the economy. In all impulse response figures the vertical line indicates the period for which sign restrictions are imposed. The dotted line represents the median-target impulse responses as discussed before, which are always very close to the median response. Interestingly, the latent variable remains persistenly positive after the initial shock, thus indicating that the tightening stance remains elevated for some time. Not surprisingly, growth and inflation fall reflecting the restrictions imposed. However, both growth and inflation remain subdued even after the period for which we impose sign restrictions. A tightening shock leads to an initial 0.40 percentage point drop in growth. Furthermore, consumption growth falls and reaches it minimum about eight months after the shock. This shows that consumption demand is sensitive to monetary policy changes in China, not just investment demand which was generally considered to be the main source of China's growth volatility. It is also understandable that the impact on consumption is relatively small as consumption generally reacts to changes in permanent income.

The response of stock prices is couterintuitive and puzzling. Stock prices increase after a tightening. This is a result which we obtain for many different specifications. One possible reason for this is that our monetary policy stance index is driven by changes of RRR and benchmark lending and deposit rates. With ample liquidity from large capital inflows, the adjustment of RRR and benchmark rates are very much behind the curve. Unless monetary policy is tightened in a dramatic way, it will not have much impact on stock prices since there will still be ample liquidity even after the increase in RRR. Another possible explanation is that there is a persistent bubble in the stock market whose trend cannot be broken by monetary policy moves. Taken at face value, it implies that monetary policy is not a suitable instrument to tackle bubbles in the stock market, which has implications for financial stability and macroprudential policy.

The latent easing pressure is presented in Figure (3). It can be seen that easing pressure peaks at the time of the global financial crisis and has increased sharply in recent months. Figure (5) plots the corresponding impulse responses. An easing shock raises growth and inflation strongly. As expected, it also leads to a strong consumption boom and stock market appreciation. When compared with

Figure (4) we see an important asymmetry of monetary policy: an easing step raises stock prices but a tightening step does not. This is hardly surprising. It shows that the PBoC's tightening move was not necessarily binding, but its easing move actually released binding constraints. For example, when PBoC raised RRR, it usually was behind the curve, and the increase was probably not large enough to mop up excess liquidity in the banking system. But when it lowered RRR, the PBoC released a large amount of liquidity. This kind of policy asymmetry could generate the asymmetric effects we found in stock prices.

The results for tightening in a specification with bank loans is presented in Figures (6). While the core macroeconomic variables respond as expected to a tightening, loans and stock prices tend to increase. This supports our view that monetary policy in the way it is conducted is probably ill suited to combat financial instability. For this and all following specifications we do not present the estimated latent variables in order to save space. The latent variables hardly differ across different specifications. Figures (7) present the corresponding finding for an easing shock. After a surprise easing of monetary policy, stock price growth increases by 10 percentage points, which is a strong appreciation in real terms as inflation increases only modestly. The loan growth tends to decrease. The response of bank loans from both tightening and easing moves are not surprising. It is well known that in China the monetary transmission from interbank market to retail lending is not effective.

During the sample period that this study covers, China encountered continuous and large scale capital inflows. Even after the PBoC took steps to sterilise capital inflows through issuing central bank notes and raising RRR, the interbank market generally had ample short term liquidity. This short term liquidity usually went to the stock, bond and short-term bill discounting market. It did not necessarily go to retail lending. This is why an increase in RRR in our sample does not necessarily change conditions in the retail lending market. Since the PBoC is usually behind the curve, the actul data shows it usually moves with increases in stock prices. The lowering of RRR, however, releases a large amount of liquidity and pushes up stock prices. On the retail lending market, the benchmark lending rate is not necessarily the equilibrium rate. The actual lending rate was fully liberalized after July 2013. Before that a non-binding floor was in place from October 2004 onwards. So adjusting the

benchmark lending rate does not necessarily change lending conditions in the credit market (see Chen, Chen and Gerlach, 2011). Therefore, loan growth appears disconnected from monetary policy moves as summarized in our tightening or easing indices. Instead, in times of an overheating economy or a serious recession, the PBoC resorts to window guidance to influence the loan growth. Since the VAR model does not include a proxy for window guidance, it cannot shed more light on the loan-market response from window guidance. In fact, there is no generally accepted variable that represents window guidance, other than loan growth itself. With full interest rate liberalization and still not so effective interest rate transmission from the interbank bank market to the retail lending market, it is unlikely that the PBoC will give up its window guidance tool, and may even use it more often to maintain financial stability.

We now want to assess the response of house prices, another asset class which is important for the monetary transmission mechanism, to a monetary tightening or easing.[9] The results are shown in Figure (8) and (9). We find that house price growth falls after both a tightening and an easing. This also seems counter-intuitive. However, it is not difficult to understand. In China, banks usually adjust mortgage rates after changes of benchmark lending rates, and mortgage loans are generally considered good assets for banks as the default rate is very low. When the PBoC raises its benchmark lending rates, banks usually raise their mortgage rates immediately. On the other hand, when PBoC lowers benchmark lending rates, banks lower mortgage rates, but usually with a delay. In the past 15 years, housing prices have shown a strong increasing trend in China. The PBoC has on several occasions had to restrict lending to real estate developers through window guidance to curb potential overheating in the housing market. In addition to the policy moves included in the Qual VAR, macroprudential policies have been used by the Chinese authorities, some of which are directed towards curtailing the house price boom. This is another factor that might explain our findings.

[9] See Bian and Gete (2015) for a VAR study with sign restrictions on Chinese house price. Unfortunately, the paper does not provide impulse response functions. They consider preference, TFP and other shocks, but not a monetary policy shock.

To summarize, by using a Qual VAR, we find that the core variables exhibit a response pattern which is very similar in timing and magnitude to the transmission of policy in advanced economies.[10] This is remarkable given that China's monetary policy transmission is found to be not very effective. This shows that by combining different policy instruments together and using them simultaneously, the PBoC can still more or less achieve its policy objectives, although this might look inefficient from an advanced economy point of view. A second finding is that a monetary policy tightening seems to have no effect on stock prices. While we show this result in an innovative model, the basic notion of it has been discussed before. Yao, Luo and Loh (2011) use a cointegrated model to show that monetary policy has little effect on the stock market. These authors ascribe this to the large bubble component of stock prices in China. Monetary easing does raise stock prices, but the effect is short-lived. Recent stock market turmoil has also suggested that monetary policy is not particularly effective in stabilizing the stock market. Stock prices in China are found to be disconnected with economic fundamentals and are very volatile. Monetary policy cannot do much about this.

