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To Guide or not to Guide? Quantitative Monetary Policy Tools and Macroeconomic Dynamics in China

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Abstract

This paper discusses the macroeconomic effects of China's informal banking regulatory tool "window guidance," introduced in 1998. Using an open-economy DSGE model that includes the commercial banking sector, we study the stabilizing effects of this non-standard quantitative monetary policy tool and the implications of quantity-based vs. price-based monetary policy instruments for welfare. The analyses are relevant to the current overhaul of Chinese monetary policy.

Keywords: Monetary policy, window guidance, China, DSGE model

JEL classification: C61, E32, E44, E52

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1. Introduction

China's monetary policy has been in flux in recent years. The People's Bank of China (PBoC) engaged in a significant relaxing of its policy settings to support flagging economic growth. To guide liquidity levels, it also implemented adjustments in its monetary policy framework to pave the way for establishing a short-term PBoC policy rate like that used in advanced economies.

In October 2015, the PBoC's interest rate cut, which was part of an easing cycle that had begun 13 months earlier, took the benchmark one-year deposit and lending rates down to record lows of 1.5% and 4.35%, respectively.¹ During 2015 – 2016, the PBoC also repeatedly lowered the reserve requirement ratio for bank deposits. For large lending institutions, the reserve requirement ratio fell from 20% to 17%. Even so, the real economy failed to respond to these easing moves. Real GDP growth decelerated to 6.7% in 2016, while the economy teetered on the brink of deflation. Consumer prices barely rose and producer prices fell.²

Aware of its policy transmission problems, the PBoC began to make changes in its approach. Broadly speaking, the central bank embraced a gradual switch from quantity-based measures to guide monetary policy toward a price-based approach that gave more weight to interest rates and let liquidity levels be determined by the price, rather than volume, of capital. The change was intended to bring the PBoC closer to the practices of its counterparts in advanced economies.

This new approach was signaled by the introduction of new liquidity-management tools. The PBoC introduced a standing lending facility and "short-term liquidity operations" in 2013. Both help the PBoC inject cash into the banking system, with the former focused on meeting demand for longer-term liquidity, while the latter provides liquidity on a short-term basis via repurchase agreement (repo) operations. The PBoC also introduced "pledged supplementary lending" that allows banks to pledge government bonds and high-quality assets as collateral to the PBoC in return for funds that are

¹ In October 2015, the PBoC announced it would allow commercial banks to offer depositors whatever interest rates they liked. Observers, however, cautioned of any sweeping effect. Since 2013, commercial banks had been free to set lending rates as they choose and benchmark lending rates were only guidelines. In practice, loan rates still correlate rather closely with PBoC benchmarks.

² The effectiveness of China's monetary policy framework has been undercut by the economy's emerging shadow banking sector. Financial liberalization and innovation has driven the development of new financial instruments such as wealth-management products that have reduced the importance of commercial bank lending. This loophole has given rise to a significant portion of lending coming from non-bank sources, including trust loans and peer-to-peer lending platforms. See Funke et al. (2016).

intended for policy lending to small- and medium-sized companies. Together these instruments aim to address the structural imbalance of bank lending and target liquidity more effectively than previously preferred measures such as the reserve requirement ratio.³

The PBoC has also taken steps toward establishing a short-term policy rate. The seven-day interbank repo rate has apparently be designated the targeted short-term money market rate. It surrounding corridor is likely to be defined by the standing lending facility (upper bound) and the interest rate on excess reserves (lower bound). To this end, the PBoC increased the frequency of its open market operations from bi-weekly to daily at the beginning of 2016.

Since China is transitioning to a price-based monetary policy approach, the roles of China's administrative and quantity-based monetary policy tools are an open question.⁴ China's monetary policy has always been predominantly quantitative in nature, and the use of quantitative tools has long been the norm in implementing China's monetary policy. In particular, the PBoC has relied on lending quotas known as "window guidance" since 1998 to influence bank behavior and pump money into the economy.⁵

While some commentators argued that the repackaging of the PBoC's loan guidance was just "old wine in new skins," it is now part of the new Macro-Prudential Assessment (MPA) System. In addition to controlling loan growth, the MPA requires the PBoC to review the capital adequacy, leverage ratios, asset and liability ratios, liquidity, pricing of interest rates, asset quality, and foreign debt risks of banks. A broad range of credit products, not just bank loans, are evaluated under the new MPA (BBVA, 2015).

The PBoC's renewed focus on window guidance may reflect eroding policy buffers. During the global financial crisis and its immediate aftermath, many countries employed expansionary fiscal and monetary policies to support economic growth. Their ability to employ effective countercyclical policy during the crisis was a major accomplishment. However, the erosion of policy buffers in many countries has made it more difficult to curtail the slowdown in growth through monetary stimulus.

³ Traditionally, the PBoC has steered reserve requirements to sterilize liquidity injections and withdrawals related to its interventions in the foreign exchange markets. For this reason, we omit the reserve requirement rate as a monetary policy tool from our Section 3.3 discussion.

⁴ The IMF (2016, p. 14) recently proposed terminating quantity-based tools such as setting credit targets through window guidance, unless they were used to effect macroprudential policy.

⁵ China's window guidance system closely follows the Japanese system, which was in place for over 40 years until its suspension in the early 1990s. The Chinese system uses suasion to get banks and other financial institutions to follow official PBoC guidelines. Some of the success of window guidance in China can be attributed to Chinese hierarchic structures. The governor of the PBoC ranks higher in the pecking order than heads of commercial banks.

Central bank attempts to deal with the new environment vary. For example, the Bank of England's funding for its 2012 lending scheme made the provision of cheap central-bank financing conditional on banks writing more loans to companies and households. The European Central Bank has made several attempts at inducing bank lending, but with little success.

As this problem persists, monetary policymakers must increasingly contemplate radical approaches to tackling the next downturn. The precise choice of policies and the degree of radicalism may vary across countries and with the nature of threats, but a large systemic shock such as a Chinese hard landing would require monetary policymakers to take bold action against economic recession and efforts to pull their economies out of zero lower bound quicksand. This especially problematic as firms flooded with cheap loans are unlikely to feel much pinch from the shock, making it hard to rely on market forces. Excessive window guidance also fosters financial fragility. These drawbacks beg the question of whether quantitative monetary policy tools are more of a problem than a solution.⁶

The economic messaging of the Chinese government is conflicted. It pledges to let markets play a "decisive" role in the economy, but the desire for more efficient allocation of capital clashes with the Communist's Party reflexive instinct for control. Thus, the tension between reform and control is quite evident in Chinese monetary policy and not a minor factor behind the PBoC's fitful push toward a coherent monetary policy approach.

The remainder of the paper is as follows. Given the emphasis on window guidance, Section 2 presents descriptive evidence about window guidance and describes how window guidance affects lending in China. In Section 3, a canonical New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model with window guidance is presented. The model accounts for the distinctive features of monetary policy in China and thus provides insights into Chinese style financial intermediation. To give a sense of the magnitudes, Section 4 calibrates the model and provides a set of numerical experiments. Section 5 discusses the pros and cons of window guidance. Section 6 concludes.

⁶ Because credit controls went out of fashion following deregulation in the 1980s and 1990s, most advanced economies have little up-to-date experience with credit regulation. Elliot et al. (2013) note that credit control measures in the United States were quite successful in steering the credit cycle and that restrictions on reserve requirements aimed at affecting liquidity were less effective.

2. Window guidance and financial intermediation in China

The origins of window guidance date back to 1998 when the PBoC abolished its pure quantity-based credit plan, a direct control on the credit quantity of state-owned banks. Window guidance relies on moral suasion rather than hard rules to pressure banks to adjust the amount and pace of credit supply until a credit growth target is met. It is also used to optimize the credit structure by moderating banks' allocation of credit to sectors and regions in line with policy objectives.

Following the narrative approach of Romer and Romer (1989) and Romer and Romer (2004), we summarize the episode-by-episode development of PBoC's window guidance policy with the corresponding economic situation at that moment.⁷ This approach relies on the reading of the central bank's documents to infer additional information on PBoC's intentions. The policy stance is identified and in addition, the driving force of each policy movement is detected. We study all issues of the *Quarterly Monetary Policy Report* (QMPR) from 2001 onward and construct an indicator for the window guidance policy stance.⁸

The PBoC's window guidance policy can be classified into five stances.⁹ Table 1 presents definitions of indicators corresponding to five different stances of window guidance. Appendix A gives a quarter-by-quarter summary of stances of PBoC window guidance policy from the QMPR.

Employing the above dummy variable approach for the stance of window guidance gives the following timeline of the window guidance policy stance:

⁷ The approach was applied by He and Pauwels (2008) and Shu and Ng(2010) on classifying the monetary policy stance, based on the information in PboC's Quarterly Monetary Policy Report. Yoshino and Angrick (2016) also used the similar approach on classifying the stance of window guidance policy.

⁸ The quarterly publication has been released since 2001Q1. Its purpose is to increase policy transparency and enhance communication with the general public. For the purposes of this discussion, the useful feature is that the PBoC has commented consistently on window guidance since 2001.

⁹ Our classification for window guidance is based on the wording used by PBoC in the paragraph describing the window/loan guidance policy in its *Quarterly Monetary Policy Report*. As a policy tool of moral suasion, window guidance is used to fine-tune the amount and pace of bank credit to fulfill its monetary policy goal. Therefore, the terms "monetary policy" and "window guidance" overlap, but are not the same even if window guidance policy is impliedly consistent with the monetary policy stance. Comparing the wording for window guidance and monetary policy stance, we can find that most of the time PBoC characterized its monetary policy stance in such terms as "sound" or "prudent," while speaking of "discouraging" (2006–2007) or "implicitly encouraging" (2014–present) lending under window guidance.

- a) **1998–2000.** The PBoC started to implement window guidance in 1998 in the wake of the Asian Financial Crisis.¹⁰ The PBoC sought to boost the economic growth by stimulating the supply of bank credit through an *encouraging* window guidance policy. The PBoC cautioned banks, however, about real estate lending (Zhang and Ji, 2012).
- b) **2001–2002.** The PBoC gave *no explicit direction* on window guidance during this period.
- c) **2003–2008.** The PBoC strengthened window guidance to curb accelerated growth in lending, particularly to the real estate sector. During this period, the PBoC expressed a *strongly discouraging* window guidance stance to cool credit growth (2004 and 2006 – mid-2008), and a *weakly discouraging* stance in 2005, when the PBoC guided banks to optimize the credit structure in light of falling CPI inflation.
- d) **2008–2009.** The onset of the global financial crisis in September 2008 adversely affected the Chinese economy. Facing rapidly deteriorating economic growth, Chinese authorities introduced a 4-trillion yuan stimulus plan, which the PBoC simultaneously removed all rigid constraints on commercial bank lending and adopted a window guidance policy the *strongly encouraged* banks to provide loans in the last quarter of 2008. The policy continued through mid-2009.
- e) **2009–2010.** Surging bank lending, particularly to real estate investment, alerted the Chinese authorities to an emerging risk of overheating. The PBoC responded with a sharp policy reversal on window guidance to *strongly discourage* lending. It emphasized the role of banks in risk prevention and controlling credit growth.
- f) **2010–2012.** As credit growth gradually slowed in early 2010, PBoC assumed a *weakly discouraging* window guidance stance. The PBoC encouraged banks to manage the pace and structure of credit supply and sought to discourage lending in overcapacity sectors.
- g) **2012–2014.** While a production growth slowdown and overcapacity concerns prevented the PBoC from stating an explicit direction for credit growth under its window guidance stance, it was able to emphasize loan reallocation. Specifically, it said its target now was optimizing the credit structure and focused window guidance by sector. A *discouraging* stance was recommended for overcapacity sectors and an *encouraging* stance for policy sectors. The period marked the beginning of an era in which the PBoC emphasizes the loan reallocation function of window guidance.

¹⁰ To enhance the information exchange in its window guidance decisions, the PBoC holds monthly meetings with representatives of government macroeconomic-policy-related departments and commercial banks.

h) **2014–present.** As economic growth has slowed, the PBoC has *encouraged* banks to lend more. The nuanced response of sector focus means, however, that overcapacity sectors still receive “differentiated treatment” and “one-size-fits-all” measures have been eliminated.

The shifting intensity and focus of the window guidance policy stance reflects the business cycle, mainly in terms of output growth, inflation, and the pace of credit growth. We use heatmaps to visualize the stance of window guidance along with the output gap and changes in the output gap. Specifically, Figure 1 shows the level and changes in the industrial-production-based output gap and the annual CPI inflation rate overlaid with the shifting window guidance stance. Here, we use industrial-production-based output gap instead of the GDP-based output gap, because, at least in our view, the PBoC’s loan-related policies have tended to focus mainly on output growth.

The extent to which window guidance affects loan growth is important as its objective is adjusting the quantity and the pace of lending. Applying the above classification of the window guidance stance, new loans to GDP ratio and quarter-on-quarter changes in loans-to-GDP ratio shown in Figure 2 may provide hints on the relationship between window guidance and loan growth, particularly in lending to non-financial sectors.

Based on the above graphical evidence, some summary statistics are calculated for illustrating the descriptive empirical evidence of how well the lending of commercial banks in China responds to window guidance. On the one hand, we generally expect that the PBoC employs window guidance policy in a countercyclical way. The correlation between the five-value indicator for window guidance and the change in output gap is -0.44, while the correlation is -0.25 between the indicator and CPI inflation. The negative correlation provides empirical evidence confirming the countercyclical nature of window guidance policy. On the other hand, the window guidance policy could lead bank lending behavior. Figure 2 suggests positive correlations between the indicator for window guidance and loan growth indicators. Specifically, correlations between the indicator and new loans are 0.29 for total loans and 0.38 for loans to non-financial sectors, while the correlations between the indicator and changes in loans-to-GDP ratios are 0.31 for total loans and 0.36 for loans to non-financial sectors. Applying Granger-causality tests, the window guidance indicator Granger-causes the lending.¹¹

¹¹ The indicator for window guidance Granger-causes all four loan growth indicators shown in Figure 2. Conversely, there is no significant feedback from loans to the window guidance indicator. It is important to emphasize that providing a precise

Each level in the range of *discouraging* and *encouraging* window guidance policies displays certain characteristics.

