

Loan Loss Provision, Unsecured-Collateralized Loan Choice and Macro-Stability in China

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Abstract

We develop a novel dynamic stochastic general equilibrium model with loan-loss provisions (LLPs) and unsecured-collateralized loan choice, the latter being endogenously determined due to enterprises having heterogeneous production capacity. Further, due to the presence of a second source of production uncertainty, which is only observed ex-post to loan contracting, type-specific aggregate default rates are endogenously determined too, which results in a model economy whose cyclicality can be driven significantly by LLP adjustment shocks. We estimate the model using actual Chinese data from 2004Q4 to 2020Q4. Our estimated model is able to generate co-movement between LLPs and the unsecured-collateralized loan ratio, a feature of the Chinese banking system that is consistent with empirical evidence. We also find that banks' LLPs are countercyclical, despite the overall LLP regime still remaining relatively backwards-looking, indicating that the present Chinese banking regulations can be overly prudent.

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1 Introduction

Since the early 2000s, the banking system of China has undergone significant reforms and development. Notably, strong policy commitments have been made to reform its largest state-owned commercial banks to improve their competitiveness, followed by domestic banking deregulations (Dobson and Kashyap, 2006). The former was especially important, given that the pre-banking reform, the state-owned banks were frequently documented as the least profitable and most inefficient banks in China, underlined by significant shares of problem loans (García-Herrero et al., 2009; Lin and Zhang, 2009). In addition, the China Banking Regulatory Committee was established in 2003 to regulate and monitor banks (Lo and Ng, 2009), which together with continuing efforts in restructuring problem loans, has since contributed to a much-improved banking system, characterized by greater diversity in ownership, corporate governance, and competitive state-owned banks (Berger et al., 2009).

The persistent commitments to banking reform have contributed to a ‘new normal’ for the China banking system, highlighted by low non-performing loan (NPL) ratios and a robust level of capital adequacy. As an example, the four largest state-owned banks (Agriculture Bank of China, China Construction Bank, Industrial & Commercial Bank of China, and Bank of China) have seen their NPL ratios decline from double-digit levels in the early 2000s to healthy levels of 1-3%. Overall, banks in post-reform China have also been documented empirically by studies such as He et al. (2017) to register higher profitability. While there is no doubt that banking system resiliency in China has significantly improved, in the context of macro-financial stability it is likely that different policy challenges would assume greater significance in the ‘new normal’ for China. Specifically, despite seeing their collective shares reduced over the years, the Big 4 banks still collectively accounted for over 30% of the banking sector’s asset size in 2019. As seen in Figure 1, while NPL ratios have declined to healthy levels in recent years, the Big 4 banks have registered larger shares of unsecured lending. Indeed, as loan loss provisions (LLPs) have contributed to the build-up of healthy loan loss reserves (LLR), this perhaps positions the Big 4 banks to have a greater risk-taking appetite in lending. With a policy stance emphasizing macro-financial stability being more appropriate for the ‘new normal’, we argue that a deeper understanding of both the cyclicity and optimality of these aggregate patterns in China’s banking system, as well as their ties to the real economy, is required.

This paper develops a novel dynamic stochastic general equilibrium (DSGE) model with both LLPs and unsecured loan choices, the latter being endogenously determined due to enterprises having heterogeneous production capacity. Faced with these loan choices, the bank sets aside LLPs by assessing collateralized loans collectively while unsecured loans individually. Further, due to the presence of a second source of production uncertainty, which is only drawn and observed ex-post to loan contracting, type-specific aggregate default rates are endogenously determined, which results in a model economy whose cyclicity can be driven significantly by an LLP adjustment shock. In addition to these theoretical novelties (compared to LLP-based DSGE models such

as Agénor and Zilberman, 2015; Agénor and Pereira da Silva, 2017), we estimate the model using the Bayesian approach, utilizing actual Chinese time series data for key variables from 2004Q4 to 2020Q4, including aggregate LLP and non-performing loan default rates of the Big-4 banks (limited to them due to the infrequent window of financial reporting required for LLPs and unsecured loan shares). Our simulation analysis finds a positive cyclical association between LLPs and unsecured-collateralized loan ratio. We also uncover a unique feature of the Chinese banking system in the post-reform ‘new normal’, where bank behaviors tend to be countercyclical with more LLPs being made during business cycle upturns, despite the overall LLP regime still remaining relatively backwards-looking. Nevertheless, the caveat of our findings is that, our calibrated model economy is also by design, driven significantly by the structural shock associated with LLP adjustments, alongside the traditional driver of capital investment shock. Interestingly, we also find an optimal reserve requirement ratio that ought to be lower than the current level (in terms of consumption equivalence).

Indeed, for a more integrated analysis, utilizing annual bank-level data, we first undertake econometric analysis to estimate the contemporaneous relationship among LLPs, unsecured loans, and bank profitability. We find a statistically significant positive correlation between the LLP and unsecured loan ratio, though the effect on bank profitability remains inconclusive. This is robust across various sets of bank-specific characteristic controls. Moreover, the DSGE model-based simulation results are consistent even for smaller banks too. In sum, we therefore uncover a unique feature of the Chinese banking system in the post-reform ‘new normal’, where bank behaviors tend to be countercyclical with more LLPs being made during business cycle upturn. This is in contrast to the majority of experiences observed outside of China, where banking prudential behaviors tend to be reactionary to NPL spikes (e.g., Cavallo and Majnoni, 2002; Laeven and Majnoni, 2003; Bikker and Metzmakers, 2005). These findings suggest that the present Chinese banking regulations may be overly prudent, perhaps reflective of the unwavering policy commitments to avoid another episode of high NPLs observed in the early 2000s.

Despite its stylized nature, we believe our model is unique to China in the following three features: 1) the systemically significant bank is state-owned, and therefore tied to the fiscal budget; 2) the financial system liquidity is money supply quantity driven instead of interest rate driven, as evidenced by the well-documented M2 growth rule being the go-to monetary policy instrument in China (Minetti and Peng, 2018; Chang et al., 2019); 3) the significant heterogeneity exists across firms’ production capacity resulting not only in the demand for uncollateralized loans but also in a tendency for banks to undertake individual LLP assessments for a significant portion of their loans.¹ In addition, our evaluation of the systematic vulnerability to the banking system in China is also consistent with Shi et al. (2022), which highlights worrying risk concentration associated with the many commonalities among Chinese banks. These factors, coupled with our usage of the Bayesian

¹Indeed, Laurenceson and O’Donnell (2014), Li and Lv (2021) are studies that have evidence in support of the widely dispersed and uncertain production capacity across China.

approach to estimate the structural parameters using actual Chinese time series data, allow us to infer that the unique cyclical properties documented are indeed applicable to China.

Our study is related to two branches of the banking literature. First, we contribute to the relatively under-explored literature on the determinants of unsecured loan choice, by proposing a novel endogenous mechanism related to the uncertain capacity level of enterprises. Indeed, our theoretical framework is consistent with the agency-cost hypothesis proposed in the China-focused empirical study of Chen et al. (1998), who argue that less productive enterprises with fewer growth opportunities use more unsecured loans. Likewise, the moral hazard hypothesis proposed by Zhang et al. (2016) also support a similar rationale in explaining the increased risk-taking made by Chinese banks. Based on individual lending data from a large Brazilian bank, Divino et al. (2013) claim that lower interest rates, implied by easing monetary policy, lead to more unsecured loan contracts. Theoretically, our enterprise-driven determination of unsecured-collateralized loan choice differs from the contribution of Kim (2015, 2020), who focuses on explaining mortgage and unsecured loan default choice as being endogenously determined by heterogeneous households. The focus of his studies is therefore on households' optimal default decisions. We allow for endogenous determination of the type-specific aggregate default rates too, by exploiting the timing involved between pre-loan contracting and post-loan contracting to introduce a second source of mean-one production uncertainty, which is only drawn and observed ex-post to loan contracting.

Second, on top of the aforementioned DSGE models with LLPs, we also contribute to the debates on the cyclicity of LLPs. In the empirical literature, studies focusing on the United States find that stringent regulatory guidelines lead to more discretionary changes made to LLPs, therefore enhancing their procyclicality (Balla et al., 2012). Likewise, based on 517 US banks' quarterly financial data from 2006-2010, Morris et al. (2016) show that discretionary LLPs are often practised, which can exacerbate their procyclicality while negatively impacting reported earnings. In terms of European evidence, it is documented in studies such as Bouvatier et al. (2014) and Olszak et al. (2017), that banks with more concentrated ownership tend to use LLPs in smoothing their income and therefore exacerbate their procyclicality. However, improved corporate governance and financial regulations would weaken such procyclicality. Perhaps, this explains the unique features observed in our analysis, where across all structural shocks examined the large Chinese banks tend to build up their LLR during cyclical upturns. Indeed, despite empirical evidence showing Chinese banks engaging in discretionary LLP management to smooth income too (Chen et al., 2021), Wang et al. (2019) find mixed evidence regarding the overall LLP effects on credit fluctuations in the Chinese economy. In the empirical evidence of Shi and Zhu (2024), alterations in loan spreads may directly influence firms' risk-taking appetite. On aggregate, this means separate modelling of the secured and the collateralized loans is essential in understanding their business cycle implications. Zhou et al. (2023) find that, under certain conditions, an expansion in financing cost can increasingly incentivize capable firms to become more productive, but the opposite is true for less competent

firms.

Finally, our study is also related to studies documenting the countercyclical benefits of dynamic provisioning. Following well-documented benefits associated with the Spanish experiment of dynamic provisioning in the late-2000s (Jiménez et al., 2017), subsequent policy experiment results based on commercial banks in the United States (Balla and McKenna, 2009) and Latin America (Agénor and Pereira da Silva, 2016, 2017) have also documented the effectiveness of cyclically adjusted/dynamic provisioning in mitigating procyclicality and financial risks. Empirically, based on large cross-country evidence, Olszak et al. (2018) also find the countercyclicality of dynamic provisioning that is independent of national and bank-specific characteristics. Our model, estimated based on the Big 4 banks' actual NPL and LLP data, allows us to implement similar policy experiments to study whether the benefits of dynamic provisioning would translate to Chinese banks.

The rest of the paper is structured as follows. Section 2 provides some econometric evidence in support of our key research motivation, i.e., there is a positive association between LLP behaviors and the unsecured loan share observed in Chinese banks, a nexus that requires further examination in the context of macro-financial stability. Section 3 presents our model. Section 4 discusses our estimation strategy, which is then followed by a review of the results in Section 5. Subsequently, we also evaluate the cyclicity and macro-financial stability properties associated with dynamic provisioning and other banking policy parameters in the context of China. Section 6 concludes the paper.

2 Empirical Evidence

Based on an unbalanced panel of financial data for 35 Chinese banks collected manually from Refinitiv and annual financial reports, we empirically examine the correlation between unsecured loan choice and the LLP allowance made by the Chinese banks. We focus on the post-reform period of 2004-2020. Specifically, we implement six different variations of the following fixed-effect regression model:

$$L_{jt}^U = \alpha_0 + \alpha_1 LP_{jt} + \sum_{s=1}^S \psi_j X_{jt}^s + \sum_{j=1}^{J-1} \mu_j + \sum_{t=1}^{T-1} \mu_t + \varepsilon_{jt}, \quad (1)$$

where L_{jt}^U (LP_{jt}) is the unsecured loan share (LLP allowance to NPL) of bank j in year t , X_{jt}^s are the S number of bank-specific control variables, μ_j (μ_t) are bank- and year-specific fixed effects, and ε_{jt} is the random error term. The results are summarized in Table 1, with the summary statistics of relevant variables and the list of sample banks provided in Appendix C. Note that we use the logarithm of the LLP allowance-to-NPL ratio to satisfy the normality assumption, due to its overall distribution being much wider than usual ratios.