5. Comparing the Qual VAR results with conventionally measured policy

The previous sections presented the response of the endogenous variables to a one standard deviation shock to the latent variable estimated by our Qual VAR. As discussed before, using the Qual VAR has several advantages over a conventional VAR. There is, however, one drawback: the size of the policy shock is not directly comparable to a change in an observable policy instrument. For that reason, we present in this section an estimated conventional VAR model with exactly the same variables as in our baseline model and the same sign restrictions imposed. The only change with respect to our baseline model is that we transform the Qual VAR into a VAR by substituting the latent variable with the observable change in required reserve ratios (RRR).

Figure (10) reports the results on an unexpected cut in RRRs by one standard deviation. We see that this is an expansionary policy step as output and inflation as well as consumption increase. When

[10] This is consistent with Fernald, Spiegel and Swanson (2014).

comparing the magnitude of the impact response of industrial production with the impact response in Figure (5), we note that the responses are roughly similar. The impulse response functions of one of these two models would lie in the confidence bands of the other model. This thought experiment, in turn, implies that the easing shock to the latent variable of one standard deviation that we studied before is roughly equivalent to a 0.20 percentage point cut in RRR. This comparison is illustrative only as we cannot study the asymmetry of the responses in this conventional VAR model.

6. Robustness

As Chinese data on real economic activity is often believed to be not very reliable, we use this section to present results based on an alternative index of real growth. We build an index of economic activity inspired by the remarks of the Chinese Prime Minister Li Keqiang, then party secretary in the Liaoning province, to the then US-ambassador in 2007. Li suggested measuring real activity using indicators of electricity consumption, new bank loans and cargo freight volume.[11] Since we do not have data for new loans dating back to 1999, we use only the growth rate of electricity consumption and the growth rate of cargo measured in ton-kilometers. After normalizing both series we use the average of both normalized growth rates as our measure of economic activity. Figure (11) presents the growth rates of industrial production and the Li Kequiang index, respectively. Both series exhibit a remarkable comovement over the sample period.

The estimation results are presented in Figure (12). A monetary policy easing leads to a persistent 0.01 percentage point increase in the growth rate of the Li Keqiang index. Given the overall size of fluctuations in this measure, this is a quite strong response. All other responses remain virtually unchanged. Hence, we can conclude that our results are reasonably robust with respect to alternative measures of real economic activity.

[11] See also *Financial Times*, 29. September 2015, for a detailed report and a discussion of the reduced reliability of the Li Keqiang index due to the growth of the service sector.

7. Conclusions

This paper uses a Qual VAR to study the effects of China's monetary policy. Since the PBoC usually uses several instruments simultaneously in setting monetary policy, it is difficult to measure the policy stance. This paper uses latent policy variables to reflect tightening and easing policy steps by the PBoC. By combining binary information on observed policy steps with a conventional VAR model this paper backs out the latent measures of the policy stance from observables through Bayesian methods. Based on impulse response functions we show the dynamic effects of the PBoC's monetary actions on macroeconomic variables. The recovered latent measures of the tightening and easing stance, respectively, show the intensity and the cyclical nature of the PBoC's tightening or easing pressure.

We find that the PBoC, by using a multitude of policy instruments, generally achieves its macroeconomic stabilization aims, such as curbing an overheating economy and reducing inflation. This paper also finds asymmetric effects of the PBoC's monetary policy actions. The easing steps are typically more effective than the tightening measures, in particular with respect to the response of stock prices to monetary policy changes. A policy tightening actually increases stock prices initially, which is opposite of what would be expected. The main reason for this counter-intuitive effect is that the PBoC's tightening actions are usually behind the curve. Even after a tightening action, there is still abundant liquidity in the banking system, which makes the policy ineffective. Changes in retail lending appear disconnected from either tightening or easing action.

These findings show that the monetary policy transmission through bank lending channel is not very effective in China. That is why the PBoC from time to time has to resort to what is known as window guidance. The effects of monetary policy on stock prices, loan growth and house prices show that monetary policy might not be a good tool to achieve financial stability.

This paper mainly focuses on the dynamic effect of the PBoC's monetary policy actions. Given that the policy moves of the PBoC are increasingly influential for global financial markets, it is certainly interesting to study the reaction function of the PBoC. He and Pauwels (2008) found that the PBoC focuses more on inflation and money growth, but not so much on the output gap. With China's history of hyperinflation, this is understandable. Given that the proclaimed objectives of the PBoC include promoting economic growth and financial stability, and the asymmetry found in this paper, this is an area that deserves further study.

Most recently, in October 2015, the PBoC lifted the upper limit of interest rates on deposits. This completed the process of interest rate liberalization. Now interest rates across the yield curve are fully liberalized.

It is the PBoC's objective to establish a new monetary policy framework with short-term interest rates as its main policy instruments. The short-term rates in money markets have been very volatile, the PBoC has been trying to stabilize short-term rates through repo operations. Its longer term objective is to build a system similar to the ECB's interest rate corridor system with a short-term rate such as the 7-day repo rate as its main policy target, the rates on excess reserve and the standing lending facility serving as its lower and upper bound for short-term liquidity respectively. It will be of interest to study the effects of this policy shift on the monetary policy transmission. We leave this for future research.

