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Financial system reforms and China's monetary policy framework: A DSGE-based assessment of initiatives and proposals

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Michael Funke and Michael Paetz

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Financial System Reforms and China's Monetary Policy Framework: A DSGE-Based Assessment of Initiatives and Proposals

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Abstract

This paper evaluates various financial system reform initiatives and proposals in China in a DSGE modelling setting. The key reform steps analysed include phasing out benchmark interest rates, deepening the direct finance market, reducing government's quantity-based intervention on financial institutions. Our counterfactual model simulation results suggest that the reforms will be beneficial only, if Chinese monetary policy continues to rely on quantity-based interventions on financial institutions or tightens the interest rate rule.

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Keywords: DSGE model, financial sector reform, monetary policy, China.

JEL classification: E42, E52, E58.

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1 Introduction

To achieve the objectives of monetary policy, the People's Bank of China (PBoC) is currently using several standard and nonstandard monetary policy instruments in combination. China's unconventional approach to monetary policy includes three notable particularities. First, Chinese banks operate within tight limits. PBoC imposes a floor on loan rates and there are caps on deposit rates. Second, the PBoC uses non-market tools such as loan quotas and window guidance, which essentially involves telling banks how to do their jobs. Just as window guidance influences the direction of lending, China's quantitative credit quotas are important in regulating the amount of credit. Finally, the required reserve ratio, rarely used as a policy instrument by Western-type central banks, has over the last decade become an important tool for the short-run fine-tuning of monetary policy in China.¹

At the same time, however, a flurry of reform initiatives and proposals have been suggested and put forward recently in an effort to move towards a more liberalised financial market and a more market-based monetary policy framework. These most recent reform initiatives include inter alia (i) the creation of an over-the-counter (OTC) equity market to provide new financing for SME firms, especially high-tech firms (announced in April 2012); (ii) the creation of a high-yield SME bond market in June 2012; (iii) the creation of jointly issued notes as a pooled debt instrument, issued in China's inter-bank bond market by at least two, but no more than ten, SMEs [see Zhang and Wu (2012)]; (iv) widening of the interest rate benchmark band in July 2012, allowing banks to set lending rates 20 percent below the official benchmark, compared with the previous 10 percent limit. Banks were also given the option of setting deposit rates 10 percent above the official level; (v) a credit-backed securization programme in June 2012 allowing banks to turn loans into securities and thus increase the funds for additional lending; (vi) the renminbi exchange rate band widening in June 2012, allowing more flexibility vis-à-vis the daily rate set by the PBoC; (vii) the creation in June 2012 of so-called wealth management products that can substitute traditional bank deposits and offer consumers and firms a higher returns; and (viii) the Wenzhou Financial Liberalisation announced in March 2012, allowing private lenders in the city to operate as investment firms and to finance entrepreneurial companies.

Despite the above reforms, the Chinese financial system is still underdeveloped and weighted towards banks.² Furthermore, there is also an imbalance in the capital

¹For an analysis of standard and nonstandard Chinese monetary policy tools in a fully specified DSGE model, see Chen et al. (2012). Given the prominence of nonstandard monetary policy tools in China, one might expect these nonstandard monetary policy tools to be at the heart of most mainstream papers on monetary policy in China. Perhaps somewhat surprisingly, however, it is quite common to abstract altogether from this quintessential multi-faceted nature. For such a fragmentary and simplistic Taylor-rule analysis, see Zheng et al. (2012) and the literature cited therein.

²For some indicators of financial sector size and depth, see Worldbank (2012), p. 154. Recent

markets, as the Chinese corporate bond market remains underdeveloped. Some of these reforms may be of symbolic significance, but most of them are intended to liberalise the financial markets. The skewed interest rates offered by Chinese banks so far represent a tax on depositors and a subsidy for industry.³ The regulated interest rates suppress consumption in favour of investment. The tightly regulated interest rates also impede the use of market-based monetary policy instruments. A more liberalised financial system would encourage more productive investment. Therefore, an important Chinese policy objective is to gradually phase out the remaining interest rate controls.

To summarise, China is in a transition phase in moving to a market-based economy. With the opening of financial markets and liberalisation of interest rates, we are seeing financial innovation and a parade of new financial products. Given the various reform initiatives and proposals, it is surprising that despite the growing importance of the Chinese economy, the impact of financial reform on the design of Chinese monetary policy has not yet been rigorously investigated. What do these developments imply for the conduct of monetary policy in China? This is an important question, one that does not lend itself to a neat answer. Below we contribute to the resolution of this question within the framework of a calibrated DSGE modelling.

The paper proceeds as follows. Section 2 provides a comprehensive review of China's financial system and explores directions of future financial system development. Section 3 lays out the dynamic stochastic general equilibrium (DSGE) model which is the backbone of the paper. Section 4 presents model calibrations, and section 5 concludes. The appendices contain information that is not essential to understanding the monetary policy simulations, but does further clarify certain technical points.

2 A Snapshot of Chinese Financial System Reform

China is in the midst of transforming its monetary system from one dominated by direct control measures to one with a more indirect approach based on open market operations. This section briefly summarises key features of China's financial reform and points out some challenges ahead. China's financial reform is aimed specifically

research indicates that the optimal financial structure becomes more market-oriented as economies develop [Demirguc-Kunt et al. (2012)]. This principle may well hold, but country-specific features are also important.

³Hsieh and Klenow (2009) have used plant-level manufacturing establishment data to quantify the potential extent of misallocation in China versus the US arising from artificially cheap capital. They measure sizable gaps in marginal products of labour and capital across firms in China compared with the US. When capital and labour are hypothetically reallocated to equalise marginal products to the extent observed in the United States, they calculate TFP gains of 30 to 50 percent in China.

at establishing a more indirect monetary policy regime. Currently, monetary policy resembles a transitional system, largely dominated by quantity-based control measures, including window guidance, benchmark lending and deposit rates, and credit and money growth targets. This is expected to give way to a more indirect system based on open-market operations - already partly in place - and the development of an active bond market. The key reform steps envisaged include phasing out benchmark interest rates, deepening the direct finance market, reducing government's quantity-based intervention on financial institutions, capital account liberalisation, and exchange rate liberalisation.⁴

At the current juncture, liberalising interest rates refers to lifting administrative guidelines in terms of lending rate floors and deposit rate ceilings. The purpose of liberalising interest rates is to improve the efficiency of capital allocation, and risk pricing, and to promote effective monetary policy transmission. Control of retail interest rates has been an obstacle for the central bank's conduct of effective policy through open market operations, and it has prevented market interest rates from serving as benchmarks for the pricing of other financial assets. This reform is highlighted in the 12th five-year plan for 2011-2015.

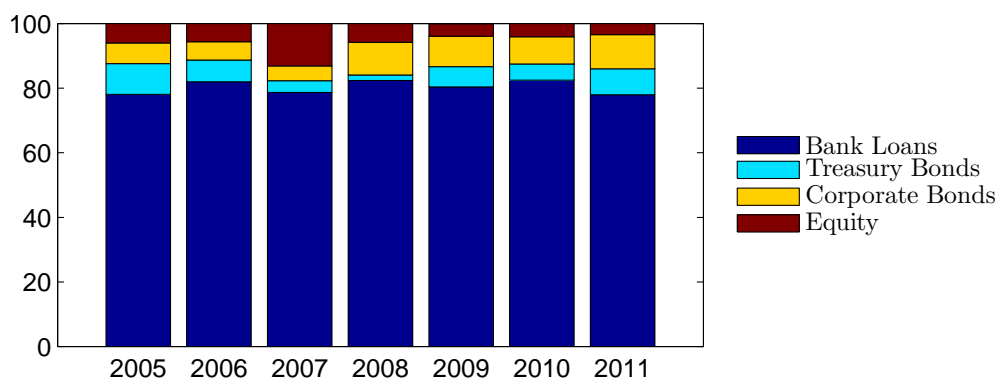
In order to enhance the effectiveness of the monetary transmission mechanism via the policy short-term interest rate, the PBoC intends to develop deeper bond markets, including treasury bonds, commercial bank paper and corporate bonds. Regarding the various financing channels, bank loans are still dominant. The evidence for China's financing structure from 2005-2011 in Figure 1 indicates that bank loans accounted for more than 78 percent of total financing in 2011. Although the changes over the period 2005 - 2011 may look like mere tweaks, the surge of pro-reform proposals and initiatives currently under way suggests a sign that the financial system reform is under way. One recent example is the creation of a high-yield bond market for small domestic enterprises in June 2012. Small domestic firms that are not listed on the stock exchange are eligible to participate. Issuance will be conducted through private placement. Notwithstanding these recent changes, large state-owned firms are still the main issuers of corporate enterprise bonds.⁵ Interest rates in these markets, including interbank rates and bond yields, have been liberalised and now move flexibly to clear markets for borrowing and lending reserves. During the changeover, the PBoC is relying on price-based tools. In particular, PBoC aims to use market based tools through open market operations, and to establish the Shanghai Interbank Offered Rate (SHIBOR) as the benchmark interest rate for asset pricing.

Figure 2 shows the composition of outstanding bonds in December 2011. Financial institutions account for the largest market share, 46 percent of the total bond

⁴For reviews of the reform initiatives and proposals, see Conway et al. (2010) and IMF (2012).

⁵The bond markets in China consists of two sub-markets: one for institutional investors, called the interbank bond market; and the other for individual investors, which is operated by the stock exchanges in Shanghai and Shenzhen. The majority of the bonds are traded in the interbank bond market, with its share of turnover exceeding 80 percent in 2003 and close to 99 percent since 2007.

Figure 1: China's Financing Structure, 2005 - 2011 in Percent



Source: IMF (2012) and WIND.

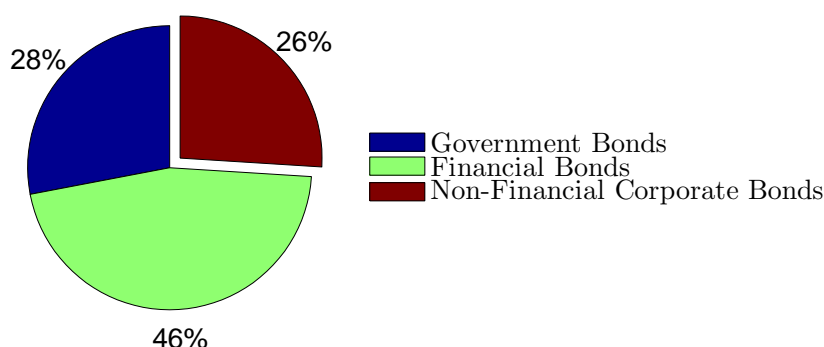
market. Government bonds, the majority being central government bonds, account for 28 percent, and non-financial firms account for 26 percent. Altogether, owing to the deepening of bond markets and improved price signalling, intermediation outside of the traditional deposit-and-loan business has gained in importance.