From Table 1, we clearly see that there is a statistically significant positive relationship between LLPs and unsecured loan share of the sample of Chinese banks. Specifically, if we increase the LLP allowance-to-NPL ratio

by 1 percent, we expect the unsecured loan share to increase by approximately $0.020 - 0.025$ percentage shares of unsecured loans. This positive association is robust across different sets of bank-specific characteristic controls. Essentially, the results imply that, as Chinese banks have undergone a decade-long reform and improved banking supervision, the higher level of LLPs made (relative to the decreased NPL) appears to have increased the risk appetite of banks in their lending behaviors. Indeed, while not presented to save space, it is also worth noting that a second-step regression involving the use of the predicted value from the estimation of (1)—which is a theoretical unsecured loan choice series attributing greater cushioning from higher LLPs—is insignificant in explaining profitability variables such as the ROA and ROE of the banks. This suggests that there is no clear-cut evidence that such a higher risk appetite translates into greater profitability in Chinese banks, thus presenting a potential challenge to the macro-financial stability of the Chinese banking system that calls for a model-based analysis.

3 Theoretical Model

Given the systematic implications of the trifecta of LLPs, unsecured loan choices, and bank profitability, and the uncertainty associated with the effects of this nexus in determining the macro-financial stability of China, a novel DSGE model is developed to provide a much-needed theoretical basis for our integrated financial analyses. Specifically, the model economy consists of a continuum of households, a capital good producer, intermediate goods (IG) enterprises, a state-owned retailer, a state-owned commercial bank, the government, and the central bank. All IG enterprises are mapped along a Melitz (2003) style uncertain capacity distribution, and this allows for endogenous determination of the share of enterprises opting for unsecured (with higher loan rate) versus collateralized loans (lower loan rate, but at the cost of a fraction of the owners' endowed housing services serving as collateral). All IG enterprises borrow to pay for their total production costs, which is consistent with Chinese firms' external financing strategy (Guariglia and Liu, 2014). Unlike growth models like Song et al. (2011), our novel endogeneity distinguishes between enterprises' capacity and productivity, and it is the heterogeneity across the former that drives the (re-)allocation of total loans in the economy, whereas the latter serves its standard Hicks-neutral technical progress role. As such, although we do not introduce a separate heterogeneous group of state-owned IG enterprises (to avoid unnecessary complications), our model is still unique to China due to three stylized features: (i) state-owned retailer and commercial bank; (ii) liquidity in the financial system is influenced by monetary quantity (M2 growth rule); (iii) wide heterogeneity across production capacity of firms influencing unsecured loan choice, resulting in a significant share of loans undergoing individual LLP assessments. Feature (i) is consistent with the abundance of empirical studies documenting how China's state-owned bank-dominated financial system can be significantly influenced by credit originated from the government's fiscal budget (e.g., Liu et al., 2018; Zheng et al., 2018); feature (ii) is commonly applied in China focused DSGE models (e.g.,

Chang et al., 2019); and feature (iii) is alluded to studies such as Laurenceson and O'Donnell (2014), which present provincial and industrial evidence of the widely dispersed and uncertain production capacity of Chinese firms.

For analytical convenience, we assume that total loans consist of only collateralized and unsecured loans (in practice, there are separate categorizations of pledged, guaranteed and secured loans too). The bank sets the unsecured loan rate at a premium of the collateralized loan rate, and makes provision for loan losses. In line with the accounting data, unsecured lending is subject to individual assessment, whereas collateralized lending is subject to collective assessment. Given this asymmetry, we modify the LLP specification in standard DSGE models with LLPs (e.g., Agénor and Zilberman, 2015; Tayler and Zilberman, 2016, 2021; Agénor and Pereira da Silva, 2017) by modelling the realization of default as a weighted combination of collateralized loans' default rate (subject to aggregate stochastic shock common to all such loans) and unsecured loans' default rate (each being specific to an enterprise and negatively dependent on its heterogeneous capacity). Finally, apart from the State-ownership of the retailer and bank, the government assumes standard features where it issues bonds to finance its expenditures.

The overview of the model is illustrated in Figure 2. Following the practice of recent financial-stability studies such as Agénor and Flamini (2022), we present analytically only the key novel model features that are critical to the understanding of the trifecta of variables and their transmission mechanisms. Other sectors that are relatively standard in DSGE models are presented in Appendix A.

3.1 IG enterprises' unsecured loan and default choice

There are $j \in (0, 1)$ IG enterprises operating in a monopolistically competitive product market but facing competitive factor markets. Each IG firm j employs N_{jt}^E labor units supplied by the household and rents K_{jt}^E units of capital from the capital good producer to produce a distinct, perishable good, Y_{jt}^E , using technology,

$$Y_{jt}^E = A_{jt}^E (K_{jt}^E)^\alpha (X_t N_{jt}^E)^{1-\alpha}, \text{ where } \alpha \in (0, 1), \quad (2)$$

X_t is labor-augmenting productivity (common to all enterprises) growing at a constant rate γ_Y , and A_{jt}^E consists of

$$A_{jt}^E = (\varepsilon_{jt})^{\zeta_1} (\kappa_{jt})^\zeta A_t, \quad \zeta \in (0, 1), \quad (3)$$

where $\zeta_1 \in (0, 1)$, $\zeta \geq 0$, A_t is the economywide Hicks-neutral productivity level governed by an AR(1) process, $A_t = (A_0)^{1-\rho_A} (A_{t-1})^{\rho_A} \exp(v_t^A)$, $A_0 = 1$, $\rho_A \in (0, 1)$ and v_t^A are persistence and errors respectively. Further, unique to our model, productivity is subject to two sources of uncertainties with different point of realization: (i) κ_{jt} is a firm-specific capacity level initially observable only to the individual firm but become observable to all

after loan contracting, following a uniform distribution with support $(0, \kappa_{UP})$, $\kappa_{UP} > 1$, a density function $f(\kappa)$, and cumulative distribution function $F(\kappa)$; (ii) ε_{jt} is a pure idiosyncratic mean-one shock with constant variance distributed uniformly with support $(0, 2)$. As in Faia and Monacelli (2007), Tayler and Zilberman (2016), we assume this additional source of uncertainty to be akin to each firm taking a random draw from a distribution $f(\varepsilon)$ at the end of the period t , right before loan repayment choice is made. This may be viewed as a ‘catch-all’ term that reflects the inherent credit risk of each IG enterprise. Indeed, the former is the firm heterogeneity induced uncertainty that influences each firm’s unsecured versus collateralized loan choice, whereas the latter is the production uncertainty that influences the repayment outcome at the end of the period, resulting in the aggregate default rates solely determined endogenously in equilibrium.

In line with asymmetric-information-induced loan contracting models (e.g., Agénor and Pereira da Silva, 2021), ex-ante prior to the contracting of loans, only firms observe their own production capacity. Once a loan has been contracted, the bank then observes ex-post the true production capacity of the borrower of a specific loan contract. In this regard, firms are heterogeneous to an uncertain production capacity, κ_{jt} , observable only to themselves and follow a uniform distribution with support $(0, \kappa_{UP})$, $\kappa_{UP} > 1$, a density function $f(\kappa)$, and cumulative distribution function $F(\kappa)$. In each period t , it is assumed that a firm j can only apply to, and be granted with one type of loan, therefore the strategy for opting for a mixture of lending is ruled out in this model. Nevertheless, the difference in this heterogeneous uncertain capacity level contributes to some enterprises choosing unsecured loans and others collateralized loans to pay for their total production costs, $TC_{jt} = P_t w_t N_{jt}^E + P_t r_t^{EK} K_{jt}^E$, where P_t is aggregate price level, w_t (r_t^{EK}) is the real wage (capital rental) rate. Note that at this decision point, firms do not know the actual realization of ε_{jt} (to be drawn at the end of the period), and the decision is therefore based on its expected value, plus the ex-ante expectation of the aggregate loan-type specific default rates.

Specifically, in each period t , for an enterprise with capacity level κ_{jt} , it is optimal to pay a higher interest rate, $i_t^{L,U}$, to take out unsecured loan [repayable at $(1 + i_t^{L,U})L_{jt}^{E,U}$] overcharging its owner’s housing unit as collateral for the lower rate, $i_t^{L,C}$, if and only if the expected (real) earnings from such an arrangement exceeds the expected earnings of financing using cheaper collateralized loan [repayable at $(1 + i_t^{L,C})L_{jt}^{E,C}$], as in:

$$\mathbb{E}_t \frac{\Pi_{t+1}^{E,C}}{P_t} \geq \mathbb{E}_t \frac{\Pi_{t+1}^{E,U}}{P_t}.$$

As derived in Appendix B, given that the ex-ante expectation of the idiosyncratic shock to be drawn right before loan repayment, ε_{jt} , is merely its unconditional mean of one, there exists a threshold capacity level, κ_t^C , below which an enterprise prefers unsecured loans (in the event of a default, it does not have to pay anything)

over collateralized loans:

$$\kappa_t^C = \left\{ \frac{\left[(1 - \eta_t^C)(1 + i_t^{L,C})l_t^{E,C} - (1 - \eta_t^U)(1 + i_t^{L,U})l_t^{E,U} \right] + \eta_t^C \varphi^{-1} \frac{P_{t+1}^H}{P_t} \bar{H}}{A_t \left[\frac{P_t^{E,C}}{P_t} (K_t^{E,C})^\alpha (X_t N_t^{E,C})^{1-\alpha} - \frac{P_t^{E,U}}{P_t} (K_t^{E,U})^\alpha (X_t N_t^{E,U})^{1-\alpha} \right]} \right\}^{\frac{1}{\zeta}}. \quad (4)$$

where $l_{jt}^{E,U} = L_{jt}^{E,U}/P_t$, $l_{jt}^{E,C} = L_{jt}^{E,C}/P_t$ are real values of loans, $\varphi \in (0, 1)$ the loan-to-value (LTV) ratio, $(P_{t+1}^H/P_t)H_{jt}$ the real value of the owner's housing assets. In (4), we see that the threshold capacity—therefore the endogenous determination of unsecured-collateralized loan choice—depends not only on the relative cost of credit and the relative production values between the two types, but also the cost in using housing collaterals, the Hicks-neutral productivity shock (A_t), and the loan type-specific aggregate default rates (η_t^C, η_t^U).

Regardless of financing choice, cost minimization yields the type-specific optimized unit marginal costs:

$$mc_t^{E,C} = \frac{(1 + i_t^{L,C})(w_t)^{1-\alpha}(r_t^{EK})^\alpha}{\alpha^\alpha(1-\alpha)^{1-\alpha}(\frac{\kappa_{UP} + \kappa_t^C}{2})^\zeta A_t X_t^{1-\alpha}}; \quad mc_t^{E,U} = \frac{(1 + i_t^{L,U})(w_t)^{1-\alpha}(r_t^{EK})^\alpha}{\alpha^\alpha(1-\alpha)^{1-\alpha}(\frac{\kappa_t^C}{2})^\zeta A_t X_t^{1-\alpha}}, \quad \forall j. \quad (5)$$

Facing (5), the IG enterprise j sets its prices in a Calvo-Yun type staggered pricing framework, with period-specific price adjustment following an aggregate price indexing rule of Smets and Wouters (2003) at a probability $\varpi \in (0, 1)$.² With log-linearization, the hybrid New Keynesian Phillips curves (NKPC) for $\Gamma = C, U$ are given by

$$\hat{\pi}_t^{E,\Gamma} = \frac{\beta}{1 + \beta\Xi} \mathbb{E}_t \hat{\pi}_{t+1}^{E,\Gamma} + \frac{\Xi}{1 + \beta\Xi} \hat{\pi}_{t-1}^{E,\Gamma} + \frac{(1 - \varpi)(1 - \varpi\beta)}{\varpi(1 + \beta\Xi)} \widehat{mc}_t^{E,\Gamma} + \hat{\varepsilon}_t^{\pi,E,\Gamma}, \quad \Gamma = C, U \quad (6)$$

where $\Xi \in (0, 1)$ is price adjustment parameter, $\beta \in (0, 1)$ is the subjective discount factor, $\hat{\varepsilon}_t^{\pi,E,\Gamma}$ serve as an unanticipated stochastic ‘cost-push’ shock with AR(1) persistence, $\rho_\pi \in (0, 1)$, and standard errors, v_t^π .

