Emerging Markets Review 55 (2023) 100964

Contents lists available at ScienceDirect

Emerging Markets Review

journal homepage: www.elsevier.com/locate/emr

Does bank efficiency affect the bank lending channel in China?☆

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ARTICLE INFO

JEL:
E52
G21

Keywords:
Chinese banks
Monetary policy
Bank efficiency
Bank lending channel

ABSTRACT

This work examines the impact of bank efficiency on the bank lending channel in China. Using a sample of 148 Chinese banks over the period 2006–2017, we investigate how the reaction of the loan supply to monetary policy actions depends on a bank's efficiency. We find limited evidence that bank efficiency hampers the effectiveness of monetary policy transmission. In addition, bank efficiency does favor the transmission of monetary policy for banks with low loan-to-deposit ratios. These results suggest that bank efficiency may influence the bank lending channel in certain cases.

1. Introduction

Bank lending channel is crucial for the monetary policy transmission. Through this channel monetary policy influences the supply of bank loans due to the imperfect substitutability between bank lending and bonds. An easing of monetary policy, for example, reduces the opportunity cost of holding deposits, causing an increase in bank lending in line with the enhancement of funding sources, and thereby incentivizes banks to expand their loan supply. How a particular bank behaves depends on certain characteristics already investigated in the relevant literature including its size, capitalization and liquidity (Kashyap and Stein, 1995, 2000).

In this paper we aim to examine the possible role the bank's level of efficiency plays in the transmission of monetary policy through the bank lending channel.[1] Two competing hypotheses can be offered to explain how bank efficiency affects the transmission of monetary policy.

According to the first hypothesis, increased bank efficiency *improves* the effectiveness of monetary policy, i.e. the lending of efficient banks is more sensitive to changes in monetary policy. As changes in monetary policy influence the cost of funding for banks, efficient banks transmit policy best.

Under the second hypothesis, increased bank efficiency *hampers* the transmission of monetary policy. Because efficient banks have better access to alternative funding sources than their less efficient counterparts, they are less sensitive to shifts in monetary policy. Specifically, access to alternative funding sources is dependent on individual bank characteristics that include efficiency, an attribute associated with good bank management.

☆ For valuable comments and suggestions we thank Iikka Korhonen, Juuso Kaaresvirta and Riikka Nuutilainen, as well as participants of the BOFIT online seminar in Helsinki (January 2021).

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[1] We consider the role of bank efficiency in addition to the bank characteristics that have already been studied in the literature (bank size, capitalization and liquidity) and thus bank efficiency is complementing these variables.

https://doi.org/10.1016/j.ememar.2022.100964
Received 13 August 2021; Received in revised form 12 August 2022; Accepted 14 September 2022
Available online 19 September 2022

Somewhat surprisingly, the role of bank efficiency in the transmission of monetary policy has been largely overlooked in the literature. The important exception, the study of Jonas and King (2008), examines how bank efficiency influenced the transmission of monetary policy in the US between 1983 and 2005. It backs the first hypothesis, concluding that greater bank efficiency fosters effective transmission of monetary policy.

While this question to our best knowledge has not been investigated in other frameworks, the implications of bank efficiency should be particularly interesting in China's case. Numerous studies note China's low bank efficiency relative to Western countries (e.g. Berger et al., 2009; Fungáčová et al., 2013), which raises the possibility that the low efficiency of Chinese banks may affect the effectiveness of monetary policy transmission.

In this investigation of the influence of bank efficiency on the transmission of monetary policy in China, we analyze the reaction of loan supply to monetary policy actions using the methodology of Kashyap and Stein (1995, 2000), an approach often used in studies of the bank lending channel (e.g. Ferri et al., 2014; Fungáčová et al., 2014). By interacting bank characteristics, including bank efficiency, with monetary policy indicators in an equation explaining loan growth, we identify how various kinds of banks react to shifts in monetary policy. Bank efficiency is measured with the same stochastic frontier approach applied to estimate efficiency scores of Chinese banks in e.g. Berger et al. (2009), Dong et al. (2016), and Fungáčová et al. (2020). We consider cost efficiency, measuring the difference between bank's actual cost and its optimal cost when producing the same bundle of outputs. We complement Bankscope (2006–2015) and Fitch (2016–2017) bank-level financial statement data of Chinese banks with hand-collected data taken from annual reports of individual banks posted online.

This paper confirms the findings of many studies concerning a bank lending channel in China (e.g. Gunji and Yuan, 2010; Nguyen and Boateng, 2013; Chen et al., 2018; Cheng and Wang, 2020). Our first contribution to the literature, however, is that we go beyond the widely scrutinized effectiveness of monetary policy instruments on the bank lending channel to consider how bank efficiency affects the transmission of monetary policy. Unlike many of the previous studies our dataset does not only focus on listed banks and consists of 148 individual banks for the years 2006 to 2017. It covers the bulk of Chinese banking sector assets.

The second contribution of this study is its analysis of Chinese bank efficiency. Numerous papers have studied the level of efficiency of Chinese banks with a focus on differences in efficiency between bank types and their evolution over time (Chen et al., 2005; Fu and Heffernan, 2007; Ariff and Can, 2008; Berger et al., 2009; Zhang et al., 2013; Fungáčová et al., 2013; Dong et al., 2016; Fang et al., 2019; Fungáčová et al., 2020). We extend this literature by analyzing how the level of efficiency of a bank affects monetary policy transmission to shed light on the macroeconomic consequences of bank efficiency in China.

The rest of the article is structured as follows. Section 2 describes Chinese monetary policy. Section 3 discusses the data. Section 4 develops the methodology. Section 5 presents the findings. Section 6 concludes.

2. Monetary policy in China

China's monetary policy framework is different from those of advanced economies in many aspects (Huang et al., 2020). First, the People's Bank of China (2012) is not independent but practices monetary policy under the leadership of the State Council and the Monetary Policy Committee plays an advisory role at best. Among different monetary policy instruments, it seems that PBoC has somewhat more discretion over the reserve requirement ratio (Ma et al., 2013).

Moreover, while the sole objective of monetary policy specified under Chinese law is maintaining exchange rate stability to foster economic growth, the government simultaneously pursues multiple monetary policy agendas. Among other things, the PBoC is tasked with maintaining price stability, boosting economic growth, promoting employment, and broadly maintaining the balance of payments (Zhou, 2016). Finally, quantitative instruments dominate the monetary toolkit even if China's monetary framework has been migrating slowly toward price-based policies.

After abolition of credit plans in 1998, the PBoC moved from direct credit control with quotas for credit and cash toward indirect control of liquidity. As the Chinese financial system was dominated by commercial banks, bank credit and money supply, which were seen to reflect underlying economic conditions, became the main intermediate targets of monetary policy (Huang et al., 2020).

During the 2010s, the regulation in the banking sector was strengthened as Chinese authorities introduced macroprudential policies (Sun, 2019). This shifted money creation toward non-traditional channels. Real estate and other sectors suffering from excess capacity were targeted with specific credit regulations. Banks moved away from traditional lending to shadow banking instruments designed to meet the financing needs of real estate developers and local government financing vehicles (Sun, 2019).

Unlike in advanced economies, Chinese shadow banking system is primarily bank-based. Fig. 1 shows that banks' shadow activities[2] took off in the fourth quarter of 2011, rising from CNY 7.2 trillion to nearly CNY 50 trillion over the next five years. By 2017, banks' shadow activities accounted for 30% of total money creation. Traditional shadow banking (i.e. credit creation by non-bank financial institutions) also soared to CNY 28 trillion over the same period. This surge in rapid money creation outside traditional bank lending poses a variety of challenges for monetary policymakers (Sun, 2019).

Perhaps the best-known quantitative tool in the PBoC's extensive monetary policy toolkit is the required reserve ratio (RRR). The PBoC began to engage in frequent adjustment of RRRs around 2005–2006 (Huang et al., 2020).[3] Provided that a bank had no reserves

[2] Sun (2019) defines *banks' shadow* as banks' money creation through accounting treatments that generate liabilities from assets, whereas *traditional shadow banking* refers to credit creation by non-bank financial intermediaries through money transfer. As both provide funding to the real sector, only banks' shadow activities create new supply of money and affect the intermediate monetary policy objective.

[3] Other quantitative tools include e.g. central bank bills, central bank lending, and use of treasuries on open market operations (OMOs).

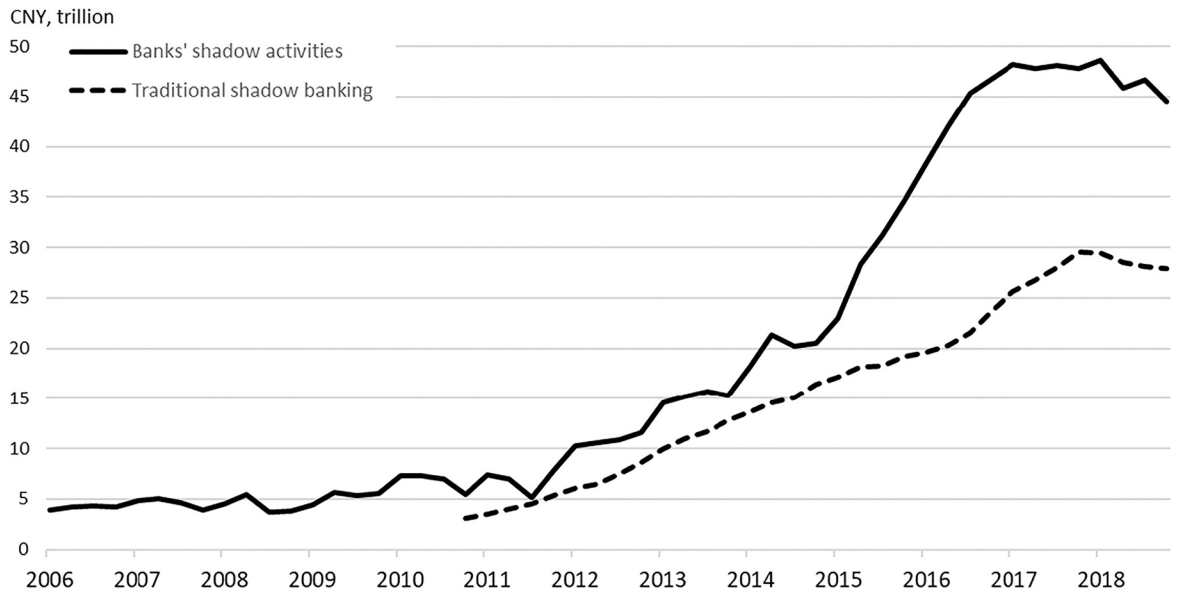

Fig. 1. Development of traditional shadow banking and the shadow activities of banks. (Source: Sun, 2019).

in excess of the required amount, any increase in a bank's RRR diminished its lending capacity. In 2008, the central bank began to differentiate between large banks and small and medium-sized banks.[4] Notably, the RRRs of small and medium-sized banks have remained consistently lower than those of large banks since 2009 (Fig. 2).

The weighted average of borrowing rates among banks, the China Interbank Offered Rate (CHIBOR), was established in 1996 together with a unified interbank lending market. Interbank lending terms range from overnight to four months, the most liquid being the overnight and one-week maturities. Bank deposit and lending rates were largely regulated throughout our estimation period. The PBoC sets benchmark deposit and lending rates for domestic currency deposits and loans of different maturities. In 2004, the PBoC removed lending rate ceiling and deposit rate floor, so banks were given permission to freely adjust lending rates upward and deposit rates downward from the benchmark rate. The 2013 liberalization of lending rates was followed by a liberalization of deposit rates in 2015. Even with the removal of interest-rate ceilings and floors, however, rates remain largely regulated through measures such as PBoC "window guidance" and advisories from regulatory bodies (Huang et al., 2020) (see Fig. 3).

