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The direction and intensity of China's monetary policy conduct: A dynamic factor modelling approach

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Michael Funke and Andrew Tsang

The direction and intensity of China's
monetary policy conduct: A dynamic
factor modelling approach



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Michael Funke and Andrew Tsang

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Abstract

The recent upgrade of the People's Bank of China's monetary policy framework establishes a corridor system of interest rates. As the revamped policy arrangement now features a multiple-instrument mix of liquidity tools and pricing signals, we employ a dynamic factor modelling approach to derive an indicator of China's monetary policy stance. The approach is based on the notion that comovements in several monetary policy instruments have a common element that can be captured by a single underlying, unobserved component. To clarify and interpret the derived index, we employ a baseline DSGE model that can be solved analytically and allows tracing of the expansionary and contractionary on-and-off phases of Chinese monetary policy.

Keywords: China, monetary policy stance, dynamic factor model, DSGE model

JEL Classification: C54, E52, E58, E61, E32

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1 Introduction

Since the People's Bank of China (PBoC) began to function exclusively as a central bank in 1984, much progress has been made in its conduct of monetary policy. China's monetary policy framework has gradually moved away from a repressive financial system resting on preset deposit and lending rates, as well as "window guidance" lending quotas, to a more market-based regime with money growth as the main intermediate target. As part of this transition, interest rates have been liberalised, making them more responsive to market signals and the monetary policy toolkit modernised. However, these changes can also make it hard to interpret the central bank's signalling.¹

On December 18, 2018, China celebrated the 40th anniversary of the start of its reform and opening period and the rebirth of the economy following the devastating years of the Cultural Revolution. After four decades of transformative growth, it is undisputed that China is now a heavy-weight in the global economy. Understanding the objectives and formulation of PBoC monetary policy is complicated by the fact that China's monetary policy is in a state of flux as the PBoC struggles with its conflicted objectives of cutting back risky lending while ensuring that money keeps flowing to the economy. Moreover, the PBoC is not independent, but institutionally subordinate to the State Council, Beijing's equivalent of a cabinet, and ultimately the Communist Party of China (CPC). The State Council signs off on all important PBoC measures, occasionally going so far as to approve the wording of central bank announcements.²

Prior to the full liberalisation of interest rates, the PBoC directly controlled funding costs of bank borrowers and saving returns of depositors by adjusting benchmark interest rates. Pricing power today is in the hands of commercial banks. While the PBoC renamed benchmark interest rates as "reference rates" to guide public expectations, their real influence on lending and deposit rates has weakened and officials downplay their significance.³ Instead, the PBoC has recently shifted to a multi-instrument mix of liquidity tools and pricing signals to achieve its competing policy goals. This hybrid monetary policy framework forces PBoC watchers and market participants, including international investors, to monitor several fronts simultaneously as they try to discern the stance of Chinese monetary policy. The need for this is self-evident. China, as the world's second largest economy, is a huge contributor to global growth. Financial markets are highly sensitive to any shifts in Chinese monetary policy.

¹ For a detailed discussion of the monetary policy in China across decades, see Sun (2015).

² The PBoC has operational independence in setting short-term interest rates through its open market operations, short-term liquidity operations, as well as in setting rates on standing- and medium-term lending facilities. However, key decisions need to be approved by the State Council approval is needed, for example, for changes in the benchmark interest rate and reserve.

³ See <https://www.bloomberg.com/news/articles/2018-06-14/china-s-evolving-toolkit-to-manage-monetary-policy-quicktake>.

Given China's massive global footprint and the fact that the PBoC is still tweaking its multi-instrument policy toolkit, this paper presents a new method to measure China's post-realignment monetary policy stance. An empirical assessment of individual monetary policy instruments is hamstrung by the difficulty of isolating the effect of one policy from many in an economy buffeted by numerous forces. While there has been a great deal of literature chronicling individual tools, less attention has been paid to estimating an overall indicator for the monetary policy stance. An exception is Girardin *et al.* (2014, 2017). Building on the instrument-set approach of He and Pauwels (2008), Xiong (2012) and Sun (2015), they construct a simple weighted-average measure of the PBoC's monetary policy stance using price, quantitative and administrative measures. The above-mentioned re-orientation of China's monetary policy is not included. Shu and Ng (2010) and Sun (2013, 2018) have employed the alternative narrative approach propounded by Romer and Romer (1989). The obtained monetary policy index depicts a numerical scale that indicates the stance of monetary policy as inferred from central bank policy documents. It entails a mapping of the qualitative discussions in policy records to a quantitative scale by assigning a number indicating the degree of easing or tightening of policy stance. A possible drawback is that the quantitative interpretations of policy statements in terms of such indices are subjective, and thus debatable. Against this background, our main contribution is to construct a scorecard for measuring China's monetary policy stance from May 2012 to December 2018 on a monthly basis taking account the PBoC's current multiple instrument toolkit.

The paper is structured as follows. In section 2, we describe how the PBoC influences money market conditions. Section 3 describes our data set, presents our dynamic factor model and discusses the empirical result. Subsequently, we assess our derived monetary stance indicator against various benchmarks. Section 4 presents an estimated baseline DSGE model using the derived monetary stance indicator. A graphical evaluation of the DSGE model allows us to evaluate the mode of action of monetary policy over time and the various macroeconomic impacts. Finally, section 5 concludes with a summary of the main messages, policy issues and future research opportunities.

2 The evolution of China's multiple instrument monetary framework

After wrapping up its decades-long process of interest rate liberalisation in late 2015, the PBoC upgraded its monetary policy framework to include a corridor system of interest rates. The basic principle of the corridor system is as follows: the central bank provides a lending facility tool (the

upper bound of the corridor) and a deposit facility tool (the lower bound of the corridor) to form an interbank interest rate corridor, while the PBoC's interest rate target is somewhere within the corridor. The interest rate target is a new anchor in China's financial system much like benchmark short-term interest rates in North America and Europe. Under this system, the new policy target is the pledged 7-day interbank market rate. The rates of the Standing Lending Facility (SLF) constitute the upper bound of the corridor.⁴ The pledged 7-day interbank market rate applies to all financial institutions (including the non-bank financial institutions authorised to trade) in the interbank market without restrictions on the bond securities used as collateral for the repo. The Medium-term Lending Facility (MLF), launched in 2014, allows the PBoC to provide funds with longer maturities and stabilise market expectations with maturities ranging from three months to a year. The range of acceptable collateral includes government bonds and notes, local government debt and highly rated loans of small companies. As Chinese financial markets still lack depth, MLFs also help improve rate transmission by setting borrowing costs at the long end of the curve.

The PBOC has created tools similar to the MLF to offer funding to various banks in different scenarios. Besides the tools of Short-term Liquidity Operation (SLO) and Contingent Reserve Allowance (CRA), China recently introduced the Pledged Supplementary Lending (PSL) program to fund investment by the nation's three policy banks. PSL was introduced to guide long-term interest rates and money supply. Selected policy banks are injected with funds so that they can provide loans to specific sectors. Until now only the China Development Bank, the Agricultural Development Bank of China and the Export-Import Bank of China have received this facility. SLO, introduced in 2013, was aimed at relaxing the market pressure in the event of sudden tightening of money market conditions. The SLO tool has not been used since 2016. CRA is a new tool for providing temporary liquidity to banks during the Chinese New Year, when there is usually a cash shortage. CRA was used once in 2018, and it could be used again if needed. Finally, by setting the interest rate it pays on excess reserves, the PBoC effectively marks the lower bound of the interbank interest rate corridor.

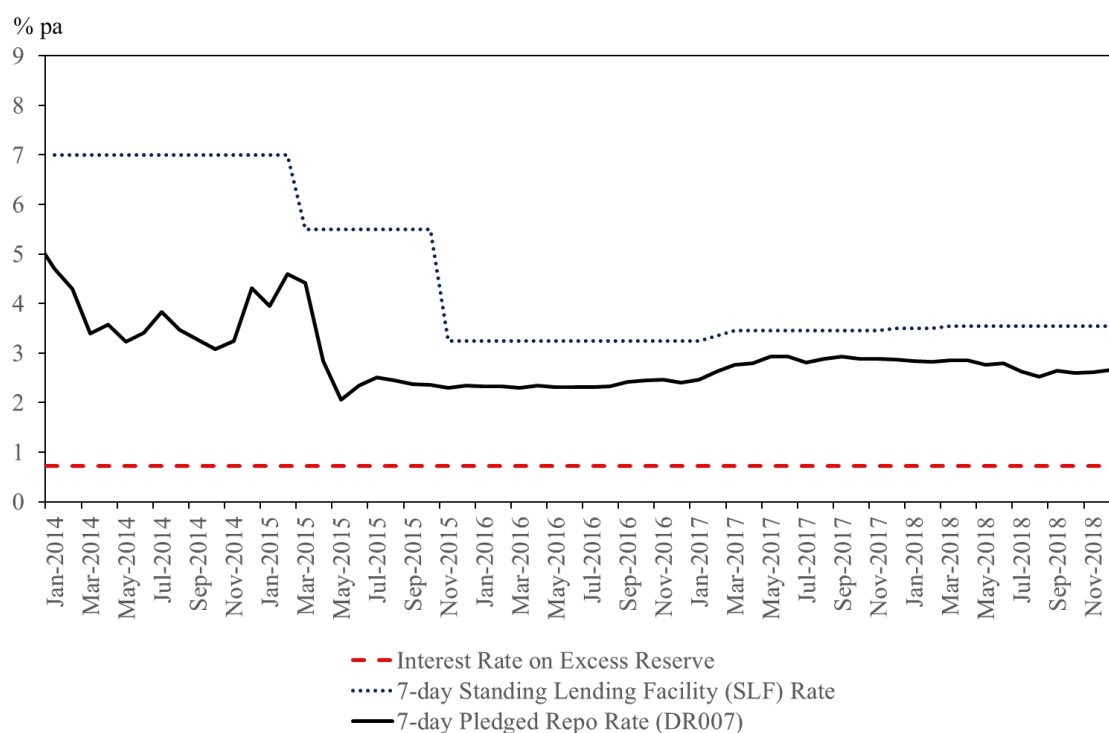
The PBoC uses various instruments to steer the corridor system. In practice, the PBoC conducts monetary policy by scaling the size of its open market operations or adjusting SLF and MLF rates. Open market operations mostly involve repurchase or reverse repurchase agreements. Repurchase operations remove liquidity from the system as the PBoC sells short-term bonds to commercial banks. The opposite is the reverse repurchase agreement, i.e. buying up the repurchase

⁴ The new policy has not been completely successful. Part of the reason is that the Standing Lending Facility (SLF) is only available for larger lenders. The 7-day repo rate has surged beyond the SLF lending rate with the same maturity on several occasions.

contracts. These operations give the PBoC control over the money supply and interest rates on a short-term basis. For this reason, short-term interest rate signals gained in importance.