For *strongly discouraging*, the change in output gap is generally positive and above 1% (particularly at 2009) and the CPI inflation rate shows an explicit upward trend. During periods of strongly discouraging window guidance, the supply of new loans and loans-to-GDP ratio show sharp declines.

For *weakly discouraging*, the change in output gap is positive, but does not exceed 1% (particularly during 2010–2012), and the CPI inflation rate declines from a relatively high levels (above 3%). The supply of new loans stabilizes at a low level (below 15% for total loans and 10% for loans to non-financial sectors) and the change in loans-to-GDP ratio is near negative or negative.

For *no explicit direction*, the change in output gap was around zero and the CPI inflation rate remained at a low level (below 3% yoy, particularly since 2012). The change in loans-to-GDP ratio was positive.

For *weakly encouraging*, the change in output gap is negative (as for the recent negative output gap recorded since mid-2014), and the year-on-year CPI inflation rate remains at a low level (below 3%). There are large changes in loans-to-GDP ratio and non-financial-loans-to-GDP ratio (above 20%).

For *strongly encouraging*, the change in output gap is negative and below -2% and the CPI inflation rate declines even to deflation levels (during 2008–2009). Large swings in the loans-to-GDP ratio and non-financial-loans-to-GDP ratio (reached 80%) are recorded.

Although PBoC is trying to introduce macro-prudential bank lending policies, it is clear that window guidance remains the PBoC's most prominent quantity-based monetary instrument.¹² It is repeatedly emphasized in the PBoC's monetary policy reports. It fits the picture that the quantity-based window

quantification of the role of loans is inherently a difficult task. As in the Granger-causality literature, the bivariate empirical analysis focuses only on part of the complex web of relationships. This comes with the caveat that other factors may simultaneously affect loans and GDP. Not taking these into account likely leads to an upward bias in the estimated role of loans in predicting the GDP dynamics. For this reason, our structural modeling approach in Sections 3 and 4 takes a holistic approach.

¹² In 2011, the PBoC rolled out macro-prudential bank lending measures such as the “dynamic adjustment mechanism for the differentiated reserve requirement” and “desirability lending.” Both practices were somehow connected to window guidance policy. The PBoC's 2014Q3 *Monetary Policy Report*, Box 3 notes: “...desirability lending is a transparent, rule-based macro-prudential policy tool based on capital requirements. It is different from administrative controls on the lending quota.” Even so, market participants treated it as another credit quota (BBVA, 2015). At the end of 2015, PBoC announced it would upgrade the previous mechanism of macro-prudential measures of bank lending to its new Macro-Prudential Assessment System. In recent years, the PBoC has emphasized the role of window guidance in optimizing the credit structure.

guidance policy is closely coordinated with interest rate setting, a price-based policy tool. Figure 3 shows the systematic pattern between window guidance and price-based monetary policy tools.

When the window guidance stance is *encouraging*, interest rates decrease, and vice versa. Specifically, the correlation between the indicator for window guidance and quarterly changes in the 1-year base lending rate was -0.54 (same for 1-year base deposit rate). In addition, the correlation between the indicator for the window guidance and changes in the interbank interest rate (3-month CHIBOR) was -0.3.

While a descriptive empirical exploration of the application and efficacy of window guidance gives a sense of the transmission channels of window guidance, it does not provide evidence on specific effects from a particular window guidance stance. Isolating the effect of window guidance from complementary policies or other economic developments constitutes a significant empirical challenge and requires cautious interpretation. To address this difficulty, a large strand of literature on the impact of monetary policy employs DSGE modeling frameworks. In this tradition, we model the window guidance toolkit in a DSGE framework for mainland China. As noted by Blanchard (2016), DSGE model architecture allows for integration of relevant empirical findings and facilitates coherent discussion of results.¹³

3. The model

To place monetary policy discussions in China in a coherent conceptual framework, we develop a DSGE framework that considers China's unique monetary transmission characteristics. The model is designed to be tractable to obtain intuitive results. From the modeling standpoint, the global financial crisis has shown that macroeconomic models based on frictionless financial markets do not reproduce salient features of the business cycle. In particular, policy models that implicitly assumed perfectly

¹³ China's recent focus on window guidance may also reflect the eroding policy buffer issues encountered in many countries. During the global financial crisis and its immediate aftermath, countries often resorted to expansionary fiscal and monetary policies to support economic growth. While the ability to employ effective countercyclical policy during the crisis was heralded as a major accomplishment, the erosion of policy buffers since have made it increasingly difficult to counteract slowing growth through traditional fiscal and monetary stimulus measures.

functioning capital markets in the decade leading up to the crisis failed to capture the procyclicality of the financial system or predict the persistence and the intensity of the global recession.

A large body theoretical literature has arisen in recent years on incorporating financial features and the banking sector into DSGE models. In the strand represented by Gerali et al. (2010), the model economy features patient and impatient households, as well as entrepreneurs. Impatient households and entrepreneurs are collaterally constrained. Interest rates are set optimally by banks subject to quadratic menu costs, makes their pricing decisions intertemporal. The authors show that monetary policy shocks are attenuated, while total factor productivity (TFP) shocks are amplified and propagated. Shocks that emerge from the banking sector can also have sizable impacts on the real economy.¹⁴

Here, we extend Gerali et al. (2010) by modeling a small, partially open economy. We assume world interest rates do not respond to Chinese economic conditions. Only tradeables are produced and purchased both domestically and abroad. Both consumption and investment goods can be imported from abroad. The ratio of domestic and imported goods in the consumption and investment bundles depends on the relative prices. Despite baby steps toward liberalization, the Chinese capital account remains largely closed (e.g. private entities are not free to hold assets denominated in foreign currency). Instead, foreign assets, accumulated from positive current account balance, are exchanged for securities denominated in local currency by the PBoC.¹⁵ Two consequences arise from arrangement. First, nominal exchange rate fluctuations, as well as any misalignment between foreign and domestic interest rates, are not reflected in the budget constraint of private agents – but they *do affect* the PBoC's profit/loss position. Second, the standard uncovered interest rate parity (UIP) may not hold in equilibrium, because arbitrage between domestic and foreign assets is administratively prohibited. The UIP condition is replaced by an equation that allows exchange rate to reflect only a small fraction of the *ex ante* spreads between the returns of domestic and foreign assets. This

¹⁴ See Gertler and Kiyotaki (2010) for an assessment of this research.

¹⁵ The Chinese government has recently sought to liberalize the country's capital account. Part of this effort include the roll-out of investment vehicles for foreigners wanting to invest in China and Chinese firms exploring overseas opportunities. The first of these was the Qualified Foreign Institutional Investor (QFII) scheme, which allowed a limited number of foreign investors to purchase onshore equities. The next step was the Qualified Domestic Institutional Investor (QDII) scheme, which allowed Chinese firms to invest overseas. A year later, China introduced offshore RMB-denominated "Dim Sum" bonds. While these all represent incremental liberalizations of China's capital account, the pace of change has been slow. The various investment schemes are subject to set quotas and are available only to a limited number of firms in China and abroad. Extensive capital controls remain intact, limiting room for speculative maneuvering.

arrangement stabilizes exchange rate movements and nests two extreme cases – fully open and fully closed capital accounts.

3.1 Households

Time is discrete and indexed by t . Households, indexed by j , maximize their lifetime utility, discounted by β_P^t subject to a usual budget constraint in real terms and a downward-sloping labor demand curve. Their instantaneous utility depends *positively* on their individual current $c_t^P(j)$ and aggregate lagged c_{t-1}^P consumption (due to habit formation), and *negatively* on hours worked $l_t(j)$. Individual consumption preferences are subject to an exogenous disturbance ϵ_t^Z that follows an AR(1) process. Households supply differentiated labor input and receive in return wages that are sticky in nominal terms. Their income is formed from payroll $w_t l_t(j)$, dividends $t_t^P(j)$ and *real* gross interest income on last period's deposits $\frac{(1+r_{t-1}^d)d_{t-1}(j)}{\pi_t}$. Current income is reduced by the quadratic wage adjustment costs $\Omega(W_t(j), W_{t-1}(j)) = \frac{\kappa_w}{2} \left(\frac{W_t(j)}{W_{t-1}(j)} - \pi_{t-1}^{i_w} \right)^2 \frac{W_t(j)}{P_t}$, where W_t are nominal wages and $\pi_{t-1}^{i_w}$ is the wage indexation rule. Households use this income to buy consumption goods or save in new deposits $d_t(j)$. Inflation is denoted by π_t and nominal wage inflation is defined as $\pi_t^w = \frac{w_t}{w_{t-1}} \pi_t$.

$$\max_{c_t^P(j), d_t(j), l_t(j)} E_0 \sum_{t=0}^{\infty} \beta_P^t \left[(1 - a^P) \epsilon_t^Z \log(c_t^P(j) - a^P c_{t-1}^P) - \frac{l_t(j)^{1+\phi}}{1+\phi} \right]$$

$$c_t^P(j) + d_t(j) \leq w_t l_t(j) + \frac{(1 + r_{t-1}^d) d_{t-1}(j)}{\pi_t} - \Omega(W_t(j), W_{t-1}(j)) + t_t^P(j)$$

$$l_t(j) = \left(\frac{W_t(j)}{W_t} \right)^{-\epsilon_l} l_t,$$

where W_t and l_t are aggregate wage and hours worked, respectively. The first-order conditions w.r.t. $c_t^P(j), d_t(j), l_t(j)$ are:

$$(1 - a^P) \epsilon_t^Z = \lambda_t^P (c_t^P(j) - a^P c_{t-1}^P) \quad (1)$$

$$\lambda_t^P = \beta_P \lambda_{t+1}^P \left(\frac{1 + r_t^d}{\pi_{t+1}} \right) \quad (2)$$

$$\kappa_w (\pi_t^w - \pi_{t-1}^w \bar{\pi}^{1-i_w}) \pi_t^w = \beta E_t \left[\frac{\lambda_{t+1}^P}{\lambda_t^P} \kappa_w (\pi_{t+1}^w - \pi_t^w \bar{\pi}^{1-i_w}) \frac{(\pi_{t+1}^w)^2}{\pi_{t+1}} \right] + (1 - \epsilon_l) l_t(j) + \epsilon_l \frac{l_t(j)^\phi}{\lambda_t^P w_t} \quad (3)$$

Equations (1) and (2) form the Euler equation, while (3) is a wage Phillips curve.

3.2. Entrepreneurs

Entrepreneurs, indexed by i , combine capital $k_t^E(i)$ that depreciates at rate δ , and labor $l_t(i)$, to produce a homogenous intermediate good in accordance with the standard Cobb-Douglas production function.¹⁶ The production function is subject to an autoregressive TFP shock, A_t^E . The real price of capital is denoted by q_t^k . Capital utilization rate, $u_t(i)$, can also vary over time and is chosen every period by entrepreneurs. Capital utilization costs are determined by the quadratic function $\psi(u_t(i))$. The firms borrow $b_t(i)$ at nominal interest rate r_t^{bE} , to partially finance the purchase of productive capital and decide their consumption profile $c_t^E(i)$ to maximize lifetime utility from consumption, discounted by β_E^t . Borrowing is constrained by the total stock of capital.

$$\max_{c_t^E(i), b_t^E(i), k_t^E(i), u_t(i), l_t(i)} E_0 \sum_{t=0}^{\infty} \beta_E^t [(1 - a^E) \log(c_t^E(i) - a^E c_{t-1}^E(i))]$$

$$c_t^E(i) + w_t l_t(i) + \frac{(1 + r_{t-1}^{bE}) b_{t-1}(i)}{\pi_t} + q_t^k k_t^E(i) + \psi(u_t(i)) k_{t-1}^E(i) \leq \frac{y_t^E(i)}{x_t} + b_t(i) + q_t^k (1 - \delta) k_{t-1}^E(i)$$

$$y_t^E(i) = A_t^E [u_t(i) k_{t-1}^E(i)]^\alpha l_t(i)^{1-\alpha} \quad (4)$$

$$\psi(u_t(i)) = \chi_0 (u_t(i) - 1) + \frac{\chi_1}{2} (u_t(i) - 1)^2 \quad (5)$$

¹⁶ The budget constraint of entrepreneurs expressed in terms of consumption goods and output is sold at producer prices. Thus, firm revenues should be discounted by a retail mark-up, x_t .

$$(1 + r_t^{bE})b_t(i) \leq m_t^E E_t[q_{t+1}^k(1 - \delta)k_t^E(i)\pi_{t+1}] \quad (6)$$

The first-order conditions of the entrepreneurs' problem w.r.t. $c_t^E(i)$, $b_t(i)$, $k_t^E(i)$, $l_t(i)$, $u_t(i)$ are:

$$(1 - a^E) = \lambda_t^E(c_t^E(i) - a^E c_{t-1}^E) \quad (7)$$

$$\beta_E \lambda_{t+1}^E (q_{t+1}^k(1 - \delta) + r^k(i)) - \psi(u_{t+1}(i)) + \mu_t^E [m_t^E q_{t+1}^k(1 - \delta)\pi_{t+1}] = \lambda_t^E q_t^k \quad (8)$$

$$r_t^k(i)k_t^E(i) = \alpha \frac{y_t^E(i)}{x_t} \quad (9)$$

$$w_t l_t = (1 - \alpha)v \frac{y_t^E(i)}{x_t} \quad (10)$$

$$\lambda_t^E - \beta_E \lambda_{t+1}^E \left(\frac{1 + r_t^{bE}}{\pi_{t+1}} \right) = \mu_t^E (1 + r_t^{bE}) \quad (11)$$

$$r_t^k(i) = \chi_0 u_t(i) + \chi_1 (u_t(i) - 1) \quad (12)$$

3.3 Central bank

Inflation is the foremost goal of monetary policy in advanced economies. In China, the PBoC is mandated with maintaining overall stability. In other words, the PBoC may attach high priority to inflation-fighting, but safeguarding high GDP growth rates is the top priority. In the modeling framework, the PBoC provides funds at the policy rate, r_t , and exchanges bonds denominated in foreign currency (D_t^*) for assets in local currency (D_t^{CB}).¹⁷

$$\Delta D_t^{CB} = S_t \Delta D_t^* \quad (13)$$

¹⁷ Exporters are obliged by law to exchange foreign assets with the central bank.