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Table 2: Important tightening steps of the PBC

Tightening Date	Required Reserves Ratio (in %)	Benchmark Lending Rate (in %)	Benchmark Deposit Rate (in %)
2003/09	7.00 (+1.00)		
2004/04	7.50 (+0.50)		
2004/10		5.58 (+0.37)	2.25 (+0.27)
2006/04		5.85 (+0.27)	
2006/07	8.00 (+0.50)		
2006/08	8.50 (+0.50)	6.12 (+0.27)	2.52 (+0.27)
2006/11	9.00 (+0.50)		
2007/01	9.50 (+0.50)		
2007/02	10.00 (+0.50)		
2007/03		6.39 (+0.27)	2.79 (+0.27)
2007/04	10.50 (+0.50)		
2007/05	11.00 (+0.50)	6.57 (+0.18)	3.06 (+0.27)
2007/06	11.50 (+0.50)		
2007/07		6,84 (+0.27)	3.33 (+0.27)
2007/08	12.00 (+0.50)	7.02 (+0.18)	3.60 (+0.27)
2007/09	12.50 (+0.50)	7.29 (+0.27)	3.87 (+0.27)
2007/10	13.00 (+0.50)		
2007/11	13.50 (+0.50)		
2007/12	14.50 (+1.00)	7.47 (+0.18)	4.14 (+0.27)
2008/01	15.00 (+0.50)		
2008/03	15.50 (+0.50)		
2008/04	16.00 (+0.50)		
2008/05	16.50 (+0.50)		
2008/06	17.50(+1.00)		
2010/01	15.50 (+0.50)		
2010/02	16.00 (+0.50)		
2010/05	16.50 (+0.50)		
2010/10		5.56 (+0.25)	2.50 (+0.25)
2010/11	17.50 (+1.00)		
2010/12	18.00 (+0.50)	5.81 (+0.25)	2.75 (+0.25)
2011/01	18.50 (+0.50)		
2011/02	19.00 (+0.50	6.06 (+0.25)	3.00 (+0.25)
2011/03	19.50 (+0.50)		
2011/04	20.00 (+0.50)	6.31 (+0.25)	3.25 (+0.25)
2011/05	20.50 (+0.50)		
2011/06	21.00 (+0.50)		
2011/07		6.56 (+0.25)	3.50 (+0.25)

Notes: Each tightening date is coded as +1 in y_t^{tight}.

Table 3: Important easing steps of the PBC

Easing Date	Required Reserves Ratio (in %)	Benchmark Lending Rate (in %)	Benchmark Deposit Rate (in %)
1999/06		5.85 (-0.54)	2.25 (-1.53)
1999/11	6.00 (-2.00)		
2002/02		5.31 (-0.54)	1.98 (-0.27)
2008/09	17.25 (-0.25)	7.20 (-0.27)	
2008/10	16.75 (-0.50)	6.66 (-0.54)	3.60 (-0.54)
2008/11		5.58 (-1.08)	2.52 (-1.08)
2008/12	15.00 (-1.75)	5.31 (-0.27)	2.25 (-0.27)
2011/12	20.50 (-0.50)		
2012/02	20.00 (-0.50)		
2012/05	19.50 (-0.50)		
2012/06		6.31 (-0.25)	3.25 (-0.25)
2012/07		6.00 (-0.31)	3.00 (-0.25)
2014/11		5.60 (-0.40)	2.75 (-0.25)
2015/02	19.00 (-0.50)		
2015/03		5.35 (-0.25)	2.50 (-0.25)
2015/04	18.00 (-1.00)		
2015/05		5.10 (-0.25)	2.25 (-0.25)
2015/06		4.85 (-0.25)	2.00 (-0.25)

Notes: Each easing date is coded as +1 in y_t^{ease}.

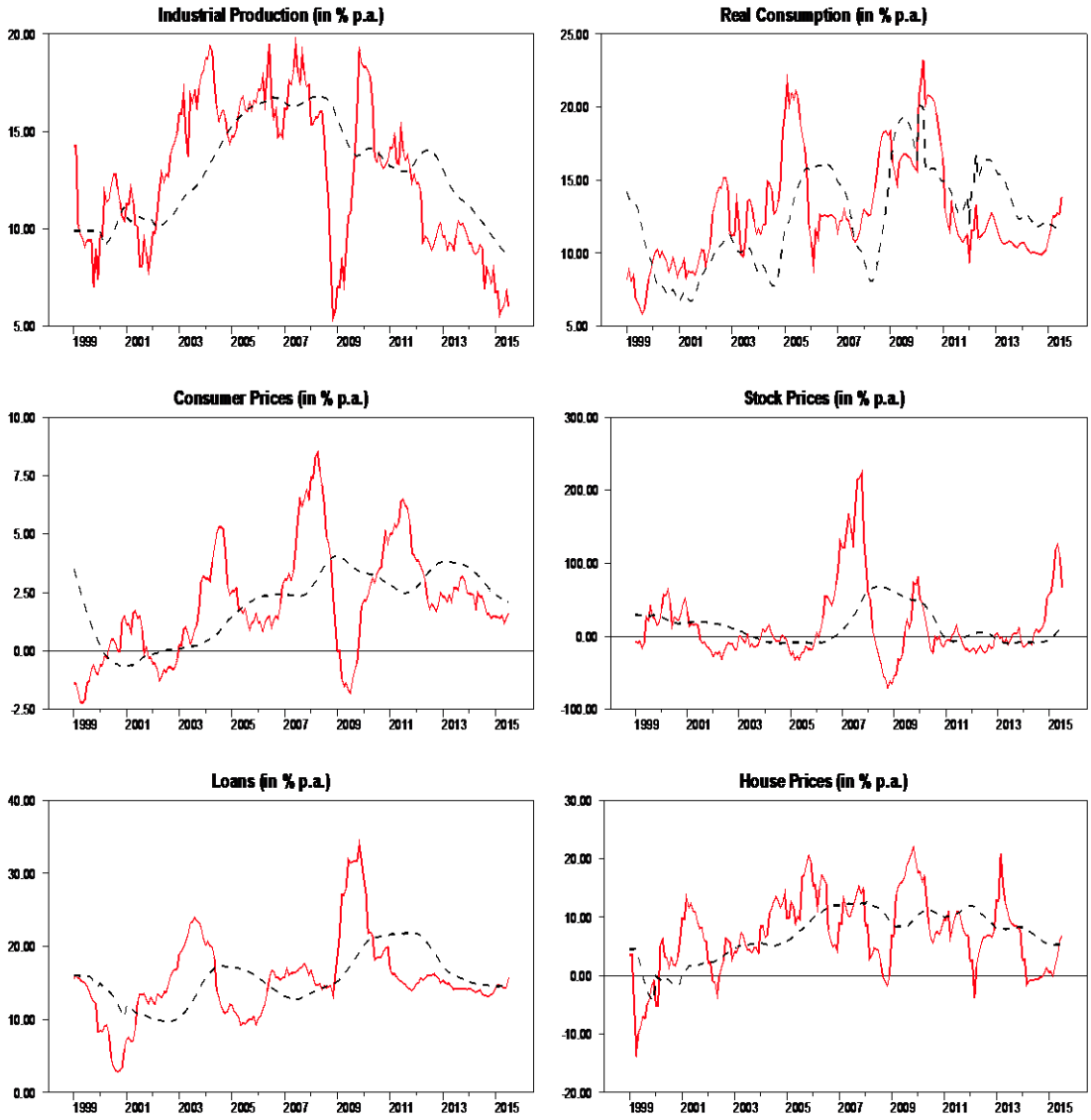

Figure 1: Growth rates (red) and moving-average growth rate (black)