The Chinese banking sector is dominated by four massive state-owned commercial banks: the Bank of China, the China Construction Bank, the Industrial and Commercial Bank of China, and the Agricultural Bank of China. These four banks are also the world's largest banks measured by total assets.[5] Adding in the Bank of Communications, we fill out the complement of China's giant state banks, the so-called "Big Five." While these large banks provide nationwide wholesale and retail services, they focus on serving state-owned enterprises (SOEs). According to the China Banking and Insurance Regulatory Commission (CBIRC), Big Five assets represented 37% of total banking sector assets at the beginning of 2018. At that same time, the twelve joint-stock commercial banks providing nationwide banking services accounted for 18% of the total banking sector assets.

City commercial banks and rural commercial banks operate regionally. City commercial banks (134 in 2017) were originally established to carry out local government lending operations. Some are still owned by local governments. These banks are important in that they finance small and medium- sized enterprises (SMEs). In addition to the several hundred rural commercial banks that mainly serve rural communities and businesses, China has around 2000 small rural cooperative banks, rural credit cooperatives, or village and township banks.

Foreign banks (39 in 2017) are generally allowed to offer the same services as domestic banks, but their market share (and hence importance) has remained small. The value of total bank assets of the Chinese banking sector increased from USD 5.1 trillion in 2006 to USD 31 trillion in 2017. The total number of banking institutions was around 4500 in 2017. The Big Five, joint-stock commercial banks, and city commercial banks accounted for the majority of sector assets, even if they were vastly outnumbered by small and medium-sized banks.

[4] Further, in 2011, the PBoC introduced a "dynamically differentiated RRR" scheme where RRRs can be adjusted individually based on e.g. banks' credit portfolios, soundness, and systemic importance (Fungáčová et al., 2016).

[5] Based on S&P Global Market Intelligence's annual global bank ranking for 2019.

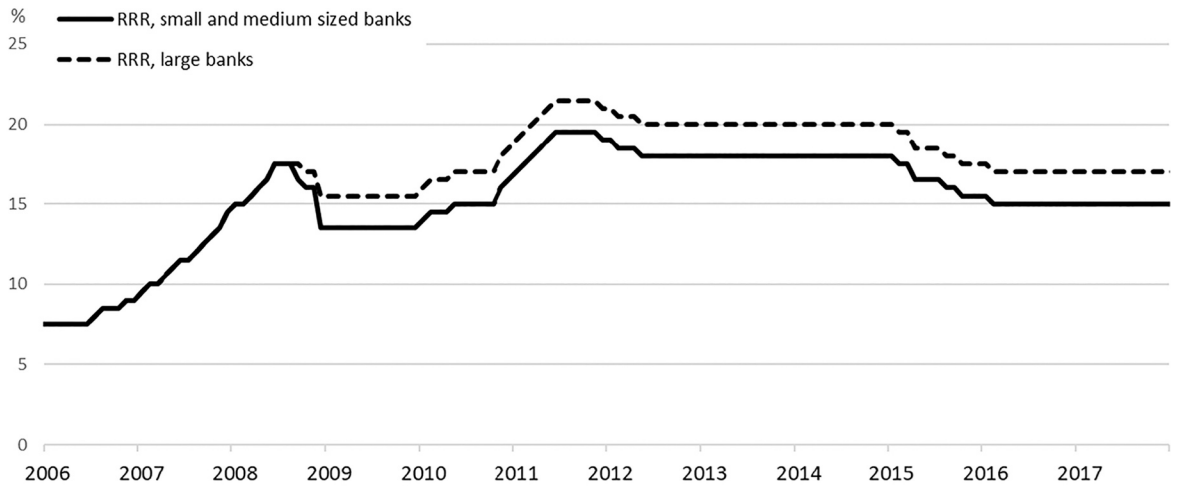

Fig. 2. China began to differentiate among banks in application of the required reserve ratio, or RRR, in 2008 (Sources: PBoC and Macrobond).

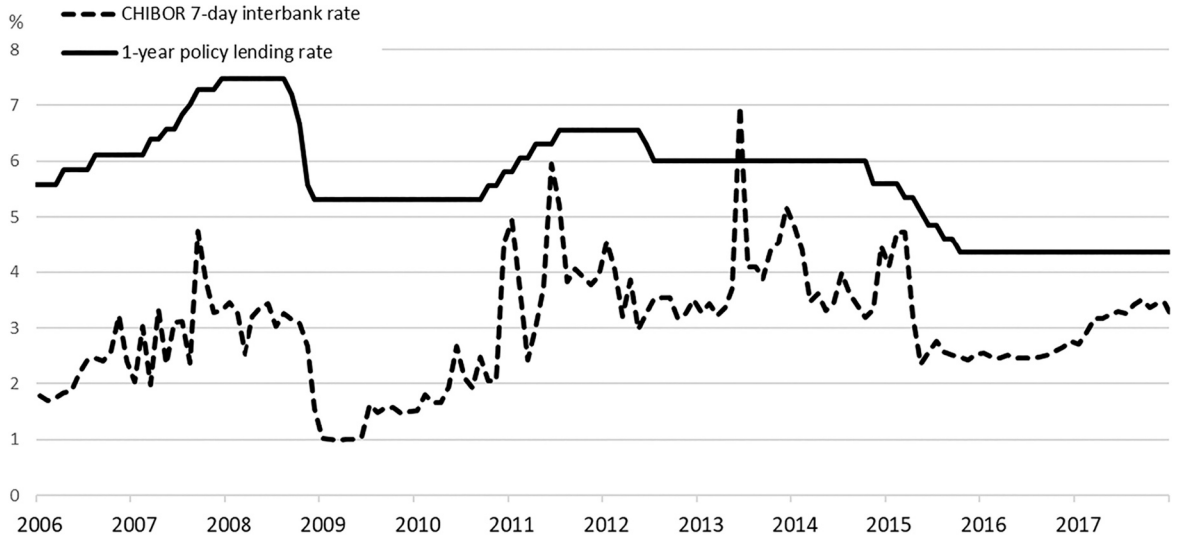

Fig. 3. 7- day CHIBOR interbank rate and 1-year policy lending rate, 2006–2018. (Sources: PBoC and Macrobond.)

3. Data and methodology

3.1. Data

We use bank-level financial statement data that has been compiled by Bankscope, a database maintained by Bureau Van Dijk.[6] For years 2016 and 2017 we complement them with data by Fitch. We further fill in the missing variables in these statements with hand-collected data from the annual reports of individual bank posted on their websites. Thus, our dataset is an unbalanced panel covering 165 individual Chinese banks for the period 2006–2017. Data limitations on input and output costs when computing an efficiency score (our main variable of interest) together with some missing values for control variables enable us to include 148 banks in the main estimations.

Descriptive statistics of the main variables are presented in Table 1. The average bank in our dataset has total assets of CNY 935 billion. Bank size varies substantially across bank groups. Each Big Five bank on average has nearly CNY 12 trillion in total assets. Foreign banks are smallest, with an average of CNY 58 billion in total assets. Throughout our estimation period, city commercial and joint-stock commercial banks experience the strongest loan growth and foreign banks the weakest. Foreign banks, however, are much

[6] Bankscope database does not exist anymore and the last available data are for 2015.

Table 1
Descriptive statistics.

All banks					
Variable	# of obs	Mean	Std.dev.	Min	Max
Loan growth	1168	0,170	0,261	−3489	3475
Total assets (CNY bln)	1274	935,4	2984	0,127	26,100
Capitalization	1274	0,090	0,077	0,005	0,914
Liquidity	983	0,286	0,148	0,031	0,938
Share of state ownership	1281	0,272	0,261	0,000	1000
Loan to deposit ratio	1259	0,764	0,746	0,000	11,229
Efficiency score	888	0,875	0,095	0,103	0,980
Efficiency score (2nd approach)	873	0,271	0,129	0,102	1000
Efficiency score (3rd approach)	888	0,666	0,133	0,372	0,987
Change in policy rate	1196	−0,162	0,708	−1733	0,958
Change in CHIBOR 1w	1196	0,102	0,961	−1728	1835
Change in RRR	1196	0,523	2071	−1750	4625
GDP growth	1196	0,082	0,017	0,065	0,133
Regulation	1281	−0,233	0,047	−0,289	−0,147
Shadow banking growth	1281	0,273	0,199	−0,047	0,584
Big Five Banks					
Variable	# of obs	Mean	Std.dev.	Min	Max
Loan growth	54	0,131	0,069	−0,114	0,399
Total assets (CNY bln)	60	11,900	6135,9	1719,5	26,100
Capitalization	60	0,065	0,014	0,015	0,082
Liquidity	56	0,193	0,067	0,073	0,309
Share of state ownership	60	0,641	0,193	0,122	100,000
Loans to deposit ratio	60	0,691	0,088	0,508	0,904
Efficiency score	60	0,860	0,073	0,395	0,930
Efficiency score (2nd approach)	60	0,219	0,048	0,114	0,290
Efficiency score (3rd approach)	60	0,397	0,022	0,372	0,438
Joint-stock commercial banks					
Variable	# of obs	Mean	Std.dev.	Min	Max
Loan growth	122	0,206	0,117	0,089	0,888
Total assets (CNY bln)	132	1951,8	1711,9	15,3	6416,8
Capitalization	132	0,055	0,027	0,005	0,313
Liquidity	117	0,273	0,110	0,065	0,500
Share of state ownership	132	0,382	0,252	0,000	0,931
Loans to deposit ratio	132	0,747	0,098	0,501	1383
Efficiency score	114	0,900	0,031	0,747	0,952
Efficiency score (2nd approach)	114	0,244	0,064	0,106	0,415
Efficiency score (3rd approach)	114	0,578	0,038	0,544	0,689
City commercial banks					
Variable	# of obs	Mean	Std.dev.	Min	Max
Loan growth	588	0,215	0,175	−0,120	3244
Total assets (CNY bln)	635	144,2	231,8	0	2329,8
Capitalization	635	0,069	0,023	0,017	0,308
Liquidity	505	0,271	0,131	0,039	0,729
Share of state ownership	639	0,345	0,242	0,000	0,994
Loans to deposit ratio	627	0,624	0,148	0,210	2886
Efficiency score	443	0,874	0,082	0,371	0,980
Efficiency score (2nd approach)	434	0,232	0,067	0,102	0,508
Efficiency score (3rd approach)	443	0,660	0,076	0,397	0,888
Rural commercial banks					
Variable	# of obs	Mean	Std.dev.	Min	Max
Loan growth	112	0,142	0,064	0,011	0,346
Total assets (CNY bln)	125	152,6	297,3	0,207	4654,8
Capitalization	125	0,073	0,017	0,005	0,107
Liquidity	105	0,223	0,101	0,031	0,437
Share of state ownership	125	0,211	0,190	0,000	0,799
Loans to deposit ratio	120	0,673	0,094	0,466	1201
Efficiency score	92	0,894	0,073	0,494	0,966
Efficiency score (2nd approach)	92	0,238	0,064	0,108	0,412
Efficiency score (3rd approach)	92	0,693	0,084	0,521	0,895

(*continued on next page*)

Table 1 (*continued*)

All banks					
Foreign banks					
Variable	# of obs	Mean	Std.dev.	Min	Max
Loan growth	282	0,081	0,443	−3489	3475
Total assets (CNY bln)	310	58,1	91,1	0,109	808,9
Capitalization	310	0,164	0,125	0,032	0,914
Liquidity	189	0,403	0,186	0,087	0,938
Share of state ownership	313	0,334	0,096	0,000	0,389
Loans to deposit ratio	308	1013	1224	0,000	11,229
Efficiency score	174	0,856	0,150	0,130	0,975
Efficiency score (2nd approach)	168	0,404	0,174	0,131	1000
Efficiency score (3rd approach)	174	0,808	0,131	0,399	0,985

This table reports descriptive statistics for all the variables used in the estimations. *Capitalization* is bank's equity to total assets. *Liquidity* is the ratio of liquid assets to total assets. *Efficiency* is the efficiency score calculated for each bank using the stochastic frontier approach described in Section 3.2. *Efficiency score (2nd approach)* is the efficiency score calculated as described in Section 4.5. *Efficiency score (3rd approach)* is the efficiency score calculated based on the approach by Karakaplan and Kutlu (2017) described in Section 4.5. *State share* is the share of the bank owned by state. *GDP growth* is year-on-year growth of real GDP. *Regulation* stands for regulatory quality indicator by World Bank. *Shadow banking growth* is measured as the year-on-year growth of banks' shadow assets, as described in Sun (2019) and shown by Fig. 1.

better capitalized and tend to have more liquid assets than other bank groups. For the overall time period on average, joint-stock commercial banks are the most efficient, followed closely by rural commercial banks. In the regressions, all bank-specific variables are normalized with respect to the full sample mean.