Figure 1 shows the development of the interest rate corridor system. The corridor is currently asymmetric and the PBoC is gradually narrowing the range of the interest rate corridor.

Figure 1 Implementation of China's interest rate corridor system



Note: The 7-day pledged repo rate for financial institutions authorised to trade in the interbank market (R007) is used before 2015.

Although the described policy shifts are works in progress, a growing body of literature (e.g. Fernald *et al.*, 2014 and Chen *et al.*, 2017) suggests that monetary policy transmission in China has started to resemble that of advanced economies. There has been a reorientation of monetary policy away from the use of quantity targets to one where the PBoC manages a key short-term interest rate. The IMF (2017, p. 34) arrived in 2017 at the tentative verdict that “the conduct of [China’s] monetary policy increasingly resembles a standard interest-rate-based framework”. Kamber and Mohanty (2018) confirm this in their examination of movements in 1-year interest rate swap contracts based on the interbank 7-day repo rate to measure market expectations of PBoC’s future monetary policy.

The reserve requirement ratio is a quantity-based monetary policy instrument used actively by the PBoC. While the reserve requirement ratio is usually considered a prudential measure to ensure lenders can handle customer withdrawals, its importance in China lies with money supply management, especially in dealing with the country’s persistent current account surpluses. The adjustment of the reserve requirement ratio can unleash or lock up huge amounts of liquidity. Thus,

this traditional monetary policy tool has become a powerful weapon in the PBoC's arsenal.⁵ In particular, the authorities can resort to the reserve requirement ratio tool in times of market stress to give a clear and strong policy signal to the market. It is worth noting that the reserve requirement ratio has actively been used as a macro-prudential policy instrument (see Wang and Sun, 2013).

Finally, the PBoC occasionally still provides window guidance to commercial banks. The quantity-based window guidance tool relies on moral suasion rather than hard rules to pressure banks to adjust the amount and pace of credit supply until a set credit growth target is met. Window guidance may also be used to optimise the credit structure by moderating banks' allocation of credit to sectors and regions in line with policy objectives.⁶

Whether one describes China's current monetary policy framework as hybrid or hodge-podge, it is clear that the market-based reforms described above have brought Chinese monetary policy closer to the norm in developed markets – an essential transition for an increasingly complex economy. It is also clear that the multiple-instrument monetary policy framework in its current state remains opaque and hinders assessment of the prevailing policy stance.

3 Setup of the dynamic factor model

We propose a two-step approach to answer the questions posed above. First, we set up a dynamic factor model to estimate an indicator of China's monetary policy stance. In section 4, we will employ the derived indicator to estimate a baseline dynamic stochastic general equilibrium (DSGE) model to evaluate the impacts of Chinese monetary policy over time.

3.1 Methodology

Dynamic factor models are used in applied econometrics to quantify unobserved variables. Such models are particularly valuable in business-cycle analyses (e.g. Forni and Reichlin, 1998; Eickmeier, 2007; Ritschl, Sarferaz and Uebele, 2016), forecasting (e.g. Stock and Watson, 2002a, 2002b) and nowcasting the state of an economy (e.g. Banbura *et al.*, 2013). The numerical procedures used in such models smooth over missing values, thus dealing with the ragged or jagged edge problem. Dynamic factor model applications to date suggest that the data reduction methodology can provide timely information on the stance of monetary policy in China's multi-instrument setting.

⁵ The overarching objective of the Chinese policy approach is to safeguard economic and political stability. This is considered a necessary to avoid entering territory where further financial market liberalisation and capital account opening starts undermining, rather than fostering, economic growth.

⁶ The IMF (2016, p. 14) has proposed terminating credit targets through window guidance, unless they are used to achieve macroprudential policy objectives.

The unobserved monetary policy stance is based on the notion that the comovements in different monetary policy instruments have a common element that can be captured by a single underlying, unobservable variable.⁷ The dynamic factor model in first differences is specified as follows:

$$\Delta I_{i,t} = \beta_i \Delta M_t + e_{i,t} \quad (1)$$

$$\Delta M_t = \varphi_1 \Delta M_{t-1} + \varphi_2 \Delta M_{t-2} + u_t \quad (2)$$

$$e_{i,t} = \rho_{i,1} e_{i,t-1} + \rho_{i,2} e_{i,t-2} + v_{i,t} \quad (3)$$

where Δ is the first-difference operator, M_t is the unobserved common component at time t , I_i ($i = 1, \dots, 5$) are the five monetary policy instruments, β_i are the factor loadings, $u_t \sim \text{i.i.d. } N(0, \sigma_u^2)$ and $v_{i,t} \sim \text{i.i.d. } N(0, \sigma_i^2)$. The common factor M_t is referred to as the dynamic factor. An essential feature of the factor model is that the common factor and the factor loadings are unobservable. Despite the resemblance, equations (1) – (3) are not a multivariate regression model.⁸ We suppose that every monetary policy indicator $I_{i,t}$ is a weakly stationary process that has at least finite second-order moments, and perform unit root tests. If the null hypothesis of non-stationarity cannot be rejected, then we take first-differences. On top of this, as suggested by Stock and Watson (1991), the series are also demeaned. The state-space representation contains a measurement equation (signal equation), which links observed variables to latent states, and a state equation, which describes how the states evolve over time. In the state-space model, the measurement equation is written as

$$\begin{bmatrix} \Delta I_{1,t} \\ \Delta I_{2,t} \\ \Delta I_{3,t} \\ \Delta I_{4,t} \\ \Delta I_{5,t} \end{bmatrix} = \begin{bmatrix} \beta_1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_2 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_4 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ \beta_5 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \Delta M_t \\ \Delta M_{t-1} \\ e_{1,t} \\ e_{1,t-1} \\ e_{2,t} \\ e_{2,t-1} \\ e_{3,t} \\ e_{3,t-1} \\ e_{4,t} \\ e_{4,t-1} \\ e_{5,t} \\ e_{5,t-1} \end{bmatrix}, \quad (4)$$

⁷ In using the maximum-likelihood method, the number of common factors must be given a priori. Popular estimators for the number of factors in approximate factor models can be found in Bai and Ng (2002), Onatski (2010) and Ahn and Horenstein (2013). The empirical evidence suggests that a single factor exists.

⁸ While collinearity is generally harmful for conventional estimation methods such as OLS, multicollinearity is preferred when extracting factors since the goal for the extracted factors is to cover the main bulk of variation in the monetary policy instruments.

and the state equation is

$$\begin{bmatrix} \Delta M_t \\ \Delta M_{t-1} \\ e_{1,t} \\ e_{1,t-1} \\ e_{2,t} \\ e_{2,t-1} \\ e_{3,t} \\ e_{3,t-1} \\ e_{4,t} \\ e_{4,t-1} \\ e_{5,t} \\ e_{5,t-1} \end{bmatrix} = \begin{bmatrix} \varphi_1 & \varphi_2 & 0 & 0 & & 0 & 0 \\ 1 & 0 & 0 & 0 & & 0 & 0 \\ 0 & 0 & \rho_{1,1} & \rho_{1,2} & \dots & 0 & 0 \\ 0 & 0 & 1 & 0 & & 0 & 0 \\ & & \vdots & & \ddots & \vdots & \\ 0 & 0 & 0 & 0 & & \rho_{5,1} & \rho_{5,2} \\ 0 & 0 & 0 & 0 & \dots & 1 & 0 \end{bmatrix} \begin{bmatrix} \Delta M_{t-1} \\ \Delta M_{t-2} \\ e_{1,t-1} \\ e_{1,t-2} \\ e_{2,t-1} \\ e_{2,t-2} \\ e_{3,t-1} \\ e_{3,t-2} \\ e_{4,t-1} \\ e_{4,t-2} \\ e_{5,t-1} \\ e_{5,t-2} \end{bmatrix} + \begin{bmatrix} u_t \\ 0 \\ v_{1,t} \\ 0 \\ v_{2,t} \\ 0 \\ v_{3,t} \\ 0 \\ v_{4,t} \\ 0 \\ v_{5,t} \\ 0 \end{bmatrix} \quad (5)$$

This fast, versatile estimation procedure involves four steps. First, the parameters of the dynamic factor model in equations (4) and (5) are estimated using the maximum likelihood estimation (MLE) method based on the predicted error decomposition.⁹ Second, the current state of the unobserved common factor, i.e. the change in monetary policy stance index (ΔM_t), is obtained by applying a Kalman filter and smoother to the estimated dynamic factor model.¹⁰ Third, the monetary policy stance (M_t) is calculated by accumulating the estimated series of ΔM_t , assuming the initial value of M_t is 0 at $t = 0$. Finally, the monetary policy stance is normalised to a range between -2 and 2.¹¹ By construction, we get

$$\left(\frac{M_t - \frac{M^{max} + M^{min}}{2}}{M^{max} - M^{min}} \right) \times 4 \quad (6)$$

This normalisation allows the relative strength of the indicator to be observed over time and facilitates comparison with other indicators in the literature (e.g. Sun, 2018; McMahon *et al.*, 2018).¹²

Overall, the advantages of the dynamic factor model approach are its intuitiveness and the incorporation of dimension reduction and variable selection into a single model. Moreover, the

⁹ As an alternative, Doz *et al.* (2012) demonstrate that the space spanned by the factors may be directly and consistently estimated by quasi-maximum likelihood using the Kalman filter. If the procedure is iterated, it is equivalent to the expectation-maximisation (EM) algorithm.

¹⁰ Harvey (1989) shows that for a stationary transition equation, the Kalman gain approaches a steady-state Kalman gain as $t \rightarrow \infty$. See Harvey (1989) and Durbin and Koopman (2012) for thorough treatments.

¹¹ Since the Kalman filter is orthogonally separating signal and noise terms, the factor extracted by this method could be either positive and negative (Bai and Wang, 2015). The series could be multiplied by (-1) if needed. Moreover, the derived factor is identified only up to an arbitrary choice of the initial value.

¹² The fact that the index is 0 in a given month does not imply necessarily that the PBoC has assumed a neutral policy stance.

framework can indicate the respective weights of the input variables, thereby enabling an understanding of the algorithmically determined input-output relationship, a feature often missing from techniques criticised for their black-box nature (e.g. Chakraborty and Joseph, 2017).