From (6), we see that, apart from the one-period lead-lag terms of inflation, the only difference between the price inflation of both groups arises from the log-deviation in real marginal cost, $\widehat{mc}_t^{E,\Gamma}$. Given that κ_t^C essentially determines the distribution of the two types of IG firms, the aggregate inflation rate is therefore

$$\hat{\pi}_t = \frac{\kappa_t^C}{\kappa_{UP}} \hat{\pi}_t^{E,U} + \frac{(\kappa_{UP} - \kappa_t^C)}{\kappa_{UP}} \hat{\pi}_t^{E,C}. \quad (7)$$

At the end of the period, each IG enterprise j observes his/her realization of ε_{jt} , and decides on whether to default on the loan. For a collateralized loan borrower j , in a non-default state he/she pays back $(1 + i_t^{L,C})l_t^{E,C}$, whereas in a default state he/she loses $\varphi^{-1}(P_{t+1}^H/P_t)\bar{H}$ of collateral value. Given this, a typical collateralized

²As per typical criticism of the Calvo-Yun framework, one might argue that a Rotemberg (1982) price-setting framework might be more suitable here, due to the fact that the probability of moving to a different price-setting regime, ϖ , might be time-varying due to the endogenous determination of loan choice. However, the different price-setting regime here is one of indexing its selling price to the aggregate price index, which it is too small to influence. Hence, the potential feedback of its loan choice to this probability can be ruled out. Moreover, the log-linearized solution in a Rotemberg (1982) specification would yield an NKPC that is similar to (6), but without the forward-looking inflationary term, $\mathbb{E}_t \hat{\pi}_{t+1}^{E,\Gamma}$. We opt for a richer dynamics here.

loan borrower j would always pay back if and only if:

$$\frac{P_{jt}^{E,C}}{P_t} (\varepsilon_{jt})^{\varsigma_1} (\kappa_{jt})^{\varsigma} A_t (K_{jt}^{E,C})^\alpha (X_t N_{jt}^{E,C})^{1-\alpha} + \varphi^{-1} (P_{t+1}^H / P_t) \bar{H} - (1 + i_t^{L,C}) l_t^{E,C} \geq 0. \quad (8)$$

For an unsecured loan borrower j , in a non-default state he/she pays back $(1 + i_t^{L,U}) l_t^{E,U}$, and in a default state he/she pays back nothing. To rule out the case where it will always be in an unsecured loan borrower's interest to intentionally default, we follow the tradition of Gale and Hellwig (1985) and assume that the commercial bank always spends to undertake costly state verification, such that when a default is claimed, its genuine-ness will always be verified to allow all non-zero production value of falsely claimed defaulter to be appropriated. Given this, no intentional default will be made, and a typical unsecured loan borrower j would always pay back if and only if:

$$\frac{P_{jt}^{E,U}}{P_t} (\varepsilon_{jt})^{\varsigma_1} (\kappa_{jt})^{\varsigma} A_t (K_{jt}^{E,U})^\alpha (X_t N_{jt}^{E,U})^{1-\alpha} - (1 + i_t^{L,U}) l_t^{E,U} \geq 0. \quad (9)$$

3.2 State-owned Commercial Bank

Balance Sheet: The representative state-owned bank is funded by one-period deposits, $D_t = \int_0^1 D_{ht} dh$, from the continuum $h \in (0, 1)$ households and capital, V_t^G , (in one-period debt form) from the government. Given that ex-ante the bank does not observe individual uncertain capacity levels, and only observes this ex-post after the loan contract has been granted, the bank gives out loans to enterprises so long as there is demand. As such, it cannot selectively grant loans only to the firms with the highest capacity level. In each period t , total lending is given by $L_t = L_t^{E,U} + L_t^{E,C}$, where given (4), the total unsecured loans, $L_t^{E,U}$, and total collateralized loans, $L_t^{E,C}$, would equal:

$$L_t^{E,U} = L_t^E \int_0^{\kappa_t^C} f(\kappa) d\kappa = \frac{\kappa_t^C}{\kappa_{UP}} L_t^E; \quad L_t^{E,C} = L_t^E \int_{\kappa_t^C}^{\kappa_{UP}} f(\kappa) d\kappa = \frac{(\kappa_{UP} - \kappa_t^C)}{\kappa_{UP}} L_t^E. \quad (10)$$

The bank's balance sheet (in real terms) is given by:

$$(l_t^{E,U} + l_t^{E,C}) + RR_t + b_t^B = d_t + v_t^G, \quad (11)$$

where $l_t^G = L_t^G / P_t$, $l_t^{E,U} = L_t^{E,U} / P_t$, $l_t^{E,C} = L_t^{E,C} / P_t$, $v_t^G = V_t^G / P_t$, b_t^B is the safe assets held (assumed to be government bonds), and RR_t is the required reserves held at the central bank, given by $RR_t = \mu d_t$, where $\mu \in (0, 1)$ is the required reserves ratio (RR).

In line with the standard assumption made in studies on LLPs (Bouvatier and Lepetit, 2012), we assume the bank invests its LLR in the government bonds, earning interest, $1 + i_t^B$, hence $LR_t = b_t^B$. Using (11), v_t^G

can be derived residually as

$$v_t^G = (l_t^{E,U} + l_t^{E,C}) - (1 - \mu)d_t. \quad (12)$$

Loan Loss Provision: The bank builds up its LLR by provisioning for loan losses, LP_t , in a partial adjustment form following Agénor and Zilberman (2015), Agénor and Pereira da Silva (2017),

$$LR_t = A_t^R (LR_{t-1})^{\phi_R} (LP_t)^{1-\phi_R}, \quad \phi_R \in (0, 1), \quad (13)$$

where A_t^R is a mean-one shock to the provisioning adjustment process following an AR(1) process, $A_t^R = (A_0^R)^{1-\rho_R} (A_{t-1}^R)^{\rho_R} \exp(v_t^R)$, where $A_0^R = 1$, $\rho_R \in (0, 1)$ and v_t^R are the persistence and standard errors respectively, and the LLP set in each period t , LP_t , constitutes a weighted average of the provisions for two types of loans, as in:

$$LP_t = (LP_t^{E,C})^{\Upsilon_C} (LP_t^{E,U})^{\Upsilon_U}, \quad (14)$$

where $\Upsilon_C, \Upsilon_U \in (0, 1)$ are the loan shares (in the total provisions), $\Upsilon_C + \Upsilon_U = 1$.

The (13)-(14) specifications are consistent with the actual dynamics of LLR in practice, where in each period the change in LLR is not only influenced by the net change in credit impairment allowances (charged minus reversal) but also due to ‘noises’ such as accounting practices of accreted interest on impaired loans, and recoveries of loans and advances previously written off. In essence, the structural shock, A_t^R , represents a measure of a discretionary LLP adjustment in our model.

To be consistent with the practice of how credit impairment losses are charged by the Chinese banks, where expected loan losses are both individually and collectively assessed, we model LLPs as follows. First, for the collateralized loans, LLPs are based on collective assessments, where the generalized form that accounts for both backwards- and forwards-looking provisions in Agénor and Zilberman (2015) are specified,

$$LP_t^{E,C} = \Omega_0^C \eta_t^C l_t^{E,C} + F(\tilde{\eta}^C - \eta_t^C) \Omega_0^C l_t^{E,C}, \quad (15)$$

where Ω_0^C is the steady-state fraction of NPLs covered by LLPs for collateralized loans, $\tilde{\eta}^C$ the steady-state NPL ratio for collateralized loans, $F \in (0, 1)$ denotes the degree of dynamic LLP smoothing. When $F = 0$, we are strictly in a backwards-looking provision regime. When $0 < F \leq 1$ and is getting larger, then the impact of the overall business cycles will be accounted for more in setting impairment losses.

For unsecured loans, we introduce a novel approach that is consistent with the spirit of individual assessment. Specifically, assuming the credit profile of individual firm j (proxied by its capacity level) taking out unsecured loans is observed and assessed, and that the bank provides more provision as an individual firm j exhibits a lower capacity level (relative to the overall distribution) at a magnitude, $\iota \in (0, 1)$. Collectively, $LP_t^{E,U} =$

$$\Omega_0^U \eta_t^U l_t^E \int_0^{\kappa_t^C} [\frac{\kappa_j}{\kappa_{UP}}]^\iota d\kappa = \Omega_0^U \eta_t^U l_t^E (\frac{\kappa_t^C}{\kappa_{UP}})^\iota, \text{ or, in terms of } l_t^{E,U} \text{ [using (10)],}$$

$$LP_t^{E,U} = \Omega_0^U \eta_t^U l_t^{E,U} (\frac{\kappa_t^C}{\kappa_{UP}})^{\iota-1}, \quad (16)$$

where Ω_0^U is the steady-state LLP coverage on unsecured NPLs. Given the individual assessment-based nature, LLPs for unsecured loans focus strictly on short-term credit risk.

Although it is customary to specify default rate either directly or as an exogenous AR(1) shock when actual non-performing loan data is available in LLP and prudential regulation based macroeconomic models (e.g., Agénor and Zilberman, 2015; Tayler and Zilberman, 2016; Barrdear and Kumhof, 2022; Lim et al., 2024), note that the aggregate default rates in our model are solely determined endogenously as equilibrium outcomes, determined by the borrowers' random draw of ε_{jt} right before loan repayments, as is specified in (2)-(3) earlier.

Bank's Profit Maximization Problem: Before we solve the bank's profit maximization problem, we first derive the incentive-compatibility constraint for both lending types to exist. Suppose it is assumed that the bank is required by laws to issue both types of loan, for both loan types to be deemed equal (assuming that it is required by laws to issue both types of loans), the bank must aim to equalize the *expected* net income from both loan types, as in:

$$(1 - \eta_t^C)(1 + i_t^{L,C})l_t^{E,C} + \eta_t^C \varphi^{-1}(\frac{P_t^H}{P_t})\bar{H} = (1 - \chi)(1 + i_t^{L,U})l_t^{E,U} - \eta_t^U(1 + i_t^{L,U})l_t^{E,U},$$

where $\chi \in (0, 1)$ is the fraction of unsecured loan income spent in costly state verification (to rule out intentional/false default), which then allows for an indirect expression of the unsecured loan rate to be expressed as:

$$(1 + i_t^{L,U}) = \frac{(1 - \eta_t^C)(1 + i_t^{L,C})l_t^{E,C}}{(1 - \chi - \eta_t^U)l_t^{E,U}} + \frac{\eta_t^C}{(1 - \chi - \eta_t^U)l_t^{E,U}} \varphi^{-1}(\frac{P_t^H}{P_t})\bar{H}, \quad (17)$$

which suggests it to be at a premium to the collateralized loan rate, even if both the type-specific loan rates and quantities were to be equal. Note that the aggregate type-specific default rates are endogenously determined as equilibrium outcomes (due to the realization of ε_{jt} having determined the share of each loan types that have been defaulted).