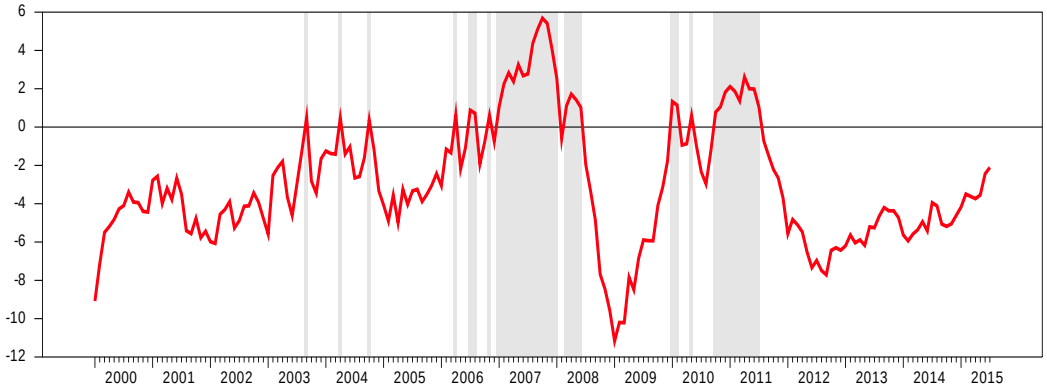

Figure 2: Latent tightening pressure for baseline model

Notes: The red line indicated tightening pressure; the shaded areas reflect actual tightening episodes of the PBoC.

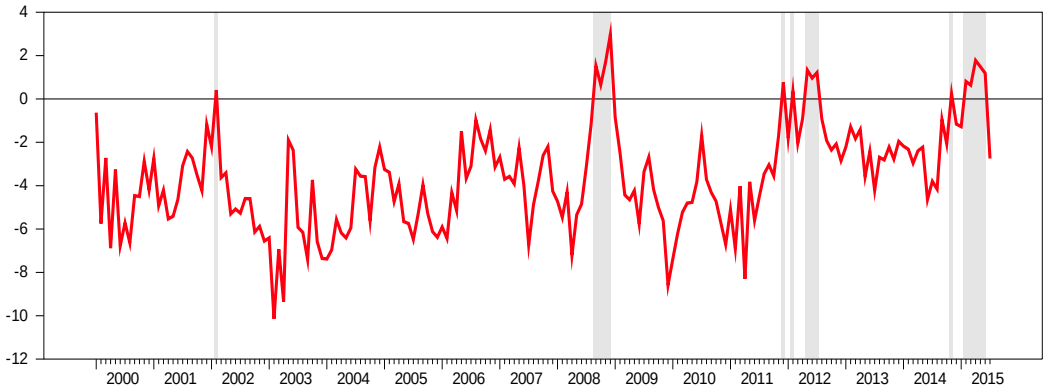

Figure 3: Latent easing pressure for baseline model

Notes: The red line indicated easing pressure; the shaded areas reflect actual easing episodes of the PBoC.

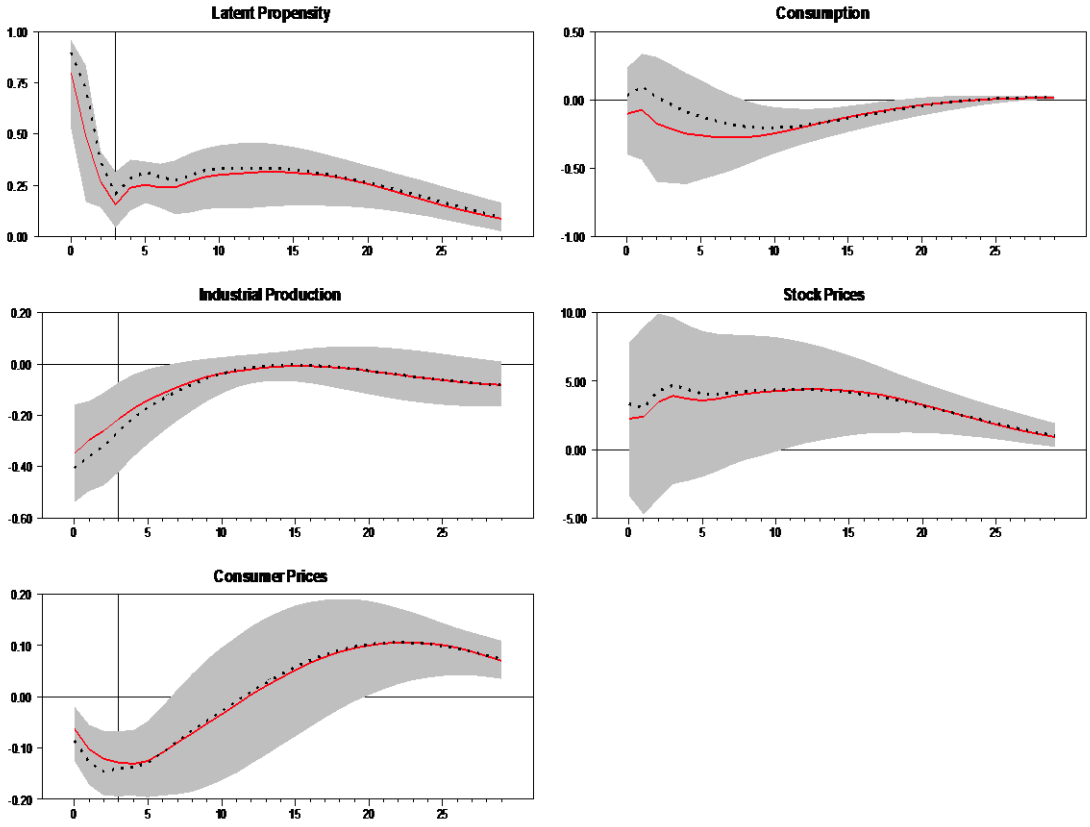

Figure 4: Response to tightening in the baseline model

Notes: The red line is median response; the dotted line is the Fry-Pagan median-target response. Confidence bands around the median response are shaded grey. The vertical line indicates the four months for which sign restrictions are imposed.