3.2 Data description and results

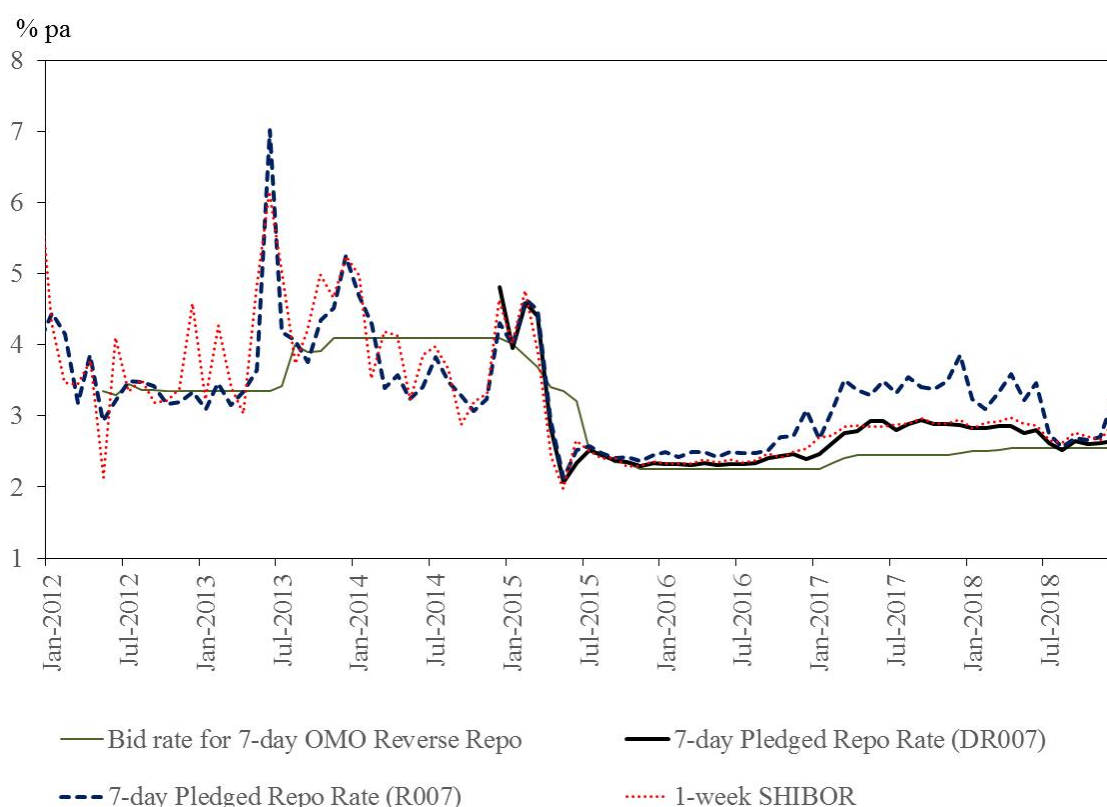
Here, a five-variable dynamic factor model on monthly frequency is used for extracting the monetary policy stance. These five variables summarise the monetary policy tools used by the PBoC: the 7-day pledged repo rate (DR007); the required reserve ratio (RRR); the PBoC's open market operations, including standing lending facility (SLF), rediscount and relending, etc.; the medium-term lending facility (MLF); and pledged supplemental lending (PSL). The data for the 7-day pledged repo rate are taken from the National Interbank Funding Center archives. All other data have been released by the PBoC. Table 1 summarises these five variables.

Table 1 Variables included in the dynamic factor model

Variable	Data description
Change in the 7-day pledged repo rate	Change in the monthly average of the 7-day pledged repo rate for depository institutions in the interbank market (DR007). Since this rate was first published on December 5, 2014, changes in the 7-day pledged repo rate for financial institutions authorised to trade in the interbank market (R007) is used for the period before 2015.
Changes in required reserve ratio (RRR)	Changes in the required reserve ratio (RRR, within the month). Since a different RRR has been applied to different sizes of banks since September 2008, the overall RRR for the banking sector is estimated as $75\% \times RRR \text{ for large banks} + 25\% \times RRR \text{ for small and medium-sized banks}$. This formula is also used by the CEIC.
Net OMO withdrawal / total loans ($t - 1$)	The net amount of funds reduced through the PBoC's open market operations (OMO) from the banking sector (net amount during the month). The net amount of funds withdrawn in other items in the central bank's claims on the banking sector such as standing lending facility (SLF), rediscount, relending, etc., is also included in this variable. The variable is calculated by subtracting the monthly change in the central bank's claims on the banking sector by the net MLF withdrawal and the net PLS during the month. The variable is normalised by lagged total loans and seasonally adjusted.
Net MLF withdrawal / total loans ($t - 1$)	The net amount of funds withdrawn through the PBoC's medium-term lending facility (MLF) from the banking sector (net amount during the month). Before the introduction of MLF in September 2014, the value is 0 for this variable. The variable is normalised by lagged total loans and seasonally adjusted.
Net PLS withdrawal / total loans ($t - 1$)	The net amount of funds withdrawn through the PBoC's pledged supplemental lending (PSL) from the banking sector (net amount during the month). Before the introduction of PLS in April 2014, the value is 0 for this variable. The variable is normalised by lagged total loans and seasonally adjusted.

The 7-day pledged repo rate for depository institutions in the interbank market (DR007) is used for the interest-rate variable in the model, as this is the PBoC's likely policy target.¹³ Although the PBoC has yet to introduce an official policy interest rate in China, the 7-day repo rate is the main indicator for PBoC's target interest rate in its open market operations (OMO). Since 2012, the PBoC has injected liquidity through its open market operations with reverse repos. It introduced the 7-day reverse repo in May 2012. In parallel, the PBoC started to relax its control on the lending and deposit lending rate of commercial banks in June 2012. All controls were lifted in October 2015. This fits in with PBoC's roll-out of the pledged 7-day interbank market rate as its new monetary policy target.¹⁴ The DR007 series are available from December 15, 2014. To extend the estimation period, we have employ the similar, but longer, series of 7-day pledged repo rate for all financial institutions authorised to trade in the interbank market (R007) between May 2012 and December 2014.¹⁵ Figure 2 compares these interest rates to the Shanghai interbank offered rate (SHIBOR). All time series are aligned.

Figure 2 Chinese policy interest rates relevant to monetary policy



Data sources: PBoC and National Interbank Funding Center.

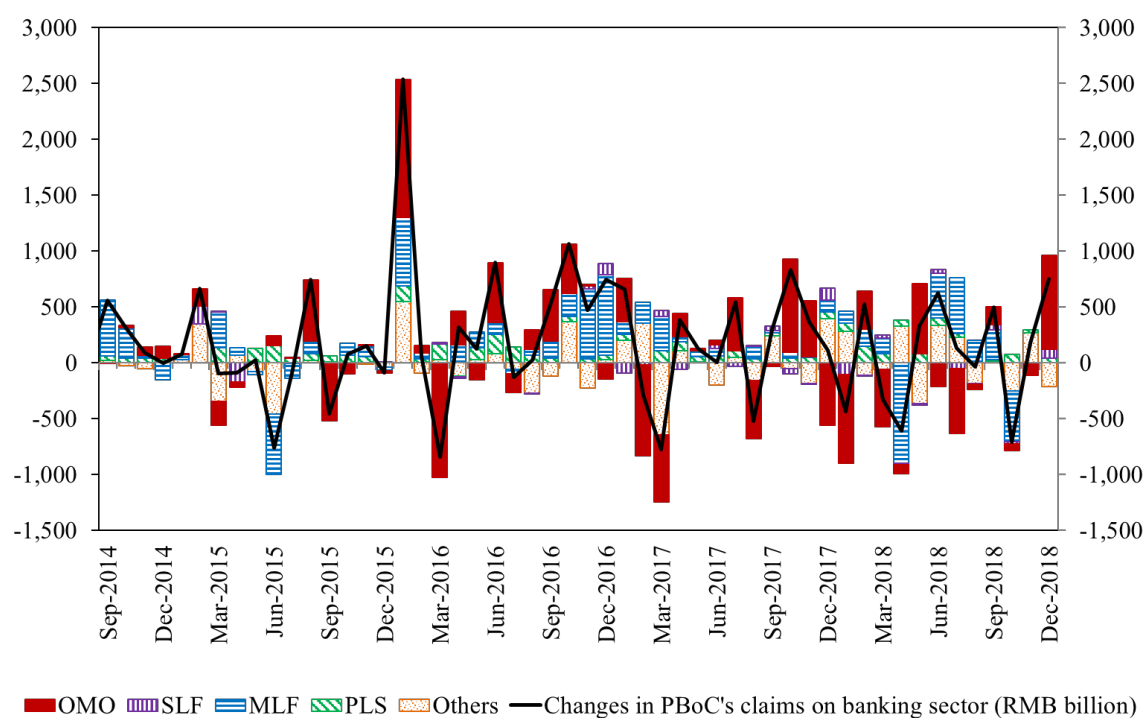
¹³ This repo interest rate only encompasses sovereign bonds, which includes government bonds, central bank bills and the bonds issued by policy banks as collateral.

¹⁴ The same assessment is also conveyed by McMahon *et al.* (2018).

¹⁵ In the case of R007 operations, collateral is not restricted to sovereign bonds.

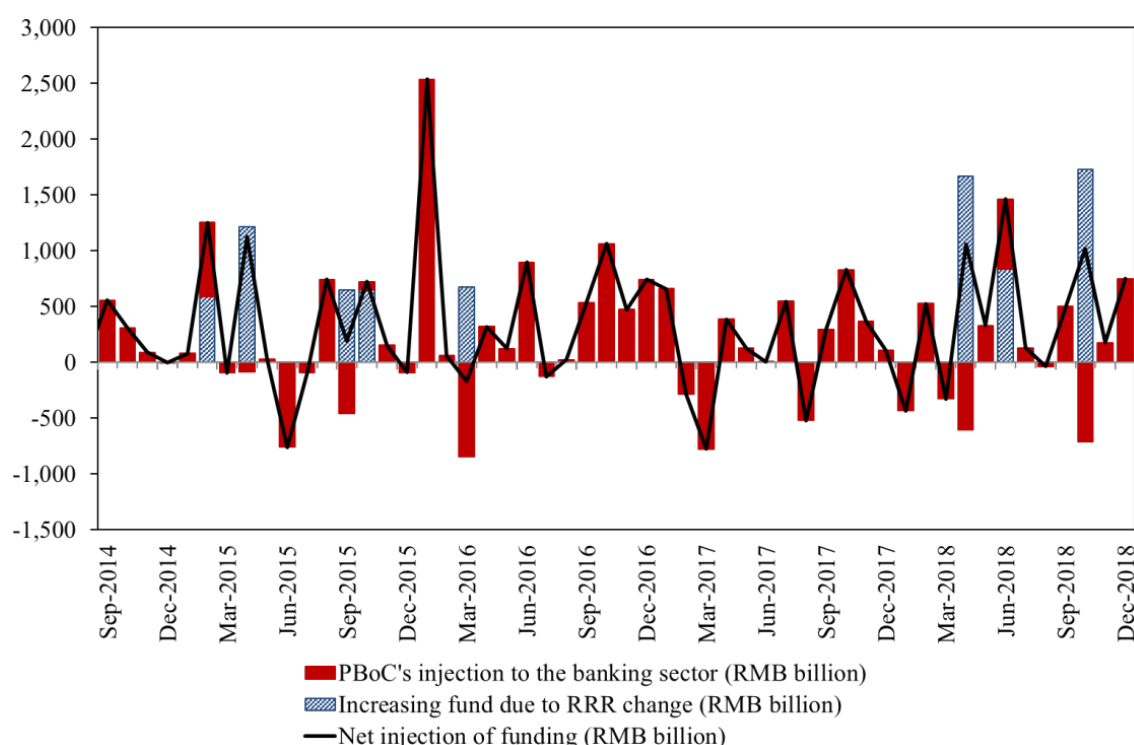
The required reserve ratio (RRR) and the PBoC's fund injection/withdrawal tools are the PBoC's quantitative policy instruments. Positive (negative) changes in PBoC's claims on commercial banks (in the balance sheet of PBoC) can be treated as PBoC's fund injection into (withdrawal from) the banking sector. The OMO, MLF and PLS are fairly important fund injection/withdrawal tools for the PBoC, so all three measures are included as factors in our dynamic factor model. All fund withdrawal series are normalised by the level of total loans at the end of the previous month to ensure the stationarity of the series. Furthermore, since the PBoC always injects funds before the Chinese New Year and withdraws funds thereafter, all indicators are seasonally adjusted. The temporal profiles and the interaction of the different quantitative instruments are shown in Figure 3 and Figure 4, respectively.