Given the incentive compatibility constraint (17), in each period t , the bank sets the deposit rate, $1 + i_t^R$, the collateralized loan rate, $1 + i_t^{L,C}$, the unsecured loan rate, $1 + i_t^{L,U}$, taking ex-ante expectations of the aggregate default rates, collaterals, and other policy parameters as given, so as to maximize the expected value of end-of-period real profits:

$$\max \mathbb{E}_t(\frac{\Pi_{t+1}^B}{P_t}) = (1 - \eta_t^C)(1 + i_t^{L,C})l_t^{E,C} + (1 - \chi - \eta_t^U)(1 + i_t^{L,U})l_t^{E,U} + \eta_t^C \varphi^{-1}(\frac{P_t^H}{P_t})\bar{H}$$

$$+(1+i_t^R)\mu d_t + (1+i_t^B)b_t^B - (1+i_t^R)(d_t + v_t^G) - c^V v_t^G - LP_t^{E,C} - LP_t^{E,U},$$

where the government's capital is assumed to yield the same gross interest returns as the deposits but incurs a unit cost $c^V > 0$ each time equity capital has to be raised. Formally, this is essentially a **static maximization problem**, where the bank maximizes its expected real profits at the end of period t , $\mathbb{E}_t(\Pi_{t+1}^B/P_t)$, by choosing deposit rate $(1+i_t^R)$ and collateralized loan rate $(1+i_t^{L,C})$ —by extension via (17), therefore choosing the uncollateralized loan rate $(1+i_t^{L,U})$ too—taking (12)-(16) and the parameters, as given. The step-by-step derivations are in Appendix B, which can be summarized to the two following first-order conditions:

$$(1+i_t^R) = \frac{c^V d_t}{\left[d_t + \frac{v_t^G}{(1-\mu)}\right]} \xi_{R,t}, \quad (18)$$

$$\begin{aligned} & (1-\eta_t^C)l_t^{E,C} + (1-\chi-\eta_t^U)l_t^{E,U} + (1-\chi-\eta_t^U)\frac{\partial l_t^{E,U}}{\partial(1+i_t^{L,C})}[(1+i_t^{L,U}) - (1+i_t^{L,C})] \\ &= \frac{\partial LP_t^{E,C}}{\partial(1+i_t^{L,C})} + \frac{\partial LP_t^{E,U}}{\partial(1+i_t^{L,C})}, \end{aligned} \quad (19)$$

where the partial derivatives in (19), are given by:

$$\begin{aligned} \frac{\partial l_t^{E,U}}{\partial(1+i_t^{L,C})} &= -\frac{\partial l_t^{E,C}}{\partial(1+i_t^{L,C})} \\ &= \left[1 + \frac{l_t^E(1-\eta_t^C)(\kappa_t^C)^{1-\zeta}}{\kappa_{UP}\zeta\Psi_{E,t}}(2+i_t^{L,C}+i_t^{L,U})\right]^{-1} \times \left\{ \frac{l_t^E(1-\eta_t^C)(\kappa_t^C)^{1-\zeta}}{\kappa_{UP}\zeta\Psi_{E,t}}l_t^{E,C} + \frac{\kappa_t^C l_t^E}{\kappa_{UP}(1+i_t^{L,C})}\xi_{E,t} \right\}, \end{aligned} \quad (20)$$

$$\frac{\partial LP_t^{E,C}}{\partial(1+i_t^{L,C})} = [\Omega_0^C \eta_t^C + F(\tilde{\eta}^C - \eta_t^C)\Omega_0^C] \frac{\partial l_t^{E,C}}{\partial(1+i_t^{L,C})}, \quad (21)$$

$$\frac{\partial LP_t^{E,U}}{\partial(1+i_t^{L,C})} = \Omega_0^U \eta_t^C (\kappa_t^C)^{\iota-1} \left\{ \left[1 + (\iota-1)\Omega_0^U l_t^{E,U} \frac{(1-\eta_t^C)(\kappa_t^C)^{-\zeta}}{\zeta\Psi_{E,t}}(2+i_t^{L,C}+i_t^{L,U})\right] \frac{\partial l_t^{E,U}}{\partial(1+i_t^{L,C})} + (\iota-1)\Omega_0^U l_t^{E,U} \frac{(1-\eta_t^C)(\kappa_t^C)^{-\zeta}}{\zeta\Psi_{E,t}}l_t^{E,C} \right\}, \quad (22)$$

where $\xi_{E,t} = [\partial l_t^E / \partial(1+i_t^{L,C})][(1+i_t^{L,C})/l_t^E]$ and $\xi_{R,t} = [\partial d_t / \partial(1+i_t^R)][(1+i_t^R)/d_t]$ are the interest elasticities of total loan demand and total deposits respectively, and $\Psi_{E,t} = A_t \left[\frac{P_t^{E,C}}{P_t} (K_t^{E,C})^\alpha (X_t N_t^{E,C})^{1-\alpha} - \frac{P_t^{E,U}}{P_t} (K_t^{E,U})^\alpha (X_t N_t^{E,U})^{1-\alpha} \right]$.

Due to the endogenous determination of the share of IG enterprises taking unsecured versus collateral loans in (4), the partial derivatives of the interest demand for both loan types are not constant and in fact, direct opposite of the other. By implication, an increase in the collateralized loan rate is expected to lead to a decrease (increase) in LLPs for collateralized (unsecured) loans due to more enterprises switching to unsecured loans. Further, in (19), we also see that the equilibrium loan interest spread, having adjusted for both the sensitivity of unsecured lending and the scale effects associated with defaults (LHS), would equate the sum of the partial derivatives of the LPs of the two loan types.

3.3 Government and the Central Bank

The government issues one-period bonds (in real terms), b_t , which are held by households (b_t^H), commercial banks (b_t^B), and the central bank (b_t^C). The government also collects lump-sum taxes from households, $T_t = \int_0^1 T_{ht} dh$, to pay for its expenditure, G_t , which follows an AR(1) process, $G_t = (G_0)^{1-\rho_G} (G_{t-1})^{\rho_G} \exp(v_t^G)$, where $G_0 > 0$, $\rho_G \in (0, 1)$ and v_t^G are the persistence and standard errors with constant variance (σ_G^2). The fiscal budget constraint is then $b_t - \frac{(1+i_{t-1}^B)}{1+\pi_t} b_{t-1} + \frac{\pi_t^B + \pi_t^R}{(1+\pi_t)} = (G_t - T_t)$, where π_t^B, π_t^R are real profits.

On behalf of the government, the Central Bank holds one-period bank capital (v_t^G) in the commercial bank. The central bank's period-specific balance sheet (in real terms) is represented by:

$$v_t^G + b_t^C = m_t + RR_t, \quad (23)$$

where given that $RR_t = \mu d_t \forall t$, in each period evolve according to the flow-of-funds constraint,

$$\left[v_t^G - \frac{(1+i_{t-1}^R)}{1+\pi_t} v_{t-1}^G \right] + \left[b_t^C - \frac{(1+i_{t-1}^B)}{1+\pi_t} b_{t-1}^C \right] \leq (m_t - \frac{m_{t-1}}{1+\pi_t}) + \left[\mu d_t - \frac{(1+i_{t-1}^R)}{1+\pi_t} \mu d_{t-1} \right], \quad (24)$$

where consistent with China-focused studies such as Minetti and Peng (2018) and Chang et al. (2019), monetary policy is implemented using an M2 growth rule,

$$\gamma_t^m = \gamma_m \left(\frac{1+\pi_t}{1+\pi^T} \right)^{\tau_m} \left(\frac{Y_t}{\tilde{Y}} \right)^{\tau_Y} A_t^m, \quad (25)$$

where $\tau_m \leq 0, \tau_Y \geq 0, \gamma_m$ and $\tilde{Y}$ are the steady-state values of real money supply growth and final goods, π^T target inflation rate, A_t^m denotes a monetary policy shock governed by AR(1) process, $A_t^m = (A_0^m)^{1-\rho_m} (A_{t-1}^m)^{\rho_m} \exp(v_t^m)$, where $A_0^m = 1, \rho_m \in (0, 1)$, and v_t^m the persistence and standard errors respectively.

3.4 Other aspects, market-clearing conditions, and aggregate default rates

For the remaining aspects of the model, the representative state-owned retailer purchases the differentiated IGs in type-specific baskets to assemble composite final goods, Y_t in a standard Dixit-Stiglitz CES fashion. On the other hand, the privately owned representative capital good producer buys gross amounts, I_t^E , of final goods from the retailer to produce aggregate capital goods, K_t^E . These are then rented to the IG enterprises. Capital accumulation is subject to a $\delta^E \geq 0$ depreciation rate, and a A_t^K capital adjustment shock (where $\Theta_{E,K} \geq 0$ adjustment cost parameter), governed by AR(1) process, $A_t^K = (A_0^K)^{1-\rho_K} (A_{t-1}^K)^{\rho_K} \exp(v_t^K)$, with persistence, $\rho_K \in (0, 1)$, and standard errors, v_t^K . In each period t , the capital good producer chooses the level of capital goods, taking rental rate (r_t^{EK}) and existing stock as given, so as to maximize its lifetime discounted value of

(real) rental income, yielding:

$$\mathbb{E}_t r_{t+1}^{EK} = \left[\frac{1}{A_t^K} + \Theta_{E,K} \left(\frac{K_{t+1}^E}{K_t^E} - 1 \right) \right] \left(\frac{1 + i_t^B}{1 + \pi_{t+1}} \right) - \frac{(1 - \delta^E)}{A_{t+1}^K} - \frac{\Theta_{E,K}}{2} \left[\left(\frac{K_{t+2}^E}{K_{t+1}^E} \right)^2 - 1 \right]. \quad (26)$$

The continuum $h \in (0, 1)$ infinitely lived households solve their respective intertemporal utility maximization problem to determine their optimal choices of labor supply [subject to the usual $\varsigma_N \geq 1$ (inverse) Frisch elasticity of labor supply], consumption C_{ht} [at relative utility weight, ϑ_C], housing services H_{ht} [at relative utility weight, ϑ_H], bonds (b_{ht}^H), and composite monetary assets [at relative utility weight, $\vartheta_\varkappa$]. Real composite monetary assets are given by $\varkappa_{ht+s} = (m_{ht+s})^{\vartheta_M} (d_{ht+s})^{1-\vartheta_M}$, where $\vartheta_M \in (0, 1)$ denoting the relative demand of cash. House price appreciates at a $(1 + \pi_{t+1}^H) = P_{t+1}^H / P_t^H$ rate. Households' intertemporal choices are influenced by two sources of preference shocks. Specifically, A_t^C is a standard preference shock following an AR(1) process, $A_t^C = (A_0^C)^{1-\rho_C} (A_{t-1}^C)^{\rho_C} \exp(v_t^C)$, where $\rho_C \in (0, 1)$ and v_t^C are the persistence and standard errors respectively. Further, given the significance of China's housing policy in influencing individual behaviors (Chen and Wen, 2017; Jia and Lim, 2021), we follow Agénor and Pereira da Silva (2017) by introducing a housing services demand shock, A_t^H , to serve as a 'catch-all' housing policy shock, which follows an AR(1) process, $A_t^H = (A_0^H)^{1-\rho_H} (A_{t-1}^H)^{\rho_H} \exp(v_t^H)$, where $\rho_H \in (0, 1)$ and v_t^H are the persistence and standard errors.

The symmetric and dynamic general equilibrium of the model is defined in Appendix A, which yields an aggregate final goods market-clearing condition, $Y_t = C_t + I_t^E + G_t$. All other markets are also clear. Given (8)-(9) earlier, as well as the threshold capacity level determined in (4), the equilibrium collateralized, η_t^C , and unsecured loan default, η_t^U rates can be determined by:

$$\eta_t^C = \left(\int_0^{\hat{\varepsilon}_t^C} f(\varepsilon) d\varepsilon \right) / l_t^{E,C}; \text{ and } \eta_t^U = \left(\int_0^{\hat{\varepsilon}_t^U} f(\varepsilon) d\varepsilon \right) / l_t^{E,U}, \quad (27)$$

with $\hat{\varepsilon}_t^C$ and $\hat{\varepsilon}_t^U$ being the threshold production uncertainty values below which all collateralized and unsecured loan-holders would default respectively, given by:

$$\hat{\varepsilon}_t^C = \left[\frac{[(1 + i_t^{L,C}) l_t^{E,C} - \varphi^{-1}(P_{t+1}^H / P_t) \bar{H}]}{(P_t^{E,C} / P_t) A_t (K_t^{E,C})^\alpha (X_t N_t^{E,C})^{1-\alpha}} \right]^{\frac{1}{\varsigma_1}} \left(\int_{\kappa_t^C}^{\kappa_{UP}} f(\kappa) d\kappa \right)^{-\frac{\varsigma}{\varsigma_1}}; \quad (28)$$

$$\hat{\varepsilon}_t^U = \left[\frac{(1 + i_t^{L,U}) l_t^{E,U}}{(P_t^{E,U} / P_t) A_t (K_t^{E,U})^\alpha (X_t N_t^{E,U})^{1-\alpha}} \right]^{\frac{1}{\varsigma_1}} \left(\int_0^{\kappa_t^C} f(\kappa) d\kappa \right)^{-\frac{\varsigma}{\varsigma_1}}. \quad (29)$$

4 Calibration and Estimation

To study the model in the context of macro-financial stability in the post-banking reform, ‘new normal’ of China, we use an actual data-based Bayesian estimation strategy in the tradition of Smets and Wouters (2003) to estimate the model. Specifically, given China’s lack of publicly available quarterly macroeconomic series, we estimate the model using a mixed frequency technique based on actual data of 7 detrended time series, covering the period of 2004Q4 to 2020Q4 ($T = 65$). These include five variables with original series available in quarterly frequency (CPI inflation rate, M2 stock, China’s one-year government bond yield and LLR), and three standard macroeconomic series (real per capita GDP, real per capita consumption, real per capita private investment) converted to quarterly frequency using the quadratic average method. For the banking-specific series pertinent to our research questions, in the absence of aggregate level data, we focus on capturing the behavioral patterns of the Big 4 commercial banks by manually aggregating the information from their respective financial reports.