The Chinese capital account, as noted, is closed, so the usual UIP condition must be modified. The nominal exchange rate, S_t , reflects only partially the differences in interest rates at home and abroad, so

$$\frac{S_{t+1}}{S_t} - 1 = \kappa^r (r_t - r_t^*), 0 < \kappa^r \leq 1. \quad (14)$$

Monetary policy employs standard and nonstandard monetary tools. The standard monetary toolkit consists of a Taylor rule, whereby the PBoC sluggishly closes deviations of inflation from the long-run target rate and gaps between actual and potential output.

$$(1 + r_t) = (1 + \bar{r})^{(1-\phi_R)} (1 + r_{t-1})^{\phi_R} \left(\frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi (1-\phi_R)} \left(\frac{y_t}{y_{t-1}} \right)^{\phi_y (1-\phi_R)} \epsilon_t^r \quad (15)$$

When these coefficients are positive, monetary policy is said to be countercyclical. The coefficient ϕ_R captures the degree of inertia in monetary policy, implying that the PBoC adjusts the interest rate gradually toward its target rate.¹⁸

In modeling window guidance, the descriptive empirical evidence in Section 2 strongly argues for nonlinearity in the use of window guidance. In that spirit, we augment the PBoC's toolkit with a nonlinear window guidance instrument. The attraction of integrating nonlinearities into DSGE models is that they can produce rich medium-term models useful in shaping policy.¹⁹

The window guidance policy instrument in the PBoC's toolbox is modeled as follows. We first assume that the central bank has the power to define and implement a lower bound B^{lb} and an upper bound B^{ub} on the stock of loans to entrepreneurs. Irrespective of the means to achieve its goal (moral suasion or administrative measures), these limits are respected by the commercial banks. The rules for B^{lb} and B^{ub} are assumed to be symmetric, hence only the lower bound is described below for brevity:

¹⁸ Woodford (2003) presents the theoretical argument that the central bank must engage in a certain amount of policy-rate smoothing to optimally signal the market about its policy intentions.

¹⁹ Nonlinear monetary policy reaction function has been studied largely in reduced-form empirical work, but not in a structural model. See, for example, Brüggemann and Riedel (2011), Cukierman and Muscatelli (2008), and Lamarche and Kousta (2012).

$$B^{lb} = \Delta^{lb} \bar{B}, \quad (16)$$

where \bar{B} is the steady state level of B . The fractions Δ^{lb} can be exogenously fixed by the monetary authority or can vary countercyclically with the business cycle stance, i.e. $\Delta^{lb} = \bar{\Delta}^b \left(\frac{Y}{\bar{Y}}\right)^{\epsilon^{lb}}$, $\epsilon^{lb} \geq 0$. The nonstandard window guidance toolkit addresses situations in which the PBoC is limited in the use of its policy interest rate. Equation (16) can also be interpreted as an attempt to avoid the “dark corners” first noted by Olivier Blanchard.²⁰ Pointing out that standard Taylor rules lack this pronounced risk-avoidance property, Blanchard makes a strong case that macroeconomic policymakers should give high priority to avoiding dark corners and may have to resort to novel tools to do so. We explore this issue further in the next sections of this paper. To our knowledge, this is the first time that a nonlinear window guidance rule is analyzed in a DSGE modelling framework.

The next section on commercial banks discusses how an occasionally binding window guidance constraint might affect bank behavior. Impulse response functions of the general equilibrium effect and the trade-offs arising from the window guidance are explained in detail.

3.4 Wholesale banking

The asset side of the wholesale bank sector comprises loans to firms (B_t) and central bank bonds denominated in the domestic currency (D_t^{CB}). On the liability side, wholesale banks combine deposits from households (D_t) and bank capital (K_t^b):

$$B_t + D_t^{CB} = D_t + K_t^b. \quad (17)$$

Their *real* net worth evolves as a law of motion,

$$\pi_t K_t^b = (1 - \delta^b) K_{t-1}^b + j_{t-1}^b, \quad (18)$$

²⁰ See <http://www.imf.org/external/pubs/ft/fandd/2014/09/blanchard.htm>. We want to assess monetary policy for an economy subject to rare, but highly damaging, disruptions. It is therefore important to assess monetary policy in the model those conditions in which window guidance might only bind in rare “bad” states. Bernanke and Reinhart (2004) recommends aggressive preemptive measures to avoid the complications raised by the zero lower bound. In that light, Equation (16) aims at providing insurance for avoiding severe recessions.

where $\delta^b K_{t-1}^b$ is the per-period cost for managing bank capital and j_{t-1}^b is last period's *real* profits of financial intermediaries. To stabilize the capital adequacy ratio in the long run, it is necessary to introduce a (small) friction on the interbank market. The spread between loan rate (R_t^b) and deposit rate (R_t^d) should depend negatively on banks' leverage $\frac{K_t^b}{B_t}$. In the steady-state, this margin disappears such that

$$R_t^b - R_t^d = -\kappa_{Kb} \left(\frac{K_t^b}{B_t} - \nu^b \right) \left(\frac{K_t^b}{B_t} \right)^2. \quad (19)$$

Following Gerali et al. (2010), we assume that deposit rates on the wholesale market are equal to the policy rate (r_t): $R_t^d = r_t$.

3.4.1. Retail banking

Financial flows are channeled through an imperfectly competitive banking sector. Banks supply deposits and loans to their agents, and set interest rates on both deposits and loans to maximize profits. Retail banks supply slightly differentiated credit services, $b_t^E(j)$, to firms. Facing quadratic “menu” costs and taking into account the downward-sloping demand for loans, they set up interest rates in a sticky manner. This gives rise to positive mark-up for interest rates on loans to firms (r_t^b) over the interest rates prevailing on wholesale money market (R_t^b). Sectoral profits are countercyclical in equilibrium. The objective of a retail lending bank is to maximize its profits, discounted by the consumption-based discount factor ($\Lambda_{0,t}^P$):

$$\max_{r_t^b(j)} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[r_t^b(j) b_t^E(j) - R_t^b b_t^E(j) - \frac{\kappa_{bE}}{2} \left(\frac{r_t^b(j)}{r_{t-1}^b(j)} - 1 \right)^2 r_t^b b_t^E \right],$$

where b_t^E is the average level of retail bank loans. The downward-sloping demand for loans is expressed as

$$b_t^E(j) = \left(\frac{r_t^b(j)}{r_t^b} \right)^{-\epsilon^b} b_t^E, \quad (20)$$

where ϵ^b is the elasticity of loan demand. The existence of a lower bound on loans to firms enters the commercial banks' model block via a Lagrange multiplier λ^B . Assuming a symmetric equilibrium, the F.O.C. w.r.t. r_t^b is

$$1 - \epsilon^b + \epsilon^b \frac{r_t^b}{r_t^b} - \kappa_b \left(\frac{r_t^b}{r_{t-1}^b} - 1 \right) \frac{r_t^b}{r_{t-1}^b} + \Lambda_{t,t+1}^P \kappa_b \left(\frac{r_{t+1}^b}{r_t^b} - 1 \right) \left(\frac{r_{t+1}^b}{r_t^b} \right)^2 \frac{b_{t+1}^E}{b_t^E} - \frac{\lambda^B \epsilon^b b^E}{r_t^b} = 0. \quad (21)$$

Following the Kuhn-Tucker necessary conditions for an optimum, one of two cases (i) $\lambda^B = 0; b_t^E > b^{lb}$, or (ii) $\lambda^B > 0; b_t^E = b^{lb}$ must hold. The more binding the lower bound on credit, the greater the shadow price λ^B .

By (21), it follows that r_t^b should decline. For the central bank to increase the supply of credit, the economic intuition here is that interest rates must be lower than in the unconstrained case. Since the model assumes full rationality and perfect foresight, banks on impact anticipate the constraint ultimately binds. Given that lending rates are sticky, banks react to these expectations in advance by inducing a milder credit crunch than in the case without window guidance, and thus avoid spending time in a constrained regime that is more costly to them than an interior equilibrium.

3.4.2. Deposit branch

The deposit branch supplies differentiated deposit services, $d_t^P(j)$, to patient households at interest rates, $r_t^d(j)$, that are lower than on the wholesale market due to their monopolistic power. Limited participation prevents households from transacting directly with the wholesale branch or with foreign lenders, or arbitraging away the mark-down on retail deposit rates. The intertemporal optimization of a retail deposit bank is

$$\max_{r_t^d(j)} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[r_t d_t^P(j) - r_t^d(j) d_t^P(j) - \frac{\kappa_d}{2} \left(\frac{r_t^d(j)}{r_{t-1}^d(j)} - 1 \right)^2 r_t^d d_t \right],$$

where d_t is the average level of retail bank deposits. The downward-sloping demand for loans is expressed as

$$d_t^P(j) = \left(\frac{r_t^d(j)}{r_t^d} \right)^{-\epsilon^d} d_t. \quad (22)$$

Assuming a symmetric equilibrium, the F.O.C.s w.r.t. r_t^d are

$$-1 + \epsilon^d - \epsilon^d \frac{r_t}{r_t^d} - \kappa_d \left(\frac{r_t^d}{r_{t-1}^d} - 1 \right) \frac{r_t^d}{r_{t-1}^d} + \Lambda_{t,t+1}^P \kappa_d \left(\frac{r_{t+1}^d}{r_t^d} - 1 \right) \left(\frac{r_{t+1}^d}{r_t^d} \right)^2 \frac{d_{t+1}}{d_t} = 0. \quad (23)$$

3.5 Retailers in the goods market

Retailers costlessly repackage homogenous domestic intermediate goods into differentiated final goods. They set up domestic prices subject to quadratic “menu” costs and a downward-sloping demand curve. A well-known New Keynesian Phillips curve for domestic inflation, π_t^H , emerges, i.e.

$$1 - \epsilon^y + \frac{\epsilon^y}{x_t} - \kappa_p [\pi_t^H - (\pi_{t-1}^H)^\iota (\bar{\pi}^H)^{1-\iota}] \pi_t^H + \Lambda_{t,t+1}^P \kappa_p [\pi_{t+1}^H - (\pi_t^H)^\iota (\bar{\pi}^H)^{1-\iota}] (\pi_{t+1}^H)^2 \frac{Y_{t+1}}{Y_t} = 0 \quad (24)$$

The optimal bundle of domestic products, C_t^H , is combined with imported goods, C_t^F , with the objective to minimize costs. Denote the domestic price level relative to aggregate consumer prices as $p_t^H = P_t^H / P_t$ and the relative price of imported goods as $p_t^F = P_t^F / P_t$. Then

$$C_t = \left[(\eta^c)^{1/\epsilon^c} (C_t^H)^{(\epsilon^c-1)/\epsilon^c} + (1 - \eta^c)^{1/\epsilon^c} (C_t^F)^{(\epsilon^c-1)/\epsilon^c} \right]^{\epsilon^c/(\epsilon^c-1)}, \quad (25)$$

and

$$1 = \eta^c (p_t^H)^{1-\epsilon^c} + (1 - \eta^c) (p_t^F)^{1-\epsilon^c}. \quad (26)$$

Optimization sets up the ratio of the two consumption bundles as a function of the relative prices (real effective exchange rate):

$$\frac{C_t^H}{C_t^F} = \frac{\eta^c}{1 - \eta^c} \left(\frac{P_t^H}{P_t^F} \right)^{-\epsilon^c} . \quad (27)$$

By analogy, the ratio of domestic to foreign investment goods is given by

$$\frac{I_t^H}{I_t^F} = \frac{\eta^I}{1 - \eta^I} \left(\frac{P_t^H}{P_t^F} \right)^{-\epsilon^I} . \quad (28)$$

3.6 Net exports

The volume of exports depends on the relative prices of domestic and foreign goods. The real effective exchange rate in the end determines the trade balance of the country by altering foreign demand for exports and domestic demand for imports such that

$$\frac{C_t^{H*}}{C_t^*} = \left(\frac{P_t^{H*}}{P_t^*} \right)^{-\epsilon^F} . \quad (29)$$

3.7 Capital producers

In the capital-goods producing sector, producers buy old capital and convert it to new productive capital. As in Gerali et al. (2010), producers of physical capital goods are used as a modeling device to make explicit the dependence of price of capital on lagged, contemporaneous and future investment levels, (i_{t-1}, i_t, i_{t+1}) , or Tobin's Q, which enters the borrowing constraint of entrepreneurs. During the upturn, rising capital prices relax the borrowing constraint of entrepreneurs, thus amplifying and propagating the initial shock. The F.O.C. is as follows:

$$1 = q_t^K \left(1 - \frac{\kappa_i}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 - \kappa_i \left(\frac{i_t}{i_{t-1}} - 1 \right) \frac{i_t}{i_{t-1}} \right) + \Lambda_{t,t+1}^E q_{t+1}^K \kappa_i \left(\frac{i_{t+1}}{i_t} - 1 \right) \left(\frac{i_{t+1}}{i_t} \right)^2 . \quad (30)$$

3.8 Market clearing

Budget constraints must be satisfied. Thus, wages should clear the labor market and the real effective exchange rates should achieve domestic market equilibrium.