Figure 3 PBoC fund injection and monetary policy tool selection



Note: The positive (negative) values represent PBoC fund injections (withdrawal). The chart uses RMB billion. Data Source: PBoC.

Figure 4 Quantitative monetary policy tools: Required Reserve Ratio and PBOC fund injections



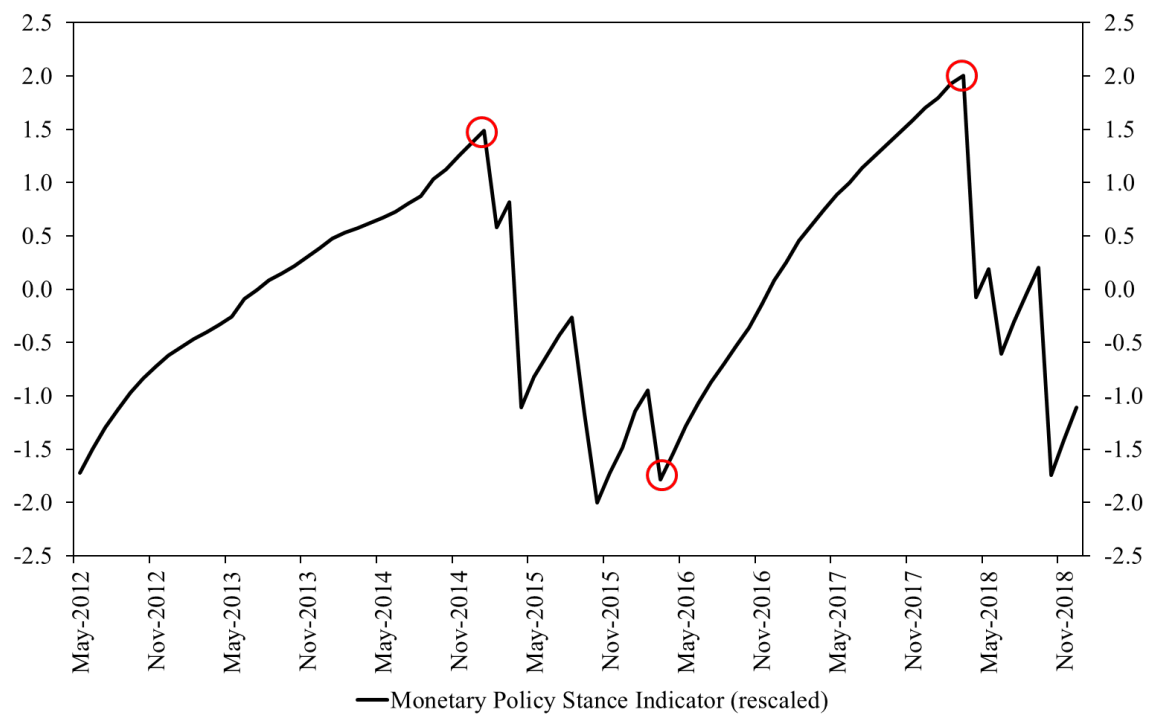
Data Source: PBoC.

Figure 5 shows the indicator, based on our dynamic factor model, with discernible turning points in the monetary policy strategy marked with red circles.¹⁶ Higher (lower) values of the indicator represent a monetary policy tightening (easing).

From Figure 5, we can comfortably divide monetary policy stance into four sub-periods, two tightening periods (May 2012–January 2015 and April 2016–March 2018) and two easing periods (February 2015–March 2016 and April 2018–December 2018). During the tightening periods, the bid rate for the 7-day reverse repo increased, the required reserve ratio remained unchanged and the average monthly fund injections by PBoC were reduced. During the easing periods, the repo rate and the required reserve ratio fell, and the average monthly fund injections by PBoC increased to over 0.4% of total loans. (See Table 2 for details.) The turning points of the indicator capture the major policy changes quite precisely.

¹⁶ The complete factor model estimation results are available in Appendix A.

Figure 5 DFM-based indicator of the Chinese monetary policy stance



Notes: Rising values for the indicator represents monetary tightening, while a falling value implies easing. The red circle marks the major turning points of the indicator, and the details of the turning points are shown in Table 2. The calculated index of the Chinese monetary policy stance is available online at <https://www.bofit.fi/en/publications/discussion-papers/>.

Table 2 PBoC Monetary policy actions, monetary policy turning points based on our dynamic factor model and other indicators

Period	PBoC policy actions	DFM-based turning points	Comments on DFM-based turning points	Starting points in McMahon <i>et al.</i> (2018)	Starting points in Sun (2018)
May 2012 – Jan 2015 (Tightening)	<p>During May 2012 to late-Jan 2015, the bid rate for 7-day reverse repo increased by 80 basis points, although PBoC lowered the benchmark lending interest rate three times by 96 basis points between June 2012 and November 2014.</p> <p>After lowering RRR in mid-May 2012, the PBoC did not change the RRR at all during this period.</p> <p><u>Average monthly fund injection</u>: 0.08%</p>	Jan 2015	The turning point was just at the first fall in the bid rate for 7-day reverse repo, and just before the next fall in the RRR, and captures the end of the tightening period quite well.	Apr 2011 (tighter)	Apr 2012 (easier) Jan 2013 (tighter) Apr 2014 (easier)
Feb 2015 – Mar 2016 (Easing)	<p>During late-Jan 2015 to Mar 2016, the bid rate for 7-day reverse repo dropped by 185 basis points.</p> <p>Meanwhile, Mar 2015 to Oct 2015, PBoC lowered the benchmark interest rate five times by 125 basis points. Since Oct 2015, PBoC removed all the controls on the interest rates of the commercial banks. Also, after Oct 2015, PBoC did not release the benchmark lending interest rate again.</p> <p>Feb 2015 to Mar 2016, PBoC lowered RRR five times by 3 percentage points.</p> <p><u>Average monthly fund injection</u>: 0.45%</p>	Mar 2016	The turning point matched with the final fall in RRR, and captures the end of the easing period quite well.		
Apr 2016 – Mar 2018 (Tightening)	<p>Between Feb 2017 and Mar 2018, the bid rate for 7-day reverse repo increased by 30 basis points.</p> <p>RRR did not change during this period.</p> <p><u>Average monthly fund injection</u>: 0.22%</p>	Mar 2018	The turning point was just before the next fall in the RRR, and captures the end of the tightening period quite well.	Jan 2017 (tighter)	Jan 2017 (tighter)
Apr 2018 – Dec 2018 (Easing)	<p>The bid rate for 7-day reverse repo remained unchanged during this period.</p> <p>From April 2018 to October 2018, the PBoC lowered the RRR three times by in total by 2.5 percentage points.</p> <p><u>Average monthly fund injection</u>: 0.46%</p>				Apr 2018 (easier)

Note: In the cases of McMahon *et al.* (2018) and Sun (2018), tighter/easier compare the current monetary policy stance against the previous period.

3.3 Assessment of the monetary policy stance indicator against various benchmarks

As there is no unanimity in the literature on the best way to construct an indicator of China's multiple instrument monetary policy stance, we compare our derived comprehensive indicator against other indices suggested in the literature. Special attention is paid to the Chinese monetary shock indicator recently developed by Kamber and Mohanty (2018), as well as the narrative indicators suggested McMahon *et al.* (2018) and Sun (2018).

We start by addressing important methodological differences. Our indicator and the alternative indicators of McMahon *et al.* (2018) and Sun (2018) are *monetary stance measures*. Monetary policy stance should not be conflated with monetary policy shocks. The PBoC can respond to incoming news about output and inflation by changing its policy stance, but shifts in its policy stance can also affect agent expectations about future trends in the economy. To separate the surprise component from the expected component, we must control for the variation in economic fundamentals to which the monetary policy endogenously responds. A simple way to obtain unexpected changes is to fit a VAR model to the variables, with the residuals representing the unexpected monetary policy shock. This clarification is important because the indicator of Kamber and Mohanty (2018) is a monetary surprise indicator.