We estimate the model using the Bayesian approach. To avoid stochastic singularity, the model is estimated based on these 7 series, which is one less than the number of structural shocks. Indeed, given that the actual housing price data is not included in the estimation, it turns out that the housing demand shock, A_t^H , becomes the “odd one out”, in that its inclusion is more for meeting the Blanchard-Quah condition for identification than reflecting its actual contributions to the Chinese business cycles. In truth, the actual variations attributed to housing demand are likely captured by our default shock, compared to other China DSGE models (e.g., Minetti et al., 2019; Liu and Ou, 2021; Ge et al., 2022).

In total, our estimation yields 26 dynamic parameters [ς_N , ϑ_C , ϑ_M , ϑ_κ , ϕ_R , F , Ξ , ϖ , τ_m , τ_Y , 8 AR(1) parameters, and 8 standard deviation parameters]. The remaining parameters are calibrated to match the initial steady-state values to describe the long-run state of China, as in the following two categories: (i) key macroeconomic ratios (consumption-to-GDP ratio of 52%; non-residential investment ratio of 33%; government spending ratio of 15%; residential housing-to-GDP ratio of 2.7%); and (ii) key banking variables [deposit rate, $\bar{r}^R = 0.02$; unsecured loan rate, $\bar{r}^{L,U} = 0.16$; collateralized loan rate, $\bar{r}^{L,C} = 0.06$; unsecured-collateralized (U-C) loan ratio, $\omega_t^{Loan} = l_t^{E,U} / l_t^{E,C} = 1/3$].

The calibrated parameters are summarized in Table 2. In the households sector, the discount factor, $\beta = 0.994$, is consistent with an average government bond yield of 2.4% per annum. The relative utility weight for housing, ϑ_H , is set at 0.03, to target the steady-state residential housing-to-GDP ratio outlined above. For the production parameters, following empirical evidence documented for China, we set the capital depreciation rate, $\delta^E = 0.05$ (estimates in Penn World Table 10.0) and labor share, $\alpha = 0.5$ (Brandt et al., 2012; Zhu, 2012). For the capital adjustment cost parameter, we set it at $\Theta_{E,K} = 5$, which is slightly above the 3.75 used in Minetti et al. (2019). In the absence of a corresponding reference, the productivity elasticity, $\zeta = 0.1$ is set. In the banking sector, the reserve requirement ratio, μ , is set at 0.125, which approximates the average reported by

the People’s Bank of China over the past 5 years. Similarly, the parameter, $\varphi = 1.67$ is set which reflects an LTV ratio of 0.6, slightly below the usual maximal LTV ratio of 0.8 but in line with the average observed in the corporate sector in China. The elasticity in the individual assessment-based LLPs for unsecured loans, ι , is set at a small value of 0.1, which together with $\Upsilon_C = 0.75$, allows for the target steady-state U-C loan ratio, $\omega_t^{Loan} = 1/3$ to be achieved. The steady-state probability of default is calibrated to $\tilde{\eta} = 0.05$, which is in line with the data of the Big 4 banks but slightly higher than the 3.0 percent reported by the China Banking and Insurance Regulatory Commission. Finally, both the steady-state loan loss provision-to-NPL ratios (Ω_0^U, Ω_0^C) are set at 0.136, in accordance with the data for the Big 4 banks.

Next, we evaluate the Bayesian-estimated dynamic parameters. Table 3 reports the prior and posterior distributional forms, means, and standard deviations. The priors and distribution chosen for these parameters are in line with existing Bayesian estimation-based DSGE studies for China. Specifically, to reflect a relatively inelastic labor supply in the context of a developing economy, we set the prior mean of the inverse of the Frisch elasticity of labor supply to $\varsigma_N = 3.0$, which is below the 3.48 required to match aggregate business-cycle data in King and Rebelo (1999), but close to the mean (1.83) documented for aggregate hours in Smets and Wouters (2007). The priors for the relative weights of consumption and composite monetary assets are set at $\vartheta_C = 0.5$ and $\vartheta_\pi = 0.0025$, following the parameterized values of Agénor and Pereira da Silva (2017). The prior for the share of cash in composite assets, ϑ_M , is conveniently set at 0.5 to reflect an even split between cash and deposit. For the two parameters in the NKPC (ϖ, Ξ), we set priors of $\varpi = 0.67$, $\Xi = 0.5$, following Liu and Ou (2021), which uses a similar Calvo-Yun pricing setup. For the M2 growth rule, we follow the calibration of Chang et al. (2019), hence $\tau_m = -0.65$ and $\tau_Y = 0.3$. Next, the priors for the two LLP parameters are determined as follows. For the relative weight between existing reserves and fresh loan loss provisions, $\phi_R = 0.7$ is set, as in Agénor and Zilberman (2015). For the degree of provisioning smoothing, our benchmark case is based on $F = 0.1$, which reflects a largely backwards-looking provisioning regime with some slight dynamic adjustments. Nevertheless, this is a key parameter that we analyze across its entire domain in the later section.

For the shock persistence and standard deviation parameters, following the rationale of Hristov and Hülsewig (2017), we give relatively large prior variance so that the kurtosis of posterior distributions is not heavily influenced by the prior means: the data can therefore “speak for themselves”. Indeed, our overall strategy with setting priors and distribution is consistent with the existing Bayesian DSGE literature, such as Smets and Wouters (2003), Christiano et al. (2005). Specifically, we assume Beta distribution with a mean of 0.5 and a standard deviation of 0.2 for the AR(1) parameters, and inverse-gamma distribution with 0.1 mean and 2.0 standard deviation for the standard deviation parameters.

The estimated posterior mean for the inverse Frisch elasticity, ς_N , is 2.1802, well within the acceptable range for a macroeconomic model. The estimated posterior means for the relative utility weights are $\vartheta_C = 0.573$,

$\vartheta_{\varkappa} = 0.0025$, $\vartheta_M = 0.500$, which indicate little variations from the priors. While this can be a concern, the small standard deviations indicate that any alternative set of priors here would likely have made little difference to the qualitative nature of our results later. The posteriors for the two LLP parameters are $\phi_R = 0.697$ and $F = 0.118$, which are close to the priors too. The two Calvo-Yun NKPC parameters, Ξ and ϖ , are estimated at 0.03 and 0.095, which are smaller than the priors but within the range of a study such as Liu and Ou (2021). Lastly, for the M2 growth rule of Chang et al. (2019), the posterior means estimated based on China's M2 series are $\tau_m = -0.741$ and $\tau_Y = 0.290$.

5 Analysis

First, we examine the estimated results from both the variance decomposition and impulse response analyses. Table 4 presents the results of the unconditional variance decomposition for all key variables in the model. To assess the cyclical properties and dynamic responses of these variables to structural shocks, Figures 3–6 display the impulse response functions (IRFs) corresponding to standard macroeconomic shocks—namely productivity, capital adjustment, inflation and the LLP shock.³

After that, we evaluate the effects of dynamic provisioning by examining the IRFs of key variables to structural shocks under two contrasting LLP regimes. In addition to the cyclicity evaluation, we also examine the potential optimality associated with the degree of dynamic LLP smoothing and other central banking policy parameters. Specifically, following Benigno and Woodford (2008), we evaluate welfare by maximizing the consumption equivalence (CE), which is derived from the household's utility function. This measure allows us to express welfare differences across policy regimes as the permanent percentage change in consumption that would make the representative household indifferent between two scenarios. The consumption equivalent variation is then computed to quantify the welfare gain (or loss) relative to the benchmark.

$$\max CE = \exp [(1 - \beta)(\mathcal{W} - \mathcal{W}^*)] - 1, \quad (30)$$

$$\mathcal{W} = \mathbb{E}_h \sum_{s=0}^{\infty} \beta^s \left[\ln(C_{ht+s})^{\vartheta_C} A_t^C + \ln(H_{ht+s})^{\vartheta_H} A_t^H + \ln(\varkappa_{ht+s})^{\vartheta_{\varkappa}} - \frac{(N_{ht+s}^E)^{1+\varsigma_N}}{1+\varsigma_N} \right], \quad (31)$$

where $\mathcal{W}$ and $\mathcal{W}^*$ represent the household's expected lifetime utility under different policy regimes and the benchmark calibration, respectively.

³To save space, the IRFs of the three policy-related shocks, as well as for preference shock (all of which contribute relatively small shares of the overall variations of key variables in the model), are made available in Appendix C.

5.1 Variance Decomposition and Impulse Responses

In Table 4, we observe that capital investment is the main driver of the business cycle in our simulated economy, which is consistent with the investment-driven growth experience of China over the past two decades (Song et al., 2011; Wen and Wu, 2019). In terms of the variations in final good and its sectorial composition, this is then followed by the productivity shock, with both combined to account for over 60 percent of the variations in these variables. For the other ‘conventional’ macroeconomic variables: (i) capital investment shock drives 55 percent of the variations in inflation, but predictably (ii) consumption is primarily driven by the preference shock (54.5 percent); and (iii) money supply primarily by inflation shock (57.1 percent). In both (ii) and (iii), capital investment shock plays second fiddle, and therefore continues to be a significant driver. These are largely consistent with the main drivers in most other estimation-based DSGE models for China (e.g., Minetti et al., 2019; Liu and Ou, 2021).

In terms of the endogenous variables novel to our model, first we note that the bulk of the variations in the threshold capacity level, κ_t^C , which influences unsecured-collateralized loan choice, is mainly driven by the combination of capital investment and inflation shocks (in combination, 89 percent). These results stay largely consistent in terms of the variations in the equilibrium levels of the unsecured and collateralized loans, as well as the LLP allocated to both types of loans, where the two shocks combine for at least 66 percent in their variations. In these banking variables, the novel structural shock associated with LLP adjustment introduced account for quite significant shares of the aggregate variations projected. Indeed, by virtue of the partial derivatives in (19) having contributed to the sensitivities in the loan rates ($i_t^{L,C}, i_t^{L,U}$) and consequently, the type-specific aggregate default rates determined in (27)-(29), we see that the LLP adjustment shock adds a third significant driver alongside investment and inflation shocks. Indeed, it is the primary driver of the variations in real bank profit (67 percent), which ties back to our preliminary regression evidence earlier. In essence, this simple exercise suggests that frequent discretionary changes made to loan loss provisions, including accounting adjustments of accreted interest on impaired loans, write-offs and recoveries, would have material impacts on aggregate economic fluctuations of the economy, though this is not systemically more significant than aggregate default or other macroeconomic fundamentals, which echoes some of the empirical findings reviewed earlier (Wang et al., 2019; Chen et al., 2021).

In direct contrast, despite China being nominally a command economy, the combined policy shocks of fiscal and monetary policies account for very small shares of variation in most variables. In essence, these results indicate that policies are largely stable over time, and therefore play small roles in explaining economic fluctuations. Indeed, the low significance of fiscal policy shock in driving the overall economic fluctuations is in line with the results of China-focused DSGE study, such as Liu and Ou (2021), indicating relatively stable government spending patterns. Likewise, overall money supply growth has been relatively stable over time,

similar to Lim et al. (2024), who have also attempted to Bayesian-estimate the M2 growth rule for China, we also find a relatively small contribution from monetary policy shock.