Furthermore, the Chinese government has begun to formalise the shadow banking industry in Wenzhou city, in another trial run for boosting the direct financing markets. The city has a long history of private lending. At the end of March 2012 the Chinese government announced that Wenzhou would be named a "special financial zone", the scene of a pilot scheme. Informal lenders are encouraged to register as private lending institutions free to operate as investment companies, the goal being to increase financing for small and medium enterprises. Moreover, complementary regulations and financial infrastructure such as a risk information sharing system are also under consideration by the Chinese authorities. In summary, what do these reforms tell us? The Chinese roadmap for financial system reform aims at a more market-oriented financial system that fosters stable and inclusive economic growth, facilitates internal rebalancing, and safeguards financial stability. There is a serious effort under way to bolster China's monetary policy toolkit, and policymakers are looking around the world for best practices. Strengthening nonbank financial intermediation will subject banks to competitive discipline, and will offer enterprises alternative avenues for finance. In parallel, the central bank can move to liberalise the limits on loan and deposit rates and allow them to be market determined. Finally, monetary policy should move towards price-based means instead of administrative controls on lending.⁶ This step-by-step process also tells us that the gradualist approach to reform still dominates the thinking.

Given the complexity of the reform process, we analyse the interconnections between different aspects of the financial system reform in a DSGE framework below. While not a crystal-ball, the DSGE model provides a well-organised conceptual

⁶Reinhart and Rogoff (2008) emphasise the need for a carefully-calibrated financial liberalisation approach.

Figure 2: Outstanding Bonds, December 2011



Source: WIND

framework for discussing the macroeconomic effects of financial system reforms.⁷

3 The Model

The literature so far has not developed an encompassing DSGE model appropriate for modelling Chinese financial system reform, but several elements have already been developed, and we naturally build on them. The paper by Chen et al. (2012) develops a DSGE model that captures China's unconventional monetary policy toolkit. In this paper we augment their framework with a domestic bond market. For this purpose, we extend the model by Chen et al. (2012) by introducing large-scale corporations with access to bond finance via institutional investors. Following the seminal work of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) on credit cycles, we distinguish between patient and impatient households.⁸ In our model, impatient households are modelled as entrepreneurs and denoted by superscript E . We further split the group of enterprises into two subgroups: small enterprises (denoted S) and large scale corporates (denoted L). The reason for distinguishing between these two types of entrepreneurs is that for capital raising purposes only large institutional investors have access to bond finance. We incorporate this into our model by assuming that only a fraction γ issue bonds to finance investments, consumption and wages, while the remaining ones rely on credits from private banks. The private banks collect deposits from patient households (denoted P), provide loans for small enterprises, and can buy and sell central bank bills at

⁷Despite the trend towards a more international renminbi, it is likely that full capital account liberalisation - especially for short-term capital flows - will only occur when the bulk of the reforms cited above are in place. We therefore model the current financial reform roadmap in a closed-economy DSGE model. For those pursuing the capital account subject further, see Chang et al. (2012).

⁸A considerable literature has sprung from these papers. For a comprehensive review, see Gertler and Kiyotaki (2010).

the policy rate. Moreover, private banks can trade financial assets with large scale corporates in the bond market. To close the supply side of the model, we assume that the entrepreneurs produce intermediate goods, which they sell to a retail sector. This sector has some monopoly power and sets prices in a staggered manner.

Finally, we describe the problem faced by each economic agent, showing the corresponding optimality conditions and the shocks that perturb them. Together with market-clearing conditions, these relationships characterize the equilibrium behaviour of the model setup.

3.1 Patient households

A domestic representative patient household is allowed to hold deposits D_t at private banks, which yield a net return of r_t^D . Consequently, a household chooses sequences of consumption (C_t^P), labour supply (N_t) and deposits to maximize

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta_p^t \mathcal{V}_t \left[\frac{1}{1 - \sigma_p} (C_t^P)^{1 - \sigma_p} - \frac{1}{1 + \varphi} N_t^{1 + \varphi} \right] \right\}, \quad (1)$$

subject to a sequence of dynamic budget constraints (in real terms)

$$C_t^P + D_t = \frac{R_{t-1}^D D_{t-1}}{\Pi_t} + W_t N_t + F_t^R + F_t^B + T_t, \quad (2)$$

where W_t , F_t^R , F_t^B , and T_t represent respectively the real wage rate, the consumption price index (CPI), real lump-sum profits received from the retail and the banking sector, and real lump-sum transfers net of taxes.⁹ \mathbb{E}_t is the expectation operator at time t . For simplicity we assume that consumption and labour supply are separable in the utility function. The gross interest rate on deposits denoted as R_t^D , and consumer price inflation as Π_t . The parameters σ_p and φ represent the inverse intertemporal elasticity of substitution with respect to consumption and labour supply, respectively, and β_p is the patient households' discount factor. We also add an intertemporal preference shock, $\mathcal{V}_t \equiv \exp(\nu_t)$, reflecting shifts in the marginal utility of consumption.

In equilibrium, the conventional optimality conditions may be stated as (2), the Euler equations, and the optimal labour-leisure decision:

$$1 = R_t^D \beta_p \mathbb{E}_t \left[\left(\frac{C_{t+1}^P}{C_t^P} \right)^{-\sigma_p} \frac{P_t}{P_{t+1}} \frac{\mathcal{V}_{t+1}}{\mathcal{V}_t} \right], \quad (3)$$

$$W_t = (C_t^P)^{\sigma_p} N_t^\varphi. \quad (4)$$

⁹Deposits are measured in real terms, deflated with the consumer price index. Real lump-sum profits are described below.

3.2 Entrepreneurs

Entrepreneurs are essential agents of the model, since they demand bank loans from private banks L_t and issue bonds B_t to finance investments, consumption and wages. For reasons discussed above, we split entrepreneurs into two subgroups: Large scale corporates (denoted by L), which have access to bond markets, and small scale enterprises (denoted by S), which borrow money from private banks.¹⁰

3.2.1 Large Scale Corporates

A representative large scale corporate chooses the amount of consumption (C_t^L), capital (K_t^L), bonds (B_t), labour demand (N_t^L), and investments (I_t^L) to maximize

$$E_0 \sum_{t=0}^{\infty} \beta_e^t \mathcal{V}_t \frac{1}{1 - \sigma_e} (C_t^L)^{1 - \sigma_e},$$

subject to

$$C_t^L + W_t N_t^L + I_t^L + \frac{R_{t-1}^B}{\Pi_t} B_{t-1} + \mathcal{A}_t^L = \frac{Y_t^L}{X_t} + B_t, \quad (5)$$

$$K_t^L = (1 - \delta) K_{t-1}^L + I_t^L, \quad (6)$$

and

$$Y_t^L = A_t (K_{t-1}^L)^\alpha (N_t^L)^{1 - \alpha}, \quad (7)$$

where R_t^B denotes the gross interest rate on issued bonds, and $A_t \equiv \exp(a_t)$ labour-augmenting productivity, and a_t is an exogenous disturbance.¹¹ Y_t and X_t represent real production and the markup of final over intermediate goods.¹² The constraints of entrepreneurs are the usual flow budget constraint (5), the capital accumulation (6), and a Cobb-Douglas production function (7) for intermediate goods.¹³ The parameters δ and α denote the depreciation rate for capital and the input share of capital in the production process, respectively. Adjustment costs for installing new

¹⁰The model has the characteristics of China's bond market in short form. The initial Chinese bond categories were government bonds and corporate bonds. Over time, these have evolved into a wide range of bond varieties. Inter alia these include policy bank bonds, central bank bills, general financial bonds, hybrid capital bonds, super and short-term commercial papers, commercial papers, credit asset securitization products, listed company bonds, and local government bonds. Non-financial firms can issue bonds, provided they satisfy the requirements of the PBoC. See <http://www.chinabond.com.cn/Site/cb/en>.

¹¹Bonds and investments are likewise measured in real terms, deflated with the consumer price index. All other variables and parameters are defined as in section 3.1.

¹²Similar to Bernanke et al. (1999), we assume that retailers purchase intermediate goods from entrepreneurs at a retail price and transform them into a final good. Furthermore, we assume that small and large scale firms produce the same type of intermediate good, so that the price markup of final goods over intermediates is also the same.

¹³Some simplification is entailed in the functional forms of the model. For example, the Cobb-Douglas function is likely to overestimate substitution in some areas and underestimate it in others. Additionally, it may suggest a degree of smoothness in substitution that is not present in reality.

capital goods are represented by $\mathcal{A}_t^L \equiv \psi \left(\frac{I_t^L \mathcal{U}_t}{K_{t-1}^L} - \delta \right)^2 \frac{K_{t-1}^L}{2\delta}$, where \mathcal{U}_t is a shock to the investment cost function. Since an increase in \mathcal{U}_t increases costs and depresses investment, a negative shock can be seen as a positive investment shock.

In equilibrium the dynamics of consumption, capital, investment and labour demand are determined by (5) - (7) and

$$1 = R_t^B \beta_e \mathbb{E}_t \left[\left(\frac{C_{t+1}^L}{C_t^L} \right)^{-\sigma_e} \frac{P_t}{P_{t+1}} \frac{\mathcal{V}_{t+1}}{\mathcal{V}_t} \right], \quad (8)$$

$$v_t = (C_t^L)^{-\sigma_e} \left(\frac{\psi}{\delta} \left(\frac{I_t^L \mathcal{U}_t}{K_{t-1}^L} - \delta \right) \frac{I_t^L \mathcal{U}_t}{K_{t-1}^L} - \frac{\psi}{2\delta} \left(\frac{I_t^L \mathcal{U}_t}{K_{t-1}^L} - \delta \right)^2 \right) + \beta_e \mathbb{E}_t \left((C_{t+1}^L)^{-\sigma_e} \frac{\alpha Y_{t+1}^L}{K_t^L X_{t+1}^L} + (1 - \delta) v_{t+1} \right), \quad (9)$$

$$W_t = (1 - \alpha) \frac{Y_t^L}{X_t N_t^L} \quad (10)$$

where $v_t^L \equiv (C_t^L)^{-\sigma_e} \left[\left(1 + \frac{\psi}{\delta} \left[\frac{I_t^L \mathcal{U}_t}{K_{t-1}^L} - \delta \right] \right) \right] \mathcal{V}_t$ gives the shadow price of capital for large corporates. According to (8) the entrepreneur's consumption dynamics follow an Euler equation similar to that of patient households' consumption. However, since entrepreneurs are less risk-averse and patient, the steepness of the optimal intertemporal consumption pattern is different. As emphasized in Iacoviello (2005), equation (42) equates the shadow price of capital to the sum of (i) the capital's marginal product next period, (ii) the capital contribution to lower installation costs, and (iii) the shadow price of capital next period. The last optimality condition is a conventional labour demand curve.