As discussed, there is no single measure for the monetary policy stance as the PBoC employs a large monetary toolkit. Thus, we narrow our examination to changes in three key monetary policy measures: the annual average 7-day interbank rate (CHIBOR[7]), the annual average 1-year policy lending rate, and the annual average required reserve ratio (RRR) across bank types. We use the yearly changes of these variables in the estimations to proxy changes in the monetary policy stance. The data are taken from PBoC publications and Macrobond.

In the estimations we distinguish five different types of banks: Big Five banks, joint-stock commercial banks, city commercial banks, rural commercial banks and foreign banks. This division follows the classification by China Banking and Insurance Regulatory Commission (CBIRC).

3.2. Bank efficiency

Cost efficiency measures the difference between a bank's actual cost and its optimal cost for producing the same bundle of outputs. This difference gives information on production inefficiencies and the optimality of the chosen mix of inputs. Frontier efficiency techniques provide several approaches to estimate cost efficiency and allow estimation of the efficiency frontier on which the optimal cost is provided for each level of output.

We use the stochastic frontier approach widely adopted in the literature, which includes several works on Chinese banks (e.g. Berger et al., 2009; Fu and Heffernan, 2007; Fungáčová et al., 2013; Fang et al., 2019). This approach decomposes the distance from the efficiency frontier into an inefficiency term and a random error, which represents random disturbances reflecting luck or measurement errors. We assume a normal distribution for the random error and a half-normal distribution for the inefficiency term.

In addition to the fact that the stochastic frontier approach is commonly used in the recent literature on efficiency of Chinese banks, we prefer this approach rather than the Data Envelopment Analysis (DEA) because this latter method considers that the whole distance from the efficiency frontier is inefficiency. Consequently, the adoption of DEA presents the risk of overestimating inefficiency. This risk is particularly important when the sample is not very large as it is in our case.

In line with former literature (Berger et al., 2009; Fungáčová et al., 2013), we adopt the intermediation approach for the specification of banking inputs and outputs. This approach assumes that the bank collects deposits to transform them into loans with capital and labor. We consider two outputs in the cost function: loans and investment assets. We use three input prices: the price of funds calculated as the interest rate paid on borrowed funds, the price of labor defined as personnel expenses divided by total assets, and the price of physical capital calculated as the ratio of other operating expenses to fixed assets. Total cost is the sum of the costs incurred for borrowed funds, labor, and physical capital. We employ the commonly used translog form to model the cost frontier of banks. The cost frontier is estimated as follows:

[7] Being a market-based rate, CHIBOR differs from the other two measures in that it is not directly controlled by the central bank. However, CHIBOR reflects changes in the monetary policy and is thus a commonly used measure of the monetary policy stance.

$$ln\left(\frac{TC}{w_3}\right) = \beta_0 + \sum_m \alpha_m ln y_m + \sum_n \beta_n ln\left(\frac{w_n}{w_3}\right) + \frac{1}{2}\sum_m\sum_j \alpha_{mj} ln y_m ln y_j + \frac{1}{2}\sum_n\sum_k \beta_{nk} ln\left(\frac{w_n}{w_3}\right) ln\left(\frac{w_k}{w_3}\right) + \sum_n\sum_m \gamma_{nm} ln\left(\frac{w_n}{w_3}\right) ln y_m + u + v \quad (1)$$

where TC is total cost, y_m is the m^{th} bank's output (m = 1, 2), w_n is the n^{th} input price ($n = 1, 2$), w_3 is the price of borrowed funds, u the inefficiency term, and v the random error. For simplicity of presentation, the indices for each bank are dropped. Homogeneity conditions are imposed by normalizing total costs and prices of labor and physical capital by the price of borrowed funds. The model is estimated for all years so that we estimate a common cost frontier over the entire observation period. We include time dummy variables in the cost frontier. Table 2 shows this estimation.

Furthermore, Table 3 presents the computed annual efficiency scores for all banks and each bank group separately. Looking first at the full sample, efficiency on average decreases during global financial crisis and increases thereafter. For all banks on average, efficiency is higher at the end of our estimation period compared to 2006. This is true for joint-stock commercial banks, city commercial banks, and rural commercial banks. Rural commercial banks, in particular, increase their efficiency most during the estimation period. In contrast, the Big Five banks clearly become less efficient.

3.3. Methodology

In order to investigate whether bank efficiency affects the lending channel in China, we rely on the methodology developed by Kashyap and Stein (1995, 2000), commonly used in the literature focusing on monetary policy transmission through bank lending. They suggest that if the lending view is correct, one should expect loan portfolios of banks with different characteristics to respond differently to changes in monetary policy stance. The estimated equation has the form:

Table 2
Stochastic cost frontier regression.

Variable	Coefficient
Ln(output: loans)	1.068***
	(0.094)
Ln(output: other earning assets)	0.111
	(0.083)
Ln(input: price of labor / price of borrowed funds)	0.438***
	(0.057)
Ln(input: price of capital / price of borrowed funds)	0.275***
	(0.065)
$Ln(loans)^2$	0.147***
	(0.015)
$Ln(other\ earning\ assets)^2$	0.170***
	(0.011)
Ln(loans x other earning assets)	−0.329***
	(0.025)
$Ln(price\ of\ labor/\ price\ of\ borrowed\ funds)^2$	0.247***
	(0.017)
$Ln(price\ of\ capital/\ price\ of\ borrowed\ funds)^2$	−0.048***
	(0.007)
Ln(loans x price of labor)	0.062***
	(0.016)
Ln(loans x price of capital)	−0.058***
	(0.012)
Ln(other earning assets x price of labor)	−0.030*
	(0.016)
Ln(other earning assets x price of capital)	0.049***
	(0.010)
Constant	0.070
	(0.363)
Usigma	−4.534***
	(0.168)
Vsigma	−3.800***
	(0.071)
Observations	1124
Number of banks	169

This table shows the estimation of cost frontier for the banks based on the Eq. (1). Definition of the variables is provided in the methodological section. Time dummy variables are included but not reported. *, ** and *** denote an estimate significantly different from 0 at the 10%, 5% and 1% level, respectively.

Table 3
Efficiency scores.

Year	All banks			Big Five			Joint stock commercial banks			City commercial banks			Rural commercial banks			Foreign banks		
	#	Efficiency	Std.dev.	#	Efficiency	Std.dev.	#	Efficiency	Std.dev.	#	Efficiency	Std.dev.	#	Efficiency	Std.dev.	#	Efficiency	Std.dev.
2006	46	0.874	0.093	5	0.895	0.016	11	0.874	0.038	20	0.887	0.058	5	0.853	0.122	4	0.927	0.031
2007	77	0.851	0.150	5	0.898	0.022	11	0.904	0.037	37	0.854	0.110	7	0.880	0.076	16	0.812	0.249
2008	101	0.843	0.128	5	0.871	0.017	11	0.901	0.034	51	0.814	0.133	10	0.822	0.149	24	0.882	0.137
2009	106	0.864	0.108	5	0.906	0.008	11	0.913	0.024	57	0.845	0.110	10	0.915	0.029	23	0.855	0.143
2010	107	0.870	0.096	5	0.913	0.016	11	0.917	0.015	54	0.852	0.108	12	0.919	0.032	25	0.854	0.104
2011	119	0.859	0.114	5	0.767	0.219	11	0.903	0.055	59	0.850	0.105	13	0.906	0.044	31	0.857	0.135
2012	103	0.880	0.078	5	0.856	0.023	12	0.896	0.017	44	0.871	0.083	14	0.910	0.035	28	0.877	0.103
2013	91	0.873	0.101	5	0.856	0.043	10	0.907	0.016	44	0.886	0.049	12	0.810	0.147	19	0.867	0.164
2014	127	0.880	0.088	5	0.830	0.033	11	0.982	0.024	60	0.880	0.069	17	0.910	0.185	32	0.866	0.141
2015	86	0.899	0.033	5	0.844	0.029	8	0.895	0.022	51	0.898	0.034	20	0.911	0.191	1	0.936	.
2016	86	0.897	0.034	5	0.841	0.024	8	0.900	0.024	50	0.895	0.034	21	0.907	0.024	1	0.936	.
2017	77	0.897	0.033	5	0.842	0.018	7	0.904	0.021	43	0.897	0.032	20	0.904	0.024	1	0.923	.

This table reports efficiency scores for different types of Chinese banks. The efficiency scores are calculated for each bank using a stochastic frontier approach described in Section 3.2.

$$\Delta log\left(L_{i,t}\right) = \alpha_i + \beta_i \Delta MP_t + \gamma_i Macro_t + \delta_i X_{i,t-1} + \theta_i X_{i,t-1} \Delta MP_t + \varepsilon_{it} \quad (2)$$

where L denotes total loans to private sector by bank i at time t, ΔMP denotes change in the monetary policy measure, and *Macro* is a set of macroeconomic variables including ΔGDP (real GDP growth) and *Regulation* (regulatory index[8]). X_i are the bank-specific variables lagged by one period to overcome possible endogeneity problems and α_i is the bank-specific fixed effect.[9]

As *MP*, we use three monetary policy measures[10]: the 7-day interbank rate (CHIBOR), the 1-year policy lending rate, and the average RRR of large and small and medium-sized banks. We always use the on-year change in the average measure. The bank-specific variables that the existing literature finds to have the greatest effects on loan supply are capitalization (equity to total assets), liquidity (liquid assets to total assets) and size (log of total assets). All these characteristics impact the access of banks to external funding and are reflected in their ability to issue lending. In addition to these three bank-specific variables, we include the efficiency score, our main variable of interest, estimated using a stochastic frontier approach. We also account for the bank ownership by including the variable *State share* defined as the share of the state in a bank. More formally, the five bank-specific variables are defined as:

$$Size_{it} = log(Total\ assets_{it}) - \frac{1}{N_t}\sum_i log(Total\ assets_{it})$$

$$Liquidity_{it} = \frac{Liquid\ assets_{it}}{Total\ assets_{it}} - \frac{1}{T}\sum_t\left(\frac{1}{N_t}\sum_i\left(\frac{Liquid\ assets_{it}}{Total\ assets_{it}}\right)\right)$$

$$Capitalization_{it} = \frac{Equity_{it}}{Total\ assets_{it}} - \frac{1}{T}\sum_t\left(\frac{1}{N_t}\sum_i\left(\frac{Equity_{it}}{Total\ assets_{it}}\right)\right)$$

$$Efficiency_{it} = Efficiency_{it} - \frac{1}{T}\sum_t\left(\frac{1}{N_t}\sum_i(Efficiency_{it})\right)$$

$$State\ share_{it} = State\ share_{it} - \frac{1}{T}\sum_t\left(\frac{1}{N_t}\sum_i(State\ share_{it})\right),$$

where $i = 1,\ldots,$ N denotes the bank and $t = 1,\ldots,$T the time (years). The bank-specific variables liquidity, capitalization, state share and efficiency are normalized with respect to their sample means. Variable size is normalized with respect to the sample mean for each period to remove any persistent upward trend in the value of total assets.