Next, we examine the IRFs. First, in all the IRFs, note that we consistently observe co-movements between LLPs and the unsecured-collateralized loan ratio, which are consistent with the preliminary empirical evidence earlier. In Figures 3-4, we observe standard procyclical behaviors in final good and consumption in response to both macroeconomic shocks, leading to overall higher inflationary pressure and monetary tightening. Facing a higher level of economic activities, the bank takes more risk with its lending behaviors, as reflected in the lowering of the cost of credit for unsecured loans. The threshold capacity level, κ_t^C , becomes higher as more enterprises opt for unsecured over collateralized loans due to the combination of: (i) cheaper unsecured loan rate; and (ii) nominal value of housing collaterals having risen (therefore higher opportunity cost with collateralized loan). Indeed, this is in line with studies such as Dong et al. (2020), which documented the stylized fact where the benefits to the dispersion of enterprises' productivity is countercyclical, despite procyclical behavior to the quantity of capital and therefore output in their model.

Interestingly, in the case of our calibrated model, we observe countercyclicality at the aggregate level for loan loss provisioning behaviors, despite $F = 0.1$ being set for the benchmark model (a largely backwards-looking regime with slight dynamic adjustment). Specifically, instantaneously post-shock, we observe an increase in loan loss reserves and a decline in unsecured loan rate, though a contrasting case is observed for the implications on bank profitability. In Figure 3, which illustrates IRFs for productivity shock, real bank profit increases following the positive shock, whereas in Figure 4, which illustrates IRFs for capital adjustment/investment shock, bank profit drops initially before over-shooting after four quarters. While these seemingly counter-intuitive findings are in contrast to the non-China study of Bikker and Metzmakers (2005), our results are similar to the empirical findings of Huang and Xiong (2015). Based on a sample of 45 commercial banks in China in the 2000-10 period, they found credit growth to be countercyclical, as in addition to inflation eroding real profits, banks also appeared to set aside greater capital buffers and provisioning reserves during cyclical upturns. Indeed, this is consistent with empirical evidence documented in other countries, where lending by state banks, as in the case of China, is generally less procyclical (Bertay et al., 2015).

In Figure 5, we evaluate the IRFs following a temporary supply-side shock to inflation. In this instance, we observe effects that are largely opposite to those of standard macroeconomic shocks, which are to be expected. After an instantaneous downward adjustment to the realized inflation rate (as rational agents expect the price level to be higher in the future, they anticipate lower inflation today), the unanticipated supply-side shock to the price level eventually leads to predictably adverse effects on real production and consumption. These translate to an immediate contraction in real bank profit. However, as the central bank adopts an expansionary monetary policy to compensate for the negative output gap, the additional liquidity means greater overall lending and

borrowing activities, though the net effect is that the U-C loan ratio declines.

In Figure 6, which illustrates the IRFs following an LLP adjustment shock, predictably the immediate impact to bank profitability is negative, due to the bank taking a more prudent stance to lending while building up its loan loss reserves. Nevertheless, consistent with the counter-cyclical loan loss provisioning patterns observed earlier, this results in lower default rates, which on aggregate, leads to more final good production and the associated consumption. At the same time as the economic expansion, in response to the negative instantaneous impact on its profitability, the bank also lowers its unsecured loan rate to boost lending, therefore resulting in an eventual return to the equilibrium.

5.2 Dynamic Provisioning and Optimality Analysis

Before examining optimal LLP properties (in the context of macro-stability), we evaluate the effects of different degrees of cyclically adjusted provisioning on the model economy. In Figure 7, the IRFs of the U-C loan ratio and inflation rate to selected structural shocks are illustrated, under different degrees of dynamic LLP smoothing ($F = 0.1, 0.5$). Except for the preference shock, a higher degree of cyclically adjusted LLPs generally exhibits improved countercyclical properties, which is a finding consistent with existing LLP literature. With the preference shock playing a minor role in explaining business cycles, this indicates that the current China banking regime would potentially benefit from formal guidance on dynamic provisioning.

Next, Table 5 reports the maximized consumption-equivalent welfare gain, CE , and associated U-C loan ratio for different values of F (degree of cyclically adjusted LLPs). We observe that, as the degree of cyclically adjusted LLPs increase to 0.5, the maximum CE can be achieved. While the difference it makes to the corresponding U-C loan ratio is small, it appears that an optimal unsecured loan share should be about 66.54%, which is about the 2/3 share in the baseline economy. In other words, while dynamic LLP provisioning rule, which had been popular among European central bankers back then, is likely to contribute to improved banking stability in China, the present aggregate banking behavior in the economy has exhibited remarkable countercyclicality in loan loss provision, which perhaps contributes to an optimal degree, $F = 0.5$, that is right in the middle.

In addition to LLPs, we further search numerically for the potential existence of interior optimality in other policy parameters, in terms of the consumption equivalence (CE) welfare. We consider the (inverse) LTV ratio [$\varphi \in (0, 1)$], reserve requirement ratio (RRR) [$\mu \in (0, 1)$], and monetary policy parameters ($\tau_m \leq 0, \tau_Y \geq 0$). For the (inverse) LTV ratio, we observe that the social loss-minimizing value is at $\varphi = 1$, whereas for the inflation remit in monetary policy, the largest negative value possible for τ_m . However, with the policy function of (30), we find interior optimal parameter values for the RRR, μ , and the output stabilization remit, τ_Y , as illustrated in Figure 8. Specifically, we have $\mu = 0.085$ and $\tau_Y = 0.100$. Interestingly, the optimal RRR value is smaller than the current 12.5% observed in Chinese banks. In combination, the lower-than-expected optimal μ value

(in terms of CE), together with the remarkably consistent countercyclical banking behaviors observed in all the IRF analysis, suggest that the present Chinese banking regulations can be overly prudent, perhaps reflective of the unwavering policy commitments to avoid another episode of high NPLs observed in the early 2000s.

6 Concluding Remarks

We have developed a novel DSGE model with LLPs and unsecured-collateralised loan choices made by enterprises, the latter being endogenously determined due to enterprises having heterogeneous production capacity. Further, due to the presence of a second source of production uncertainty, which is only drawn and observed ex post to loan contracting, type-specific aggregate default rates are also endogenously determined. We estimate the model using actual Chinese data from 2004Q4 to 2020Q4. Our estimated model can generate co-movement between LLPs and the unsecured-collateralised loan ratio, a feature of the Chinese banking system that is consistent with empirical evidence. We also uncover a unique feature of the Chinese banking system in the post-reform ‘new normal’, where bank behaviors tend to be countercyclical with more LLPs being made during business cycle upturn, despite the overall LLP regime still remaining relatively backwards-looking. Nevertheless, the caveat of our findings is that, our calibrated model economy is also by design, driven significantly by the structural shock associated with LLP adjustments, alongside the traditional driver of capital investment shock. Interestingly, we also find an optimal RRR that ought to be lower than the current level (in terms of CE), which together with the remarkably consistent countercyclical banking behaviors observed in all the IRF analysis, suggests that the current Chinese banking regulations may be overly prudent, perhaps reflective of the unwavering policy commitments to avoid another episode of high NPLs observed in the early 2000s.

In terms of the generalizability of our results, although this paper is an estimated-macro-policy-simulation based study, where contributions are typically specific to the stylized features calibrated, our finding of there being potential macro-volatility-minimizing benefits to a forward-looking, cyclically adjusted LLP regime is consistent with the broader literature. The finding applies to both developed countries and developing economies, notably when the banking system is complex. Granted, our main finding (there is a unique countercyclical pattern to Chinese banks’ LLP and unsecured lending choice, where the positive correlation is most notable during business-cycle upturn), suggests that seemingly forward-looking behavior is most likely reflective of the increasing risk-taking appetite of Chinese banks during an upturn, leading to the unsecured loan expansion. However, due to the highly regulated nature, reinforced by the fact that these systemically significant banks are all state-owned, these banks are also compelled to make greater provision for potential credit losses, despite bullish economic conditions. Even among developing countries, these characteristics aren’t unique to China. For instance, in oil and resource-rich developing economies, such as the Gulf nations, Malaysia, and Senegal, most systemically significant banks are indirectly state-owned too, via the proxy of their government-investment

funds. Yet, the productivity distribution of firms in these economies is as uneven as in China. In such instance, the behaviors of banks in these economies are likely to exhibit the positive unsecured lending-LLP nexus too, therefore susceptible to similar macro-stability issues. In managing banks' incentives for riskier lending during upturns, similar lessons can therefore be learned. Rather than relying solely on the 'sticks' of government guidance in mandating greater credit loss provision to compensate for the expansion in unsecured lending (where LLP can often be just treated as an accounting guideline), financial regulations, or more specifically both micro- and macro-prudential regulations, can be more targeted at invoking the well-documented 'skin-in-the-game' effects (Mitchener and Richardson, 2013; Lin et al., 2019) among bankers. This is so as to organically incentivize the bankers to internalize more of the potential risks associated with unsecured lending (to firms with low productivity), which would then subsequently mitigate such procyclicality and the strong correlations between LLP and unsecured-collateralized choices.

For future research, we abstract from detailed modelling of the state-owned enterprise (SOE) sector—and its associated entrusted lending—in China, as this is a related but ultimately peripheral issue to our core research questions. Additionally, we do not account for potential risks to macro-financial stability arising from the external economy. As China's large banks (including the Big 4) continue expanding their overseas lending activities, the definition of credit risk they face increasingly extends beyond the scope of our current analysis.