4. Model calibration, impulse response functions, and welfare analysis

4.1. Matching the steady-state

The model is parametrized to match key features of Chinese economy. Our calibration choice is outlined in Table 2. Table 3 presents the steady-state values of selected endogenous variables. Data from our primary source, the National Bureau of Statistics of China, are augmented with up-to-date series from the International Monetary Fund (2016a), the World Bank database, and PBoC annual reports. Although the model is quarterly, annual figures are targeted due to limited quarterly data availability. Model calibration is broadly in line with the estimates of deep parameters presented in Dai et al. (2015) and Le et al. (2014).²¹

The household annual discount rate, calibrated to a conventional level of 1.3%, implies a quarterly discount factor $\beta_p = 0.99$.²² The annual discount rate for entrepreneurs is set to 7%, implying the quarterly discount factor $\beta_E = 0.983$. The steady-state real annual interest rate on loans (r^{bE}) is calibrated to 4%, i.e. the average PPI-deflated rate on one-year loans over the period 2010–2015. The entrepreneur discount factor and lending rates jointly determine the steady-state rate of return on capital.

The model assumes that in the steady-state the official policy rate (r_t) is transmitted to the interbank market (R^b) via arbitrage, where it serves as a basis for pricing deposit and loan rates. The average

²¹ Both papers employ an indirect inference method to uncover model parameters. See Canova (2007), for further discussion of indirect inference.

²² The financial repression of China's financial system makes it impossible to recover the discount rate from historical data. In December 2014, the PBoC finally started to liberalize deposit rates.

one-year SHIBOR for the period 2010–2015 is 4.2%. The 7-day repo rate average during 2011–2015 is 4.8%. The real interbank interest rate is calculated by deflating the nominal one with 2% steady-state inflation, i.e. the average annual CPI inflation for the past twenty years in China. The spreads of deposit and lending rates with respect to the interbank market determine the parameters of market power by branches of retail banks ($\epsilon^d, \epsilon^{bs}$).

The national accounts reflect China's sky-high investment-to-GDP ratio, which averaged 48% in the period 2011–2015. There is a widespread consensus, including in China, that the days of the investment-led growth model are numbered. For example, recent IMF Article IV consultations in China repeatedly state that the current downward trend in the investment ratio should continue, and that the Chinese economy is transitioning to a growth model driven increasingly by consumption and services, and that growth is slowing to a more sustainable pace. To reflect this shift, we target an investment share of 38%. Given the high investment rate, depreciation is calibrated at relatively high quarterly rate, $\delta = 0.05$. In a balanced growth context, a high depreciation rate is necessary to cover both the attrition of existing capital and labor-augmenting technological progress.

Output elasticity of capital α targets the capital income share stated in the income account. Published figures show that gross operating surplus formed 50% and 55% of aggregated gross product in 2012–2014. Zhang (2016) cites higher values for labor income as a percentage of GDP, i.e. an average of 60% for the period 2010–2015. In the model, capital income share is calibrated to $\alpha = 0.5$. Lower values would be incompatible with the high target of investment share in GDP and reasonable leverage ratios. Bank loans to entrepreneurs (B) are set at 130% of annual GDP in the model. The empirical counterpart of this variable would be the item “Bank credit to private non-financial sector” in the BIS data tables. Central bank's bonds in domestic currency (D^{CB}), held by the banking sector, are 50% of annual GDP in the model, reflecting the data in the “Balance Sheet of Other Depository Corporations.”

These calibration targets give rise to high leverage (66%) in the non-financial corporate sector. The capital adequacy ratio of banks is governed by the parameter $\nu^b = 0.1$, thus matching the average Tier I capital adequacy ratio of the Chinese banking sector for 2013–2015 as reported by the IMF (2016a). Net exports are calibrated at 3% of GDP, matching the average since 2009. Demand elasticity in the Dixit-Stiglitz aggregator (ϵ^y) is calibrated to achieve a mark-up of 5% for final goods

prices from intermediate goods prices. The home-bias parameters (η^c, η^I) are adjusted to replicate the average share of exports and imports in GDP in the period 2009–2015.

4.2 Matching second moments

Adjustment costs disappear from the steady-state and can be uncovered by targeting second moments of detrended data. The same holds true for demand elasticities when steady-state relative prices are calibrated at unity. Chinese macroeconomic series exhibit less persistence after detrending, as well as lower contemporaneous correlation between GDP and domestic absorption components (consumption and investment). These stylized facts suggest that external shocks probably drive much of the Chinese economy's fluctuations. Adjustment costs are also likely to be smaller than in a typical calibration of a developed economy. These stylized facts are also outlined in Dai et al. (2015) and Le et al. (2014).

The elasticity of foreign interest rates (r^*) to the ratio of foreign assets to GDP is held to 0.1% so as not to affect short-term dynamics but still ensure that foreign debt does not follow a random walk. The elasticity of interbank rates to the capital adequacy ratio of banks is calibrated at 8.5 to prevent sizable sways in banks leverage ratio. The habit persistence parameter (a^P) equals 0.4, in line with the estimated parameters in Dai et al. (2015) and Le et al. (2014), 0.35 and 0.47, respectively. Elasticities of domestic demand for foreign goods and foreign demand for domestic goods are parametrized at 1.2. These parameter values achieve lower cross correlation between GDP and absorption to match the actual data counterparts. Capital adjustment costs are set at $\kappa_i = 4$ to match the higher contemporaneous correlation between investment and GDP and lower autocorrelation in investment.²³ Local sensitivity analysis using the identification package developed by the Joint Research Center also suggests that these are the parameters that are relatively well identified by observed second moments in the macroeconomic data.²⁴

A key issue is the weighting of variables in the PBoC's objective function. The parameter governing PBoC's reaction to inflation is set close to conventional values, so $\phi_\pi = 1.8$. In accordance with its

²³ Le et al. (2014) document a value of 4, while Dai et al. (2015) estimate somewhat higher adjustment costs of 6.4.

²⁴ See Ratto and Iskrev (2011) for details about the software.

mandate to boost economic growth, a value higher than suggested in Gerali et al. (2010) is chosen for the coefficient of PBoC's reaction to GDP growth deviations with $\phi_\pi = 0.3$.

The price adjustment cost parameter is set close to the original estimates in Gerali et al. (2010), i.e. $\kappa_p = 3$. Wage adjustment, in contrast, is set a bit lower, i.e. $\kappa_w = 70$. These values target the correlation between cyclical variations in output and prices observed in the data and ensure positive autocorrelation in both simulated series. This calibration choice also conforms to the findings of Dai et al. (2015) and Le et al. (2014) that wages in China are more flexible than in developed economies.

4.3 Impulse response functions

We model three shocks: a *negative productivity (TPF) shock*, a *positive consumption shock*, and a *positive shock on markups over lending rates*. The size and persistence of the shocks are chosen so that the limit on loans binds for several periods. For lower magnitude shocks, the constraint does not bind, so impulse responses of our *no window guidance* and *with window guidance* cases coincide.²⁵

The model is solved up to first-order approximation with the help of the Dynare Matlab toolbox (see Adjemian et al., 2014). The computation of impulse responses with occasionally binding constraints is implemented with the OccBin toolkit (see Guerrieri and Iacoviello, 2015).²⁶ The toolbox initially guesses the periods when the constraint is binding, then computes the optimal piece-wise transition paths and verifies/rejects its guess. If the guess is incorrect, it guesses again until convergence is validated. As explained in Section 3, lending rates have to fall relative to the no-window-guidance scenario to keep credit above the equilibrium transition path. Favorable financing conditions for firms likely accelerate recovery through improved investment and income, but it remains an open question as to how much financial fragility is generated through impaired bank profits, especially if the poor financial performance of banks drags on.

²⁵ Because the model is linearized, certainty equivalence holds. In higher order approximations, impulse responses will differ even for shocks that fail to reach the lower bound on loans. A precautionary motive emerges: banks may want to step up lending activity to stay away from the contingency of hitting the floor on lending.

²⁶ In models with occasionally binding constraints, the standard perturbation methods cannot be employed as the policy function is non differentiable in the vicinity of the steady state. Some authors have suggested a global solution by value function iteration methods but due to the curse of dimensionality, this is not be feasible if the state space is rich. Another alternative might be the penalty function approach proposed by Judd (1998).

4.3.1. Contractionary technology shock

No window guidance scenario. Productivity shocks arrive every period and then gradually fade with an AR(1) coefficient of 0.8. On impact, return on capital is impaired by lower productivity levels. Thus, investment needs to remain below steady-state to prop up the return on investment and align it with lending rates.

Accordingly, the central bank raises interest rates to fight inflation. This movement is sluggishly transmitted to higher cost of credit to entrepreneurs. Positive markups over the official interest rate amplify monetary policy pass-through to retail lending rates and further drive up the required return on capital. Borrowing is driven down by higher interest rates and impaired asset prices, thus making the borrowing constraint more binding. Consumption reacts negatively due to higher interest rates and lower incomes.

Window guidance scenario. Banks still lend to entrepreneurs below the steady-state, but the decline is limited by the lower bound on credit. To move credit in times of low investment demand and falling asset prices, banks lower retail interest rates significantly. Bank profitability suffers, but investment receives a boost that helps the recovery.

Here, the transitional dynamics of inflation differ for the binding and non-binding cases. When window guidance is active, inflation is below the trajectory of the non-binding scenario. Following the New Keynesian Phillips curve (24), lower inflation levels reflect lower future real marginal costs. In the binding case, real marginal costs are depressed by lower interest rates and the lower required return on capital. In the window-guidance case, an additional positive second-round effect on official interest rates is realized. As inflation plunges below steady-state, monetary policy is relaxed, again fueling the recovery in consumption and output (Figure 4).

4.3.2. Positive demand shock

No window guidance scenario. This demand shock is implemented as a disturbance in consumption preferences that fades away with an AR(1) coefficient of 0.7. Households increasingly value current consumption, temporarily inducing lower saving rates and boosting current consumption. Output and prices react positively on impact. Since monetary policy is countercyclical, official interest rates are raised to stabilize the economy. Notably, domestic lending decelerates after a positive consumption shock, which weighs on investment. The negative reaction of banks credit activity has two causes. First, a rise in lending rates following a contractionary monetary policy response drives down credit demand. Second, as savings dry-up with the increased preference for current consumption, resources for sustaining credit expansion become scarcer.

Window guidance scenario. Given that loans to entrepreneurs are countercyclical in response to this purely preference-based shock, introducing window guidance amplifies, rather than attenuates, economic fluctuations. As with the negative productivity shock, banks must lower interest rates substantially to maintain the stock of loans prescribed by the PBoC. By the same token, inflation is below the non-binding case, i.e. lower lending rates imply lower required capital return and hence lower real marginal costs (Figure 5).

4.3.3. Positive financial market shock

No window guidance scenario. Perhaps the biggest lesson of the global financial crisis is that the forces generating monetary and financial instability are immensely powerful. We therefore consider a financial market shock. An exogenous change in the efficiency of financial intermediation, the market structure of financial markets, or both, is modelled as a positive markup shock on lending rates. The increase in spreads comes back to the steady state, following an AR(1) process at a rate of 0.7. This induces higher lending rates and a persistent decline in credit activity. The negative trend on investment drives the economy into a deep recession. Borrowing becomes sluggish in response to this shock and roughly follows the transition path of the capital stock.

Window guidance scenario. Banks anticipate the prospect of hitting the borrowing constraint, so they start lowering the cost of credit with respect to the baseline over a year before the lower bound on borrowing kicks in. This helps the recovery, but reduces profits in the banking sector (Figure 6).

The numerical results suggest that the monetary policy reaction should go beyond the simple Taylor rule. The alternative nonlinear Taylor rule with window guidance that differentiates between normal times and severe crisis has appealing properties. A provisional conclusion from these model simulations is that window guidance helps deliver additional monetary stimulus in challenging macroeconomic environments.

4.4 Welfare analysis

A possible way to determine the amount of euphoria window guidance brings is welfare analysis. We adopt a practical approach when evaluating the implications of introducing window guidance as an additional monetary policy tool. Following Glocker and Towbin (2012), we assume that the PBoC's objective is to minimize an exogenously given traditional loss function. The traditional loss function is defined as

$$\mathcal{L} = E(\hat{\pi}^2 + a^y \hat{y}^2). \quad (31)$$

The monetary authority is deemed better off with lower values of the function \mathcal{L} .²⁷ Now we add macroprudential concerns. Specifically, when financial stability is added to the objective of the PBoC, the loss function is given by

$$\mathcal{L}^f = E(\hat{\pi}^2 + a^y \hat{y}^2 + a^b \widehat{b^E}^2). \quad (32)$$

where $\widehat{b^E}$ is the percentage deviation of loans to firms and the parameter a^b reflects the relative importance of financial stability concerns of the PBoC.²⁸ Absent any direct information regarding a^y and a^b , $a^y = a^b = 1$ seems reasonable as a baseline parametrization.²⁹

²⁷ It seems appropriate to introduce the welfare function in an ad hoc manner, because the Chinese government has an objective function that not unlike the same as the representative agent in the modeling framework. In particular, the government faces the tension of wanting to deliver increasing prosperity without relaxing its deep-rooted efforts at maintaining political stability. See Li and Zhou (2005) on the preferences and incentives of Chinese leaders.

The task at hand is to simulate a series of exogenous shocks to technology, consumption, and lending-rate markups. We then obtain the trajectories of key endogenous variable in response to these shocks with and without window guidance, and compare their variances. Window guidance is symmetric: it kicks in when borrowing deviates more than 2% from its steady-state value. Specifically, a random sequence of 700 shocks is drawn from a normal distribution with appropriate variance. The first 300 periods are discarded to ensure simulated statistics do not depend on the starting point. Then the entire simulation is repeated 300 times and the simulated time series are stacked together.³⁰ Empirical estimates of variances with and without window guidance are computed and compared. The results suggest that quantitative targets are an effective countercyclical tool for financial shocks and they can act procyclically in the case of certain demand and supply shocks.