As monetary policy tightens (i.e. interest rates increase or RRR becomes larger), banks decrease the amount of loans supplied. We thus expect a negative coefficient β. The presence of the bank lending channel is identified when the parameter θ for the interactions of bank-specific characteristics (capitalization, liquidity, and size) and monetary policy indicator are significant and positive in line with the view that banks with a lower access to external funding (proxied by lower capitalization, liquidity, and size) are expected to react more to monetary policy variations.

As we lack access to loan-level data, we do not control for loan demand. Our approach merely assumes that all banks face the same loan demand proxied by GDP growth. We further make the safe assumption that lending growth in a given year does not impact lending growth the following year, allowing us to exclude any lagged value of the dependent variable. In order to account for the development of institutional environment in which the banks operate we include regulatory quality measure from the World Bank.[11] Following the approach of Fungáčová et al. (2014) used on annual euro area bank data, we estimate the equation in a standard fixed-effects panel regression framework.

4. Results

This section presents the results for the impact of bank efficiency on the transmission of monetary policy via the lending channel. After considering the main estimations, we focus on estimations for different types of banks. We continue by showing the estimations by separating banks based on their loan-to-deposit ratios, the estimations accounting for the period of shadow banking growth and end with a robustness test.

[8] We use measure of regulatory quality from World Bank. It captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

[9] We also estimate the main estimations using GMM and our results do not change. The estimations are available upon request.

[10] China's monetary policy framework differs from those of advanced economies. Literature on monetary policy in China shows that China differs from other countries in the sense that PBC employs a variety of policy instruments and therefore it is not enough to consider one monetary policy indicator (see e.g. Fungáčová et al., 2016).

[11] We do not take into account variations in systemic risk during the Global Financial Crisis in the estimations since Chinese banks were not significantly hit by this event. Nivorozhkin and Chondrogiannis (2020) show that systemic risk has not increased for Chinese banks during that crisis.

4.1. Main estimations

In investigating the influence of bank efficiency on the transmission of monetary policy through the bank lending channel, we consider alternatively the three monetary policy instruments in Table 4.

Three specifications are presented for each instrument. We first provide the benchmark estimation for the bank lending channel without including efficiency and the interaction term between monetary policy and efficiency, i.e. the estimation only includes the usual specification of variables for the bank lending channel with capitalization, size, liquidity together with state ownership variable, and their interaction terms with monetary policy. We then add efficiency and the interaction term between monetary policy and efficiency but drop the four other interaction terms with monetary policy. Finally, we perform the estimation by including all variables. Both latter specifications should provide evidence on how bank efficiency influences the bank lending channel.

First, we observe that the effect of monetary policy changes on loan growth has the expected negative sign. The coefficients of all three monetary policy variables are significant and negative in all estimations, in line with the view that an increase (decrease) in reserve requirements or interest rates leads to a decrease (increase) in loan growth rate.

Second, we find no evidence supporting the existence of a bank lending channel in China. The bank lending channel predicts significantly positive coefficients for the interaction terms between monetary policy and capitalization, liquidity, and size. We do not observe such results. The coefficients for the monetary policy interactions terms are respectively significantly negative for capitalization and not significant for size in all estimations. The coefficient for the monetary policy interaction term with liquidity is only significantly positive in two specifications but not significant in the four others. These results are quite similar to those obtained by Fungáčová et al. (2016) for the bank lending channel in China. They also identify monetary policy interaction terms that are not significant with size and with liquidity, and significantly negative with capitalization.

Third, the monetary policy interaction term with bank efficiency is significant (and positive) in three estimations: in both specifications when reserve requirement ratio is used as proxy for monetary policy and in the specification excluding the monetary-policy interaction terms for the other bank-specific characteristics when benchmark policy rate is used as policy measure. We find no significant results in the remaining three specifications.

We therefore find limited support for the hypothesis that increased bank efficiency hampers the effectiveness of monetary policy. We tend to show that more efficient banks have a lower loan response to changes in monetary policy. We explain this finding by the better access of efficient banks to alternative funding sources. More efficient banks are less dependent on external funding sources for their financing needs and as such are less sensitive to monetary policy changes. In analyzing the other variables in our estimations, it is notable that well-capitalized, highly liquid, and small banks achieve higher loan growth. The coefficients of capitalization and liquidity are significant and positive while they are significant and negative for size in most estimations. Interestingly, efficient banks have lower loan growth, i.e. the coefficient of bank efficiency is significantly negative in all estimations. This result can appear surprising at first glance since the most efficient banks are expected to have the highest loan growth: being more efficient, they are able to propose lower loan rates and to attract more clients. This conclusion may indicate that lending in China often serves goals other than profit maximization. Lending decisions are not motivated only by market mechanisms in China. Consequently higher cost efficiency of a bank may not be associated with a greater loan demand, which can be satisfied by the bank. It can also occur that higher cost efficiency of a bank is not reflected in lower loan prices because of regulated prices or state interference.

4.2. Estimations by bank type

The Chinese banking industry is composed of several types of banks in terms of prevailing ownership, type of clients and areas of operations. Does the impact of bank efficiency on the transmission of monetary policy differ by bank type?

Several studies suggest that bank type can affect the reaction of banks to monetary policy. In the case of China, Fungáčová et al. (2016) find evidence that the impact of changes in reserve requirements on loan growth differs across types of banks. Looking at Indian banks, Bhaumik et al. (2011) show that ownership influences the reaction of banks to monetary policy. For the euro area, Ferri et al. (2014) find evidence that locally oriented banks that are more likely to engage in relationship lending and operate in a limited geographical area, are less sensitive to monetary policy shocks and more likely to smooth credit availability conditions for their customers. Similarly, Bertay et al. (2015) find that lending by publicly owned banks is less procyclical than lending by private banks. Wu et al. (2011) find consistent evidence that foreign-owned banks are less responsive to monetary shocks in host countries and adjust their loan portfolios and interest rates to a lesser extent than domestic private banks. It is therefore worth determining whether bank type influences how bank efficiency affects transmission of monetary policy.

To investigate this question, we redo our estimations by adding four interaction terms. We create dummy variables corresponding to five bank types: Big Five, joint-stock banks, city commercial banks, rural commercial banks, and foreign banks. We perform separate estimations by considering each bank type separately as the bank type dummy variable. We add an interaction term between monetary policy and bank type, as well as interaction variables between monetary policy, the five bank characteristics (capitalization, liquidity, size, state share, efficiency), and bank type. Since our focus is on bank efficiency, we perform two estimations for each bank type. The first specification includes only the interactions between bank efficiency and monetary policy, and efficiency together with monetary policy and bank type. The second specification includes interaction terms with all bank-specific variables (capitalization, liquidity, size, state share and efficiency). We can then check whether the interaction term between monetary policy, bank efficiency, and bank type is significant for a particular bank type. This variable informs us about how the influence of bank efficiency on the bank lending channel varies across bank types.

The results are reported in Tables 5 to 7 for reserve requirements, interbank rate, and benchmark policy rate respectively. We first

Table 4
Main estimations.

Monetary policy	Average of reserve requirements			CHIBOR 7-day interbank rate			1-year benchmark policy rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
MP	−0.020***	−0.019***	−0.019***	−0.025***	−0.029***	−0.028***	−0.037***	−0.044***	−0.042***
	(0.004)	(0.005)	(0.005)	(0.008)	(0.008)	(0.008)	(0.011)	(0.011)	(0.012)
Capitalization	2.037***	0.802***	1.019***	1.607***	0.776**	0.272	1.450***	0.783***	0.212
	(0.249)	(0.298)	(0.291)	(0.244)	(0.302)	(0.309)	(0.254)	(0.301)	(0.333)
Liquidity	0.337***	0.362***	0.259***	0.316***	0.324***	0.220**	0.422***	0.355***	0.303***
	(0.083)	(0.094)	(0.093)	(0.084)	(0.094)	(0.094)	(0.087)	(0.095)	(0.099)
Size	−0.086***	−0.067**	−0.049	−0.102***	−0.061*	−0.079**	−0.112***	−0.055	−0.059
	(0.029)	(0.034)	(0.034)	(0.029)	(0.035)	(0.034)	(0.031)	(0.035)	(0.039)
State share	−0.025	−0.031	−0.040	−0.039	−0.040	−0.048	−0.069	−0.038	−0.079
	(0.068)	(0.080)	(0.077)	(0.070)	(0.081)	(0.079)	(0.073)	(0.080)	(0.085)
MP*capitalization	−0.312***		−0.373***	−0.283**		−0.598***	−0.626***		−0.852***
	(0.053)		(0.063)	(0.116)		(0.130)	(0.155)		(0.185)
MP*liquidity	0.082***		0.004	0.071		−0.070	0.326***		0.075
	(0.029)		(0.035)	(0.060)		(0.067)	(0.093)		(0.114)
MP*size	−0.000		−0.002	0.000		−0.002	−0.004		−0.009
	(0.002)		(0.002)	(0.005)		(0.005)	(0.006)		(0.007)
MP*state share	−0.017		−0.008	−0.030		−0.034	−0.075*		−0.045
	(0.014)		(0.015)	(0.029)		(0.032)	(0.043)		(0.048)
GDP	2.472***	1.824***	1.623**	1.744***	1.394**	1.228**	1.947***	1.318**	1.300**
	(0.571)	(0.640)	(0.635)	(0.540)	(0.598)	(0.585)	(0.552)	(0.591)	(0.612)
Regulation	0.566***	0.536**	0.404*	0.284	0.249	0.091	0.389*	0.364*	0.266
	(0.201)	(0.219)	(0.215)	(0.191)	(0.204)	(0.205)	(0.200)	(0.208)	(0.215)
Efficiency		−0.629***	−0.592***		−0.461***	−0.462***		−0.446***	−0.458***
		(0.118)	(0.115)		(0.105)	(0.103)		(0.105)	(0.108)
MP*efficiency		0.106***	0.066*		0.066	−0.008		0.169*	0.148
		(0.035)	(0.036)		(0.071)	(0.075)		(0.099)	(0.111)
Observations	940	720	720	940	720	720	895	720	687
R-squared	0.196	0.142	0.204	0.153	0.123	0.173	0.175	0.130	0.166
Number of banks	165	148	148	165	148	148	157	148	142

This table shows results of fixed effects panel regressions as indicated in Eq. (2). The dependent variable is growth in bank lending. We report three model specifications for each of three monetary policy measures (*MP*): reserve requirements (average reserve requirements for large and small and mid-sized banks), 7-day interbank rate (CHIBOR) and 1-year policy lending rate. We use the on-year change in the average MP measure. *Capitalization* is bank's equity to total assets. *Liquidity* is the ratio of liquid assets to total assets. *Size* is the logarithm of bank's total assets. *Efficiency* is the efficiency score calculated for each bank using the using a stochastic frontier approach described in Section 3.2. *State share* is the share of the bank owned by state. All bank level variables are demeaned and lagged by one period. *Regulation* stands for regulatory quality indicator by World Bank. Standard errors clustered at bank level appear in brackets below estimated coefficients. *, **, *** denote an estimate significantly different from 0 at the 10%, 5%, and 1% level, respectively. Bank and year fixed effects are included.

Table 5
Estimations by ownership type with reserve requirements.