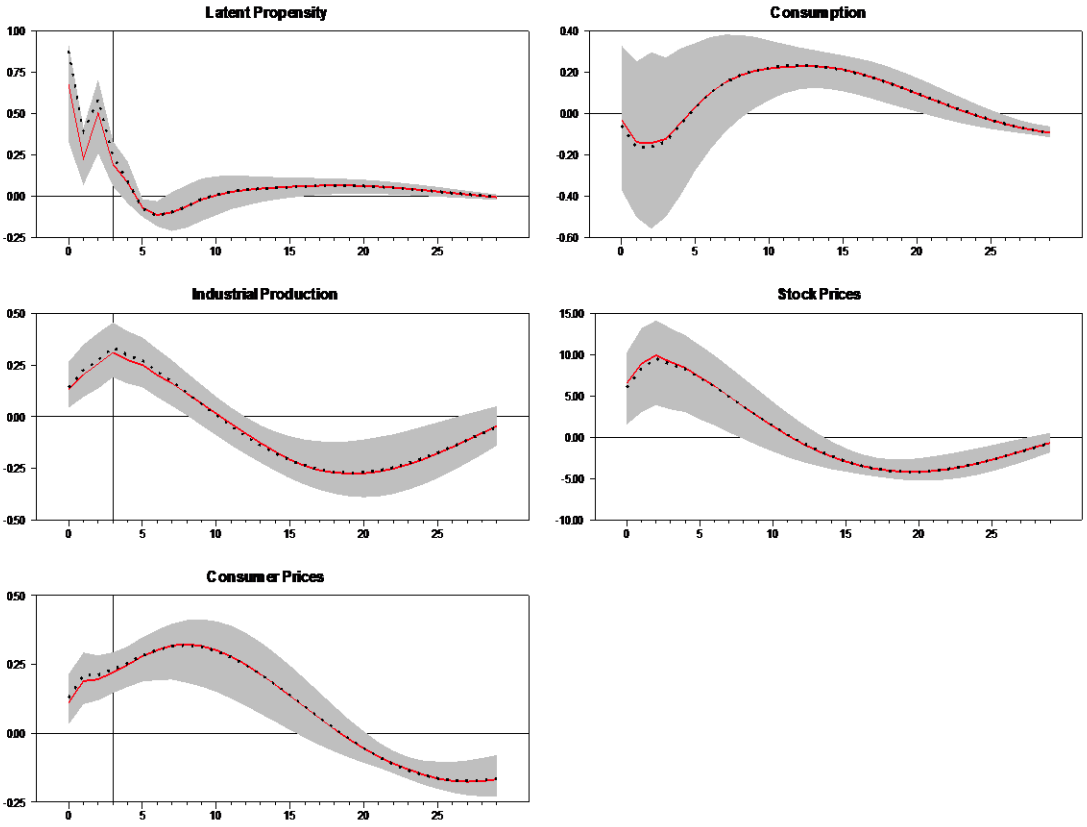

Figure 5: Response to easing in the baseline model

Notes: The red line is median response; the dotted line is the Fry-Pagan median-target response. Confidence bands around the median response are shaded grey. The vertical line indicates the four months for which sign restrictions are imposed.