4.4.1 Technology shocks

While window guidance can be useful in stabilizing the volume of bank loans in response to technology shocks, it increases volatility in output and inflation (Figure 7).³¹ When no weight is given to financial stabilization ($a^b = 0$), window guidance is procyclical and welfare diminishing. When macroprudential considerations form a substantial part in the measure of welfare, however, window guidance may be worthwhile for stabilizing policy. In the current simulation, a^b needs to be roughly ten times larger than the inflation volatility coefficient to guarantee welfare improvement.

4.4.2 Demand shocks

As discussed, window guidance increases the volatility of output and inflation, leading to higher values of the policymaker's loss function \mathcal{L} (Figure 8). The macroprudential loss function \mathcal{L}^f also

²⁸ Chen et al. (2016) emphasize the PBoC's mandate in steering GDP growth.

²⁹ The same parametrization is employed by Batini et al. (2003). Here, we make our welfare calculations for extensive value ranges of a^y and a^b . The qualitative results reported below are robust for a large array of values.

³⁰ Our decision to repeat a simulation of 700 periods 300 times (rather than simulating a time series of 120,000 quarters, or, say, ten series of 12,000 periods), is driven by the nature of the OccBin toolbox. The software employs a guess-and-verify approach for choosing between the binding and non-binding regimes, so the procedure becomes time-consuming and inefficient in long simulations.

³¹ For lower loans-to-GDP ratios, window guidance reduces the variance of output in response to productivity shocks.

increases unambiguously. Although window guidance limits the range of loan deviations, the empirical distribution is more dispersed, i.e. less concentrated around the zero mean. Thus, window guidance to encourage lending may jeopardize normal functioning of the real economy.

4.4.3 Lending rate markup shocks

Imposing symmetric upper and lower limits on lending activity can effectively and widely combat the effects of financial shocks, even outside the financial sector, where volatility is reduced by over half. The real economy exhibits less volatility in both output and inflation (Figure 9). Interpreting this result on heuristic grounds, we note that the shock originates at the financial sector. Thus, a policy tool that directly focuses on financial intermediaries has the potential cope with the shock with minimal collateral damage. More precisely, because the markup shock exogenously inflates bank profits, curbing those profits by reining in credit activity (and forcing lower lending rates) can successfully bring the economy back to steady-state.

4.5. Policy conclusions

The evidence presented above brings a modicum of clarity to the polarized debate on the efficacy of window guidance. Specifically:

- In the face of large negative productivity and financial shocks, window guidance appears to be an effective tool in steering the economy out of recession (at the cost of reduced financial sector profits).
- Large, purely demand-driven shocks cannot be addressed by imposing limits on lending activity, since it amplifies, rather than attenuates, the cyclical response of the economy.
- Employing window guidance practices to steer the economy in the presence of small repeated supply or demand shocks is inefficient and contributes to higher volatility of real variables.
- Window guidance can effectively mitigate the effects of repeated small financial shocks on the real economy by insulating it from the turmoil on the financial side.

- Welfare analysis underlines the importance of a fine-grained approach to the study of window guidance.

5. Window guidance – panacea or curse?

Window guidance is an administrative measure for monetary policy implementation. Given that China's banking system is dominated by large state-owned banks, the PBoC's window guidance has shown itself to be very effective in short-run stabilization. However, over the long run, it generates distortions and inefficiency.

Window guidance is much easier to implement in conditions of excess liquidity, a common situation in China, where the banking system often carries excess reserves.

In terms of allocation of credit or addressing misallocation of credit among different sectors, window guidance is also a direct measure, and therefore quite effective. Given that it overrides the market mechanism, it could lead to inconsistency and structural imbalance in the long run.

Some of the overcapacity problems in the Chinese economy could well be the consequence of the past window guidance policy. The PBoC has used window guidance as a supplementary policy to regular monetary policy and fiscal policy. In a transition economy with substantial distortions, administrative measures such as window guidance can help partly correct distortion effects, but in the long run, structural and institutional reforms are needed to create a smoothly functioning market economy and allow market incentives to work. Thus, window guidance should be used sparingly to correct market failures, as well as in times of crisis to avoid hard landings or dark corners.

China's window guidance policy provides several lessons for policymakers. The Chinese economy has gone through boom-and-bust cycles since the launch of reforms in early 1980s. Whether the issue was overheating, recession, or structural imbalances such as overcapacity in some sectors, window guidance was a go-to tool to affect bank lending.

The first lesson is that excessive encouragement of banking lending may prevent the economy from falling into deep recession, but can also lead to high levels of debt that may be unsustainable. In 2008–2009 at the height of the global financial crisis, the Chinese government implemented a 4-trillion-yuan fiscal stimulus package and encouraged banks to lend another 10 trillion yuan to finance “infrastructure” projects. The drastic increase of bank credit caused the credit-to-GDP ratio to soar, and tolerated reckless lending practices. Even after the government’s efforts to deleverage both the government and private sectors, overall debt levels in China are quite high and still rising.

By late 2015, China’s private non-financial debt exceeded 200% of GDP, a level close to the peak levels of Japan and Spain just before their crises (Figure 10) – and only slightly lower than in Japan during the onset of the Lost Decade. Among major economies, only China attempted to sustain a high pace of credit growth after the global financial crisis. The recent surge in China’s credit growth since 2012 is partly reflects the PBoC’s failure to curb lending and remaining reliant on bank credit to support the economic growth through window guidance policy. Over-reliance on window guidance, subsequently, has ratcheted up corporate debt to unsustainable levels.³²

As we have seen, window guidance can correct misallocation of credit in a distorted economy. But it can also create further distortion. To optimize the bank credit structure, the PBoC introduced a differentiated window guidance policy approach in 2012. This nuanced approach allows the PBoC to rein in bank lending in overcapacity sectors, while encouraging the banks to step up policy lending to the real economy. Credit growth in overcapacity sectors (e.g., cement, coal, steel, glass, real estate, etc.) decreased to single digits in during the 2011–2015 period (in 2015, the growth rate was 1.5%, 2.4 percentage points lower below the 2014 figure), while the growth in total loans exceeded 10% in the same period. In the first half of 2016, loans to these sectors showed negative growth.³³ This development suggests that more selective use of window guidance may help improve bank credit structure and that steering window guidance in a targeted and effective manner may help in with

³² The Bank for International Settlements (2016) raised the red flag of debt overhang when it reported a “credit gap” of 30% for China. Drehmann and Tsatsaronis (2014) assert that credit gap is a reliable and robust early-warning indicator of impending banking crises. Moreover, the International Monetary Fund (2016b) estimates that “debt-at-risk” had increased to 14% of listed Chinese corporate debt, up from 4% in 2010, signaling a deterioration in China’s loan quality. In contrast, Dell’Ariccia et al. (2012) argue that not all credit growth booms end up in a crisis. Good booms expand the productive capacity of an economy. Thus, when deciding on how to act, policymakers need to consider the imperfect nature of the signal. In the context of window guidance, it implies that the central bank should exercise reasonable judgment on the nature of growth and actively communicate this in its window guidance decisions.

³³ The information on growth rates of lending to overcapacity sectors was taken from Chinese-language news reporting on credit growth. For instance, see <http://cn.reuters.com/article/pboc-fin-cost-idCNKCS0UT00Y> and http://www.gov.cn/xinwen/2016-07/15/content_5091793.htm.

overcapacity problems. However, it is not easy *a priori* for the PBoC to say how much it needs to tighten credit or deleverage in the overcapacity sector, or how much it should encourage banks to lend to policy sectors such as the high-tech sector or small and medium-sized enterprises. Window guidance ultimately is a crude measure and may lead to dynamic inefficiency. Some sectors appearing to suffer from overcapacity during a downturn may face capacity constraints when the economy recovers.

Furthermore, with the ongoing process of financial liberalization, the effectiveness of window guidance gradually wears off. China's financial system is still dominated by banks, but its stock and bond markets have grown very fast, not to mention the shadow banking sector. Banks are also increasingly subject to market discipline and profit pressure. All these developments dilute the effectiveness of window guidance measures focused solely at traditional banks (Fukumoto et al., 2010).

Thus, while window guidance may help the PBoC in fulfilling its multiple policy objectives, its use (if at all) must be highly restrained and applied only in exceptional circumstances. The overuse of window guidance leads to such problems as overshooting monetary targets and misallocation of credit. It leaves the PBoC with a trade-off between short-term stabilization and deep structural reform.

6. Conclusions

The DSGE model presented here provided insights into the pros and cons of the non-standard monetary policy tool, window guidance, in China. Policymakers should find our modeling exercise worthwhile and serves as a serious starting point in the current discussion on overhauling Chinese monetary policy.

Window guidance remains an important policy instrument as evidenced from PBoC monetary policy reports. Here, we applied a DSGE modeling approach enriched by a non-standard window guidance toolkit to shed light on the efficiency of window guidance. While the DSGE framework suggests that window guidance can help provide additional monetary policy stimulus, our welfare analysis shows

that the window guidance toolkit has to be handled carefully to secure benefits and mitigate risks. In a nutshell, the theoretical results confirm the intuition and general wisdom that window guidance should be employed with utmost caution.

In coming years, financial institutions in China will have to provide much more efficient allocation of capital as the old investment-based paradigm fades. Declining marginal returns and an increasing capital-stock-to-output ratio imply an environment where price and information distortions may bring about significant losses and financial stability risks. Against this background, we expect quantity-based instruments such as window guidance be phased out as price-based monetary policy instruments are capable of effectively distinguishing financial risks. Ultimately, we expect the PBoC to manage the economy solely with price-based instruments, with financial institutions allocating capital according to policy-driven market-priced credit.

References

- Adjemian, S., H. Bastani, F. Karamé, M. Juillard, J. Maih, F. Mihoubi, G. Perendia, J. Pfeifer, M. Ratto, and S. Villemot (2014). "Dynare: Reference Manual, Version 4." Dynare Working Paper No. 1, Paris.
- Bank for International Settlements (2016). *BIS Quarterly Review*. September 2016, Basel.
- Batini, N., R.T. Harrison, and S.P. Millard (2003). "Monetary Policy Rules for an Open Economy." *Journal of Economic Dynamics & Control*, 27, 2059-2094.
- BBVA (2015). *PBoC Announces Launch of New Macro-Prudential Assessment System to Curb Risks*. Hong Kong.
- Bernanke, B.S., and V.R. Reinhart (2004). "Conducting Monetary Policy at Very Low Short-Term Interest Rates." *American Economic Review*, 94, 85-90.
- Blanchard, O. (2016). *Do DSGE Models Have a Future?* Peterson Institute for International Economics, Washington.
- Brüggemann, R., and J. Riedel (2011). "Nonlinear Interest Rate Reaction Functions for the UK." *Economic Modelling*, 28, 1174-1185.
- Canova, F. (2007). *Methods for Applied Macroeconomic Research*. Princeton (Princeton University Press).
- Chen, K., Higgins, P., Waggoner, D.F., and T. Zha (2016). "China Pro-Growth Monetary Policy and its Asymmetric Transmission." *NBER Working Paper No. 22650*, Cambridge (Mass.).
- Cukierman, A., and A. Muscatelli (2008). "Nonlinear Taylor Rules and Asymmetric Preferences in Central Banking: Evidence from the United Kingdom and the United States." *BE Journal of Macroeconomics*, 8, 1-29.
- Dai, L., P. Minford, and P. Zhou (2015). "A DSGE Model of China." *Applied Economics*, 47, 6438-6460.
- Dell'Ariccia, G., D. Igan, L. Laeven and H. Tong (2012). "Policies for Macrofinancial Stability: Options to Deal with Credit Booms." *IMF Staff Discussion Note SDN/12/06*, Washington.
- Del Negro, M., G. Eggertsson, A. Ferrero, and N. Kiyotaki (2016). "The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities." NBER Working Paper No. 22259, Cambridge (Mass.).
- Drehmann, M., and K. Tsatsaronis (2014). "The Credit-to-GDP Gap and Countercyclical Capital Buffers: Questions and Answers." *BIS Quarterly Review*, March 2014, 55-73.
- Elliott, D.J., G. Feldberg, and A. Lehnert (2013). "The History of Cyclical Macroprudential Policy in the United States?" Federal Reserve Board of Governors, Finance and Economics Discussion Series No. 29, Washington.
- Fukumoto, T., M. Higashi, Y. Inamura, and T. Kimura (2010). "Effectiveness of Window Guidance and Financial Environment in Light of Japan's Experience of Financial Liberalization and a Bubble Economy." *Bank of Japan Review*, Discussion Paper No. 10-E-4, Tokyo.

Funke, M., P. Mihaylovski, and H. Zhu (2015). "Monetary Policy Transmission in China: A DSGE Model with Parallel Shadow Banking and Interest Rate Control." BOFIT Discussion Paper No. 9/2015, Helsinki.

Geiger, M. (2008). *Instruments Of Monetary Policy In China And Their Effectiveness: 1994–2006*. United Nations Conference on Trade and Development, Geneva.

Gerali, A., S. Neri, L. Sessa, and F.M. Signoretti (2010). "Credit and Banking in a DSGE Model of the Euro Area", *Journal of Money, Credit and Banking* 42, 107-141.

Gertler, M., and N. Kiyotaki. (2010). "Financial Intermediation and Credit Policy in Business Cycle Analysis", in: Friedman, B.M. and M. Woodford (eds.) *Handbook of Monetary Economics*, Volume 3, Amsterdam (Elsevier), 547-599.

Glocker, C., and P. Towbin (2012). "Reserve Requirements for Price and Financial Stability: When Are They Effective?" *International Journal of Central Banking*, 8, 65-113.

Guerrieri, L., and M. Iacoviello (2015). "OccBin: A Toolkit for Solving Dynamic Models with Occasionally Binding Constraints Easily." *Journal of Monetary Economics*, 70, 22-38.