3.2.2 Small Scale Enterprises

Currently, issuers with lower credit ratings such as small- and medium-size firms are excluded from the bond market. A representative small scale firm therefore chooses the amount of consumption (C_t^S), capital (K_t^S), loans (L_t), labour demand (N_t^S), and investment (I_t^S) to maximize

$$E_0 \sum_{t=0}^{\infty} \beta_e^t \mathcal{V}_t \frac{1}{1 - \sigma_e} (C_t^S)^{1 - \sigma_e},$$

subject to

$$C_t^S + W_t N_t^S + \frac{R_{t-1}^L}{\Pi_t} L_{t-1} + I_t + \mathcal{A}_t^S = \frac{Y_t^S}{X_t} + L_t^S, \quad (11)$$

$$K_t^S = (1 - \delta) K_{t-1}^S + I_t^S, \quad (12)$$

and

$$Y_t^S = A_t (K_{t-1}^S)^\alpha (N_t^S)^{1 - \alpha}, \quad (13)$$

where R_t^L and all other variables and parameters are defined as for large scale corporates.¹⁴

The first order conditions of the small scale firms are given by (5) - (7) and

$$1 = R_t^L \beta_e \mathbb{E}_t \left[\left(\frac{C_{t+1}^S}{C_t^S} \right)^{-\sigma_e} \frac{P_t}{P_{t+1}} \frac{\mathcal{V}_{t+1}}{\mathcal{V}_t} \right], \quad (14)$$

$$v_t = (C_t^S)^{-\sigma_e} \left(\frac{\psi}{\delta} \left(\frac{I_t^S \mathcal{U}_t}{K_{t-1}^S} - \delta \right) \frac{I_t^S \mathcal{U}_t}{K_{t-1}^S} - \frac{\psi}{2\delta} \left(\frac{I_t^S \mathcal{U}_t}{K_{t-1}^S} - \delta \right)^2 \right) + \beta_e \mathbb{E}_t \left((C_{t+1}^S)^{-\sigma_e} \frac{\alpha Y_{t+1}^S}{K_t^S X_{t+1}} + (1 - \delta) v_{t+1} \right), \quad (15)$$

$$W_t = (1 - \alpha) \frac{Y_t^S}{X_t N_t^S} \quad (16)$$

where $v_t^S \equiv (C_t^S)^{-\sigma_e} \left[\left(1 + \frac{\psi}{\delta} \left[\frac{I_t^S \mathcal{U}_t}{K_{t-1}^S} - \delta \right] \right) \right] \mathcal{V}_t$ gives the shadow price of small firms' capital. These equations can be interpreted in exactly the same way as equations (8) - (10).

3.3 Retailers

For the modelling of the retail sector we utilize the framework of Bernanke et al. (1999) and Iacoviello (2005), who assume that retailers of mass one have some monopoly power and set prices in a Calvo-staggered manner. Scattered price adjustment implies that prices of some pairs of goods differ for firms that periodically adjusted their prices, which implies differences in demands for these goods, and consequently in labour demand across firms. This represents an inefficient allocation, given that firms use the same technology. While these price dispersions are generally low and disappear in a first-order approximation around a zero inflation steady state, they could have a stronger impact in a model with non-linearities.¹⁵ Since the interest rate corridor of the PBoC represents a very strong nonlinearity, we take these dispersions into account.

If retailers of mass 1, denoted by z , purchase entrepreneur's intermediate goods, differentiate them at no costs into $Y_t(z)$, then individual demand curves are given by $Y_t(z) = (P_t(z)/P_t)^{-\left(\frac{1+\mu_t}{\mu_t}\right)} Y_t$, where Y_t denotes the final good, and μ_t a time-varying net markup in the goods market, often referred to as a "cost-push" shock. Using the standard Calvo (1983) pricing mechanism, a randomly selected fraction of

¹⁴There is a technical detail that must be mentioned. Note that small and large firms are modelled as completely symmetric in all respects except the type of financing. Also note that we implicitly assume that labour is perfectly mobile between firm types.

¹⁵Braun and Körber (2011) for example argues that price dispersions in a Calvo scheme or price adjustment costs in a Rotemberg (1996) quadratic cost model might imply very different dynamics of output and inflation, when the interest rate is at the zero lower bound.

retailers $(1 - \theta)$ then adjusts prices while the remaining fraction θ does not adjust.¹⁶ Solving the usual price setting problem under these assumptions yields the optimal price setting:

$$(1 + \mu_t) G_{1,t} = G_{2,t}, \quad (17)$$

$$G_{1,t} = \frac{Y_t}{X_t} (C_t^P)^{-\sigma_p} \mathcal{V}_t + \theta \beta_p \mathbb{E}_t \left(\Pi_{t+1}^{\left(\frac{1+\mu_t}{\mu_t}\right)} G_{1,t+1} \right), \quad (18)$$

$$G_{2,t} = \Pi_t^* \left[Y_t (C_t^P)^{-\sigma_p} \mathcal{V}_t + \theta \beta_p \mathbb{E}_t \left(\frac{\Pi_{t+1}^{(1/\mu_t)}}{\Pi_{t+1}^*} G_{2,t+1} \right) \right], \quad (19)$$

$$1 = \theta \Pi^{(1/\mu_t)} + (1 - \theta) (\Pi^*)^{-(1/\mu_t)}, \quad (20)$$

$$\Delta_t = \theta \Pi_t^{\left(\frac{1+\mu_t}{\mu_t}\right)} \Delta_{t-1} + (1 - \theta) (\Pi_t^*)^{-\left(\frac{1+\mu_t}{\mu_t}\right)}, \quad (21)$$

where $\Pi^* = P_t^*/P_t$ represents the relative price of the price adjusters, $G_{1,t}$ and $G_{2,t}$ are auxiliary variables, and the $\Delta_t \equiv \int_0^1 (P_t(z)/P_t)^{-\left(\frac{1+\mu_t}{\mu_t}\right)} dz$ represent the price dispersions, discussed above. These price dispersions imply that the aggregate supply of the final good is $Y_t = \frac{A_t}{\Delta_t} K_t^\alpha N_t^{1-\alpha}$, where the aggregated values of labour demand and capital are defined below. Finally, we assume that profits $F_t = (1 - 1/X_t) Y_t$ are rebated to patient households.

3.4 Aggregation and Market Clearing

Aggregation of small and large scale firms imply the following results for aggregated values of capital, investment, labour demand, and consumption:

$$K_t \equiv \gamma K_t^L + (1 - \gamma) K_t^S = (1 - \delta) K_{t-1} + I_t, \quad (22)$$

$$Y_t^E \equiv \gamma Y_t^L + (1 - \gamma) Y_t^S = A_t K_{t-1}^\alpha N_t^{1-\alpha} = \Delta_t Y_t, \quad (23)$$

$$I_t \equiv \gamma I_t^L + (1 - \gamma) I_t^S, \quad (24)$$

$$N_t \equiv \gamma N_t^L + (1 - \gamma) N_t^S = (1 - \alpha) \frac{Y_t^E}{X_t W_t}, \quad (25)$$

$$C_t^E \equiv \gamma C_t^L + (1 - \gamma) C_t^S. \quad (26)$$

In addition, goods market clearing requires $Y_t = C_t^P + C_t^E + I_t$.

3.5 Private banks

The banking sector of the model is closely related to the partial-equilibrium modelling of He and Wang (2012) and Chen et al. (2011) of a Chinese banking sector

¹⁶In its recent struggle to suppress inflationary pressures, China announced plans to curb price hikes on a range of goods from instant noodles to milk, describing the action as a temporary intervention to stem surging inflation. The government has long set prices for oil and electricity and has pledged to freeze them at current levels. Calvo price-setting therefore also reflects administered prices in China.

Table 1: Balance Sheet of the Representative Private Bank

Assets	Liabilities
Deposits from patient households represent a fraction of the created deposits and are used as required reserves, D_t	Newly created deposits (money creation), D_t/η_t
Funds provided to entrepreneurs, $\gamma B_t + (1 - \gamma) L_t$	Net position in interbank market, IB_t

Note: The DSGE framework does not include bank capital and so bank capital is not included in the bank's net worth on the liability side.

and Gerali et al. (2010), which included a banking sector in a DSGE framework. More precisely, we embed the parts of the first two papers that are needed to analyze Chinese monetary policy within the wholesale banking branch introduced in Gerali et al. (2010). However, we refrain from introducing banking capital or a retail branch, to keep the focus on the transmission of Chinese monetary policy. The banking sector determines the demand function for deposits and excess reserves and the supply function for loans, taking all interest rates as given. The deposit and lending rates are thus market-determined as long as the guidelines of the central bank are not binding.¹⁷

In addition, we enhance the framework of Chen et al. (2012) by introducing money creation by the private banking sector. Although the deposit multiplier is a well-known concept even in standard macroeconomics undergraduate textbooks, the fact that banks create money has been widely ignored in the modern DSGE literature on banking.¹⁸ A simplified balance sheet of a representative private bank in our model is given in Table 1. The bank chooses the amount of loans, bonds, deposits, and borrowings from the interbank market. However, a private bank is more than a pure financial intermediary that collects funds from households and provides them to firms. Actually it creates new deposits by expanding the balance sheet, creating an asset and a liability at the same time in accord with the double-entry bookkeeping. For a given required reserve ratio (η_t), the amount of newly created deposits on the liabilities side of the balance sheet must be equal to D_t/η_t , so that by construction a fraction η_t is deposited as required reserves. Consequently, the flow budget constraint of the representative bank is given by

$$IB_t + D_t/\eta_t = (1 - \gamma) L_t + \gamma B_t + D_t. \quad (27)$$

We assume that money creation induces management costs, given by a quadratic

¹⁷Contrary to Chen et al. (2012), we abstract from excess reserves, to keep the analysis as simple as possible.

¹⁸A notable exception is the recent IMF paper on the "Chicago Plan" of a full reserve banking system. See Kumhof and Benes (2012) for details.

cost function:¹⁹

$$\mathcal{C}_t \equiv \frac{1}{2Y} \left\{ c_d \left[(D_t/\eta_t)^2 - (D/\eta)^2 \right] + (1 - \gamma) c_l \left[L_t^2 - L^2 \right] + \gamma c_b \left[B_t^2 - B^2 \right] \right\}. \quad (28)$$

In addition, banks are constrained by the guidelines of the monetary authority. We assume that deviations of actual credits from the target of the central bank (L_t^{CB}) induce costs, given by $\frac{\kappa}{2} (1 - \gamma) (L_t - L_t^{cb})^2$. Hence the cash flows of a representative bank are given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_b^t \left\{ \begin{array}{l} (1 - \gamma) (R_t^L L_t - L_{t+1}) + R_t^R D_t - D_{t+1} + \gamma (R_t^B B_t - B_{t+1}) \\ - \left(\frac{R_t^D D_t}{\eta_t} - \frac{D_{t+1}}{\eta_{t+1}} \right) - (R_t^{IB} I B_t - I B_{t+1}) - \frac{\kappa}{2} (L_t - L_t^{cb})^2 - \mathcal{C}_t \end{array} \right\} \quad (29)$$

where $I B_t$, R_t^{IB} and R_t^R denote net borrowings from the interbank market, the interest rate on these borrowings, and the interest rate on required reserves, respectively. Moreover, β_b represent banking sector's discount factor.