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Figures and Tables

Figure 1: China's Big 4 Banks
- NPL ratio and unsecured loan share, 2003-2019

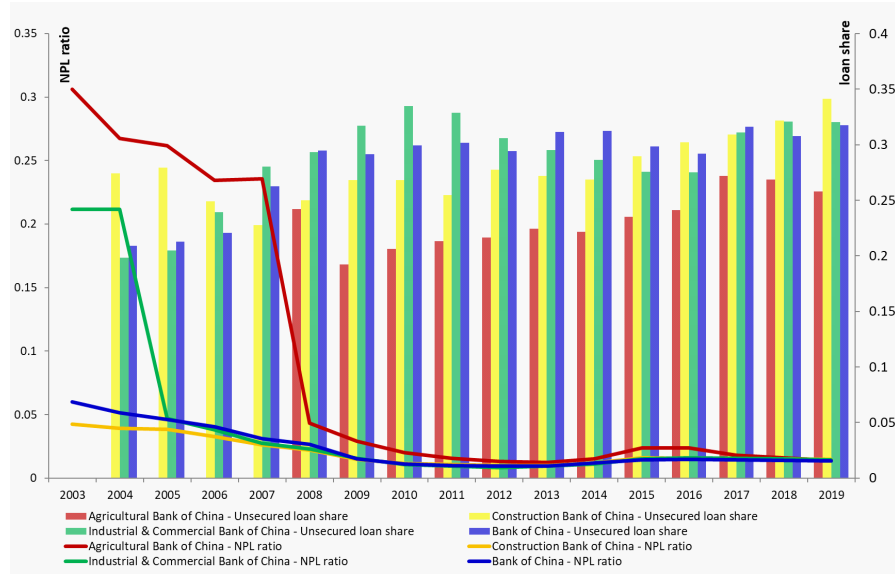


Figure 2: Model Overview

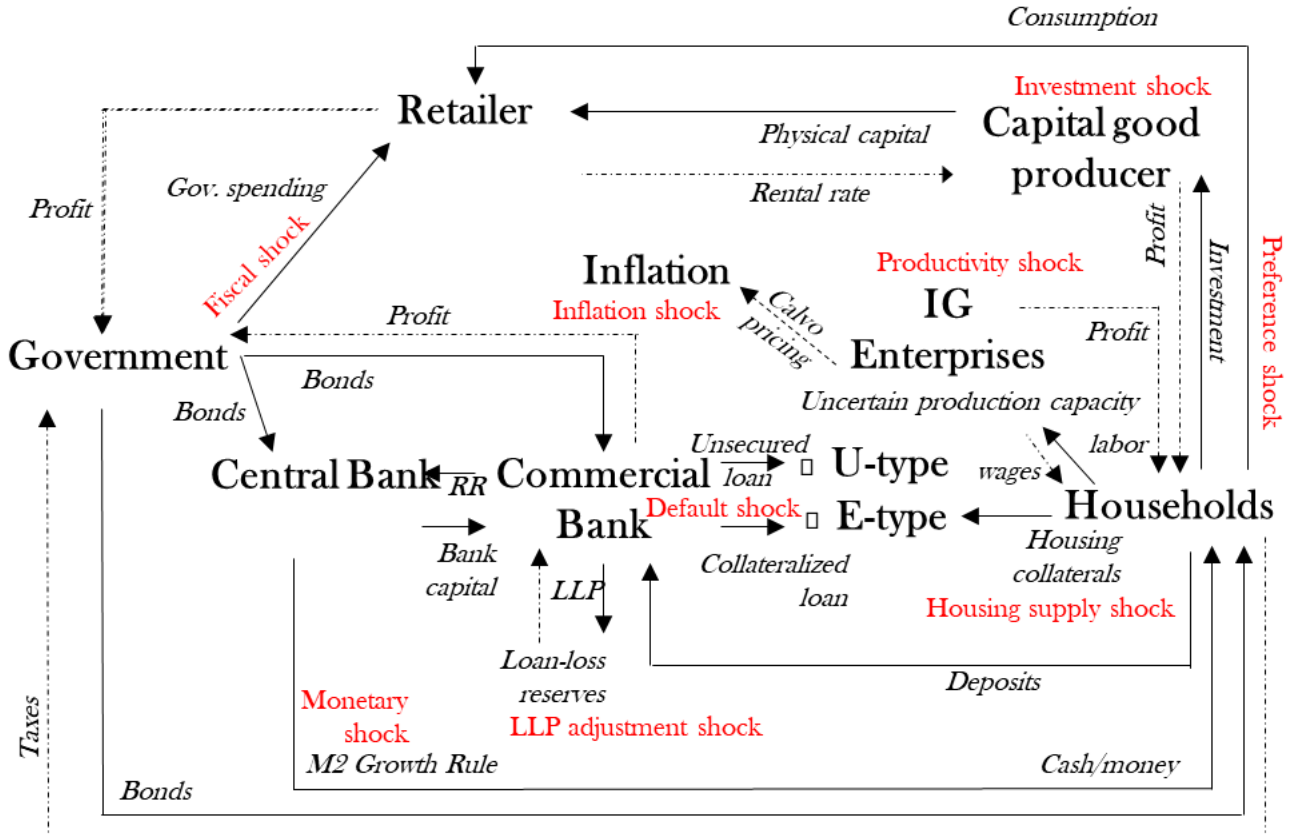


Figure 3: IRFs to productivity shock

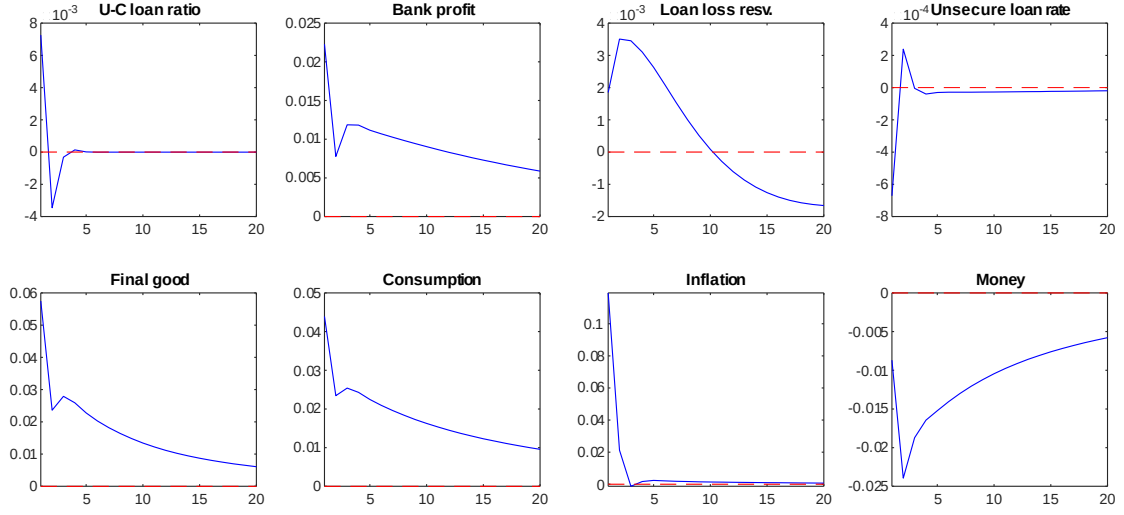


Figure 4: IRFs to capital adjustment/investment shock

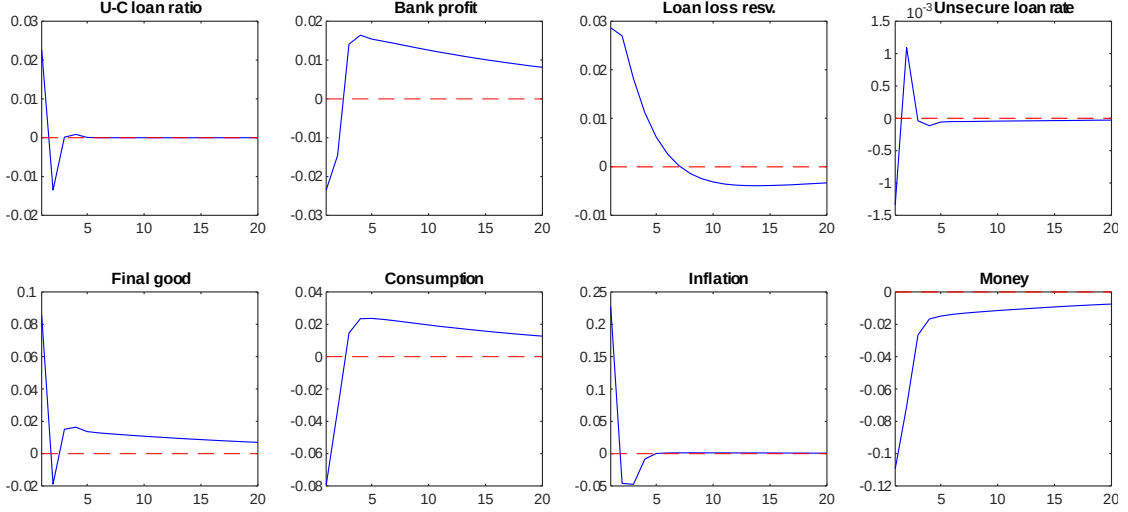


Figure 5: IRFs to Inflation shock

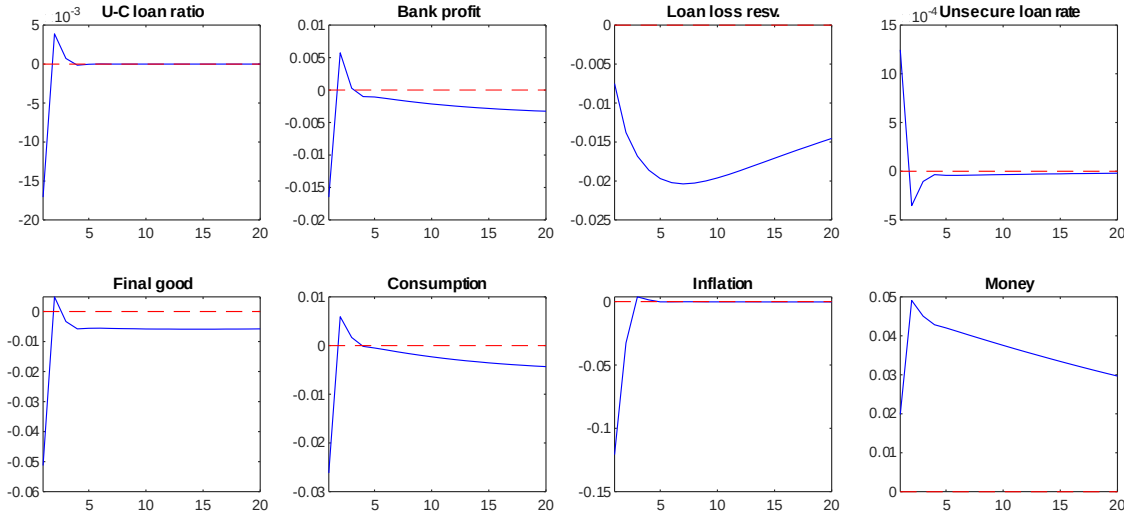


Figure 6: IRFs to LLP adjustment shock

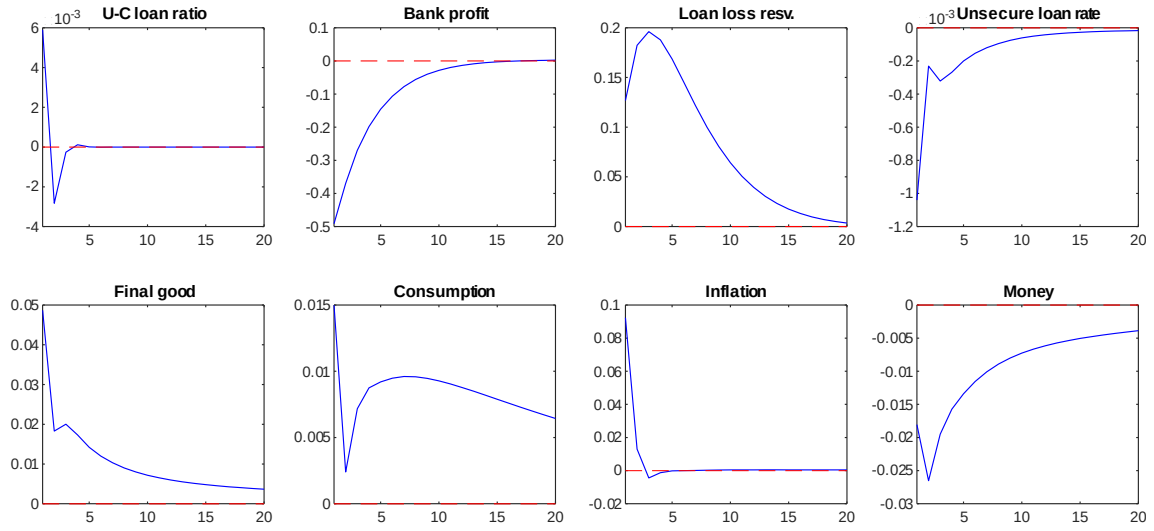
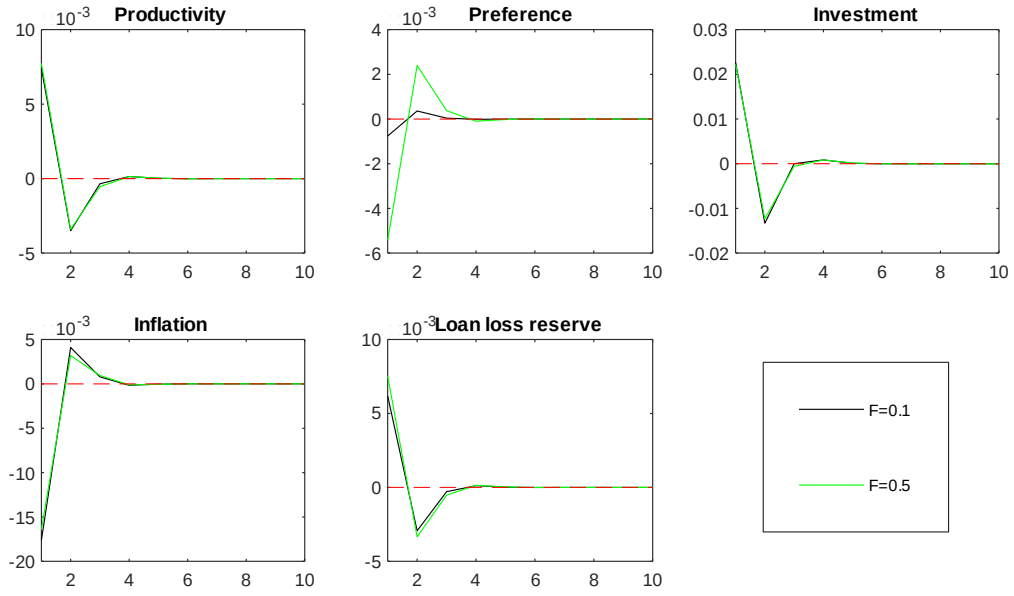