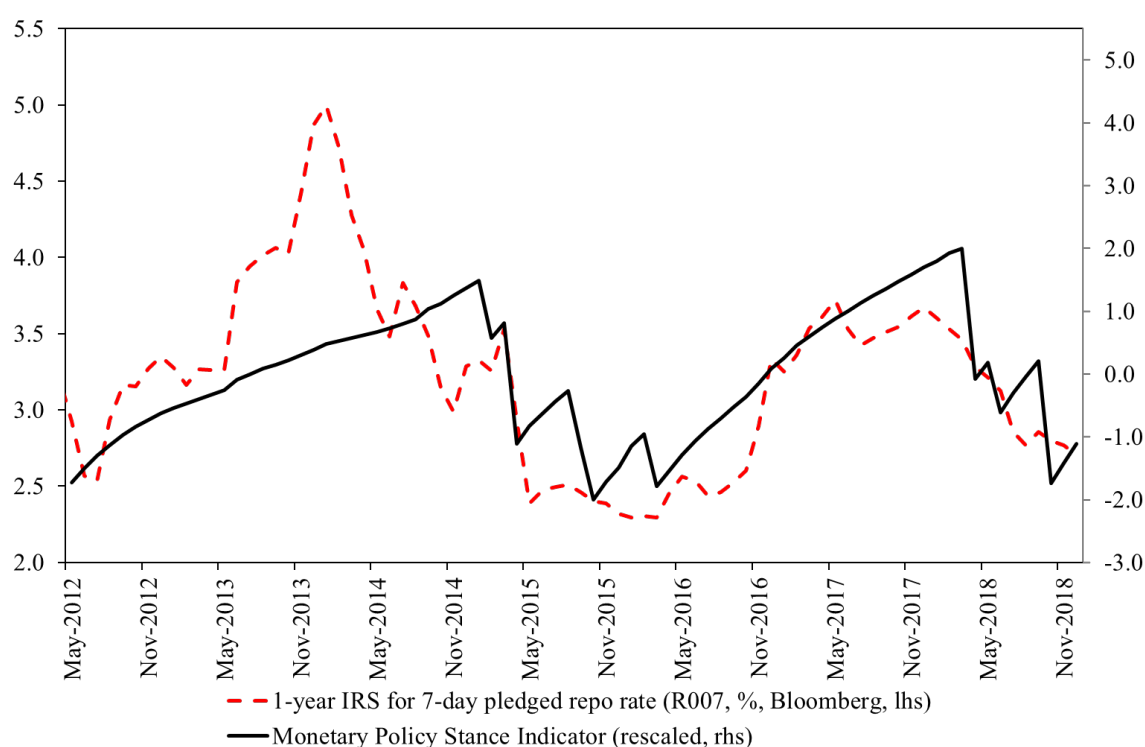
In Kamber and Mohanty (2018) the impact of monetary policy surprise is measured by the daily change in the nearest closing price of 1-year interest rate swap (IRS) for 7-day pledged repo rate (R007) after the time of policy announcement. To compare the monthly DFM-based monetary policy stance indicator with the cumulative effects of the monetary policy surprises, the monthly average of the 1-year IRS for 7-day pledged repo rate is used to proxy the cumulative effects of the monetary policy surprise during the month. To this end, the 1-year IRS time series for the 7-day pledged repo rate is downloaded from Bloomberg.¹⁷

Figure 6 compares the dynamic factor model based indicator with the movement of the monthly average of the 1-year IRS for the 7-day pledged repo rate. Overall, the movements of the two series are very similar despite the methodological differences. The only significant discrepancy occurred in the period from June 2013 to April 2014, which a sharp jump appears in the series of 1-year IRS for 7-day pledged repo rate. Although the 1-year IRS for 7-day pledged repo rate largely reflects the cumulative effects of the monetary policy surprise, it also reflects the market expectation and sentiment to the liquidity condition in the market. The sharp jump in the series of 1-year IRS

¹⁷ Both the data in Kamber and Mohanty (2018) and our data of 1-year IRS for 7-day pledged repo rate are downloaded from Bloomberg. Please note that the replication exercise yields minor differences for about one third of the observations. For the details, see Appendix B.

for 7-day pledged repo rate since Jun 2013 was partly due to a special situation in the interbank liquidity market. Although monetary policy remained unchanged during this period (no changes in benchmark lending interest rate and required reserve ratio), liquidity in the interbank market dried up in June 2013. The PBoC asserts that the shortage of liquidity in the interbank market was triggered by several special factors at the time. These included stronger market expectations of an unconventional monetary policy unwinding in the US, a slowdown of foreign exchange inflows and large cash withdrawals ahead of the holidays and anticipated corporate tax payments. In the first half of 2014, interbank liquidity market improved significantly and the effects from these special factors evaporated.

Figure 6 Monetary policy surprise vs. monetary policy stance



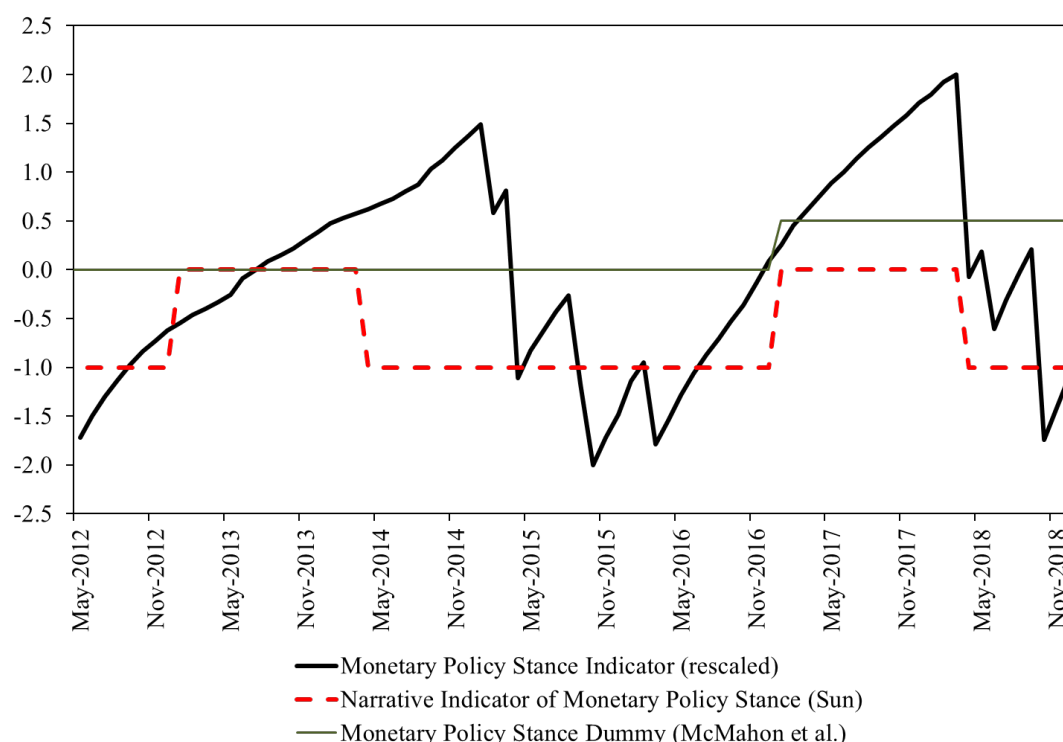
Note: The impact of monetary policy surprise is measured by the monthly average of the 1-year IRS for 7-day pledged repo rate (Kamber and Mohanty, 2018).

Data Sources: Bloomberg and author's calculation.

Figure 7 compares our DFM-based indicator with the two quarterly narrative indicators of McMahon *et al.* (2018) and Sun (2018). (For the related monetary policy decisions, see Table 2.) Since the narrative indices only include a few values, we see little variation in monetary policy. Another low-plausibility impression conveyed is that the direction and intensity of Chinese monetary policy has remained unchanged for years. This applies particularly to the narrative indicator of McMahon *et al.* (2018), which employs information in the quarterly PBoC's monetary policy re-

ports to capture policy changes. Unfortunately, wording used in the central bank's published statements often suggest an unchanged policy. During the sample period, the only variation of the narrative indicator of McMahon *et al.* (2018) is seen in the PBoC's characterisation of the interest rates hikes in 2017Q1.

Figure 7 Monthly dynamic factor model monetary policy indicator vs. quarterly narrative monetary policy stance indicators



Notes: As the monetary stance dummy series in McMahon *et al.* (2018) end in 2018Q1, we extend the index to the end of 2018 by applying the method described in McMahon *et al.* (2018). The published monetary stance dummy series in Sun (2018) ends in 2014Q4, but updated values can be downloaded from <https://sites.google.com/site/rongrong-sun2013/sun-mp-ind>.

Sun (2018) uses more information in the quarterly PBoC's monetary policy reports to construct her narrative indicators. The immediate consequence is that the indicator has somewhat greater variability. Sun's indicator differs with our dynamic factor model indicator in two ways. First, there is a different turning point for the monetary policy change in 2014-2015. Between April 2014 and January 2015, both the repo rate and RRR did not fall until February 2015. Also, the 7-day pledged repo rate rose in late 2014. Sun's indicator thus provides a leading signal for easing. The second difference appears in 2017Q1. Sun's indicator puts the arrival of tightening in 2017Q1, while the turning point in our dynamic factor model based indicator was already in March 2016. The RRR fell in March 2016, and there was no change in RRR from April 2016 to March 2018. Although the bid rate for 7-day reverse repo started to increase in February 2017, the PBoC's policy target, 7-day pledged repo rate (DR007), had increased since April 2016. In other words, the turning point of the

dynamic factor model based indicator aligns with the final drop in the RRR and the beginning of the rise in the 7-day pledged repo rate.

Our data-rich dynamic factor model indicator seems to offer a reliable measure of the Chinese monetary policy stance. The turning points are quite plausible, and the index provides a good compromise in terms of volatility. Moreover, it offers a more nuanced view than the two narrative indicators and volatile temporary changes in expectations are avoided. All in all, it can be said that the derived index provides a useful scorecard for measuring the stance of China's monetary policy.

4 Temporal evolution of monetary policy through the lens of a DSGE model

Pushing our analysis further, we employ the derived monetary stance indicator in an estimated plain-vanilla DSGE model to fathom what might prompt the PBoC to change or hold its monetary policy stance, as well as clarify the effects of monetary policy impulses on such things as the output gap and CPI inflation.¹⁸

For evaluation, we employ the simple, analytically tractable DSGE model of Ireland (2004) and Jones and Kulish (2016) derived via explicit aggregation of the micro-level behaviour of individuals and firms.¹⁹ We start with a brief sketch of the theoretical DSGE model, the central paradigm of New Keynesian economics,²⁰ and then transform the model into a supply and demand curve, relating inflation to output growth. The graphical representation of the estimated model illustrates how the underlying structural shocks have moved Chinese aggregate demand and supply simultaneously over time. This graphical device facilitates tracking of changes in monetary policy highlighted in Figure 5 in the inflation-output growth space. The ingredients that characterise this linearised DSGE model are

$$\hat{x}_t = E_t \hat{x}_{t+1} - (\hat{r}_t - E_t \hat{\pi}_{t+1}) + (1 - \omega)(1 - \rho_a) \hat{a}_t \quad (7)$$

$$\pi_t = \pi + \beta E_t \hat{\pi}_{t+1} + \psi \hat{x}_t - \hat{e}_t \quad (8)$$

¹⁸ In his famous critique of the Burns and Mitchell (1946) empirical characterisation of business cycles seven decades ago, Koopmans (1947) articulated the limited nature of conclusions that follow measurement without theory.

¹⁹ Of course, several features of the highly stylised DSGE framework are open to dispute and controversy. However, the fact that they are explicitly stated and discussed gives the reader a feel for the eventual impairment done in the model specification process.