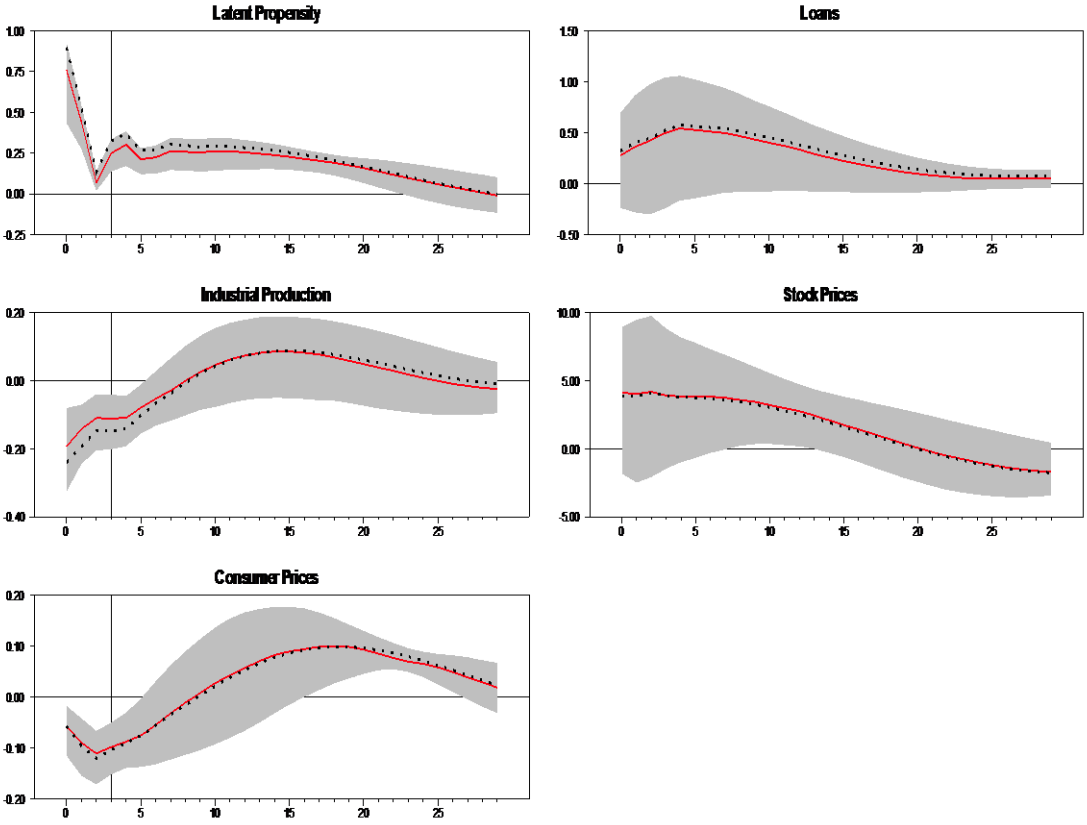

Figure 6: Response to tightening in the model with loans and stock prices

Notes: The red line is median response; the dotted line is the Fry-Pagan median-target response. Confidence bands around the median response are shaded grey. The vertical line indicates the four months for which sign restrictions are imposed.

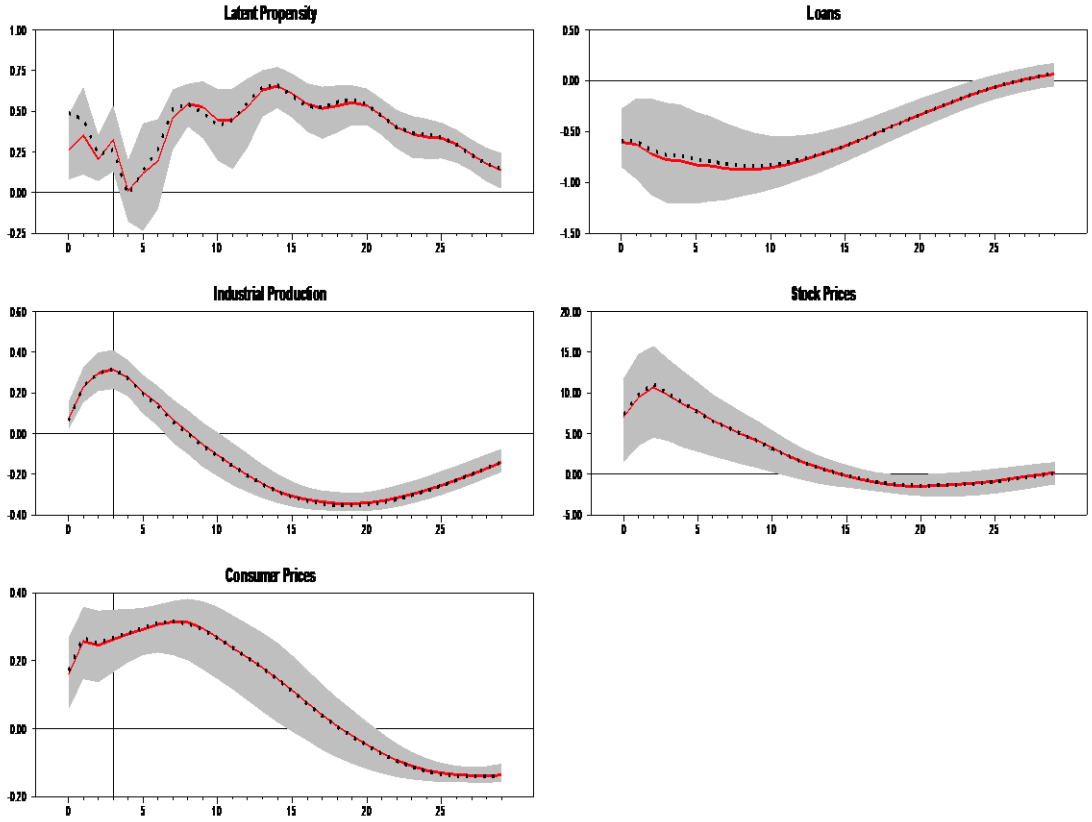

Figure 7: Response to easing in the model with loans and stock prices

Notes: The red line is median response; the dotted line is the Fry-Pagan median-target response. Confidence bands around the median response are shaded grey. The vertical line indicates the four months for which sign restrictions are imposed.