Bank type	Big Five		Joint stock		City commercial banks		Rural commercial banks		Foreign banks	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
MP	−0.019***	−0.019***	−0.020***	−0.019***	−0.021***	−0.016**	−0.020***	−0.020***	−0.014***	−0.018**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.008)	(0.005)	(0.005)	(0.005)	(0.007)
MP*type	0.014	−0.012	−0.004	−0.002	0.003	−0.006	0.021	0.024	−0.017*	0.022
	(0.016)	(0.259)	(0.012)	(0.041)	(0.007)	(0.010)	(0.013)	(0.032)	(0.010)	(0.021)
Capitalization	0.794***	1.012***	0.794***	1.006***	0.837***	1.019***	0.771***	1.024***	0.881***	0.943***
	(0.299)	(0.305)	(0.300)	(0.307)	(0.299)	(0.305)	(0.298)	(0.305)	(0.298)	(0.308)
Liquidity	0.358***	0.266***	0.364***	0.277***	0.360***	0.311***	0.368***	0.281***	0.334***	0.284***
	(0.095)	(0.099)	(0.095)	(0.099)	(0.095)	(0.100)	(0.094)	(0.099)	(0.095)	(0.099)
Size	−0.071**	−0.045	−0.067*	−0.043	−0.064*	−0.039	−0.069**	−0.041	−0.060*	−0.047
	(0.035)	(0.039)	(0.034)	(0.039)	(0.035)	(0.039)	(0.034)	(0.038)	(0.034)	(0.038)
State share	−0.036	−0.058	−0.033	−0.062	−0.030	−0.042	−0.030	−0.047	−0.036	−0.047
	(0.080)	(0.083)	(0.080)	(0.083)	(0.080)	(0.083)	(0.080)	(0.084)	(0.079)	(0.082)
Efficiency	−0.654***	−0.632***	−0.626***	−0.579***	−0.653***	−0.607***	−0.698***	−0.633***	−0.706***	−0.588***
	(0.121)	(0.126)	(0.118)	(0.122)	(0.118)	(0.123)	(0.122)	(0.126)	(0.120)	(0.128)
MP*capitalization		−0.401***		−0.382***		−0.404***		−0.364***		−0.152
		(0.070)		(0.068)		(0.079)		(0.066)		(0.166)
MP*liquidity		0.010		0.003		−0.002		0.004		0.011
		(0.036)		(0.039)		(0.051)		(0.036)		(0.043)
MP*size		−0.004		−0.001		−0.001		−0.002		−0.001
		(0.003)		(0.003)		(0.004)		(0.002)		(0.002)
MP*state share		−0.012		−0.015		−0.035		−0.010		0.001
		(0.017)		(0.018)		(0.026)		(0.016)		(0.017)
MP*efficiency	0.111***	0.077**	0.102***	0.059	0.156***	0.084*	0.127***	0.081**	0.018	0.020
	(0.036)	(0.038)	(0.036)	(0.038)	(0.043)	(0.045)	(0.037)	(0.039)	(0.049)	(0.050)
MP*capitalization*type		0.794		0.090		0.209		−0.004		−0.280
		(1.023)		(0.528)		(0.219)		(0.747)		(0.218)
MP*liquidity*type		−0.004		0.056		0.006		0.080		0.042
		(0.344)		(0.120)		(0.070)		(0.205)		(0.082)
MP*size*type		0.016		−0.004		−0.004		−0.008		0.015
		(0.059)		(0.011)		(0.007)		(0.029)		(0.015)
MP*state share*type		−0.043		−0.005		0.054		0.052		−0.045
		(0.120)		(0.041)		(0.035)		(0.144)		(0.082)
MP*efficiency*type	−0.334	−0.316	0.181	0.281	−0.134**	−0.041	−0.324**	−0.240	0.156**	0.073
	(0.443)	(0.508)	(0.255)	(0.292)	(0.066)	(0.069)	(0.164)	(0.176)	(0.065)	(0.068)
GDP	1.755***	1.695**	1.874***	1.858***	1.883***	1.768***	1.784***	1.730***	1.773***	1.805***
	(0.647)	(0.673)	(0.646)	(0.675)	(0.641)	(0.660)	(0.638)	(0.664)	(0.637)	(0.665)
Regulation	0.523**	0.363	0.543**	0.390*	0.562**	0.416*	0.542**	0.390*	0.526**	0.426*
	(0.220)	(0.229)	(0.220)	(0.228)	(0.219)	(0.229)	(0.219)	(0.229)	(0.220)	(0.228)
Observations	720	687	720	687	720	687	720	687	720	687
R-squared	0.143	0.207	0.143	0.205	0.149	0.210	0.150	0.205	0.157	0.216
Number of banks	148	142	148	142	148	142	148	142	148	142

This table shows results of fixed effects panel regressions as indicated in Eq. (2). The bank type dummy variables are included (Big Five banks, joint stock commercial banks, city commercial banks, rural commercial banks and foreign banks). The dependent variable is growth in bank lending. We report two model specifications for each bank type. Monetary policy is measured by reserve requirements (average reserve requirements for large and small and mid-sized banks). We use the on-year change in the average reserve requirements. *Capitalization* is bank's equity to total assets. *Liquidity* is the ratio of liquid assets to total assets. *Size* is the logarithm of bank's total assets. *Efficiency* is the efficiency score calculated for each bank using the using a stochastic frontier approach described in Section 3.2. *State share* is the share of the bank owned by state. All bank level variables are demeaned and lagged by one period. *Regulation* stands for regulatory quality indicator by World Bank. Standard errors clustered at bank level appear in brackets below estimated coefficients. *, **, *** denote an estimate significantly different from 0 at the 10%, 5%, and 1% level, respectively. Bank and year fixed effects are included.

Table 6
Estimations by ownership type with CHIBOR interbank rate.

Bank type	Big Five		Joint stock		City commercial banks		Rural commercial banks		Foreign banks	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
MP	−0.029***	−0.028***	−0.027***	−0.026***	−0.032***	−0.024*	−0.032***	−0.029***	−0.024***	−0.030**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.010)	(0.014)	(0.008)	(0.008)	(0.009)	(0.012)
MP*type	0.008	−0.022	−0.023	−0.023	0.006	−0.010	0.033	0.048	−0.019	0.108**
	(0.029)	(0.504)	(0.031)	(0.087)	(0.014)	(0.019)	(0.024)	(0.054)	(0.018)	(0.043)
Capitalization	0.769**	0.259	0.780**	0.250	0.761**	0.279	0.732**	0.253	0.695**	0.435
	(0.303)	(0.312)	(0.303)	(0.311)	(0.303)	(0.312)	(0.302)	(0.311)	(0.304)	(0.313)
Liquidity	0.323***	0.218**	0.327***	0.217**	0.316***	0.233**	0.324***	0.222**	0.300***	0.232**
	(0.094)	(0.094)	(0.094)	(0.094)	(0.095)	(0.094)	(0.094)	(0.094)	(0.094)	(0.093)
Size	−0.060*	−0.079**	−0.059*	−0.079**	−0.062*	−0.074**	−0.057*	−0.077**	−0.063*	−0.071**
	(0.035)	(0.034)	(0.035)	(0.034)	(0.035)	(0.034)	(0.035)	(0.034)	(0.035)	(0.034)
State share	−0.040	−0.047	−0.042	−0.054	−0.040	−0.050	−0.045	−0.053	−0.044	−0.048
	(0.081)	(0.080)	(0.081)	(0.079)	(0.081)	(0.079)	(0.081)	(0.079)	(0.080)	(0.078)
Efficiency	−0.477***	−0.476***	−0.460***	−0.465***	−0.444***	−0.479***	−0.514***	−0.494***	−0.469***	−0.430***
	(0.108)	(0.105)	(0.106)	(0.103)	(0.107)	(0.105)	(0.108)	(0.107)	(0.105)	(0.103)
MP*capitalization		−0.613***		−0.612***		−0.626***		−0.592***		−0.330
		(0.140)		(0.133)		(0.157)		(0.132)		(0.342)
MP*liquidity		−0.066		−0.068		−0.131		−0.065		−0.015
		(0.069)		(0.072)		(0.097)		(0.069)		(0.080)
MP*size		−0.003		0.001		−0.000		−0.002		−0.003
		(0.006)		(0.005)		(0.007)		(0.005)		(0.005)
MP*state		−0.036		−0.045		−0.075		−0.032		0.002
		(0.033)		(0.035)		(0.054)		(0.033)		(0.033)
MP*efficiency	0.072	0.001	0.067	−0.020	0.130	−0.076	0.103	0.022	−0.036	−0.016
	(0.071)	(0.077)	(0.072)	(0.077)	(0.102)	(0.109)	(0.074)	(0.081)	(0.086)	(0.089)
MP*capitalization*type		0.155		0.373		0.235		0.534		0.185
		(2.996)		(1.311)		(0.427)		(1.587)		(0.422)
MP*liquidity*type		0.028		0.132		0.111		0.191		−0.049
		(0.620)		(0.256)		(0.131)		(0.361)		(0.155)
MP*size*type		0.006		−0.005		−0.006		−0.006		0.096***
		(0.108)		(0.024)		(0.014)		(0.047)		(0.026)
MP*state*type		0.034		0.001		0.089		0.140		0.067
		(0.222)		(0.092)		(0.071)		(0.217)		(0.176)
MP*efficiency*type	−0.480	−0.441	0.400	0.618	−0.119	0.129	−0.368	−0.258	0.292**	−0.112
	(0.629)	(0.679)	(0.692)	(0.820)	(0.143)	(0.156)	(0.236)	(0.262)	(0.148)	(0.178)
GDP	1.410**	1.233**	1.434**	1.311**	1.400**	1.195**	1.433**	1.283**	1.406**	1.314**
	(0.600)	(0.598)	(0.601)	(0.593)	(0.599)	(0.587)	(0.597)	(0.590)	(0.597)	(0.579)
Regulation	0.239	0.086	0.249	0.092	0.243	0.122	0.244	0.097	0.223	0.153
	(0.204)	(0.210)	(0.204)	(0.207)	(0.205)	(0.207)	(0.203)	(0.209)	(0.204)	(0.205)
Observations	720	720	720	720	720	720	720	720	720	720
R-squared	0.124	0.174	0.124	0.178	0.125	0.179	0.130	0.177	0.132	0.205
Number of banks	148	148	148	148	148	148	148	148	148	148

This table shows results of fixed effects panel regressions as indicated in Eq. (2). The bank type dummy variables are included (Big Five banks, joint stock commercial banks, city commercial banks, rural commercial banks and foreign banks). The dependent variable is growth in bank lending. We report two model specifications for each bank type. Monetary policy is measured by interbank rate (CHIBOR). We use the on-year change in the average interbank rate. *Capitalization* is bank's equity to total assets. *Liquidity* is the ratio of liquid assets to total assets. *Size* is the logarithm of bank's total assets. *Efficiency* is the efficiency score calculated for each bank using the using a stochastic frontier approach described in Section 3.2. *State share* is the share of the bank owned by state. All bank level variables are demeaned and lagged by one period. *Regulation* stands for regulatory quality indicator by World Bank. Standard errors clustered at bank level appear in brackets below estimated coefficients. *, **, *** denote an estimate significantly different from 0 at the 10%, 5%, and 1% level, respectively. Bank and year fixed effects are included.

Table 7
Estimations by ownership type with benchmark policy rate.