By substitution of the bank's budget constraint, the problem can be reduced to periodic maximization of profits:

$$\begin{aligned} F_t^B \equiv & (1 - \gamma) (R_t^L - R_t^{IB}) L_t + \gamma (R_t^B - R_t^{IB}) B_t \\ & + \left((R_t^R - R_t^{IB}) + \frac{1}{\eta_t} (R_t^{IB} - R_t^D) \right) D_t - (1 - \gamma) \frac{\kappa}{2} (L_t - L_t^{CB})^2 - \mathcal{C}_t, \end{aligned} \quad (30)$$

which are related to patient households. Optimally, the amount of loans, excess reserves, deposits and net borrowings from the interbank market are chosen, so that the marginal benefits from these assets are equal to the opportunity costs of holding them:

$$R_t^L = R_t^{IB} + \kappa (L_t - L_t^{CB}) + (c_l/Y) L_t, \quad (31)$$

$$R_t^B = R_t^{IB} + (c_b/Y) B_t, \quad (32)$$

$$R_t^D = R_t^{IB} + \eta_t \left((R_t^R - R_t^{IB}) - (c_d/Y) (D_t/\eta_t^2) \right). \quad (33)$$

According to (31) and (32) opportunity costs of loans and bonds are given by the sum of the interbank rate, management costs, and costs of deviating from the central bank loan target. Equation (33) shows that the opportunity costs of deposits are given by the interbank rate adjusted for the interest yields on required reserves and the management costs of deposits. To close the banking side of our model, we follow Gerali et al. (2010) and assume that banks have unlimited access to a lending facility at the central bank. Thus, arbitrage ensures that the interbank rate equals the policy rate ($R_t^{IB} = R_t$).

¹⁹All variables without a time index represent steady state values. We normalise the cost function by steady state output, as this ensures a well-defined steady state. We choose this functional form because it gives zero management costs in equilibrium.

3.6 Monetary policy

To tie macroeconomic performance to policy variables and to reflect the particularities of Chinese central banking mentioned above, we enhance the description of the conventional monetary policy toolkit.

First, conventional monetary policy follows a Taylor-type rule:

$$R_t = R_{t-1}^{\phi_r} \left(R \left(\frac{\Pi_t}{\bar{\Pi}} \right)^{\phi_\pi} \left(\frac{Y_t}{Y} \right)^{\phi_y} \right)^{(1-\phi_r)}, \quad (34)$$

where $\bar{\Pi}$ represents the inflation target of the central bank, and the ϕ 's reflect the preferences of the central bank with respect to inflation and output gap stabilization, and the smoothing of interest rate dynamics, respectively. This rule implies that if inflation and/or output growth rise above (fall below) their baseline levels, then the interest rate is raised (lowered) at a rate that depends on the coefficient ϕ_r . It should also be emphasized that existence, uniqueness and stability of model's solution path under rational expectations require the PboC to take an aggressive stance regarding the current inflation pressure, and paying less attention to changes in the output gap.

Loan and deposit rates are restricted by the guidelines of the central bank: $R_t^L \geq R_t^{L,CB}$, $R_t^D \leq R_t^{D,CB}$. Technically, due to the restrictions of the monetary authority, the actual lending and deposit rates are given by

$$R_t^L = \max \left(R_t^{L,CB}, R_t^{L,PB} \right), R_t^D = \min \left(R_t^{D,CB}, R_t^{D,PB} \right), \quad (35)$$

where $R_t^{L,PB}$ and $R_t^{D,PB}$ denote the market rates, determined by (31) and (33). Hence, deposit and lending rate guidelines form a corridor around the policy rate. We assume that the central bank sets interest rates according to

$$R_t^{D,CB} = (R_{t-1}^D)^{\phi_r^d} \left(R_t \frac{R^D}{R} \right)^{(1-\phi_r^d)}, \quad (36)$$

$$R_t^{L,CB} = (R_{t-1}^L)^{\phi_r^l} \left(R_t \frac{R^L}{R} \right)^{(1-\phi_r^l)}, \quad (37)$$

where ϕ_r^l and ϕ_r^d are preference parameters for smoothing the lending and deposit rate guidelines, respectively.

In addition, the central bank influences the credit supply via window guidance. The use of credit quotas is primarily directed at preventing excessive credit growth. Hence, we assume that the loan targets of the central bank follow a Taylor-type rule:

$$L_t^{CB} = (L_{t-1}^{CB})^{\phi_i^{cb}} \left(L \left[\frac{L_t}{L} \right]^{\phi_l^l} \left[\left(\frac{\Pi_t}{\bar{\Pi}} \right)^{\phi_\pi^l} \left(\frac{Y_t}{Y} \right)^{\phi_y^l} \right]^{(1-\phi_l^l)} \right)^{(1-\phi_i^{cb})}, \quad (38)$$

Essentially, equation (38) says that loans are restricted to slower growth if inflation or the output gap are positive, in order to cool the economy. Moreover, ϕ_i^π and

ϕ_t^y determine the strength of the reaction to inflation and output, respectively, and ϕ_t^{cb} determines the persistence of the reaction. In addition, a positive value for ϕ_t^l ensures that the PboC does not eliminate the loan supply, when the economy is in a boom and needs funds for investment. In a nutshell, the PBoC tries to smooth real activity by smoothing loan growth.

In addition, we assume that the interest rates on required reserves passively follow the policy rate: $R_t^R = R_t$. Equations (34) - (38), describing the essence of Chinese monetary policy, close the circle to give us a complete model. At the same time, equations (34) - (38) clearly deviate from the policy rule which is assumed in almost all variants of existing DSGE models.²⁰

3.7 Shocks

To close the model, we need to describe the shocks. The driving forces of the model are given by the following 4 different shock types:

$$\mu_t = \mu^{(1-\rho_\mu)} \mu_{t-1}^{\rho_\mu} \exp(\varepsilon_t^\mu), \quad (39)$$

$$A_t = A^{(1-\rho_a)} A_{t-1}^{\rho_a} \exp(\varepsilon_t^a), \quad (40)$$

$$\mathcal{V}_t = \mathcal{V}^{(1-\rho_\nu)} \mathcal{V}_{t-1}^{\rho_\nu} \exp(\varepsilon_t^\nu), \quad (41)$$

$$\mathcal{U}_t = \mathcal{U}^{(1-\rho_u)} \mathcal{U}_{t-1}^{\rho_u} \exp(\varepsilon_t^u), \quad (42)$$

where (39) - (42) represent a cost-push, a productivity, a preference, and an investment shock, respectively. Moreover, all innovations are assumed to be: $\varepsilon_t^i \stackrel{i.i.d.}{\sim} \mathcal{N}(0, \sigma_i^2)$.

4 A DSGE-Based Assessment of Financial System Reform Initiatives and Proposals

Our counterfactual DSGE simulation experiments shed considerable light on the current financial system reform and proposals in China. We assess several financial system reform initiatives and proposals. Many of the Chinese financial reform measures are unprecedented, with macroeconomic effects that are difficult to predict in advance. Furthermore, we acknowledge that most Chinese reforms occur gradually, having to clear numerous hurdles. Of course, identifying the pivotal steps in the financial reform is a nontrivial task. Therefore we build our analysis in steps, starting with a baseline pre-reform scenario. In subsequent model calibrations we consider the impact of an interest rate liberalization and/or a growing importance of domestic bond markets on monetary policy.²¹ The calibration of the model is largely

²⁰The interest rate ceilings and floors entail the challenge of solving a nonlinear DSGE model under binding constraints. For a novel numerical method solving the DSGE model with interest rate thresholds, see Chen et al. (2012) and Holden and Paetz (2012).

²¹All calibrations are carried out using the DYNARE package, developed by M. Julliard, available at <http://www.dynare.org>.

from Chen et al. (2012) and is summarised in Table 2. The settings are chosen to match Chinese data. Since the banking sector is a modified version of Chen et al. (2012), we decreased the cost parameters in the banking sector, and consequently the cost parameter regarding window guidance. Moreover, we reduced the Calvo parameter, since the model already generates strong persistence for lower values of θ . In addition, we added an inflation target of 2.45%, which ensures reasonable values for equilibrium interest rates.

After deriving all the equilibrium conditions set out in Appendix A, we approximate the system by a first order approximation around the non-stochastic steady state of the model and analyse the linearised equations of the model. In addition, we use the method proposed in Holden and Paetz (2012) to handle the inequality constraints given by (35).²² As our aim is to investigate the consequences of a partial interest rate liberalisation, the interest rate corridors are modelled as a weighted average of (37) and (36) and the market rates determined by (31) and (33):

$$R_t^{D,CB} = (1 - \mathcal{W}) \left[(R_{t-1}^D)^{\phi_r^d} \left(R_t \frac{R^D}{R} \right)^{(1-\phi_r^d)} \right] + \mathcal{W} [R_t - (c_d/Y) (D_t/\eta_t^2)], \quad (43)$$

$$R_t^{L,CB} = (1 - \mathcal{W}) \left[(R_{t-1}^L)^{\phi_r^l} \left(R_t \frac{R^L}{R} \right)^{(1-\phi_r^l)} \right] + \mathcal{W} [R_t + \kappa (L_t - L_t^{CB}) + (c_l/Y) L_t]. \quad (44)$$

This allows us to study impulse response functions for different degrees of interest rate liberalisation simply by changing the weight parameter \mathcal{W} .

To explore how the model behaves under various shocks, we examine the effects of the shocks on the main variables, using impulse response functions. For this reason, we set the shock volatilities at $\sigma_\mu = 0.05$, $\sigma_a = 0.005$ and $\sigma_u = 0.05$, and $\sigma_\nu = 0.005$, and the persistence parameters ρ_j at the standard value 0.7.²³ In the following we concentrate upon inflation shocks and preference shocks which resemble macroeconomic supply and demand shocks.²⁴

In the current monetary policy framework, China's banks operate within tight limits. The PBoC imposes a ceiling on the deposit interest rate and a floor under the lending rate. On June 7 and July 5, 2012, however, Chinese banks were given

²²A sketch of the algorithm is given in Appendix B

²³Note that for an average response following a cost push shock, e.g., the shock sizes of all other shocks are also relevant. Since some shocks have a stronger impact than others, we chose standard deviations so as to render the impulse responses comparable.

²⁴For deriving average impulse responses, we use the technique described in section 2.5 in Holden and Paetz (2012), based on the algorithm used by Dynare, to derive impulse responses in non-linear models. Hence, we run each stochastic simulation twice, but add a shock of size σ_i in the second run at period 100. The difference between these two simulations then gives us one impulse response function. We repeated this procedure 500 times and use the average to derive the following figures. (Note that for the model without constraints, average and steady state impulse responses coincide.)