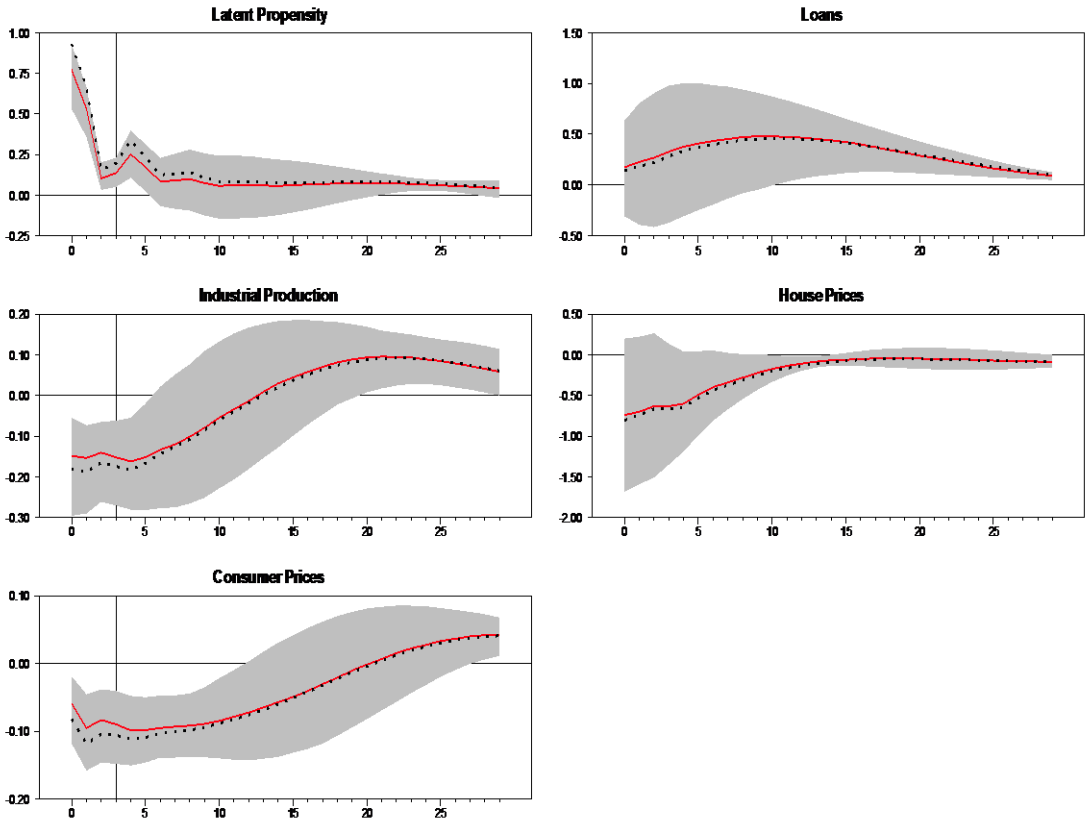

Figure 8: Response to tightening in the model with loans and house prices

Notes: The red line is median response; the dotted line is the Fry-Pagan median-target response. Confidence bands around the median response are shaded grey. The vertical line indicates the four months for which sign restrictions are imposed.

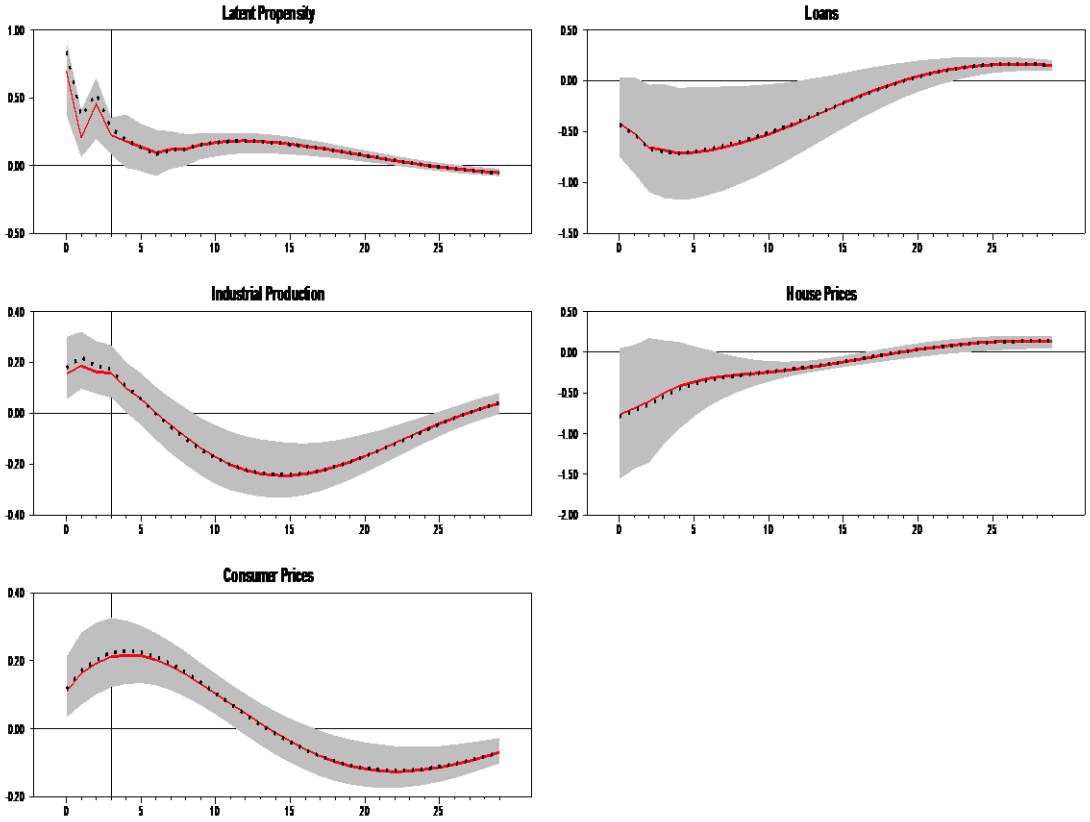

Figure 9: Response to easing in the model with loans and house prices

Notes: The red line is median response; the dotted line is the Fry-Pagan median-target response. Confidence bands around the median response are shaded grey. The vertical line indicates the four months for which sign restrictions are imposed.