Bank type	Big Five		Joint stock		City commercial banks		Rural commercial banks		Foreign banks	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
MP	−0.043***	−0.039***	−0.041***	−0.037***	−0.044***	−0.006	−0.049***	−0.041***	−0.048***	−0.054***
	(0.012)	(0.012)	(0.012)	(0.013)	(0.015)	(0.018)	(0.012)	(0.012)	(0.013)	(0.018)
MP*type	−0.013	0.227	−0.023	−0.006	−0.005	−0.052*	0.031	0.010	0.012	0.108**
	(0.041)	(0.474)	(0.036)	(0.116)	(0.021)	(0.027)	(0.037)	(0.071)	(0.026)	(0.042)
Capitalization	0.788***	0.168	0.788***	0.198	0.782***	0.139	0.737**	0.197	0.769**	0.096
	(0.302)	(0.322)	(0.302)	(0.322)	(0.301)	(0.324)	(0.300)	(0.319)	(0.299)	(0.329)
Liquidity	0.354***	0.265***	0.355***	0.285***	0.354***	0.303***	0.360***	0.293***	0.344***	0.276***
	(0.095)	(0.096)	(0.095)	(0.097)	(0.095)	(0.096)	(0.094)	(0.096)	(0.094)	(0.095)
Size	−0.054	−0.076**	−0.055	−0.069**	−0.056	−0.067*	−0.055	−0.066*	−0.056	−0.069**
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.034)	(0.034)	(0.034)
State share	−0.036	−0.058	−0.040	−0.055	−0.030	−0.030	−0.049	−0.062	−0.038	−0.041
	(0.081)	(0.080)	(0.081)	(0.080)	(0.080)	(0.080)	(0.080)	(0.079)	(0.079)	(0.078)
Efficiency	−0.445***	−0.487***	−0.446***	−0.480***	−0.430***	−0.485***	−0.505***	−0.532***	−0.469***	−0.518***
	(0.106)	(0.105)	(0.106)	(0.105)	(0.106)	(0.105)	(0.107)	(0.106)	(0.104)	(0.104)
MP*capitalization		−0.921***		−0.866***		−1.109***		−0.867***		−0.440
		(0.193)		(0.194)		(0.227)		(0.190)		(0.486)
MP*liquidity		0.110		0.085		0.174		0.133		0.029
		(0.113)		(0.123)		(0.159)		(0.114)		(0.130)
MP*size		−0.018**		−0.011		−0.026***		−0.018**		−0.006
		(0.008)		(0.009)		(0.009)		(0.007)		(0.008)
MP*state share		−0.006		−0.007		0.020		0.002		0.027
		(0.032)		(0.033)		(0.034)		(0.033)		(0.033)
MP*efficiency	0.171*	0.197*	0.177*	0.170	0.333**	0.280*	0.284***	0.331***	−0.125	−0.081
	(0.100)	(0.110)	(0.102)	(0.111)	(0.134)	(0.146)	(0.108)	(0.121)	(0.119)	(0.126)
MP*capitalization*type		2.571		0.393		0.679		0.245		−0.877
		(3.028)		(1.585)		(0.618)		(2.547)		(0.573)
MP*liquidity*type		−0.808		0.227		−0.160		−0.050		0.622**
		(0.903)		(0.399)		(0.220)		(0.659)		(0.268)
MP*size*type		−0.035		−0.001		0.015		0.031		0.013
		(0.100)		(0.033)		(0.019)		(0.045)		(0.038)
MP*state share*type		0.060		0.043		0.072		0.089		0.011
		(0.114)		(0.088)		(0.081)		(0.080)		(0.080)
MP*efficiency*type	−0.182	−0.024	0.143	0.024	−0.362*	−0.233	−0.638**	−0.629*	0.893***	0.899***
	(1.740)	(1.824)	(0.827)	(1.058)	(0.198)	(0.221)	(0.264)	(0.329)	(0.206)	(0.260)
GDP	1.340**	1.064*	1.350**	1.250**	1.349**	1.237**	1.334**	1.245**	1.438**	1.250**
	(0.595)	(0.608)	(0.595)	(0.599)	(0.590)	(0.589)	(0.588)	(0.590)	(0.585)	(0.588)
Regulation	0.362*	0.280	0.362*	0.305	0.373*	0.344*	0.381*	0.330	0.393*	0.324
	(0.208)	(0.207)	(0.208)	(0.206)	(0.208)	(0.205)	(0.207)	(0.205)	(0.205)	(0.203)
Observations	720	720	720	720	720	720	720	720	720	720
R-squared	0.131	0.171	0.131	0.171	0.136	0.179	0.143	0.180	0.159	0.203
Number of banks	148	148	148	148	148	148	148	148	148	148

This table shows results of fixed effects panel regressions as indicated in Eq. (2). The bank type dummy variables are included (Big Five banks, joint stock commercial banks, city commercial banks, rural commercial banks and foreign banks). The dependent variable is growth in bank lending. We report two model specifications for each bank type. Monetary policy is measured by 1-year benchmark policy rate. We use the on-year change in the average policy rate. *Capitalization* is bank's equity to total assets. *Liquidity* is the ratio of liquid assets to total assets. *Size* is the logarithm of bank's total assets. *Efficiency* is the efficiency score calculated for each bank using the using a stochastic frontier approach described in Section 3.2. *State share* is the share of the bank owned by state. All bank level variables are demeaned and lagged by one period. *Regulation* stands for regulatory quality indicator by World Bank. Standard errors clustered at bank level appear in brackets below estimated coefficients. *, **, *** denote an estimate significantly different from 0 at the 10%, 5%, and 1% level, respectively. Bank and year fixed effects are included.

observe that the interaction term between monetary policy and bank efficiency is significantly positive in most estimations with reserve requirements and the benchmark policy rate, confirming our finding that higher bank efficiency tends to hamper monetary policy effectiveness.

We find that overall the interaction term between monetary policy, bank efficiency, and bank type is not significant in most estimations. It can however be significant for three bank types. The interaction term is significantly positive in both specifications for foreign banks with the policy rate and in one specification with the two other monetary policy instruments (reserve requirements and interbank rate). Thus, bank efficiency dampens the transmission of monetary policy for foreign banks. In other words, efficient foreign banks hinder the transmission of monetary policy. Nevertheless, we need to keep in mind that the foreign banks only account for less than 2% of the banking sector assets in China and therefore their role in the banking system is limited.

Furthermore, the interaction term is significantly negative for rural commercial banks in both specifications with the policy rate and in one specification with the reserve requirements. Finally, the interaction term is significantly negative for city commercial banks with two monetary policy instruments (reserve requirements and policy rate). We find this result only in the specification that excludes the three interaction variables between monetary policy, the four other bank-specific characteristics (capitalization, liquidity, size, state share) and bank type. These findings provide limited support that bank efficiency influences the transmission of monetary policy in the case of rural commercial banks and city commercial banks.

Hence, these estimations provide limited evidence that the impact of bank efficiency on the bank lending channel in China differs depending on bank type.

Table 8
Estimations by loan-to-deposit ratio.

Monetary policy measure	Reserve requirements		CHIBOR 7-day interbank rate		Policy rate	
Loan-to-deposit ratio	Above median	Below median	Above median	Below median	Above median	Below median
	(1)	(2)	(1)	(2)	(1)	(2)
MP	−0.009**	−0.018**	−0.013**	−0.029**	−0.025***	−0.062***
	(0.004)	(0.008)	(0.006)	(0.012)	(0.008)	(0.020)
Capitalization	0.684***	0.874*	0.617***	−0.107	0.436*	0.288
	(0.221)	(0.510)	(0.237)	(0.469)	(0.245)	(0.485)
Liquidity	0.245***	0.198	0.202***	0.084	0.242***	0.230*
	(0.074)	(0.132)	(0.072)	(0.127)	(0.071)	(0.134)
Size	−0.234***	−0.046	−0.235***	−0.085**	−0.222***	−0.055
	(0.039)	(0.043)	(0.038)	(0.041)	(0.037)	(0.044)
State share	−0.043	0.029	−0.044	0.017	−0.046	0.018
	(0.056)	(0.139)	(0.055)	(0.135)	(0.054)	(0.139)
MP*capitalization	−0.094*	−0.430***	−0.117	−0.908***	−0.339***	−1.292***
	(0.054)	(0.087)	(0.099)	(0.172)	(0.129)	(0.300)
MP*liquidity	0.049	0.015	0.068	−0.024	0.192**	0.108
	(0.033)	(0.047)	(0.063)	(0.086)	(0.092)	(0.158)
MP*size	−0.002	0.000	−0.007**	0.008	−0.015***	0.007
	(0.002)	(0.003)	(0.003)	(0.007)	(0.005)	(0.009)
MP*state	−0.008	−0.009	−0.020	−0.073*	−0.032	−0.053
	(0.012)	(0.022)	(0.023)	(0.044)	(0.031)	(0.068)
GDP	1.872***	1.007	1.511***	0.594	1.787***	0.849
	(0.467)	(1.058)	(0.422)	(0.940)	(0.410)	(0.992)
Regulation	0.281*	0.315	0.135	−0.029	0.215	0.293
	(0.162)	(0.310)	(0.151)	(0.284)	(0.142)	(0.298)
Efficiency	−0.000	−1.127***	0.098	−1.270***	0.059	−1.318***
	(0.096)	(0.168)	(0.073)	(0.158)	(0.071)	(0.168)
MP*efficiency	0.027	−0.027	0.139***	−0.278**	0.240***	−0.376**
	(0.025)	(0.065)	(0.051)	(0.107)	(0.071)	(0.163)
Observations	378	342	378	342	378	342
R-squared	0.332	0.398	0.353	0.425	0.403	0.380
Number of banks	94	107	94	107	94	107

This table shows results of fixed effects panel regressions as indicated in Eq. (2). The dependent variable is growth in bank lending. We report two model specifications for each of three monetary policy measures (*MP*): reserve requirements (average reserve reequipments for large and small and mid-sized banks), 7-day interbank rate (CHIBOR) and 1-year policy lending rate. The first specification considers the sample of banks which have the value of loan-to-deposit ratio above the median value and the second specification is for the banks with value of loan-to-deposit ratio below the median. We use the on-year change in the average MP measure. *Capitalization* is bank's equity to total assets. *Liquidity* is the ratio of liquid assets to total assets. *Size* is the logarithm of bank's total assets. *Efficiency* is the efficiency score calculated for each bank using the using a stochastic frontier approach described in Section 3.2. *State share* is the share of the bank owned by state. All bank level variables are demeaned and lagged by one period. *Regulation* stands for regulatory quality indicator by World Bank. Standard errors clustered at bank level appear in brackets below estimated coefficients. *, **, *** denote an estimate significantly different from 0 at the 10%, 5%, and 1% level, respectively. Bank and year fixed effects are included.

Table 9
Influence of shadow banking expansion.