He, D. & L. L. Pauwels (2008). "What Prompts the People's Bank of China to Change its Monetary Policy Stance? Evidence from a Discrete Choice Model." *Hong Kong Monetary Authority Working Paper* 06/2008.

International Monetary Fund (2016a). *The People's Republic of China: Selected Issues*. Washington DC.

International Monetary Fund (2016b). *Global Financial Stability Report*. April 2016, Washington DC.

Judd, K.L. (1998). *Numerical Methods in Economics*, Cambridge (The MIT Press).

Lamarche, J.-F., and Koustas (2012). "Estimation of a Nonlinear Taylor Rule Using Real-Time US Data." *Studies in Nonlinear Dynamics & Econometrics*, 16, 1-25.

Le, V.P.M., M. Kent, D. Meenagh, and P. Minford (2014). "Banking and the Macroeconomy in China: A Banking Crisis Deferred?" *Open Economies Review*, 25, 123-161.

Levy, H., and H.M. Markowitz (1979). "Approximating Expected Utility by a Function of Mean and Variance." *American Economic Review*, 69, 308-317.

Li, H., and L.-A. Zhou (2005). "Political Turnover and Economic Performance: The Incentive Role of Personnel Control in China." *Journal of Public Economics*, 89, 1743-1762.

PBoC, Quarterly Monetary Policy Reports, various issues.

Ratto, M., and N. Iskrev (2011). *Identification Analysis of DSGE Models with DYNARE*. Joint Research Centre, European Commission Brussels.

Romer, C.D. and D.H. Romer (1989). "Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz." *NBER Macroeconomics Annual* 1989, 4, 121-184.

Romer, C.D. and D.H. Romer (2004). "A New Measure of Monetary Shocks: Derivation and Implications." *American Economic Review*, 94, 1055-1084.

Shu, C. & B. Ng (2010). "Monetary Stance and Policy Objectives in China: A Narrative Approach." Hong Kong Monetary Authority: *China Economic Issues* 1/10.

- Woodford, M. (2003). "Optimal Interest-Rate Smoothing." *Review of Economic Studies*, 70, 861-886.
- Yoshino, N., and S. Angrick (2016). "Quantities and Prices in China's Monetary Policy Transmission: From Window Guidance to Interbank Rates." City University of Hong Kong: *Global Research Unit Working Paper*, No. 2016-024.
- Zhang, M.L. (2016). *Rebalancing in China – Progress and Prospects*. International Monetary Fund, Washington.
- Zhang, X., and Z. Ji (2012). *China Monetary Policy*. Chinese Financial Press, Beijing.

Appendix A: Detailed window guidance data description

This appendix provides a timeline of window guidance in China. As discussed in Section 2, we describe the PBoC's window guidance policy with a five-level indicator. The table summarizes the period-by-period description of the use of PBoC's window guidance policy, first mentioned 2001 in its Quarterly Monetary Policy Report (QMPR). Our five-level indicator is constructed from this data. Indicator definitions are summarized in Table 1 in Section 2.

Period-By-Period Use of Window Guidance, 2001Q1 – 2016Q2

Date	WG indicator	Description of Window Guidance/Credit policy guidance in <i>Quarterly Monetary Policy Report</i>	Page
2001Q1	0	Report does not mention window guidance or credit policy.	–
2001Q2	0	Report does not mention window guidance or credit policy.	–
2001Q3	0	Report does not mention window guidance or credit policy.	–
2001Q4	0	Since 1998, the macroeconomic-related departments in the government, PBoC and commercial banks have attended a monthly meeting on economic and financial trend analysis. It plays an important role in PBoC's window guidance for commercial banks.	(Summarized from Chinese version)
2002Q1	0	Report does not mention window guidance or credit policy.	–
2002Q2	0	In the second half of 2002, PBoC continued to use window guidance to guide banks to optimize the credit structure. The PBoC wants banks to increase lending to the agricultural sector and personal loans on housing, vehicles and education, but strictly restrict consumer lending without specific purpose.	(Summarized from Chinese version)
2002Q3	0	Report does not mention window guidance or credit policy.	–
2002Q4	0	(In 2002), PBoC used credit policy to enhance the economic structure adjustment.	(Summarized from Chinese version)
2003Q1	-2	(See 2003 Q4 Report)	–
2003Q2	-2	(See 2003 Q4 Report)	–
2003Q3	-2	After July, the PBoC called three window guidance meetings to analyze the monetary developments of 2003 and issue warnings of the possible systemic risks that could be caused by the excessive credit expansion.	(Summarized from Chinese version)
2003Q4	-2	Faced with excessive growth in commercial bank lending, particularly to the real estate sector, the PBoC signaled risks in real estate lending in June to standardize practices and strengthen window guidance for commercial bank loans. From early 2003, commercial banks were pushed to take note of rising credit growth and rein in credit growth.	(Summarized from Chinese version)
2004Q1	-2	The PBoC strengthened window guidance and its warnings about bank lending related to the excessive credit expansion. The PBoC reined in lending to overheated sectors.	(Summarized from Chinese version)
2004Q2	-2	The PBoC strengthened its control of credit aggregates and window guidance for commercial banks to manage credit growth.	(Summarized from Chinese version)

2004Q3	-2	The PBoC strengthened window guidance by issuing alerts to commercial banks to prevent excessive credit expansion and encourage commercial banks to manage credit growth.	(Summarized from Chinese version)
2004Q4	-2	Throughout 2004, the PBoC strengthened window guidance by providing alerts for commercial banks to prevent the excessive credit expansion and guide commercial banks to manage the pace of credit growth and optimize the credit structure.	(Summarized from Chinese version)
2005Q1	-1	The PBoC instructed commercial banks to take a forward-looking approach in response to cyclical changes and industrial trends,... and enhance capacity to identify and assess risks. Commercial banks were also encouraged to... be more conscious in optimizing credit structure.	13
2005Q2	-1	The PBoC... guided commercial banks in taking a forward-looking approach to respond to changes of economic cycles and industrial development and to improve the credit structure.	13-14
2005Q3	-1	The PBoC... provided clear-cut “window guidance” and risk alerts for commercial banks, and guided financial institutions to appropriately control the speed of credit expansion, optimize the credit structure, and improve financial services.	14
2005Q4	-1	The PBoC strengthened the “window guidance”... and to promote the rational allocation of credit resource allocation and optimization of national economic structure.	18
2006Q1	-1	(The) PBoC... (enhanced) “window guidance” and risk warning toward commercial banks to guide them to optimize the credit structure and improve financial services.	12
2006Q2	-2	The PBoC convened three window guidance meetings, requiring commercial banks to be on the alert to the risks associated with an excessive growth of loans, to enhance risk control capacity, to avoid blind credit expansion driven by excessive profit seeking, and to control credit aggregates.	16
2006Q3	-2	The PBoC... (enhanced) communication with financial institutions through window guidance to help them meet the requirements of the state for macroeconomic management, and reasonably control credit growth and adjust the lending structure.	16-17
2006Q4	-2	The PBoC... (strengthened) guidance on credit policy, and (enhanced) communication with financial institutions through window guidance to help... reasonably control credit growth and adjust the lending structure.	15-16
2007Q1	-2	To cope with the increasing pressures from credit extension, the PBoC strengthened window guidance and credit policy guidance, required commercial banks... to reasonably curb credit volume and growth.	18
2007Q2	-2	The PBoC continued to strengthen the role of window guidance and credit policy guidance to alert commercial banks of the risks arising from an excessively rapid growth of loans and to guide them in controlling the size and pace of credit extension.	11-12
2007Q3	-2	The PBoC continued to strengthen the role of window and credit policy guidance to convey the purpose of the macro-adjustment measures, alert the commercial banks of the risks arising from an excessively rapid growth of loans.	10-11
2007Q4	-2	The PBoC continued to strengthen the role of window and credit policy guidance to convey the purpose of the macro-adjustment measures, alert the commercial banks of the risks arising from an excessively rapid growth of loans.	10-11
2008Q1	-2	The PBoC continued to strengthen window and credit policy guidance to call attention to strengthening credit control, to appropriately balance the pace of credit extensions within the year, and to prevent excessive loan fluctuations.	12

2008Q2	-2	Efforts have been made to guide the commercial banks to strengthen credit control, appropriately balance the pace of credit extensions within the year, and prevent excessive fluctuations of loans.	13
2008Q3	2	Given the changing overall situation, the PBoC removed the commercial banks' credit ceilings and guided financial institutions to make lending based on effective demand in the real economy and at an appropriately balanced pace.	8-9
2008Q4	2	In the second half of the year, in accordance with the changed situation, the PBoC timely eliminated the rigid constraints on credit programming of commercial banks, guided financial institutions to reasonably extend loans in accordance with the effective demands of the real economy.	15-16
2009Q1	2	The financial institutions were encouraged and guided to continue to follow the principle of differentiated treatment to borrowers to support the development of some industries on the basis of balanced growth of credit aggregates.	12
2009Q2	-2	The PBoC continued to follow the principle of differentiated lending treatment to support certain sectors and industries, guided financial institutions to further optimize the credit structure to support development of the real economy and restructuring and to ward off financial risks. (See also 2009 Q4 Report.)	16
2009Q3	-2	Financial institutions were guided to control the pace of credit extensions, improve the credit structure, and prevent credit risks.	14
2009Q4	-2	In April and May of 2009, the PBoC provided window guidance to commercial banks, requiring commercial banks to become "stabilizers" rather "amplifiers" by reasonably controlling the speed of credit issuance and striking a balance between credit support and risk prevention. Since the middle of 2009, with domestic demand gradually supporting economic growth, the PBoC strengthened window guidance and required financial institutions to strengthen risk assessments of extended credits.	10-11
2010Q1	-2	The PBoC encouraged financial institutions to properly manage aggregate credit provision, to optimize the credit structure, and to pace credit extensions through enhanced window guidance and credit policy guidance for financial institutions.	14
2010Q2	-1	The PBoC continued to improve window guidance,... encouraged financial institutions to properly manage the pace of credit provisions and improve the credit management system, fully leveraging the role of credit policy to support economic and social development... In the meantime, the PBoC strengthened management of lending activities for local government financing platforms, cut back lending to high energy-consuming and polluting industries and industries with an overcapacity.	15
2010Q3	-1	The PBoC continued to improve window guidance of financial institutions. It encouraged financial institutions, in accordance with the differentiated credit policy requirements, to properly adjust the credit structure and manage the pace of credit provisions... tightened lending to heavily energy-consuming industries, highly polluting industries, and industries at overcapacity.	16
2010Q4	-1	The PBoC enhanced window guidance on financial institutions. It improved credit policy guidance and encouraged financial institutions to properly adjust the credit structure and manage the pace of credit provisions so as to provide greater support to economic restructuring and the shift in the development pattern... the PBoC cut back lending to high energy-consuming and polluting industries and industries with excessive capacity, and restricted unauthorized lending to local government financing platforms.	8-9

2011Q1	-1	The PBoC enhanced the coordination of money and credit policy with other policies and strengthened window guidance to encourage financial institutions to improve the credit structure following a differentiated credit policy.	10-11
2011Q2	-1	The PBoC continued to strengthen and improve window guidance for financial institutions and employed a mix of monetary policy tools, including central bank lending and rediscounts, to encourage financial institutions to improve the structure and pace of credit supply, increase support for economic restructuring and a shift in the development pattern, and expand credit supply to agriculture, rural areas, and farmers, as well as to small-and medium-sized enterprises (SMEs) and other weak links in the economy.	12
2011Q3	-1	Continuing to strengthen and improve window guidance, the PBoC encouraged financial institutions to properly manage the pace of credit supply, improve the credit structure, and prevent credit risks. The PBoC also encouraged financial institutions to enforce a differentiated mortgage policy, strengthen management of lending to local government financing platforms, and rein in lending to heavily energy-consuming and polluting industries as well as to industries with excess capacity, thus supporting the economic restructuring.	10-11
2011Q4	-1	Continuing to strengthen and improve window guidance and to implement a differentiated credit policy, the PBoC encouraged financial institutions to properly manage the pace of credit supply, to improve the credit structure, and to prevent credit risks to enhance financial services to the real economy and in areas that are key to the people's livelihood.	18
2012Q1	-1	The PBoC followed a differentiated approach to credit guidance, enhanced examination of lending distribution, promoted better coordination between credit policy and industrial policy, and encouraged improvements in the credit structure... The PBoC also reined in lending to heavily energy-consuming and polluting industries as well as industries with excess capacity.	11
2012Q2	-1	The PBoC continued to enhance and improve window guidance of financial institutions. It encouraged better coordination between credit policy and industrial policy, and guided financial institutions to properly manage the credit structure and the lending pace to improve financial services to the real economy and to the people's livelihood by pursuing a differentiated credit policy, thereby accelerating economic restructuring and a shift in the economic development pattern... The PBoC continued to strictly implement the differentiated mortgage policies... and to rein in lending to industries with heavy energy consumption, high emissions, and excessive capacity.	11-12
2012Q3	0	Following a differentiated approach to credit guidance, the PBoC enhanced coordination between credit policy and industrial and regional development policies, and encouraged financial institutions to improve the credit structure and to strengthen financial services to the real economy and the people's livelihood to accelerate economic restructuring and shifts in the economic development pattern... The PBoC reined in lending to industries with heavy energy consumption, high emissions, and excessive capacity.	13
2012Q4	0	The PBoC brought into full play of the role of macro credit policies in transforming economic growth pattern and adjusting economic structure, while strengthening adjustments of aggregate money and credit.	15