Table 2: Benchmark Calibration of the Model

Description	Value
<i>Households:</i>	
Discount factors of different household types	$\beta_p = 0.9985, \beta_e = 0.9925$
Cost parameters in the Banking Sector	$c_l = c_e = c_d = 1\%$
Equilibrium required reserve ratio	$\eta = 0.1$
Intertemporal elasticities of substitution	$\sigma_p = \sigma_e = 1$
Frisch elasticity	$\varphi = 1$
Depreciation rate of capital	$\delta = 0.03$
Adjustment cost parameter	$\psi = 2$
<i>Firms:</i>	
Price Rigidity	$\theta = 0.6$
Output elasticity of capital	$\alpha = 0.5$
Steady state net mark-up	$\mu = 0.1$
<i>Monetary Policy:</i>	
Taylor rule	$\phi_\pi = 1.5, \phi_y = 0.125, \phi_r = 0.5$
Benchmark deposit and lending rates	$\phi_r^l = \phi_r^d = 0.7$
Window Guidance	$\phi_l^{cb} = 0.5, \phi_l^l = 0.3,$ $\phi_l^\pi = 50, \phi_l^y = 5, \kappa = 1$
Annual inflation target	$\bar{\Pi} = 2.45\%$

a bit more leeway. The PBoC cut its benchmark deposit and lending rates to help stimulate the economy. The one-year benchmark deposit rate was lowered by 50 basis points to 3 percent, and the lending rate by 56 basis points to 6 percent. Adjustments were also made to benchmark interest rates on deposits and loans of other maturities. These were the first reductions since 2008. As a result, the highest possible one-year deposit interest rate was lowered from 3.5 percent to 3.3 percent (10 percent above the new 3.0 percent benchmark). At the same time, it said that banks could offer depositors an interest rate 10 percent above the benchmark. The minimum lending interest rate, previously 90 percent of the benchmark rate, was lowered to 70 percent. The minimum one-year lending interest rate therefore declined from 5.9 percent to 4.2 percent.²⁵ As a result, the margin between the minimum lending interest rate and the maximum deposit interest rate at the one-year tenor was narrowed by 150 basis points, from 240 basis points to 90 basis points. Below we examine the effects of this new (partial) financial freedom, banks to having more flexibility in setting interest rates.²⁶

We evaluate the benefit of interest rate liberalization based on whether they make

²⁵See IMF (2012), Box 2 on p. 9.

²⁶Presumably, all other benchmark policy parameters are kept constant. We are well aware that this assumption sweeps a number of potentially important reactions under the rug, and we return to these reactions at the end of this section.

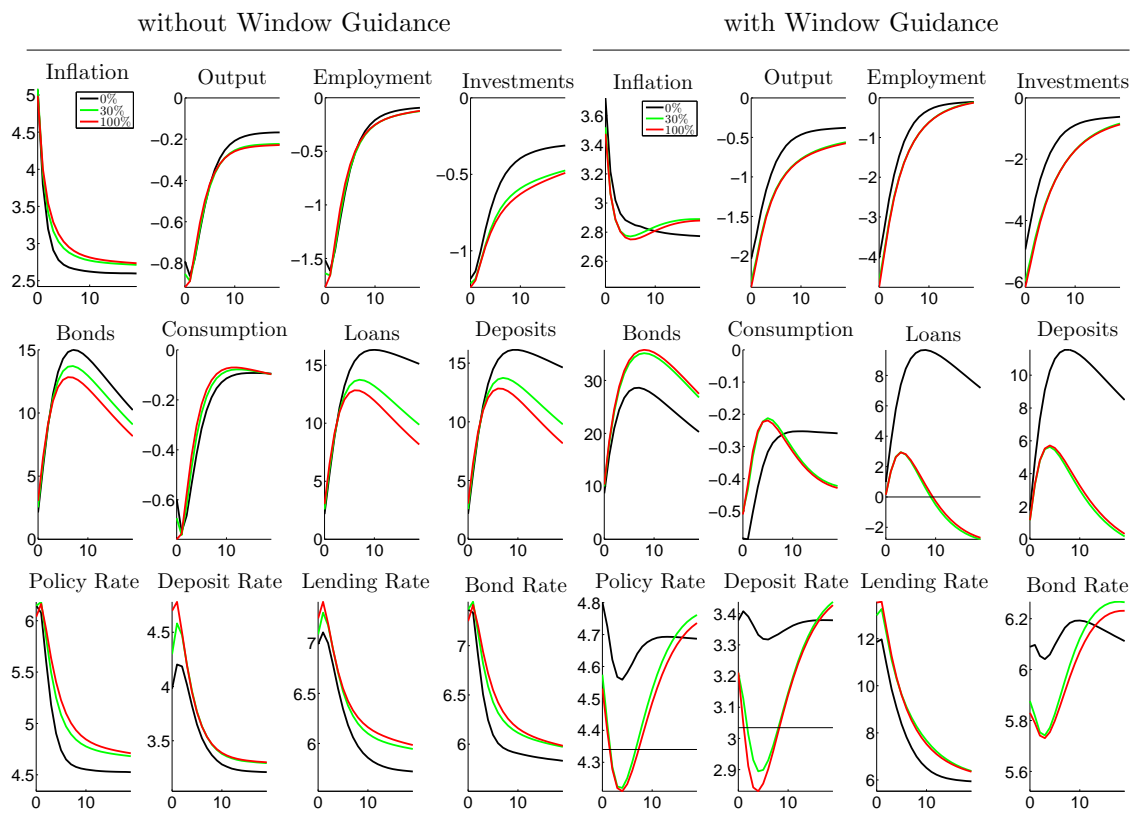
the monetary policy operation more effective and are able to reduce the volatility of output and inflation after some shocks, as well as whether the interest rate channel is smooth, i.e. whether the various interest rates move in unison. Figures 3 and 4 provide the average impulse response functions for an inflation shock and a preference shock, respectively, under the assumption of a partial interest rate liberalisation. We therefore set the share of the bond market at 10%, in line with Figure 1. Moreover, we fix the required reserve ratio at 10% to isolate the effect of an interest rate deregulation from policy measures involving the required reserve ratio. To investigate the effect of credit quotas separately, we show simulations for a model with and without window guidance.

The left panel of Figure 3 shows the impulse responses for a positive cost-push shock without credit quotas. The shock boosts inflation and, as a consequence, the PBoC tightens monetary policy to discourage consumption and investment and decrease the inflationary pressure. As a result, the output gap, employment and investment fall. Due to the fall in income, entrepreneurs increase their credit demand and the supply of corporate bonds to pay interest yields on previous debt contracts. Moreover, the increase in the deposit rate encourages households to increase their savings, which are transmitted via the banking sector as funds to entrepreneurs. When the central bank tightens the policy rate by selling central bank bills and raising interest rates, the deposit rate ceiling prevents the deposit rate from rising sharply. However, given a lower deposit rate, the banking sector's first order condition, equating interest rates to opportunity costs, implies a greater demand for deposits, resulting in more available funds in equilibrium and a lower lending rate. As a consequence, investments recover faster, but consumption falls by slightly more, allowing for an overall faster recovery of the economy. The other side of the coin is that interest rate deregulation leads at the same time to higher volatility in output and inflation, so that welfare could deteriorate. Moreover, monetary policy becomes more aggressive, showing that in the absence of a binding interest rate corridor, the PBoC needs to step-up its open market operations.²⁷

In the right panel of Figure 3 the responses with window guidance are shown. The results in these figures are quite different. First of all, credit quotas already reduce the impact effect of the cost-push shock considerably. As expected in case of a supply side shock, this can only be achieved at the cost of less aggregate activity and employment. However, with window guidance, loans, deposits, and consumption show a much less volatility, while volatility in the bond market increases. The latter effect obviously comes from the fact, that the bond market need not follow the credit quotas. Contrary to the scenario without window guidance the responses in the right panel suggest that a deregulation need not imply higher inflation and consumption volatility. Summing up, the graphs show that window guidance might be very helpful for avoiding negative side effects from a liberalisation of interest rates.

²⁷This might cause a conflict, if e.g. the PBoC's monetary operations are also aimed at a specific exchange rate.

Figure 3: Impulse Response Functions for a Positive Cost-Push Shock Under Different Degrees of Interest Rate Deregulation



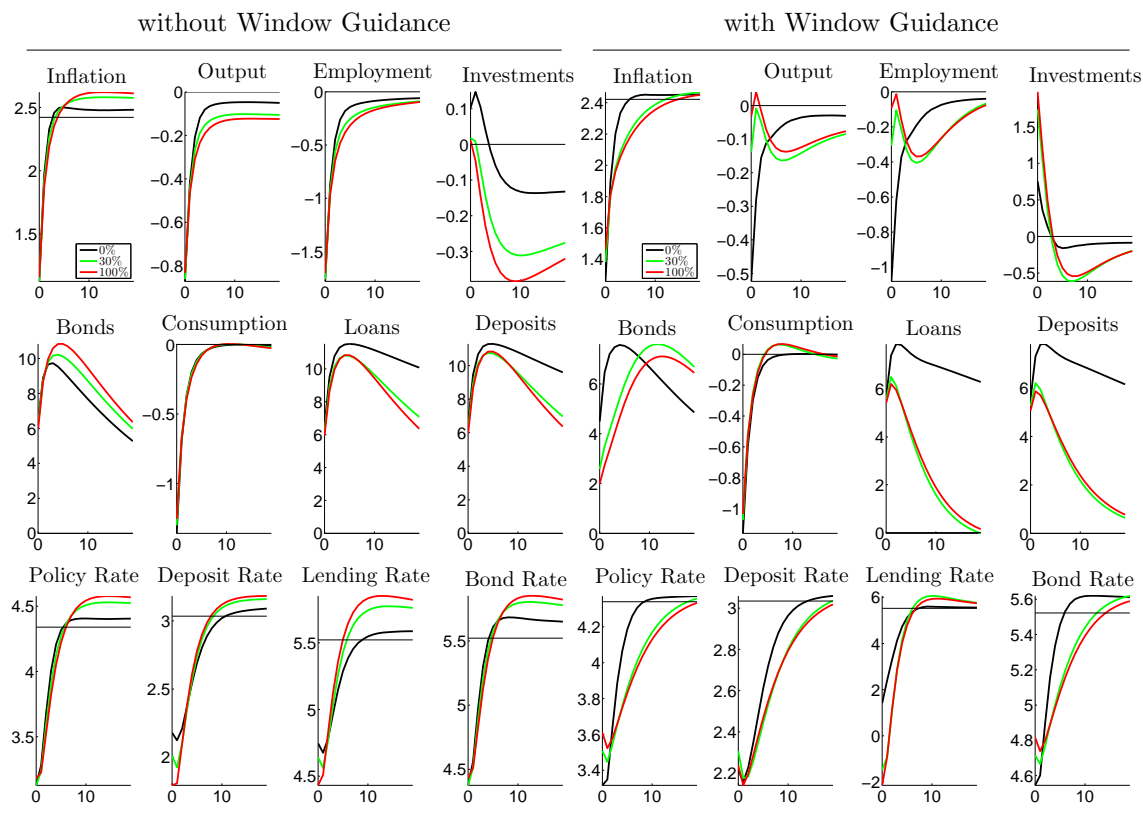
Note: The Impulse Responses are drawn under different assumptions on the parameter \mathcal{W} . For $\mathcal{W} = 100\%$ the interest rate constraints are ignored, while $\mathcal{W} = 0\%$ refers to fully binding constraints. Inflation and interest rates are measured in percent; all other variables are measured in percentage deviations from equilibrium.

Moreover, credit quotas increase the effectiveness of conventional contractionary monetary policy by amplifying the impact on the lending rate.

Figure 4 displays the impulse response functions for a contractionary preference shock. The output gap decreases and inflation falls. Fighting the contractionary shock, the PBoC loosens monetary policy to increase output. This expansionary monetary policy boosts investment, and employment starts to increase again as the economy recovers. In this situation, lending rate floors prevent banks from lowering lending rates, but this need not imply less available funds, as the banks increase their credit supply given the higher yield. Comparable to the responses following a positive supply side shock, deregulation seems to increase the strength of boom-bust cycles. On the other hand, regulated banking rates smooth the monetary policy reaction, and hence dampen the volatility of private banking interest rates. On the whole, interest rate liberalisation will therefore reduce the effectiveness of monetary policy in China.