²⁰ In recent years, criticism of the DSGE hegemony dominating macroeconomics has been voiced repeatedly. In his recent piece on DSGE models, Olivier Blanchard (2018) concludes that, while there are many reasons to dislike current DSGE models, they are improvable and central to the future of macroeconomics. The *Oxford Review of Economic Policy* recently devoted an eminently worthwhile special issue to the current state of macroeconomics (<https://academic.oup.com/oxrep/issue/34/1-2>).

$$\hat{r}_t = \hat{r}_{t-1} + \rho_\pi(\pi_t - \pi) + \rho_g(g_t - g) + \rho_x \hat{x}_t + e_{r,t} \quad (9)$$

$$\hat{x}_t = \hat{y}_t - \omega \hat{a}_t \quad (10)$$

$$g_t = g + \hat{y}_t - \hat{y}_{t-1} + \hat{z}_t \quad (11)$$

$$\hat{a}_t = \rho_a \hat{a}_{t-1} + \varepsilon_{a,t} \quad (12)$$

$$\hat{e}_t = \rho_e \hat{e}_{t-1} + \varepsilon_{e,t} \quad (13)$$

$$\hat{z}_t = \varepsilon_{z,t} \quad (14)$$

where the variables marked with a hat (circumflex) represent deviations from steady-state values. \hat{y}_t denotes the deviation of detrended output from its steady-state, \hat{x}_t the deviation of the output gap from its steady state, \hat{r}_t the deviation of the monetary policy stance derived above from its steady-state and $\hat{\pi}_t$ the deviation of the one-period inflation rate from its steady state. Movements in the main macroeconomic variables are the result of three types of (exogenous) stochastic disturbances: preference shocks, cost-push shocks and total factor productivity shocks. Thus, \hat{a}_t in equation (12) is an AR(1) preference shock, \hat{e}_t in equation (13) is an AR(1) negative cost-push shock and \hat{z}_t in equation (14) is a total factor productivity shock. E is the usual expectation operator.²¹

Equation (7) is derived from the representative household's Euler equation. Monetary shocks are transmitted to the real sector through changes in monetary policy stance. A tighter monetary policy stance raises the cost of agents to bring forward future consumption by borrowing, while increasing the return on saving. This direct effect drives the impact of policy.²² Equation (8) represents the economy's Phillips curve, positively relating inflation to the output gap. The parameter ψ is decreasing in the output cost that intermediate goods producing firms face when changing prices. The PBoC's reaction function is given by equation (9) with the PBoC adjusting the stance of monetary policy in response to inflation, output growth and the output gap. Equation (10) defines the output gap, and equation (11) defines output growth.

²¹ The modelling approach stays within the realm of linearised DSGE models. Global solution methods and higher-order expansions have recently gained ground as the zero lower bound has been hit. See e.g. Schmitt-Grohé and Uribe (2004). In the case of China, the nonlinearities triggered by the zero lower bound are hardly relevant.

²² Heterogeneous Agent New Keynesian (HANK) models are built around a nuanced view of household consumption. HANK models extend the standard incomplete-markets model by allowing households to hold two assets: a low-return liquid asset and a high-return illiquid asset subject to transaction costs. While the direct intertemporal substitution effect is small, the indirect effects through changes to disposable income can be substantial. As the data evidence, the presence of uninsurable risk, combined with the coexistence of low- and high-yielding assets, produces a sizeable fraction of poor and wealthy hand-to-mouth households. See Kaplan *et al.* (2018).

The methodology followed here consists of evaluating the implied aggregate demand and aggregate supply curves in the inflation-output growth space. Formally, the (π_t, g_t) space is defined with the linear supply curve is given as

$$\pi_t = \psi g_t + \hat{s}_t + (\pi - \psi g), \quad (15)$$

where

$$\hat{s}_t = \beta E_t \hat{\pi}_{t+1} + \psi \hat{y}_{t-1} - \psi \hat{z}_t - \omega \psi \hat{a}_t - \hat{e}_t. \quad (16)$$

The slope of the aggregate supply curve (15) depends upon the degree of price stickiness. In the special case of flexible prices given by $\psi \rightarrow \infty$, the supply curve is vertical. Conversely, for rigid prices given by $\psi \rightarrow 0$, the supply curve flattens. Rearranging the relationship between output and inflation gives us the aggregate demand curve

$$\pi_t = - \left(\frac{1 + \rho_g + \rho_x}{\rho_\pi} \right) g_t + \hat{d}_t + \left(\pi + \frac{1 + \rho_g + \rho_x}{\rho_\pi} g \right), \quad (17)$$

where

$$\begin{aligned} \hat{d}_t = & -\frac{1}{\rho_\pi} \hat{r}_{t-1} + \frac{1}{\rho_\pi} E_t \hat{x}_{t+1} + \frac{1}{\rho_\pi} E_t \hat{\pi}_{t+1} - \left(\frac{1 + \rho_x}{\rho_\pi} \right) \hat{y}_{t-1} + \left(\frac{1 + \rho_x}{\rho_\pi} \right) \hat{z}_t \\ & + \frac{\omega(1+\rho_x) + (1-\omega)(1-\rho_a)}{\rho_\pi} \hat{a}_t - \frac{1}{\rho_\pi} e_{r,t}. \end{aligned} \quad (18)$$

The slope of the aggregate demand curve (17) depends upon the parameters of the monetary policy reaction function. A greater response of the PBoC to deviations from target, ρ_π , flattens the curve. Stronger responses to output growth, ρ_g , and the output gap, ρ_x , steepen the aggregate demand curve. The reduced-form representation of (17) and (18) in terms of the structural disturbances is given by

$$\begin{bmatrix} \pi_t \\ g_t \end{bmatrix} = \begin{bmatrix} 1 \\ 1 + \rho_g + \psi \rho_\pi + \rho_x \end{bmatrix} \begin{bmatrix} \pi(1 + \rho_g + \psi \rho_\pi + \rho_x) + \psi \rho_\pi \hat{d}_t + (1 + \rho_g + \rho_x) \hat{s}_t \\ g(1 + \rho_g + \psi \rho_\pi + \rho_x) + \rho_\pi \hat{d}_t - \rho_\pi \hat{s}_t \end{bmatrix}. \quad (19)$$

The environment presented above encompasses the essential elements necessary for a quantitative analysis of monetary policy. At any point in time, the economy can be characterised by the intersection of the aggregate demand curve (17) and the aggregate supply curve (15) in the inflation–output growth space (π_t, g_t) . The structural analysis of the Chinese growth dynamics is a byproduct.

Based on the above model, we employ seasonally adjusted quarterly data on real GDP growth and CPI inflation and our derived monetary stance indicator to estimate the DSGE model and generate aggregate demand and aggregate supply curves for China. The estimation sample is 2012Q3–2018Q4. The chosen shapes and parameters of the prior distributions, are reported in Table 3.²³

Table 3 Priors for Bayesian estimates of the DSGE Model for China

Parameter	Distribution
ρ_a	Beta(0.85,0.05)
ρ_e	Beta(0.30,0.10)
ρ_π	Normal(0.40,0.10)
ρ_g	Normal(0.60,0.10)
ρ_x	Normal(0.40,0.05)
σ_a	Uniform(0,0.1)
σ_e	Uniform(0,0.1)
σ_z	Uniform(0,0.1)
σ_r	Uniform(0,0.1)

Bayesian estimation methods have gained ground as a highly attractive alternative to classical methods in the field of dynamic stochastic general equilibrium models (DSGE). Unlike the frequentist approach, the Bayesian approach uses both information from the available data and prior knowledge to provide posterior estimates. Metropolis-Hastings Markov Chain Monte Carlo (MCMC) methods are employed to generate random samples for the purpose of numerical evaluation of the posterior distributions. A comprehensive treatment of MCMC techniques, with further references, can be found in Gelman *et al.* (2003) and Robert and Casella (2004). A detailed treatment of Bayesian estimation of DSGE models can be found in Fernandez-Villaverde (2010). The estimation of the Bayesian DSGE model here was performed with the Dynare software package.²⁴

²³ Results are robust against more or less diffuse priors, provided they are independent distributions.

²⁴ <https://www.dynare.org/>.

Following Ireland (2004) and Jones and Kulish (2016), we apply the benchmark values $\beta = 0.99$, $\psi = 0.1$, $\omega = 0.06$.²⁵ The Bayesian estimates for the model parameters are presented in Table 4, and Figure 8 shows the estimated Chinese aggregate demand and aggregate supply curves at the steady state. The evolution of the economy in the inflation–output growth space can be described by the intersection of the aggregate supply and demand schedules at each point in time. A shock will shift the curves, which over time revert towards the steady state. The estimated slopes of the aggregate demand and the aggregate supply curves are -5.8 and 0.1, respectively, which implies that the aggregate supply curve is relatively flat. A direct consequence of this is the importance of demand shocks for GDP fluctuations.²⁶

Table 4 Bayesian estimates of the baseline DSGE model for China

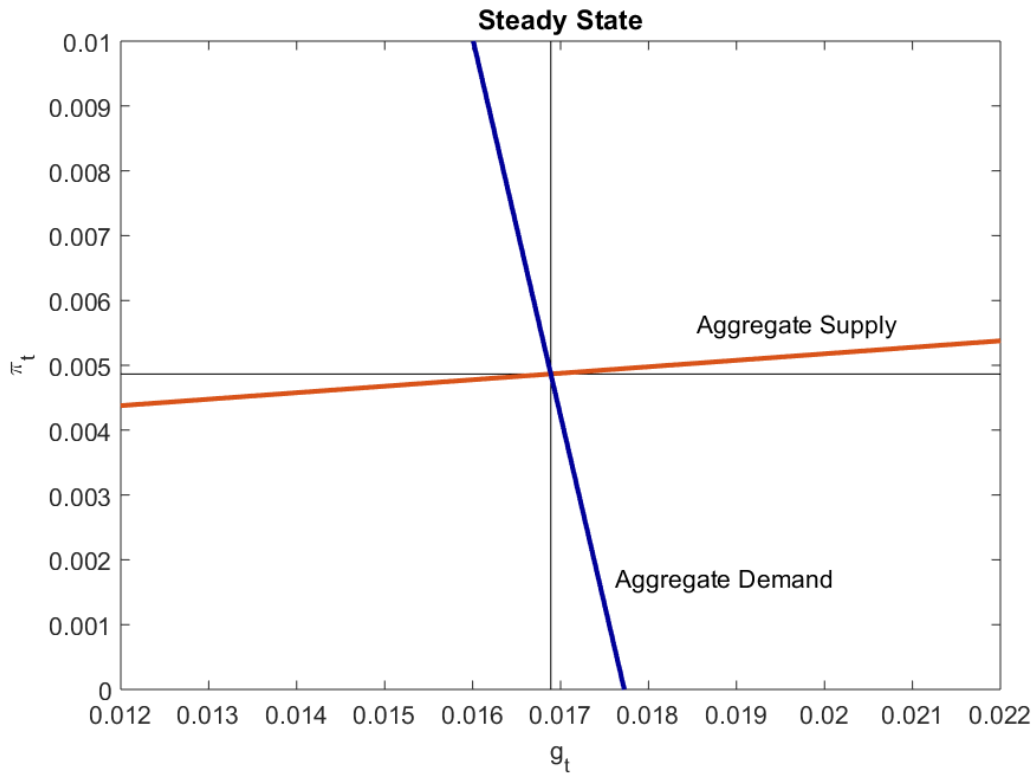
Parameter	Estimate	SE
ρ_a	0.8255	0.0483
ρ_e	0.2136	0.0757
ρ_π	0.3671	0.0901
ρ_g	0.7157	0.0948
ρ_x	0.4222	0.0481
σ_a	0.0129	0.0030
σ_e	0.0021	0.0003
σ_z	0.0017	0.0006
σ_r	0.0022	0.0004

Note: The estimates for the parameters are the posterior means.