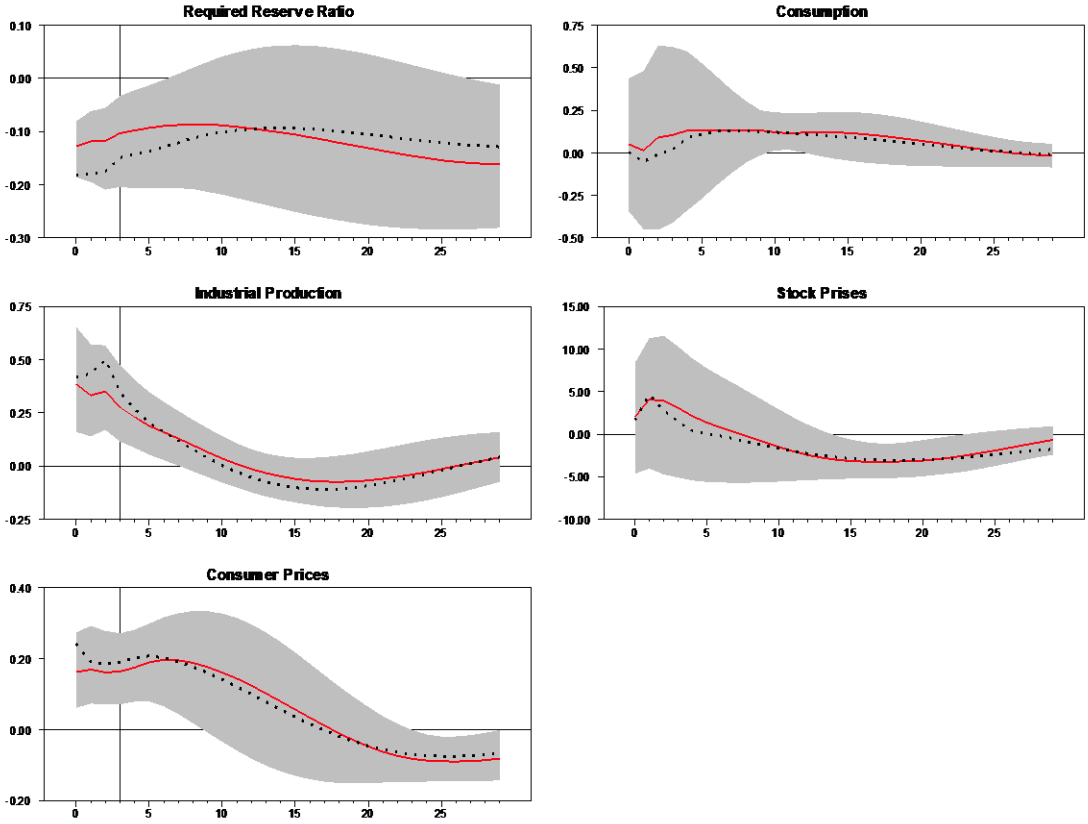

Figure 10: Response to change in required reserve ratio in conventional VAR for baseline model

Notes: The red line is median response; the dotted line is the Fry-Pagan median-target response. Confidence bands around the median response are shaded grey. The vertical line indicates the four months for which sign restrictions are imposed.

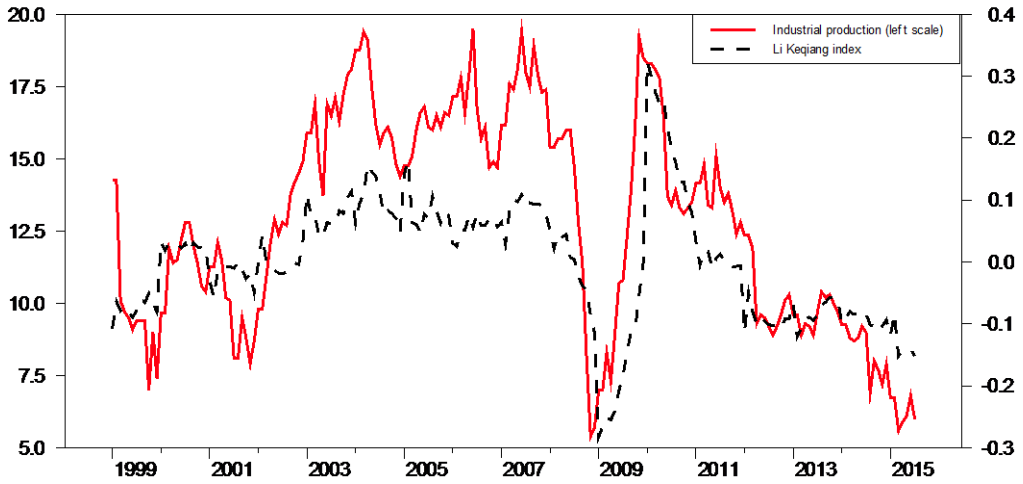

Figure 11: Growth rates of industrial production and Li Keqiang index

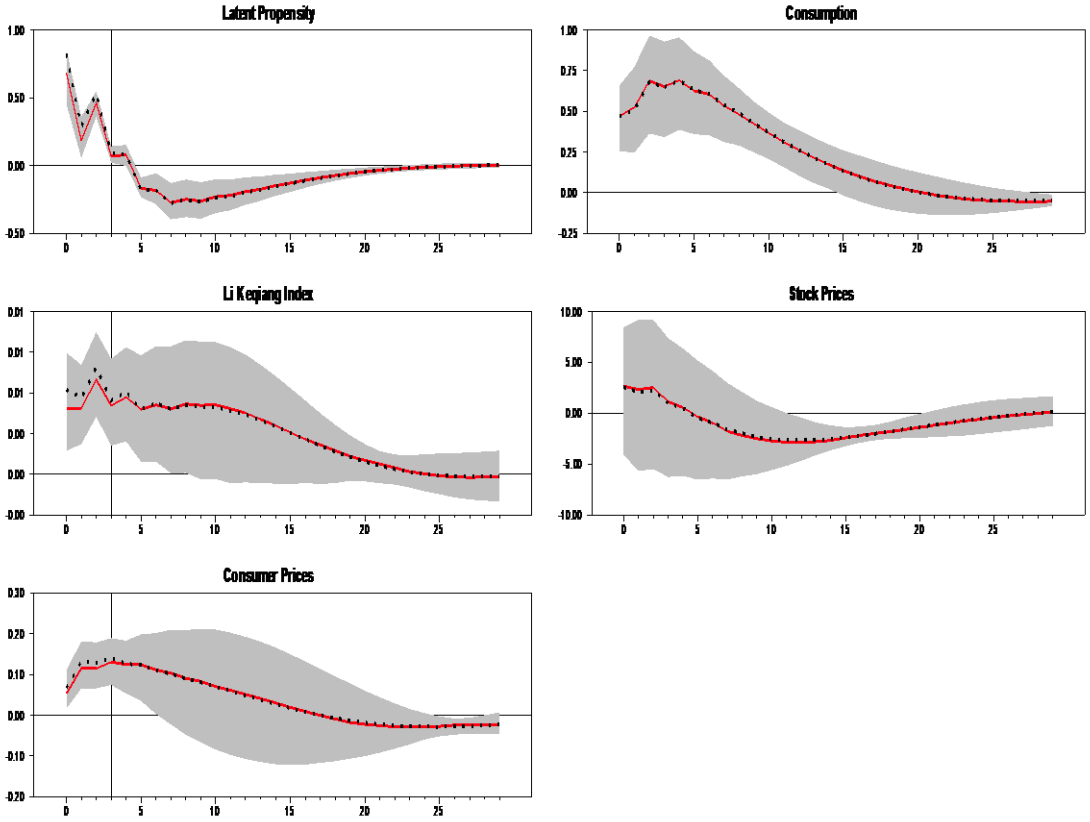

Figure 12: Response to easing in the model with Li Keqiang index

Notes: The red line is median response; the dotted line is the Fry-Pagan median-target response. Confidence bands around the median response are shaded grey. The vertical line indicates the four months for which sign restrictions are imposed.