The right panel Figure of 4 allows us to study the relationship between interest

Figure 4: Impulse Response Functions for a Negative Preference Shock Under Different Degrees of Interest Rate Deregulation



Note: The Impulse Responses are drawn under different assumptions on the parameter \mathcal{W} . For $\mathcal{W} = 100\%$ the interest rate constraints are ignored, while $\mathcal{W} = 0\%$ refers to fully binding constraints. Inflation and interest rates are measured in percent; all other variables are measured in percentage deviations from equilibrium.

rate regulation and window guidance in the case of a negative preference shock. The graphs clearly confirm the results from the previous figure, showing that with window guidance, interest rate liberalisation has a positive effect. Whereas under fully regulated banking rates the responses with credit quotas are very similar to those above, elimination of the interest rate corridor implies very different dynamics. As window guidance increases the available funds to support recovery, output and employment increase on impact and lead to much smoother dynamics of inflation, and all interest rates except the lending rate. A practical lesson from Figures 3 and 4 would therefore be to rely more on quantity-based monetary actions implemented by administrative tools and to abandon the interest rate regulation.

Chinese authorities are determined to promote sustainable development of the bond market in China to optimise the allocation of market resources and to strengthen market discipline and risk-sharing. For this purpose, a bond market was established to allow enterprises to raise funds from securities markets for project financing, reducing their dependence on the banking sector. Given this strategic objective, we next analyse the connectivity of bond market development and monetary policy

within the DSGE setting.

What role can a bond market play in the interest rate liberalization process? Does it generate any mechanism or incentive to induce the abandoning of the interest rate regulation by banks? Does it allow for gradual improvement of the interest rate channel of monetary policy transmission? Does it complement monetary policy in reducing the volatility of output and inflation when there is still an obstacle to increasing interest rate regulation?

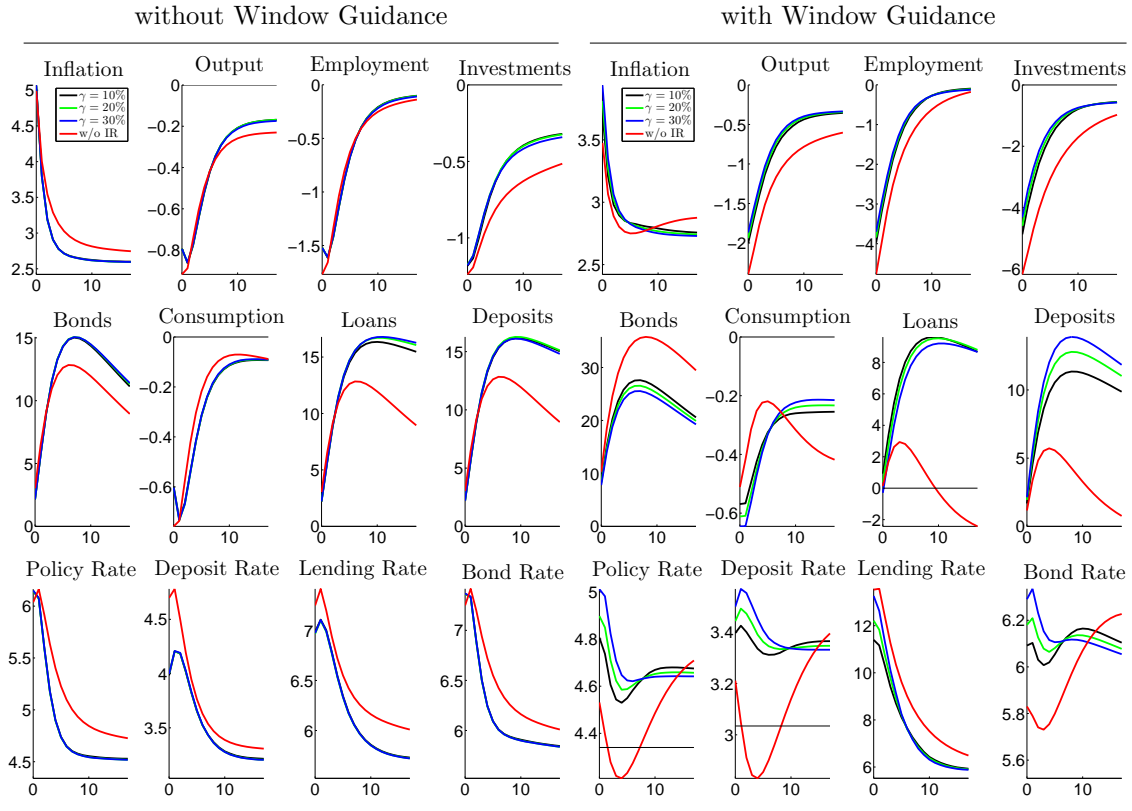
The roadmap for Chinese financial reform includes several components. Therefore the connections between reform steps have to be taken into account. Furthermore, gradually achieving a monetary policy framework that relies less on administrative tools for bank lending requires a careful sequencing. Next we therefore analyse the consequences of financial reform for the effectiveness of window guidance. Window guidance is considered an important independent instrument of monetary policy by the PBoC. The scope of window guidance includes the allocation of bank lending and the extent of loan growth. According to the PBoC, China's experience in recent years indicates that improving transparency via window guidance is not only conducive to reducing the costs of monetary policy operations, but also to helping the central bank realise its monetary policy objectives and enhance the effectiveness of monetary policy. Whether and to what extent will the effectiveness of window guidance be affected by financial market liberalisation? The standard assumption is that progress in financial liberalisation erodes the validity of window guidance over time and makes interest rate policy more important as a monetary policy instrument.²⁸ The reason is that a large Chinese firm can bypass the quantitative regulation by issuing bonds, i.e. by using intermediary channels not subject to window guidance.²⁹ Below we therefore address the question how the bond market intermediary channel influences the effectiveness of window guidance.

Figures 5 and 6 show the impulse responses to an inflation and preference shock, respectively, under the assumption of gradually phasing-in bond markets. To quantify the effects of liberalizing the bond market, we compare the impulse responses across degrees of deregulation. The dynamics are plotted separately in the same figure as the benchmark results for the case of a 10% bond market share. As expected, bond market liberalisation allows enterprises to raise funds from securities markets, reducing their dependence on the banking sector. On the other hand, it decreases the share of the regulated credit market and therefore potentially increases the volatility of the business cycle. Overall, Figure 5 illustrates that raising the bond market share does not have a strong impact, although it tends to slightly increase the inflation response. However, it seems that giving up the interest rate

²⁸So far, the Chinese government applies relatively rigid restrictions to international capital transactions. Another loophole undermining the effectiveness of window guidance would arise if Chinese firms would be allowed to lend offshore.

²⁹Fukumoto et al. (2010) showed how the development of financial market liberalisation in Japan reduced the effectiveness of Japanese window guidance as an independent policy tool in the 1980s. This finally led to the abolition of window guidance in 1991.

Figure 5: Impulse Response Functions for a Positive Cost-Push Shock Under Different Degrees of Bond Market Deregulation



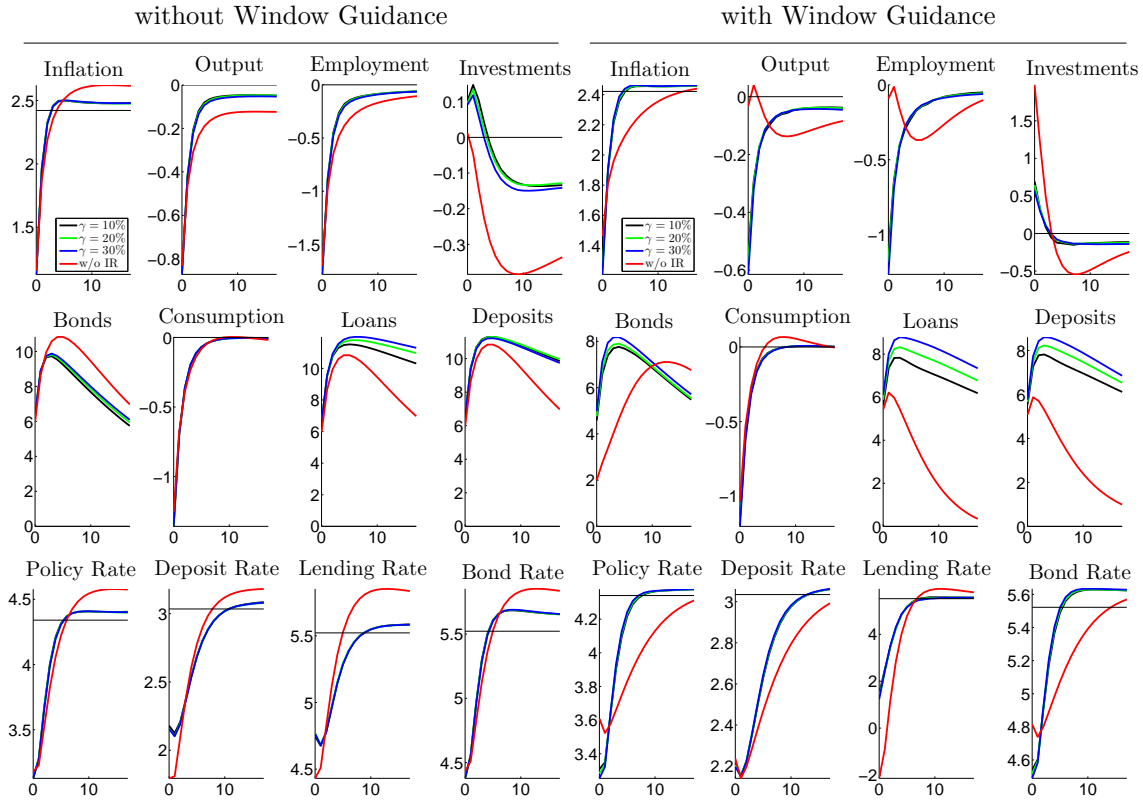
Note: The Impulse Responses are drawn under different assumptions on the parameter γ , which represents the share of the bond market. In the last scenario ('w/o IR') the bond market share is fixed at today's value of 10%, but the interest rate regulation is abolished. Inflation and interest rates are measured in percent; all other variables are measured in percentage deviations from equilibrium.

corridor has a much bigger effect. This also holds for Figure 6. In addition, the Figures show that the effectiveness of credit quotas is not greatly reduced. In other words, window guidance does strengthen the impact of open market operations and may thus be beneficial. If this finding stands up to scrutiny, abolishing window guidance altogether may not be very beneficial. More simulations and cases need to be examined for this to truly be a robust implication.³⁰

Next, let us revise the model calibration to incorporate induced changes in the Taylor rule. For now, let us assume that ϕ_π increases to 2.5, when all regulations are abolished. We compare in Figure 7 the outcomes of such a policy (green line) with a benchmark scenario with Window Guidance, but without interest rate regulation (black line), and a scenario including Window Guidance with the more aggressive

³⁰The benefit of using open market operation in combination with window guidance in an environment with deregulated bond markets is subject to several requirements. First, PBoC must use the appropriate loan level properly. Second, the shock-dependency implies that the PBoC has to identify the nature of shocks in real time.