Monetary policy	Average reserve requirements			CHIBOR 7-day interbank rate			1-year benchmark policy rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
MP	−0.015**	−0.017**	−0.011	−0.027**	−0.018	−0.019	−0.072***	−0.014	−0.030
	(0.006)	(0.007)	(0.008)	(0.013)	(0.013)	(0.015)	(0.025)	(0.028)	(0.031)
Shadow banking growth	0.046	0.019	0.036	0.081	0.061	0.027	0.050	0.105	0.077
	(0.067)	(0.074)	(0.077)	(0.060)	(0.068)	(0.069)	(0.058)	(0.067)	(0.068)
MP*shadow banking growth	0.018	−0.032	−0.048	0.054	−0.031	0.002	0.326**	−0.126	0.077
	(0.034)	(0.038)	(0.042)	(0.059)	(0.058)	(0.067)	(0.144)	(0.157)	(0.184)
Capitalization	1.852***	0.382	1.226**	0.987***	0.434	0.443	1.476***	0.407	1.018*
	(0.408)	(0.404)	(0.476)	(0.350)	(0.403)	(0.424)	(0.400)	(0.407)	(0.519)
Capitalization*shadow banking growth	1.311	4.107***	1.476	3.875***	4.079***	2.912***	1.769*	4.080***	1.052
	(1.143)	(0.894)	(1.292)	(0.928)	(0.891)	(1.018)	(0.961)	(0.897)	(1.179)
Liquidity	0.011	0.239	−0.018	0.282	0.145	−0.135	0.340*	0.212	0.042
	(0.229)	(0.203)	(0.291)	(0.195)	(0.196)	(0.238)	(0.195)	(0.197)	(0.246)
Liquidity*shadow banking growth	0.705	0.189	0.564	−0.291	0.299	0.338	−0.007	0.255	0.620
	(0.558)	(0.438)	(0.693)	(0.431)	(0.431)	(0.515)	(0.399)	(0.439)	(0.483)
Size	−0.055	−0.023	−0.002	−0.072*	−0.024	−0.055	−0.081**	−0.024	−0.048
	(0.037)	(0.043)	(0.044)	(0.037)	(0.043)	(0.043)	(0.036)	(0.043)	(0.043)
Size*shadow banking growth	−0.046	−0.012	−0.060*	−0.004	−0.009	−0.022	−0.020	−0.013	−0.040
	(0.033)	(0.025)	(0.035)	(0.026)	(0.025)	(0.027)	(0.025)	(0.025)	(0.026)
State share	0.032	−0.003	0.017	0.009	−0.010	0.002	−0.024	−0.007	0.004
	(0.084)	(0.099)	(0.106)	(0.086)	(0.099)	(0.106)	(0.085)	(0.100)	(0.107)
State share*shadow banking growth	−0.019	−0.017	−0.043	0.022	−0.016	−0.139	0.025	−0.016	0.029
	(0.126)	(0.141)	(0.148)	(0.159)	(0.141)	(0.185)	(0.125)	(0.141)	(0.145)
MP*capitalization	−0.443***		−0.428***	−0.386*		−0.893***	−2.034***		−2.639***
	(0.109)		(0.130)	(0.232)		(0.268)	(0.521)		(0.705)
MP*capitalization*shadow banking growth	2.761***		1.814**	2.406**		3.019**	10.214***		12.145***
	(0.603)		(0.734)	(1.044)		(1.218)	(2.960)		(4.056)
MP*liquidity	0.100*		0.078	−0.001		0.283*	−0.194		0.101
	(0.057)		(0.076)	(0.119)		(0.151)	(0.209)		(0.274)
MP*liquidity*shadow banking growth	0.031		−0.319	−0.382		−1.674***	2.026*		0.651
	(0.296)		(0.379)	(0.464)		(0.561)	(1.130)		(1.458)
MP*size	−0.005		−0.007*	−0.008		−0.017*	−0.013		−0.017
	(0.003)		(0.004)	(0.008)		(0.009)	(0.014)		(0.016)
MP*size*shadow banking growth	0.012		0.015	0.039		0.072*	0.017		−0.002
	(0.018)		(0.020)	(0.035)		(0.038)	(0.079)		(0.085)
MP*state share	−0.025		−0.020	−0.053		−0.051	−0.093		−0.169
	(0.017)		(0.021)	(0.047)		(0.055)	(0.087)		(0.106)
MP*state share*shadow banking growth	0.114		0.132	0.155		0.229	0.054		0.802
	(0.124)		(0.144)	(0.234)		(0.269)	(0.472)		(0.575)
GDP	2.871***	3.055***	3.280***	2.055**	2.309**	1.303	1.848**	2.080**	1.966**
	(0.982)	(1.157)	(1.176)	(0.903)	(1.026)	(1.047)	(0.848)	(1.011)	(0.997)

(*continued on next page*)

Table 9 (*continued*)

Monetary policy	Average reserve requirements			CHIBOR 7-day interbank rate			1-year benchmark policy rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Regulation	0.297	0.264	0.053	0.293	0.105	−0.287	0.401	0.363	0.232
	(0.299)	(0.323)	(0.364)	(0.286)	(0.324)	(0.335)	(0.274)	(0.323)	(0.334)
Efficiency		−1.020***	−0.970***		−1.000***	−0.973***		−0.905***	−0.786***
		(0.255)	(0.267)		(0.227)	(0.227)		(0.282)	(0.280)
Efficiency*shadow banking growth		0.478	0.490		0.286	0.102		0.285	0.196
		(0.601)	(0.626)		(0.531)	(0.535)		(0.561)	(0.557)
MP*efficiency		0.095	0.100		0.217*	0.292**		0.125	0.002
		(0.071)	(0.078)		(0.128)	(0.143)		(0.332)	(0.346)
MP*efficiency*shadow banking growth		−0.413	−0.331		−1.183**	−1.675***		−0.348	1.009
		(0.378)	(0.397)		(0.593)	(0.619)		(2.035)	(2.071)
Observations	776	720	720	776	720	720	776	720	720
R-squared	0.196	0.201	0.223	0.170	0.199	0.257	0.233	0.195	0.266
Number of banks	152	148	148	152	148	148	152	148	148

This table shows results of fixed effects panel regressions as indicated in Eq. (2). The dependent variable is growth in bank lending. We report three model specifications for each of three monetary policy measures (*MP*): reserve requirements (average reserve reequipments for large and small and mid-sized banks), 7-day interbank rate (CHIBOR) and 1-year policy lending rate. We use the on-year change in the average MP measure. We account for the period when shadow banking was growing fast by including variable *Shadow banking growth.* This variable is defined as the year-on-year growth of banks' shadow activities as defined in Sun (2019) and shown in Fig. 1. *Capitalization* is bank's equity to total assets. *Liquidity* is the ratio of liquid assets to total assets. *Size* is the logarithm of bank's total assets. *Efficiency* is the efficiency score calculated for each bank using the using a stochastic frontier approach described in Section 3.2. *State share* is the share of the bank owned by state. All bank level variables are demeaned and lagged by one period. *Regulation* stands for regulatory quality indicator by World Bank. Standard errors clustered at bank level appear in brackets below estimated coefficients. *, **, *** denote an estimate significantly different from 0 at the 10%, 5%, and 1% level, respectively. Bank and year fixed effects are included.

Table 10
Robustness check: main estimations with the alternative efficiency measure from the WITHIN model.

Monetary policy	Average of reserve requirements			CHIBOR 7-day interbank rate			1-year benchmark policy rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
MP	−0.020***	−0.016***	−0.017***	−0.025***	−0.021**	−0.022**	−0.037***	−0.033**	−0.025*
	(0.004)	(0.005)	(0.005)	(0.008)	(0.008)	(0.009)	(0.011)	(0.013)	(0.013)
Capitalization	2.037***	0.884***	1.030***	1.607***	0.841***	0.368	1.447***	0.855***	0.316
	(0.249)	(0.305)	(0.295)	(0.244)	(0.303)	(0.312)	(0.245)	(0.304)	(0.320)
Liquidity	0.337***	0.414***	0.341***	0.316***	0.360***	0.260***	0.389***	0.406***	0.316***
	(0.083)	(0.097)	(0.095)	(0.084)	(0.095)	(0.095)	(0.083)	(0.095)	(0.096)
Size	−0.086***	−0.078**	−0.064*	−0.102***	−0.080**	−0.089**	−0.098***	−0.071**	−0.080**
	(0.029)	(0.035)	(0.034)	(0.029)	(0.035)	(0.035)	(0.029)	(0.035)	(0.035)
State share	−0.025	−0.040	−0.044	−0.039	−0.047	−0.053	−0.053	−0.044	−0.061
	(0.068)	(0.081)	(0.078)	(0.070)	(0.081)	(0.080)	(0.069)	(0.081)	(0.081)
MP*capitalization	−0.312***		−0.403***	−0.283**		−0.608***	−0.619***		−0.824***
	(0.053)		(0.067)	(0.116)		(0.137)	(0.151)		(0.187)
MP*liquidity	0.082***		−0.024	0.071		−0.071	0.319***		−0.033
	(0.029)		(0.035)	(0.060)		(0.068)	(0.089)		(0.109)
MP*size	−0.000		−0.001	0.000		−0.002	−0.004		−0.007
	(0.002)		(0.002)	(0.005)		(0.005)	(0.006)		(0.006)
MP*state share	−0.017		−0.010	−0.030		−0.028	−0.068*		−0.030
	(0.014)		(0.016)	(0.029)		(0.032)	(0.041)		(0.046)
GDP	2.472***	1.912***	1.392**	1.744***	1.446**	1.136*	1.899***	1.312**	0.848
	(0.571)	(0.650)	(0.650)	(0.540)	(0.606)	(0.599)	(0.533)	(0.608)	(0.621)
Regulation	0.566***	0.647***	0.458**	0.284	0.360*	0.204	0.387**	0.477**	0.339
	(0.201)	(0.223)	(0.218)	(0.191)	(0.209)	(0.213)	(0.190)	(0.212)	(0.211)
Efficiency		−0.353***	−0.360***		−0.375***	−0.260**		−0.347***	−0.275**
		(0.118)	(0.114)		(0.120)	(0.120)		(0.120)	(0.120)
MP*efficiency		−0.016	0.084**		−0.100	0.068		0.024	0.210*
		(0.033)	(0.037)		(0.066)	(0.077)		(0.102)	(0.116)
Observations	940	714	714	940	714	714	940	714	714
R-squared	0.196	0.115	0.184	0.153	0.111	0.153	0.171	0.109	0.147
Number of banks	165	142	142	165	142	142	165	142	142

This table shows results of fixed effects panel regressions as indicated in Eq. (2). The dependent variable is growth in bank lending. We report three model specifications for each of three monetary policy measures (*MP*): reserve requirements (average reserve reequipments for large and small and mid-sized banks), 7-day interbank rate (CHIBOR) and 1-year policy lending rate. We use the on-year change in the average MP measure. *Capitalization* is bank's equity to total assets. *Liquidity* is the ratio of liquid assets to total assets. *Size* is the logarithm of bank's total assets. *Efficiency* is the efficiency score calculated as described in Section 4.5. *State share* is the share of the bank owned by state. All bank level variables are demeaned and lagged by one period. *Regulation* stands for regulatory quality indicator by World Bank. Standard errors clustered at bank level appear in brackets below estimated coefficients. *, **, *** denote an estimate significantly different from 0 at the 10%, 5%, and 1% level, respectively. Bank and year fixed effects are included.

Table 11
Robustness check: main estimations with the alternative efficiency measure from Karakaplan and Kutlu (2017).

Monetary policy	Average reserve requirements			CHIBOR 7-day interbank rate			1-year benchmark policy rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
MP	−0.016***	−0.018***	−0.018***	−0.024***	−0.030***	−0.032***	−0.031**	−0.048***	−0.050***
	(0.005)	(0.005)	(0.004)	(0.008)	(0.008)	(0.008)	(0.013)	(0.011)	(0.010)
Capitalization	0.503	−0.405	0.006	0.322	−0.386	−0.328	0.252	−0.402	−0.568*
	(0.413)	(0.404)	(0.366)	(0.350)	(0.402)	(0.313)	(0.379)	(0.405)	(0.329)
Liquidity	−0.149	−0.010	−0.059	−0.140	−0.048	−0.071	−0.092	−0.020	−0.007
	(0.128)	(0.091)	(0.087)	(0.120)	(0.092)	(0.087)	(0.132)	(0.093)	(0.084)
Size	−0.003	−0.016***	−0.016**	−0.006	−0.017***	−0.019***	−0.006	−0.016***	−0.016***
	(0.005)	(0.006)	(0.006)	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
State share	0.135***	0.054*	0.067**	0.130***	0.052	0.048	0.124***	0.052	0.050
	(0.032)	(0.032)	(0.033)	(0.030)	(0.033)	(0.033)	(0.031)	(0.033)	(0.033)
MP*capitalization	−0.203**		−0.414***	−0.210		−0.794***	−0.483*		−1.078***
	(0.095)		(0.090)	(0.228)		(0.163)	(0.250)		(0.181)
MP*liquidity	0.071		0.046	0.065		0.045	0.299*		0.190*
	(0.045)		(0.033)	(0.113)		(0.085)	(0.172)		(0.115)
MP*size	−0.002		0.001	−0.001		0.001	−0.008*		0.004
	(0.002)		(0.002)	(0.003)		(0.004)	(0.005)		(0.005)
MP*state share	−0.011		−0.018	−0.021		−0.011	−0.040		0.014
	(0.014)		(0.014)	(0.029)		(0.032)	(0.040)		(0.040)
GDP	3.334***	2.557***	2.283***	2.628***	1.875***	1.739***	2.758***	1.956***	1.778***
	(0.566)	(0.435)	(0.487)	(0.472)	(0.349)	(0.348)	(0.450)	(0.333)	(0.350)
Regulation	0.022	0.167	0.112	−0.168	−0.084	−0.127	−0.109	0.026	0.005
	(0.227)	(0.156)	(0.152)	(0.223)	(0.151)	(0.150)	(0.220)	(0.148)	(0.146)
Efficiency		−0.238*	−0.271*		−0.224	−0.248*		−0.193	−0.170
		(0.144)	(0.151)		(0.137)	(0.136)		(0.137)	(0.135)
MP*efficiency		0.044	0.101***		0.029	0.175*		0.162**	0.417***
		(0.030)	(0.035)		(0.069)	(0.093)		(0.082)	(0.100)
Observations	940	720	720	940	720	720	940	720	720
R-squared	0.065	0.058	0.108	0.052	0.057	0.110	0.062	0.064	0.112
Number of banks	165	148	148	165	148	148	165	148	148