Figure 7: IRFs to selected different shocks

Unsecured-collateralized loan ratio



Inflation

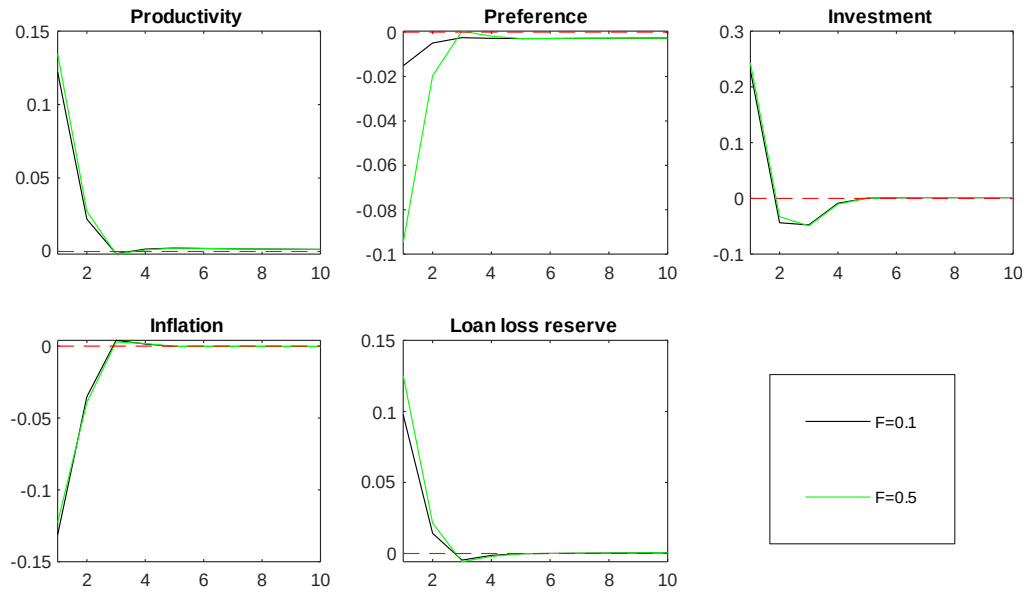


Figure 8: Optimality Search: RRR and M2 growth rule, output gap

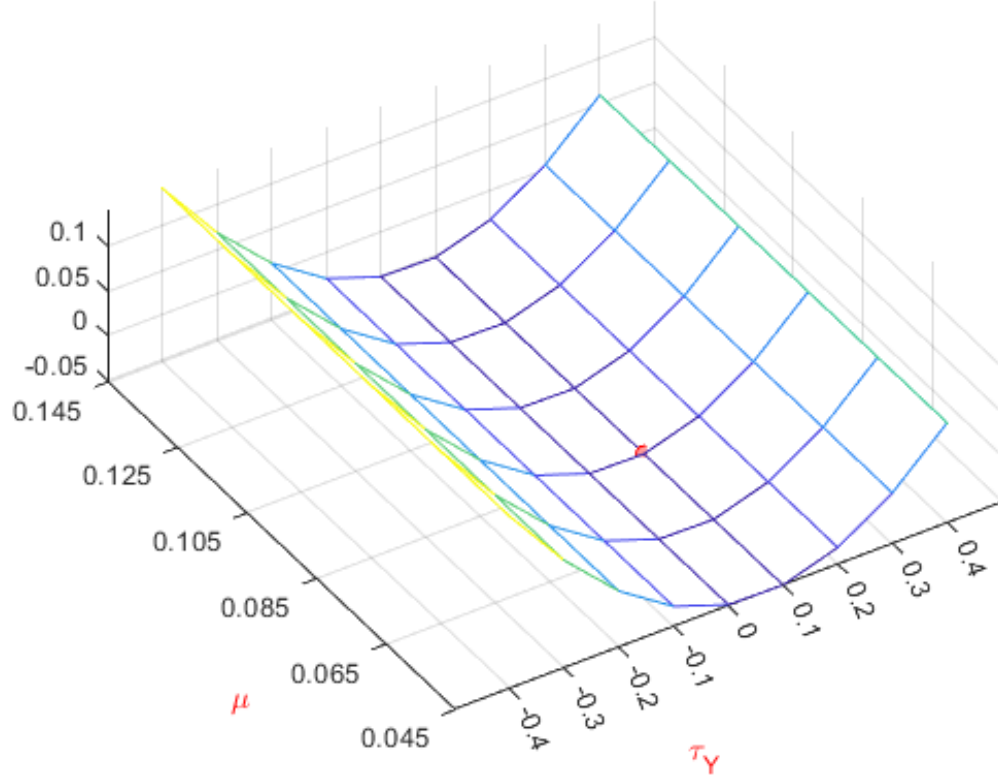


Table 1: Fixed-effect regression results of unsecured loan share on loan-loss-provision allowance

	Unsecured loan share as percentage of total loans					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Log LLP allowance to NPL	0.0221*	0.0216*	0.0231*	0.0207*	0.0199*	0.0248**
	(0.0129)	(0.0125)	(0.0133)	(0.0107)	(0.0102)	(0.0102)
NPL rate		-0.1056			-0.3535	
		(0.1685)			(0.3360)	
Loan growth		0.0209			0.0189	
		(0.0164)			(0.0182)	
Asset growth			-0.0004			-0.0576
			(0.0426)			(0.0492)
Deposit growth			0.0256			0.0840
			(0.0446)			(0.0525)
Book value per share				0.0011	0.0012	0.0011
				(0.0023)	(0.0025)	(0.0024)
Capital adequacy ratio				0.0029	0.0011	0.0006
				(0.0031)	(0.0036)	(0.0036)
Equity/total assets				0.0026	0.0026	0.0028
				(0.0019)	(0.0020)	(0.0021)
Loan-to-deposit ratio				0.0356	0.0312	0.0581
				(0.0872)	(0.0933)	(0.0898)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Group/Obs	32/298	32/294	32/293	32/292	32/289	32/288
Overall R-sqr	0.0065	0.0061	0.0071	0.0002	0.0016	0.0050
F-stats (P-value)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: *** denotes 1%, ** denotes 5%, * denotes 10% significance.

All reported standard errors are robust standard errors.

Table 2: Benchmark calibrated parameter values

Parameter	Definition	Value
Households		
β	Household's discount factor	0.994
ϑ_H	Housing preference	0.03
Production		
φ	inverse of LTV ratio	1/0.6
δ^E	Capital depreciation rate	0.05
α	Labor income share	0.5
$\Theta_{E,K}$	Capital adjustment cost parameter	5
Banking & policy		
ζ	elasticity, productivity wrt uncertain capacity	0.1
Ω_0^C	steady-state LLP ratio, secured loan	0.136
Ω_0^U	steady-state LLP ratio, unsecured loan	0.136
μ	Reserve requirement ratio	0.125
ι	elasticity, LLP individual assessment	0.1
Υ_C	security loan share in LLP	0.75
$\tilde{\eta}^C = \tilde{\eta}^U$	steady state probability of default	0.05

Table 3: Summary statistics for prior and posterior distribution of parameters

Parameter	Prior distribution			Posterior	
	Distribution	Mean	Std	Mean	Std
Structural Parameters					
ς_N	Normal	3.0	0.10	2.1802	0.0961
ϑ_C	Gamma	0.5	0.01	0.5729	0.0843
ϑ_M	Gamma	0.5	0.01	0.5000	0.0101
ϑ_κ	Gamma	0.0025	0.0001	0.0025	0.0001
ϕ_R	Beta	0.7	0.01	0.6969	0.0096
F	Beta	0.1	0.01	0.1177	0.0563
Ξ	Beta	0.5	0.1	0.0299	0.0202
ϖ	Beta	0.67	0.05	0.0953	0.0096
τ_m	Normal	-0.65	0.05	-0.7409	0.0416
τ_Y	Normal	0.3	0.01	0.2901	0.0099
Shock Persistence Parameters					
ρ_A	Beta	0.5	0.2	0.8454	0.0246
ρ_C	Beta	0.5	0.2	0.9389	0.0087
ρ_H	Beta	0.5	0.2	0.7048	0.1957
ρ_K	Beta	0.5	0.2	0.2732	0.0758
ρ_R	Beta	0.5	0.2	0.7429	0.0407
ρ_π	Beta	0.5	0.2	0.9716	0.0035
ρ_G	Beta	0.5	0.2	0.9701	0.0098
ρ_m	Beta	0.5	0.2	0.5758	0.0580
Shock Standard Deviation Parameters					
$100\sigma_A$	Inv. gamma	0.1	2	0.0385	0.0044
$100\sigma_C$	Inv. gamma	0.1	2	0.1615	0.0140
$100\sigma_H$	Inv. gamma	0.1	2	0.0092	0.0081
$100\sigma_K$	Inv. gamma	0.1	2	0.2764	0.0244
$100\sigma_R$	Inv. gamma	0.1	2	0.3801	0.0326
$100\sigma_\pi$	Inv. gamma	0.1	2	0.2788	0.0301
$100\sigma_G$	Inv. gamma	0.1	2	0.0319	0.0029
$100\sigma_M$	Inv. gamma	0.1	2	0.0150	0.0015

Table 4: Variance decomposition

	Productivity	Preference	Investment	LLP	Inflation	Fiscal policy	Monetary policy
Consumption, C_t	13.4	54.5	23.5	3.5	3.6	1.4	0.1
Final good, Y_t	27.0	7.6	34.0	15.7	15.4	0.0	0.2
Final good with unsecured loans, $Y_t^{E,U}$	24.0	6.8	37.3	14.8	16.8	0.0	0.3
Final good with collateralized loans, $Y_t^{E,C}$	27.4	7.5	33.9	15.6	15.4	0.0	0.2
Threshold capacity level, κ_t^C	5.9	0.1	60.4	4.2	28.6	0.0	0.8
Capital with unsecured loans, $K_t^{E,U}$	8.5	44.1	30.9	6.4	10.0	0.2	0.0
Capital with collateralized loans, $K_t^{E,C}$	8.2	44.2	31.2	6.4	9.8	0.2	0.0
Unsecured loans, $L_t^{E,U}$	5.1	0.2	46.3	23.9	23.8	0.0	0.6
Collateralized loans, $L_t^{E,C}$	5.1	0.2	44.9	25.9	23.4	0.0	0.6
Unsecured/collateralized ratio, ω_t^{Loan}	5.9	0.1	60.4	4.2	28.6	0.0	0.8
Loan loss reserves, LR_t	1.0	0.5	3.9	90.0	4.5	0.0	0.1
Loan loss provision, LP_t	2.7	0.2	19.8	66.6	10.3	0.0	0.3
LLP for unsecured loans, $LP_t^{E,U}$	29.3	0.2	45.0	3.3	21.7	0.0	0.6
LLP for collateralized loans, $LP_t^{E,C}$	5.4	0.5	44.6	25.3	23.5	0.0	0.6
Default rates for collateralized loans, η_t^C	6.9	10.7	38.7	19.4	23.5	0.1	0.7
Default rates for unsecured loans, η_t^U	2.3	0.2	41.9	32.5	22.5	0.0	0.6
Collateralized loan rate, $i_{t,C}^{L,C}$	4.2	0.2	46.0	26.1	22.8	0.0	0.6
Unsecured loan rate, $i_{t,U}^{L,U}$	4.1	0.2	44.9	27.7	22.4	0.0	0.6
Bank profit, $\frac{\Pi_{t+1}^B}{P_t}$	2.7	0.2	19.6	67.0	10.2	0.0	0.3
Inflation, $\hat{\pi}_t$	15.0	0.5	55.0	9.6	17.8	0.0	2.0
Money supply, m_t	4.3	6.6	24.4	7.2	57.1	0.3	0.1
Note: An eighth structural shock, Housing Demand shock, is included in the model to meet the Blanchard-Quah condition for identification required for model estimation, which is based on 7 actual time series data.							

Table 5: Optimality analysis results: different degree of dynamic provisioning

	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
F	0.020284	0.021196	0.022012	0.022688	0.023164	0.02336*	0.02316	0.022408	0.020874	0.01823	0.013987
W	66.51711	66.52143	66.52614	66.53127	66.53691	66.54314	66.55008	66.55786	66.56668	66.57677	66.58849
U-C ratio											