Figure 6: Impulse Response Functions for a Negative Preference Shock Under Different Degrees of Bond Market Deregulation

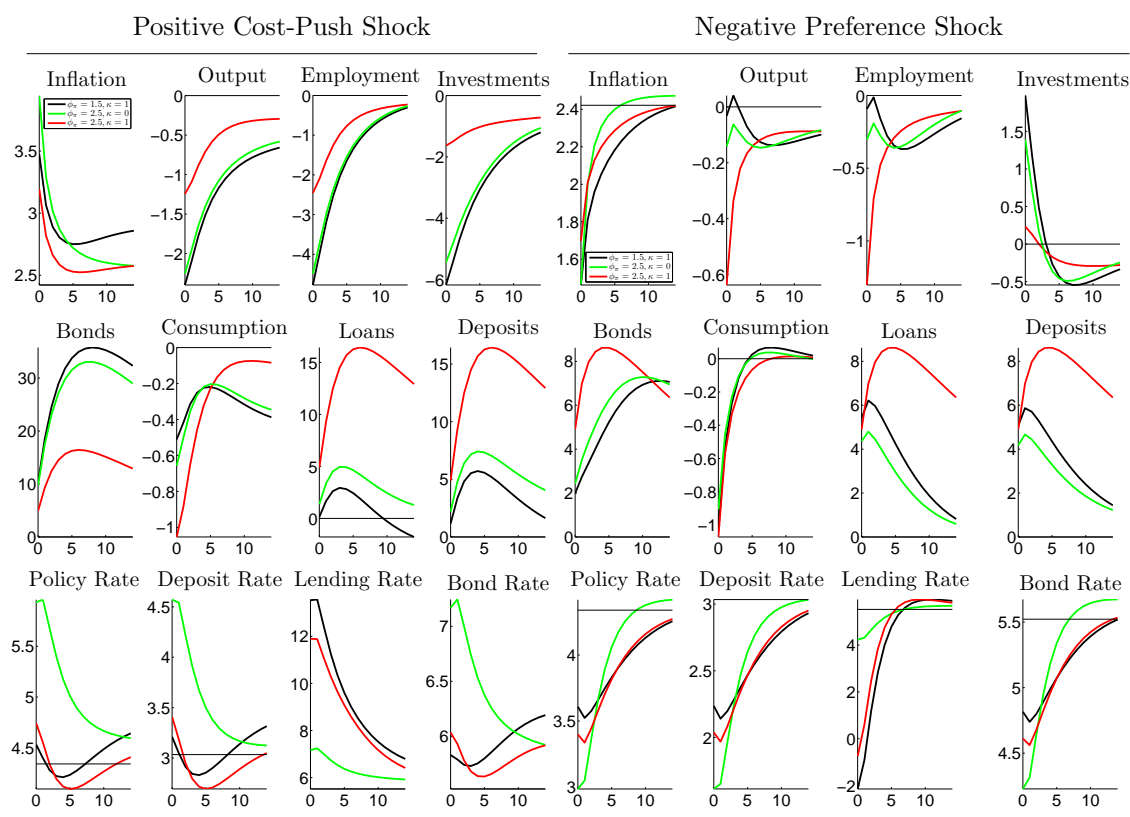


Note: The Impulse Responses are drawn under different assumptions on the parameter γ , which represents the share of the bond market. In the last scenario ('w/o IR') the bond market share is fixed at today's value of 10%, but the interest rate regulation is abolished. Inflation and interest rates are measured in percent; all other variables are measured in percentage deviations from equilibrium.

policy rule (red line). For a positive cost-push shock, the stronger response of the central bank cannot restore the smaller increase in inflation at impact, with window guidance, but does imply smoother dynamics. However, combining the more aggressive rule with credit quotas leads to even smaller deviations from equilibrium for output, inflation, employment, investments, the policy rate, and loan and deposit rates. Hence, in case of a cost-push shock window guidance seems to be preferable. In contrast, the dampening of inflation volatility for a preference disturbance can only be achieved at a high cost in terms of declines in output and employment.

To fully evaluate the performance of different policy scenarios we simulated the full model for 100,000 periods, ignoring the first 1,000. The results are summarized in Table 3 and confirm several results from the analysis of the impulse response functions. First, lowering the degree of regulation of retail lending and deposit rates tends to increase the volatility of almost all variables of interest. However, the stabilising effect of regulated interest rates can only be achieved along with an increase in the volatility loans and deposits. Second, window guidance can reduce inflation

Figure 7: Impulse Response Functions for a more Aggressive Taylor Rule



Note: The Impulse Responses are drawn under different assumptions on window guidance and the response of monetary policy with respect to inflation. The black line represents the benchmark scenario with window guidance and $\phi_\pi = 1.5$; the green line assumes a more aggressive reaction of the central bank ($\phi_\pi = 2.5$), but no window guidance ($\kappa = 0$); the red line assumes a more aggressive response and window guidance. Inflation and interest rates are measured in percent; all other variables are measured in percentage deviations from equilibrium.

volatility, but may increase the volatility of output, employment, and investment. As we saw in the Figures above, the impact of window guidance depends on the nature of the underlying shock.³¹ Third, the share of bond finance seems not to have a big impact at all (on neither the effectiveness of window guidance nor on volatility in general).

In the lowest panel of Table 3, we show the results for a more aggressive Taylor rule. These simulations clearly show that a more aggressive Taylor rule is in generally able to offset less interest rate regulation and the abandoning of window guidance. Under this scenario, a larger reduction in inflation volatility can be achieved at less cost in terms of higher output volatility. On the other hand, the stronger Taylor rule leads to greater volatility in the dynamics of loans and deposits.³²

Since the global crisis of 2008-2010, governments around the world have faced

³¹A similar result is found in Chen et al. (2012).

³²Not all results are unduly sensitive to the parametrisation of equation (38).

Table 3: Standard Deviations of Different Policy Scenarios

		FULL INTEREST RATE REGULATION ($\mathcal{W} = 0$)													
		<i>y</i>	<i>c</i>	π	<i>n</i>	<i>r</i>	r^l	r^d	r^b	<i>l</i>	<i>d</i>	<i>b</i>	<i>i</i>	<i>w</i>	<i>x</i>
		Without Window Guidance													
Low share of bond finance		5.90	5.79	1.71	5.99	1.68	1.67	1.64	1.70	196.52	183.65	86.49	8.92	7.73	10.25
High share of bond finance		5.86	5.75	1.71	6.05	1.68	1.67	1.64	1.70	200.16	161.47	87.96	8.95	7.68	10.27
		With Window Guidance													
Low share of bond finance		7.18	6.19	1.63	6.92	1.51	4.85	1.57	1.65	114.39	112.69	131.92	11.72	8.28	10.11
High share of bond finance		6.95	6.14	1.66	6.66	1.55	5.31	1.59	1.67	124.84	116.94	125.66	11.02	8.23	10.17
		LOWERED INTEREST RATE REGULATION ($\mathcal{W} = 0.3$)													
		<i>y</i>	<i>c</i>	π	<i>n</i>	<i>r</i>	r^l	r^d	r^b	<i>l</i>	<i>d</i>	<i>b</i>	<i>i</i>	<i>w</i>	<i>x</i>
		Without Window Guidance													
Low share of bond finance		6.08	5.86	1.84	6.18	1.88	1.90	1.84	1.93	94.94	93.86	84.60	9.47	7.65	10.11
High share of bond finance		5.94	5.75	1.82	6.21	1.87	1.89	1.82	1.92	97.22	93.82	86.30	9.32	7.54	10.14
		With Window Guidance													
Low share of bond finance		8.54	6.59	1.66	8.35	1.51	7.06	1.60	1.73	43.49	39.17	176.12	15.70	8.84	10.18
High share of bond finance		8.01	6.43	1.72	7.66	1.60	7.96	1.64	1.80	45.61	46.76	151.27	13.97	8.62	10.04
		NO INTEREST RATE REGULATION ($\mathcal{W} = 1$)													
		<i>y</i>	<i>c</i>	π	<i>n</i>	<i>r</i>	r^l	r^d	r^b	<i>l</i>	<i>d</i>	<i>b</i>	<i>i</i>	<i>w</i>	<i>x</i>
		Without Window Guidance													
Low share of bond finance		6.12	5.88	1.90	6.23	1.98	2.04	1.96	2.04	83.96	83.96	83.96	9.64	7.56	10.00
High share of bond finance		5.97	5.76	1.88	6.24	1.97	2.03	1.94	2.03	84.79	84.79	84.79	9.47	7.45	10.02
		With Window Guidance													
Low share of bond finance		8.87	6.77	1.69	8.36	1.52	7.48	1.63	1.77	43.61	38.34	180.13	16.17	9.08	10.05
High share of bond finance		8.32	6.60	1.78	7.79	1.66	8.59	1.71	1.89	47.57	45.67	154.42	14.51	8.82	10.03
		MORE AGGRESSIVE TAYLOR RULE ($\phi_\pi = 2.5$)													
		<i>y</i>	<i>c</i>	π	<i>n</i>	<i>r</i>	r^l	r^d	r^b	<i>l</i>	<i>d</i>	<i>b</i>	<i>i</i>	<i>w</i>	<i>x</i>
		Without Window Guidance													
Low share of bond finance		4.48	4.36	0.89	5.79	1.47	1.53	1.45	1.53	81.90	81.90	81.90	8.39	6.33	9.21
High share of bond finance		4.41	4.31	0.89	5.80	1.47	1.52	1.45	1.52	81.50	81.50	81.50	8.34	6.28	9.21
		With Window Guidance													
Low share of bond finance		6.44	4.72	0.71	7.92	1.04	5.60	1.08	1.13	19.54	29.99	160.62	12.89	7.20	9.87
High share of bond finance		6.07	4.66	0.76	7.37	1.11	6.16	1.13	1.22	17.63	48.29	139.48	11.63	7.13	9.79

Note: Standard Deviations are measured in percent, based on model simulations over 100,000 periods.

the challenge of revamping regulatory structures for governing financial markets. The ultimate aim is to reduce the odds of future boom-bust periods, and improving the ability of banks and other financial institutions to weather the fallout from unexpected adverse changes in asset prices. A rule-based window guidance policy as in equation (38) may represent a step in that direction.³³ It is worth noting that these modelling results are consistent with the lessons from past regulatory reforms in Scandinavian countries. Prior to deregulation in the 1980s, the bank-centred financial systems of Finland, Norway and Sweden similar in several important ways to the current financial regime in China. Interest rates were regulated and kept under control, and credit was rationed. The three Nordic countries abolished interest rate controls during the late 1970s and early 1980s. Initially, credit quotas were still used to limit credit growth, but soon these restrictions were eased. Soon afterwards, lending surged. It did not take long to sink into a deep banking crisis [Chen et al. (2009)]. Drawing on this lesson, monetary policy needs to be vigilant against excess credit demand when interest rate constraints are removed from the banking system.