This table shows results of fixed effects panel regressions as indicated in Eq. (2). The dependent variable is growth in bank lending. We report three model specifications for each of three monetary policy measures (*MP*): reserve requirements (average reserve reequipments for large and small and mid-sized banks), 7-day interbank rate (CHIBOR) and 1-year policy lending rate. We use the on-year change in the average MP measure. *Capitalization* is bank's equity to total assets. *Liquidity* is the ratio of liquid assets to total assets. *Size* is the logarithm of bank's total assets. *Efficiency* is the efficiency score calculated based on the approach by Karakaplan and Kutlu (2017). *State share* is the share of the bank owned by state. All bank level variables are demeaned and lagged by one period. *Regulation* stands for regulatory quality indicator by World Bank. Standard errors clustered at bank level appear in brackets below estimated coefficients. *, **, *** denote an estimate significantly different from 0 at the 10%, 5%, and 1% level, respectively. Bank and year fixed effects are included.

4.3. Estimations by loan-to-deposit ratio

So far, our findings have generally suggested that bank efficiency does not affect the bank lending channel. However, it may be that the transmission of monetary policy differs across banks due to their structure of activities. Depending on their efficiency, banks with a higher loan-to-deposit ratio might be differently affected by changes in monetary policy. Differences in the funding structure and the composition of assets can influence the way bank efficiency affects the transmission of monetary policy.

To test this hypothesis, we redo our estimations to consider two groups of banks based on their loan-to-deposit ratios. The first group of banks have loan-to-deposit ratios higher than the median, while the second group has loan-to-deposit ratios below the median value of our sample. We only consider a specification that includes all monetary policy interaction terms. Table 8 reports the estimations.

Any evidence that bank efficiency favors the transmission of monetary policy relates to banks with lower-than-median loan-to-deposit for two out of three measures of monetary policy. With policy rate and interbank rate, we show that the interaction term between monetary policy and bank efficiency is significantly negative for banks with a low loan-to-deposit ratio and significantly positive for banks with a high loan-to-deposit ratio. With reserve requirements, the interaction term between monetary policy and bank efficiency is never significant, although the coefficients are of the same sign as the coefficients in the estimations with policy rate and interbank rate.

These findings support the view that the loan-to-deposit ratio plays a role in the impact of bank efficiency on the bank lending channel. We can interpret this result according to either hypothesis on the influence of bank efficiency on the bank lending channel. On the one hand, a low loan-to-deposit ratio means that the bank is more sensitive to the cost of funding since deposits play a greater role in financing. For such banks, higher efficiency is associated with a bigger reaction in loan growth to changes in monetary policy. On the other hand, a high loan-to-deposit ratio means that the bank is less dependent on deposits to finance its activities, and therefore less sensitive to monetary policy variations. Thus, for these banks, greater efficiency fosters access to alternative funding sources and thus hampers the transmission of monetary policy.

4.4. The influence of shadow banking expansion

The Chinese banking system underwent major changes during the observation period. Among these many changes, the growth of shadow banking is of particular importance as it has been shown to affect monetary policy transmission. Chen et al. (2018) find that the rise of shadow banking loans during 2009–2015 reduced the effectiveness of monetary policy. Cheng and Wang (2020) confirm this finding through an investigation of the lending behavior of Chinese listed banks over the period 2011–2018.

As these findings suggest that the bank lending channel might have also been influenced, we examine whether the expansion of shadow banking affected the bank lending channel, and more specifically, how this channel may have been influenced by bank efficiency. To this end, we add the dummy variable *Shadow banking growth* equal to the year-on-year growth of banks' shadow activities as defined in Sun (2019). As discussed in Section 2 (see also Fig. 1), traditional shadow banking and banks' shadow activities increased at an accelerating pace from 2012 to 2016. We interact *Shadow banking growth* with all variables to check whether the bank lending channel has evolved over the period of study.

Table 9 reports the results. For each monetary policy instrument, we perform the same set of three estimations as in the main estimations. This enables us to directly compare the findings. The first column presents the estimation for the bank lending channel without efficiency and the interaction term between monetary policy and efficiency. The second column adds efficiency and the interaction term between monetary policy and efficiency but drops the three other interaction terms with monetary policy. The third column displays the estimation with all variables. Two main conclusions emerge.

First, we find limited evidence that the bank lending channel was hampered by the rise of shadow banking. The interaction terms between monetary policy, capitalization and *Shadow banking growth* are significantly positive in all estimations. However, the interaction terms between monetary policy, *Shadow banking growth* and the three other bank-specific variables (liquidity, size, state share) are not significantly positive in any systematic way. This provides limited support for the fact that monetary policy transmission through bank lending channel has not been hampered during the period of ballooning shadow banking activities in 2012–2016 when compared to the rest of the period.

Second, we find limited evidence that the effect of bank efficiency on monetary policy transmission has changed with the expansion of shadow banking. The interaction term $MP \times Efficiency \times Shadow\ banking\ growth$ is significantly negative in estimations with the interbank rate, but not significant in estimations with reserve requirements and policy rate.

These results seem to suggest that the expansion of shadow banking reinforced the transmission of monetary policy among the more efficient banks to a certain extent, but why? More efficient banks may have had smaller increases in their shadow banking activities at the expense of bank loans because they had lower incentives to do so. Greater efficiency means they are under less pressure to boost profitability by venturing into more lucrative shadow banking activities. Thus, if more efficient banks are expected to engage less in shadow banking activities than other banks, higher bank efficiency could be associated with more effective monetary policy transmission as shadow banking activities are increasing.

4.5. Alternative efficiency measures

To check the validity of our empirical findings, we adopt two alternative approaches to measure efficiency. While in the main estimations we have utilized the stochastic frontier approach to estimate the cost frontier as it is standard in the literature, the

literature on banking efficiency offers a wide range of techniques for estimating cost efficiency (e.g. Bauer et al., 1998).

First, we use the time-varying WITHIN model proposed by Cornwell et al. (1990). This technique has been applied in several works on bank efficiency (e.g. Esho, 2001), and notably by Fungáčová et al. (2013) as a robustness check to measure efficiency of Chinese banks. It also relies on panel data, so the WITHIN model does not require distributional assumptions on the inefficiency term and the random error. The term φ_{it} is modeled as follows:

$$\varphi_{it} = \theta_{1i} + \theta_{2i}\, t + \theta_{3i}\, t^2, \tag{3}$$

where $\varphi_{it} = \varphi$ - u_{it}, i indexes bank, t represents time, φ the intercept in the cost function, and the θs are cross-section bank-specific parameters.

We report the results of estimations including efficiency scores computed with the WITHIN model in Table 10. For each monetary policy instrument, we present the same three specifications as in the main estimations.

We find that the monetary policy interaction term with bank efficiency is significant in two specifications. We obtain positive and significant coefficient for the specification with all variables for reserve requirements and policy rate. The interaction term is not significant for any specification with the interbank rate and in the specification with other interaction terms for reserve requirements and policy rate. Therefore, we find again limited support for the detrimental effect of bank efficiency on the monetary policy transmission. This is in line with our main conclusion, obtained with efficiency scores based on a stochastic frontier approach.

For the rest, these estimations show the same findings for the other variables. On the one hand, the effect of monetary policy changes on loan growth has the expected negative sign in accordance with the fact that an increase (decrease) in reserve requirements or interest rates leads to a decrease (increase) in loan growth rate. On the other hand, we do find no evidence supporting the existence of a bank lending channel in China. We only obtain a significant positive coefficient for the monetary policy interaction term for liquidity in two specifications.

Second, we employ the approach by Karakaplan and Kutlu (2017) which handles the endogeneity problem of both frontier and inefficiency variables. The Stata command xtsfkk developed in Karakaplan (2022) fits a panel stochastic cost frontier model that can handle endogenous variables in the frontier and/or the inefficiency. The input prices in our cost frontier model are specified as exogenous.

Table 11 displays the estimations with efficiency scores obtained with the approach by Karakaplan and Kutlu (2017). Once again, we adopt the same three specifications as in the main estimations for each monetary policy instrument.

We find that the monetary policy interaction term with bank efficiency is positive and significant in four out of six specifications. It is not significant in the estimations without interaction terms for reserve requirements and the interbank rate. This confirms some support for the finding that bank efficiency hampers monetary policy transmission.

We obtain similar findings for the other control variables. We still find that the effect of monetary policy changes on loan growth has the expected negative sign in accordance with the fact that an increase (decrease) in reserve requirements or interest rates leads to a decrease (increase) in loan growth rate. We again point out no evidence supporting the existence of a bank lending channel with a significant positive coefficient for the monetary policy interaction term only for liquidity in two estimations.

All in all, our main findings are confirmed using two alternative approaches to measure bank efficiency.

5. Conclusion

In this paper, we examine how bank efficiency influences the bank lending channel in China. We obtain limited evidence for the hypothesis that increased bank efficiency hampers the effectiveness of monetary policy transmission. We explain this finding so that efficient banks have better access to alternative sources of funding, making them less sensitive to monetary policy changes. This conclusion is robust to various monetary policy indicators, a set of explaining variables, and two alternative specifications of the efficiency frontier.

The analysis of bank types shows that this finding is more pronounced for foreign banks, for which higher efficiency strongly dampens monetary policy transmission. Given the small balance sheets of these banks relative to total banking sector assets, their relative importance in affecting monetary policy transmission in China is minor.

Furthermore, we observe that bank efficiency favors the transmission of monetary policy for banks with low loan-to-deposit ratios. Thus, the transmission of monetary policy is facilitated by higher bank efficiency when banks have a structure of activities with a lower share of loans relative to deposits. Respectively, for banks with high loan-to-deposit ratios, higher bank efficiency is acting as a dampening factor in the transmission of monetary policy. Finally, we find some support that the expansion of shadow banking activities has improved the monetary policy effectiveness for efficient banks.

The policy implications are that measures implemented to favor bank efficiency in China as a whole can hamper monetary policy transmission. The low efficiency of Chinese banks would be to a certain extent a blessing for the effectiveness of monetary policy transmission.

Our work opens avenues for further research. First, it will be of interest to investigate whether the increase of shadow banking activities in China contributes further to bank efficiency and enhances the effectiveness of monetary policy transmission in the years ahead. Second, this investigation of bank efficiency could be extended to other bank characteristics to help policymakers better identify which characteristics influence monetary policy transmission in China. Third, the impact of bank efficiency on monetary policy transmission should be investigated for other countries. This study on China and the work of Jonas and King (2008) on the US are the only two studies on this question. Future studies will doubtless help us refine our understanding of the impact of bank efficiency

on monetary policy transmission in a variety of national contexts.

Declaration of Competing Interest

None.

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