²⁵ As results to be used for policy analysis in principle should be reasonably robust to a different prior specification, we also estimate the model with the prior of a much steeper aggregate supply curves ($\psi = 0.9$). We found that there is little difference with respect to the benchmark prior case.

²⁶ Unlike an aggregate demand and supply model with backward-looking expectations, a shock in a model with forward-looking agents shifts both the aggregate demand and aggregate supply curves by affecting expectations.

Figure 8 Aggregate demand and aggregate supply curves at the steady state



While the supply and demand curves at steady state in Figure 8 characterise the structure of the economy over the entire sample period, the performance of the Chinese economy in specific historical episodes is perhaps of greater interest. For this purpose, we trace out the underlying supply and demand curves for selected sub-periods to explore whether DSGE model simulations provide any pointer to the usability of the derived index for the analysis of monetary policy decisions in real time. As shown in Figure 5, the dynamic factor model yields several turning points in the monetary policy stance (highlighted red circles).

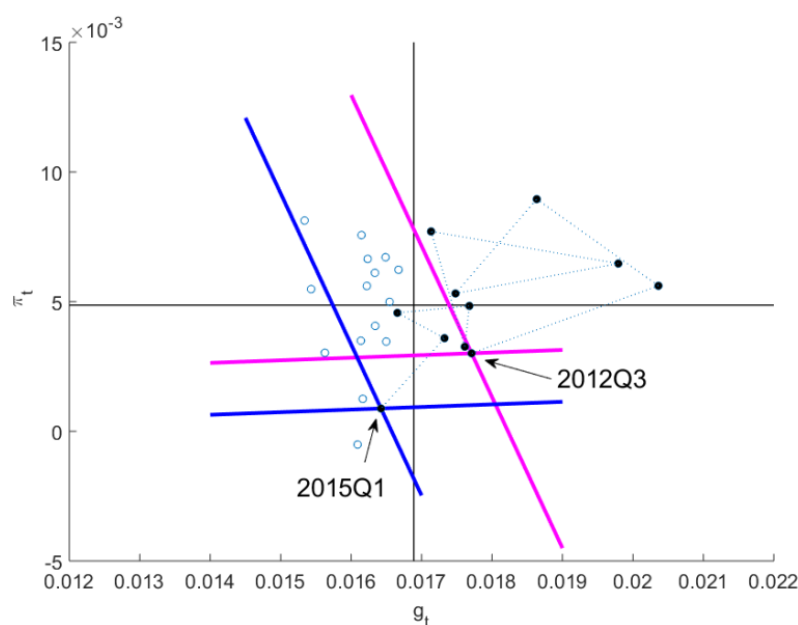
The three panels in Figure 9 present the movements of the derived aggregate demand and supply curves for three sub-periods: 2012Q3–2015Q1, 2015Q1–2016Q1 and 2016Q1–2018Q1. As a supplement to Figure 9, the decomposition of the aggregate demand curve and the aggregate supply curve by various shock components at the corresponding turning points are shown in Table 5.

The supply and demand curves at these respective starting points provide an indication of the initial economic situation. Comparison of this initial economic situation with the altered orientation of the PBOC's monetary policy stance provides indications of the Chinese monetary policy reaction function. Shifts in the curves give clues as to the effects of the time-varying monetary policy impulses.

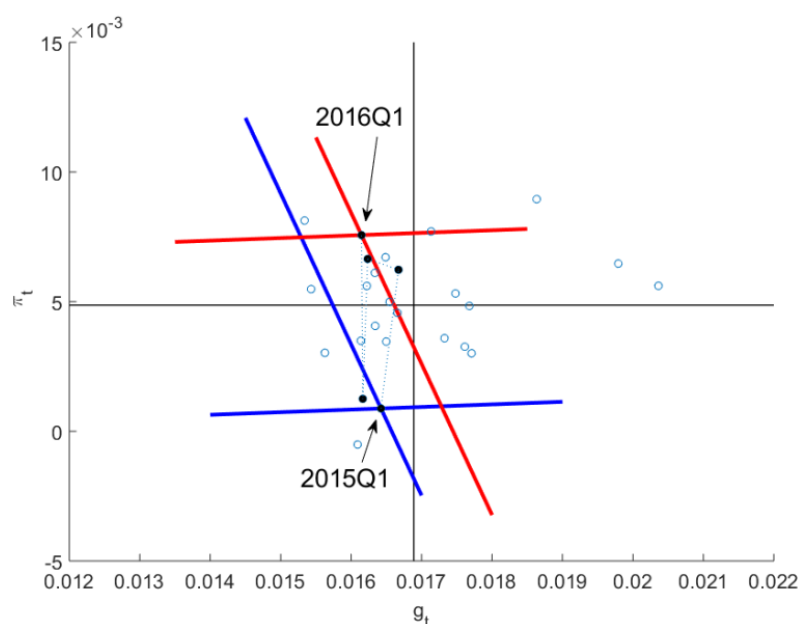
How did the supply and demand curve behave over the sample period? At quick glance at Figure 9 and Table 5 give two immediate impressions. First, the shifts of the two curves were caused by the coincidence in time of several shocks of various natures with the corresponding mix changing substantially over time. Second, the relative contribution of each shock varies across the three sub-periods. It is impossible to pick two sub-periods with a similar profile.

Figure 9 Aggregate demand and aggregate supply curves for 2012Q3–2018Q4)

(i) 2012Q3–2015Q1



(ii) 2015Q1–2016Q1



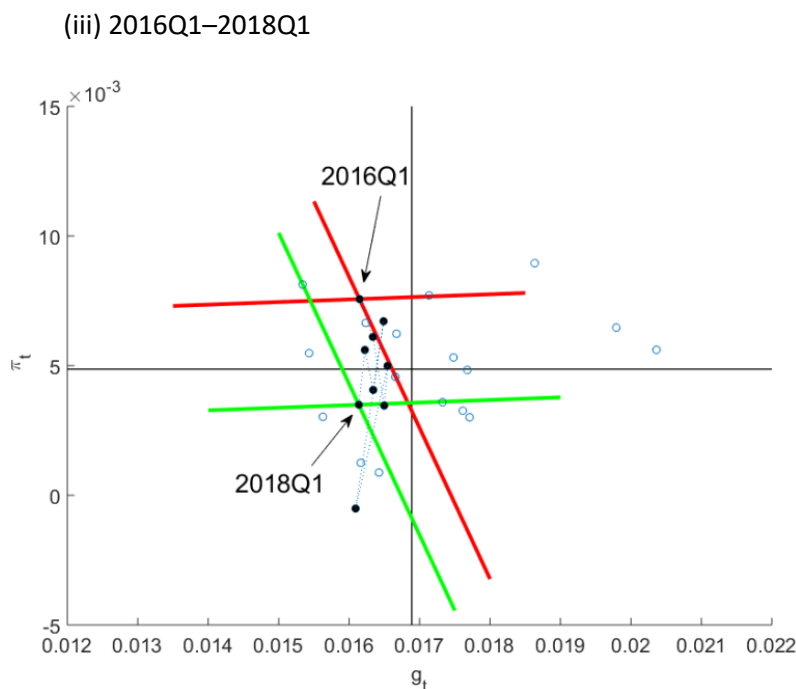


Table 5 Decomposition of Chinese aggregate demand and aggregate supply, 2012Q3–2018Q1

Component	2012Q3	2015Q1	2016Q1	2018Q1
Aggregate demand				
\hat{d}_t	0.00292	-0.00669	-0.00162	-0.00575
$\frac{1}{\rho_\pi} E_t \hat{x}_{t+1}$	-0.00393	-0.00091	0.00337	-0.00333
$\frac{1}{\rho_\pi} E_t \hat{\pi}_{t+1}$	-0.00119	-0.00283	0.00265	-0.00216
$-\left(\frac{1+\rho_x}{\rho_\pi}\right) \hat{y}_{t-1}$	0.01608	-0.00457	-0.00057	-0.00570
$-\frac{1}{\rho_\pi} \hat{r}_{t-1}$	0.00625	-0.00852	0.01182	-0.01081
$\left(\frac{1+\rho_x}{\rho_\pi}\right) \hat{z}_t$	0.00355	0.00168	-0.00475	0.00118
$\frac{\omega(1+\rho_x) + (1-\omega)(1-\rho_a)}{\rho_\pi} \hat{a}_t$	-0.01578	0.01234	-0.01460	0.02185
$-\frac{1}{\rho_\pi} e_{r,t}$	-0.00205	-0.00389	0.00047	-0.00679
Aggregate supply				
\hat{s}_t	-0.00194	-0.00394	0.00278	-0.00130
$\beta E_t \hat{\pi}_{t+1}$	-0.00043	-0.00103	0.00096	-0.00078
$\psi \hat{y}_{t-1}$	-0.00042	0.00012	0.00001	0.00015
$-\psi \hat{z}_t$	-0.00009	-0.00004	0.00012	-0.00003
$-\omega \psi \hat{a}_t$	0.00014	-0.00011	0.00013	-0.00020
$-\hat{e}_t$	-0.00114	-0.00287	0.00154	-0.00044

Several observations deserve note. Sub-period (i) of Figure 9 shows that the starting position in 2012 was characterised by higher growth rates and rising inflation rates. Looking back at Figure 5, situation this prompted the central bank to impose a tighter monetary policy stance. The Chinese

authorities pivoted towards economic reform. In particular, thought to rein in credit growth which had grown at alarming rates in 2010-2014. China also took steps to open up China's financial markets and the capital account.