2013Q1	0	The PBoC further improved guidance for macro-credit policy, strengthened its coordination with industrial policy, and enhanced the effects of credit-policy guidance so that credit policy will continue to play an active role in promoting sustainable and healthy economic development, harmony, and stability in the society... Credit support to industries with high energy consumption and high emissions and industries with an overcapacity needs to be controlled.	15
2013Q2	0	The PBoC continued to employ monetary policy tools, macro-prudential tools, and credit policies to guide structural improvements, and enhanced coordination with industrial policies to support the economic restructuring and upgrading and to strengthen the financial sector's capacity to serve the real economy... Lending to heavily energy-consuming and polluting industries as well as to industries with excess capacity was subject to strict controls.	18-19
2013Q3	0	The PBoC... continued to employ monetary policy tools, macro-prudential tools, and credit policies to guide structural improvements, and enhanced coordination with industrial policies to support the economic restructuring and upgrading and to strengthen the financial sector's capacity to serve the real economy... Strict controls continued to restrict lending to highly-polluting, energy-consuming industries, and to those industries with excess capacity.	11-12
2013Q4	0	The PBoC... continued to use central bank agro-linked loans, central bank discounting, and the reserve requirement ratio to guide credit structural improvements, enhanced coordination between monetary policy and industrial policy and regional development policy, and strengthened the financial sector's capacity to serve the real economy... Strict controls continued to restrict lending to highly polluting and high energy-consuming industries, and to sectors burdened with overcapacity to resolve the overcapacity problem.	10-11
2014Q1	0	The PBoC... continued to use central bank loans and discounts and the reserve requirement ratio to guide credit structural improvements, enhance coordination between monetary and credit policy and industrial policy and regional development policy, and strengthen the financial sector's capacity to serve the real economy... Lending to heavy energy-consuming, highly polluting industries, and those burdened with overcapacity was strictly controlled.	9-10
2014Q2	0	The PBoC continued to use monetary policy, macro-prudential management policy, and credit policy to send signals and guide structural adjustments, strengthened the coordination of credit policy and industrial policy, and guided the optimization of the credit structure of financial institutions... Lending to heavy energy-consuming, highly polluting industries and those burdened with overcapacity was strictly controlled.	15
2014Q3	1	The PBoC continued to use monetary policy, macro-prudential management policy, and credit policy to send signals and guide structural adjustments, strengthened the coordination of credit policy and industrial policy, conducted assessments of credit policy guidance, and encouraged banking financial institutions to make innovations in terms of organizations, mechanisms, products, and service models and to optimize the credit structure... A differentiated approach was adopted toward profit-making enterprises in industries with excess capacity.	19-20

2014Q4	1	The PBoC continued to use monetary policy, macro-prudential management, and credit policy to send signals and to guide structural adjustments, strengthened the coordination of credit policy and industrial policy, further improved assessments of the effects of credit policy guidance, and guided financial institutions to optimize their credit structure... As for industries with excess capacity, in line with the principle of “differentiated treatment and no one-size-fits-all approach,” the PBoC urged financial institutions to strengthen and improve credit management by way of absorbing, relocating, consolidating, and eliminating excess capacity.	13-14
2015Q1	1	Financial institutions were guided to mobilize the stock of credit assets, optimize the structure of new loans, and support structural adjustments and upgrading... With respect to financial services for industries with excess capacity, in line with the principle of “differentiated treatment and no one-size-fits-all approach,” the PBoC urged financial institutions to strengthen and improve credit management by way of absorbing, relocating, consolidating, and eliminating excess capacity.	22
2015Q2	1	Financial institutions were guided to properly handle new loans, mobilize the stock of credit assets, innovate their organizational structures, collaterals, and product and service modes, and to provide more credit and loans to important areas and to weak links in the economy... With respect to financial services for industries with excess capacity, in line with the principle of “differentiated treatment and no one-size-fits-all approach,” the PBoC urged financial institutions to strengthen and improve credit management by way of absorbing, relocating, consolidating, and eliminating excess capacity.	20
2015Q3	1	Financial institutions were guided to make good use of new loans, mobilize the stock of credit assets, make innovations in their organizational structure, collaterals, and product and service modes, and provide more credit to important areas and to weak links in the economy... With respect to financial services for industries with excess capacity, in line with the principle of “differentiated treatment and no one-size fit all,” the PBoC urged financial institutions to strengthen and improve credit management by absorbing, relocating, consolidating, and eliminating excess capacity.	13-14
2015Q4	1	PBoC strengthened the signaling and leading functions of the window guidance and credit policy. Financial institutions were guided to make good use of new loans, mobilize the stock of credit assets, make innovations in their organizational structure, collaterals, and product and service modes, and provide more credit to important areas and to weak links in the economy.	(Summarized from Chinese version)
2016Q1	1	Financial institutions were guided to make good use of new loans, mobilize the stock of credit assets, rationally use the funding provided by PBoC, make innovations in their organizational structure, collaterals, and product and service modes, and provide more credit to important areas and to weak links in the economy.	(Summarized from Chinese version)
2016Q2	1	PBoC strengthened the signaling and leading functions of the window guidance and credit policy... Financial institutions... were guided to make good use of new loans, mobilize the stock of credit assets, make innovations in their organizational structure, collaterals, and product and service modes, and provide more credit to important areas and to weak links in the economy.	(Summarized from Chinese version)

Appendix B. Data description for other variables

Output Gap

The industrial-production-based output gap is the log-difference between the actual production and the trend production. Until recent years, both output gap series based on GDP and industrial production showed a similar development. However, the industrial-production-based output gap showed a significant decline in output gap in recent years, while the same behaviour was not reflected in the GDP-based output gap. The former series should be more consistent with the recent slowdown in China's production. Data for industrial production are the series of real value-added of industrial production index, constructed by using series of the month-on-month changes and year-on-year changes released by NBS and seasonally adjusted by applying X-12 method. All seasonal adjustments for variables here use the X-12 method. The trend production is estimated by HP-filter with λ equal to 129,600 (for monthly data) as suggested by Ravn and Uhlig (2002).

CPI

Year-on-year changes in CPI released by NBS.

Loans

This is based the following PBoC lending data:

- i. Loans to non-financial sectors (includes loans to non-financial enterprises and government agency and organizations).
- ii. For new loans-to-GDP ratio. "New loans" refers to the increase of total loans (seasonally adjusted). If the level of loans decreases, the figures are negative. GDP is seasonally-adjusted quarterly nominal GDP.
- iii. The loans-to-GDP ratio is the seasonally-adjusted level of loans divided by the seasonally-adjusted quarterly nominal GDP. The loans-to-GDP ratio trend is based on a one-sided HP filter using

a smoothing parameter (λ) equal to 400,000. The loans-to-GDP gap is the loans-to-GDP ratio minus the HP-trend of the loans-to-GDP ratio.

GDP

The NBS is the source for quarterly nominal GDP, while data for quarterly real GDP are constructed using the series of quarterly real GDP (released by NBS since 2012) and dated back using the NBS-released series of quarterly year-on-year changes in real GDP. Seasonally adjusted series for both nominal and real GDP are adjusted with the X-12 method.

Table 1. Window guidance policy stances

Indicator	Stance	Period	Definition
-2	Strongly discouraging	2003Q1 – 2004Q4 2006Q2 – 2008Q2 2009Q2 – 2010Q1	QMPR explicitly discourages growth of total credit
-1	Weakly discouraging	2005Q1 – 2006Q1 2010Q1 – 2012Q2	QMPR states the target of optimizing credit structure, provides risk alerts and/or mentions that banks should manage the pace of credit growth
0	No explicit direction	2001Q1 – 2002Q4 2012Q3 – 2014Q2	QMPR only states the target of optimizing credit structure and separately listing the sectors that should be both discouraging and encouraging (differentiated approach to credit guidance) <i>or</i> no explicit direction of credit growth
1	Weakly encouraging	2014Q3 – present	QMPR only lists sectors that to be encouraged for the target of optimizing credit structure
2	Strongly encouraging	1998Q1 – 2000Q4 2008Q3 – 2009Q1	QMPR encourages the growth of total credit explicitly

Sources: Author's classification based on the information from PBoC's QMPR and Zhang and Ji (2012).

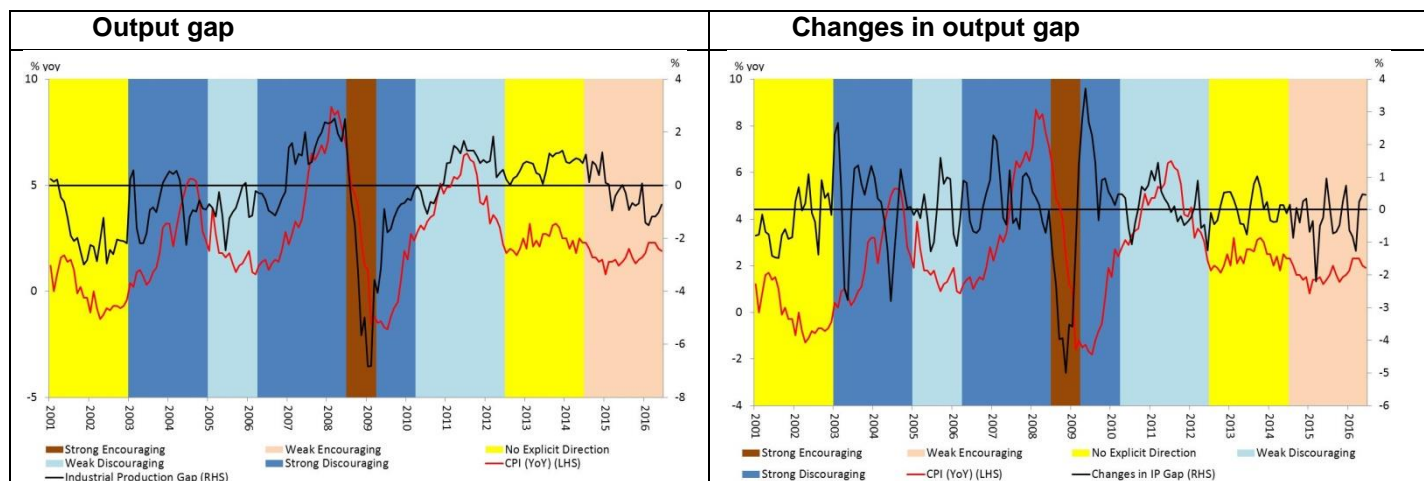
Table 2. Calibrated parameters

Parameter	Description	Value
β_P	Discount factor of households	0.997
β_E	Discount factor of entrepreneurs	0.983
ϵ^d	Demand elasticity for deposits	-1.31
κ_d	Deposit rate adjustment cost	3.5
ϵ^{bs}	Demand elasticity for loans	2.37
κ_{bE}	Lending rate adjustment cost	9.36
δ^b	Commercial banks capital depreciation rate	0.08
γ^b	Target capital adequacy ratio	0.1
κ_{Kb}	Elasticity of the spread on the interbank market w.r.t. banks leverage	8.5
κ^r	Exchange rate elasticity to the spread b/n domestic and foreign interest rates	0.001
a^P	Habit formation parameter	0.4
ϵ_l	Demand elasticity for differentiated labor input	6.3
κ_w	Wage adjustment cost	70
i_w	Wage indexation parameter	0.28
m^E	Loan-to-value constraint parameter	0.7
α	Output elasticity of capital	0.5
δ	Depreciation rate	0.05
κ_i	Capital adjustment cost parameter	4
ϕ	Inverse Frisch elasticity of labor supply	1
ϵ^y	Demand elasticity for differentiated goods	21
κ_p	Price adjustment (menu) cost	30
ϵ^C	Demand elasticity for domestic consumer goods	1.2
ϵ^I	Demand elasticity for domestic investment goods	1.2
ϵ^F	Foreign demand for domestic goods (exports)	1.2
η^c	Home bias parameter for consumption goods	0.77
η^I	Home bias parameter for investment goods	0.77
χ_0	Capital utilization adjustment cost (linear part)	0.069
χ_1	Capital utilization adjustment cost (non-linear part)	0.0069
ϕ_R	Policy inertia parameter in the Taylor rule	0.89
ϕ_π	Inflation parameter in the Taylor rule	1.8
ϕ_y	Output parameter in the Taylor rule	0.3

Table 3. Steady state values of endogenous variables

Variable	Description	Value
r^d	Real interest rates on retail deposits (annual)	1.3%
r^{bE}	Real interest rates on retail loans (annual)	4%
r	Policy interest rate	2.3%
$1 + x$	Price mark-up	1.05
$x \frac{rk}{y}$	Capital income share	0.5
k/y	Capital-to-GDP ratio (annualized ratio)	1.96
C/Y	Consumption share in GDP	0.59
I/Y	Investment share in GDP	0.38
$\frac{C^F + I^F}{Y}$	Import share in DGP	0.22
C^{H*}	Export share in GDP	0.25
$\frac{B}{Y}$	Loans to non-financial corporations to GDP (annualized ratio)	1.3
$\frac{D^{CB}}{Y}$	Central bank's bonds in domestic currency, held by commercial banks, to GDP (annualized ratio)	0.5
$\frac{B}{K}$	Non-financial corporations leverage	0.66
$\frac{K^b}{B}$	Capital adequacy ratio	0.1

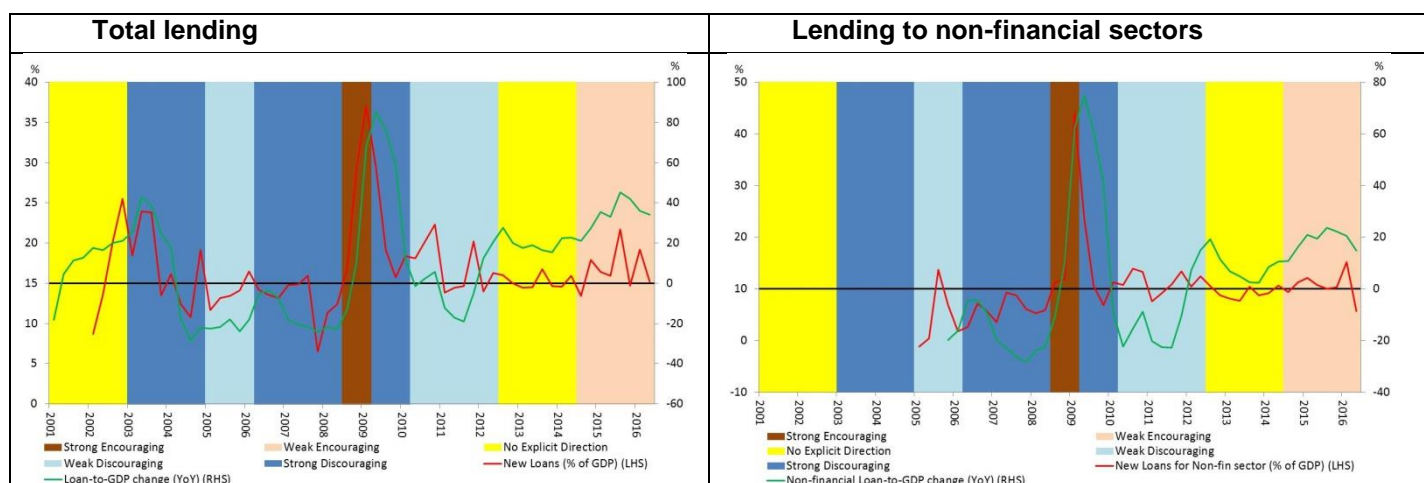
Figure 1. Output gap, CPI inflation, and window guidance stance



Note: The definitions of variables are described in Appendix B.