5 Conclusions

Central banks have increasingly put DSGE modelling at centre stage. Formal DSGE models serve as an essential tool for rational policy-making. The DSGE model entails logical arguments consistent with economic principles, provides a comprehensive picture of the economy's components, and allows for rational discussion of alternative policy scenarios. DSGE models can also serve as a communication tool enabling simultaneous internal analyses and discussion.

Given the growth and accelerating globalisation of the Chinese economy, financial liberalisation in China is of vital importance. Along the way, China will face significant challenges regarding the conduct of monetary policy is conducted. This paper analyses the interplay of financial system reform and the design of monetary policy in a DSGE setting that accommodates the specific features and policy framework of the Chinese economy. The paper reaches several conclusions. First, the present interest rate regulation dampens the business cycle. Second, whether the deregulation of deposit and lending rates is beneficial depends on whether the PBoC still relies on quantitative credit quotas, which seem to be an effective tool to hedge against the downside risks of financial market deregulation. In addition, window guidance does not contradict monetary policy signals, but instead leads to smoother interest rate dynamics, and consequently a less aggressive monetary policy. Finally, the effectiveness of these quotas is not notably affected by an increase in bond finance.

³³Such a rule-based window guidance approach may bring additional benefits. The banks themselves may engage in lending consistent with the goal of countercyclical credit growth. If banks anticipate future window guidance changes, they may take them into account already in their current lending decisions, which may reduce the costs of adjusting credit growth targets when required and the associated volatility.

However, our results also show, that by increasing the monetary policy response a similar reduction in inflation volatility can be achieved at lower costs in terms of output and employment volatility, but with greater volatility of loans and deposits. Whether such a more aggressive policy is possible and not in conflict with external goals of monetary policy - e.g. the exchange rate dynamics - is a question, that lies far beyond the scope of this study.

Our financial system reform analysis has monetary policy implications since, far from being the deus ex-machina that enables the achievement of macroeconomic targets, financial reform will increase the efficiency of monetary policy. Our modelling exercise also shows that a comprehensive approach to financial system reform is preferable.

Appendices

Appendix A: The Non-Stochastic Steady State

In the following we derive the non-stochastic steady state of the model. The interest rates are given by $R^D = \Pi/\beta_p$, $R^L = R^B = \Pi/\beta_e$ via the Euler equations for patient households and entrepreneurs, and the equilibrium interest rate equals the policy rate by assumption. Hence, the equilibrium value of loans, deposits and bonds are determined by the first-order conditions of the private banking sector:

$$L = \frac{R^L - R}{c_l} Y, \quad (\text{A.1})$$

$$B = \frac{R^B - R}{c_b} Y, \quad (\text{A.2})$$

$$D = \eta \frac{R - R^D}{c_d} Y, \quad (\text{A.3})$$

Next we use $D/\eta = (1 - \gamma)L + \gamma B + D$ to obtain the equilibrium policy rate, which is a weighted average of the interest rates on loans, deposits and bonds:³⁴

$$R = \frac{(1 - \eta) c_l c_b R^D + c_d c_b (1 - \gamma) R^L + c_d c_l \gamma R^B}{(1 - \eta) c_l c_b + c_d ((1 - \gamma) c_b + \gamma c_l)}. \quad (\text{A.4})$$

Furthermore, assuming that the credit quota of the PBoC equals the steady state amount of credits ($L^{CB} = L$), bank profits in equilibrium are given by

$$F^B = (R^L - R) L + (R_t^B - R) B + \frac{1}{\eta_t} (R - R^D) D, \quad (\text{A.5})$$

For firms, the price setting procedure of retailers determines the price markup of

³⁴Note that the net position in the interbank market for the whole banking sector must be zero.

final over intermediate goods, relative prices, and price dispersions:

$$X = (1 + \mu) \frac{1 - \theta\beta\Pi^{1/\mu}}{\Pi^* \left(1 - \theta\beta_p\Pi^{\frac{1+\mu}{\mu}}\right)}, \quad (\text{A.6})$$

$$\Pi^* = \left(\frac{1 - \theta\Pi^{1/\mu}}{1 - \theta}\right)^{-\mu}, \quad (\text{A.7})$$

$$\Delta = \theta\Pi^{\left(\frac{1+\mu}{\mu}\right)}\Delta + (1 - \theta)(\Pi^*)^{-\left(\frac{1+\mu}{\mu}\right)}. \quad (\text{A.8})$$

The capital accumulation equations of large and small scale entrepreneurs imply $I^j = \delta K^j$, ($j = L, S$), which yields $I = \delta K$ by aggregation. As investment costs are zero in equilibrium, the shadow values of capital for both types of entrepreneurs is determined by $v^j = (C^j)^{-\sigma_e}$. Moreover, the optimal investment decision yields

$$K^j = \frac{\alpha\beta_e}{1 - \beta_e(1 - \delta)} \frac{Y^j}{X}, \quad (j = L, S), \quad (\text{A.9})$$

which again holds also on an aggregate level. Combining this with the labour demand for both firm types, given by $N^j = (1 - \alpha)Y^j/(WX)$, ($j = L, S$), determines the capital-labour ratio:

$$\frac{K^L}{N^L} = \frac{K^S}{N^S} = \frac{K}{N} = \beta_e \left(\frac{\alpha}{1 - \alpha}\right) \frac{W}{1 - \beta_e(1 - \delta)}. \quad (\text{A.10})$$

Because the production functions imply $Y^j/N^j = (K^j/N^j)^\alpha$, ($j = L, S$), the labour demand schedules and the capital-labour ratio yield the real wage:

$$W = \left[\frac{1 - \alpha}{X} \left(\left(\frac{\alpha}{1 - \alpha}\right) \frac{\beta_e}{1 - \beta_e(1 - \delta)}\right)^\alpha\right]^{\frac{1}{1-\alpha}}. \quad (\text{A.11})$$

Next, we derive the equilibrium output, which allows us to obtain the steady state loans, bonds, and deposits given in (A.1) - (A.3) as well as all the other missing values. Steady state consumption of patient households can be derived by combining the labour supply schedule (4) with (23) and aggregated labour demand (10):

$$C^P = \left[W^{(1+\varphi)} \left(\frac{X}{(1 - \alpha)\Delta Y}\right)^\varphi\right]^{\frac{1}{\sigma_p}}. \quad (\text{A.12})$$

Entrepreneurs' consumption is derived by the household's budget constraints combined with (A.1) - (A.3):

$$C^L = \alpha \frac{Y^L}{X} + \left(1 - \frac{R^B}{\Pi}\right) \frac{R^B - R}{c_b} Y - I^L, \quad (\text{A.13})$$

$$C^S = \alpha \frac{Y^S}{X} + \left(1 - \frac{R^L}{\Pi}\right) \frac{R^L - R}{c_l} Y - I^S. \quad (\text{A.14})$$

Combining goods market clearing with (A.12) - (A.14) and (23) yields the steady state output:

$$Y = \left(\frac{\left[W^{(1+\varphi)} \left(\frac{X}{(1-\alpha)\Delta} \right)^\varphi \right]^{\frac{1}{\sigma_p}}}{1 - \frac{\alpha\Delta}{X} - \gamma \left(1 - \frac{R^B}{\Pi} \right) \frac{R^B - R}{c_b} - (1 - \gamma) \left(1 - \frac{R^L}{\Pi} \right) \frac{R^L - R}{c_l}} \right)^{\frac{\sigma_p}{\sigma_p + \varphi}}. \quad (\text{A.15})$$

Given (A.15) the consumption of patient households is given by (A.12), and $Y^E = \Delta Y$. The labour supply is determined by (4) and the steady state values for aggregated capital and investments can be derived via (A.9). Since both types of entrepreneurs use the same production function and face the same costs in terms of real wages and investment, per-capita production for both sectors must equal Y^E , and the derivation of all remaining sector-specific variables is straightforward.

Appendix B: The Numerical Solution Technique

The numerical algorithm used to solve the model under nonlinear constraints was first established in Holden (2011). A very detailed description of the theoretical foundations can be found in Holden and Paetz (2012). The idea is based on the introduction of one-period size 1 shadow price shocks to the bounded equations in subsequent periods. To sufficiently restrict these shocks one need only solve a simple quadratic optimisation program, which yields the linear combination of shocks needed to push the variable against the bound, whenever the constraint is violated. The whole procedure can be explained in 4 steps:

1. To use the shadow price algorithm we first introduce two auxiliary variables, which are bounded by 1 (zero after log-linearisation):

$$R_t^{L,aux} \equiv \left(R_t^{L,PB} / R_t^{L,CB} \right) \geq 1, \quad (\text{A.16})$$

$$R_t^{D,aux} \equiv \left(R_t^{D,CB} / R_t^{D,PB} \right) \geq 1. \quad (\text{A.17})$$

Given (A.16) and (A.17) the deposit and lending rates are determined by $R_t^L = R_t^{L,aux} R_t^{L,CB}$ and $R_t^D = R_t^{D,CB} / R_t^{D,aux}$. Next, we multiply (A.16) and (A.17) with $\exp \sum_{s=0}^{T^*-1} \epsilon_{s,t-s}^{SP_j}$, where $j = L, D$, T^* represents enough periods to ensure that the constraint no longer binds, and $\epsilon_{s,t-s}^{SP_j} = 1$ if and only if $t = s$.

2. Then we can generate impulse responses for this extended version of the model. Let $M_{j,l}$ denote the the matrix formed from horizontally concatenating column vectors of the relative impulse responses of $R_t^{j,aux}$ to a shock $\epsilon_t^{SP,l}$, where $l, j \in \{L, D\}$, and let $M_{j,l}^*$ be the upper square submatrix of M of size $T^* \times T^*$.
3. To get the linear combination of the shadow price shocks needed to constrain

$R_t^{L,aux}$ and $R_t^{D,aux}$ solve the following simple quadratic optimisation problem:

$$\begin{aligned} \alpha^* &\equiv [\alpha_L^* \quad \alpha_D^*]' \\ &= \arg \min [\alpha_L' \quad \alpha_D'] \left[\begin{bmatrix} v_L \\ v_D \end{bmatrix} + \begin{bmatrix} M_{L,L}^* & M_{L,D}^* \\ M_{D,L}^* & M_{D,D}^* \end{bmatrix} \begin{bmatrix} \alpha_L \\ \alpha_D \end{bmatrix} \right], \end{aligned}$$

subject to $\alpha_j \geq 0$,³⁵ and $v_j + \sum_{l=L,D} M_{j,l} \alpha_l \geq 0$, for $j = L, D$, where v_L and v_D represent the unconstrained impulse responses of R^L and R^D . A solution is admissible if and only if the objective function is 0 at the optimum, if this is not the case T^* must be increased, and the algorithm re-run from the start.

4. The constrained impulse responses for a variable $x_{j,t}$ are now given by $m_j + v_j^i + \sum_{l=L,D} M_{j,l} \alpha_l^*$.

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³⁵This is assuming $M_{j,j}$ has a positive diagonal for all $j \in \{L, D\}$. Where this does not hold, we instead have to impose $\text{sgn}(\alpha_j^i) = \text{sgn}(\text{diag}(M_{j,j}))$.

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