The second sub-period (ii) in Figure 9 shows a very different economic situation at the beginning of 2015. Weakening global demand has caused Chinese growth to slow, with China's industrial growth decelerating significantly from 10% p.a. to around 6% after the second half of 2014. In addition, there is a significant decline in inflation, driven largely by declining commodity prices. As shown in Figure 5, the immediate consequence was that monetary softening. In other words, the PBoC injected a short-term monetary boost to halt the downward spiral.²⁷ China also put plans to lift capital controls on ice. The measures turned out to be premature: as constraints on capital movement were loosened, money fled the country and stock prices plummeted.

In the third panel (iii) of Figure 9, we see a turnaround in monetary policy towards a more restrictive monetary policy that begins in mid-2016. This is manifested in the increase of the latent monetary stance index (see Figure 5). Some of this reflects the stabilisation of financial markets after the turmoil of late 2015 and early 2016. China again confronts the necessity of deleveraging to avert the risk of excessive lending.

A different economic situation emerged in spring 2018. Economists ceased to celebrate the emergence of a broad synchronised global growth upsurge on news of a trade war between China and the US.²⁸ In an era of interconnected markets and global supply chains, the trade conflict had widespread repercussions. Global manufacturing activity slowed and economies especially reliant on trade, such as China, suffered. As expected, the model captures the declining growth momentum apparent in panel (iii) of Figure 9 as a contractionary supply effect. At the time of this writing, the trade conflict remains unresolved. The expected monetary easing of the central bank was not long in coming and became effective at the beginning of 2018. China again turned on the stimulus taps.

In summary, the graphical evaluation of the structural DSGE model in Figure 9 illustrates the countercyclical orientation of Chinese monetary policy. Whenever growth has slowed in the past, the PBoC has reliably responded with expansionary monetary policies and a strong nudge to

²⁷ In addition to monetary policy, expansionary fiscal policy also contributed to a shift in the aggregate demand curve. Officially, China's fiscal deficit expanded only modestly in 2015 and 2016, but the government is adept at using off-budget financing vehicles, primarily at the local-government level, to borrow and direct funds to projects. The IMF (2018, p. 82) estimates that China's "augmented" budget deficit, which includes such tactics, rose to around 68% of GDP in 2017, while government debt narrowly defined was 37% of GDP in 2017.

²⁸ Throughout 2018, president Trump unleashed a wave of tariffs against the largest trading partners of the US, including China, Canada, the European Union and Mexico. Even India was affected, particularly by tariffs on steel and aluminium. For an up-to-date tariff guide, see <https://piie.com/blogs/trade-investment-policy-watch/trump-trade-war-china-date-guide>. The policy has triggered retaliation. China raised tariffs by 25 percentage points on similar amounts of imports from the US on the same dates that the US tariffs came into force.

commercial banks to increase lending. This applies at least in the absence of overt inflationary pressures. The significant parameters ρ_π and ρ_g in the Taylor-type reaction function of the PBoC confirm this assessment.

Several modelling results are not very surprising, but the fact that they have been obtained with a plain-vanilla DSGE model estimated with the aid of our monetary policy index derived above, allows us to see them as supporting evidence for the empirical relevance of the dynamic factor monetary policy stance indicator.

5 Conclusions

Given China's growing importance to the global economy, understanding the Chinese monetary policy toolkit and how the People's Bank of China conducts monetary policy has aroused growing interest. The financial markets, in particular, eagerly seek timely information on Chinese monetary policy. The problem is not the information about monetary policy measures per se, but difficulty in interpreting China's monetary objectives. A particular difficulty lies in the fact that China's current multi-instrument policy design complicates reading of PBoC signals. Against this background, our monthly index offers a practical yet rigorous measure of the Chinese monetary policy stance. It strikes a balance between broad-based complexity and transparent simplicity. We hope this dataset and the periodically performed updates can be useful for monitoring and evaluating PBoC's monetary policy in the future. We also hope this dataset and future updates will enable a deeper understanding of the mechanisms driving China's macroeconomic development.

The PBoC recently began to sell short-term securities in Hong Kong, signalling the creation of a separate "offshore" monetary policy. This reform measure could pave the way for a regular programme allowing the PBoC to better manage RMB liquidity outside mainland China and to keep the onshore and offshore exchange rates in a narrow range. Given the offshore focus of these open market operations, we have not included this tool in our onshore index and leave a more detailed analysis of this innovation for future research.

Looking ahead, the further opening of the capital account is an important issue that could have consequences for the course of Chinese monetary policy. The idea of having monetary policy autonomy, exchange rate stability and financial market openness all at once would be attractive to any policymaker, but it is also a pipe dream. According to the "impossible trinity" or the "trilemma" facing central banks, no monetary authority can obtain all three at once.²⁹ China is no exception.

²⁹ See Rey (2016) for a comprehensive analysis of limiting the scope of independent monetary policy. Taking a cue from the familiar economic trilemma, Rodrik (2011) posits a political globalisation trilemma, whereby deep economic integration, national sovereignty and democracy are mutually incompatible. Thus, an equilibrium is only feasible if one

Indeed, with growing international capital flows, this “impossible trinity” will become increasingly relevant for China.³⁰ While it is possible to achieve desired levels of two out of the three attributes, it is impossible to achieve simultaneously the desired levels for all three. Consequently, the choice of exchange rate regime must be made in conjunction with the choices on monetary policy autonomy and financial market openness. It can be presumed that for China, maintaining monetary policy management appropriate for its specific cyclical and structural conditions is an important policy goal. It remains to be seen how the Chinese institutional setup, the policy objectives and the instrument mix evolve.

of the three elements is sacrificed. Rodrik then argues that, since democracy remains one of humanity’s greatest achievements and global government is inconceivable at this point, economic globalisation is what needs to be constrained. China, in contrast, seems to be willing to sacrifice the democracy element and stick with the first two elements. Indeed, president Xi has retreated from the tentative steps of his predecessors towards political liberalisation.

³⁰ <https://www.bloomberg.com/news/videos/2015-01-22/china-and-the-impossible-trinity> .

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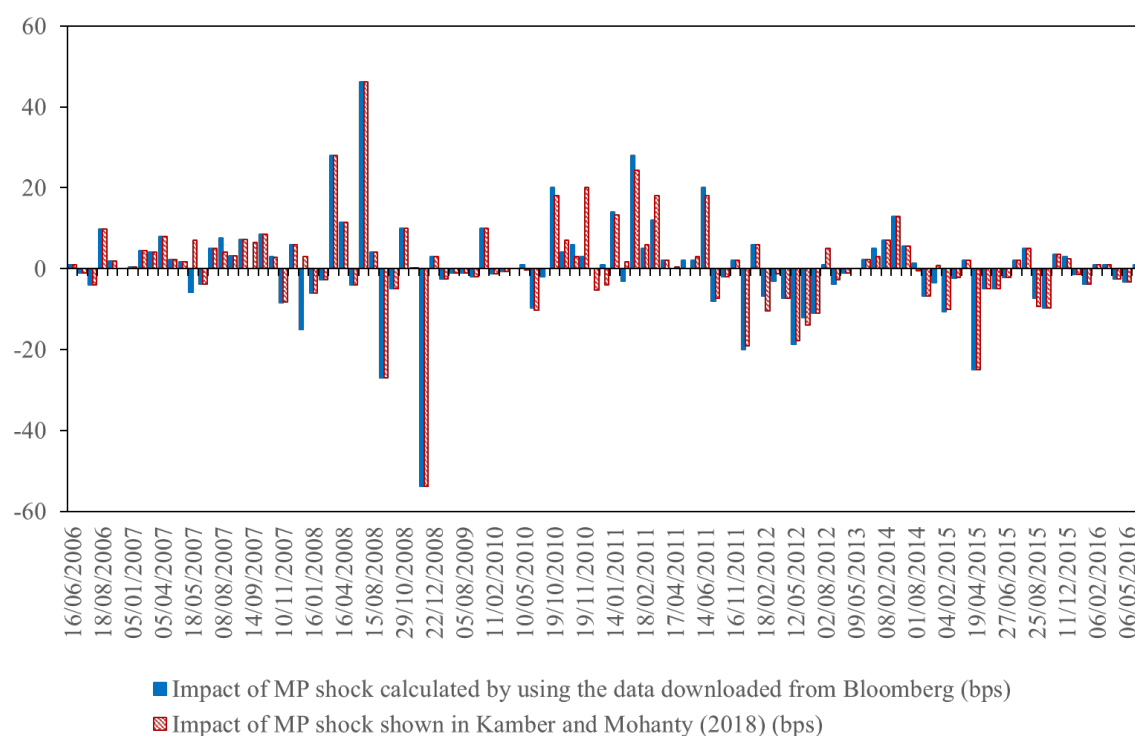
Appendix A Parameter estimates of dynamic factor model of monetary policy stance indicator

Variables	Parameters	Estimates	(t-Statistic)
ΔM_t	φ_1	-0.1168	(-0.7316)
	φ_2	0.0633	(0.4044)
$\Delta I_{1,t}$	β_1	-0.1125	(-1.6353)
	$\rho_{1,1}$	-0.3282	(-2.875)
	$\rho_{1,2}$	-0.0901	(-0.7883)
	σ_1^2	0.3178	(5.5443)
$\Delta I_{2,t}$	β_2	-0.2090	(-7.3948)
	$\rho_{2,1}$	0.2924	(0.3187)
	$\rho_{2,2}$	0.4688	(0.5957)
	σ_2^2	0.0034	(0.5044)
$\Delta I_{3,t}$	β_3	0.0567	(1.0457)
	$\rho_{3,1}$	-0.1950	(-1.5811)
	$\rho_{3,2}$	-0.0825	(-0.6867)
	σ_3^2	0.1460	(6.5423)
$\Delta I_{4,t}$	β_4	0.0834	(4.2163)
	$\rho_{4,1}$	0.4270	(3.4459)
	$\rho_{4,2}$	-0.2720	(-2.191)
	σ_4^2	0.0294	(6.1391)
$\Delta I_{5,t}$	β_5	0.0058	(1.3031)
	$\rho_{5,1}$	0.3360	(3.4001)
	$\rho_{5,2}$	0.2532	(2.4737)
	σ_5^2	0.0013	(7.3714)
Log likelihood		79.60	

Appendix B Replication of monetary policy shocks described in Kamber and Mohanty (2018)

As their proxy for the Chinese monetary policy shocks, Kamber and Mohanty (2018) employ the daily change in the nearest closing price of 1-year interest rate swap (IRS) for the 7-day pledged repo rate (R007) after the time of monetary policy announcement. When replicating their estimates using data from Bloomberg, we found minor discrepancies for various observations by applying the same data source and calculation methodology. These differences appear in about one third of the observations.

Differences in the estimated results of monetary policy shocks



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