Sources: Author's calculation based on the information from PBoC and National Statistical Bureau of China.

Figure 2. Window guidance stance and the impact on lending growth



Note: The definitions of variables are described in Appendix B.

Sources: Author's calculation based on the information from PBoC and National Statistical Bureau of China.

Figure 3. Coordination between window guidance and price-based monetary policy tools

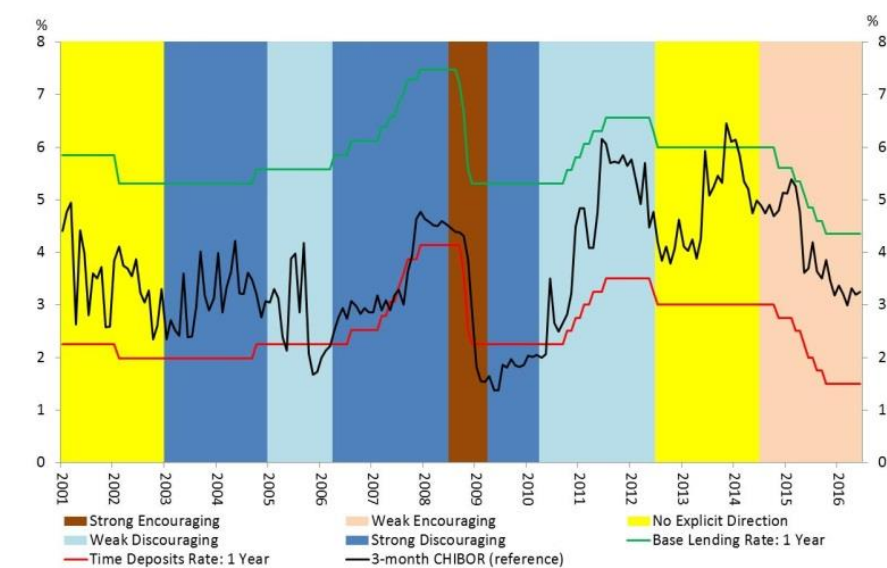


Figure 4. IRFs from a negative TFP shock without (---) and with (—) window guidance

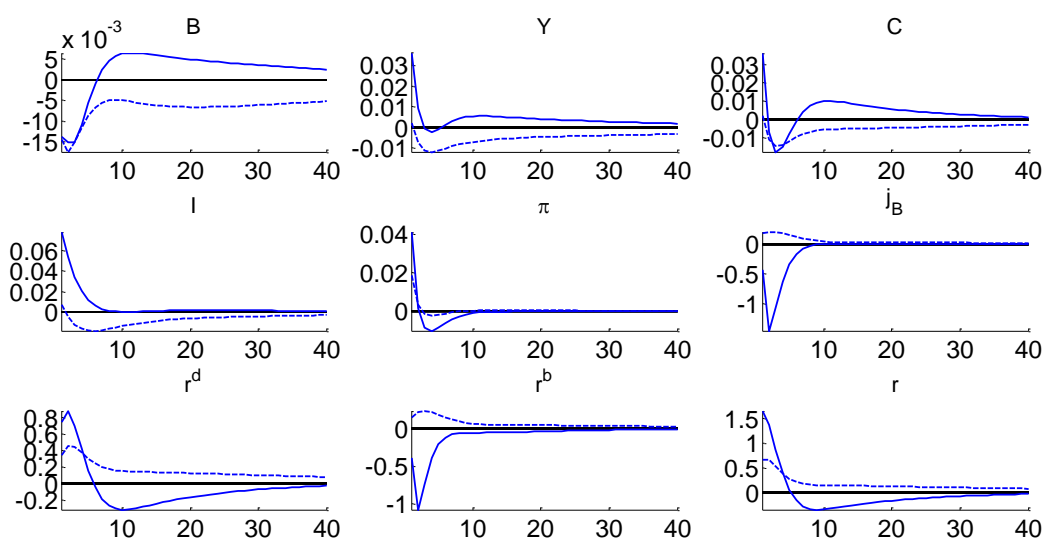


Figure 5. IRFs from a positive demand shock without (---) and with (—) with window guidance

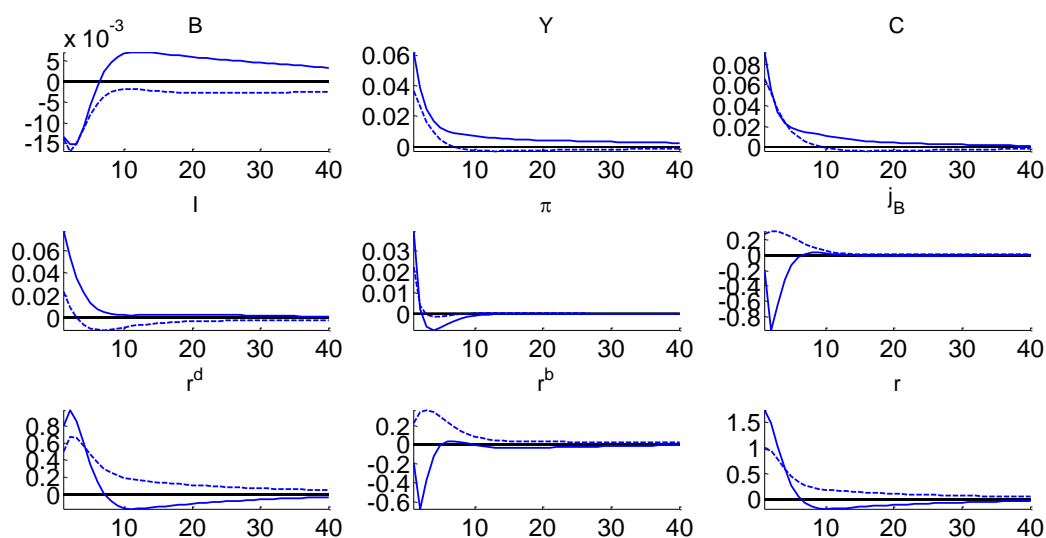


Figure 6. IRFs from a Positive Markup Shock without (---) and with (—) with Window Guidance

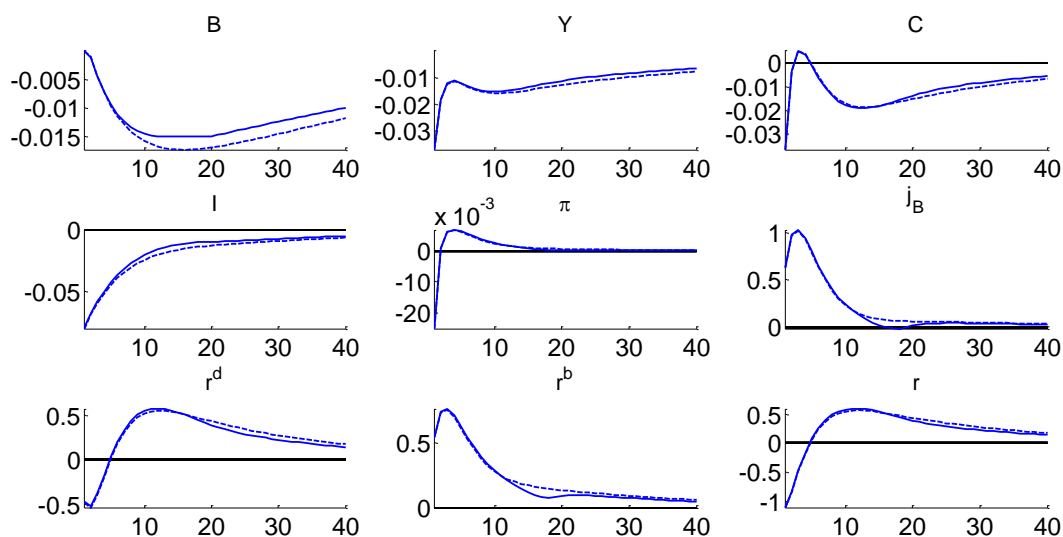


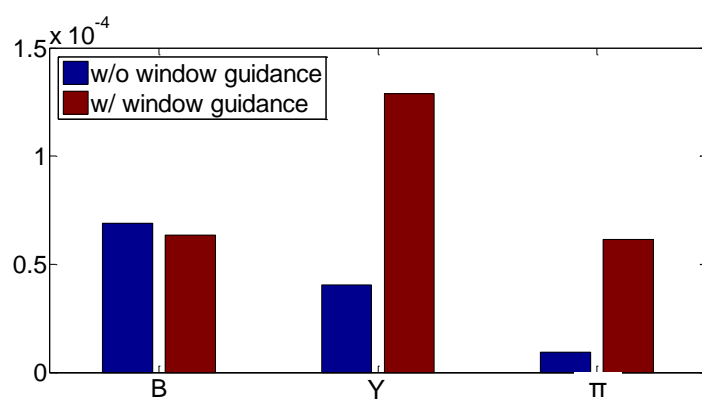
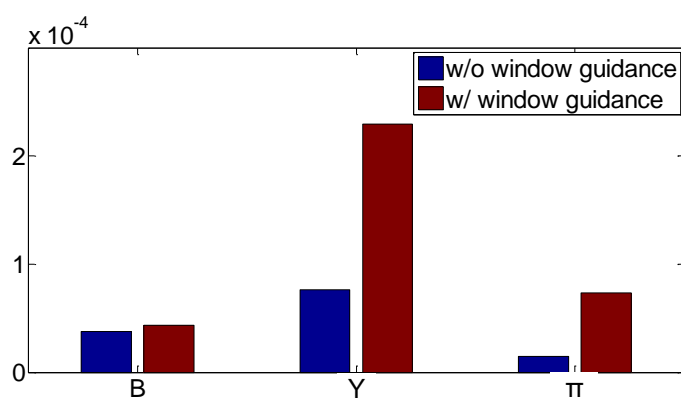
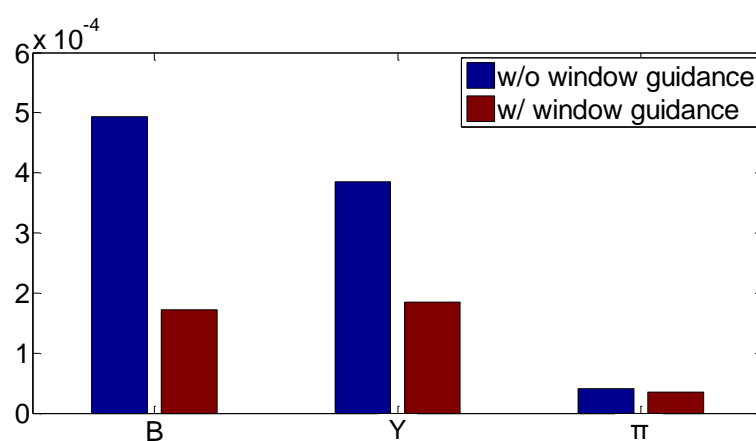
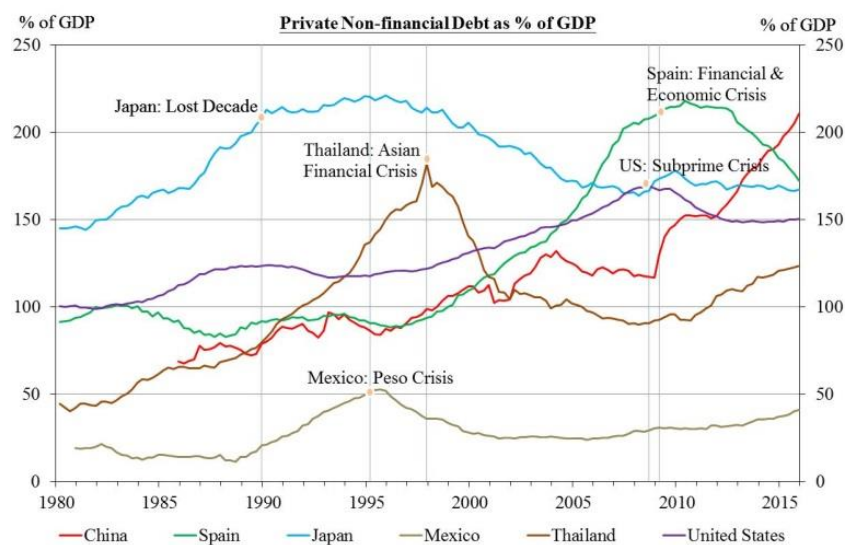
Figure 7. Variance in key macroeconomic variables in response to TFP shocks**Figure 8. Variance in key macro variables in response to consumption shocks****Figure 9. Variance in key macro variables in response to financial intermediation shocks**

Figure 10. Private non-financial loans and financial crises in selected economies

Source: Bank for International Settlements and authors' calculations.